MARINE EXPLOITATION AT SOUTH POINT, HAWAI'I ISLAND: AN ASPECT OF ADAPTIVE DIVERSITY IN HAWAIIAN PREHISTORY

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INTRODUCTION

Island ecosystems have several significant characteristics, such as relative isolation, limitation in size, limitation in or even absence of certain resources, limitation in organic diversity, etc. (Fosberg 1965). Therefore, man in the island ecosystem must cope with several stresses, among which food is the most substantial. Food resources in the Pacific are usually limited quantitatively and qualitatively. Quantitatively, the amount of food is limited by land area; in other words, there is a clear carrying capacity in island ecosystems. Qualitatively, animal protein on islands is limited due to the general absence of mammals in the Pacific islands. Both quantitative and qualitative limitations in terrestrial food resources have led to an emphasis on exploitation of marine resources. Marine resources have been well preserved by traditional conservation mechanisms (Johaness 1978; 1981), and marine exploitation has worked to increase man's adaptability to the Pacific environment.

ETHNOGRAPHIC AND ARCHAEOLOGICAL STUDY OF MARINE EXPLOITATION IN THE PACIFIC

Man is originally a land mammal and therefore he cannot adapt to a marine/aquatic environment without cultural means. The sea is a three-dimensional, complex ecosystem, and so man inevitably needs complex technology for marine exploitation (Hewes 1948; Oswalt 1976). In the Pacific, technology for marine exploitation was more complex than technology for horticulture (Alkire 1978:26).

Among several ethnographic studies of fishing gear and strategies in the Pacific, Anell's work (1955) was a landmark. His distributional study of ethnographic specimens is still useful for a general view of fishing patterns throughout the Pacific. Nordhoff's (1930) detailed description of traditional fishing lore in the Society Islands is also excellent, and includes ecological as well as technological factors.

Beyond these descriptive works, recent studies of marine exploitation have been focused on the ecological relationship between man and the marine environment. Johaness's (1981) ecological study of Palauan marine lore has made clear how systematically the traditional marine lore is related to complex ecological situations. His work indicates how traditional fishermen understand the swimming, feeding, and spawning behavior of fish in relation to tidal and lunar cycles, sea currents, etc. In addition, his analysis of Tobian fishhooks shows that there are certain relationships between fishhook form and function. His analysis has considerable applicability to archaeology.

Following the pioneer work in fishhook typology by Emory, Bonk, and Sinoto (1959), Sinoto went on to establish more comprehensive typological and chronological systems of Hawaiian archaeological fishhooks (Sinoto 1975, 1967). Head types of fishhooks are a good time-indicator, and throughout the Pacific the basic dichotomy of fishhook form, jabbing and rotating, seems to have a functional meaning.

Reinman (1967, 1970) emphasized the functional flexibility of fishhooks, which are used to exploit both surface and sub-surface zones. According to him, the introduction of fishhooks into the Pacific contributed to the stability and adaptation of culture, because fishhooks enabled men to exploit stable sub-surface and/or offshore zones. The same kind of functional flexibility and importance of fishhooks seems to be found in other areas such as Alaska and the Aleutian Islands (Goto 1981).

Reinman (1970) further indicated the mechanical and functional difference between jabbing and rotating forms. His speculation is confirmed in Johaness's recent work (1981:110-23), showing that rotating hooks are adaptive in the coral reef zone, because they are less liable to hook on the coral-studded bottom. Rotating hooks are more difficult to swallow than jabbing hooks, but the former are less likely to let fish escape once the point penetrates the body of the fish.

It seems, therefore, that fishhook forms are closely related to fish ecology and the environmental situation. Fishhook forms, as Kirch (1980a; 1980b) has argued, seem to reflect "selection factors" of the environment. By adopting this viewpoint Goto (n.d.) has attempted to identify various kinds of selection factors on the process of change in fishhook assemblages of Japanese prehistory.

From the above, we see a systematic relationship between form and the structure of fishing gear, fish ecology, and ecological factors. It may be possible to reconstruct prehistoric marine exploitation strategies through ethnoarchaeological inference, by synthesizing archaeological data (fishing gear and midden), data on fish ecology, and site location in terms of the local ecological situation (Kirch and Dye 1978).

MARINE EXPLOITATION AT KA'U, SOUTH POINT AREA, ISLAND OF HAWAI'I

The southernmost area of Hawai'i Island, South Point has attracted special interest in the archaeological study of Hawaiian marine exploitation (Fig. 1). The typology and chronology of Hawaiian fishhooks were established on the basis of materials excavated there (Emory, Bonk, and Sinoto 1959; Sinoto 1967). In addition to these studies, Sinoto and Kelly (1975) reported on more recent excavations in this area. The author has had the opportunity to analyze archaeological data (fishing gear and midden materials) from Sinoto and Kelly's investigation, and this paper presents the results of my analysis.

The archaeological sites under consideration were found in the western portion of the South Point area, surrounded by lava flows. The coast in this region is characterized by bare, basalt-pebble beaches. The deep, sheltered waters around South Point produce large pelagic fish such as tuna and jackfish (Kirch 1979b). Without doubt, the prehistoric settlements at South Point were oriented toward marine exploitation and especially to pelagic fishing. Of the 26 sites excavated, three rock shelters (B21-20, B22-64, and B22-248) are important because these are stratified, and contained midden materials. Sinoto ascertained the temporal sequence of the head types of one-piece hooks (HT1a/1b --> HT4) and of 2-piece hook points (notch --> knob), which he had demonstrated in his earlier study (1967). A schematic diagram of this fishhook sequence, with C14 dates, is shown in Figure 2. As to midden data, I analyzed fish bones from sites B22-64 and B22-248, and the results of this analysis are given in Table 1. The minimum number of individuals (MNI) is estimated for each layer of both sites. Except for sharks and parrot fish, the

TABLE 1

FISH BONE FROM SITES B22-248 AND B22-64 AT KA'U, SOUTH POINT

	B22-248					B22-64				
	VI	III	II	I	Subtotal	IV	III	II	I	Subtotal
(Sharks)	1	1	1	1	4(2.6%)	0	1	1	1	3(8.8%)
Holocentridae (squirrel fish)	6	11	6	0	23(15.1%)	1	2	2	0	5(14.7%)
Sphyraenidae (barracuda)	5	2	2	1	10(6.6%)	1	2	0	0	3(8.8%)
Serranidae (grouper)	1	0	0	0	1(0.7%)	0	0	0	0	0(0.0%)
Pricanthidae (big-eye fish)	1	0	0	0	1(0.7%)	0	0	0	0	0(0.0%)
Apogonidae (cardinal fish)	0	1	1	0	2(1.3%)	0	0	0	1	1(2.9%)
Lutjandae (snapper)	2	2	1	2	7(4.6%)	0	1	0	0	1(2.9%)
Sparidae (porgy fish)	0	1	1	0	2(1.3%)	0	0	0	0	0(0.0%)
Mullidae (goat fish)	3	1	2	1	7(4.6%)	0	0	0	0	0(0.0%)
Carangidae (jack fish)	1	2	3	3	9(5.9%)	1	2	0	0	3(8.8%)
Labridae (wrasse)	4	2	1	1	8(5.3%)	0	3	0	0	3(8.8%)
Scaridae (parrot fish)	12	16	15	5	48(31.6%)	1	5	1	1	8(23.5%)
Scarus	6	12	11	2	31	1	2	1	1	5
Calotomus	6	4	4	3	17	0	3	0	0	3
Cirrhitidae (hawk fish)	2	1	0	1	4(2.6%)	0	1	0	0	1(2.9%)
Scombridae (tuna/mackerel)	1	0	0	0	1(0.7%)	0	0	0	0	0(0.0%)
Acanthuridae (surgeon fish)	3	3	1	1	8(5.3%)	0	0	1	1	2(5.9%)
Balistidae (trigger fish)	5	1	2	8	16(10.5%)	0	0	2	0	2(5.9%)
Diodontidae (burr fish)	0	0	0	0	0(0.0%)	0	1	1	0	2(5.9%)
Subtotal	47	44	36	25	152(100%)	4	17	8	4	33(100%)

Number of each column indicates the estimated MNI.

TABLE 2

GENUS AND/OR SPECIES
(Tentative Identification)

Sphyraenidae
- *Sphyraena barracuda*

Lutjanidae
- *Aphareus* spp.
- *Lutjanus* spp.
- *Pristipomoides* spp.

Carangidae
- *Caranx* spp. (*ignobilis*?)
- *Elegatis* spp. (*bipinnulatus*?)
- *Carangoides* spp.
- *Trachurops* spp.

Labridae
- *Bodianus* spp.
- *Cheilinus* spp.
- *Thalassoma* spp.
- *Coris* spp.
- *Stethojulis* spp.

Acanthuridae
- *Naso* spp.

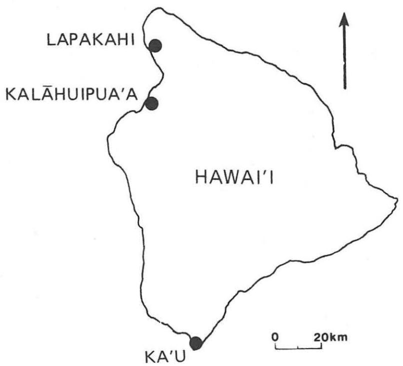


Fig. 1. ISLAND OF HAWAI'I.

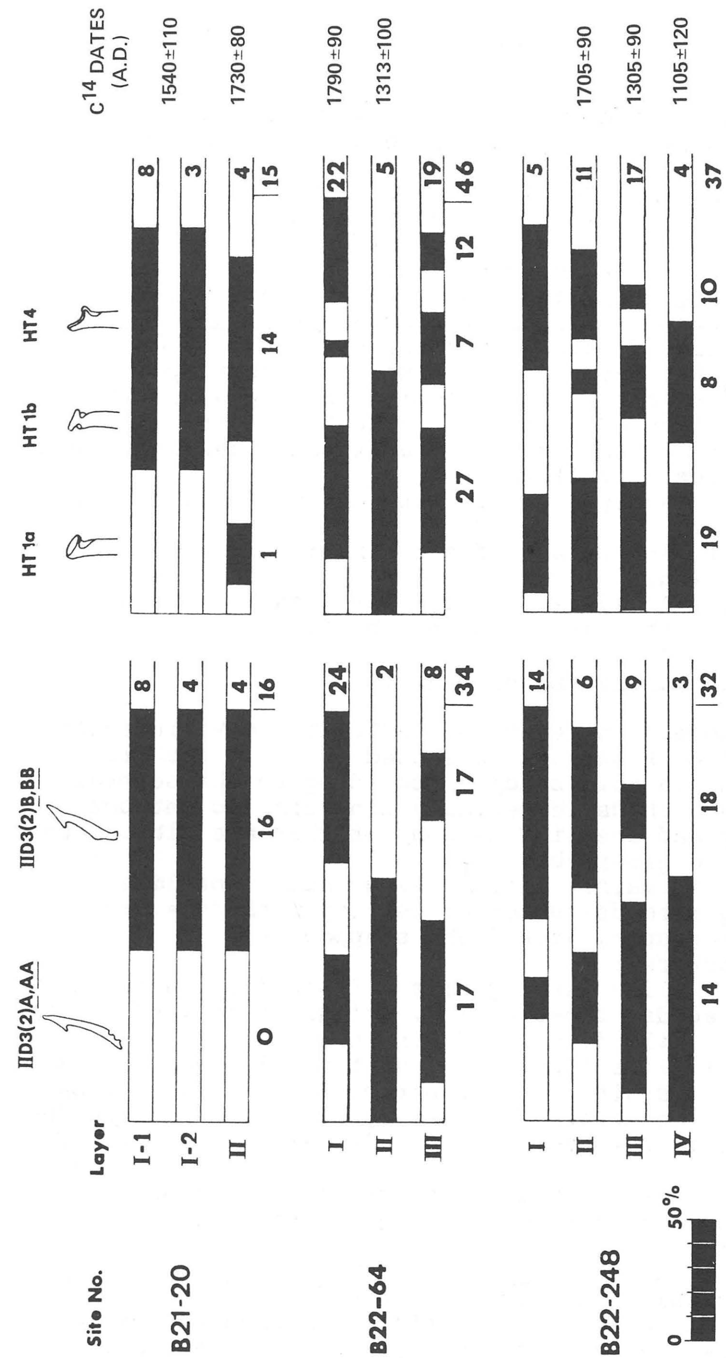


Fig. 2. FISHHOOK SEQUENCE AND RADIOCARBON DATES FROM SOUTH POINT. After Sinoto and Kelly 1975:fig. 14, table 2.

results of identification are shown by family, with some families subdivided into genus and/or species.

COMPARISON OF PREHISTORIC FISHING STRATEGIES ON THE ISLAND OF HAWAI'I

I shall argue that fishing strategies are based on fish ecology, and that such strategies have two basic aspects, fishing method and fishing habitat. These three factors are closely related to each other. For example, it is unlikely that spears would be used to catch fish swimming in deep water, or that pelagic fish such as tuna would be caught inside of the reef. I analyze the traditional Hawaiian fishing strategies as follows:

(1) Analysis of fishing method to catch each fish.

(2) Analysis of fishing habitat (in relation to fish ecology).

(3) Analysis of the relationship between fishing method and fishing habitat.

Analysis of Fishing Method (Table 3)

Table 3 (after Newman 1970, Table V) indicates what kind of methods were used to catch the fish relevant to this study. According to the several fishing methods (especially line fishing methods vs. netting and spearing methods) fishes are classified into five groups by:

(a.) mainly line fishing (number of line fishing methods:number of netting methods = 3:0 or 3:1)---grouper, jack fish, snapper, and tuna/mackerel;

(b) line fishing plus netting (line:net = 2:1) ---barracuda, big-eye fish, trigger fish (and probably file fish), and cardinal fish;

(c) line fishing and netting (line:net = 1:1) ---shark, squirrel fish, parrot fish and goat fish;

(d) netting and spearing plus line fishing (net & spear:line = from 2:1 to 5:2)---wrasse and surgeon fish;

(e) mainly netting or spearing (net or spear:line = 1:0)---hawk fish, puffer (and probably burr fish).

In this analysis, I have had to ignore the efficiency of particular fishing methods, because few data are available on this point. I have considered simply what kinds of line fishing methods, compared with netting and spearing, were used to catch particular fish.

TABLE 3

TRADITIONAL HAWAIIAN FISHING METHODS (AFTER NEWMAN 1970:TABLE V)

	Line Fishing				Netting and Spearing				
	Hook/line	Surface	Subsurface troll	Long handline	Seine/bag net	Gill net	Bag net	Basket trap	Spear
grouper	+		+	+					
jack fish	+		+	+	+				
snapper	+		+	+	+				
tuna/mackerel	+	+	+		+				
barracuda	+		+		+				
big-eye fish	+		+			+			
trigger fish (& file fish)	+	+				+			
cardinal fish	+		+		+				
shark	+				+				
squirrel fish	+		+		+		+		
parrot fish	+		+		+	+	+		
goat fish	+		+		+	+			
wrasse	+		+		+	+	+	+	
surgeon fish	+	+			+	+	+	+	+
hawk fish						+			
puffer (& burr fish)									+

-----Note-----

1. I excluded an introduced method, cast net.

Analysis of Fishing Habitat

Table 4 is basd on data from Gosline (1965), Gosline and Brock (1960), Hiatt and Strasburg (1960), and Tinker (1978). According to feeding pattern, these fishes popular in tropical waters are classified into: algae feeder (surgeon fish), coral polyp feeder (parrot fish), facultative omnivores (wrasse, trigger fish, file fish, and puffer), and typical carnivores (burr fish, cardinal fish, big-eye fish, hawk fish, snapper, porgy fish, goat fish, grouper, squirrel fish, jack fish, barracuda, tuna/mackerel and shark). Though some fish move between inshore and offshore zones, the fishing habitat for each taxon is estimated as follows, by consulting the data of usual habitat of each fish (right half of Table 4) and feeding pattern:

A. Reef zone---surgeon fish, wrasse, parrot fish, puffer, burr fish, big-eye fish, cardinal fish, goat fish and grouper.

B. Inshore zone---trigger fish, file fish, hawk fish, snapper, porgy fish, and squirrel fish.

C. Pelagic zone---jack fish, barracuda, tuna/mackerel and shark.

Zone A (reef zone) and Zone B (inshore zone) are overlapping, to some extent, and are considered as shallow zones, compared with Zone C.

Analysis of Relationships Between Fishing Method and Fishing Habitat

Table 5 is cited from Kirch (1979a, Table 1). Together with the analysis of fishing habitat by Reinman (1967) and Kirch (1979b), we can conclude that line fishing is the only method used to exploit the pelagic and benthic zones. On the other hand, netting sems to be more productive in inshore and/or reef zone(s).

In order to assess the characteristics of fishing strategy at South Point, I have compared the data of Table 2 with quantitative data from two other areas of Hawai'i Island, Kalahuipua'a (Kirch 1979a) and Lapakahi (Newman 1970). (The locations of these two areas are indicated in Fig. 1). Table 6 summarizes the comparison of midden data in relation to fishing method and fishing habitat. Then the differences in fishing strategies between these three areas are analyzed, according to two criteria: the relative importance of fishing methods and the relative importance of fishing habitats.

Firstly, as I have already shown, fish are

TABLE 4

ECOLOGY OF FISHES POPULAR IN TROPICAL WATER

	Feeding Pattern				Habitat			
	Algae	Coral polyp	Omnivore	Carnivore	Flat reef	Surge	Sub-surge	Pelagic
surgeon fish	+				+	+	+	
wrasse		+	+	+	+	+	+	D
parrot fish	(+)	+			+		+	
trigger fish	+	+	+	+			+	D
file fish		+	+	+			+	D
puffer	(+)	+	+	+	+		+	
burr fish				+	+		+	
cardinal fish				+	+		+	D
big-eye fish				+	+	+		
hawk fish				+			+	
snapper				+		+	+	D
porgy fish				+		+	+	
goat fish				+	+	+	+	
grouper				+	+			D
squirrel fish				+		(+)	+	
jack fish				+				+
barracuda				+				+
tuna/mackerel				+				+
shark				+				+

-----Note-----
1. "D" indicates fishes which usually live in shallow water but are also found in deep water between 30 and 200 m.
2. puffer = Tetradontidae

TABLE 5

FISHING METHOD AND FISHING HABITAT
After Kirch 1979:table 1.

Exploitation Technique	Biotope: I Pelagic	II Benthic	III Littoral	IV Fishponds
Gathering			X	X
Fish traps		X		X
Netting				
Hand nets		X	X	X
Seine nets		X		X
Spearing		X		X
Octopus lure method		X		
Angling				
Small hooks		X		?
Shark hooks	X			
Trolling	X	?		

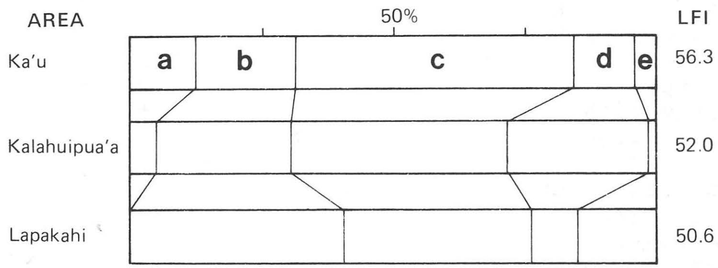


Fig. 3. COMPARISON OF FISHING STRATEGY: FISHING METHOD.

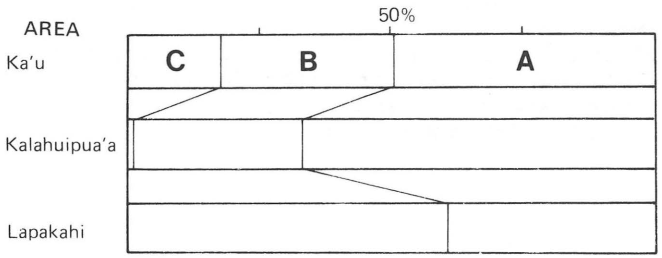


Fig. 4. COMPARISON OF FISHING STRATEGY: FISHING HABITAT.

TABLE 6
COMPARISON OF MIDDEN DATA IN RELATION TO
FISHING METHOD AND FISHING HABITAT

	Ka'u	Kalahuipua'a	Lapakahi	Fishing Method	Fishing Habitat
shark	3.8%	1.7%	1.0%	c	C
squirrel fish	15.1%	0.0%	21.0%	c	B
barracuda	7.0%	0.0%	0.1%	b	C
grouper	0.5%	0.0%	0.0%	a	A
big-eye fish	0.5%	0.0%	0.0%	b	A
cardinal fish	1.6%	0.0%	0.0%	b	A
snapper	4.3%	5.0%	0.0%	a	B
porgy fish	1.1%	0.0%	1.0%	(a)	B
goat fish	3.8%	1.7%	0.0%	c	A
jack fish	6.5%	0.0%	0.0%	a	C
wrasse	5.9%	26.4%	7.3%	d	A
parrot fish	30.3%	37.7%	12.4%	c	A
hawk fish	2.7%	0.0%	0.0%	e	B
tuna/mackerel	0.5%	0.0%	0.0%	a	C
surgeon fish	5.4%	0.0%	1.0%	d	A
trigger fish	9.7%	26.4%	5.0%	b	B
file fish	0.0%	0.0%	35.0%	(b)	B
puffer	0.0%	0.0%	3.0%	e	A
burr fish	1.1%	1.1%	11.0%	(e)	A

Fishing Method
- a: mainly line fishing
- b: line plus net (line > net)
- c: line and net (line = net)
- d: net and spear plus line (net/spear > line)
- e: mainly net or spear

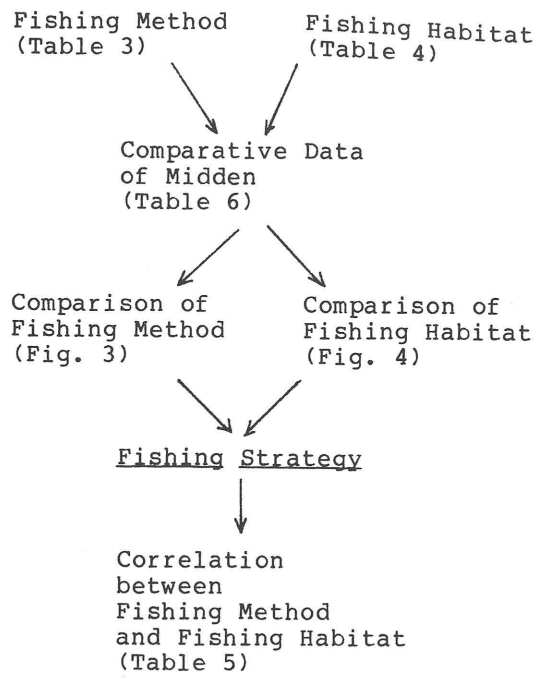
Fishing Habitat
- A: reef and inshore zones
- B: inshore zone
- C: pelagic zone

-----Note-----
1. Ka'u (B22-248 & B-64); Total of MNI = 185
2. Kalahuipua'a (E1-324, -342, -343, -355, -368, -328, -350E, and E2-51); Total of MNI = 183 (Kirch 1979a:Table 25 - Table 30)
3. Lapakahi (Koaie Hamlet); Total of MNI is unknown (Newman 1970:Fig. 13)
4. I assumed that fishing method of porgy fish was similar to that of smapper, because of similarities in ecology of both fishes (Hiatt and Strasburg 1960:86)
5. & 6. In the same way I assumed that fishing method of file fish was similar to that of trigger fish, and that fishing method of burr fish was similar to that of puffer.

classified into five groups, according to fishing methods. The percentages of these five groups of fish in each area are shown in Figure 3. I have used coefficients for LFI (line fishing index). The group coefficients for fishes are (a) 1.00; (b) 0.75; (c) 0.50; (d) 0.25; and (e) 0.00. LFI is calculated as follows (the data for South Point are presented here to illustrate the method of calculation): LFI = 1.00 X 12.9(%) + 0.75 X 18.8(%) + 0.50 X 53.0(%) + 0.25 X 11.3(%) + 0.00 X 3.8(%) = 56.3. If the percentage of fish caught mainly by line fishing or by line fishing methods plus netting is relatively larger, this LFI tends to be larger. Thus, this index indicates the relative importance of line fishing methods among fishing strategies. The results of the calculation for three areas are shown in the right-hand column of Figure 3. Efficiency of each fishing method is ignored here, but this analysis may be relevant to relative importance between line fishing, netting, and spearing. It seems that the relative importance of line fishing methods in the three areas is ordered as : South Point > Kalahuipua'a > Lapakahi. The importance of netting and spearing is understood in the opposite order.

Secondly, according to Figure 4, the fishing habitat is classified into three categories. The data in Table 6 are rearranged, according to three major fishing habitats, and the result is shown in Figure 4. This figure indicates that at South Point, fishing in the pelagic zone had a substantial importance in marine exploitation, but at Kalahuipua'a and Lapakahi, marine exploitation was focused on shallow zones (reef and inshore zones). Kalahuipua'a especially was characterized by reef fishing.

These two analyses (of fishing methods and fishing habitats) and Table 5 indicate the following relationships. The importance of line fishing strategies at South Point must have been correlated with the importance of pelagic fishing in this area, because fishhooks were the only gear type used to exploit pelagic and/or deeper zones. Conversely, the importance of netting and spearing in the other two areas was related to an inshore-oriented strategy. My analytical procedure so far is summarized as follows.



Additional data are also available for comparison between South Point and Kalahuipua'a: (1) fishhook size; (2) fishhook form; and (3) size of fish bone. The sizes of one-piece hooks from both areas are shown in Figure 5. The histogram and mean sizes of measurements (shank length, breadth and point length) of fishhooks indicate that one-piece hooks from South Point are slightly larger than those from Kalahuipua'a (Kirch 1979a:192-3), which probably reflects the variation in fishing strategies. At South Point, fishermen often ventured into pelagic waters to catch larger fish such as jacks, tuna, and barracuda, by surface and mid-layer trolling and long line. Fishermen at Kalahuipua'a usually did line-fishing inside of the reef to catch smaller fish.

Changes in fishhook form differ between these two areas (see Table 7). In both areas, two types of hooks, jabbing and rotating, were used. But at Kalahuipua'a, rotating hooks seem to have been preferred in later times, because most of the later hooks with HT4 were rotating types. The opposite phenomenon is observed in fishhook assemblages at

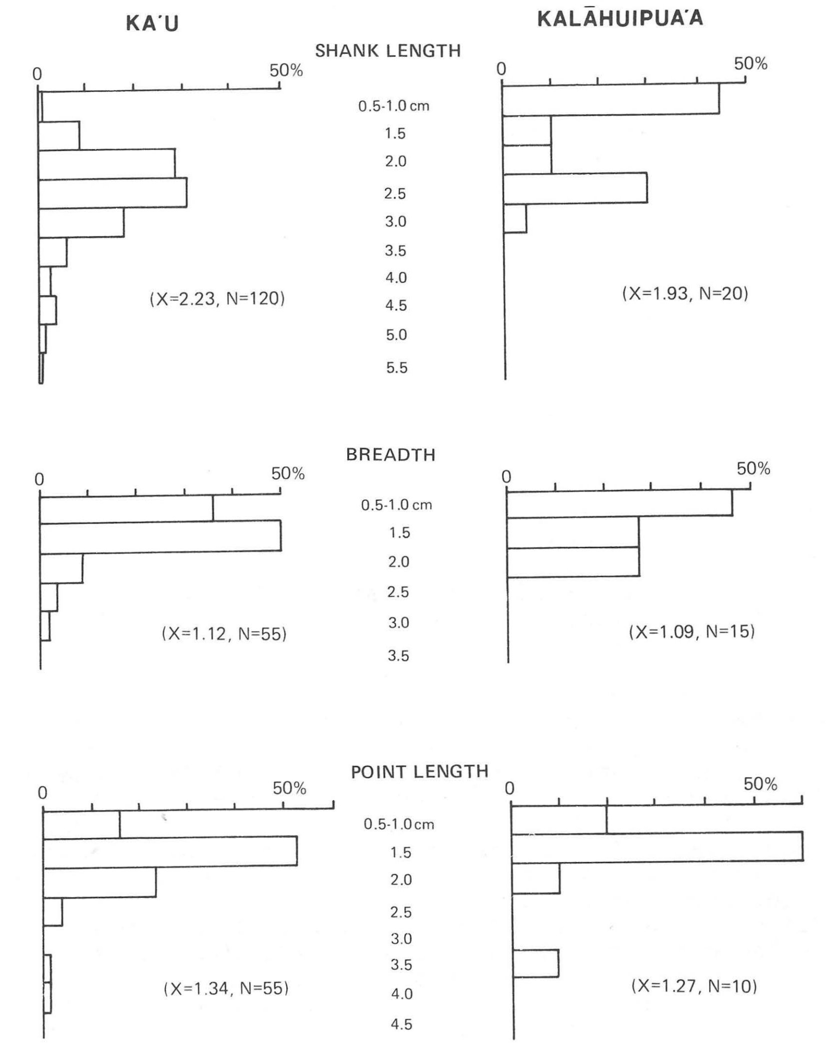


Fig. 5. COMPARISON OF FISHHOOKS: KA'Ū AND KALĀHUIPUA'A. After Kirch 1979a:fig. 74.

TABLE 7

CORRELATION BETWEEN HEAD TYPES AND FISHHOOK FORM: KA'U AND KALAHUIPUA'A

	Ka'u		Kalahuipua'a	
	HTla/lb	HT4	HTla/lb	HT4
Jabbing	15(38%)	11(52%)	7(70%)	1(20%)
Rotating	24(62%)	10(48%)	3(30%)	4(80%)
Total	39	21	10	5

Kalahuipua'a (after Kirch 1979a: Table 37 & Table 64)

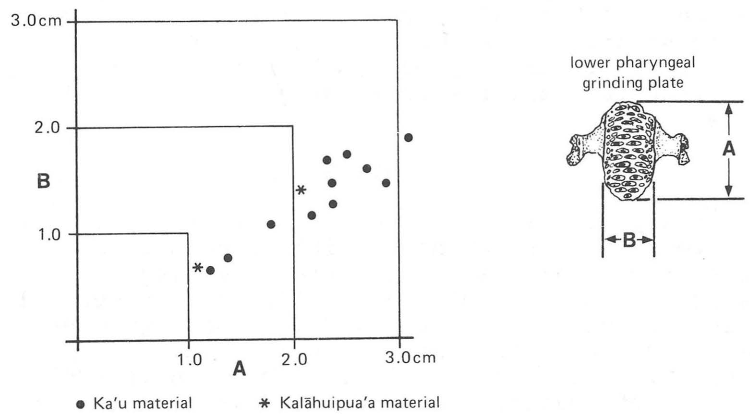


Fig. 6. SIZE RANGE OF LOWER PHARYNGEAL GRINDING PLATE OF PARROTFISH: KA'Ū AND KALĀHUIPUA'A. After Kirch 1979a:fig. 64.

South Point. Jabbing hooks increased or were still preferred to rotating ones in later times. The increase of rotating hooks at Kalahuipua'a seems to have been correlated with the development of coral reef (Moberly and Chamberline 1964), because rotating hooks are less liable to hook on a coral bottom (Johaness 1981:116).

Size of fish also differs between the two areas. In order to estimate body length or weight, we need species data. Measurements of the size of lower pharyngeal plates of parrot fish are shown in Figure 6, with Kalahuipua'a data from Kirch (1979a: Fig. 64). This indicates clearly that parrot fish caught at South Point were larger than those at Kalahuipua'a. I argue that an offshore-oriented strategy at South Point is ascertained in this aspect as well.

In this paper, I have not discussed other factors related to fishing strategy, such as seasonality, division of labor, efficiency of each fishing method, settlement location, etc. But two kinds of analyses of fishing strategy, fishing method and fishing habitat, among three areas on the Island of Hawai'i, and additional analyses of fishhook assemblages (size and form of one-piece hooks) and quantitative comparison of fish bone between South Point and Kalahuipua'a, indicate that comparison of fishing strategies should be done "multi-dimensionally". No single criterion is sufficient to grasp the full variation of adaptive strategy.

CONCLUSION

This paper has indicated the diversity of adaptive strategies within an island ecosystem. Prehistoric Hawaiians chose certain fishing strategies from the cultural pool formed in central tropical Polynesia (Sinoto 1970), according to each local situation within an island. Marine exploitation on Hawai'i Island shows an aspect of diversity of adaptive patterns in Hawaiian prehistory. According to Binford:

> Adaptation is always a local solution to basically local conditions. Because of this we can anticipate considerable variability among systems in the character of the adaptation achieved (1977:495). Adaptation is not necessarily determined by means, but instead derived from the pattern of use to which means are put in seeking security. We may anticipate, therefore, interregional differences in many aspects of the archaeological record that refer directly to the character of the adaptations achieved, even though the culture or the means known to the people may be similar or identical. (Ibid.)

Changes in fishhook assemblages exemplify selective retention of cultural traits in the adaptive process (Kirch 1980a). The basic logic of this paper has been ecological, but in a future study I plan to include symbolic factors, such as food taboo (Kirch and Yen 1982) and the symbolic value of fishing activity (e.g. Goto 1983).

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