Hawaiian Aquacultural System

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CHAPTER 1

INTRODUCTION

Aquaculture, or aquiculture, refers to the cultivation of aquatic lifeforms to serve the food needs of man. The discipline is commonly divided into two branches, Mariculture and Pisciculture. The former refers to the raising of large marine animals, e.g., whales, turtles, and seals, outside the brackish water zone (Bardach 1968:1105), and the latter refers to the cultivation of fish (Maar, Mortimer, and Van Der Lingen 1966:4). Aquaculture, then, encompasses the cultivation of marine animals, fish, and vegetable lifeforms in the sea, along the shore, and in bodies of water in the interior of the land.

Early man successfully hunted and gathered the wild or free food about him. Emphasis seems to have been placed on the control of a large variety of plants and animals. Control of aquatic food forms was, however, more difficult. It has been determined that the shore, the estuary, and the fertilized fishpond are capable of a greater productivity of food than farm land of equivalent size (Masefield 1970:62; Bardach 1968:1104). Fishponds can be likened to estuaries, which, according to Doctor Eugene Odum, are 20 times as productive as the open sea, 7 times as productive as an

more complete picture of architectonic fishing devices in Hawai'i, the author has included under the term "aquaculture" various fish trapping techniques employing semi-permanent structures. In so doing, fishtraps, weirs, fish shelters, and dams are also included for study. The Hawaiian aquacultural system, from this point on referred to also as Hawaiian aquaculture, is defined as the indigenous economic, technological, and political control of natural pools, ponds, and lakes, and of man-made ponds, enclosures, traps, and dams for the culture and harvest of fish, turtles, crustaceans, shellfish, and seaweed for food production, generally divorced from the vagaries of weather and season.

Considerable piecemeal work has been done in the field of aquaculture, but until now only one attempt, by Catherine Summers (1964), has been made at synthesizing data. That work, Hawaiian Fishponds, is not, however, an in depth study, but rather a descriptive report and so is too general to elicit interpretations. This dissertation is, then, an attempt to integrate and synthesize as much of the tremendous bulk of data as possible into a cohesive interpretation of the socio-political, economic, and religious aspects of aquaculture in the development of Hawaiian society.

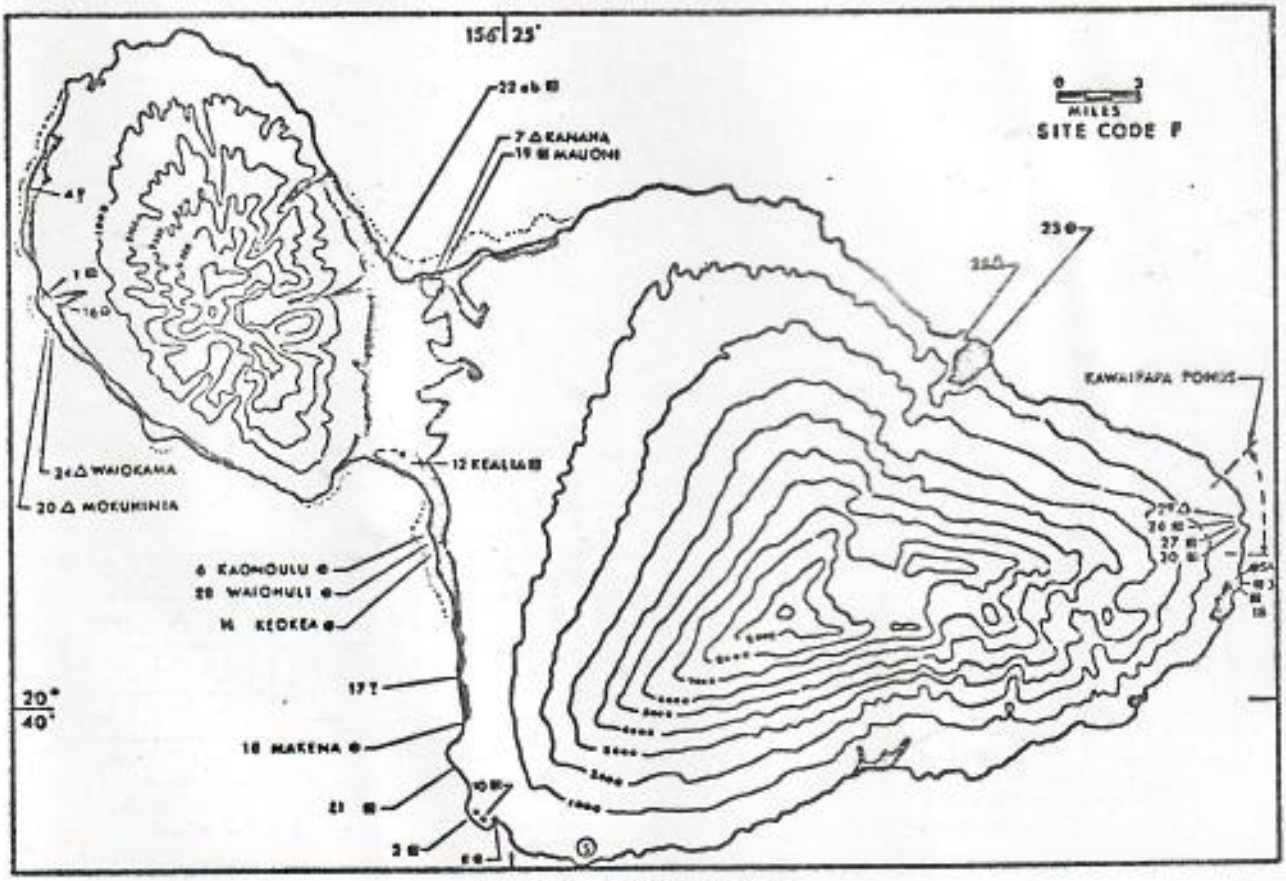
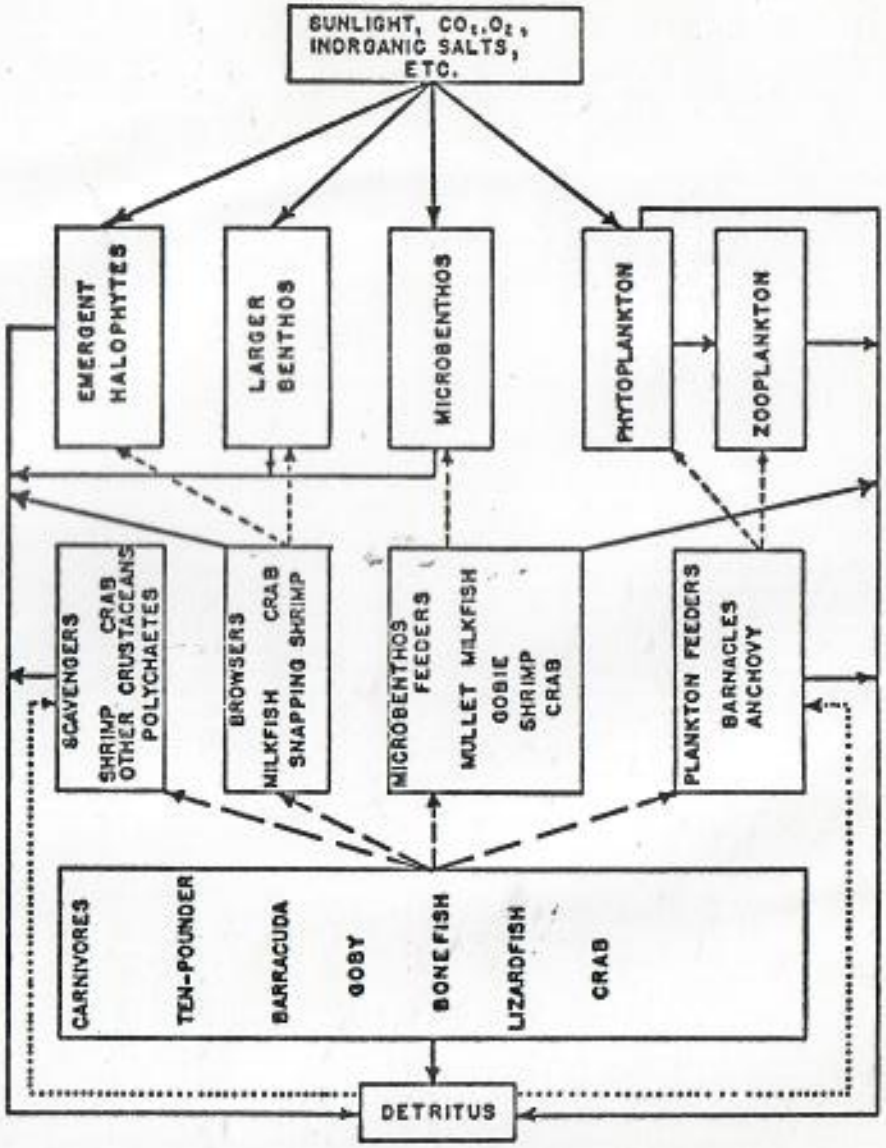


Fig. 23. Maui Island



AFTER HIATT 1947:276

Fig. 34. Food Chain Diagram of Some Hawaiian Fishponds

the 'ōpae-kākala, a spiked shrimp, are noted as entering the kuapā and pu'uone fishponds from the sea (Kamakau 1964: 84). 'Ōpae-'oeha'a (Macrobrachium grandimanus), clawed shrimp, washed into the taro plot ponds through the makahā (Kamakau 1869b). The only kinds of crabs reportedly related to fishponds are the 'alamihi (Metropograpsus messor) (Summers 1971:85), a common black crab, and the papa'i, a general term for crabs (Nakumaia 1922a).

Seaweed. Over 70 distinct species of edible seaweeds, limu, are present in the Hawaiian Islands (Reed 1906:62-63; MacCaughey 1916:476) and are found along the seashore and, in one instance, in fresh water ponds, rivers, and streams. MacCaughey (1916:477) remarks that certain fishponds were chosen in which to cultivate selected seaweeds. He further states that some nobility preferred to segregate and transplant choice seaweeds in the ocean in the vicinity of their beach residences, where the limu would be available at any time. Queen Liliuokalani's beach residence in Honolulu is reputed to have had such an ancient seaweed sea-garden nearby.

Only limu-kala-wai (Spirogyra spp.) is recorded as being an edible product of fresh water fishponds (Kamakau 1869b). Reed (1906:67-68) and Pukui and Elbert (1957:190) refer also to limu-'Ilio (Stigeoclonium amoenum), or hulu-'Ilio, as being an edible fresh water alga.

Miscellaneous Resources. Occasionally, turtles, or honu, were caught and deposited in fishponds or small pools where they were preserved in good health and kept for later consumption. Pāhonu, site C127, was an enclosure made principally for holding turtles (Pukui and Elbert 1966:22). An early visitor to the Waikiki area remarked that the ruling chief of O'ahu, Kahekili, "mentioned also some others [fishponds] where he had a quantity of turtle (Meares 1791:20)."

An unusual food resource, reported only at site C67, Kawainui fishpond, is lepo-'ai-ia, edible mud. Tradition states that Ka'ulu-a-Kalana, a noted chief, brought the mud from Kahiki (general term for a foreign place) to O'ahu and placed it into the fishpond. The mud is described as thick and jelly-like, having the color of poi, mashed taro (Alona 1939). During the invasion of O'ahu, the warriors and servants of King Kamehameha I mixed the mud with their poi in order to stretch their food resources. McAllister (1933:186) records that Mr. John Bell remembered eating the soil when he accompanied King Kalākaua (1847-1891), thus indicating the popularity of this unique food item.

There are no references to the actual harvest of any shellfish, bivalves, or mollusks from fishponds or fishtraps. It is assumed that the Hawaiians did, however,

use all available food resources, and that, in the case of shellfish, bivalves, and mollusks, the harvest was marginal, seasonal, and occasional. The Pearl Harbor Lochs were once famous for their edible oyster and did support a wide range of edible bivalves, as noted by Pukui (1943:66): kupekala (Chama sp.); mahamoe (genera not known); nahawele, 'owa'owaka, and pāpaua (Isognomonidae family); and pipi (Pinctada galtsoffi). Common to all shore fishponds and fishtraps are the edible shellfish: kūpe'e (Nerita polita), pipipi (Nerita picea and Nerita neglecta), and the choice limpet, 'opihi (Helcioniscus sp.).

fish growth and taste. "If sea water was made to enter the fresh water at times, the fish would grow more rapidly, and they would be delicious and full of fat (Kamakau 1869b)." Summers (1964:3) notes that "the fish's food thrived best in brackish water. The streams also benefited the ponds by washing in inorganic material, thus fertilizing and consequently increasing the food supply." Hiatt (1947:266), Walsh (1967:430), and Malone (1968:45) note that streams, springs, and tidal flow carry inorganic and organic nutrients along, depositing them into the fishponds.

Artificial Fertilization

The Hawaiian likened the fishpond culture to agriculture and the raising of animals for food. These he provided with fertilizer, or food, in order to promote more rapid growth.

One structure specifically designed to attract fish is the fish shelter, type VIII. This artificial construction lured fish by virtue of providing rock faces that formed halls on which algae grew to create an underwater micro-garden.

The native caretaker provided food for the fish in fishponds. This fertilizer was never offal or matter containing blood. No sewage was used, only green food scrappings. Three common foods were sweet potatoes, poi, and boiled taro, as reported by Coulter (1931:10). Taro and

breadfruit were fed to the fish in the river of Huleia on Kaua'i (BPBM Tape M-41Y5). For the Waiakea ponds in Hilo, Hawai'i, Ellis (1963:240) writes, "Along the stone walls which partly encircle these ponds, we saw a number of huts, where the persons reside who have the care of the fish, and are obliged frequently to feed them with a small kind of mussel, which they procure in the sands around the bay." Titcomb (1952:7) writes, "Stones with seaweed attached were collected and set within the ponds to increase the food supply of these herbivorous fish." The fish within the type IV, taro plot pond, "fed upon the ripe leaf stems (ha pala) of the taro, and thus quickly acquired size (Kamakau 1869b)." Tilden (1905:142) records that stigeoclonium seaweed grew attached to pebbles in streams and that these were used as bait to catch mullet. It is probably this seaweed to which Titcomb refers above.

It is documented that selected fishing grounds in the ocean were assigned to individuals whose task was to feed the fish seaweed 2 to 3 times a week. This "feeding-training" worked on the Pavlovian system, whereby, when the chief had selected his feast day, fish could be quickly and most assuredly harvested (Fiddler 1956:2). Phelps (1937: 15) notes that fish at certain locales were fed taro at regular intervals in order to allow for the netting of a large quantity of fish "at call." Whether this was done at fishponds as well is uncertain, but it does serve to

indicate that artificial feeding was not an uncommon practice. No details were found concerning the preparation of the food and the ceremony surrounding the feeding.

Maintenance

Maintenance of fishponds and fishtraps was a vital and constant task, as disrepair, silting, and overgrowth would adversely affect productivity. Silting and overgrowth with seaweeds seem to have been the most prevalent problems. Summers (1964:11) reports that one method of cleaning the Moloka'i fishponds of silt was to provide sluice grates on both sides of the ponds at the shore end in order to allow the ebbing of the tide to flush out the mud and silt. Both Phelps (1937:15) and Handy and Handy (1972:260-61) note that on Moloka'i a weighted bamboo rake, kope'ohe, was towed behind a small canoe to stir and harrow the bottom sediments at high tide so that at the ebbing of the water the silt was naturally swept out at the sluice grates. An informant of Handy and Handy (1972:260-61) in 1931 stated that as the tide was receding, an individual would scrape mud and silt into the 'auwai o ka makahā and so would clean out portions of the pond.

Organic muck and algae are present on the walls and sides of sites H27, H28, H37, H38, and H48A-C on the western coast of Hawai'i Island (Kikuchi and Belshe 1972). Evidently, cleaning out of the muck and algae was a continuous

process, as some ponds display large mounds of accumulated muck and areas in which rocks were piled into mounds. The Kuki'o fishpond, H38, contains definite cleared areas and mounds of rock and also platforms which suspiciously appear to be the result of rock clearing.

The tenants of the land were summoned by the konohiki to clean the fishponds "when few fish were caught, owing to the accumulation of algae preventing the nets that were used for catching the fish from reaching the bottom of the pond (Summers 1964:22)." At Alekoko pond, B2, women were called to gather the seaweed into piles, allowing for new growth of seaweed for the fish to feed on (BPBM Tape H-62B). Once Kawainui fishpond, C67, was "much larger and very clean. The people of that locality saw to it that the ponds were kept clean in the olden days (Alona 1939)." Summers (1964:22) adapts the following from Kekoowai (1922): "...the konohiki...commanded the men, women, and children of Waunawili, Kailua, and Waimanalo to come to Kawainui. The people went into the pond, and with their hands, broke the limu (algae) loose, piling it up and twisting it under as it was gathered." The pond required 3 days to clean.

Men, women, and children, who as tenants owed their ali'i certain responsibilities, worked to clean the fishponds. Women are reported more frequently as the cleaners than are men; however, it is not known if this was a matter of reporting or if it was the practice. Bates (1854:115-16)

observed 5 or 6 women cleaning an old taro patch with the purpose of converting it into a fishpond.

Tenants of the land on which taro plot fishponds as well as taro plots occurred were required as holders of water rights to repair and maintain the dams and ditchs which provided water for their plots. Nakuina (1894:81-82) states that these tenants, when their turn came up, were required to go to the dam and see that it was in good condition as well as to follow the ditchs and remove all obstructions from them. If the tenant was unable to provide duty at the appointed time, he had to find a substitute to do his work or else the konohiki or the luna wai, the general foreman for any job concerning irrigation work, would withhold water from the plots.

Very little is documented on the clearing of predators from fishponds. The only references found are modern, one (Swenson 1967) for the removal of barracuda and eels from Kōli'i pond, C112, and another (Richard Paglinawan, Informant) for the dismantling of all umu shelters in which eels were found. Probably the predators were considered food and were harvested as such, thus the lack of detail on any concerted efforts to eradicate them as nuisances.

seen, then, how the gods were omnipresent, permeating every aspect of the heavens, the land, and the sea.

In aquaculture, the shark 'aumakua and mo'o were the most prevalent of the supernatural beings. According to Beckwith (1970:125), the arrival in the islands of the shark-spirits preceded that of the mo'o.

Shark 'Aumakua. A total of 54 shark 'aumakua are noted for the Hawaiian Islands: 2 for Kaua'i; 9 for O'ahu, 1 for Moloka'i; 4 for Kaui; 35 for Hawai'i; and 3 with no single island attachment (Cobb 1902:389-92; Beckwith 1917: 510-14; Sterling and Summers 1962, Bk. 5, Vol. 1:13). Each of these sharks was named and had certain areas to patrol.

Universally worshipped as a friend and as protector of the worshipper, each shark was identified through color or spotting and through sex, and each had a history and genealogy (Beckwith 1917:509; Cobb 1902:390). The shark 'aumakua also had a caretaker or human keeper, kahu, whose job was to feed the shark pig or fowl; to give it 'awa, a narcotic-like drink made from the roots of the kava shrub (Piper methysticum); and to generally care for its needs. In return, the shark protected its kahu and the families who worshipped it from any misfortune on both land and sea.

A stingy chief at Kualoa on O'ahu is recorded (Sterling and Summers 1962, Bk. 5, Vol. 1:13) as having been punished by his shark 'aumakua. The shark flooded the

land of the chief, destroyed a fishpond, and finally killed the chief.

Some fishponds had shark guardians living in or around the bodies of water. Normally, the abode of these 'aumakua were underwater caves and shelters. McAllister (1933:164) records that Huilua, C18, was inhabited by a shark guardian, while Beckwith (1917:514) reports that Uko'a, C149, was inhabited by two shark 'aumakua, Puhi-ula and Niukala. Hi'u is named by Soehren (1963:194) as being the shark 'aumakua of Wai'alohe fishpond, F25, at Keanae. Alekoko is the name given both the fishpond, B2, and its shark guardian (Kaiwi 1921:117).

Mo'o. The guardian spirits that were most directly connected with fishponds were the mo'o. These supernatural beings probably came from Tahiti, where they were the gods to the royal Oropa'a family (Beckwith 1970:128). They were also associated with the Pele family of demigods. Mo'o are described as having arrived in a great procession, distributing family members throughout the islands (Manu 1885a: 868). This would account for their wide dispersion.

On Kaua'i, Nomilu is the name of a fishpond, B18, as well as of its mo'o (BPBM Tape H-41Y5). Papalinahoa is the name of site B19, as well as of its mo'o (BPBM Tape H-62D).

McAllister (1933:133,157,1P6) notes the mo'o for three ponds on O'ahu: Kamaoha of Luakini, C97, and

geomorphology, i.e., the lack of large, reef protected, shallow shoals. Eventually, the general evolutionary trend in the Hawaiian Islands was to utilize practically all available bodies of water for the culture of fish and other sea-life.

Economic Role

Place of Fish in the Hawaiian Diet

All foods in the Hawaiian society were divided into those from the land and those from the water, either fresh or salt. The ethnosemantics of the Hawaiian language reflect the importance placed on edible fish: 11 anatomical name parts; 4 or more terms for the stages of growth; and 118 indigenous names for 57 scientific family names. This is only a partial enumeration of names and terms, as documented by Titcomb (1952:52-54). Many more exist, but were intentionally not included in Titcomb's work.

Culturally, fish was the main source of protein in the Hawaiian diet. Pig, dog, fowl, and birds provided only sporadic and infrequent protein-intake for commoners (Titcomb 1952:1-3). Archaeological sites do not indicate any great reliance on either seafoods or land animals, as kitchen midden is absent. However, this absence probably reflects the custom of secretly disposing of the remains of meals, a cultural practice which grew out of the fear of

sorcery. Modern Hawaiians still highly value fish and consider certain ones as being prized and preferred foods.

Productivity of Fishponds

Yield of fish of the totality of aquacultural sites would help to determine the economic role of the entire system. Unfortunately, only data for fishponds is available, making it impossible to examine the economic productivity of all types. Practically no figures on yield exist in pre-1900 references, as sources refer only very generally to pond productivity and potential. Only Cobb (1902) took exact care in 1901 in his documentation of the yield of Hawaiian fishponds, and so his figures are used here to approximate prehistoric yield.

A tally was taken of all fishponds for which documented acreage is available (Table 7 and Appendix B). Out of a total of 360 ponds, acreage was found for 304 fishponds on 7 Hawaiian Islands. Total acreage came to 5,608.48 acres, or an average of 18.44 acres per fishpond.

Table 8 shows Cobb's figures on the 1900 fishpond yields of several kinds of fish for Kaua'i, O'ahu, Moloka'i, and Hawai'i (Cobb 1902:431-43). The mullet, 'ama-'ama, and tenpounder, awa, are singled out here for study, as these are the only fish for which Cobb gives statistics for all ponds noted. Too, these were the preferred fish of the Hawaiians and must have shown the greatest yield

B25B Nameless Pond, Waioli
Type IV; 0.12 acres
Land belonged to Opi'o since 1840

O'ahu Island (C)

C1 Ahua, Moanalua
Type Ib; 45 acres
Wall 1500'L

C2 Amana (Loko-Amana or Loko-A-Mano), South Halawa, Pearl Harbor
Type Ib; 1.0+ acres

C3 Ananoho, Kalihi
Type Ia2; 46 acres
Coral walls 4700'L x 6'W x 3'H

C4 Apala (Loko Apala), Waiawa, Pearl Harbor
Type Ia1; 7.6 acres
Wall 225'L

C5 Apili, Kalihi
Type Ia2; 28 acres
Wall 1500'L

C6 Au'iki, Kalihi
Type Ia2; 12 acres
Wall 900'L

C7 'Awa'awaloa, Moanalua
Type Ib1; 8.8 acres
Coral wall 900'L; 2 makahā

C8 Ea (Loko-ea), Waialua
Type II1 2.48 acres
1 makaha

C9 Eo (Loko eo), Waipi'o, Pearl Harbor
Type Ib; 137 acres
Coral wall 2040'L x 6'W x 4'H; 6 makahā

C10 Nameless Pond, Halawa, Pearl Harbor
Type unknown; 5 acres

C11 Halehou (Halekou), Mōkapu, Kane'ohe
Type Ia2; 92 acres
Wall 1600'L

P17 Nameless Pond, Ma'ahi, Paeahu
Type unknown; Acreage unknown

P18 Nameless Pond, Makena
Type Ia; Acreage unknown

P19 Mau'oni, Kahului
Type III; Acreage unknown
Partially built by Kapiiohookalani; Completed by Kamehamehanui; Kihapiilani built kuapa between pond and Kanaha pond

P20 Mokuhinia, Lahaina
Type III; 11.4 acres
Mo'o named Kihawahine

P21 Paniaka, Paniaka
Type II; 1 acre

P22A Paukukalo I, Waihe'e
Type II; Acreage unknown
Mo'o named Kihawahine

P22B Paukukalo II, Waihe'e
Type II; Acreage unknown
Mo'o named Kihawahine

P23 Pu'uolu, Pauwalu
Type IV; 1.5 acres

P24 Waiakama, Lua'ehu
Type IIIb; 1 acre
Mo'o named Kihawahine

P25 Waialohe, Ke'anae
Type unknown; Acreage unknown
Shark 'aumakua named Hi'u

P26 Waihonu, Hana
Type II; 0.21 acre

Stream - Waihonu 3 miles toward Kipahulu

P27 Waikoloa, Hana
Type unknown; Acreage unknown
Builder named Ku'ulakai; Mo'o named Kihawahine

P28 Waiohuli-kai, Kalepolepo
Type Ia; 30+ acres

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