APPENDIX 2.

THE SHORELINE FISHERY OF AMERICAN SAMOA:
A 12-YEAR COMPARISON

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ABSTRACT

Harvesting fish and shellfish from the fringing reefs surrounding their islands has been an way of life for the people of American Samoa since time immemorial. In spite of its importance, only two studies of this largely subsistence fishery have been conducted, and the most recent one is now over 12 years old.

A concern for the condition of the reef resources and the need for more current information for the fishery prompted the implementation of a program to monitor the shoreline fishery of Tutuila Island in July 1990. Data were collected using similar methodology and in roughly the same area as the program conducted in 1979 by Wass (1980). This report describes the fishery in 1991 and compares current catch and effort levels with those from 1979.

Island-wide expansions of 1991 catch and effort estimates from the study area show that the annual catch and effort levels (439,000 lb and 224,000 gear-hours, respectively) were somewhat lower to those in 1979. The fishery, however, has not kept pace with the growth of the human population on Tutuila, which increased by 46% over the last 12 years. This is illustrated by a decline of over 50% of both per capita catch and effort for reef-resident fish and invertebrates since 1979.

In spite of this decline, the shoreline fishery harvested over 4 times the amount of pelagic and bottomfish taken in the domestic commercial fisheries in American Samoa. From this prospective, and considering the large number of people that participate in the shoreline fishery, it is recommended that resources be directed toward continued monitoring and research needed to maintain the fishery.

INTRODUCTION

Throughout their history, the people of American Samoa have relied on fish and shellfish food sources harvested on the reefs surrounding their islands. Prior to western influence, fishing provided a substantial portion of the protein in the Samoan diet. Although technological advances such as refrigeration, the availability of canned goods, and the gradual shift from a subsistence to a cash economy have created new options for meeting protein requirements, fishing remains an important part of the Samoan way of life.

The domestic fishery is comprised of two major components, the offshore commercial fishery and the shoreline subsistence fishery. The offshore fishery, described in detail in Aita'oto et al (1991), has evolved considerably from historical times. Outrigger canoes and sennit lines have been replaced with outboard driven catamarans and monofilament lines, through the effort of several fishery development programs. However, marketing problems, resource depletion, and difficulties maintaining vessels have been all contributed to the fishery's failure to thrive (Itano 1991). The present day offshore fishery supports both a commercial and a subsistence/recreational component, with approximately 70% of the total harvest being sold.

The shoreline fishery is primarily a subsistence fishery that targets fish and invertebrates from the fringing reef adjacent to the shoreline. Unlike the offshore fishery in which participation is limited by the number of seaworthy boats, the shoreline fishery is highly accessible to the inland's populace since all of the narrow, fringing reef can be reached on foot from shore. Fishing takes place at all hours of the day and night by all sectors of the population.

In spite of its popularity, very little is know about the shoreline fishery, and the information that exists is dated. A study was conducted in 1976 (Hill 1978) which focused on the reef area between the villages of Fagiatua and Malaloa, part of the southeastern shoreline. During the years 1977-1979 a more quantitative study was conducted to determine catch and effort levels for the area between Lauli'i and Faganeanea (Fig.1), as well as for four representative outer villages from which island-wide estimates were extrapolated (Wass 1980). While those studies provided important, historical insights into the fishery, the many changes, both social and ecological, that have occurred since that time render the data inadequate to describe the fishery today.

Concerns regarding the current status of the shoreline fishery and frequent information requests regarding catch and effort data stimulated DMWR to implement a new monitoring program. Since sampling the entire shoreline was not economically feasible, various sampling strategies were evaluated. A decision was made to re-assess the Lauli'i to Faganeanea shoreline area using similar sampling procedures as were used in the 1977-1979 study, thereby enabling comparisons between the two study periods to be made. A slight modification of sampling procedures (discussed later) allowed the reef area between Faganeanea and Nu'uuli to be included in this study.

The study area is a 16-km stretch of shoreline, centered around Pago Pago Harbor (Fig. 1). It exhibits an extreme range of reef health, from the relatively undisturbed setting in outer villages such as Lauli'ituai to the heavily impacted, industrialized shore of inner Pago Pago Harbor.

Since the time of the last study, many changes have taken place in the study area which may have impacted the shoreline fishery there. For example, in 1977-78, there was a crown-of-thorns (Acanthaster planci) infestation on the reefs surrounding Tutuila Island. Surveys conducted during the outbreak showed the reefs, including the study area, were heavily infested. A bounty program throughout

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the island recovered nearly a half a million starfish from the fringing reefs (Birkeland and Randal, n.d.).

Hurricanes hit the island in 1979 and 1990, subjecting the island to 75- and 93-knot winds respectively. Although quantitative data on resultant reef damage is sparse, qualitative observations suggest that damage was incurred, particularly in the latter storm.

The reef ecosystem has also been impacted as a result of the significant human population growth that has occurred over the last several years (Fig. 2). Rapid development and the accompanying environmental degradation have affected the study area in many ways: 1) Coastal roads have been protected with heavily armored banks which encroached on the reef flat. 2) Land clearing for new construction, and new plantations on steep slopes have exacerbated the siltation problems which exist in a high-island environment. 3) The amount of fish processed at the canneries has increased, which has increased the amount of waste the canneries dispose into inner Pago Pago Harbor. A clear trend of increasing total phosphorous and total nitrogen levels in the inner harbor occurred over the period 1979 to 1987 (Chamberlin et al 1989). In addition, low dissolved oxygen content due to high nutrient levels are suspected to be the cause of several fish kills in the inner harbor.

A recent toxicity study of the Pago Pago Harbor confirmed the presence of heavy metals, PCBs and pesticides in fish tissue samples taken from the inner harbor (AECOS 1991). Lead concentrations in the fish liver (9.3 ppm) and muscle tissue (2.9 ppm) were high enough to warrant the issuance of a health advisory, recommending that inner harbor fish not be eaten and prompting health officials to test for lead levels in the blood of children who have eaten fish from the harbor. The sale of fish caught in the impacted area was eventually banned.

METHODS

To estimate catch and effort levels for the shoreline fishery, a roving creel survey, described in detail below, was established to collect data within the study area. Sampling shifts were scheduled to cover the seven-day-a-week, 24-hour-a-day nature of the fishery. Analysis procedures, also described in detail below, entailed 1) the expansion of observed fishing effort to calculate the annual effort and 2) the estimation of annual catch by multiplying CPUE from observed catches by the annual effort.

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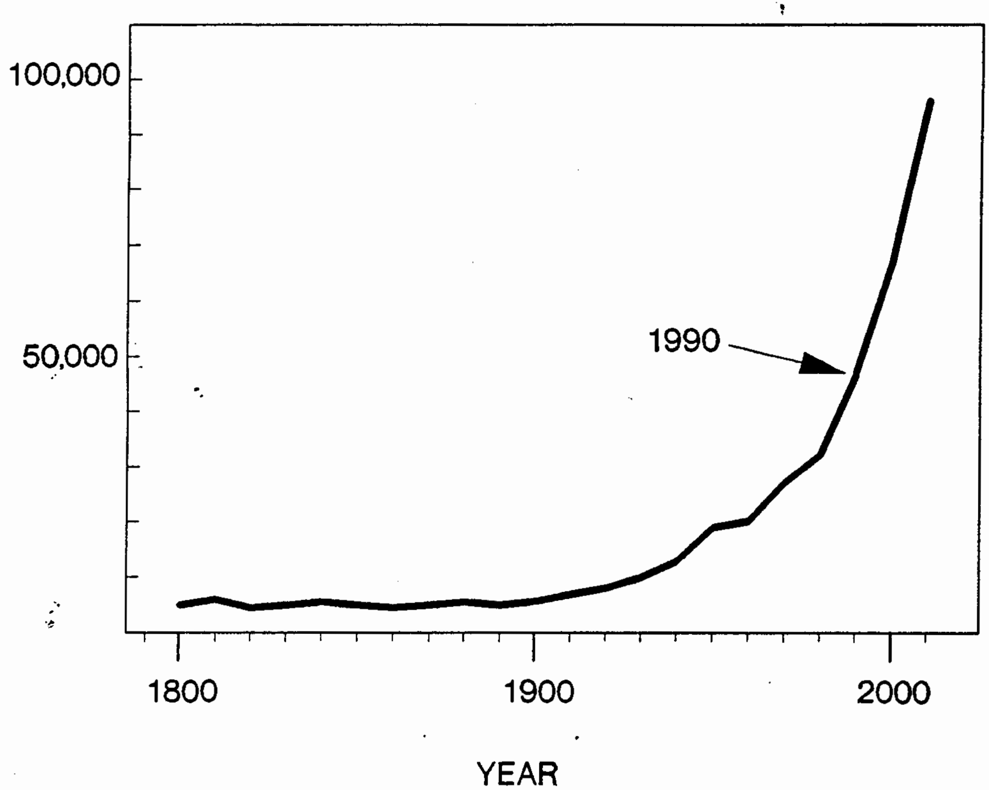

Figure 2. Growth of the human population in American Samoa. Source: Craig 1991.

FIELD SAMPLING

Sampling was conducted three days a week on a monthly schedule designed so each of the 24 hours in a day, every day of the week, and all lunar, tidal and weather conditions were representatively sampled over time. This regime provided a sample rate of approximately 6% of all possible hours in the year-long study. In a given eight hour sampling shift, two types of data were collected: (1) participation data, which is the number of people observed harvesting reef resources, and (2) catch data, the results of the harvest efforts.

Participation Data

A series of four, 1-hr sampling sweeps were made during each 8-hr shift to collect participation data. A sampling sweep consisted of a drive from Lauli'ituai to Nu'uuli that began on the hour and ended within the same hour, during which all fishing activity was recorded on a data form. This represented a departure from the methodology used in the 1979 study (Wass 1980) where a sweep was conducted each hour of an 8-hr shift. This modification was made to allow the study area to be extended from Faganeanea (in the Wass study) to Nu'uuli as the western-most boundary of the present study.

General information such as date, sampler name, and type of day (week day or week end-holiday) was recorded along with information specific to each observation: time, village, fishing method, number gear units (i.e. number of rods, spears, etc.), number of people in the fishing party, weather conditions and additional comments.

Catch Data

Catch data were collected opportunistically during the shifts. Most catch sampling was done between sweeps, but if time allowed, catches were also sampled during a sweep. This was also a departure from the 1979 sampling regime, where full sampling days were dedicated to either participation or catch sampling. Our modification was made in an attempt to improve efficiency.

Individuals or groups fishing were sampled only if they had been fishing at least half an hour. Parties that had no catch were recorded as such and included in the computation of CPUE. Catch data included date, type of day (weekday or weekend-holiday), village, whether the trip was concluded or in progress, time of interview, fishing method used, number of hours fished at the time of the interview, number of gear units (rods, nets, spears, etc.) employed, number of people in the fishing party and the count and weight of each species or species group caught. Fish were weighed to the nearest ounce using a spring scale.

Sociological information was also collected during each interview. Participants were categorized by sex and age (14 or less, 15 or older). Each fishing party was asked how much of the catch was to be sold or kept, and whether or not they were fishing adjacent to their home village.

Palolo Data

Palolo (Eunice viridis), an important species in the shoreline fishery, required an auxiliary sampling effort due to the brevity and magnitude of its appearance in the fishery. Once a year at the beginning of the last lunar quarter of October or November, these burrowing annelids release egg- and sperm-filled body segments (epitokes) into the surrounding water (Caspers 1984, Itano 1986, Itano and Buckely 1988). Samoans, who consider the epitokes a delicacy, gather in large numbers at midnight on the predicted night to collect the epitokes from shoreline waters using scoop nets or long lengths of screen. Palolo are harvested at various locations throughout the island. Within the study area, the stretch of shoreline from Faga'alu to Nu'uuli supported the greatest number of participants.

A separate sampling effort was applied to the palolo fishery to accommodate its unique attributes. On the peak night of harvesting activity, 8 October 1990 between 12:30 and 2:00 a.m., a count was made of all people in the water actively participating in the harvest of palolo. The high number of spectators on the shoreline were not counted. As fishing parties ended their trips, they were interviewed to obtain catch data, including the number of people in the group, the length of time spent fishing for palolo and the weight and volume of the catch. Six fishing parties, representing a total of 23 people, were sampled for a sampling rate of 3%.

ANALYSIS

Data were entered into a database and a series of interactive DBase IV programs were used to expand the sample data to annual catch and effort estimates for the study area.

Participation Analysis

All effort estimates are reported as gear-hours, rather than the more commonly used person-hours, because it is common for a fishing party to include people who are not actively fishing. For example, a fishing party may consist of two people one of whom fishes with a rod and reel while the other holds the catch. The fishing power of that party is better defined by amount of gear they have, rather than the number of people participating.

Effort data were grouped into four temporal categories, to produce separate expansions for day/night, weekday/weekend of catch and effort. The categories were a) WEEKDAY DAY 0601-1800 Sunday through Friday, b) WEEKDAY NIGHT 1801-0600 Sunday through Thursday, c) WEEKEND DAY 0601-1800 Saturday, and d) WEEKEND NIGHT 1800-0600 Friday and Saturday. Because fishing in many villages is still forbidden during all or part of the day on Sundays, we suspected Sunday effort levels would more similar to that of a weekday than a Saturday. Consequently, Sundays were treated as a weekday rather than the as a weekend day, as it was in the Wass (1980) study.

The study area encompassed 22 villages. Low fishing effort or sample size for some of the smaller villages required that data be pooled into larger fishing areas to have adequate sample size for effort and catch expansions. All estimates of catch and effort are reported by the village groupings, which are consistent with those used by Wass (1980):

AREA	VILLAGES
Lauli'i	Lauli'ituai, Lauli'ifou
Aua	Onososopo, Aua
Leloaloa	Lepua, Leloaloa, Atu'u, Anua
Pago Pago	Satala, Lalopua, Pago Pago
Fagatogo	Malaloa, Fagatogo
Utulei	Utulei
Faga'alu	Faga'alu, Fatumafuti
Matu'u	Matu'u
Faganeanea	Uasa'aiga, Faganeanea
Nu'uuli	Avau, Oneoneloa, Nu'uuli

Separate estimates for fishing effort were calculated for each weekday/weekend, day/night, fishing method and area combination (hereafter referred to as a stratum). The first step in estimating total effort was, for each stratum, to sum the total number of gear units observed and divide it by the total number of hours observed to produce a mean number of gear units per hour. The second step was to multiply this value by the total number of hours possible in the 1-yr study for each stratum.

Catch Analysis

Catch estimation involved several steps. First, a CPUE value for each catch that was sampled was calculated by dividing the total number of pounds caught by the total effort (where total effort equalled the product of number of gear units and the number of hours fished). The unit for CPUE is, therefore, pounds per gear-hour. Mean CPUE for each stratum was calculated by summing the CPUE for each interview and dividing the result by the number of interviews. Expanded catches were generated by multiplying the mean CPUE for each stratum by the expanded effort estimate for each respective stratum.

Species composition estimates (by weight) were then calculated. The proportion of each species in the sampled catch was multiplied by the total estimated catch to get the expanded species composition. Fish weights are expressed as whole fish and shellfish weights include the shell.

Data were not expanded on the basis of the sociological information collected (i.e., catch sold/not sold, age/sex composition of fishing parties). Unweighted analyses were conducted on raw, unexpanded data, which assumes that sampling was proportional across all strata such as area, method, time of day, etc. Although the results are not as reliable as a weighted analysis, they provided a general profile of the fishery.

Palolo Analysis

Palolo data were analyzed independently from the rest of the data, but using similar methods. For each fishing party sampled, the trip length was multiplied by the number of people in the fishing party to obtain a number of person hours of effort. The party's catch in pounds was divided by the number of person-hours to derive the CPUE (pounds per person hour). A mean CPUE was calculated by dividing the sum each trip's CPUE by the number of trips. Mean CPUE was then multiplied by the total number of people participating to get total harvest.

DATA LIMITATIONS

Darkness and poor visibility due to rain were the two main factors affecting the accuracy of participation data. During sampling shifts on nights surrounding the new moon period, the data collectors often relied on counts of flashlights since the fishermen, themselves, could not be seen. If the lights were submerged and offshore, as was often the case for night divers, they could have been easily missed. Rod and reel anglers who fish the edge of the reef often went for long periods of time without turning on a flashlight, making them difficult to see on dark nights.

Low estimates for nighttime effort would have a ripple affect on the rest of the estimation process. They would result in low expanded catch estimates for selected species, most notably for lobsters, alogo (blue-lined surgeonfish), and squirrelfish and soldierfish. Thus, catch and effort estimates for nighttime should be considered conservative, especially for the diving method.

RESULTS

Fishery Profile

A diverse array of fish and shellfish species were harvested from the reef using several different fishing methods. Of the three hook-and-line methods (bamboo pole, handline, and rod and reel), handline and rod and reel methods were the most commonly used and were responsible for the highest landings of all seven fishing methods (Fig. 3) Together, they accounted for 71% of the total effort and 63% of the total catch. Bamboo pole fishing was the least commonly used method, perhaps because it offered the shortest casting distance. Handline fishing consisted of a weighted hook tied on monofilament line being fed off a spool (often the dispenser the line is sold on or a partially crushed aluminum can) into the water. Fish were retrieved by pulling the line in hand-over-hand, and once the fish was removed the line was rewound. The rod and reel method has the advantage over the other two methods in being able to cast a greater distance. Hook-and-line methods were used throughout the reef area, from the shoreline during high tide to the reef edge or the edge of an ava, a channel in the reef, during low tide as well as from docks and small boats.

Two fishing methods involved the use of nets. Gill nets ranging from 50 to 300 feet in length, with stretched mesh sizes between 1.5 and 4 inches, were used either as passive gear (the net was set and allowed to soak undisturbed for a period of time and then was checked for fish), or as active gear (the net was set in a semicircle and a line of people approach the open side while pounding the water with sticks or palm fronds to drive the fish into the net). The other netting method, throw netting, employed a small meshed, circular net ranging from 5 to 8 feet in diameter, with weights around the perimeter which is cast out and then retrieved by a line secured to the center of the net. Both of the net methods were used mainly on the shallow reef flat.

Gleaning involved the collection of reef flat fish and invertebrates at low tide. Rocks and coral rubble were overturned and holes were probed either bare handed or using a tool such as a knife, steel rod or stick in search of the desired prey.

Skindiving for fish and invertebrates took place both on the reef flat and the reef front. Equipment used tended to be simple: swimming goggles for eye protection and a steel rod sharpened to a point to use as a spear or to be shot from a hand-made slingshot. Occasionally, divers using a mask and snorkel and fiberglass, three-pronged spears were encountered. Catches were strung from a stringer tied at the diver's waist or suspended from a styrofoam float. Diving was the only fishing method, other than handline and rod and reel, that contributed greater than 10% to both catch and

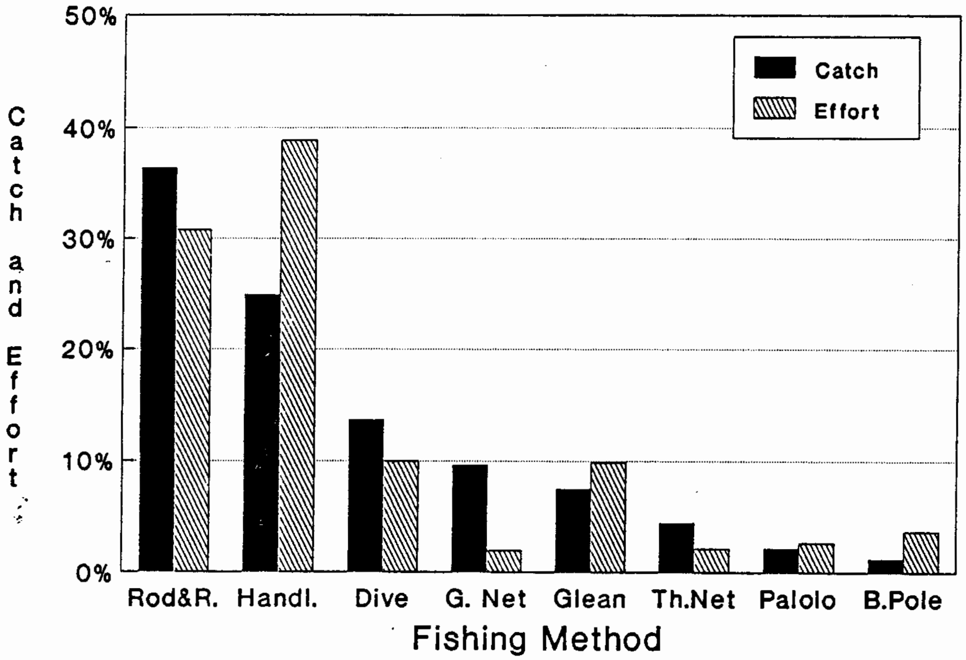

Figure 3. Contribution to total catch (lb) and effort (gear hours) for each fishing method based on a year-long study of the inshore fishery between the villages of Lauli'i and Nu'uuli, American Samoa, July 1990 through June 1991.

effort totals, and those estimates, as previously described, are considered to be underestimated because of sampling difficulties.

A team approach was most often used for harvesting palolo. Fishing parties ranged in size from two to 5 or more and additional family members or friends often lined the shoreline to watch the process. Individuals within the fishing group split the tasks of holding the lantern or flashlight, carrying the bucket, and scooping the epitokes from the water with small nets or lengths of screen.

Based on general observations while catch sampling, participants in the shoreline fishery were fairly non-discerning with respect to the size and species of fish they keep. Fish and invertebrates were rarely, if ever, deemed undesirable and returned to the water. The collection of weight data for individual fish was beyond the scope of the sampling regime. However, total count and weight for each species were recorded, from which an average weight per individual for selected species was calculated:

Species Group	Average Weight (lb)	Aggregate Number Weighed
Octopus	2.2	80
Jacks	1.4	613
Mullet	.9	884
Surgeonfish	.5	1034
Groupers	.4	191
Atule	.3	3729
Snappers	.3	206

Among these species, snappers and groupers stand out as having very low mean weights compared to their potential weight at maturity. Length frequency of the catch and size at maturity data for these fish would be valuable to determine how severely they are impacted by the fishery.

Fishing Effort, Catch and CPUE

Estimates of fishing effort are based on 495 sampling sweeps of the study area which equates to a 6% sampling rate of all hours, day and night, in the one-year study period (July 1990 through June 1991). CPUE and catch estimates are based on 366 interviews, which represented 1257 gear-hours of effort.

The annual effort of 64,500 gear-hours resulted in the harvest of 152,500 pounds of fish and invertebrates in the study area (Table 1; Appendix 1 presents these results in more detail). When palolo are added into the catch statistics, the totals become 66,250 gear-hours and 155,996 pounds.

Table 1. Partial fish and invertebrate catch (lb) and effort (gear-hours) by area and method for villages between Lauli'ituai and Nu'uuli inclusive during July 1990 through June 1991. Not included in the totals are 1,750 gear-hours and 3446 lb for the palolo harvest between Nu'uuli and Faga'alu.

AREA		ROD REEL	HAND LINE	BAMBOO POLE	GLEAN	DIVE	THROW NET	GILL NET	TOTAL
LAULI'I	CATCH	593	493	17	805	1272	96	307	3583
	EFFORT	353	140	24	796	445	38	23	1819
AUA	CATCH	2183	471	367	524	169	1876	1612	7202
	EFFORT	1193	155	533	685	606	235	317	3724
LELOALOA	CATCH	741	473	142	368	1921	1188	919	5752
	EFFORT	477	197	214	226	613	302	70	2099
PAGO PAGO	CATCH	258	748	145	0	0	1237	139	2527
	EFFORT	301	818	221	0	0	142	10	1492
FAGATOGO	CATCH	25483	33741	975	65	0	184	153	60601
	EFFORT	10021	22439	896	42	0	31	105	33535
UTULEI	CATCH	21010	2182	82	878	1596	228	8867	34843
	EFFORT	6108	1795	122	257	1152	78	634	10146
FAGA'ALU	CATCH	1698	353	82	2819	9630	1113	28	15723
	EFFORT	484	116	266	1502	1584	287	15	4254
MATU'U	CATCH	249	53	39	650	533	199	421	2144
	EFFORT	89	15	125	340	189	121	10	889
FAGANEANEA	CATCH	1370	75	8	451	330	352	139	2725
	EFFORT	484	21	11	257	171	76	11	1031
NU'UULI	CATCH	3270	300	32	5105	5812	504	2427	17450
	EFFORT	851	85	44	2436	1843	129	123	5511
TOTAL	CATCH	56855	38889	1889	11665	21263	6977	15012	152550
	EFFORT	20361	25781	2456	6541	6603	1439	1318	64500

For reasons presented in "Methods", estimates of both effort and catch should be considered conservative.

The harbor village areas of Fagatogo and Utulei ranked highest in their contributions of 40% and 23% to total catch and 52% and 16% to total effort, respectively (Fig. 4), largely due to their accessibility to the migratory atule schools which seasonally congregate in the harbor. Catch and effort levels of each of the other villages contributed less than 11% to the totals.

Fishing effort was distributed fairly evenly throughout the week. Weekday days and nights (0601 Sunday - 1800 Friday, or 79% of all hours in a week) accounted for 69% of all effort and 86% of all catch.

Time-of-day influenced the choice of fishing method used. Gleaning, diving, throw netting and gill netting methods were used more during daylight hours, whereas hook-and-line methods (rod and reel, handline and bamboo pole) were used predominantly during the night (Fig. 5). The high use of rod and reel and handline methods during the night was attributable to their popularity for harvesting atule, which were fished mainly at night.

The mean CPUE across all strata was 3.0 lb/gear-hour. CPUE values varied greatly among the various strata (Appendix 1), but several generalizations were apparent (Table 2). First, CPUE was higher in the day than at night. Second, of the seven fishing methods, gill netting had by far the highest CPUE (12.2 lb/gear-hour) and bamboo pole had the lowest (0.7). Handline CPUE is considered to be unrealistically high because of one atypically high catch of 80 lb/gear-hour. If this one catch interview was ignored, the handline CPUE would be 1.4 lb/gear-hour. Third, CPUE by village was highly variable. The Matu'u area had the highest area-based CPUE (8.2 lb/gear-hour) mainly because gill nets, the most efficient fishing method, were commonly used there. Atule fishing contributed greatly to the high CPUE at Utulei (4.1).

Island-Wide Catch and Effort

Data from the study area were used to extrapolate island-wide catch and effort estimates. A cautionary note regarding the representativeness of this expansion is that the study area was not made up of villages selected at random. Only villages from the south shore of the island were monitored during this study. The study area did, however, comprise 20% of all villages, 35% of the total population, and 12% of the total linear shoreline on Expansions were made by multiplying the annual per capita catch (PCC) in the study area by the island-wide population. Thus, in 1991 the study area catch (155,966 lb) divided by the study area population (15,850 people) yielded an annual PCC of 9.8 lb.

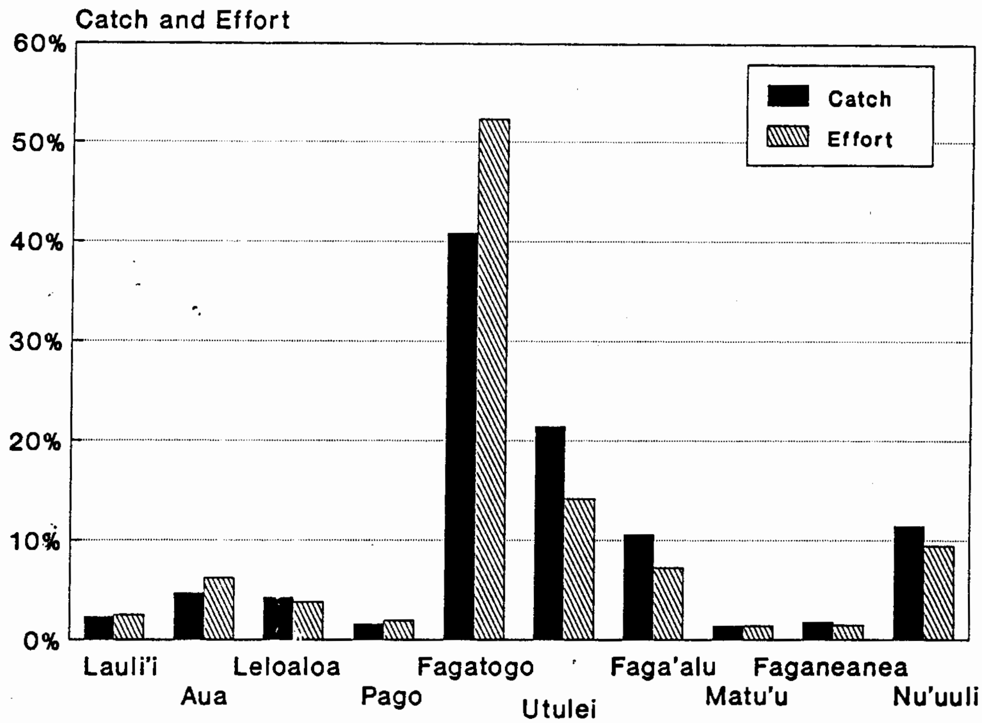

Figure 4. Contribution to total catch (lb) and effort (gear hours) for each area. Palolo catch and effort for the area between Faga'alu and Nu'uuli area are not included.

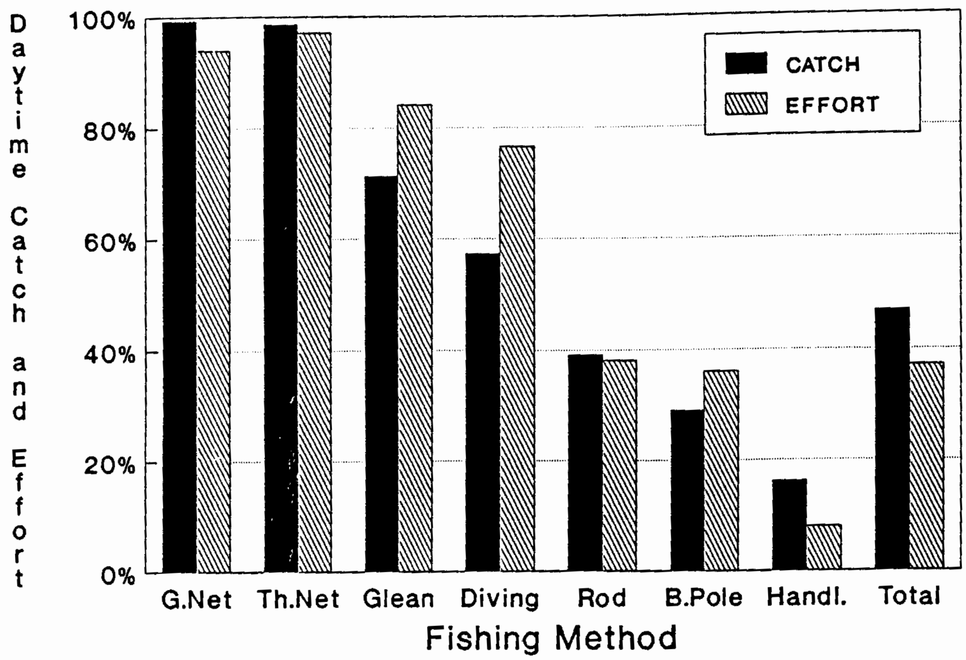

Figure 5. Percent of fishing (by method) that occurred during daylight hours.

Table 2. Mean CPUE by time of day, method and area based on 366 interviews (N).

STRATA COMPARISON		CPUE (lb/gear-hour) MEAN	STD	N
BY TIME OF DAY	DAY	3.7	8.2	212
	NIGHT	2.0	2.6	154
BY METHOD	GILL NET	12.2	16.9	13
	THROW NET	4.9	7.3	45
	DIVING	2.9	3.2	38
	ROD & REEL	2.9	3.3	113
	HANDLINE	2.1*	7.9*	110*
	GLEANING	1.7	1.8	29
	BAMBOO POLE	0.7	0.6	17
BY AREA	MATU'U	8.2	17.3	6
	UTULEI	4.1	7.9	52
	LELOALOA	3.4	5.5	11
	NU'UULI	3.3	4.4	40
	FAGANEANEA	3.3	4.1	10
	FAGA'ALU	3.2	3.7	29
	PAGO PAGO	3.0	8.9	21
	AUA	2.8	4.7	25
	FAGATOGO	2.4	6.6	167
	LAULI'I	1.8	2.0	5

*CPUE=1.4, STD=1.4 and N=109 if one outlier is deleted (see text)

STD=standard deviation

When this is multiplied by the total population for Tutuila Island (44,580, based on the 1990 census), an island-wide annual harvest of 439,000 lb is produced.

Island-wide effort was calculated by substituting the study area effort for catch in the above formula, which produced an island-wide annual effort of 181,000 gear-hours.

By applying the average market price of locally-sold fish to the island-wide catch, a value of the shoreline harvest was calculated. Fish are sold at one price, regardless of size or species and the average price during the study period was $1.75 per pound. Obtaining a mean price for the invertebrate harvested was considerably more complex since many species were not sold and those that were went for various prices. To simplify the calculation, the entire shoreline harvest for Tutuila (439,000 lb) was multiplied by the average fish price ($1.75 per lb) to arrive at a value of $768,000 in 1991.

Species Composition

Sixty nine species or species groups of fish and invertebrates were harvested in the shoreline fishery during the study period (Table 3). Fish constituted most of the total catch (86%). One carangid fish species, the atule (*Selar crumenophthalmus*), dominated the harvest in spite of being only seasonally present in shoreline waters. Atule accounted for 46% of the total fish and shellfish catch, and it is the only species to contribute greater than 10% to the total harvest.

Because annual changes in the abundance of the migratory atule is probably much greater than changes in the abundance of the other more reef-resident species, it is also useful to view the composition of the catch without the influence of atule (Table 4). In this manner, jacks, mullet, surgeonfish and octopus account for much (55%) of the non-atule catch.

Sampling rates were insufficient to produce monthly estimates of catch by species, which would have been the best method to illustrate the seasonal nature of the atule run. However, based on unexpanded catch data, it is apparent that they accounted for much of the total catch in all months except October-January (Fig. 6).

The study period, July 1990 to June 1991, actually straddled a portion of two atule runs, and based on anecdotal information gathered from atule anglers, both runs were unusual. Typically, atule run from February to July and are most abundant from April to June. However, in 1990, atule catches remained high through September and in 1991 were much higher in February and March than has been typical.

Table 3. Annual shoreline catch by species within the study area. Shellfish weights include shells.

FISH NAMES SAMOAN	COMMON	SCIENTIFIC	POUNDS LANDED IN STUDY AREA	PERCENT OF TOTAL FISH	PERCENT OF GRAND TOTAL
Atule	Big-eye scad	*Selar crumenophthalmus*	71750	53	46
Lupo, ulua	Jacks	Carangidae	14655	11	9
Anae, fuafua	Mullet	Mugilidae	9886	7	6
Palagi	Yellow surgeonfish	*Acanthurus xanthopterus*	5996 *	4	4
Alogo	Lined surgeonfish	*Acanthurus lineatus*	4054 *	3	3
Gatala	Groupers	Serranidae	2870	2	2
Malau	Squirrelfish	Holocentridae	2789 *	2	2
Poge	Surgeonfish	Acanthuridae	2152 *	2	1
Atuleau	Mackerel scad	*Decapterus macrosoma*	2012	1	1
Ga	Mackerel	Rastrelliger spp.	1667	1	1
Fuga, laea	Parrotfish	*Scaridae*	1618 *	1	1
Pusi gatala	Spotted eels	*Gymnothorax spp.*	1298	1	1
Manini	Convict tang	Acanthurus triostegus	1200 *	1	1
Pa'u malo	Filefish	Monacanthidae	1161	1	1
Sapatu	Barracuda	*Sphyraena spp.*	1009	1	1
Afulu	Yellowstripe goatfish	*Mulloides flavolineatus*	797	1	1
Tamala	Flametail snapper	*Lutjanus fulvus*	735	1	<1
I'asina	Yellowfin goatfish	*Mulloides vanicolensis*	666	<1	<1
Lai, tavai	Letherback	*Scomberoides lysan*	610	<1	<1
Lalafutu	Pompano	*Trachinotus spp.*	600	<1	<1
Ta'iva	Onespot snapper	Lutjanus monostigmus	566	<1	<1
Sugale	Wrasses	Labridae	539	<1	<1
Mata'ele	Flagtail grouper	*Cephalopholis urodeta*	539	<1	<1
Tu'u'u	Angels, damselfish	Pomacanthidae, Pomacentridae	489	<1	<1
Filoa, mata'ele'ele	Emperors	Lethrinidae	477	<1	<1
Lo	Rabbit fish	Siganidae	458	<1	<1
Gatalauli	Peacock grouper	*Cephalopholis argus*	417	<1	<1
Nanue, ganue	Rudderfish	Kyphosidae	346	<1	<1
Kavakava, atualo	Little tuna	*Euthynnus affinis*	298	<1	<1
Tautu	Porcupine fish	*Diodon spp.*	284	<1	<1
Pelupelu	Herrings	*Clupeidae*	265	<1	<1
Tagi	Dogtooth tuna	*Gymnosarda unicolor*	252	<1	<1
Mala'i	Paddletail snapper	Lutjanus gibbus	247	<1	<1
Sumu, molua	Triggerfish	Balistidae	235 *	<1	<1
I'aui	Conger eels	Congridae	224	<1	<1
Papa, velo	Lunartail grouper	*Variola louti*	175	<1	<1
Ta'uleia	Indian goatfish	*Parupeneus indicus*	122	<1	<1
Tolai, mumu	Yellowspt emperor	*Gnathodentex aureolineatus*	120	<1	<1
Malie	Sharks	Chondrichthyes	104	<1	<1
Tifitifi	Butterflyfish	Chaetodontidae	102	<1	<1
Gofu	Scorpionfish	Scorpaenidae	90	<1	<1
Ume, ili, ili'ilia	Unicornfish	*Naso spp.*	86	<1	<1
Safole, sesele	Mountain bass	Kuhlia spp.	85	<1	<1
Unident. finfish			81	<1	<1
Lalafi, malakea	Wrasses	*Cheilinus spp.*	73	<1	<1
Matu	Mojarras	*Gerres spp.*	70	<1	<1
Ava'ava	Terapon perch	*Terapon jarbua*	69	<1	<1
Ise, a'u	Needlefish	Belonidae	50	<1	<1
Sue	Pufferfish	Tetradontidae	40	<1	<1
Mumu	Ponyfish	Leiognathidae	30	<1	<1
Maogo	Whitespotted surgeonfish	*Acanthurus guttatus*	27 *	<1	<1
Mutu,Mamo	Seargent major	*Abudefduf saxatilis*	26	<1	<1
Moamoa	Trunkfish	Ostraciidae	12	<1	<1
Fo	Cardinalfish	Apogonidae	9	<1	<1
Taoto, taotao	Lizzardfish	Synodontidae	3	<1	<1
I'usina, laulama	Surgeonfish	*Acanthurus glaucopareius*	2 *	<1	<1
		Total Fish	134537	100	86

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Table 3. cont.

INVERTEBRATE NAMES					
SAMOAN	COMMON	SCIENTIFIC	POUNDS LANDED IN STUDY AREA	PERCENT OF TOTAL INVERTEBRATES	PERCENT OF GRAND TOTAL
Fe'e	Octopus	*Octopus spp.*	8380	39	5
Palolo	Palolo	*Eunice viridis*	3446	16	2
Tuitui	Sea urchin	Ecinometra	3261	15	2
Pule, sisi	Seashells	Gastropoda	2381	11	2
Vaga	Sea urchin	Echinoids	1192	6	1
Sea,lole,mama'o,gau	Sea cucumbers	Holothuroidea	1163	5	1
Ula	Spiny lobsters	*Panulirus pencillatus*	612 *	3	<1
Alili, ali'ali	Turban snail	*Turbo chrysostomus*	472	2	<1
Ofaofa	Heart urchin	Spatangoids	193	1	<1
Pipi	Clam	Bivalvia	129	1	<1
Matamalu	Sea anenome	Anthozoa	128	1	<1
Uga	Hermit crab	*Coebites spp.*	81	<1	<1
Pa'a	Crab	Crustacea	21	<1	<1
		Total Invertebrate	**21459**	**100**	**14**
		GRAND TOTAL	**155996**	**100**	**100**

* Denotes likely underestimate due to being harvested primarily by night divers (see text).

Table 4. Annual shoreline catch by species, excluding atule, within the study area. Shellfish weights include shells.

FISH NAMES SAMOAN	COMMON	SCIENTIFIC	POUNDS LANDED IN STUDY AREA	PERCENT OF TOTAL FISH	PERCENT OF GRAND TOTAL
Atule	Big-eye scad	*Selar crumenophthalmus*	EXCLUDED	EXCLUDED	EXCLUDED
Lupo, ulua	Jacks	Carangidae	14655	23	17
Anae, fuafua	Mullet	Mugilidae	9886	16	12
Palagi	Yellow surgeonfish	*Acanthurus xanthopterus*	5996 *	10	7
Alogo	Lined surgeonfish	*Acanthurus lineatus*	4054 *	6	5
Gatala	Groupers	Serranidae	2870	5	3
Malau	Squirrelfish	Holocentridae	2789 *	4	3
Poge	Surgeonfish	Acanthuridae	2152 *	3	3
Atuleau	Mackerel scad	*Decapterus macrosoma*	2012	3	2
Ga	Mackerel	Rastrelliger spp.	1667	3	2
Fuga, laea	Parrotfish	*Scaridae*	1618 *	3	2
Pusi gatala	Spotted eels	*Gymnothorax spp.*	1298	2	2
Manini	Convict tang	Acanthurus triostegus	1200 *	2	1
Pa'u malo	Filefish	Monacanthidae	1161	2	1
Sapatu	Barracuda	*Sphyraena spp.*	1009	2	1
Afulu	Yellowstripe goatfish	*Mulloides flavolineatus*	797	1	1
Tamala	Flametail snapper	*Lutjanus fulvus*	735	1	<1
I'asina	Yellowfin goatfish	*Mulloides vanicolensis*	666	<1	<1
Lai, tavai	Letherback	*Scomberoides lysan*	610	<1	<1
Lalafutu	Pompano	*Trachinotus spp.*	600	<1	<1
Ta'iva	Onespot snapper	Lutjanus monostigmus	566	<1	<1
Sugale	Wrasses	Labridae	539	<1	<1
Mata'ele	Flagtail grouper	*Cephalopholis urodeta*	539	<1	<1
Tu'u'u	Angels, damselfish	Pomacanthidae, Pomacentridae	489	<1	<1
Filoa, mata'ele'ele	Emperors	Lethrinidae	477	<1	<1
Lo	Rabbit fish	Siganidae	458	<1	<1
Gatalauli	Peacock grouper	*Cephalopholis argus*	417	<1	<1
Nanue, ganue	Rudderfish	Kyphosidae	346	<1	<1
Kavakava, atualo	Little tuna	*Euthynnus affinis*	298	<1	<1
Tautu	Porcupine fish	*Diodon spp.*	284	<1	<1
Pelupelu	Herrings	*Clupeidae*	265	<1	<1
Tagi	Dogtooth tuna	*Gymnosarda unicolor*	252	<1	<1
Mala'i	Paddletail snapper	Lutjanus gibbus	247	<1	<1
Sumu, molua	Triggerfish	Balistidae	235 *	<1	<1
I'aui	Conger eels	Congridae	224	<1	<1
Papa, velo	Lunartail grouper	*Variola louti*	175	<1	<1
Ta'uleia	Indian goatfish	*Parupeneus indicus*	122	<1	<1
Tolai, mumu	Yellowspt emperor	*Gnathodentex aureolineatus*	120	<1	<1
Malie	Sharks	Chondrichthyes	104	<1	<1
Tifitifi	Butterflyfish	Chaetodontidae	102	<1	<1
Gofu	Scorpionfish	Scorpaenidae	90	<1	<1
Ume, ili, ili'ilia	Unicornfish	*Naso spp.*	86	<1	<1
Safole, sesele	Mountain bass	Kuhlia spp.	85	<1	<1
Unident. finfish			81	<1	<1
Lalafi, malakea	Wrasses	*Cheilinus spp.*	73	<1	<1
Matu	Mojarras	*Gerres spp.*	70	<1	<1
Ava'ava	Terapon perch	*Terapon jarbua*	69	<1	<1
Ise, a'u	Needlefish	Belonidae	50	<1	<1
Sue	Pufferfish	Tetradontidae	40	<1	<1
Mumu	Ponyfish	Leiognathidae	30	<1	<1
Maogo	Whitespotted surgeonfish	*Acanthurus guttatus*	27 *	<1	<1
Mutu,Mamo	Seargent major	*Abudefduf saxatilis*	26	<1	<1
Moamoa	Trunkfish	Ostraciidae	12	<1	<1
Fo	Cardinalfish	Apogonidae	9	<1	<1
Taoto, taotao	Lizzardfish	Synodontidae	3	<1	<1
I'usina, laulama	Surgeonfish	*Acanthurus glaucopareius*	2 *	<1	<1
		Total Fish	62787	100	75

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Table 4. cont.

INVERTEBRATE NAMES			POUNDS	PERCENT OF	PERCENT OF
SAMOAN	COMMON	SCIENTIFIC	LANDED IN STUDY AREA	TOTAL INVERTEBRATES	GRAND TOTAL
Fe'e	Octopus	*Octopus spp.*	8380	39	10
Palolo	Palolo	*Eunice viridis*	3446	16	4
Tuitui	Sea urchin	Ecinometra	3261	15	4
Pule, sisi	Seashells	Gastropoda	2381	11	3
Vaga	Sea urchin	Echinoids	1192	6	1
Sea,lole,mama'o,gau	Sea cucumbers	Holothuroidea	1163	5	1
Ula	Spiny lobsters	*Panulirus pencillatus*	612 *	3	<1
Alili, ali'ali	Turban snail	*Turbo chrysostomus*	472	2	<1
Ofaofa	Heart urchin	Spatangoids	193	1	<1
Pipi	Clam	Bivalvia	129	1	<1
Matamalu	Sea anenome	Anthozoa	128	1	<1
Uga	Hermit crab	*Coebites spp.*	81	<1	<1
Pa'a	Crab	Crustacea	21	<1	<1
		Total Invertebrate	**21459**	**100**	**25**
		GRAND TOTAL	**84246**	**100**	**100**

* Denotes likely underestimate due to being harvested primarily by night divers (see text).

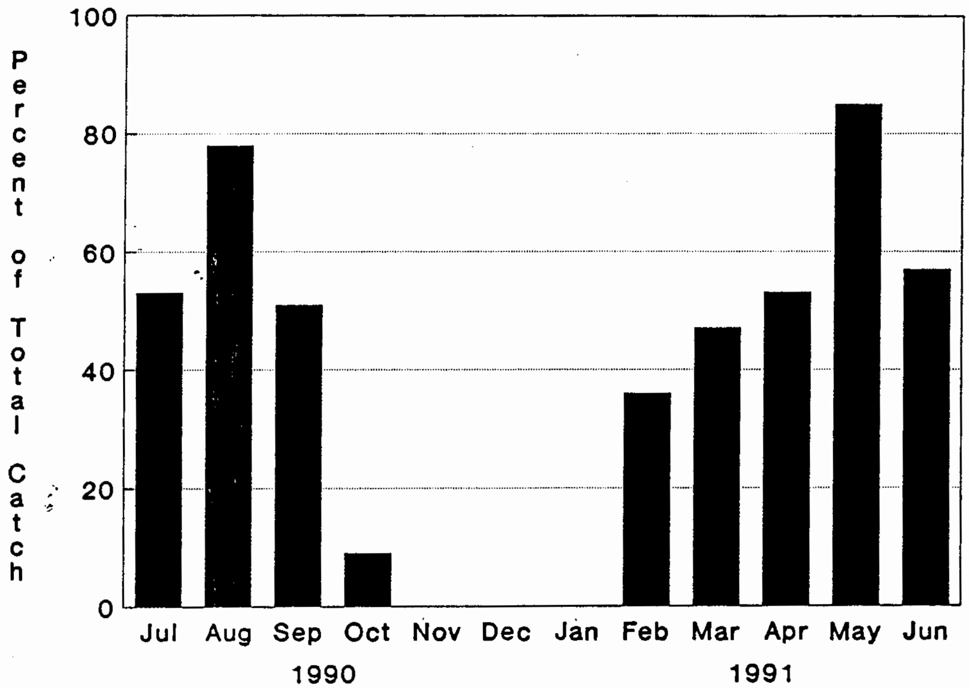

Figure 6. Atule catch by month, expressed as their contribution to the total catch for all hook-and-line harvest methods.

Atule were harvested throughout the study area, but most (91%) were landed in Fagatogo and Utulei (Fig. 7). The commercial wharf in Fagatogo and fuel dock in Utulei provided easy access to the schooling fish. According to several anglers interviewed, fishing at the docks was enhanced by the high powered lights run by longline and purse seine boats tied up at the docks.

Gill net users capitalized on the high concentrations of atule in the shallow, reef flat habitat off Utulei. However, the pulinu'u (village mayor) banned the use of gill nets during the peak of the run in response to complaints by those fishing with rod and reel. Gill nets were allowed back into the Utulei area when both success rates and effort levels of hook-and-line fishing dropped.

Carangids of the genus Caranx comprised 9% of the total catch. A diverse size range of carangids was caught, from 1-2 oz fish often landed by handliners to a 56 lb fish speared at the reef edge. Much of the total catch of Caranx was landed in conjunction with atule. Mackerel scad (Decapterus macrosoma), a seasonal carangid, contributed 1% to total catch, but this is suspected to be an underestimate due to misidentification of them as atule during early months of the study.

Landings of acanthurids (surgeonfish) totalled 13,431 lb, or 9% of the total catch. Two species, palagi (Acanthurus xanthopterus) and alogo (Acanthurus lineatus), comprised 82% of the total acanthurid catch. All of the palagi were caught by hook and line methods and 79% by weight were caught in the Fagatogo area. Most of those were caught by hand line and rod and reel anglers fishing from small canoes. Alogo were caught almost exclusively by divers, and 78% of the catch was landed at night. Since night divers were, perhaps, the most difficult fishery participants to see, this number should be considered an underestimate.

Mullet comprised 6% of the total catch. As detritivores, they were susceptible to harvest mainly by gill and throw netting, and comprised 46% of the catch by those methods. Sizes of fish landed varied from a few ounces, caught by small-meshed throw nets, to the 3-lb range, caught by gill nets.

Invertebrate landings, totalling 21,159 lb (which includes shell weights), made up 14% of the total catch. Octopus landings were highest in this category, making up 39% of the total invertebrates. Most of the catch was landed by divers (81%), with gleaners landing the remainder. Most of the octopus were caught during the day (96%) due to the method used to harvest them. Divers and gleaners would search for sign of the octopus' presence, such as a hole where the sand is blown clean of debris by the current from the exhalent syphon, or a collection of broken gastropod shells or opercula. A stick or a metal rod is put into the hole, and the octopus is then pulled from the hole as it defends itself by attacking the probe.

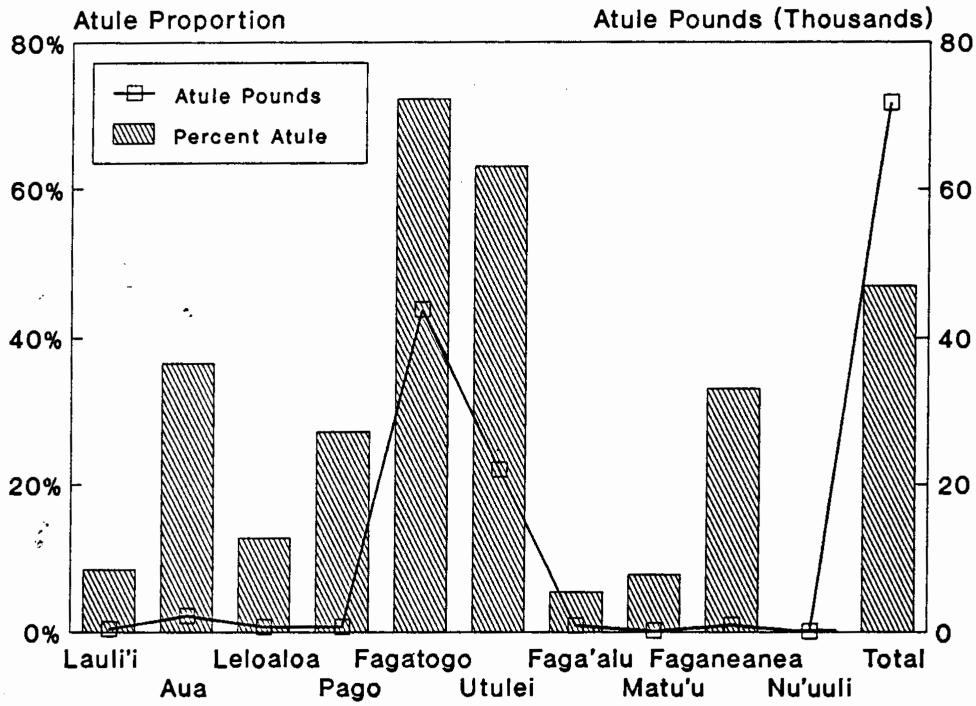

Figure 7. Catch of atule by area expressed as a) the percentage of total catch and b) in pounds, in combined gill net and hook-and-line catches, July 1990 through June 1991.

Sea urchins contributed 4,646 pounds, or 21%, of the invertebrate catch. Obtaining accurate CPUE data for sea urchins was difficult, however, because a portion of the catch was often consumed during the harvest process.

Palolo had the third highest contribution (3,446 lb, 16%) among invertebrate species groups in spite of its very limited appearance (2-3 days) in shoreline waters. The palolo fishery was sampled again in 1991 using he methods previously described, and the results are presented below to illustrate the variability of the fishery, although the 1991 season was outside the overall study period reported in this paper. These data represent the palolo harvest between Nu'uuli and Faga'alu for the peak night only of the spawning event (8 November 1990 and 30 November 1991):

YEAR	PARTICIPANTS IN THE STUDY AREA	CATCH (lbs)	POUNDS/PERSON-HOUR
1990	764	3446	2.0
1991	1463	600	0.2

Harvest success, according to anecdotal information, is dependant on the strength of the swarming event and the presence of offshore winds that concentrate the epitokes near the shoreline, making them more accessible to the fishermen.

Sociological Information

As was mentioned earlier, effort was recorded as gear-hours rather than person-hours because it was considered a better gauge of fishing power. However, the number of people who participated in the fishery, regardless of whether they actively fished or just held the bag is of interest from the sociological standpoint. While expanded effort for the study area was 64,500 gear-hours, the number of person-hours totaled 67,328 (Appendix 2). Gill net an throw net methods had the highest difference between the number of person-hours and number of gear-hours (-40% and -51% respectively) because a team approach is used most often for these methods. All other methods except bamboo pole had a difference between the two statistics of 1% or less. The bamboo pole method had a 6% difference which is explained by the fact that the main users of this method are young people who fish in groups and take turns using the pole.

The following sociological information is based on the analysis of unexpanded data, as previously mentioned in Methods. Males dominated the fishery for all methods but gleaning, accounting 70% of the total effort sampled (Fig. 8). Adult women contributed 18% to the total effort and were the major component of the gleaners. Boys and girls younger than 14 contributed 11% and 1%, respectively, to the total effort.

Historically, village councils have controlled fishing on the reefs adjacent to their villages, and often limited outsider's use of the village reef. The ratio of resident to non-resident use of each reef can indicate the level of traditional village control that remains intact: 70% of all people interviewed were fishing on the reef adjacent to their home village. Percentages of local participants by area varied:

AREA	NUMBER OF PEOPLE INTERVIEWED	PERCENT FISHING IN HOME VILLAGE
Lauli'i	7	71
Aua	54	59
Leloaloa	34	65
Pago Pago	42	93
Fagatogo	270	73
Utulei	114	66
Faga'alu	51	61
Matu'u	19	100
Faganeanea	20	65
Nu'uuli	76	63
	Total 687	Mean 70

Aua, Pago Pago, Utulei and Faga'alu areas all contain public parks adjacent to the water front which facilitates the use of these areas by non-residents. Similarly, the fuel dock in Utulei and main dock in Fagatogo are used by people from various villages during the atule season. However, the percentage of outsiders in these areas did not differ greatly from the percentage of outsiders in the remaining areas.

Fishermen were also asked during catch interviews if their catch was to be sold or kept. Based on their response, 25% of all observed fish an invertebrates (by weight) were sold. The amount sold varied by fishing method: diving (63%), gillnet (22%), hook-and-line (21%) and throw net (0%).

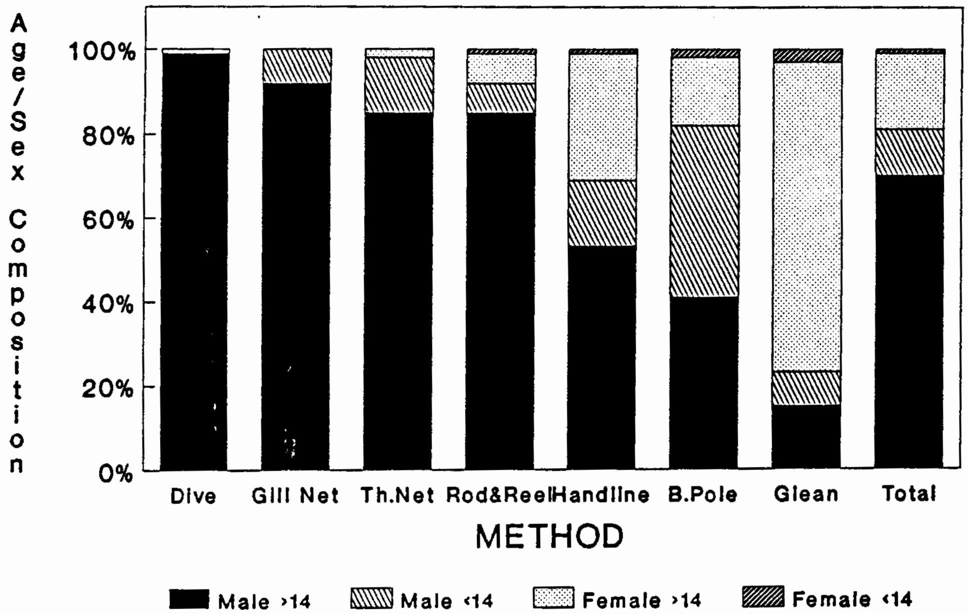

Figure 8. Age and sex composition of fishery participants by harvest method used.

DISCUSSION

Comparison between Shoreline and Offshore Fisheries

Catch

Subsistence fishing has long been an important way of life in the Territory in contrast with the newer concept of commercial fishing, which has remained at comparatively low levels. Based on the island-wide expansion, the shoreline fishery harvested over four times as many pounds of fish and invertebrates in one year as the boat-based offshore fishery did in 1990, but over 30 times the amount of effort was invested doing it:

	SHORELINE "SUBSISTENCE" FISHERY	OFFSHORE "COMMERCIAL" FISHERY		
		BOTTOMFISH	PELAGIC	TOTAL
CATCH (lb)	439,000	14,500	87,800	102,300
EFFORT (gear-hrs)	181,000	1,400	4,100	5,500

Although the catch is higher, it is clear that the shoreline fishery is considerably less efficient than the offshore fishery. Factors which influence the comparative efficiencies of the fisheries include: 1) since the offshore fishery is predominantly a commercial fishery, its participants must break even over time, which dictates how long a boat will search unsuccessfully for fish, and 2) the fish caught off shore are generally larger than those from the shoreline fishery.

Value

Another method of comparing the relative importance of the two domestic fisheries in the Territory is to convert them to their respective dollar values. The average prices were applied to the total harvest of the fisheries:

	FISHERY		
	Shoreline	Offshore Bottomfish	Offshore Pelagics
Average Price/lb	1.75	1.66	1.07
Pounds Landed	439,000	14,500	87,800
Value	$768,000	$24,000	$94,000

In this comparison, the shoreline fishery's relative importance was even more pronounced, since reef fish commanded the highest price among the species groups caught by domestic fishermen. The value of the shoreline fishery catch was over six times that of the offshore fishery.

Trends in the Shoreline Fishery

Although shoreline fishery estimates of catch and effort can be variable from year to year, they can serve as a benchmark to show fishery trends. A basis from which to evaluate fishery trends in the shoreline fishery was provided in this study, because it was designed to essentially repeat that conducted by Wass (1980) 12 years ago. Some departures from the 1979 study design were made, however, and should be taken into consideration when comparing the results of the two studies (Appendix 2). Nevertheless, such differences do not greatly affect the general comparisons made below.

Catch, Effort and CPUE

Both catch and effort in the study area declined somewhat from their 1979 levels when data from villages common to both study periods are compared (i.e. excluding both the 1991 data from the villages west of Faganeanea, and the 1979 data from the outlying villages). Note that the effort value for 1991 was converted from gear-hours to person-hours, the unit used by Wass (1981), for comparative purposes:

	1979	1991	CHANGE
CATCH (lb)	157,276	135,100	-14%
EFFORT (person-hrs)	73,680	61,720	-16%

For the purposes of comparison, 1991 CPUEs were also re-calculated using the 1980 methods (Appendix 2). Overall CPUE remained fairly similar to 1980 levels, but varied among the different fishing methods. CPUE increased for rod and reel and night diving methods, but declined for all other fishing methods (Fig. 9).

While the general 12-year comparison indicates stability in the fishery, differences in the run strength of atule, a seasonal migrant to the shoreline area, mask important changes that have occurred in the fishery. The atule catch in 1979 was 28,190 lb, or 13% of the total catch. In 1991, the atule catch was 69,557 lb, or 46% of the total catch. To examine catch trends for reef-resident fish, atule must be subtracted from effort and catch totals. For 1991, the atule catch for the villages common to both study periods (61,686 lb) was subtracted out of the total catch for those villages. Since atule catch by village was not available for

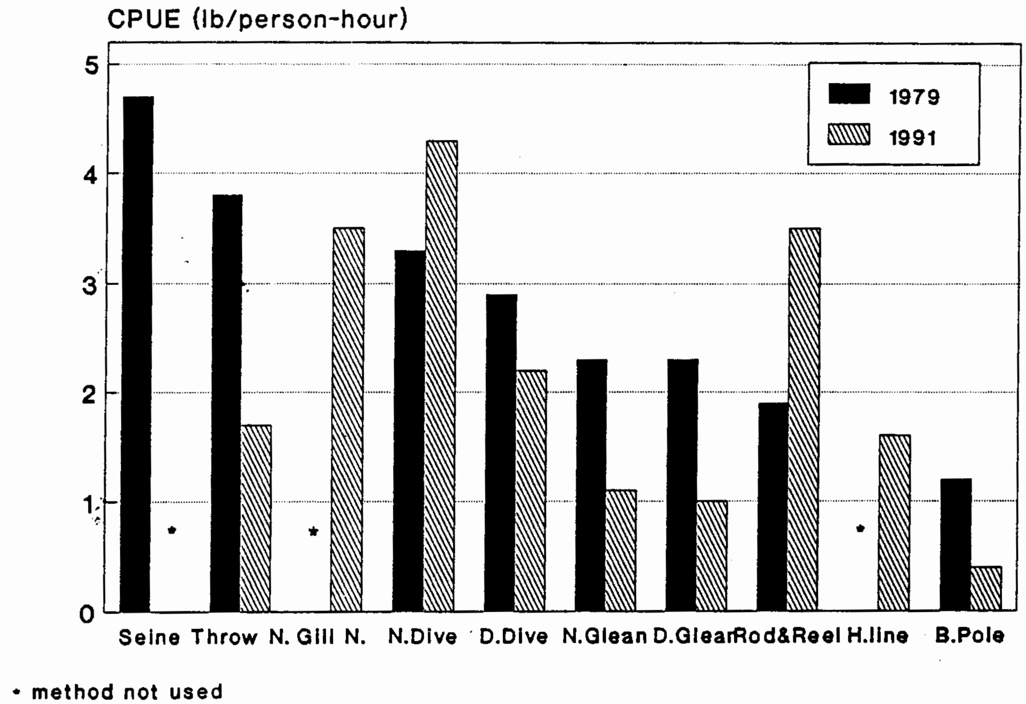

Figure 9. Comparison of CPUEs (lb/person-hour) in 1991 (current study) and 1979 (Wass 1980) for the locations common to both studies.

1979, the atule catch for the common study area was obtained by multiplying the 1979 catch from the common study area (157,276 lb) by the percent contribution of atule to the total (13%).

Subtracting atule effort out of the total effort estimates was more complex because effort was estimated by fishing method, rather than by target species. For 1991, a mean CPUE for atule (3.2 lb/gear-hour) was calculated and the atule catch was divided by that to produce an atule effort estimate (22,402 gear-hours). For 1979, data were not available in sufficient detail to enable an atule CPUE to be calculated by the same method. Instead, the atule catch was divided by the overall mean CPUE (2.4 lb/person-hour) to get an approximation of atule effort (8,501 person-hours). When the atule estimates are subtracted from the total catch and effort, the adjusted catches of reef-resident fish and invertebrates are as follows:

	1979	1991	CHANGE
ADJUSTED CATCH (lb)	136,541	63,414	-54%
ADJUSTED EFFORT (gear-hours)	65,179	36,587	-44%

Using this adjustment, catch and effort are 54% and 44% lower, respectively, than the 1979 estimates. This adjustment provides a clearer picture of the decreased fishing pressure and resultant harvest of resident, shoreline fish stocks.

The reduction in catch and effort over the last 12 years is significant and somewhat unexpected, considering that the human population grew by 46% during the same time (Fig. 2). Some explanations for the reduced effort include sociological changes such as less leisure time, a shift in dietary preferences from fresh fish to other protein sources, or a preference to buy fresh fish than to fish for them personally.

Major shifts in catch and effort distribution among areas were apparent, due largely to the atule fishery. In 1979, catches were fairly evenly distributed among the village areas (Fig. 10) compared to 1991 when the highest catches were centered in the Fagatogo and Utulei areas. The same atule-driven shift to Fagatogo can be seen in effort patterns for 1991 compared to 1979 (Fig. 11).

A change in fishing methods between the two periods was also noted. Seining was responsible for 8% of the total fish harvest in 1979, but seines were not observed at all in 1991. They appear to have been replaced with monofilament gill nets, which were observed regularly in 1991 but were absent in 1979. Also, handline fishing, responsible for over 40% of all fishing effort in 1991, was not observed in 1979.

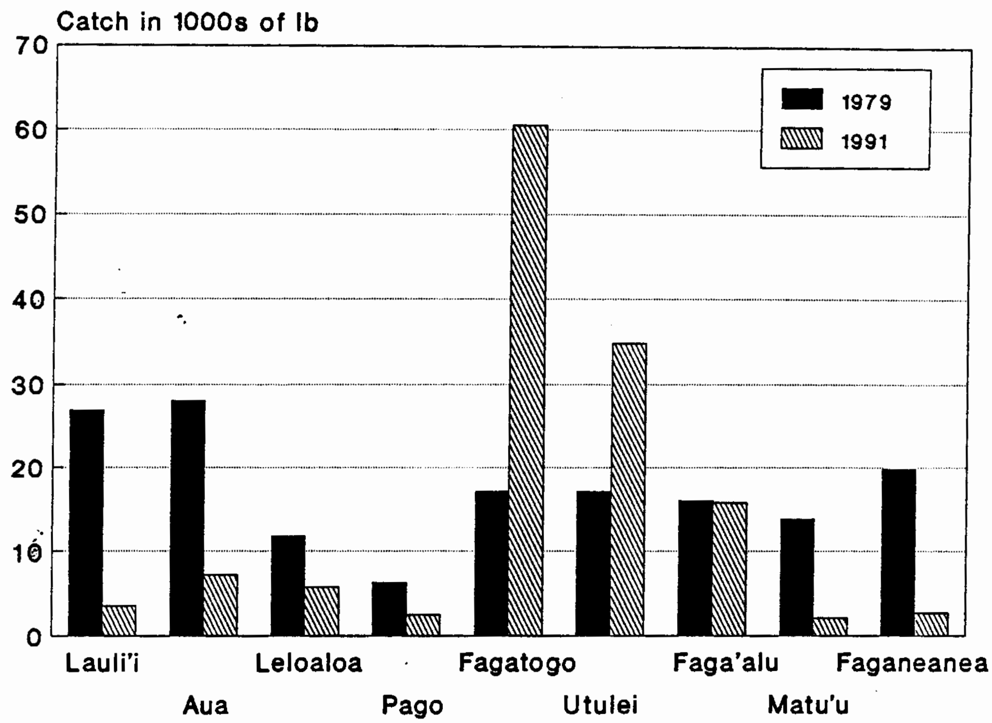

Figure 10. Catch by area for the inshore fishery between the villages of Lauli'i and Faganeanea in 1979 (Wass 1980) and 1991.

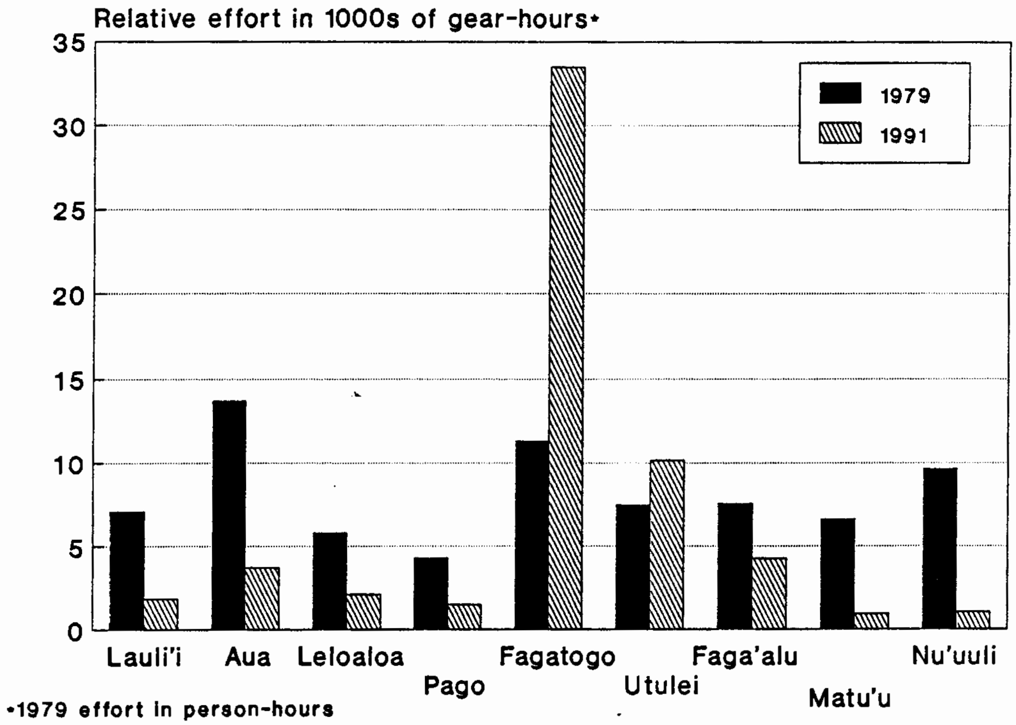

Figure 11. Relative effort by area for the inshore fishery between the villages of Lauli'i and Faganeanea in 1979 (Wass 1980) and 1991.

Island-Wide Catch and Effort

The 1979 study extrapolated an island-wide catch estimate of 597,000 lb using the same method as described in the Results section for 1991:

YEAR	PER CAPITA CATCH (lb)	ISLAND POPULATION	ISLAND-WIDE HARVEST (lb)
1979	19.4	30,626	597,000
1991	9.8	44,580	439,000

This expansion equates to a 30% decline in island-wide catch since 1979. The decline in per capita catch is a function of both the decline in catch and increase in population since 1979. Per capita catch was lower for all villages except Fagatogo and Utulei, where atule landings boosted the landing levels (Appendix 3).

To facilitate comparisons between reef-resident and atule catches in the island-wide catch, island-wide estimates for atule were calculated by multiplying the each years' total catch by their respective percent contribution for atule in the study area. Effort estimates were calculated by multiplying the per capita effort within the study area by the island-wide population. This was done for both the total and atule-adjusted values:

	CATCH (lb)		EFFORT	
	1979	1991	1979[a]	1991[b]
Reef Residents	519,000	237,000	135,000	124,000
Atule	78,000	202,000	97,000	57,000
Total	597,000	439,000	232,000	181,000

a 1979 effort in person-hours

b 1991 effort in gear-hours (which are nearly identical to person-hours, see Appendix 2)

The island-wide estimates again illustrate the decline in shoreline fishing catch and effort since 1979. Significant drops in both catch and effort occurred during a period when the human population of the island increased significantly. This implies that the importance of shoreline fishing has diminished over the last 12 years (Fig. 12).

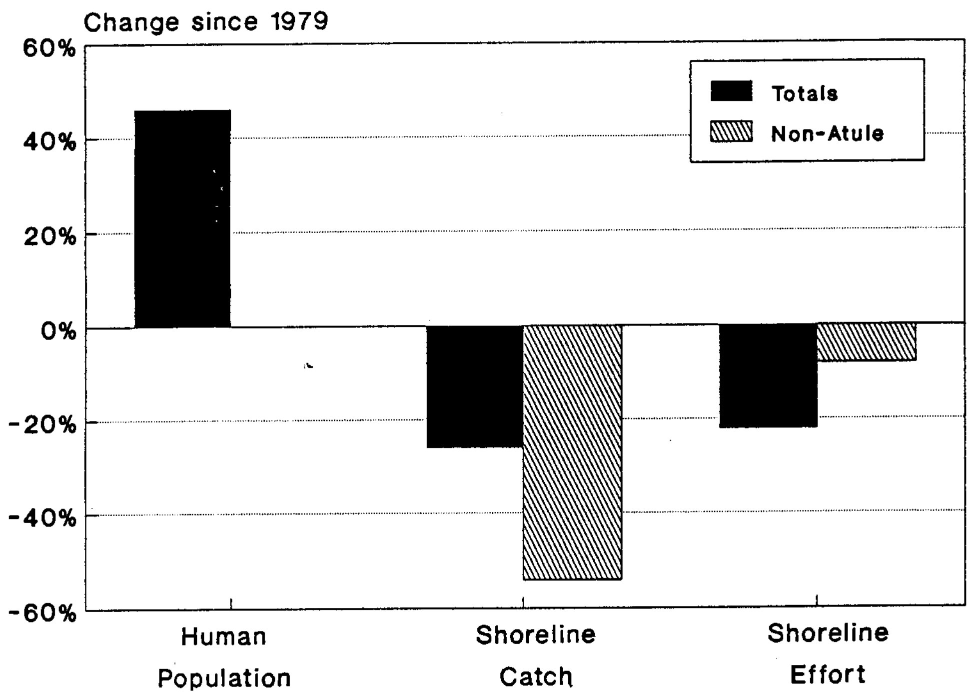

Figure 12. Increase in island-wide human population on Tutuila island compared to decreases in island-wide catch and effort for the nearshore fishery between 1979 and 1991.

Species Composition

Just as CPUE is an important tool to evaluate overall changes in the shoreline fishery, shifts in species composition lend insight into the condition of individual species or species-groups within the harvest. In the absence of 1979 data describing catches of individual species, comparisons were done on a species-group basis. One major change in species composition since 1979 has been the reduction in the contribution of invertebrates to the total harvest. Shellfish comprised 59% of the non-atule total catch in 1979 compared to 25% in 1991. The overall drop in the amount of effort for diving and gleaning (38,793 person-hours in 1979 versus 13,242 person-hours in 1991) was the key to the drop in shellfish harvest.

Leading contributors for both fish and invertebrate species generally remained the same between the two years, although their contributions differed somewhat (Table 5). The percent contribution of mullet increased substantially (from 5% to 16%), probably due to the addition of the highly efficient gill net method since the last study. Sea urchins had the largest increase in percent contribution among the invertebrates, increasing from 5% to 25% of the invertebrate harvest.

While they were not major contributors to total catch, substantial drops in percent contribution were experienced by snappers (73%), groupers (54%), and parrotfish (50%). Supporting data, such as size composition for these species would be useful in evaluating the condition of those stocks. Similarly, among the invertebrates, declines in the contribution of clams (91%) and crabs (90%) were notable.

Reef Yields

Reef-associated fisheries are often compared with one another in terms of reef yield, expressed as catch per unit of reef area. A yield of 4 to 5 metric tons/km2/yr was suggested as the generalized potential for the reef area Marshall (1980) termed the tropical super-ecosystem, defined as the "coral reefs, the shallows adjacent thereto, plus the immediate slope beyond the reef".

Catches in American Samoa for were converted to yield per unit area of reef within the 8-m isobath. Reef yield from the study area in 1979 was 25 metric tons/km2 compared to 13 metric tons/km2 in 1991. As was noted in the previous section, this decline in yield was a function of a reduction of fishing effort rather than the collapse of the fishery.

Yields for the study area in 1979 were high compared to other areas described in the literature and were judged to be at maximum sustainable yield based on the heavy fishing pressure they

Table 5. Adjusted species composition of shoreline catches in 1979 and 1991. Atule have been excluded from the fish catch for both studies to exclude the influence that the different run sizes had on overall species contribution. Palolo were excluded from the invertebrate total for 1991 because they were not sampled in 1979.

	CONTRIBUTION (%)	
SPECIES	1977	1991
FISH		
Surgeonfish	23	21
Jacks	17	23
Groupers	13	6
Snappers	8	3
Parrotfish	6	3
Damselfish	6	1
Mullet	5	16
Squirrelfish	4	4
Misc.	18	23
TOTAL	100	100
INVERTEBRATES		
Octopus	44	47
Snails	18	16
Clams	11	1
Anenomes	7	1
Sea Cucumbers	7	6
Urchins	5	26
Crabs	5	<1
Lobsters	2	3
Misc.	1	0
TOTAL	100	100

represented (Russ 1984, Munro 1984). Wass (1982) offered the following possible explanations for the 1980 study's average yield of nearly 25 metric tons/km2: 1) ease of access results in more intensive fishing effort, 2) the Samoan catch consists of diverse assemblage of smaller fish generally not taken in areas where the fishery are largely commercial, 3) one third of the catch was invertebrates which are not included in the calculations for other areas, and 4) the yields were based on the relatively shallow, highly productive reef areas rather than including deeper offshore banks as other yield calculations did. These conditions are still generally true for the shoreline fishery today.

CONCLUSIONS

In spite of its decline since 1979, the shoreline fishery still landed far more fish than the boat-based offshore fishery. The narrow fringing reefs provide easy access and allow a broad cross section of the populace to participate in the fishery. While only a small portion of the catch is actually sold, the overall value of the harvest is considerable if converted to its dollar value ($768,000).

The decline in catch and effort has been attributed to the gradual departure from the traditional, subsistence economy in Samoa. It is expected that the shift toward a cash economy will continue and that shoreline fishing will respond to that shift by evolving into more of a recreational activity.

RECOMMENDATIONS

Monitoring Program

Monitoring in the current study area should continue through at least the second year to allow between-year comparisons of CPUE and species composition. Should monitoring be continued beyond the second year, the following modifications to the protocol should be made:

1. Restructure programs to simplify the estimation of atule catch and effort.

   Annual fluctuations in atule made annual comparisons of catch, effort and CPUE levels difficult. As the data currently exist, the catch of an individual species can be subtracted from the total, but not the effort, since effort is calculated on the basis of fishing method rather than target species.

Field sampling and analysis methods could, however, be modified to allow both catch and effort for atule trips to be subtracted out of the totals, and an independent CPUE to be calculated. The most accurate method would be to treat atule fishing as a unique fishing method. It is generally possible to discern if an angler is targeting on atule during the normal roving participation survey. Regardless of what hook-and-line method was employed (rod and reel, handline, bamboo pole), individuals presumed to be targeting on atule would be coded as ATULE for method. Once the existing analysis programs were modified to accept the additional method code, a unique catch, effort and CPUE value would be generated for that species. This would not only facilitate annual comparisons, but would also produce more accurate values for CPUE, catch and effort.

2. Improve sample size for catch data

The current scheme of opportunistically sampling catches while collecting participation data seemed like the most efficient use of personnel time, but perhaps did not allow enough time to interview fishing parties. Sample rates, expressed as number of gear units sampled divided by number of gear units present, ranged from as high as 19% to as low as 5% in the four quarters of the 2-yr sampling period.

Since expansions of participation data are done by method and area strata, a particular stratum can be selectively targeted for catch sampling without biasing its expansion. This allows samplers to target catch sampling efforts on specific methods, villages or combinations thereof without biasing the expansion process. By monitoring sample size by stratum, directed sampling within a weak stratum could be done to correct sample size deficiencies. If this method is unsuccessful, additional staff hours, dedicated exclusively to catch sampling, could be added to the schedule.

Management Plan

A management plan should be developed for the shoreline fishery while it is in its present state of health. Items such as the following should be addressed in the plan:

1) overall management objectives for the fishery

2) objectives and options for fishery monitoring

3) identification of key species and any background information available on these species in general and in Samoan waters

4) identification of key habitats to the fishery

5) research priorities for necessary support information that may be required

6) policies on issues such commercial versus recreational/subsistence use, stock rebuilding, and resource use in protected areas.

7) a plan for implementation of additional regulations should they become necessary.

Possible areas for research include:

1) Size at maturity and the size composition of the harvest for groupers, snappers and parrot fish would be valuable, considering the small size at which they are currently harvested.

2) Comparative studies of species composition and size structure in areas of different exploitation rates, to observe how the community structure responds to fishing pressure.

3) Tagging fish species which are caught by both the shoreline and offshore fisheries, such as some of the groupers and snappers, to study movements between the areas exploited by the two fisheries would be of interest. For example, is the reef flat habitat replenished by fish from offshore when the stocks are fished down?

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APPENDICES

Appendix 1. Annual effort, CPUE, and catch by strata for the study area, excluding palolo effort (1750 gear-hrs), and catch (3446 lb).

DAY/ NIGHT	WEEKDAY/ WEEKEND	METHOD		EFFORT (gear-hours)	CPUE (lb/ gear-hr)	CATCH (lb)
DAY	WEEKDAY	ROD & REEL	LAULI'I	264	1.4	357
			AUA	423	0.2	71
			LELOALOA	95	3.0	284
			PAGO PAGO	201	0.6	121
			FAGATOGO	455	3.5	1578
			UTULEI	4811	2.9	14093
			FAGA'ALU	275	3.8	1047
			MATU'U	11	3.0	32
			FAGANEANEA	137	3.0	410
			NU'UULI	571	5.0	2875
		HANDLINE	LAULI'I	127	3.6	450
			AUA	106	3.6	375
			LELOALOA	85	3.6	300
			PAGO PAGO	264	0.6	149
			FAGATOGO	751	4.6	3427
			UTULEI	370	1.0	361
			FAGA'ALU	85	3.6	300
			FAGANEANEA	21	3.6	75
			NU'UULI	74	3.6	263
		BAMBOO POLE	LAULI'I	11	0.7	8
			AUA	222	0.8	183
			LELOALOA	11	0.7	8
			PAGO PAGO	201	0.7	131
			FAGATOGO	11	1.1	11
			UTULEI	21	0.7	15
			FAGA'ALU	264	0.3	81
			MATU'U	42	0.7	31
			FAGANEANEA	11	0.7	8
			NU'UULI	42	0.7	31
		GLEANING	LAULI'I	687	0.8	538
			AUA	518	0.4	188
			LELOALOA	201	1.5	308
			FAGATOGO	42	1.5	65
			UTULEI	211	3.5	731
			FAGA'ALU	1184	1.7	2070
			MATU'U	233	1.5	356
			FAGANEANEA	211	1.5	324
			NU'UULI	1798	1.7	3017
		DIVING	LAULI'I	254	2.3	571
			AUA	444	0.3	148
			LELOALOA	317	2.7	854
			UTULEI	983	1.2	1186
			FAGA'ALU	804	3.8	3078
			MATU'U	148	2.7	399

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Appendix 1. cont.

DAY/ NIGHT	WEEKDAY/ WEEKEND	METHOD		EFFORT (gear-hours)	CPUE (lb/ gear-hr)	CATCH (lb)
			FAGANEANEA	127	1.9	246
			NU'UULI	1322	3.0	3998
		THROW NET	LAULI'I	32	2.5	79
			AUA	211	8.0	1690
			LELOALOA	275	3.9	1079
			PAGO PAGO	137	8.7	1200
			FAGATOGO	11	13.3	141
			UTULEI	74	2.9	215
			FAGA'ALU	233	4.0	934
			MATU'U	116	1.7	192
			FAGANEANEA	63	4.6	294
			NU'UULI	116	3.9	454
		GILL NET	LAULI'I	21	13.1	278
			AUA	296	5.1	1504
			LELOALOA	21	13.1	278
			PAGO PAGO	11	13.1	139
			FAGATOGO	21	2.0	43
			UTULEI	603	14.0	8422
			MATU'U	11	39.8	421
			FAGANEANEA	11	13.1	139
			NU'UULI	106	19.8	2092
	WEEKEND	ROD & REEL	LAULI'I	8	1.4	11
			AUA	110	0.2	18
			LELOALOA	40	3.0	120
			PAGO PAGO	11	0.6	6
			FAGATOGO	13	3.5	44
			UTULEI	172	2.9	503
			FAGA'ALU	70	3.8	267
			MATU'U	11	3.0	32
			FAGANEANEA	6	3.0	19
			NU'UULI	79	5.0	395
		HANDLINE	LAULI'I	13	3.6	45
			AUA	13	3.6	45
			LELOALOA	2	3.6	8
			FAGATOGO	87	4.6	397
			UTULEI	45	1.0	43
			FAGA'ALU	4	3.6	15
			MATU'U	15	3.6	53
			NU'UULI	11	3.6	38
		BAMBOO POLE	LAULI'I	4	0.7	3
			AUA	28	0.8	23
			LELOALOA	2	0.7	2
			FAGATOGO	8	1.1	9
			FAGA'ALU	2	0.3	1
			MATU'U	2	0.7	2
			NU'UULI	2	0.7	2

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Appendix 1. cont.

DAY/ NIGHT	WEEKDAY/ WEEKEND	METHOD		EFFORT (gear-hours)	CPUE (lb/ gear-hr)	CATCH (lb)
		GLEANING	LAULI'I	19	0.8	15
			AUA	19	0.4	7
			LELOALOA	6	1.5	10
			UTULEI	28	3.5	95
			FAGA'ALU	138	1.7	241
			MATU'U	6	1.5	10
			NU'UULI	202	1.7	338
		DIVING	LAULI'I	30	2.3	67
			AUA	64	0.3	21
			LELOALOA	79	2.7	211
			UTULEI	91	1.2	110
			FAGA'ALU	165	3.8	634
			MATU'U	23	2.7	63
			FAGANEANEA	4	1.9	8
			NU'UULI	199	3.0	603
		THROW NET	LAULI'I	6	2.5	16
			AUA	23	8.0	187
			LELOALOA	28	3.9	108
			PAGO PAGO	4	8.7	37
			UTULEI	4	2.9	12
			FAGA'ALU	34	4.0	136
			MATU'U	4	1.7	7
			FAGANEANEA	13	4.6	59
			NU'UULI	13	3.9	50
		GILL NET	LAULI'I	2	13.1	28
			AUA	21	5.1	108
			LELOALOA	49	13.1	641
			FAGATOGO	2	2.0	4
			UTULEI	32	14.0	445
			FAGA'ALU	15	2.0	29
			NU'UULI	17	19.8	336
NIGHT	WEEKDAY	ROD & REEL	LAULI'I	81	2.8	223
			AUA	524	3.2	1663
			LELOALOA	242	1.0	239
			PAGO PAGO	81	1.5	118
			FAGATOGO	8306	2.5	20746
			UTULEI	827	5.7	4713
			FAGA'ALU	121	2.8	334
			MATU'U	40	2.8	111
			FAGANEANEA	323	2.8	891
			NU'UULI	202	0.0	0
		HANDLINE	LELOALOA	101	1.5	151
			PAGO PAGO	544	1.1	590
			FAGATOGO	18285	1.4	25321
			UTULEI	1290	1.3	1661

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Appendix 1. cont.

DAY/ NIGHT	WEEKDAY/ WEEKEND	METHOD		EFFORT (gear-hours)	CPUE (lb/ gear-hr)	CATCH (lb)
		BAMBOO POLE	AUA	202	0.6	114
			LELOALOA	202	0.7	133
			PAGO PAGO	20	0.7	13
			FAGATOGO	786	1.1	856
			UTULEI	101	0.7	67
			MATU'U	81	0.1	7
		GLEANING	LAULI'I	81	2.8	227
			AUA	121	2.2	269
			FAGA'ALU	81	2.8	227
			MATU'U	101	2.8	284
			NU'UULI	121	4.0	484
		DIVING	LAULI'I	161	3.9	634
			AUA	81	0.0	0
			LELOALOA	181	3.9	714
			UTULEI	40	3.9	159
			FAGA'ALU	524	9.6	5047
			FAGANEANEA	40	1.9	76
			NU'UULI	141	3.8	530
		THROW NET	FAGATOGO	20	2.1	43
			FAGA'ALU	20	2.1	43
		GILL NET	FAGATOGO	81	1.3	106
	WEEKEND	ROD & REEL	AUA	136	3.2	430
			LELOALOA	99	1.0	98
			PAGO PAGO	9	1.5	13
			FAGATOGO	1248	2.5	3116
			UTULEI	298	5.7	1701
			FAGA'ALU	18	2.8	50
			MATU'U	27	2.8	75
			FAGANEANEA	18	2.8	50
		HANDLINE	AUA	36	1.4	50
			LELOALOA	9	1.5	14
			PAGO PAGO	9	1.1	10
			FAGATOGO	3318	1.4	4594
			UTULEI	90	1.3	116
			FAGA'ALU	27	1.4	37
		BAMBOO POLE	LAULI'I	9	0.7	6
			AUA	81	0.6	46
			FAGATOGO	90	1.1	98
		GLEANING	LAULI'I	9	2.8	25
			AUA	27	2.2	60
			LELOALOA	18	2.8	51
			UTULEI	18	2.8	51
			FAGA'ALU	99	2.8	280
			FAGANEANEA	45	2.8	127
			NU'UULI	316	4.0	1266

(cont. next page)

Appendix 1. cont.

DAY/ NIGHT	WEEKDAY/ WEEKEND	METHOD		EFFORT (gear-hours)	CPUE (lb/ gear-hr)	CATCH (lb)
		DIVING	AUA	18	0.0	0
			LELOALOA	36	3.9	142
			UTULEI	36	3.9	142
			FAGA'ALU	90	9.6	871
			MATU'U	18	3.9	71
			NU'UULI	181	3.8	680
TOTAL				64500	3.6	152550

Appendix 2. A) Summarization of differences in the methods used by Wass (1980) and the current study, and B) a comparison of 1991 effort in the study area calculated as both gear-hours and person-hours.

A

	WASS STUDY	CURRENT STUDY
Study area	Lauli'i to Faganeanea and 4 outer villages: Fagasa, Masefau, Faga'itua, Vaitogi	Lauli'i to Nu'uuli
Field sampling	sampled participation and catch on separate days	sampled both partcipation and catch during each shift
Effort units	person-hour	gear-hour
CPUE calculation	for each strata, sum of pounds divided by sum of person-hrs	for each strata, the average of the CPUEs for each interview
CPUE units	lb/person hr.	lb/gear-hr.

B

METHOD	1991 EFFORT IN GEAR-HOURS	1991 EFFORT IN PERSON-HOURS
Handline	25,781	25,993
Rod and reel	20,361	20,380
Diving	6,603	6,679
Gleaning	6,541	6,563
Throw net	1,439	2,398
Gill net	1,318	2,700
Total	64,500	67,328

Appendex 3. Annual per capita catch (PCC) of fish and invertebrates from villages surrounding the Pago Pago Harbor area for 1979 and 1991.

AREA	1990 POPULATION	1991 CATCH (lb)	1991 PCC[a]	1979 PCC[a]
Lauli'i	773	3,583	4.6	44.2
Aua	1,965	7,202	3.7	19.1
Leloaloa	814	5,752	7.1	15.0
Pago Pago	3,519	2,527	0.7	2.0
Fagatogo	2,138	60,601	28.3	8.6
Utulei	930	34,843	37.5	17.4
Faga'alu	1,086	15,723	14.5	21.1
Matu'u	364	2,144	5.9	44.0
Faganeanea	168	2,725	16.2	104.1
Nu'uuli	4,093	17,450	4.3	[b]
SUBTOTAL		152,550	9.6	19.4
Palolo catch		3,446		
TOTAL	15,850	155,996	9.8	19.4

a PCC expressed as pounds per person per year
b area not sampled in 1979