THE USE OF NEARSHORE MARINE LIFE AS A FOOD RESOURCE BY AMERICAN SAMOANS

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CHAPTER I

Introduction

The subsistence fisheries of the tropical Pacific traditionally provided the major portion of the protein in the diets of the peoples who inhabited the islands of Polynesia, Micronesia and eastern Melanesia (Alexander, 1902; Anell, 1955; Reinman, 1967). Utilizing a variety of generalized to highly specialized fishing techniques in their marine surroundings, Pacific fishermen harvested their catches from the bountiful coral reefs surrounding most of the high islands and all of the low islands (atolls) in the tropical Pacific. These fishing techniques included the use of nets, baskets, pots, stone traps, spears, bows and arrows and poisons, as well as hand fishing techniques and communal fish drives (Anell, 1955; Buck, 1930; Kennedy, 1962). Together with the cultivation of coconuts, breadfruit, bananas, plantains, taro and/or yams and the loose husbandry of chickens, pigs and dogs, the subsistence fisheries provided food for the needs of the inhabitants of the isolated Pacific island groups.

Fishing thus played a central role in the subsistence economies which supported self-sufficient communities of Pacific islanders. Island peoples drew upon the diversity of their tropical environments in supplying their daily needs. In spite of their inability to complement their

limited resources through trade, the peoples of the Pacific shaped comfortable and secure lifestyles, well-adapted to harmonious interaction with the Pacific island environment.

Contact with the industrial nations of the world from the eighteenth century through the present has changed the traditional subsistence economies of the Pacific's island cultures considerably. The early introduction of Western ideas and materials by explorers, missionaries, whalers, traders and military and government personnel initiated processes of social and technological change which have swept through the islands of the Pacific at different rates for nearly two centuries. This metamorphosis has accelerated over the last three decades, for the increased Western interest in the Pacific which accompanied and followed World War II has prompted a second wave of change comparable in magnitude to that experienced during the early colonization of Pacific islands by the nations of the West.

As the economies of the Pacific islands have changed from subsistence to mixed economies, the traditional subsistence fisheries have changed too. A review of the literature suggests that these fisheries have characteristically declined with the increased availability of processed foods and of manufactured fishing equipment, becoming less varied and, very probably, less productive (Alexander, 1902; Smith, 1947; Van Pel, 1954-58). Such

changes reflect general trends across the Pacific as island peoples increasingly rely upon foreign aid, family remittances and export-oriented employment to support their increasing levels of consumption and rapidly expanding populations.

The subsistence fishery of American Samoa is representative of Pacific island fisheries as they exist today, just as this American territory's social and economic conditions are characteristic of the route that development is taking in the Pacific. While probably having experienced less socio-economic impact than the fisheries of Hawaii, as much as those of Guam, Tahiti and New Caledonia, and more than those of most of the other islands of the Pacific, the subsistence fishery of American Samoa is described here as a sample of the direction taken within this traditional sphere of activity as Pacific cultures adopt market economies and integrate themselves in the modern world.

In order to better understand the subsistence fishery existing within the eastern islands of the Samoa group, we must establish its context. Detailed information of this nature is contained within the studies of Belshaw (1955), Coulter (1941), CH2M-Hill, Inc., (1976) and Wolfe Management Services (1969) in American Samoa, and the studies of Fox and Cumberland (1962), Lockwood (1971) and Pirie (1970, 1976) in Western Samoa.

The Territory of Americn Samoa is a possession of the United States which was acquired by treaties made during the early twentieth century and which is presently administered by the Department of Interior. It comprises the six eastern islands of the Samoan group and one other island (Swains Island) geographically belonging in the Tokelau group. These islands are located (approximately) at 14 degrees south latitude and 170 degrees west longitude. They experience the moderate temperatures (21-32° C.), abundant rainfall (to 770 cm. in some areas), high humidity (76-83%) and moderate southeasterly tradewinds common in the southern tropics (CH2M-Hill, Inc., 1976).

The American Samoan Islands, like so many other high islands in the Pacific, are dominated by rugged volcanic mountains covered with lush tropical rain forests. The islands' steep mountain slopes and cliffs give way to generally narrow coastal plains which serve as sites for Samoan villages. Along the southern windward shores of the islands are found nearly continuous borders of fringing reefs, while along the northern leeward shores the reefs are generally found only within the bays which characterize these coastlines.

Since the 1899 cession of the territory to the United States, change has characterized conditions in the eastern Samoan islands, contrasting strongly with the cultural

stability of previous millenia. The population has jumped from 5,000 to 30,000 inhabitants, while ten thousands of the islanders have emigrated to the United States (Wolfe Management Service, 1969). The economy has changed from that of numerous independent and self-sufficient coastal villages having little trade with one another to that of a united American territory receiving in excess of 30 million dollars in federal aid and expenditures yearly and generating several millions of dollars within its private sector (primarily tuna canning and light tourism), as well as receiving the additional moneys of family remittances supplied by "aiga" (extended family) members residing in the United States (G.A.S., 1975). The socio-political structure of the islands, while retaining the traditional "matai" (chieftal) system at the local level, has become a centralized system of government at the territorial level, with a governor, an elected bicameral legislature, a judicial system and a national identity. A system of public education through grade 12, as well as a community college, is in operation. Over 3,000 motorized vehicles use the islands' fifty miles of paved and unpaved roads (G.A.S., 1975). Several airlines use the islands' international airport. And thousands of televisions and radios receive the transmissions of the islands' broadcasting stations.

It is within the setting described above that the use of nearshore marine life as a food resource by the people

of American Samoa will be considered. The primary area of study for this consideration was the largest island of the territory, Tutuila (Figure 1).

Historically the Samoans, like other Pacific islanders, depended largely upon their coral reefs and tropical seas for animal protein (Buck, 1930; Stair, 1897; Turner, 1884). While Beasley (1928, p. 22), in his review of Pacific fish hooks, judged the Samoans to have been both poor fishermen and indifferent makers of hooks, Buck (1930), Kramer (1902-03) and Stair (1897) recorded roughly 100 methods of fishing within the traditional Samoan subsistence fishery, testifying to the importance of the sea as a traditional source of food in these islands. The efficiency of this diverse fishing technology, acting in concert with traditional forms of reef conservation (Johannes, 1973), contributed to the self-sufficiency of the Samoan subsistence economy.

Yet the reef fishery of the present has dwindled in importance and in diversity to the point that some parts of it (diving, line fishing) seem to be as much sport fishing as subsistence fishing--the difference between the two lying primarily in the necessity of obtaining a successful catch. American Samoans no longer depend upon their traditional nearshore fishery as a primary source of food, for, although the sea around them abounds with marine life,

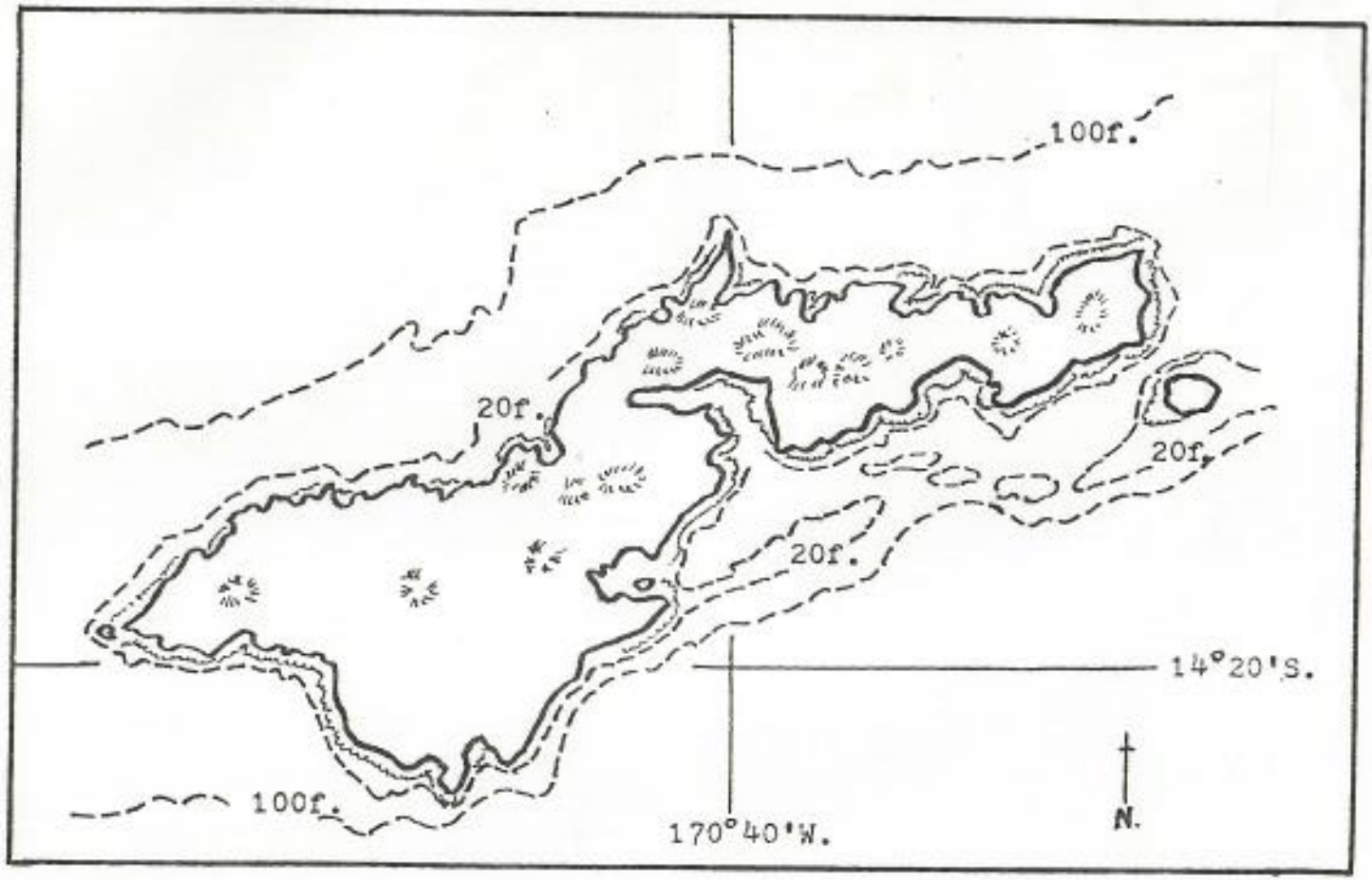

Figure 1. Map of Tutuila Island, the principal island of American Samoa, showing the major peaks of the mid-island volcanic mountain chain, the surrounding fringing reef, the southern barrier reefs and the depths of the offshore ocean, in fathoms

they rely upon imported, canned meats and fishes for their protein needs (Manar, 1969; Wolfe Management Services, 1969).

While it is unlikely that the reefs which contributed substanitally to supporting a pre-contact population of about 5,000 islanders could support the present population of over 30,000, they nonetheless constitute a form of local production meriting conscientious management. Against an economic background of nearly complete dependence upon foreign aid from the United States, the need to nurture and revitalize local forms of production, whether they be traditional subsistence activities or new types of economic activity, is self-evident.

I believe that this study of American Samoa's subsistence fishery will have implications of interest to anthropologists and to fishery and coral reef biologists. The descriptions of "who does what, where, when and why" for the fishery of these coral reefs completes a central aspect of marine resource utilization which has received little attention in the past, but which is important to an understanding of the present and necessary to the intelligent planning of the future.

CHAPTER VI

The Fishery's Catch, Its Uses and Its Distribution

The economy of American Samoa may be characterized as a mixed economy, using Fisk's (1964) definition of the term, for it includes both market and subsistence sectors within its fabric. During the past several decades the market sector has come to play the dominant role in supplying the material needs of American Samoans. In fact, the territory has been described as having essentially a U.S.-linked economy funded primarily by federal aid and by family remittances (Wolfe Management Services, 1969). The importance of the subsistence sector has diminished to the point that considerable quantities of the traditional Samoan staple, taro, are imported from neighboring Western Samoa, while an abundance of arable land remains untilled in American Samoa (Wolfe Management Services, 1969). The reduced importance of subsistence production in the islands' fishery follows the pattern of agriculture, for the marine catch no longer supports local needs (CH2M-Hill, Inc., 1976; Manar, 1969).

American Samoa's nearshore food resources have been neglected since the loss of the Samoans' traditional forms of reef management in the early twentieth century. The resulting lack of management and the steady increase in population in the islands produced the extremely

overfished condition of the reefs noted by S.P.C. Fisheries Officer H. Van Pel in his 1954 survey of the Samoan Islands. After studying the fringing reefs and the subsistence fishery, Van Pel stated that it would be useless to improve the fishing gear used in the reef areas, for they were already overfished, with fish caught elsewhere in the Pacific at lengths of 12" being taken in the Samoas at 4-5". He estimated that the total catch for Tutu'ila was less than 100 tons per year.

Such levels of production do not appear significant when distributed over a population of 30,000 Samoans. On the other hand, if this distribution of the fishery's catch was uneven, with some families relying heavily upon subsistence production and other families relying entirely upon the market economy, then the value of the subsistence fishery, overfished or not, might warrant intelligent management instead of dismissing neglect.

While the economy as a whole may no longer be characterized as a subsistence economy, the nearshore fisheries are certainly sources of food for the families of the fishermen involved in harvesting their reefs. Interviews of Samoan fishermen (Table 23, II3a-g) indicated that almost all of their catches are consumed by the fishermen's "aiga", or extended families. This was particularly true

Table 23. A sample of the short interview form used on-site, showing its questions and the information gained from the compiled answers

I. The questions: A Sample Questionnaire (compacted)

Interview #: Date:
Time:
Location:

1. Subject (s):
   a. Sex(es):
   b. Age(s):
   c. Relationships:
   d. Home village(s):
   e. Do they occupy the same domicile?
2. Fishery activity (ies):
   a. Reef harvesting:
   b. Time involved today:
   c. Time involved weekly:
   d. Equipment in use:
   e. Other information:
3. Catch data:
   a. Use or distribution of catch:
   b. Composition, number, size and fishing technique:

II. The answers: A Compilation of Information Useful to This Study (N of questionnaires=79)

1. Personal and interpersonal information:

N=29	a. Sex confirmation of road evaluation:	100%
N=29	b. Age confirmation of road evaluation:	96.6%
N=27	c. Group confirmation of road evaluation:	96.3%
N=145	d. In-group "aiga" relationships:	82.8%
N=21	e. In-group "aiga" relationships in groups with a mixture of adult males and adult females:	100%
N=145	f. In-group immediate-family relationships:	53.1%
N=150	g. Villagers of adjacent village: Of those fisherpeople not from the village adjacent to their activity, 50% were male groups involved in fishing with a thrownet or with rod and reel or in diving, and 35.5% were reef gleaners from villages without reefs	79.3%

2. Primary subsistence fishery activities:

N=76 a. Gleaning

Average time/day=	1.7 hrs.
Average days/week=	2.4 days
Average time/week=	4.1 hrs.

Equipment: short, unpronged spears
large kitchen knives
crowbars
machetes

N=13 b. Line fishing (non-pier)

Average time/day=	1.7 hrs.
Average days/week=	3.4 days
Average time/week=	5.8 hrs.

Equipment: bamboo poles, approx. 2-4 meters
rod and reels
manufactured hooks, flies and lures

N=34 c. Diving

Average time/day=	1.8 hrs.
Average days/week=	2.1 days
Average time/week=	3.8 hrs.

Equipment: 2-eyed goggles or masks
sling-shot sling
short, unpronged spears

N=17 d. Throw net fishing

Average time/day=	2.2 hrs.
Average days/week=	3.1 days
Average time/week=	6.8 hrs.

Equipment: manufactured circular throw nets

N=6 e. Gill net fishing

Average days/week=	4.7 days

Equipment: manufactured gill nets

3. Catch data:

a. Gleaning (day): 100% home consumption, excepting shells

Mollusks (edible)	1.3 lbs./hr.
octopus, "fe'e", Polypus	(0.8 lbs./hr.)
turbans, "alili", Turbo	(0.4 lbs./hr.)
giant clams, "faisua", Tridacna	
clams, "pipi", Gafrarium	
limpets, "matapisu", Patellidae	
Mollusks (jewelry)	0.2 lbs./hr.
money cowrie, "pule", Cypraea	(0.2 lbs./hr.)
other cowries, cones and augers	
Echinoderms	0.5 lbs./hr.
short-spined urchin, "tuitui", Echinometra	
sea cucumber, "loli", Holothuria	
sea cucumber, "sea", Holothuria	
long-spined urchins, "wana", Diadema and Echinothrix	

b. Gleaning (night): 100% home consumption, excepting shells

Fishes 0.6 lbs./hr.
squirrel fishes, "malau", Myripristis and Holocentrus
sea basses, "gatala", Epinephelus
snappers, "ta'iva", Lutjanus; "savane", Lutjanus; "mu", Monotaxis
goat fishes, "afulu", Mulloidichthys; "vete", Upeneus
surgeon fishes, "alogo", Acanthurus
moray eels, "pusi", Gymnothorax

Mollusks 0.2 lbs./hr.
night octopus, "fe'e po", Polypus
cowries, conches, augers, miters and cones

Crustaceans 0.4 lbs./hr.
spiny lobster, "ulatai", Panulirus
slipper lobster, "ula", Scyllarides
Samoan crabs, "pa'a", Carpilius and Scylla

c. Line fishing (non-pier): 100% home consumption

Fishes 1.1 lbs./hr.
sea basses, "gatala", Epinephelus
squirrel fishes, "malau", Myripristis and Holocentrus
snappers, "ta'iva", Lutjanus
emperors, "'awa'awa", Lethrinus; "maka ele ele", Lethrinus
jacks, "lupo", Caranx; "malauli", Caranx; "ulua", Caranx
goat fishes, "fuga", Parupeneus; "savane", Upeneus; "afulu", Mulloidichthys

d. Line fishing (pier): home consumption and market

Fishes 1.3 lbs./hr. (1.3 lbs./hr.)
mackerel, "atule", Trachurops; "atule", Selar; "opelu", Decapterus
jacks, "lupo", Caranx; "malauli", Caranx; "ulua", Caranx

e. Diving: 92% home consumption (biased in market's favor)

Fishes 1.0 lbs./hr.
parrot fishes, "fuga usi", Scarus; "lae'a", Scarus; "ufa", Scarus
surgeon fishes, "pone", Ctenochaetus; "manini", Acanthurus; "palani", Acanthurus; "siusina", Acanthurus; "maono", Zebrasoma; "ume", Naso; "alogo", Acanthurus

sea basses, "gatala", Epinephelus
moray eels, "pusi", Gymnothorax
halfbeaks, "ise", Hypothamphus
squirrel fishes, "malau", Myripristis
and Holocentrus
butterfly fishes, angel fishes, box fishes
and wrasses
Crustaceans (night only:)
spiny lobster, "ulatai", Panulirus
slipper lobster, "ula", Scyllarides
Samoan crabs, "pa'a", Carpilius and Scylla
Mollusks 0.3 lbs./hr.
octopus, "fe'e", Polypus (0.3 lbs./hr.)
cowries, augers, miters, cones,
and conches

f. Throw net fishing: 88% home consumption
Fishes per manhour: 5.5 lbs./hr.
per throw net hour: 8.3 lbs./hr.
mullets, "fuafua" and "agae",
Mugil and Crenimugil
mackerels, "atule", Trachurops;
"atule", Selar; "opelu",
Decapterus
sardines, "pelupelu", Harengula;
"pelupelu", Harengula
surgeon fishes, "manini", Acanthurus
halfbeaks, "ise", Hyporhamphus

g. Gill net fishing: 100% home consumption
Fishes 5.3 lbs./night
squirrel fishes, "malau",
Myripristis and Holocentrus;
"manifinifi", Myripristis
surgeon fishes, "pone", Acanthurus;
"fuga", Callyodon;
wrasses, "sugale", Thalassoma;
"sugale", Hemipteronotus;
"lalafi", Cheilinus
goat fishes, "matalau", Pseudepeneus
"afulu", Mulloidichthys
sea basses, "gatala", Epinephelus
snappers, "mu", Monotaxis

of the catch harvested through gleaning, diving, line fishing (other than "atule") and gill net/weir fishing, for which subsistence uses monopolized the catches (100%). Only the catches of the productive throw net fishermen and of line fishermen harvesting "atule" entered the market system, though not to a large extent. It is no wonder that questioned fishermen responded that the priorities for their catches' use were first "family foods," second "gifts of love" (traditional reciprocity) and (a distant) third "sell in the market."

The quantities of seafoods distributed through the market sector could not be estimated because the appropriate records are not kept by the island's markets and the estimates of fishermen appeared unreliable. In addition, a major portion of the catch which does enter the market sector is vended along the road, particularly in Fagatogo and Nuu'uli, where Samoan children frequently sell the strings of fish and bags of cooked turbans and clams which their families have caught and prepared.

Interviews with Tutuila's market management (Table 24) revealed that the nearshore fishery's small scale surpluses, particularly from the "atule" fishery, are channeled into the Star of the Sea Fish Market. This government-initiated fish market sells less than two tons of mackerel, herring, mullet, lobsters and octopi per year, along with much

Table 24. Summary of the market use of nearshore marine life through institutional markets

(All information below was provided by supply managers relying upon their memories, for records of this nature were not kept by any of the Samoan businesses.)

Business	Reference	Marine Life Marketed
Star of the Sea Fish Market	Pat Scanlan	(primarily offshore fishes) mackerels: 2000 lbs./yr. sardines: 200 lbs./yr. mullets: 400 lbs./yr. lobsters: 500 lbs./yr. octopus: 500 lbs./yr.
Burns Philps (market)	Martin Farrow	no local seafoods sold
Toko's Market	Ben Pakalani	(offshore fishes only: 7800 lbs./yr.)
Village Market	Charles Ho Ching	(offshore fishes only: 26000 lbs./yr.)
G.H.C. Reid (market)	Gene Reid	(offshore fishes only: no estimate)
Soli's Restaurant	Soli Laolagi	octopus: 800 lbs./yr.
Rainmaker Hotel	Tony Brown	no local seafoods sold

larger quantities of offshore fish caught by the island's small commercial fleet. One restaurant manager estimated that his business used about 800 pounds of octopus, bought from members of his "aiga" in Aua and in the Manu'a Islands, in the preparation of a traditional Samoan "fia fia" feast. Using Van Pel's estimate of 100 tons per year, it seems that roughly 3% of the nearshore catch is channeled into the established markets in American Samoa.

The nearshore fisheries do not, then, provide significant amounts of cash income to the majority of American Samoans. It is more likely that a small number of Samoan families supplement their family budgets by directing their surplus catch into the island's markets, and that these fishermen are the most active fishermen using the reefs. When such individuals were interviewed, they generally described their profession as fisherman-farmer.

Instead, the subsistence fishery plays a more substantial role in saving money by providing protein in the Samoan diet. Cook (1976), in his research in French Polynesia, and Smith (1947), in his studies of Micronesia, found that the subsistence fisheries of other island groups in the Pacific provided their native populations with the major portion of their protein. While even this is not true in American Samoa today, the information gathered in the interviews with fishermen (Table 23, II2-3) suggests

that the "average" gleaner (2.2 kg/wk), diver (2.2 kg/wk) and line fisherman (2.9 kg/wk) provide enough seafood each week to meet their own protein needs for five to six days or for a family of five for one day. Since the average household size in American Samoa is 4.7 (G.A.S., 1975), one fisherman per family would provide that family's protein for one meal per week by fishing for four to five hours during the course of the week.

A questionnaire polling high school students about their daily lives is summarized in Table 25, providing additional information about the use of nearshore marine life in the American Samoan diet. This poll indicates that reef life constitutes a small portion of the animal protein consumed by the average Samoan family. While the islands' local starches, taro, breadfruit and cooking bananas, continue to form the foundation of the Samoan diet, corned beef, chicken, spam and canned fish are now the islanders' primary animal proteins.

Only on Sunday, when the traditional weekly feast prepared in the "umu" (earthen oven) is served, were reef foods listed as a part--one of approximately three animal protein foods--of their meal by a substantial portion of the respondents (36%, versus 9% on weekdays). Combining these probabilities for the week (6x9% + 1x36% = 90%), it appears likely that an average family in American Samoa eats some reef-derived food once a week as a part of their dinner.

Table 25. A summary of information about the daily lives of the Samoan people, drawn from questionnaires completed by students of Faga'itua High School

I. The questions: A Sample Questionnaire (compacted)

1. How many people live in your household-unit?
2. At what time did you wake up?
3. What were your activities before breakfast?
4. What did your family eat for breakfast?
5. What were your activities after school yesterday?
6. What did your family eat for supper last night?
7. What were your activities after supper?
8. At what time did you go to bed?

II. The answers: A Compilation of Information Useful to This Study (N of questionnaires=91)

1. Average family size: 8.7 people/household unit

2. Average waking time: 6:05 A.M.

3. Pre-breakfast activities:

	Males	Females
Grooming	21%	28%
Leisure	47%	17%
Sports	12%	6%
Housework	2%	47%
Yardwork	2%	11%
Animal tending	9%	0
Plantation work	4%	0
Cooking	7%	4%
School work	16%	15%
*Fishing activities	0	0

4. Breakfast's composition

	Weekday
No breakfast	8%
Tea, coffee or cocoa	5%
T/C/C and toast	38%
T/C/C, toast and eggs	18%
T/C/C, toast, eggs and either juice or milk	7%
T/C/C and pancakes	2%
T/C/C and sandwich	6%
T/C/C, Samoan starch and canned meat	9%
Cereal	5%
*T/C/C, toast and "palolo"	2%
Other	2%

5. Post-school activities:	Males	Females
Leisure	19%	30%
Sports	50%	23%
Housework	0	36%
Yardwork	2%	17%
Animal tending	10%	0
Plantation	15%	0
Cooking	14%	21%
School work	0	13%
*Swimming	5%	2%
*Fishing activities	0	0
Other	4%	21%

6. Supper's composition	Weekday	Sunday
Chicken	84%	91%
Beef	91%	85%
Pork	19%	24%
Spam	56%	30%
Lamb	16%	9%
Canned fish (tuna, wahoo, mackerel, pilchard, sardine)	25%	33%
Fresh fish (agae, gatala, malauli, alogo, poge, manini, atule, tifitifi, sugale, ume, sumu)	9%	36%
Other seafoods		
Crab	0	3%
Octopus	0	3%
Average number of protein dishes per respondent	3.3	3.5
Starches		
Banana	52%	
Breadfruit	39%	
Taro	36%	
Rice	21%	
Canned spagetti	11%	
Potatoes	7%	
Bread	65%	
Other foods		
Soups	9%	
Chop suey	4%	
Cooked vegetables	9%	
Salads	3%	
Canned fruit	1%	

7. Post-supper activities	Males	Females
Leisure		
Television	28%	22%
Socializing (bingo, etc)	33%	20%
School work	75%	69%
House work	0	11%
Choir practice	0	9%
Village meeting	6%	0

8. Average bedding time: 10:15 P.M.

What types of marine life constitute the catch of the subsistence fishermen and what is the relative importance of each? While a rough idea of what local seafoods are served on the Samoan table may be obtained from the above poll, the study of the catches taken in each type of fishing activity provides better information on the reef life used as food in teh islands (Table 23, II3).

Qualitatively, the marine animals sought as food by fishermen in American Samoa are those used thusly across the tropical Pacific. Parrot fishes, surgeon fishes, soldier and squirrel fishes, goat fishes, sea basses, snappers, mullet, mackerel, octopi, clams, marine snails, limpets, sea urchins (in berry), sea cucumbers, lobsters, shrimps and crabs--these groups of animals and certain edible seaweeds (rare in Samoa) represent the primary food resources of the coral reefs. While the species vary in their importance among the Pacific islands, the genera are uniform in their distribution, belonging to the broad Indo-Malaysian zoogeographical zone (Randall, 1953), and occur throughout most of tropical Polynesia and Micronesia. A large portion of the fauna is used as human food, providing a variety in catch which is in keeping with the coral reef's biotic diversity (Banner and Randall, 1952; Catala, 1957; Harry, 1953; Hiatt, 1950).

Even with the generalized fishing techniques in use today, no single method captures all of the types of marine life available on the reef. The hands and a probe are used in gleaning and diving to seek out sessile invertebrates, while hook-and-line, spear-and-sling and nets are used to catch fin fishes. Thus the composition of the catch varies among the fishermen using different methods.

In gleaning the reef during the day Samoan fishermen harvest about 0.8 kg. (1.8 lbs.) of edible mollusks and echinoderms per hour of fishing effort, of which approximately 60% is body weight, and an additional 0.1 kg (0.2 lbs.) of cowries intended for use in making jewelry. This catch is composed primarily of octopus ("fe'e," Polypus, o.8 lbs.), with turbans ("alili," Turbo), giant clams ("faisua," Tridacna), money cowries ("pule," Cypraea), sea cucumbers ("loli" and "sea," Holothuria), short-spined urchins ("tuitui," Echinometra) and long-spined urchins ("wana," Diadema and Echinothrix) completing most of the remainder. Since so much of the catch is made up of invertebrates with heavy exoskeletons, rough field measurements and appropriate references (Kay and Magruder, 1977; Richard, 1977) were used to convert the total catch per unit effort for the edible invertebrates from 0.8 kg. to 0.5 kg. (1.2 lbs.) body weight per hour.

In gleaning the reef during the night Samoan fishermen harvest about 0.5 kg. (1.2 lbs.) of fish, crustaceans and mollusks per hour of active fishing effort. The catch of fishes (0.6 lbs.) includes chiefly squirrel fishes (Myripristis and Holocentrus), sea basses (Epinephelus) snappers (Lutjanus and Monotaxis), goat fishes (Mulloidicthys and Upeneus) and surgeon fishes (Acanthurus). The crustacean portion of the catch (0.4 lbs.) consisted primarily of spiny lobsters ("ulatai," Panulirus), slipper lobsters ("ula," Scyllarides) and xanthid crabs ("kuku pa'a," Carpilius and Scylla). Lastly, night fishermen walking the reefs with spear or machete generally pick up the colorful reef gastropods and the night octopus ("fe'e po," Polypus), and these mollusks make up the third portion of their catch (0.2 lbs.).

In line fishing from the shore and from the reef edge Samoan fishermen harvest about 0.5 kg. (1.1 lbs.) of fin fish per hour of fishing effort. Their catch is composed primarily of sea basses (Epinephelus), squirrel fishes (Lutjanus), emperors (Lethrinus), jacks (Caranx) and goat fishes (Upeneus, Parupeneus and Mulloidichthys). While the fishing catch taken by line fishermen differed between reef margin and shore and between day and night, it was not felt that the sample sizes allowed for adequately differentiating these catches.

Somewhat surprisingly, the estimated average catch per unit effort of 0.6 kg. (1.3 lbs.) per hour for Samoans fishing for the seasonal "atule" (mackerel) did not exceed the above-mentioned CPUE for line fishermen harvesting fin fish from the fringing reef by a significant amount. "Atule" fishermen using the harbor piers caught an average of 0.5 kg. (1.1 lbs.) of mackerel per hour of fishing effort during the season's "slow" periods and an average of 0.6 kg. (1.4 lbs.) during its "fast" periods. The entire range in CPUE, averaged for groups over periods of 20 minutes, extended from to 0.1 to 3.3 kilograms of "atule" per man per hour. The reaction of Samoan fishermen to fluctuations in the numbers of mackerel in the bay appeared to follow the classical entrance curve of economic theory, for as the numbers of mackerel caught increased, so did the number of Samoans fishing for them. This reaction, which might well triple to quintuple the amount of fishing activity in a given area, tended to depress the individual fisherman's catch from what it might otherwise have been, though the total catch of mackerel increased substantially. The pier fishery's catch included some jacks (Caranx), taken with lured lines, as well as the mackerels (Trachurops, Selar and ?Decapterus), taken with baited and feather-lured lines.

In spearfishing Samoan divers harvest about 0.6 kg. (1.3 lbs.) of fish and mollusks per hour of fishing effort. This catch is supplemented by an additional catch of crustaceans during the night, though my data does not permit an estimate of this weight. The catch of fish consists of parrot fishes (Scarus), surgeon fishes (Acanthurus, Ctenochaetus, Zebrasoma and Naso), sea basses (Epinephelus), moray eels (Gymnothorax), halfbeaks (Hyporhamphus), squirrel fishes (Myripristis and Holocentrus) and other reef fishes. The catch of mollusks follows the composition of that listed above for gleaning, though the size of the catch is considerably smaller (0.3 lbs./hr.).

Throw net fishing is the most productive method of fishing used on the fringing reef, with an average CPUE of 3.8 kg. (8.3 lbs.) for each throw net fisherman hour. Since such fishermen are often assisted by other men spotting schools of fish from higher positions, this CPUE fall to 2.5 kg. (5.5 lbs.) per hour of fishing effort. The catch is composed of the schooling fishes, particularly mullet (Mugil and Crenimugil), mackerel (Trachurops, Selar and Decapterus), sardines (Harengula), halfbeaks (Hyporhamphus) and surgeon fish (Acanthurus).

Finally, gill net fishing was found to yield a catch of 2.4 kg. (5.3 lbs.) per retrieval. Since the gill nets are generally set and retrieved during daylight periods of

high water and left overnight to catch fish leaving the fringing reefs as the tide falls, the catch per retrieval could be standardized to catch per manhour. Thus modified the CPUE for gill net fishing is 0.6 kg. (1.3 lbs.) per "fishing" hour, and the catch consists of squirrel fishes (Myripristis and Holocentrus), surgeon fishes (Acanthurus and Callydon), wrasses (Thalassoma, Hemipteronotus and Cheilinus), goat fishes (Pseudepeneus and Mulloidichthys), sea basses (Epinephelus) and snappers (Monotaxis).

This analysis reveals an amazing uniformity in the catch per unit effort for gleaning, diving, line fishing and gill net fishing, all of which average about 0.5 to 0.6 kg./hr. Only throw net fishing differs significantly from this CPUE, yielding catches of 2.5 kg./hr.; this highly skilled form of fishing produces four to five times the catch per unit effort that other forms of subsistence fishing yield.

These estimates of CPUE are substantially lower than those given by Smith (1947) for Micronesian atolls, where divers caught from 2 to 11 kg. of fish per hour. They are more comparable to those recorded by Lockwood (1971) in Western Samoa, where yields averaged about one kilogram of fish per hour for fishing off of the reef fronts. These low yields per unit effort confirm the overfished nature of American Samoa's fringing reef, previously indicated by

the small sizes of the individual fish caught. Unfortunately, unifrom and reliable CPUE data of a comparable nature is not available for other reef fisheries.

While the majority of the fish on and around coral reefs are quite small, 90% or more being less than 0.1 kg. in size (Stevenson and Marshall, 1974), those fish taken in American Samoa's nearshore fishery are generally less than half this size. As has been shown by Randal (1963) and others, the catch returns per unit effort decrease under the intense fishing pressure which produces such overfished conditions; these conditions are frequently associated with the rapid expansion of island populations and with urbanization (Clutter, 1971). Such socio-economic change certainly characterizes American Samoa.

Having estimated the CPUE for the different methods of subsistence fishing and having the data available to estimate the numbers of Samoans involved in the daytime fishery along the coastal section under study (especially Tables 35-37), I estimated the yearly catch for each fishing activity and for the nearshore fishery between Faga'itua and Malaloa (15.4 km.). The total catch for these fringing reefs, estimated as covering about two square kilometers, is 22524 kgs./yr., of which 65% is fish and 35% is invertebrates. An additional 9734 kgs. of "atule" (mackerel) was caught on the piers of this coast during the year, described by all fishermen as an exceptional season (Table 26).

Table 26. Yearly catch estimates for the daylight subsistence fishery activities along a coastal section (15.4 km.) of Tutuila Island, American Samoa

Subsistence fishing activity	Fisherman hours/day	Fisherman hours/year	Catch/hour (lbs. body wt.)	Catch/year (lbs. and kgs.) for 203 ha. of fringing reef
Gleaning	37.9	11824.8	Mollusks 1.0 Echinoderms 0.2	11825 lbs.=5375 kgs. 2365 lbs.=1075 kgs.
Diving	32.2	10046.4	Fish 1.0 Mollusks 0.3	10046 lbs.=4566 kgs. 3014 lbs.=1370 kgs.
Line fishing	31.4	9809.3	Fish 1.1	10790 lbs.=4905 kgs.
Throw net	4.3	1341.6	Fish 5.5	7379 lbs.=3354 kgs.
Gill net/weir	(2.5 hauls)	(780 hauls)	Fish(/haul) 5.3	4134 lbs.=1879 kgs.
Total reef platform catch			Fish (65%) Invertebrates (35%) Total	14704 kgs. 7820 kgs. 22524 kgs.
"Atule" fishery (piers)	211.2	16473.6	Fish 1.3	21416 lbs.=9734 kgs.

The analysis of the annual catch of the five primary groups of subsistence fishing activities (line fishing techniques combined as one and "paopao" activity distributed among line fishing, diving and gill net fishing) indicates that their relative importance, in terms of production is similar to that suggested by the numbers of Samoans participating in each. This follows from the rough equality in the CPUE for fishermen participating in gleaning, diving and line fishing; naturally the high CPUE of net fishing techniques improves their relative standing substantially. The distribution of the catch between these fishing activities, excluding the seasonal "atule," is as follows:

1) Gleaning 28.6%
2) Diving 26.4%
3) Line fishing 21.8%
4) Throw net fishing 13.1%
5) Gill net fishing 10.2%

When the "atule" catch, which is considerably larger than the catches of any of these reef platform fishing activities, is introduced into this assessment of the relative importance of fishing techniques as forms of production, line fishing stands as the largest contributor to the nearshore fishey's catch for the coastal section under study. This introduction must be taken with some

reservation, for much of American Samoa does not have the access to migrating schools of mackerel which the bay area does.

The analysis is Table 26 permits us to calculate the yields per unit area for the subsistence fisheries harvesting these fringing reefs. The estimated reef area, from shore to the seaward boundary of the reef slope, is 203 hectares. The daylight fishery's catch is 22524 kgs. per year. In-village studies and a small number of road surveys carried out at night suggest that the night fishing activity is no more than one tenth of the day fishing, and consists of gleaning, diving and line fishing, with a probable annual catch of about 1729 kg. The total catch, then, of the reef fishery is 24253 kgs./yr., indicating an annual yield of 119 kgs./ha.--approximately 12 M.T./km.^{2}/yr.

When compared with other tropical fisheries data this yield for American Samoa's nearshore subsistence fishery may strike the reader as too large. Stevenson and Marshall (1974, p. 153-4) list harvests of selected bottom fisheries ranging from 0.4 to 4.7 M.T./km.^{2}/yr. for the Caribbean Sea and ranging from 0.4 to 5.1 M.T./km.2/yr. for three Pacific atolls; the average annual yield per unit area for the eleven bottom fisheries considered by these researchers is two metric tons per square kilometer per year. Munro (1974, p.20), considering fisheries in

the Caribbean, concludes that rates of porduction of shelf-dwelling demersal fishes approaching 1.8 M.T./km.^{2}/yr. are attained under unregulated but intensive fishing.

The yield per unit area for the overfished reefs in American Samoa is roughly six times as large as these average yields for tropical demersal fisheries. This increased productivity is the result of the diversity of the subsistence fishery's catch, which includes a large portion of invertebrates (35%) as well as many fish species too small to be harvested by commercial fishing operations. In addition, the fisheries considered by Stevenson and Marshall and by Munro harvest their catch from deep reefs and lagoons, which Harry (1953) has observed are much less productive than shallow reefs lying under several meters of sea water.

American Samoa's highly productive fringing reefs are nonetheless underproductive--due to overfishing. The failure to develop and implement management practices for reef conservation and preservation in the face of intense socio-economic change has allowed the degradation of the reefs and the depletion of their stocks of marine life. In spite of the difficulties involved, the subsistence fishery's production could be enhanced by placing the appropriate controls on fishing pressures and by applying such controls in an effective manner.

As has been suggested by other reef fishery scientists (Clutter, 1971; Johannes, 1973), effective management of reef resources is more likely to occur when the right to fish an area is controlled by those in tenurial positions, as opposed to the open-access to the "Commons" of Western traditions. When the rights to use a resource are limited to and controlled by those holding such rights, the principle of (enlightened) self-interest tends to prevent overexploitation. In the Pacific such principles of reef tenure have the added value of having existed for millenia; they are therefore familiar and acceptable.

In American Samoa such fishing rights would be appropriately vested in the villages adjacent to the fringing reefs, as was discussed in Chapter IV. These villages already have viable forms of social and political organization in their "fonos" (council of titles family heads) and their "pule nu'u" (quasi-mayor, a Western-initiated position). This traditional structure of control could be usefully involved in forming and implementing reef management practices and policies.

Employing an existing structure in a new way, i.e., in reef conservation and preservation, would be inexpensive too. This is in keeping with the productive value of the nearshore fishery, whose total annual catch probably lies between 55 and 75 metric tons (body wt.), plus shells.

CHAPTER VII

Summary

Reef zonation was described and related to subsistence fishing activity. Certain generalizations were forthcoming. 1) Reef gleaners harvest the flat to moderately irregular areas characterized as the Porolithon ridge of the reef margin, the coralline algal flats of the outer reef and the platforms of Porites, Pavona and Psammocora on the mid and inner reef. 2) Divers spearfish the moderately to highly irregular reef slope, margin and Acropora thickets. 3) Line fishermen use several subsurface techniques in fishing the reef slope and "awas" (ravines) from adjacent shallow areas. 4) Throw net fishermen cast their nets over flat areas of the inner reef and reef margin. 5) Gill nets and weirs are set in reef passes on the outer reef and reef margin. Together these five groups of primary subsistence fishing techniques harvest the major zones existing on the fringing reef.

The relative frequency of occurrence of techniques used in the nearshore fishery was assessed. These are as follows: gleaning, 33%, diving, 26%, line fishing, 25%, throw net fishing, 6%, gill net or weir fishing, 4%, and "paopao" activity and other methods, 6%.

The relative importance of members of age-sex groups as participants in the nearshore fishery was assessed, revealing males to conduct all fishing activities except gleaning, traditionally the work of women and children, and line fishing with bamboo poles and baited hooks. The distribution of fishing activity within the reef fishery, according to age-sex groups, was as follows: adult males, 36%, male children, 17%, adult females, 16%, adolescent males, 15%, female children, 8%, adolescent females, 5%, elderly females, 2%, elderly males, 1%, and unclassified fishermen, 1%.

The relative importance of the regions across the fringing reef to the fishery in terms of their relative use was assessed, and found to be generally uniform across the reef platform. The distribution of fishing activity according to the location of its occurrence was as follows: inner reef, 29%, mid reef, 23%, outer reef, 26%, and reef front, 22%.

The analysis of longshore differences in the nature and location of the fishing activity in Pago Pago Bay and on the open sea coast revealed important differences in both. The open sea reefs receive more gleaning and spear-fishing, while the reefs within the bay receive a proportionally higher share of the line fishing. More of the

fishing activity along the sea reefs is focused on the mid and outer reef, while the distribution of the fishing pressure on the bay reefs is more uniform.

Further consideration of differences existing in the fishing activity along stretches of Tutuila's coast indicated that regions of landfilled reef in the inner bay receive only one seventh of the fishing effort applied to nearby unfilled reef.

The sensitivity of nearshore fishing activity to environmental variables was considered. The fishing activity was found to be strongly responsive to the tidal and diurnal cycles, and relatively unresponsive to changes in the weather.

The catch per unit effort for each of the primary subsistence fishing activities was calculated. These CPUE's are: throw net fishing, 2.5 kg./hr., gill net fishing, 0.6 kg./hr. (or 2.4 kg./haul), diving, 0.6 kg./hr., gleaning, 0.5 kg./hr., and line fishing, 0.5 kg./hr. The CPUE for fishermen harvesting the migrating schools of "atule," using line fishing techniques from the harbor piers, is 0.6 kg./hr. These figures do not reflect the Samoans' esteem for the nearshore marine life caught with each technique, and there is certainly a wide variety in the catch.

The yield per unit area for the fringing reef was calculated to be 119 kgs./ha./yr., or roughly 12 M.T./km^2/yr.

This yield, consisting of numerous speices of small fish and many invertebrates (35% of total), is six times as great as the average yield of tropical demersal fisheries studied by Stevenson and Marshall (1974). It attests to the high productivity of shallow coral reefs and to the ability of native populations in the Pacific to harvest this diverse produce.

Unfortunately the subsistence fishery has over-exploited the fringing reefs in American Samoa. In the face of the territory's population explosion and urban development fishing pressure has exceeded the reef's ability to produce, and the reefs are doubtlessly yielding catches below their potential. The nearshore fishery is sorely in need of an enlightened and effective program of marine resource management.

The catch for the nearshore fishery is equal to approximately 65 metric tons per year. While the value of the increased production accompanying effective management of the fishery may not warrant the expenditure of large sums in developing such management, it is proposed that the revitalization of traditional forms of reef conservation and preservation may accomplish the needed reef management. In particular, the translation of formal fisheries management into the "kapu" or "sa" (prohibition) system and the reinstatement of the village "fonos" as overseers of the reef are recommended.

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