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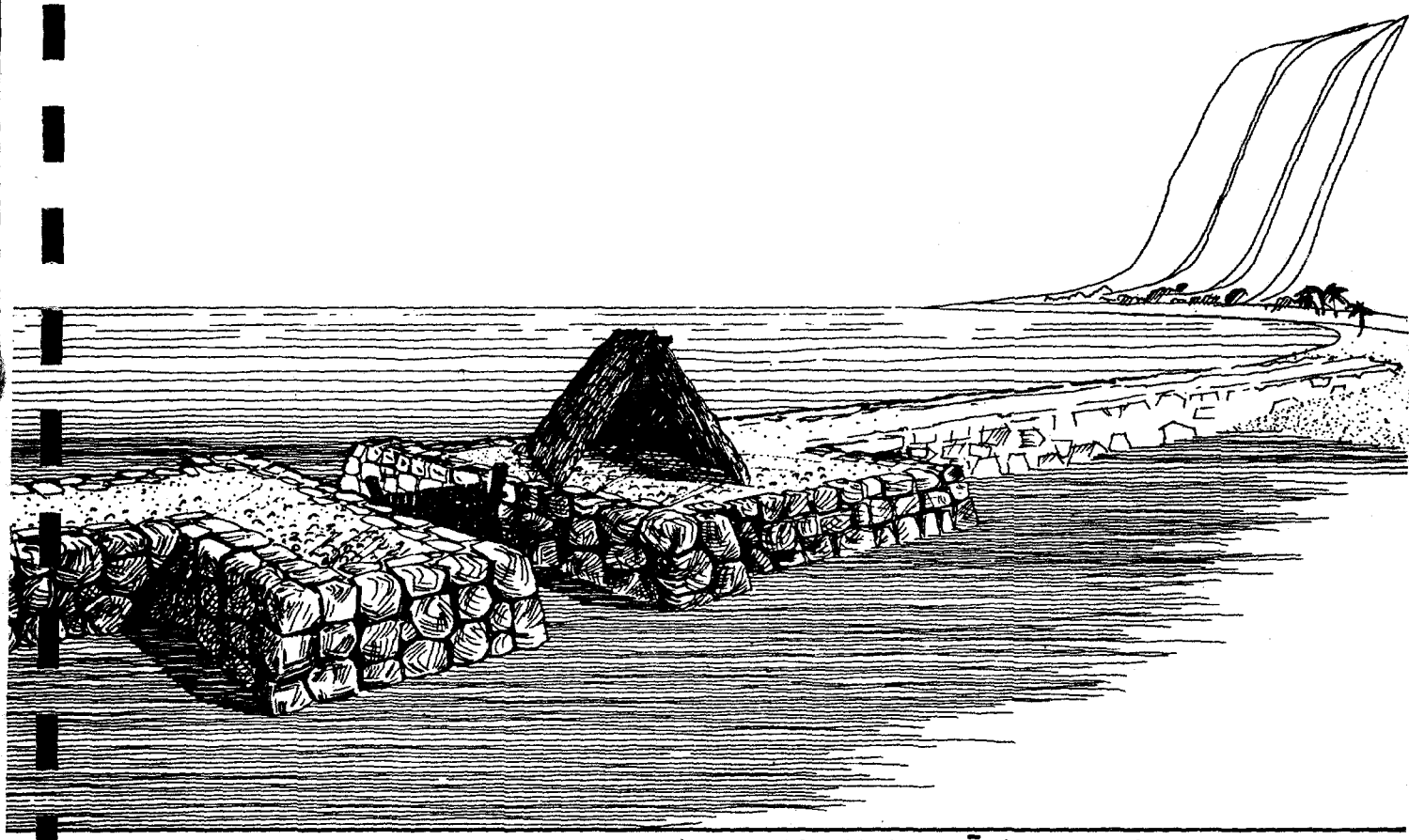

CONJECTURAL KUAPĀ (circa 1800)

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ANCIENT HAWAII SHORE ZONE FISHPONDS:

AN EVALUATION OF SURVIVORS

FOR

HISTORICAL PRESERVATION

by

Russell Anderson Apple

and

William Kenji Kikuchi

July 1975

Office of the State Director
National Park Service
United States Department of the Interior

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INTRODUCTION

Aquaculture refers to the cultivation of aquatic life forms to serve the food needs of man. In a broad sense, aquaculture includes the harvest of marine animals, fish and vegetable forms in the sea, along the shore and in bodies of water in the interior of land. In a stricter sense, aquaculture entails the holding and raising of aquatic foods.

Practically every culture in the world has practiced aquaculture in some degree. Ancient Egyptians, Mesopotamians and Assyrians stocked artificial ponds with fish; Greeks and Romans raised oysters, and Romans raised eels. Early Germans bred freshwater fish in ponds. Carp culture spread from Asia Minor and by A.D. 700 was established in Europe. Taiwan, India, Pakistan and Thailand walled off large tidal and estuarine areas for fish culture. Japan raised oysters and seaweeds. Large yields in aquaculture came from the Philippines and Indonesia. New Guineans trapped fish in baskets; Australians in stone weirs. Traps were prevalent in Melanesia and Micronesia. Polynesians in the Tuamoto, Society, Austral, Cook, and Samoan Island groups, in New Zealand and in the Polynesian Outliers entrapped fish by various methods and a few areas had ponds. It should be noted that the trapping or catching of fish and marine life forms which mature under free natural conditions is not true aquaculture.

Hawai'i had intense true aquaculture. As far as is known, fishponds existed nowhere else in the Pacific in types and

numbers as in prehistoric Hawai'i. Only in the Hawaiian Islands was there an intensive effort to utilize practically every body of water, from the seashore to the upland forests, as a source of food, either agriculturally or aquaculturally. Fish, crustaceans, shellfish, and seaweed were some of the products of the totally indigenous aquacultual system. Ancient Hawai'i's broad aquatic food production system included traps, dams, weirs and other structures designed to catch mature fish as well as structures and practices of true aquaculture.

Hawaiian aquacultural structures were found throughout the islands and included numerous man-made and natural enclosures of water in which fish and other products were raised and harvested. By the end of the 18th century, more than 300 fishponds were conspicuously owned by the high chiefs. Accessibility to these ponds and their products was limited to the elite minority of the native population -- the chiefs and priests. Prehistoric ponds and pond products appear to have been taboo to the vast majority of Hawaiians and to have yielded them no direct benefit. However, indirect public benefit came from ownership by the chiefs of exclusive food sources. Royal fishponds and their terrestrial equivalents, the royal gardens (Kō'ele), insured less demand on the commoners' food production resources. Every fish taken from a royal fishpond left its counterpart in natural habitat available to lesser chiefs and commoners. Ownership of one or more fishponds was one of the ultimate, high-status symbols in the status-conscious Hawaiian culture.

Prehistoric fishtraps, on the other hand, apparently were not as important economically since they were less reliable sources of protein. Fishtrap harvest was dependent on the tides, and fishtraps appear to have been of less religious and political significance than fishponds. This is evidenced by the accessibility of fishtraps to commoners as well as to women. While fishtraps were not included in this study they are artifacts of the overall aquacultural practices ca. 1800. Several fishtraps, nonetheless, are identified in Appendix B as having retained high structural integrity. Moloka'i and Lana'i Islands had massive fishtraps as well as fishponds.

The purpose of this study is to identify for public and private interests those surviving Hawaiian fishpond remnants worthy of preservation as part of the cultural heritage of the State of Hawai'i and the United States of America. Highest value is given in this study to those surviving remains judged to have deviated least from their conditions when in operation, i.e. about 1800.

Criteria for this study were developed and evaluation conducted without consideration for any other values the pond remnants might have, such as their biological or landscape features, their use as refuges for endangered species or in modern scientific aquacultural programs, and their potential for research in non-Hawaiian style fish farming. Judgement on these and other non-archeological, non-historical values should be made by specialists in the appropriate subject fields.

Numerous studies have been carried out on separate fishponds in the Hawaiian Islands, but it was not until 1964 that the first attempt was made to synthesize the piecemeal information. The resultant publication, Hawaiian Fishponds, by Catherine C. Summers, is a general and useful description of these structures. In 1973, Hawaiian Aquacultural System was completed by William Kikuchi as his doctoral dissertation at the University of Arizona; among the problems therein addressed are when and where the system developed, how it operated, and its function in the prehistoric Hawaiian culture. To cover the subject, Kikuchi included in his study fishtraps, weirs, fish shelters and dams, as well as fishponds. Among other things, Kikuchi's dissertation provided a long needed inventory of all known aquacultural sites in Hawai'i. The sites were typed, coded and mapped. It is Kikuchi's type code and pond numbers that have been followed in this study. Documentation, discussion, amplification and additional interpretation of the material in this introduction and in Chapter I of this study can be found in Kikuchi (1973).

Kikuchi's sources for his inventory included field work on Kaua'i, O'ahu and Hawai'i Islands, but were primarily found in archival and library facilities. Early in 1974, an aerial survey of the coasts of Ni'ihau, Kaua'i, O'ahu, Moloka'i, Lana'i, Maui and Hawai'i Islands was made by Apple to locate and photograph obvious surviving fishponds. This field survey was made by helicopter through the cooperation of the 14th Coast Guard District, U. S. Coast Guard, U. S. Department of Transportation.

That district's Search and Rescue Branch, Operations Division, coordinated the flights with missions of aircraft from the Barbers Point Coast Guard Air Station.

Fishponds in the resultant aerial photographs were then identified from the Kikuchi maps and through reference to the latest topographical quadrangle maps compiled by the U. S. Geological Survey, U. S. Department of the Interior, and/or tax maps of the State of Hawai'i. On site inspections were made by Apple and/or Kikuchi and detailed photographs were made. Aerial and ground inspections provided the physical data used in the evaluation.

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Frontispiece and Plates by Robert D. Chamberland

CHAPTER I

HAWAII FISHPONDS CA. 1800

In prehistoric times, Hawaiian aquaculture encompassed the seven major islands -- Ni'ihau, Kaua'i, O'ahu, Moloka'i, Lana'i, Maui and Hawai'i. In addition to being widespread, Hawaiian prehistoric aquaculture's distinctive and unique feature was the sluice grate (makahā) with its associated sluice. Stationary and with no moveable parts, the sluice grate was the technological innovation which probably allowed the prehistoric Hawaiians to progress from tide-dependent fishtraps to artificial fishponds which could be controlled at all times of the tide.

Hawai'i's total food production system was based on water in any form available from seacoast to upland forests. Water as rain, as fog, ponded, flowing, extruded in seeps and springs, fresh, salt and brackish was used by the Hawaiians for agriculture and aquaculture. Fresh food, available in quantity at call was the goal of these systems. Only the ravages of war and natural disasters grossly interfered with ancient Hawai'i's sophisticated water-intensive production of food.

For the purpose of this background on ancient Hawaiian littoral zone (and some inland) fishponds, 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. (Kikuchi 1973: 7)

The central interest of this study is the larger fishponds, the most royal part of ancient Hawai'i's total food production system and the most structurally massive.

Types of Fishponds and Some Fishtraps

Loko is the general Hawaiian term for any type of pond and refers to a pool, pond, lake or other enclosed body of water. Hawaiians recognized five main general types of fishponds and fishtraps. These are: (I) loko kuapā; (II) loko pu'uone (or loko hakuone); (III) loko wai; (IV) loko i'a kalo (or loko lo'i kalo); and (V) loko 'ume'iki. The first three general types, and perhaps some of the larger and more productive of the fourth and fifth types, were royal, that is, owned by paramount chiefs.

Royal Types

The three royal types, with significant remnants extant in 1975, were owned exclusively by ruling chiefs and managed by their caretaker, the kia'i loko, and to perhaps some unknown extent by

the overseer of the adjacent land, the konohiki. Sub-classifications in Western style are found in the three-page Plate 1 and are schematically illustrated in Plate 2.

Type I: Loko Kuapā. This is a fishpond whose main characteristic is a seawall (kuapā, often shorted to pā) as its artificial enclosing feature and which in most cases contains at least one sluice grate (makahā).

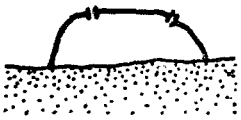
Type II: Loko Pu'uone. Also called loko haku'one, this is an isolated shore fishpond usually formed by the development of a barrier beach building a single, elongated sand ridge (pu'uone or haku'one) parallel to the coast.

Type III: Loko Wai. This is a fishpond located inland from the shore and whose main characteristic is that it is of fresh water.

I <u>Loko Kuapā</u>

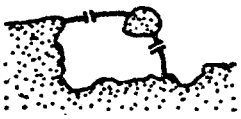
A fishpond of littoral water whose side or sides facing the sea consist of a stone or coral wall usually containing one or more sluice grates

Ia



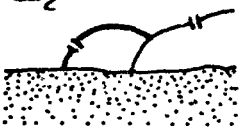
A <u>loko kuapā</u> whose wall is built from a point along a relatively straight shore to another point on the same shore, forming an arc

Ia_1



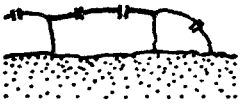
A <u>loko kuapā</u> built at a natural curvature of the shoreline utilizing an islet as part of the arc of the seawall

Ia_2



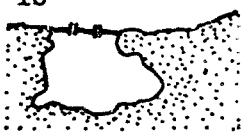
A <u>loko kuapā</u> which shares part of its wall with an adjoining pond

Ia_3



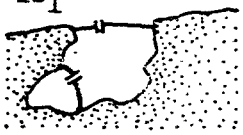
A <u>loko kuapā</u> built between two existing ponds utilizing the walls of both adjoining ponds as parts of its own wall

Ib



A <u>loko kuapā</u> whose wall completely closes the mouth of a bay

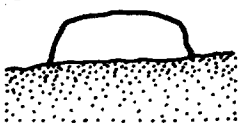
Ib_1



A <u>loko kuapā</u> within a type Ib pond formed through subdivision by a secondary wall

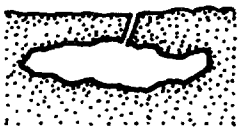
Plate 1 - Pg. 1 of 3. Typology of Royal Hawaiian Fishponds

Ic



A loko kuapā similar to a Ia or Ia_1 pond, but having no discernible sluice grate

II Loko Pu'uone Haku'one

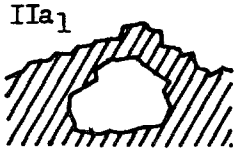


An isolated shore fishpond usually formed by the development of barrier beaches building a single, elongated sand ridge parallel to the coast and containing one or more ditches and sluice grates

IIa

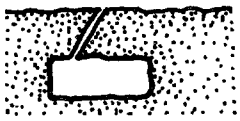
A loko pu'uone formed by a lava flow surrounding it and isolating it from the sea and having no ditches or sluice grates

IIa_1



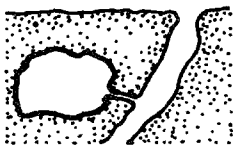
A loko pu'uone formed by a limestone or beachrock sink and having no ditches or sluice grates

IIb



A loko pu'uone which was entirely excavated by man, which is connected to the sea by a ditch, and which contains a sluice grate

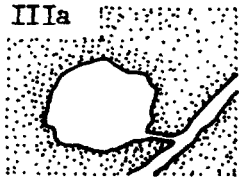
III Loko Wai



An inland fresh water fishpond which is usually either a natural lake or swamp, which can contain ditches connected to a river, stream, or the sea, and which can contain sluice grates

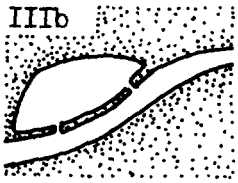
Plate 1 - Pg. 2 of 3. Typology of Royal Hawaiian Fishponds

IIIa



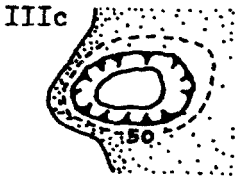
A loko wai whose shape has been altered by man

IIIb



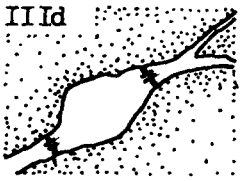
A man-altered loko wai which has a dirt and stone embankment-wall separating it from a river or stream and which has a sluice grate(s)

IIIc



A loko wai which is a volcanic crater

IIId



A loko wai which is formed by walling off a section of a river or stream and which has sluice grates at both ends

Plate 1 - Pg. 3 of 3. Typology of Royal Hawaiian Fishponds

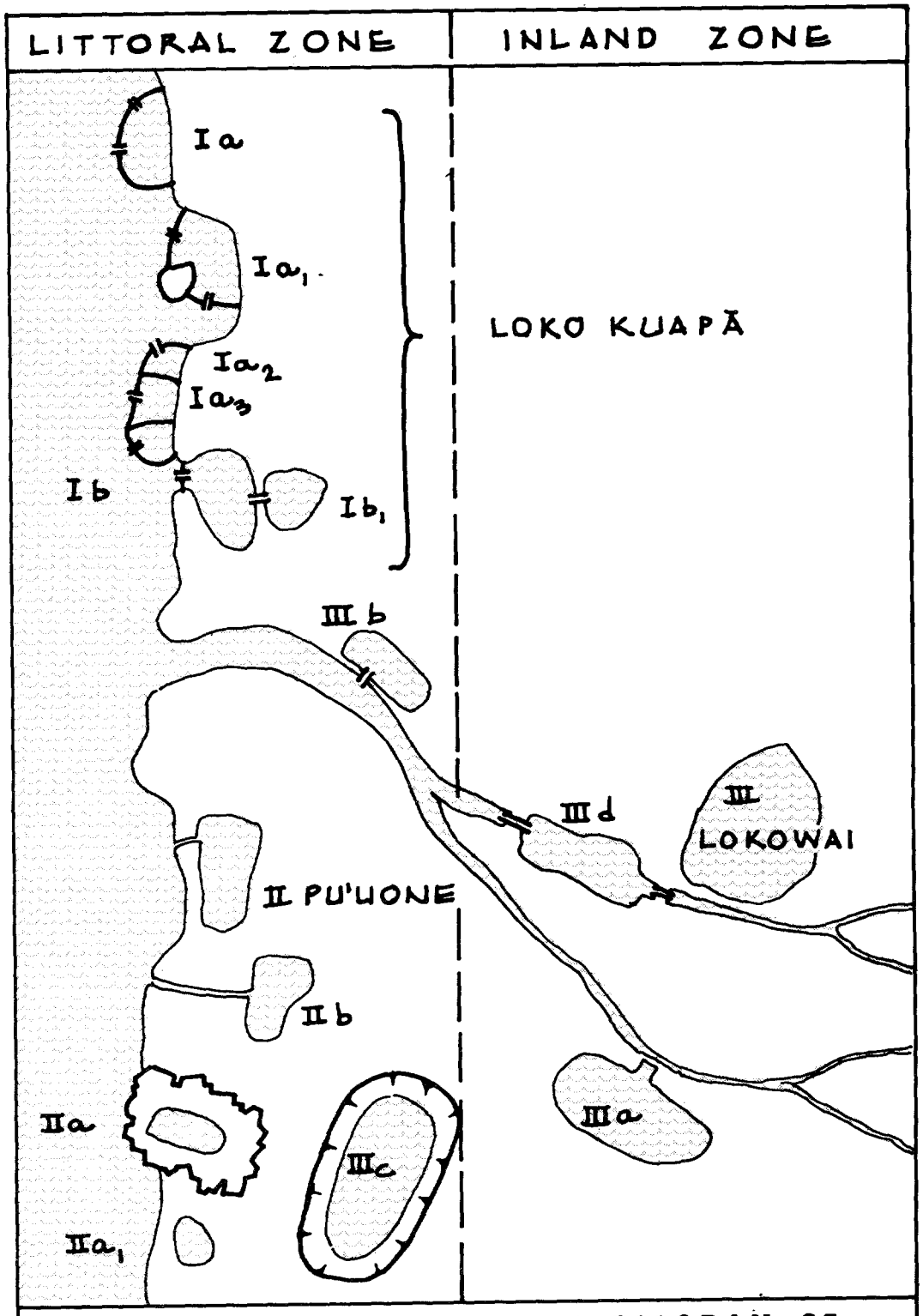


PLATE no. 2 SCHEMATIC DIAGRAM OF TYPES OF ROYAL HAWAIIAN FISHPONDS

Commoner or Commoner/Royal Types

Commoner aquacultural structures, while owned by ruling chiefs, can be considered to have been in the domain of the families, but always under the influence and in the shadow of the landlord chief and his resident manager, the konohiki. Commoners' rights to the harvest were never independent of the chief's.

Type IV: Loko i'a kalo. Also called loko lo'i kalo, this is a fishpond which utilized an irrigated taro plot. Fish were grown in the waters which flowed among earth mounds planted with taro corms. The pond could be owned exclusively by a high chief with products exclusively his.

Type V: Loko 'ume'iki. Similar in shape and construction to Type I loko kuapā, the loko 'ume'iki is a fishtrap characterized by the presence of numerous stone-flanked lanes which led fish into netting areas with the ebb and flow of the tide. In those loko 'ume'iki assigned to commoners, women were sometimes permitted to net. Several loko 'ume'iki with high structural integrity remaining in 1975 are identified in Appendix B.

Construction

Materials

All materials used in the fabrication of prehistoric fishponds came from local sources on each island. Not until the 1800's did foreign metal, cement, timber and cordage become accessible to supplement native materials.

Native materials used in the assembly of fishpond structures included stone, coral, lithified sand, alluvium, timber and vegetable materials. Shore and inland areas provided the non-organic materials, concentrated as a cooled lava flow, or dispersed as an eroded alluvial plain strewn with rocks and boulders. Timber and vegetable materials were generally obtained in the uplands, where rainfall and elevational coolness provided an ideal environment for the pristine forest.

Culture and political factors dictated the gathering and use of materials. All materials within any land division (moku, ahupua'a, or 'ili) /see glossary for definitions/ belonged to a high chief and were protected and managed by his on-site personal representative, in the case of the ahupua'a, the konohiki. Generally, construction in a land division utilized materials from that land unit. An exception might be when the chief also owned a nearby land area with more suitable or more abundant materials. Tapping of natural resources was culturally fixed and tied to the all-pervasive Hawaiian political-family etiquette patterns.

Rock. The Hawaiian word pohaku refers to all rocks regardless of genesis and applies to any rock, from very large multi-ton boulders, to tiny waterworn pebbles and detached pieces of coral. Decomposed rock, or earth (lepo) can be included in the continuum of rock types. Hawaiians distinguished in nomenclature among rocks of recent volcanism ('a'ā: clinker-type flow; pahoehoe: ropy, molasses-like lava) and the more predominate amorphous rocks of older geological areas, such as sedimentary, metamorphic and eroded igneous rocks (pohaku). Rocks of the 'a'ā and pahoehoe types are common on Hawai'i and Maui Islands, and fishpond walls on these islands commonly utilized such rocks. Slabs of pahoehoe were sometimes used as wall facing. Preferred materials on other islands for general construction of fishponds appears to have been eroded rocks without sharp angular shapes.

Calcareous Materials. Both living and dead reefs provided calcareous materials for fishpond wall construction. Dead branches and lumps of coral were collected from the shoals, beaches and shore for use as wall fill and to surface wall tops. Walls of three ponds in the Pearl Harbor area of O'ahu Island were constructed mainly of slabs of lithified beachrock, which forms the basic landform of that region. In the Kahuku area of O'ahu, three ponds utilized large sinkholes in lithified sand. One kind of living lime-secreting coralline alga (Porites spp.) may have been used intentionally by the Hawaiians in some ponds on Moloka'i Island as cementing agent in the walls.

Alluvium. Organic mud and muck dredged by hand or calabash from fishpond bottoms may have been dumped on top of some walls as part of the intermittant or periodic cleaning process. In some cases the accumulated mud/muck on top of 'a'ā walls formed a walking surface which protected bare feet from the sharp projections which are characteristic of that type of lava rock. Wall tops were also a convenient place to dispose of unwanted material. One pond with mudded 'a'ā walls is H28, a nameless pond at Ka'upulehu, in Kona, Hawai'i. A pond with kuapā of rounded boulders where dried mud/muck forms a walkway is B2, Alekoko, at Nawiliwili, Kaua'i.

Timber. Listed for use in the construction of sluice grates in royal fishponds are poles, posts and sticks of the types of wood that had strong connections with royalty, that is, they were considered to be sacred and were reserved for use in temple ceremonies and in the construction of temples and houses of high chiefs. Timber listed included the hard woods 'ōhi'a lehua (Metrosideros macropus) and lama (Diospyros), and one soft wood, 'ōhi'a 'ai (Eugenia malaccensis).

Vegetable Materials. Known cordage materials used for binding parts of sluice grates (makahā) include 'ie (Freycinetia arborea) and specially prepared stems of the hala (Pandanus odoratissimus). Likely materials for cordage used in sluice grate assembly include 'aha (coconut sennit) and hau (Hibiscus tiliaceus).

Features

Seawalls. Construction of fishpond sea (or river) walls, called kuapā and sometimes pā, appears to be similar to the mortarless walls found on land. Kuapā divide the sea (or river) from the inner pond waters and appear to be always massive and well built in contrast to secondary and tertiary walls found within the confines of a few ponds, especially some of those along the Kona coast of Hawai'i Island. Such secondary and tertiary walls appear to have been for segregation of fish, probably fry, to protect them from predators within the main area of the pond.

The widest and most massive (but not the longest) kuapā known is that of H24, Kaloko, in Kona, Hawai'i. This 750 foot (229 meters) long long wall rests directly on an ancient submerged pahoehoe flow. Kaloko's wall measures from 35 to 40 feet (about 11 meters) wide at its base, is 6.5 feet (less than 2 meters) high, and contains an estimated 150,000 cubic feet (4,248 cubic meters) of stacked rocks. Kikuchi (1973) studied the lengths of 90 fishpond walls and noted that lengths ran from 150 feet (46 meters) to 6,300 feet (1,920 meters), with the highest frequency of lengths being between 1,200 feet (366 meters) and 2,000 feet (610 meters). Kikuchi calculated that the average fishpond wall contained 33, 719 cubic feet (955 cubic meters) of stacked rocks and lithic and coralline fill. Where kuapā are in good condition, they are not submerged during high tides.

Water may approach the top of a fishpond wall, but it never passes over it under normal conditions. This would not apply to high seas or to tsunamis.

There are certain attributes of fishpond seawalls worthy of note. They are interstices, flanks and batter.

The basic exterior building blocks of Hawaiian mortarless masonry, on dry land or partly submerged, were unworked basalt or coral boulders or rocks. Smaller rocks and coral fragments, in any combination handy to the stonemason, filled the interior. An arbitrary distinction between exterior building blocks and fill material is size. A stone larger than one-half human head size might, if it had a proper facet, be used in the visible exterior surface, while smaller ones would be used, and hidded, as fill. Accumulation of interstitial gaps results in a structure greater in size than the sum of its apparent solid parts. A surface or cross-section of Hawaiian mortarless masonry contains much open space (frontispiece, Plate 3). The interstices make the wall permeable to permit the circulation of tidal water and currents into and out of pond interiors. Kikuchi's study of Kaloko's kuapā (H24) indicates that the interstices serve to reduce wave energy. Part of the tons of seawater is percolated into the pond and part is absorbed quickly and passed back into the sea.

Well-constructed wall flanks, or sides, last; poorly built ones deteriorate quickly. This is especially true of mortarless walls which are mostly submerged and subject to stress and assault from tidal, wave and current energy. While fills could be made by throwing rocks more or less hit-or-miss into the void formed by the growing flanks during initial construction or subsequent repair, and tops could be dressed and concealed by pebbles or mud, the flanks required journeyman skill in their assembly or repair. Well built flanks incorporate boulders and smaller rocks, interlocked to bond the mortarless structure into a free-standing unit. Prehistoric flanks are believed to have been one-stone thick. Doubled, or two-stone thick flanks, are believed to represent a masonry technique introduced by Western or Asian stonemasons.

One attribute of well-built flanks is that they lean in against the fill. The inward slopes of the two flanks of a free-standing wall make the base of the wall broader than its top. Even a well-built retaining wall, i.e., a wall built against a bank, has batter on its outer face, and a very good retaining wall also has it on its inner face. In independent studies both Apple and Kikuchi have noted that inclination differences exist between the pond and open-water flanks of fishpond walls. The seaward face appears to have more slope than the pond face. The function of the more inclined slope, or batter, of the seaward face appears to be to permit the seawall

to efficiently withstand wave energy and to absorb, per square foot, more energy than a more vertical batter (such as usually exists on the opposite face of the same wall where calmer pond waters lap). The combination of interstitial openings and batter of the seaward face of fishpond walls was a Hawaiian engineering device of merit.

Sluice grates. Sluice grates (makahā), with their associated sluices ('auwai o ka makahā), are the most distinctive and unique feature of the Hawaiian aquacultural system. The only other known sluice grate in Oceania existed in the Gilbert Islands of Micronesia.

In Hawai'i, the sluice grate was stationary, with no moveable parts (Plate 3). It should be noted that post-European sluices have slots on the sides which allow the grates or gates to be raised or lowered. Also a more recent innovation is a sluice with double moveable grates which permit the trapping of fish between the grates for netting at convenience.

As a technological innovation, the prehistoric Hawaiian fixed grate in the man-made sluice made its fishpond highly efficient. It allowed water to flow in and out, but retained the fish. The Hawaiian fixed grate provided a filter which aided controlled circulation. The makahā is the innovation which probably allowed the prehistoric Hawaiian to proceed from fish-traps (in which all lanes were open to the sea) and from enclosed ponds (with no controlled access to the sea or river) to

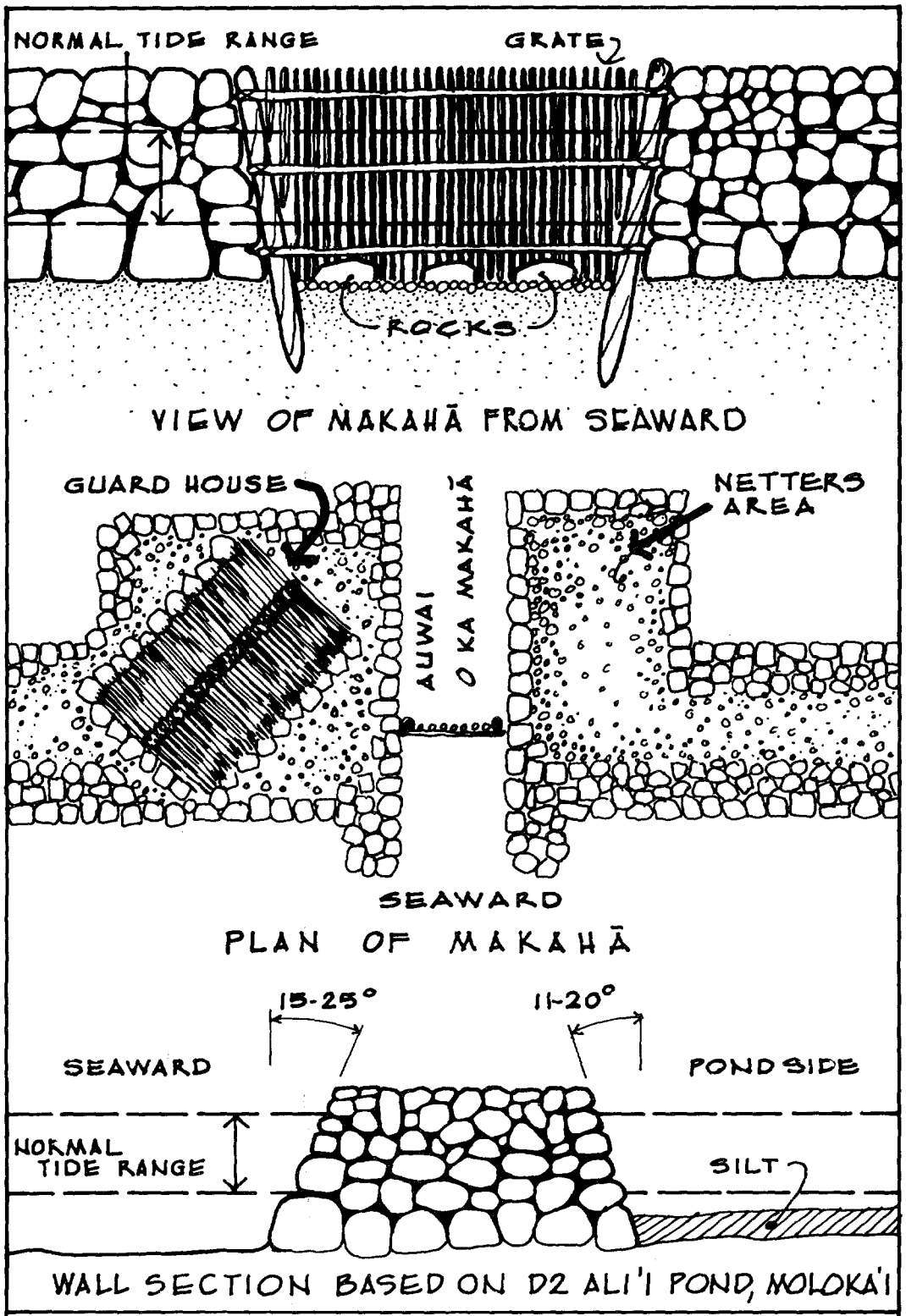


PLATE no. 3 SCHEMATIC OF POND FEATURES

artificial estuaries which could be controlled at all times of the tide. The original concept of the makahā may have been developed in the agricultural irrigated taro plots, where rudimentary sluice grates, of smaller scale were used to control the water flow.

Most makahā have sluices of various lengths which form runways as wide as the grates themselves. The sluices are called 'auwai o ka makahā, which can be translated as "ditch of the sluice grate." Masonry sluices in a kuapā can extend on either or both sides of a grate.

Sluices were simple excavated canals or ditches with a base and two walls. In some cases the sluices ('auwai or 'auwai-kai) were partly or completely lined with stone to forestall erosion of the bottom or side walls by water energy. Any makahā were installed in such stone walls, but they could also be fixed in place in earthen walls. The 'auwai carried water into a fishpond from an agricultural irrigational system, or directly from a river or spring, and some 'auwai could at times drain water. In lengths, 'auwai ranged from a few tens of feet to several miles. 'Auwai-kai were ditches which connected fishponds with the sea. Each sluice of whatever kind probably carried an individual name, but these have been lost.

Mature fish, ready for the harvest, congregate on the pond side of the sluice grate during incoming tide. Likewise, mature fish tend to congregate on the sea side of the sluice grate during outgoing tide. During harvest, there was an apparent

sorting of fish by size, and a modern operator (Uyemura, July 6, 1974) reports that fish do not come to the makahā until mature. The most common method of harvesting fish was the use of scoop nets on the pond side of makahā on the incoming tide.

For 69 ponds with makahā information, the number of makahā ranged from one to seven, with one and two the most frequent numbers. There have been ponds reported to be without sluices or grates, but it is also possible that in some of these cases prehistoric makahā may have been sealed by later construction or destroyed. There are no traditional standard locations for sluices or grates, but they were probably placed in each pond according to prevailing water-related energy patterns so as to provide flow into and draining out of the pond to effectively reduce silting and inhibit stagnation. Nutrients also entered ponds through the 'auwai o ka makahā.

Guard Houses. Guard houses (hale kia'i) are known to have been associated with seven fishponds, but they probably were associated with all Type I Loko Kuapā, Type II Loko Pu'uone, and Type III Loko Wai. Among the documented guard houses were those at C15 He'eia'uli, at He'eia, O'ahu; F3 Haneo'o, in Hana, Maui; and H24 Kaloko, in Kona, Hawai'i. A platform on which one may have stood is at H2 'Aiopi'o in Kona, Hawai'i. Hawaiian historian Samuel Kamakau wrote in 1869:

> On the nights when the tide was high every kia'i (keeper) slept by the makahā of which he had charge, and it was the kia'i loko (keeper of the pond) custom to build small hale kia'i from which to guard the fish from being stolen or from being killed by pigs and dogs . . . (Ke Au 'oko'a, Dec. 9, 1869; translated Hawaiian to English by Bernice Pauahi Bishop Museum)

Among the features which have not withstood the erosion of time and water are platforms which supported the guard houses. A conjectural plan and placement of such is shown in the frontispiece and Plate 3. It should be noted that guard houses were not the residence but the shelter of the keeper while he was on poaching patrol, and that women through 1819, and for probably decades later, were not permitted near a fishpond kuapā. An empty shelter by itself would deter poachers from a makahā. (Is a guard hidden within?)

Kikuchi noted an apparent but loose correlation between the number of guard houses and the number of makahā of a pond: there was one less house than sluice grates when sluice grate numbers exceeded two.

Assembly of Fishponds

Only 23 fishponds in the entire Hawaiian Island chain are documented as have been made by man. These include on Moloka'i: D34, Keawanui, at Kalaeloa; on Maui: F3, Haneo'o, in Hana; and on Hawai'i: H16, a nameless pond at Honu'apo, and H52, Ninole,

both in Ka'u, and H54, 'Opae'ula, at Makalawena in Kona. Of the other 312 or so ponds, many have their assemblies attributed in literature to the menehune, mythical, supernaturally endowed dwarfs. These builders were also credited with many other civil projects of antiquity. Menehune always completed their tasks in the course of one single night and always worked with rock as building material.

Whether built by man or menehune, the method attributed to the builders was similar. Builders stood in a line from the source of rock to the construction site and passed rocks of huge size along the human (or superhuman) chain. Rocks were said to be as light as feathers to the workers. Movement of the material was said to be swift and the rocks were accurately assembled at their destinations. Distances over which rocks were said to have been transported to fishpond sites often were more than a mile and sometimes over mountain ranges.

The massiveness of some of the ponds suggests that assembly was actually intensive and lengthy, as well as costly in terms of material, manpower, and any subsidy in feeding and housing. There is no documentation of the knowledge of, or use of, pulleys, rollers, or sleds to lift or transport heavy objects. Known means used were the rope, litter, digging stick and manhandling by male workers.

Size

The size, in acres, of any aquacultural site, as recorded on tax maps, aerial photographs, and in published sources, varies according to several factors: the year of the survey; the accuracy of the survey, the time of day the survey or photograph was made, the amount of silting since the last cleaning (which may have been up to a century or more); and the coastal changes that had occured since the pond was first built. Therefore, figures for acreage of fishponds vary considerably.

Unreliable data on 112 Type I Loko Kuapā were plotted on the same graph to determine an indication of the size range and distribution (Kikuchi 1973). The range was from less than an acre to almost 90 acres. Sixty-two of the Loko Kuapā were below ten acres; 42 were between ten and 40 acres; and seven between 40 and 90 acres. This does not indicate range and size distribution of Hawaiian Type I fishponds ca. 1800.

Likewise unreliable (as to ca. 1800 conditions) data on Type II Loko Pu'uone and Type III Loko Wai fishponds indicated that their sizes ranged almost continuously from 0.5 to more than 500 acres. This suggests that fishpond sizes were random.

Environmental Considerations

Compared to other Pacific Island groups, Hawaiian Island waters are poor in nutrients (plankton) on which larger forms feed.

The comparatively unproductive island waters did not affect the prehistoric Hawaiian aquaculture system. Each fishpond was an enclosed body of water, unique in its physical, chemical and biological attributes. Studies in recent historic times of various aspects of the physical and biological make up of fishponds, such as those by Hiatt (1947), MacKay (1947), Bennett (1962), Van Heukelem (1968), Malone (1968), and Kikuchi and Belshe (1971), cannot be presumed to reflect the conditions which existed in prehistoric times.

One cause of difficulty in attempts to study the prehistoric fishpond environment is the comparatively small number of ponds still in existence. Another cause centers around the vast physical changes that have taken place in the surviving ponds since prehistoric times. These changes were brought about by such causes as siltation; overgrowth; introduced marsh plants, grasses and trees; general disrepair; and extensive pollution. Prehistoric fishponds were constructed on a relatively mudless shoal and if possible on a sand base. The mud silt found along the windward coast of O'ahu Island, in the Pearl Harbor area of O'ahu and along the entire southern shore of Moloka'i Island is the result of post - 1900 erosion. This erosion was first initiated by extensive clearing of forests and grasses, and later by construction. Studies by Hiatt, MacKay, Van Heukelem and Malone were all conducted on ponds in these silted areas. Any information in these, and other modern studies, must not be viewed as representative of the pristine model of pre-European times.

Such information can be used, however, to hypothesize about the prehistoric pond environment. This hypothesis follows.

Physical Environment

Productivity potential of each royal fishpond is "a function of the nutrient materials (organic and inorganic salts) dissolved in it and available from other sources" and is not directly related to the size of the site (Bennett 1962: 38, 40). Each pond is an artificial habitat for aquatic life and forms a balanced ecosystem. While the data is incomplete, the known physical parameters are discussed below.

pH. Measured as a range from 1 to 10, the pH indicates the mineral composition of water. 1 to 6.5 is acid in salt content, 8 to 10 is alkali, and 7 is rated as neutral. The omnipresence of calcium carbonate in Hawaiian waters produces a generally alkaline reading in fishponds, with a predominance of 8.0 to 9.0 readings.

Temperature. Water temperature plays a critical role in the appetite, digestion, growth, movement and reproduction of fish and other aquatic life forms. Fluctations of water temperature occur both monthly throughout the year and hourly, being low in the morning and attaining a maximum during the afternoon hours. Fluctations are related to air and ground temperature, radiation

from the sun, and the circulation of water from outside sources into and out of the ponds. Measurements must be correlated to the month, day, hour, and location where the reading was taken. Hawaiian fishpond temperatures range from a low of 18°C (64.4°F) to a high of 31°C (87.8°F) with a mean of 24.7°C (76 ± °F).

Turbidity. Turbidity is defined as the grades of water transparency due to the lack, or presence, of foreign mineral or organic particles suspended in the water. It is measured by means of a photoelectric cell, and registered as the number of particles per million volume (ppm). High turbidity in fishponds may scale down the growth rates of fish. Turbidity is a factor in the growth rates of the plankton, phytoplankton and microbenthic life forms on which fish are dependent for food.

Oxygen. The dissolved oxygen content of water is "a complex result of photosynthetic and respiratory activities plus the influence of temperature and pressure" (Kikuchi and Belshe 1971: B18). Like water temperature, the oxygen content shows variations which reflect diurnal changes in light, air temperature and cloud cover. A total of 28 measurements in 18 fishponds showed a range of dissolved oxygen content is from 6 to 13 ppm, for a mean of 7.9 ppm and a mode of 7 ppm. The mean value indicated a high level of photosynthetic processes occuring within the fishponds.

Salinity. Salinity is defined as the amount of mineral salts dissolved in a given body of water. Variations were observed in fishponds; depending on the location, time of day, depths at which samples were taken, and on tidal fluctuations. Some of the levels of salinity of fishponds on Hawai'i Island were low enough to yield potable water. The salinity range was 2.0 to 32.4 percent. Differences were noted within individual ponds along land edges as compared with along seawalls. In many of the larger ponds, such as H1, 'Ainakapa'a, Honokohau II, in Kona, Hawai'i, and H41, Lahuipua'a, at Kalahuipua'a, in Kohala, Hawai'i, two layers of water were found: a top shallow layer of fresher water; and a bottom level of more saline water. Obviously, mechanical mixing of pond water is an on-going process.

Bottom Sediments. Found at the bottom of most fishponds is a layer of sediments. Organic muck and salt are its predominate materials. The layer is partly digested algal material that has been cycled at least once through the gut of fish or shrimp. The layer continues to decompose and change in color from dark green to dark grey or black. Intermixed in this layer of muck are particles of silt and calcareous sand delivered by wind and water action. It is this layer which, when too thick, was removed from royal fishponds (to accumulate again) by commoners and lesser chiefs as a public works project in prehistoric times. (Dredging is a modern method). This layer may repose on bedrock or on other deposited materials (which may also sometimes need removal).

The layer of sediments depletes the dissolved oxygen and produces hydrogen sulfide (H_2S). At H24 Kaloko fishpond, in Kona (Hawai'i), the oxygen of this level measured 25-33 percent (lower than at higher levels), with the H_2S measured from a low of 0.2 ppm to a high of 5.0 ppm. An excess of 3 ppm is considered injurious to young fish.

Note. Modern research aquaculturalists attempt to control, or selectively enhance or depress, the above physical elements. To do so, a completely enclosed container must be used, with control of all or selected elements which enter or leave. In Hawaiian fishponds operated Hawaiian style, these elements were largely uncontrolled and varied naturally.

Biological Environment

The food supply within the Hawaiian fishpond is almost solely dependent upon the physical features of the pond itself (see Hiatt 1947: 279). Fishponds can almost be considered estuarys. Estuarys are productive because of shallow water depth, the maximum radiation which reaches these depths, the circulation brought on by tidal flow, and the nutrients carried into the estuary by each tide. Estuarys are said to be 20 times as productive as an alfalfa field and twice as productive as a corn field (Marx 1967: 99-100). The generally shallow nature of most Hawaiian fishponds and the deposits of nutrients into

them by tide (and/or stream) permit their comparison to estuarys.

Food Chain. The chain begins with microbenthos that transform organic and inorganic detrius and nutrients into a form which can be used by phytoplankton, the next higher step. Phytoplankton is plant plankton and depends on sunlight for growth. The numerous benthic and floculent mats of green (or blue and green) filamentous algae found in Hawaiian fishponds in 1975 represents this layer, which thickens naturally over a period of time. Apparently, there is a range of optimum thickness, and if the algae became too thick when the ponds were in operation, it was thinned or eliminated by hand labor. Such disturbances may have resulted in a period of less yield of products.

The amount of sunlight which reaches various depths depends on turbidity, the translucency of the water. The proper amount of light promotes the growth of lower animal and plant life on which fish are dependent. Zooplankton (animal plankton) feed on phytoplankton (plant plankton). Zooplankton in turn is eaten by larger fish and crustaceans. The pond's food chain progresses upward until man consumes the fish, shellfish, crustaceans, and seaweed.

A food pyramid, with a base consisting of phytoplankton and a second layer of zooplankton, can be envisioned. Man is at the apex of the pyramid. In each process of transfer of energy upward, there is an energy loss of approximately 90 percent from

one level to the next higher level. That is, it takes 1,000 pounds of phytoplankton to produce 100 pounds of zooplankton, which in turn produces ten pounds of fish. A fishpond required a large nutrient supply of inorganic and organic nutrients to produce fish for the king's table. Plate 4.

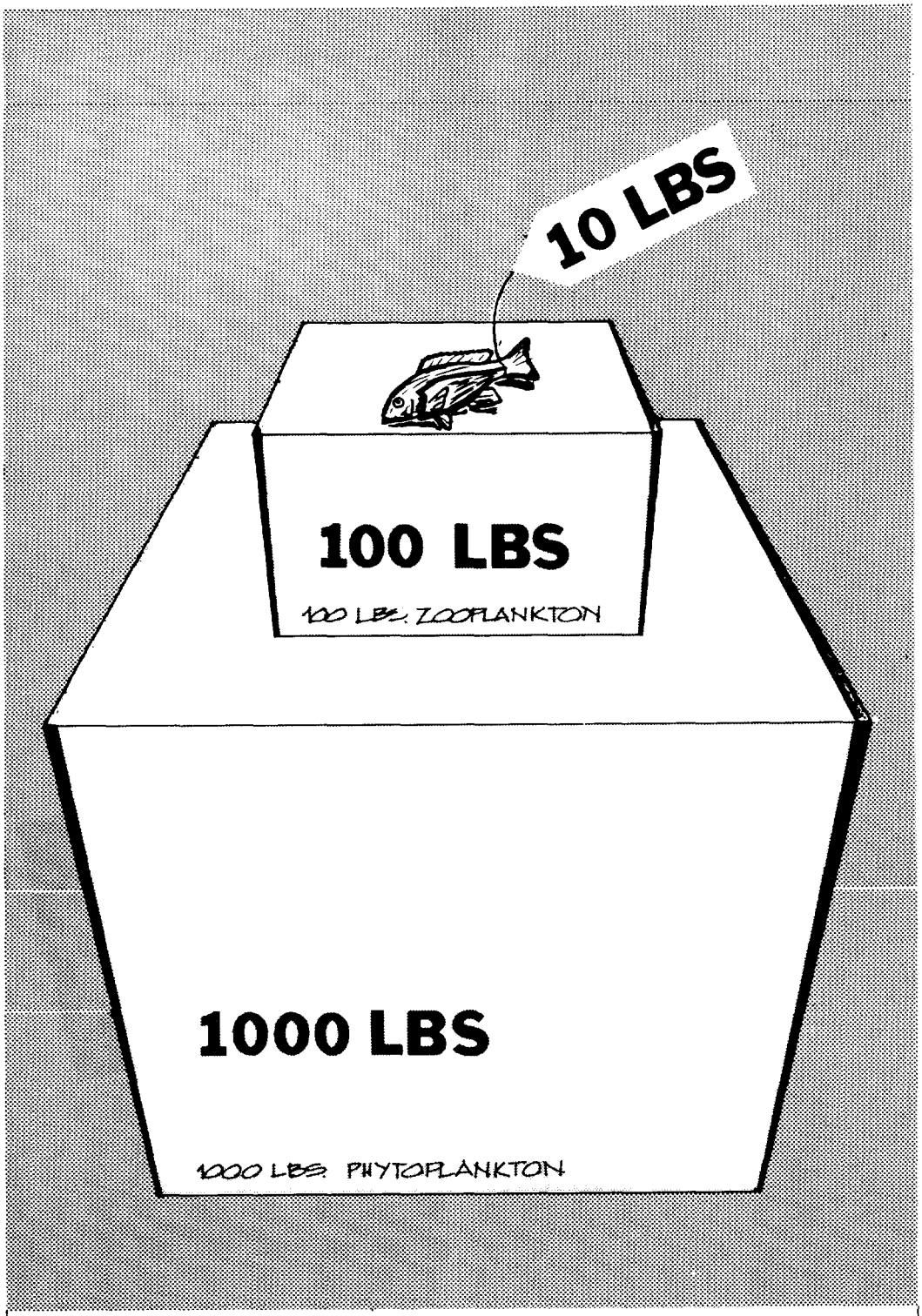


PLATE no.4 **FISHPOND FOOD CHAIN RELATIONSHIP**

Products. A wide range of foods were provided by the Hawaiian aquacultural system. In the case of royal fishponds, cultural preference controlled the harvest. The porous nature of makahā and seawalls allowed any type of aquatic life forms to penetrate a pond. Control of the kinds of products within a pond was almost impossible. Certain items were chosen as food over other items. One indication of cultural preference for some fish over others was the practice of seeking the fry of selected fish and transporting them into fishponds. Seaweed was also intentionally sought and transplanted in certain areas to provide beds for selective harvest. A listing of some of the principle food items harvested in royal fishponds follows. The first two fish listed were extremely sacred in Hawaiian culture (Pukui and Elbert 1957: 7, 341); numbers 2 through 8 were common in royal fishponds; numbers 1 and from 9 on were less common. Note that Hawaiian and modern scientific nomenclature do not always mesh.

1. Ulua: Also called jack, crevalle, crevally. Used ceremonially as substitute for human sacrifice when latter was not available. Adult is about five feet (152 cm) in length, weighs 100 pounds (45 kg) or more. Growth stages, from young to mature were termed by Hawaiians as pāpio or pāpiopio; pā'u'u; and ulua. Hawaiians gave further

qualifications to ulua. A whitish fish, probably Caranx ignobilis, was termed ulua-aukea. Dark or blackish ulua were termed ulua-'ele'ele (Caranx melampygus) and ulua-nuku-momi, if it had a pearly mouth. Ulua-pa'opa'o, Caranx speciosus, was green and yellow with vertical green bands and was considered best for eating raw. Other Hawaiian terms for this sacred fish included, with meanings if evident: ulua-kaha-uli (resembles an ahi fish in some manner); kihi, kihi-kihi, and huli-pu (resembles a small, brilliantly colored fish); ulua-lā-uli (probably a dark fin variety); ulua-mahai; ulua-uli.

2. Āhole: (Kuhlia sp. and/or Taeniure sandwichensis, etc.) Used by priests to disperse evil spirits and used ceremonially as substitute for pig sacrifice when latter not available. Termed āholehole when immature.

3. 'Ama'ama: Also called mullet, Mugil cephalus. A choice eating fish. Growth stages, from young to adult are: 'ama or

pua'ama, pua'ama'ama, pua po'ola and/or 'ola (up to finger length -- at some of these stages fry transported into pond to grow); kahala (hand length); 'ama'ama (about 8 inches -- 20 cm -- and harvestable); and 'anae (about one foot -- 30 cm -- long).

4. Awa: Also called milkfish, tenpounder, Chanos chanos. A choice eating fish. Not to be confused with 'awa, or kava (Piper methysticum), a shrub from which a ceremonial drink was made. Growth stages, from young to adult, are: puaawa and/or puawa (young); awa'aua (medium size); awa (harvest size); and awa-kalamoho (very large).

5. Kākū: Also called barracuda, Sphyraena barracuda. Other names are kūpala; and on Moloka'i Island: kua-pala.

6. Nehu: Also called anchovy, Anchoviella purpirea. Hawaiian qualifying terms included nehu-kūlani (of chiefly nature); nehu-maoli; nehu-pāki'i; and nehu-pala.

7. 'O'opu: Hawaiian generic name for fishes of the Eleotrudae and Gobiidae families. Some are in salt water near shore; others in fresh water; some may live in both.

8. Puhi: Hawaiian generic name for eel.

9. Kamanu: Also called amberfish, rainbow runner and sea salmon, Elagatis bipinnulatus.

10. Kāhala: Also called amberjack, Seriola spp. Obsolete Hawaiian names include Mokule'ia and moku-lei. Kāhala-'opio is name for young stage; kāhala-maloli and kāhala-amuka varient names for adult stage.

11. Kūmū: Also called goatfish, Upeneus porphyreus. Growth stages, from young to adult, are: kolokolopa (fingerling); ahuluhulu (hand length); kūmū a'e (medium size); kūmū (harvest size).

12. Kala: Also called surgeonfish, Teuthidae sp., Naso lituratus, Naso unicornis, Naso brevirostris. Hawaiian qualifiers are

kala-holo-ihu-loa (long nose running); kala-lemu (buttocks); and kala-li'ili'i (small).

13. Manini: The common adult reef surgeonfish, Acanthurus sandvicensis. Growth stages, from young to adult, are: ōhua-liko (earliest stage, transparent); ōhua kāni'o (next stage, striped); pala-pohāku (third stage, feed on alga of same name); kā-kala or maninini (half grown); manini (harvest size).

14. Palani: A surgeonfish with tough skin and strong odor, Acanthurus dussumieri.

15. Pualu or puwalu: A surgeonfish about 8 inches (20 cm) in length; similar to palani in skin and odor but having a blue line across soft part of its fin.

16. Uhu: The parrot fishes, especially Scarus perspicillatus. Hawaiian modifiers added as suffixes include a'a, āhiuhiu, 'ahu'ula, 'ula, 'ele'ele, halahala, kuwala-kai or pālukakuka, lā-uli, panoa, piko-'ula and uliuli. Growth stages, from young to adult, are:

'ohua (very young); pānuhu or pōnuhunuhu (medium stage); and uhu (harvest stage).

17. 'O'io: Also called bonefish, ladyfish, Albula vulpes. Growth stages, from young to adult, are: pua 'o'io (finger length); 'āmo'omo'o (forearm length); 'o'io (adult, 2 to 3 feet -- 61 to 91 cm -- long); and kuahauli (extra large).

18. 'Opae-huna: Any transparent shrimp, including Palaemonidea, Leander or Palaemonella families.

19. 'Opae-kākala: A spiked shrimp.

20. 'Alamihi: A common black crab, Metropograpsus messor.

21. Pāpa'i: Hawaiian generic name for crab.

22. Limu: Hawaiian generic term for edible seaweeds; especially limu-kala-wai (Spirogyra spp.); limu-īlio (Stigeoclonium amoenum); and hulu-īlio.

23. Miscellaneous:

Honu: Turtle. Often caught and kept in ponds.

Lepo-'ai-i'a: Edible mud; confined to fishpond C67, Kawainui, Kailua, O'ahu Island;

Shellfish, bivalves, mollusks; especially

Kupekala (Chama sp. ?)

Mahamoe (?)

Nahawele (Isognomonidae family)

'Owa'owaka (Isognomonidae family?) 'owaka

Papaua (Isognomonidae family)

Pipi (Pinctada galtsoffi or radiata)

Kūpe'e (Nerita polita)

Pipipi (Nerita picea and Nerita neglecta) picea

'Opihi (Helcioniscus sp.)

Yield

The actual prehistoric fishpond yield will probably never be known, as there are no records or indications of the number of the catch or of its weight. According to Kamakau (1869) "Fishponds were another means of prosperity to a land. A land was called rich according to the number of fishponds it contained." Richness in native ideology did not imply monetary wealth, but rather that the land was productive, and therefore, beneficial to the chiefs.

To compute a reasonable yield for the approximate 350 royal fishponds of Hawai'i ca. A.D. 1800, the average fishpond size was considered to be 15 acres, and the average annual yield per acre per annum was considered to be 350 pounds. With these basic figures, it appears that there might have been 5,025 acres of royal fishponds in 1800, with an annual yield of 1,758,750 pounds of edible fish. For each of the 365 days of the year, the average daily yield was computed to be 4,818 pounds per day. In round numbers, an estimated 5,000 people had available a pound of fish per person per day on the average. This computation ignors distribution of ponds and population. The estimated population of the Hawaiian Islands ca. 1800 was 266,000 (Schmitt 1968: 41). If the fishponds fed the entire population, each person would have averaged less than seven pounds of fish per year.

Owners and Managers

By at least the sixteenth century, the Hawaiian Islands had numerous families of high status individuals who ruled their separate domains by birthright, by geneological affinity to the major gods, and by the right of conquest. Everything on the land and in the sea in their domains belonged to these high chiefs. Since the high chiefs were the closest living relatives of the major gods, the right to conspicuous ownership was never challenged or denied them.

Since the chiefs were too sacred, too occupied with religious duties and political affairs, they did not have the time to personally supervise the affairs of state and the complex operations of the society. A bureaucracy developed. Among the managers were:

Konohiki. The konohiki was the resident and personal representative of the high chief, who was usually absent from his land in the company of the ruling chief. The landlord chief had temporary, perhaps lifetime, possession, use and control of the major land/water unit, the ahupua'a. The ahupua'a was ideally a pie-shaped section of land which extended from an apex inland out into the sea. Always a male, the konohiki was resident manager of the land/water unit and controlled its day to day operations as well as the distribution of its agricultural, aquacultural and hand crafted products. He managed and controlled all the land and water of his ahupua'a except for inholdings under the direct control of another high chief. The inholdings included royal fishponds and any 'ili kūpono, small land divisions within the ahupua'a boundaries, and which also might be ko'ele. A konohiki could be dismissed by his landlord chief, or he could be replaced with a new konohiki when and if his landlord chief died or lost his land through conquest or dispossession.

Haku-'ohana. This senior male was head and representative of a large, extended family of commoners. Each extended family

consisted of a community of homesteads, with all members related within a hierarchy of lineages. The haku-'ohana reported to and was responsible to the konohiki in charge of the ahupua'a in which he and his family resided. In contrast to the high chiefs in their landlordships and konohiki in their managerships, the haku-'ohana and his family identified with the land/water of an ahupua'a and remained there as part of the natural resources. Unlike contemporary European peasants, the family was free to leave if it felt unduly oppressed or overtaxed by a konohiki or his absentee landlord-chief.

Kia'i loko. The kia'i loko was the resident male keeper of a royal fishpond. The method of his appointment and his status in the Hawaiian society are not known. Evidently the kia'i loko was responsible directly to the high chief owner, but messages between him and his chief may have been relayed at times through the konohiki and distribution of fishpond harvest may at times have been coordinated also through the konohiki. Coordination between a kia'i loko and the konohiki would have been necessary for such operations as construction, repair and cleaning, since the konohiki controlled the laborers. Kia'i loko could eat openly of those kinds of fish harvested from the pond that were not reserved for his chief. Normal bureaucratic practices would indicate a head keeper and one or more assistants, perhaps one for each sluice grate. Part of the duties of the kia'i loko was to guard against poaching.

The larger, more productive loko kuapā (Type I), loko pu'uone (Type II) and loko wai (Type III) and perhaps some of the sizeable loko 'ume'iki, Type V fishtraps were under conspicuous ownership of a high chief and each pond was directly overseen by a resident kia'i loko. Since such pond types produced consistantly and in sufficient (to the Hawaiians) quantity throughout the year, they were highly prized and controlled for official use only Smaller fishtraps and small irrigated taro plot-ponds, were managed by the konohiki and haku-'ohana. These devices provided yields too small and erratic to be of great value economically and politically. Their main function was to provide variety in the local diet, especially to add protein. Thus, the smaller aquacultural devices were usually relegated to tenants for their primary benefit, but always under the stipulation (1) that a portion of the catch be ritually offered to the appropriate gods and (2) that a quantity be supplied to the konohiki. The konohiki used his portion to help maintain his own family and staff and, if feasible, passed a large part of it on to his chief on a gift-tax basis.

Operations

Stocking

Sieve-like sluice grates (makahā) and permeable seawalls (kuapā or pā) allow a wide range of sealife to enter fishponds, a

situation over which the prehistoric Hawaiians had no control. To increase and insure a supply of preferred fish, fingerlings of the desired kinds of fish were captured outside fishponds and transported over the walls into them.

Stocking was seasonal. Taboos prohibited the catching of fish during spawning. Netting was the method used to catch fry at specific locations where the desired kinds of fish congregated. Captured fish were probably transported in calabashes and perhaps bottle gourds and done in a swift manner to insure maximum survival. 'Ama'ama and awa were most frequently stocked. The lessee of fishpond C112 Moli'i, Kualoa, Ko'olaupoko, O'ahu, netted fingerlings in 1974 in Kane'ohe Bay from January through May.

Two types of nets were described as employed for the capture of fry for stocking. One was the simple, small scoop net, and the other the seine. Sinkers along the bases of seines, and floats along their tops kept the seines vertical. One seine type described had ½ inch (1.3 cm) mesh; another type had mesh of from one to two inches (2.5 to 5.0 cm). Seines were more than 300 feet (91 meters) long and nine feet (3 meters) wide. Seines of this size required canoes to assist in laying and in moving the nets to surround fish.

Fertilization

Fertilization was both natural and artificial. Hiatt (1974) described the general natural food resources in the estuary-like fishponds available to the aquatic population. Samuel M. Kamakau, one of the native Hawaiian informants of the 19th century, indicated that fresh water alone resulted in poor fish. He wrote that sea water added quality to the taste of pond fish, and quantity of growth.

Kia'i loko (royal fishpond keepers) fertilized artificially. For cultural reasons, the fertilizer was never offal or matter containing blood. No sewage was used. Known foods fed to fish were sweet potatoes, taro, breadfruit, mussels and seaweed which clung to stones. No details are known as to the preparation of the foods or any ceremonies involved.

Maintenance

Physical damage to walls, sluice grates and sluices, silting and overgrowth were constant occurances in Hawaiian fishponds. Maintenance was an intermittant if not constant need. Minor maintenance included such actions as replacing a few rocks that became dislodged; major maintenance included repairs after tsunamis and high seas, and the periodic de-silting.

A few ponds, especially on Moloka'i, were reported to be so sited and their makahā arranged so that tidal ebbing flushed out mud and silt. A kope'ohe (weighted bamboo rake) was towed behind

a small canoe in such ponds to stir and harrow bottom sediments at high tide so that natural flushing would carry the debris out the makahā. In these and other fishponds a natural action would be to scrape the underwater debris toward a existing makahā on receding tides. Some ponds displayed large mounds of accumulated muck and areas where surplus rocks were piled. When algae accumulated to the amount that nets could not reach the bottom of a pond, and fish could escape underneath the net, commoners were summoned to clean out the algae. Women were called to gather excess seaweed and dispose of it so that fish would benefit from new and presumably more beneficial growth. Women were reported more frequently in cleaning operations than men. It is not known if this was a matter of reporting the unusual or if this was common practice. Purification ceremonies were probably conducted for a pond after it had been worked on by women.

As in the case of assembly of new fishponds, massive repair must have involved large numbers of men to reassemble walls and sluices damaged by tsunamis and high seas, and/or to remove sand or silt deposited through unusual wave action. There were routine repair operations, which were probably handled by the loko kia'i and his staff and on occasion perhaps assisted by a few male commoners; and the unusual and massive rebuilding and/or excavation which followed a natural disaster or damage by an invasion force. At any rate, a konohiki is reported on several occasions and in dispersed ponds, as having used his authority to order the populace to clean royal fishponds.

Harvest

The term harvest implies a controlled effort to gather fish in large numbers in contrast to catching which implies a small scale extraction of fish, such as a loko kia'i might perform to supply his own table with authorized species. Harvesting by a kia'i would be to supply the landlord chief and his court.

In a sexual division of labor, generally, men fished by spear, hook-and-line, nets and by torches at night: and women and children used their hands to thrust for fish. Women also used certain types of baskets. Women specialized in collecting shellfish, seaweeds and small fish along shores and in rivers and streams. Men held the deeper waters and fishponds in their domain.

Netting was the most efficient, practical and principal method of harvesting fish from royal fishponds. Nets and canoes were prized possessions of the ali'i. Nets were well cared for, repaired as required, and stored when not in use. It was taboo for women and children to step over or even be near a net, least its power be defiled. Harvest nets were of two general types, long nets requiring many men to set up and smaller ones which could be operated by one individual. Usually the long nets (seines and gill types) were set up within a fishpond at designated locations and the fish driven into them. Driving involved frightening fish into flight, and the usual method employed was slapping the surface of the water by hands, sticks, branches and/or leaves. Some long nets may have been swept around fishponds to surround the fish.

Scoop nets were commonly used at sluice grates of fishponds by the kia'i loko when certain types of fish were to be harvested. Only a small number of fish could be ensnared, which made it an easy task to sort out the catch and to discard the unwanted fish. The preferred time to net fish seems to have been during the night or early morning hours and when the tide was high. Tide seems to have been the most influential force on fish within a pond, but daylight netting, even at high tide, resulted most commonly in lower yields for the long nets.

Conservation

The universe of the native Hawaiian can be viewed as having been a delicately balanced, tri-state system composed of the supernatural, the natural, and the cultural. Intertwined and integrated with one another, these three influences deeply affected every aspect of Hawaiian life, including royal fishponds, and could not be separated from one another without upsetting the entire system. Hawaiian culture demanded that the balance be maintained in order for the universe to function smoothly, efficiently, and abundantly.

Supernatural Orientation

The Hawaiians and everything in the universe were products of the gods. Everything was divided into two's based on sex.

The god Ku and goddess Hina considered to be the earliest gods in the islands, occur together as male and female representation. These two divided the universe into male and female, right and left, good and bad, morning and afternoon. Ku, in the form of Kū'ula-kai, produced the first fishpond and the first ko'a, a shrine for fish procreation and attraction. Hina, Ku's wife, was worshipped during afternoon hours for growth and production of fish. 'Ai'ai, their son, was another god of fishermen. Ko'a were of many sizes and types, the more elaborate had houses, some were surrounded by wooden fences and sheltered by banana trees, and some had altars, but their purpose, regardless of form, was the attraction of fish to the area. 'Aoa were major shrines associated with royal fishponds and had more formal ceremonies and offerings. Influences of the Waihau class of temple were more broad and were for fishing in general, perhaps for an entire district. Two rocks, one of which represented Kū'ula-kai and one which represented Hina, were often featured on ko'a, and perhaps in 'Aoa and Waihau class temples.

Significant in Hawaiian religion was the tremendous number of lesser gods and spirits. Among these were guardian spirits of some fishponds. Sharks were the guardian spirits of fishpond Huilua, C18, Kahana, O'ahu Island, and of Alekoko, B2, at Nawiliwili, Kaua'i Island. More frequent spirit guardians of fishponds are mo'o, supernatural lizards and always female, each described as from six to fifteen feet (almost 2 to almost 5 meters) long and black in color. A mo'o may sometimes manifest herself

as a woman combing her long black hair. The mo'o built nests within the waters, were given 'awa (Piper methysticum prepared as a drink), and were reportedly seen only on rare occasions. Mo'o are associated with fishponds Nomilu, B18, at Kalāheo, Kaua'i Island; either or both Loko-nui and Loko-iki, F3 and F3A, at Haneo'o, Hana, Maui Island; Kaloko, H24, at Kaloko, Kona, and Lokowaka, H45, at Keaukaha, Waiakea, Hilo, Hawai'i Island. Mo'o were associated with many other royal fishponds whose 1975 remnants are minor.

Whenever the wealth or spiritual health of a fishpond was adversely affected through a violation by a human of any of the prohibitions which surrounded the pond, a ceremonial appeasement was made. A pond could be spiritually contaminated by a woman during her menstrual period, neglect of propitiation by pond personnel, poaching by commoners, unauthorized catching of fish reserved to the chief, or other ways. The offerings and gifts listed for ceremonial appeasements included high-status items of black pig, white cock and 'awa and were delivered by a young child of either sex. Such children were believed to be ceremonially pure. It is unknown what rituals accompanied the construction of a royal fishpond.

Natural Forces

Native Hawaiians had to cope with the malevolent as well as the benevolent aspects of nature in order to maintain and

perpetuate the aquacultural system. Lava flows, earthquakes, landslides, faulting, tsunami, sea storms and flooding were beyond man's immediate control. These destructive acts of nature were attributed, as was practically everything, to some action by the gods, demigods and spirit-beings. Being both omnipotent and omnipresent, Hawaiian spirits commonly roamed in the guise of men and dwelt among mortals. The Hawaiians often viewed the destructive forces of nature as being balance-inducing acts, that is, punishment of man by the supernatural beings for some misdeed.

In historic times, lava flows from Mauna Loa and Kilauea volcanoes on Hawai'i Island and from Haleakala volcano on Maui have adversely affected, some to the point of complete elimination, 17 known fishponds. Earthquakes, landslides and faulting have adversely affected five known ponds, especially in the subsidence of the Puna and Ka'ū coasts of Hawai'i in 1868. The 85 known tsunami since 1813 have adversely affected 13 ponds; and sea storms and flooding -- nine royal fishponds. Natural disasters involving water moving downslope toward fishponds have had intensified adverse effect since 1850, the date by which upland areas were relatively denuded of sandalwood trees, producing unstable soil conditions. In modern times, bulldozing of large tracts of land has resulted in still heavier silt runoff. All of the fishponds and fishtraps along the entire south coast of Moloka'i Island have been affected by historic silting of the shore. Fishponds in Kane'ohe Bay and along the Ko'olau coast

of O'ahu Island have been similarly damaged. Much of the clearing inland in more recent historic times has been for cattle grazing.

Cultural Orientation

It was man within the framework of his culture who tended the fishponds and made them into viable economic subsystems upon which the political system relied. Fishponds were not operated for profit, nor were they intended for general public use. In order to insure the viability of aquaculture in all its forms in Hawaiian society by protecting the system from religious pollution and human harm, certain laws, prohibitions, and sanctions were set up and codified. Fishponds and fishtraps were considered to be part of the land. Prohibitions concerning the sea did not normally affect them, although some sanctions were considered universal.

The ultimate object of the general aquacultural probibitions was to allow fish to spawn and reproduce for five to six months a year. The paramount chiefs seemed quite aware of the importance of conserving resources. Various taboos concerning fishing and fish came on and off intermittantly throughout the year. Violation of the kapu was death. A branch of hau or a white flag placed along shorelines indicated the offshore waters were kapu. Fish that spawned in schools, that spawned in unsheltered places and those from the deep sea were specifically named as being prohibited at specified times. Certain fish were kapu at definite times of

the year, i.e. 'ama'ama (mullet), from November to March; 'ōpelu (mackerel) for the six months when 'ahi (tuna) was caught; and 'ahi for the six months when ōpelu was caught. When the kapu was lifted, commoners were allowed to fish (at least for a day or two), if they took care to follow certain rules. The ruling chiefs and royalty shared in the first day's catch.

If the kapu on 'ama'ama (mullet) lasted from November through March each year and this was the season for its reproduction, it is not known if the kia'i loko were excepted from this kapu to take fry for fishpond stocking, or if fry were excluded from the kapu, or if the end of the kapu was timed to permit the taking of fry while fry were plentiful. As noted previously, the lessee of fishpond C112, Moli'i, O'ahu Island, in 1974 netted fingerlings in Kane'ohe Bay from January through May.

Hawaiian mores and folkways of the 19th century -- some endure through 1975 -- probably are remnants of the extensive codified kapu of the pre-1800 fishing subculture. The purpose of the rules and regulations was to avoid pollution of the sea, fishponds, and fishing paraphenalia. Males refrained from taking along bananas and from talking about fishing and about fish immediately before and during fishing. Women, because of their menstrual period, faced more prohibitions than men. Females were never allowed to go near fishing equipment or a fishing canoe; to quarrel, fight, speak loudly, light a fire, or be unfaithful or flirt during the husband's absence while fishing; to touch a fish god image; to eat of the bait; or to fish in the deep sea.

As soon as a female reached menarche she became a strong polluting agent. Boys and girls were called 'ula-pa'a. Because of their preadolescent stage, the 'ula-pa'a were ritually pure, free of pollution, and chosen to carry the offerings to fish altars.

During their monthly period unmarried women were forbidden to walk on fishpond walls; married women were forbidden at all times. Consequences of such a trespass were that the fish would become thin, the women would suffer illness and eventually death. The priest in charge of a fishtrap where such a trespass occured would die if he did not appease the gods. Cultural prohibitions concerning women and fishpond walls probably affected most the females of the pondkeepers' families. Commoners, especially commoner women, were seldom in the vicinities of royal fishponds.

Certain types of fish were prohibited to members of one sex or of one social group. The basis of these kapu may have originated during the migrations to the Hawaiian Island group, or during the time of arrival of one of the gods. 'Ama'ama (mullet) were considered by the Hawaiians to be the "pig of the ocean" -- and could be ritually substituted for pig on altars when pig was not available -- was one of the types of fish to follow the major gods Kane and Kanaloa from Tahiti to Hawai'i. 'Ama'ama (mullet) was a choice and common fish raised in fishponds. Commoners were prohibited from eating mullet from fishponds, for such mullet could be consumed only by the ali'i.

Two other common pond fish were the 'awa and āhole. Both fish were used in offerings by the ali'i to Kane and Kanaloa,

two of the four major gods. There was mana, or spiritual power even in their names. When the high priest Pa'ao left Tahiti for Hawai'i ca. A.D. 1250, the 'ahi (tuna) helped propel his canoe against storm waves, while the 'ōpelu (mackerel) swam in front to break the waves with their bodies. The 'ahi and 'ōpelu were sacred fish. At least ten varieties of fish were kapu to women at all times. During pregnancy, women could not touch or eat any white-fleshed fish or fish salted by others.

No documentation has been discovered to indicate that individuals ever tore down fishpond or fishtrap walls for personal reasons. Under conditions of war, however, destruction was done to strike at the food resources of opponents. The agricultural and aquacultural wealth of Waipi'o Valley on Hawai'i Island and of the areas along the south shore of Moloka'i Island were continuous targets of ravaging armies. Economic harm was felt most strongly in these areas. After destruction, civil work projects were undertaken to restore the fishponds. 'Umi, ruling chief of Hawai'i Island in the 16th century, advised his colleague and protege Kiha-a-Pi'ilani of Maui Island to go to Moloka'i and restore the walls of the fishponds there. Kamehameha the Great, after unification of the islands ca. 1800 entered into three large projects to reconstruct damaged fishponds. These included fishponds F3 and F3A, Loko-nui and Loko-iki, Haneo'o, Hana, Maui Island, and H34, Kiholo, at Pu'uwa'awa'a, Kona, Hawai'i Island. Kiholo was later greatly reduced in size by the 1859 lava flow from Mauna Loa volcano. The 1946 tsunami put the two ponds at Haneo'o out of production.

An unusual fishpond privilege existed at fishpond H52, Hilo'e, at Ninole, Ka'ū, Hawai'i. Kauwā, the pariah caste of individuals, lived in the uplands of Ninole and were permitted to fish from Hilo'e and to obtain fresh/brackish water from one of the nearby springs. Evidently, this group of kuawā were extended these privileges in order to prevent them from ritually polluting fishing and water areas used by others.

Settlement Patterns

Found around some existing fishponds and fishtraps are a number of archeological features including stone alignments, stone walls, mounds, trails, terraces, platforms and enclosures. Near other fishponds, in districts and areas traditionally and historically classified as being settlements of nobility and as serving as court areas, any such archeological remains have been destroyed, leaving little or no evidence of the settlement patterns which once existed. These locations generally are the same locations which, because of their idyllic setting, are choice areas for tourist oriented development. The proximity of known features around certain fishponds and fishtraps suggest a relationship or association existed between fishponds and use of the areas around them by Hawaiians ca. 1800. Before discussing this relationship, a short review of some of current archeological thought, based on limited data, concerning settlement patterns in Hawai'i is offered.

There was no single pattern of settlement for the Hawaiian Islands. The patterns were complex and related to different environmental habitats. The two general types recognized are agglutinated and non-agglutinated. Relatively high population density, grouped community, clustered sites and clear boundaries between the cluster and sites outside the cluster are the characteristics of the agglutinated pattern. Agglutinated sites are subdivided into two groups based on the presence or absence of status residents, i.e., ali'i. It should be noted that agglutinated sites are found only along the shore and in coastal areas which have good spots for fishing, canoe anchorages, and beaching, and which are located in the idyllic setting of sand and surf. Ten agglutinated sites have been surveyed and detailed; nine are found on Hawai'i Island and one on Lana'i Island.

Non-agglutinated sites are the more common settlement pattern, with several groups. One group includes the occurrence of clusters of features within the general dispersion. Clusters may represent homesteads or very small hamlets. A second grouping includes zones of settlement which vary from the coast to the uplands and which are determined by and geared toward agricultural potential, i.e., rainfall and soil condition. In this group the dispersed archeological features and sites indicate permanent coastal sites, with temporary or seasonal use of upland or inland sites.

Valleys had another type of non-agglutinated settlement pattern. "Wet" valleys had permanent streams, and usually irrigation ditches and gravity-fed irrigated terraces and plots. But even "wet" valleys

had sides and areas that were "dry" with terraces to trap rainfall and moisture and utilize water runoffs down slopes, intermittent stream beds or talus areas. In valleys the limited data suggests that habitation sites were not constructed on good or potential agricultural land, but always on agriculturally unsuitable land. Some habitation sites were within fields on knolls or ridges, and others on the upper talus slopes of valley sides. One "wet" valley studied was Kahana on O'ahu. Fishpond C18, Huilua, lies on Kahana Bay and utilized the fresh water of the stream to mix within the pond with the salt water of the bay. A "dry" valley, such as Makaha on the leeward coast of O'ahu Island, utilized non-irrigated gardening and relied on rainfall and trapped soil moisture for the growing of cultigens. Evidently, whether "wet" or "dry," agriculturally good or potentially useable land in valleys was too valuable to be used for the construction of houses, pens, enclosures, graves and such structures.

The majority of aquacultural sites remaining today have been denuded of their surrounding archeological features and sites during the course of historical coastal development. Of those undenuded, the vicinities of 11 fishponds have been mapped and surveyed in detail. Based on this limited sampling, two ponds, H38, Kuki'o, and H54, 'Opae'ula, both in north Kona, Hawai'i Island, were selected as being representative of fishponds with the non-agglutinated pattern. Selected representatives of agglutinated pattern were H1, 'Aimakapa'a, H2, 'Aiopi'o and H24, Kaloko, all

also of north Kona. These represent the pattern related to individuals of high status. All three agglutinated ponds have a relative density of habitation features and the presence of temples and shrines. Also present were probably canoe and net sheds, which directly supported the activities connected with fishpond maintenance and harvest. Even the relative density of archeological features around these ponds do not indicate a very large population -- certainly not that which would have resulted had these fishponds been open for public use. There were few features near the ponds in the non-agglutinated sites. Of the two "wet" valley fishponds studied, C18, Huilua, and C144, Pukoko, both in Kahana, O'ahu Island, there was no indication that these fishponds had attractive powers for the concentration of prehistoric settlements.

The proposition throughout this study has been that the fishponds were the exclusive property of the ali'i and that the commoners did not normally profit from the presence of such fishponds. While the archeological sampling to date is too small to be truly conclusive, this evidence supports the proposition, derived from manuscript sources. It would be expected in prehistoric Hawai'i that an effort must have been made to discourage settlement around fishponds. The more neighbors, the more chance for poaching, religious pollution including that from womens' menstrual blood, and physical pollution from other human wastes.

Role of Fishponds

None of the courts which surrounded the several high chiefs established a permanent "capital" in the European sense until after the time of Captain James Cook's discovery of Hawai'i (1778 - 1779). Kamehameha the Great consolidated all of the island chiefdoms in the period between 1790 and 1810. Prior to 1812, his growing court became decreasingly mobile. During the mobile period, managers of royal fishponds administered them in the absence of the ali'i (high royalty). When a mobile court took up temporary residence within the transportation area of a royal fishpond, a fresh and sufficient supply of fish and other pond products was available on call. As chiefdoms were consolidated and as courts became less numerous and contained larger numbers of chiefs of various ranks, fishponds probably took on increased political and decreased economic roles in relation to the needs of the conquering royalty. Any fishponds in conquered chiefdoms became the personal property of the conquering high chief; whenever feasible, their harvest was used by the chief to help support him and his court. A number of royal fishponds along the north Kona coast of Hawai'i Island were within canoe or trail transportation range of Kamakahonu, at Kailua-Kona, Hawai'i Island, and could deliver fresh fish daily (Plate 10). These fishponds may have been among the reasons Kamehameha the Great chose Kamakahonu to be the "capital" (1812 - 1819) of the Kingdom of Hawai'i. He spent his last years there. Royal fishponds in other parts

of the islands probably supplied products to Kamehameha's appointed island governors and district chiefs on orders of Kamehameha, the king who owned all fishponds by right of conquest.

While royal fishponds probably produced a relatively low but dependable yield in terms of the total food needs of a royal establishment, ownership of them increasingly became a symbol of high status within Hawaiian society. Long before 1810, perhaps for centuries, conspicuous ownership of food sources in Hawai'i was a sign of a powerful chief.

With increasing Western acculturation, values came to be seen in terms of money, a concept which previously had been completely foreign to the Hawaiians. Fishponds and fishtraps experienced a steady decline in value in Western economic terms. But the value of fishponds as symbols of power through conspicuous ownership (and perhaps through long-term family ownership of them) remained at least through the mid-nineteenth century in Hawaiian thought. In the Great Mahele, which started in 1848 and which, among other things, imposed a Western-type land registration upon the traditional Hawaiian land ownership pattern, fishpond ownership and high status remained linked. In one study of the west coast of the Island of Hawai'i, along with the land units in which they were located, it was found that seven of the larger fishponds were awarded in the Great Mahele to members of the ruling Kamehameha line. The remaining ponds were awarded to others of the nobility.

Since 1800, there has been a steady decline of aquaculture throughout the islands. The reasons are mostly economic and technical and include population decline throughout the islands; movement of population from rural to urban areas; population decrease within reasonable transportation range of fishponds; change in eating habits; change from barter to cash economy; importation of more convenient or more inexpensive fish produce; diverting of streams for agricultural purposes; replacement of traditional taro agriculture by rice; high cost of transportation in remote areas; unavailability of ice for preservation of fish in remote areas; changing shoreline use; and commercial/resort development along shores.

CHAPTER II

PRESERVATION OF FISHPONDS

As stated in the Introduction, page 3, the purpose of this study is to identify for public and private interests those surviving Hawaiian fishpond remnants worthy of preservation as part of the cultural heritage of the State of Hawai'i and the United States of America.

In 1973, Kikuchi searched through available records and located 335 prehistoric royal Hawaiian fishponds, as well as 114 devices of other aquatic types. These he listed and plotted on maps.

Using Kikuchi's maps, Apple searched the coasts of all the major Hawaiian Islands by helicopter and physically identified the remains of 157 fishponds, as well as the remnants of several of the larger fishtraps. Apple and, in some cases, also Kikuchi then visited the 157 sites, approaching them from the air, the land, and/or the water.

At this point, 101 of the 157 surviving fishponds were eliminated from consideration since it was readily obvious that they did not possess sufficient integrity to merit preservation. Many were almost completely destroyed, while others were overwhelmingly altered. The remaining 56 ponds were evaluated in this study.

Criteria for Evaluation

The perimeters for evaluation are the "National Register Criteria," that is, the "criteria established by the Secretary of the Interior for use in evaluating and determining the eligibility of properties for listing in the National Register" of historic places. The Federal Register (Code of Federal Regulations, Chapter 36, part 800.10, Vol. 40. No. 24, February 4, 1975) recognizes that:

> the quality of significance in American history, architecture, archeology, and culture is present in districts, sites, buildings, structures, and objects of State and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association . . . .

The Register goes on to describe those sites qualifying for the National Register of Historic Places as being those:

> (A) that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (B) that are associated with the lives of persons significant in our past; or
>
> (C) that embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity

> whose components may lack individual distinction; or
>
> (D) that have yielded, or may be likely to yield, information important in prehistory of history . . . .

The 56 fishponds in question are all believed to have been associated with events in Hawai'i that made a significant contribution to the prehistory and history of the Islands and, therefore, to the United States of which they are a part (Criterion A). Some royal fishponds are associated with the lives of named persons significant in the past (Criterion B). All were associated with the ruling class, the ali'i, and were objects of conspicuous ownership, contributing products which were offered to the gods or eaten by the elite (Criterion B). The structures embody distinctive characteristics of a type, period, and method of construction (Criterion C). Each pond had a unique method of construction and design, utilizing a unique shoreline (or inland) feature and depending on a unique ecological habitat for its successful long-term operation (Criterion C). Individually and as a whole, the 56 surviving fishpond remnants represent true Hawaiian aquaculture, a major component of the prehistoric and protohistoric culture on all the major Hawaiian Islands (Criterion D). As archeological structures, some have yielded (and all are likely to yield) information important to Hawaiian prehistory and history (Criterion D).

Integrity of Sites

Integrity consists of the factors of location, design, setting, materials, workmanship, feeling and association. Each of the royal fishponds operating ca. 1800 is presumed to have possessed complete, or ideal, integrity at that time. Each of these ponds had a separate identity, which included an individual name (some of which have been lost), a royal owner or royal temporary landlord, a kia'i loko, location, history, a unique blend of physical and man-made features and operating conditions, and probably a reputation for yield and types of aquatic life-forms. The basic problem in this study concerns determining which royal fishpond remnants have retained the most integrity through to modern times.

To determine the integrity of the 56 fishpond remnants, conceptual isolation of three elements common to all ponds was made. The elements, basin, contents and setting, were rated individually for each pond on a scale from 0.1 to 1, the top of the scale. A rating of 1 would indicate the element to be identical to its ideal, or ca. 1800 condition. The higher the rating, the less work necessary to restore the element to its 1800 ideal. The total of the three ratings for each pond was considered to be a measure of that pond's integrity; the higher the rating, the less the drift over the years from its total integrity ca. 1800. Each pond was treated as a restoration project, and the magnitude of restoring each of the three conceptual

elements back to its presumed ideal was estimated. No individual pond restoration project should be based on this estimate, however, as no on-site measurements were made nor costs projected. Ponds were not compared with one another; rather, each pond was treated as an individual restoration project.

Basin

The basin is conceived as the irregularly shaped container which holds the contents and includes the natural and/or man-made connections to the pond's associated watertable, and/or ocean or river. Practical considerations usually limit the evaluation of the basin to its perimeter, since the greater part of the basin is often hidden by its contents. The visible perimeter includes any man-made walls and makahā, as well as the natural features utilized by the Hawaiian engineers. Each ideal, i.e., ca. 1800, perimeter was maintained by the kia'i loko through utilization of the materials and methods of work available at that time. Ideal perimeters did not contain walls with concrete mortar or makahā with metal bars. Upper surfaces of ideal perimeters were free of vegetation, since bushes could conceal poachers, and any grass was worn low by bare feet. As individual rocks in walls were dislodged, the keepers must have replaced them. Tsunami or high seas causing major damage occasioned public works projects which utilized those commoners on call by the absentee landlord-chief.

Percentages of perimeter relationships between natural and any man-made portions can vary from 100 percent natural (in those ponds which are inland of the shoreline) to 100 percent man-made (in those ponds which are seaward of a pond and utilize a portion of shoreward walls). Most ponds are a combination of natural and man-made features.

Realities of 1975 in some cases make it impractical to consider restoration of a perimeter to its ideal. For instance, several of the fishponds on the south coast of Moloka'i Island are believed to have had perimeters whose shoreward sides are now occupied by State Highway 45 and by utility lines, placed both above and below ground. For topographic reasons, the highway and utilities were placed in the only practical location between Kaunakakai, Moloka'i's principal community, and the ranches, resorts, houses and communities to the east. For evaluation in such situations, a compromise was made by selecting an alternate perimeter -- the largest practical perimeter possible in 1975. However, in most cases, the ideal perimeters proved to be fully restorable.

Contents

The contents of the basin include the quantity and quality of water; the microscopic and macroscopic aquatic flora and fauna; and the sediments, consolidated or in suspension. Ideal fishpond contents consisted of the optimal range of mixture for that pond

of sea and fresh water with nutrients -- the natural microscopic and macroscopic flora and fauna. The kia'i loko could also have added fertilizer. Any suspended sediments did not significantly interfere with yield or pond operations. Over time, of course, aquatic growth and sedimentation reached such proportions that pond yields were reduced and operations impeded. This point was the occasion for a public works project to remove excess growth and muck -- a periodic all-hands maintenance operation which restored the contents temporarily to their ideal condition.

Practical considerations usually limit the rating to the visible surface, since the greater part of the contents is below surface. If an alternate perimeter is necessary to rate a pond, the surface and cubic area of the contents are thereby reduced.

Setting

The setting is the pond's ecological habitat, including the associated ocean or river waters, the basal ground water, the air above the pond, and the surface of the associated watershed. Ideally, the setting of each pond supplied to the contents, among other things, its optimal mixture of sea and fresh water; nutrients; an acceptable (to the Hawaiians) rate of silting; and the young fishes which man transferred over the perimeter. Even migratory wildfowl became part of the setting by contributing nitrogen to the food chain of the contents through waste deposits. Any change

in the setting, either natural or man-induced, results in a change in the contents and/or rates of deposit.

The limits of the operating conditions were probably seldom exceeded in pre-European times, as the end result would have been a drastically reduced yield. Since 1800, human alteration of the land and introduction of exotic flora and fauna have changed some settings beyond their ability to support fishpond operations, Hawaiian style. On the other hand, restoration or maintenance of other settings may still be feasible.

Native vegetation has frequently been replaced by introduced plants and trees. Some of the introduced vegetation has thrived on land surfaces which in pre-European times were predominately barren. For some settings this has meant less surface drainage and siltation in 1975 than was the case in 1800. On the other hand, other introduced types of vegetation may have watershed charateristics similar to the native vegetation they replaced. Thus, the present vegetation surrounding a Hawaiian fishpond may be as beneficial to the contents and pond operations as in ca. 1800 or may be more or less so. The replacement of native vegetation by exotic vegetation does not necessarily lower the rating of a setting.

Three introduced trees, however, the mangrove, <u>haole koa</u> and <u>kiawe</u>, find favorable growing conditions in and around some fishpond remnants and their presence adversely affects the ratings. Rating depends on the extent of their invasion.

Mangrove. This tree, kukuna-o-ka-la in Hawaiian (Bruguieva sexangula and/or Rhizophora mangle), was introduced in Hawai'i ca. 1900. Its extensive roots thrive in brackish water, and its root system anchors sediments; its seeds float in salt water for distribution and sink in brackish water to plant themselves. The shade from mangrove probably inhibits photosynthesis of algae and larger flora in ponds. Mangrove roots may leach nutrients from pond waters. To restore a pond to operating condition, mangrove removal may involve cranes and underwater sawing. In removing mangrove roots grown into man-made pond walls, the walls would have to be wrecked and rebuilt.

Haole koa. Haole koa is also known as koa haole (Lucaena glauca) and is a shrub or tree introduced for cattle fodder. It can form thickets which impede human movement and obscure the terrain. It may be hand-cleared by unskilled labor with proper tools. A once-cleared area may reflush thickly, however, with hardy seedlings from seeds in the ground.

Kiawe. The algaroba trees (Prosopus sp.) was introduced to Hawai'i in 1828 and has spread rapidly since 1900. It is a tropical legume which thrives in and dominates coastal areas. Although the trees are prone to fall during wind storms, their prostrate trunks, nevertheless, continue to grow. Thorny kiawe thickets can impede human passage and block trade winds and views. The kiawe is a phreatophyte, i.e., it robs moisture from the soil. When growing near ponds or in their watersheds, the kiawe may eliminate or reduce the flow of any springs feeding the pond,

thus probably inhibiting the operation of the pond's food chain in contrast to its ideal.

Mechanical cutting and removal of large kiawe trees pose environmental problems. On-site slash-and-burning of logs can endanger adjacent properties, for kiawe roots are extensive and can transport fire underground, ignoring legal boundaries. Kiawe trunks and slash would have to be hauled to a safe area for burning, as natural disintegration of the dense wood is slow. A perhaps more desirable alternative would be to use the wood for fenceposts, in charcoal making, or as firewood. The cost of kiawe removal could be offset, in part, by sale of the wood.

The Rating Process

Apple and Kikuchi independently rated the basin, contents and setting of each of the 56 fishpond remnants considered for preservation. As stated previously, the three elements were rated for each pond on a scale of 0.1 to 1 on the basis of the amount of work necessary to restore the element to its ideal; the more work the closer the decimal rating was to 0. The final rating for each pond is the average of the two totals and expressed as a whole figure followed by two decimal points. A pond as ideal as its ca. 1800 counterpart would be rated 3.00 (there were none). A pond that had lost about half of its integrity would be rated about 1.50.

Rating of Kipapa Fishpond

To illustrate the process of rating, D36, Kipapa fishpond, located at Keonoku'ino, Moloka'i Island, was selected as the model. Kipapa was chosen since its remains as well as the contemporary condition of its basin, contents and setting can be identified on modern aerial photographs (Fig. 1). Data for the study of Kipapa was obtained in Summers' 1971 Molokai: A Site Survey (98); from aerial photographs taken 2/20/71 (Fig. 1) and 5/22/74; from four photographs taken by Apple from a boat on 7/29/74; a land inspection by Apple on 7/29/74; and from the USGS Kamalo, Hawai'i, 7.5 minute series topographic quadrangle map of 1968.

Kipapa Basin. It is believed that the ideal perimeter of Kipapa consisted of 44% natural shoreline and 56% man-made features (walls or kuapā). The natural part of the ideal perimeter was 100% soil and sand; the man-made portion was 100% dry (mortarless) masonry. In 1974, 100% of the natural perimeter was buried under fill; 20% of the ideal kuapā was buried under fill. Wall interstices were clogged with silt. About 80% of the length of the wall retained silt within the ideal pond area. Mangrove grew over the natural ideal perimeter, and their roots had invaded the kuapā. Highway 45 and utility lines twice crossed the natural ideal perimeter; therefore, an alternate natural perimeter to exclude these modern facilities had to be selected. Apple rated the basin .3, Kikuchi rated it .2.

Fig. 1 Aerial view of Kipapa pond, D36, Moloka'i

Kipapa Contents. The ideal contents would have been indicated by 100% open water within the basin. In 1974, the surface of the contents was estimated to be 85% solid and 15% open water. All of the solid surface appeared to have been the result of erosional deposits. Mangrove covered the deposits and was noted growing in the water area. Kiawe, too, was found on the pond surface near the land. About 85% of the surface of the contents needs vegetative clearing, and 15% needs minor clearing before dredging of the solid contents could begin. The open pond water had high turbidity and appeared to be shallow. There is some poaching of fish from the open water. Highway 45 and utilities crossed part of the ideal pond surface. Apple rated the contents .2 and Kikuchi rated them .1.

Kipapa Setting. In 1974, the adjacent ocean area contained dead reefs and its bottom was covered with sediment. This appeared to be carried by both clockwise and counterclockwise currents, with little coming from the land watershed. Water sources were judged to be both tidal and springs. The narrow adjacent shorelines were of sand and soil and had been invaded by mangrove and kiawe. The slopes behind Kipapa fishpond had gullies and were covered with light forest. Cattle and deer grazed in the hills behind the slopes. No surface development was evident. Apple rated the setting .7, and Kikuchi .8.

Kipapa's Total Rating. Apple's total for the three elements was 1.2 and Kikuchi's 1.1. The average and final rating is 1.15.

Kipapa received a rating which was neither the highest nor the lowest of the 56 fishponds recommended for preservation.

Fishponds Recommended for Preservation

The following 56 ponds, listed one to a page, are believed to possess in 1975 the necessary significance and integrity that would qualify them for nomination to the National Register of Historic Places. Work sheets, notes, photographs, sketches and maps used by the authors in rating the fishponds are retained at the office of the State Director, National Park Service, U. S. Department of the Interior, Honolulu, Hawai'i.

Ponds are listed in the order of their ratings, with the highest listed first. In cases where ponds received identical final ratings, the order follows islands from northwest to southeast, starting with Ni'ihau Island. Ponds which received less than 1.0 in their final ratings are listed last and their final ratings are not given. Ponds rated 1.05 and above are believed to be restorable and could be placed back as working fishponds, Hawaiian style, not considering cost. Since each pond was rated against its own ideal, caution is advised in assuming that a higher rated pond would be less costly to restore than a lower rated one. Among other things, sizes of the ponds were not included as a rating element. The tax key and ownership information is based on a 1975 study by the U. S. Army Corps of Engineers. Acreage estimates are unreliable.

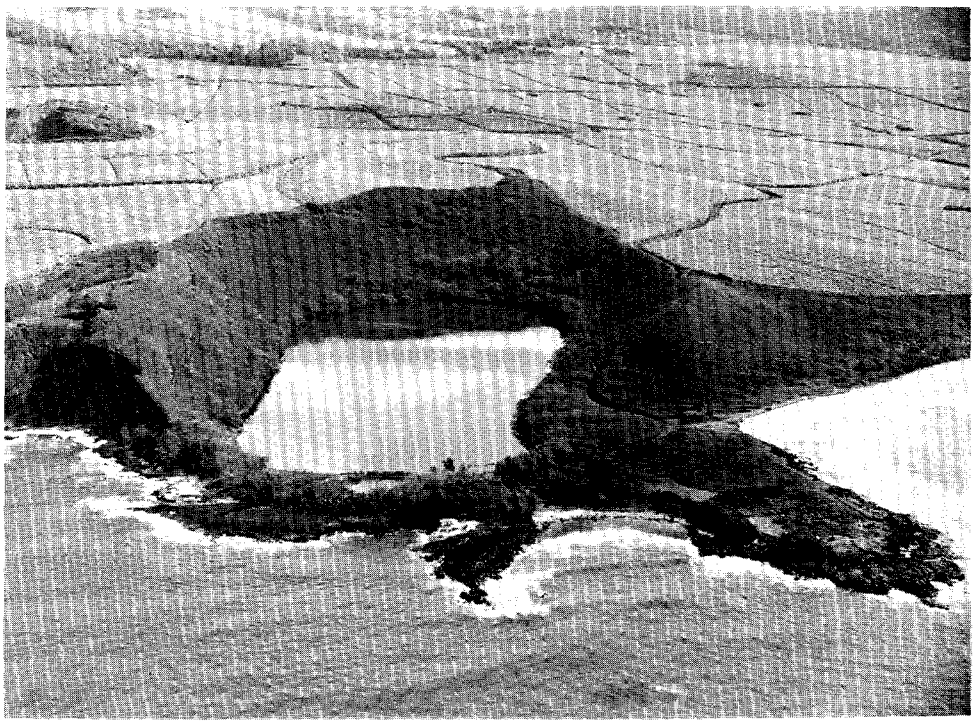


Fig. 2 Nomilu pond, May 15, 1974. Neg. # NPS - Kaua'i 1-22A.

B18 NOMILU, at Kalāheo-kai, Kaua'i
USGS Quad: Koloa
Tax Map Key: Portion of 2-3-10-2
Acreage 4 (?)
Ownership: Private

Type IIIc

The mo'o was named Nomilu.

Ratings:	Apple	Kikuchi	
Basin	.9	.7	
Contents	.9	.8	
Setting	.9	.9	
Total	2.7	2.4	Final Rating: 2.55

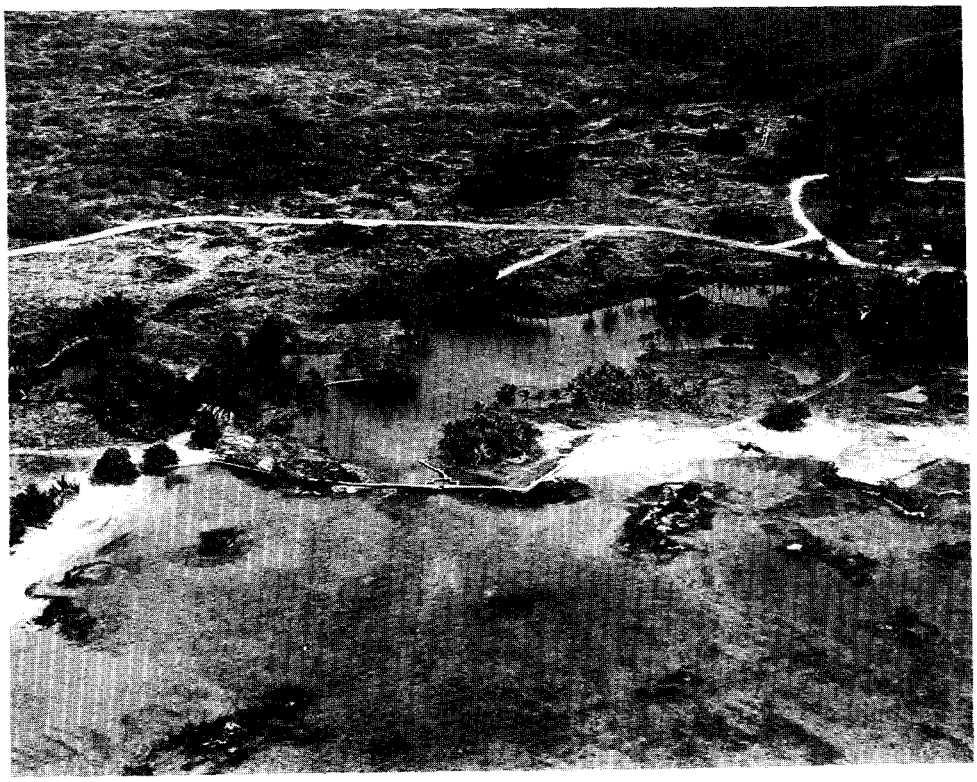


Fig. 3 Lahuipua'a and associated ponds, May 22, 1974.
Neg. # NPS - Hawai'i 4-34.

H41 LAHUIPUA'A, at Kalahuipua'a, Kohala, Hawai'i.
USGS Quad: Pu'uhinai
Tax Map Key: Portion of 6-9-01-3
Acreage 10 (?)
Ownership: Private

Type Ib

Connected to and includes H17 Hopeaia; H20 Ka'aipio; H22 Kahinawao; H49 Manoku; and H70 Waipuhi; ponds maintained continuously and owned by ali'i through 1974.

Ratings:	Apple	Kikuchi	
Basin	.9	.7	
Contents	.9	.8	
Setting	.7	.9	
Total	2.5	2.4	Final Rating: 2.45

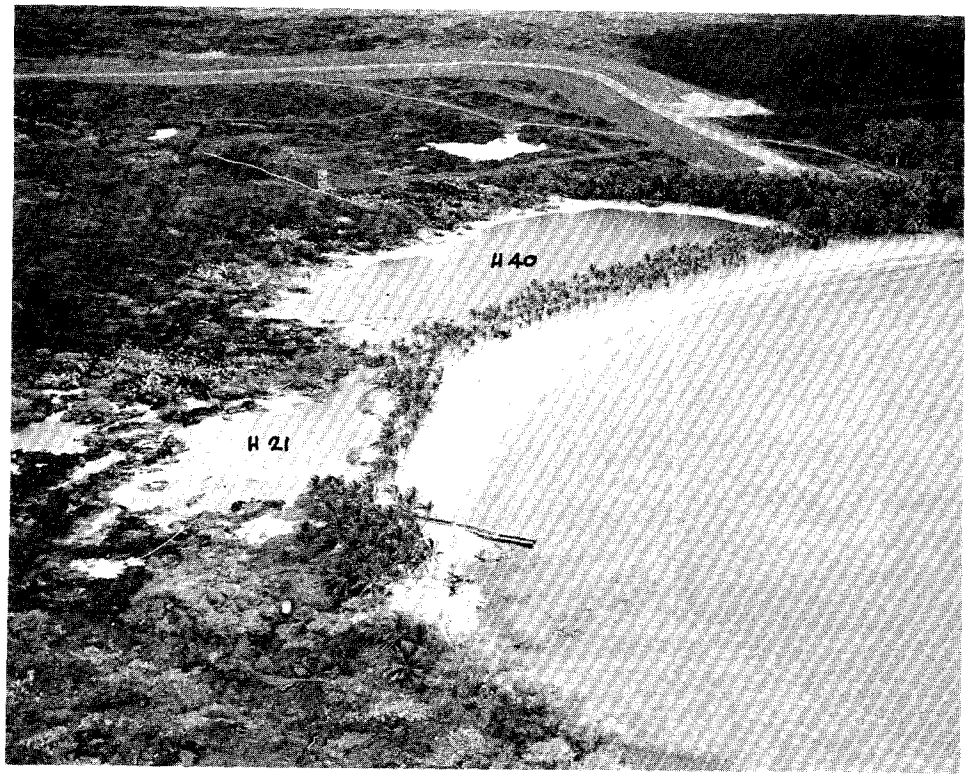


Fig. 4 Kahapapa and Ku'uali'i ponds, May 22, 1974. Neg. # NPS - Hawai'i 4-28. Note dredge in Ku'uali'i and mortared 'auwai-kai in Kahapapa.

H21 KAHAPAPA, at Anaeho'omalu, Kona, Hawai'i
USGS Quad: Anaeho'omalu
Tax Map Key: Portion of 6-9-07-16
Acreage 7 (?)
Ownership: Private

Type II

Connected to and includes H40 Ku'uali'i. Both ponds dredged in 1974.

Ratings:	Apple	Kikuchi
Basin	.9	.8
Contents	.9	.8
Setting	.6	.8
Total	2.4	2.4

Final Rating: 2.40

Fig. 5 'Aiopi'o pond, May 22, 1974. Neg. # NPS - Hawai'i 4-9.
Honokohau small boat harbor on right.

H2 'AIOPI'O, at Honokohau I, Kona, Hawai'i.
USGS Quad: Keahole pt.
Tax Map Key: 7-4-08-25
Acreage 2 (?)
Ownership: Private

Type Ia_1

Used as fishtrap in recent decades.

Ratings:	Apple	Kikuchi	
Basin	.7	.8	
Contents	.6	.7	
Setting	.8	.7	
Total	2.1	2.2	Final Rating: 2.15

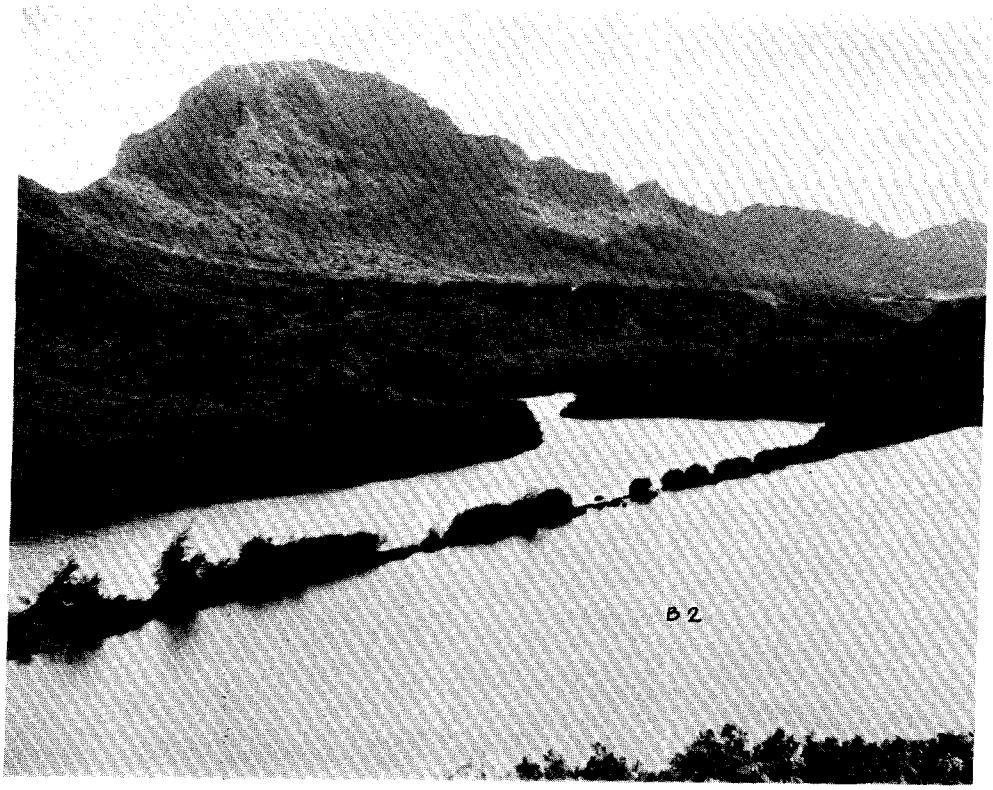


Fig. 6 Alekoko pond, June 20, 1974. Neg. # NPS - Kaua'i 7-13A.

B2 ALEKOKO, at Nawiliwili, Kaua'i.
USGS Quad: Lihue
Tax Map Key: Portion of 3-2-01-1
Acreage 32 (?)
Ownership: Private

Type IIIb

2 makahā; built by Menehune; Guardian was named Puhiula; shark 'aumakua named Alekoko.

ON NATIONAL REGISTER

Ratings:	Apple	Kikuchi	
Basin	.7	.6	
Contents	.7	.5	
Setting	.9	.8	
Total	2.3	1.9	Final Rating: 2.10

Fig. 7 Mortared 'auwai-kai at E2, March 5, 1974. Neg. # NPS - Lana'i 1-29.

E2 nameless, at Lopā, Kaohai, Lana'i
USGS Quad: Lana'i
Tax Map Key: 4-9-03-9
Acreage 1 (?)
Ownership: Private

Type II

Retaining wall was 217 feet long; 1 makahā; 'auwai-kai.

Ratings:	Apple	Kikuchi	
Basin	.8	.8	
Contents	.5	.4	
Setting	.9	.8	
Total	2.2	2.0	Final Rating: 2.10

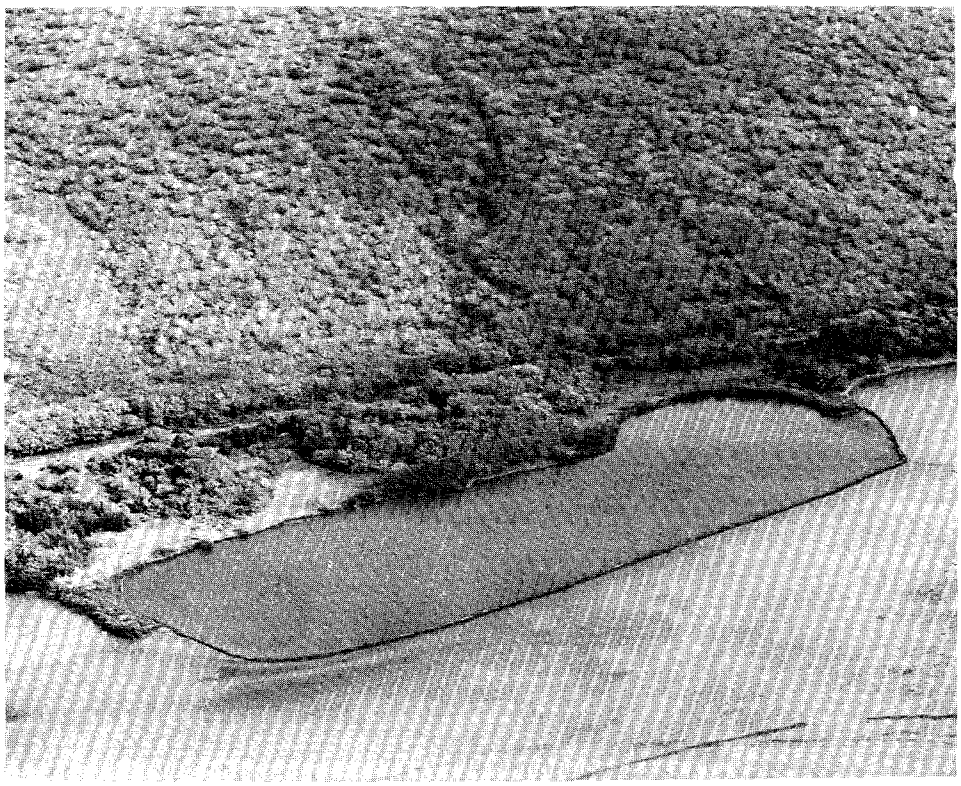


Fig. 8 Kaina'ohe pond, Feb. 20, 1971. Neg. # Photo by George Bacon #20, 2/20/71 - Pond 30.

D12 KAINA'OHE, at Ka'amola, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-6-05-22
Acreage 17 (?)
Ownership: Private

Type Ia_1

Kuapā core was of coral pieces, 1,770 feet long, 5 feet high; 2 makahā.

Ratings:	Apple	Kikuchi	
Basin	.7	.6	
Contents	.6	.6	
Setting	.8	.8	
Total	2.1	2.0	Final Rating: 2.05

Fig. 9 'Ualapu'e pond, May 22, 1974. Neg. # NPS - Moloka'i 0-12A.

D61 'UALAPU'E, at 'Ualapu'e, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-6-01-1
Acreage 22 (?)
Ownership: State of Hawai'i

Type Ia

Kuapā of coral and basalt fill, 1575 feet long; 8 to 19 feet wide, 4 feet high; 2 makahā.

Ratings:	Apple	Kikuchi	
Basin	.7	.6	
Contents	.6	.7	
Setting	.8	.7	
Total	2.1	2.0	Final Rating: 2.05

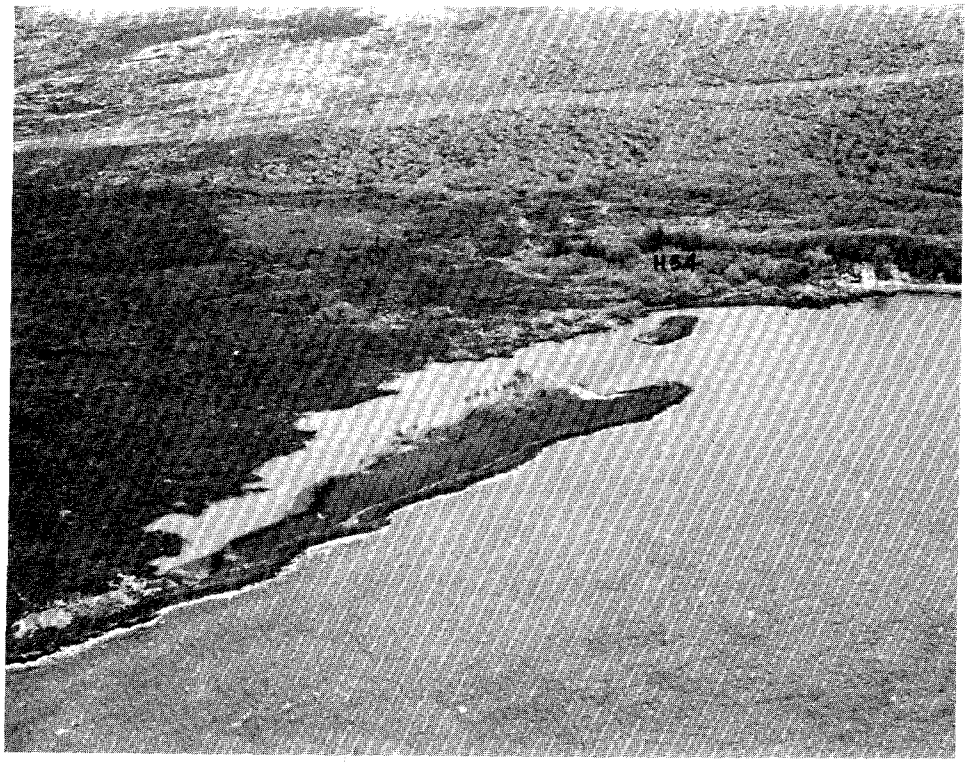


Fig. 10 Setting of "Kiholo" pond, May 22, 1975. Neg. # NPS - Hawai'i 4-20. Dark area on left is 1859 lava flow.

H34 "KIHOLO", at Pu'uwa'awa'a, Kona, Hawai'i
USGS Quad: Kiholo
Tax Map Key: 7-1-02-8
Acreage 3 (?)
Ownership: State of Hawai'i

Type II

Kuapā was 2640 feet long, 20 feet wide, 6 feet high; several makahā; built ca. A.D. 1812; mostly inundated by lava from A.D. 1859 flow from Mauna Loa.

Ratings:	Apple	Kikuchi	
Basin	.9	.6	
Contents	.6	.7	
Setting	.6	.7	
Total	2.1	2.0	Final Rating: 2.05

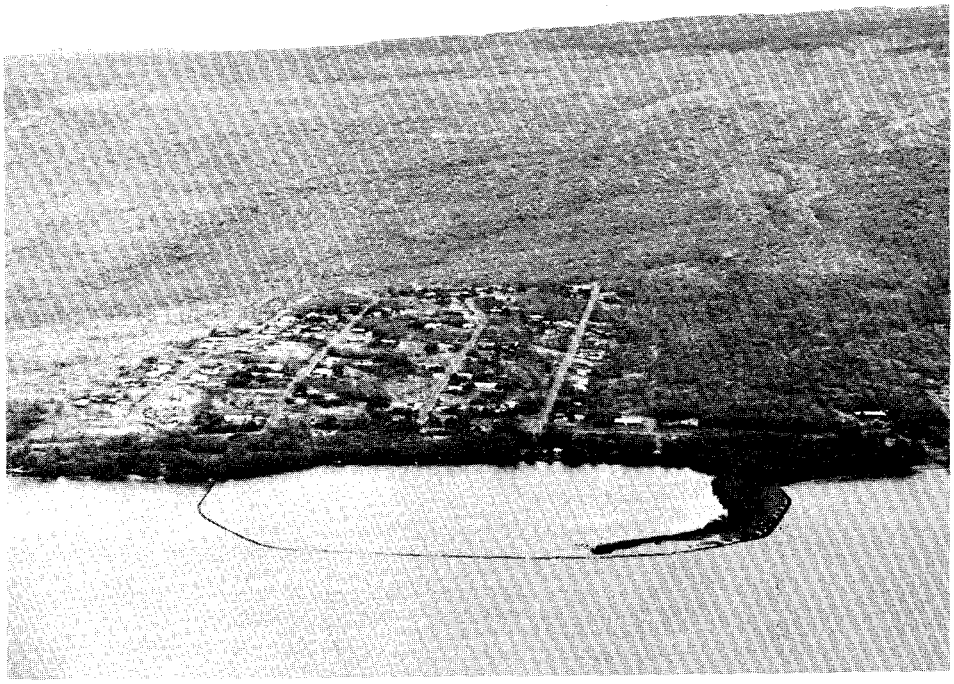


Fig. 11 Kaloko'eli pond, May 22, 1974. Neg. # NPS - Moloka'i 0-25A.

D15 KALOKO'ELI, at Kamiloloa, Moloka'i
USGS Quad: Kaunakakai
Tax Map Key: 5-4-02-14
Acreage 28 (?)
Ownership: State of Hawai'i

Type Ia

Kuapā was 2800 feet long; 2 makahā.

Ratings:	Apple	Kikuchi	
Basin	.7	.8	
Contents	.6	.5	
Setting	.7	.7	
Total	2.0	2.0	Final Rating: 2.00

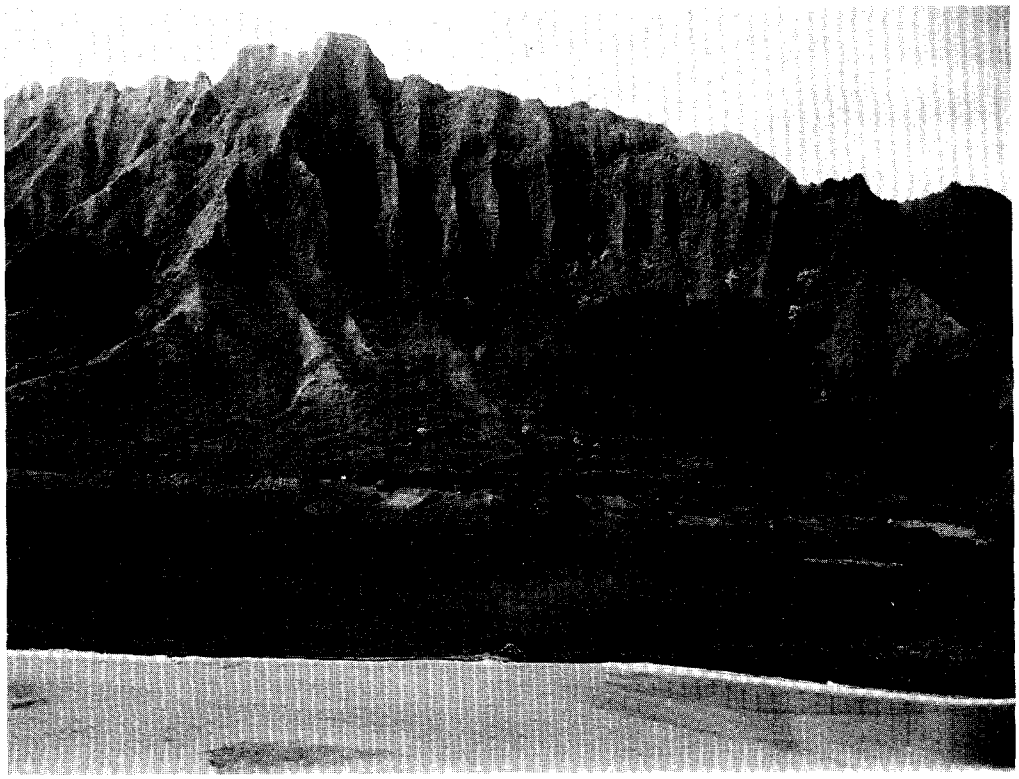


Fig. 12 Moli'i pond, July 23, 1974. Neg. # NPS - O'ahu 10-10.

C112 MOLI'I, at Kualoa, Ko'olaupoko, O'ahu
USGS Quad: Kahana
Tax Map Key: 4-9-03-43
Acreage 124 (?)
Ownership: Private

Type Ia_1

Kuapā was 4,000 feet long; 3 makahā.

Ratings:	Apple	Kikuchi	
Basin	.9	.4	
Contents	.9	.4	
Setting	.7	.5	
Total	2.5	1.3	Final Rating: 1.90

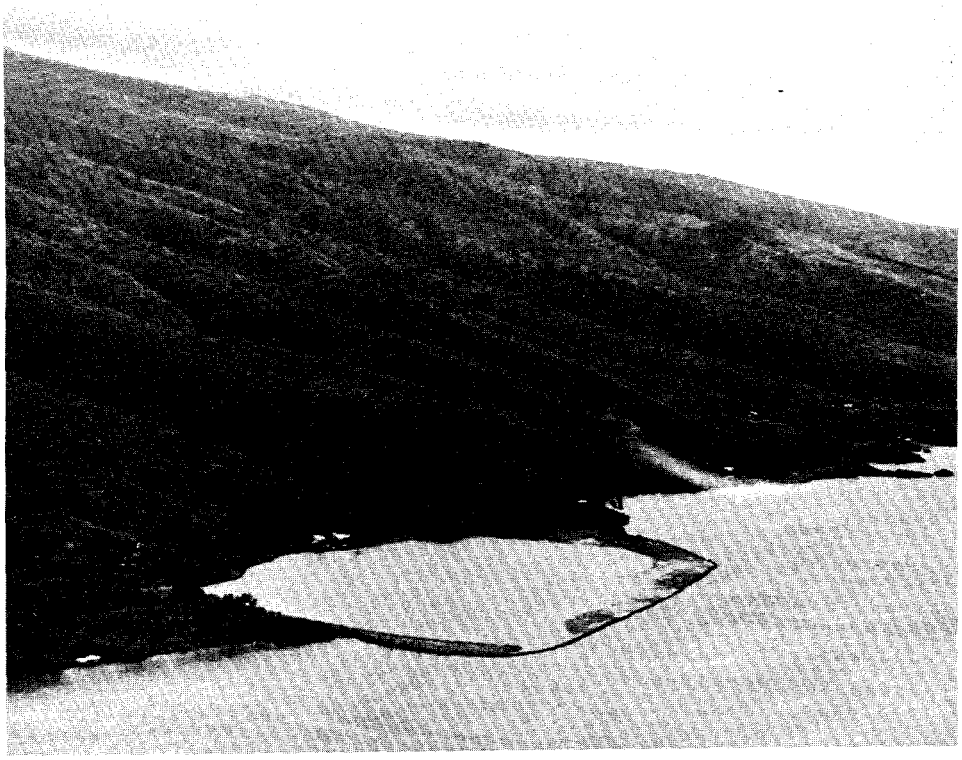


Fig. 13 Kupeke pond, May 22, 1974. Neg. # NPS - Moloka'i O-9A.

D38 KUPEKE, at Kupeke, Moloka'i
USGS Quad: Halawa
Tax Map Key: Portion of 5-7-06-1
Acreage 30 (?)
Ownership: Private

Type Ia_1

Kuapā was 2210 feet long; 1 makahā.

Ratings:	Apple	Kikuchi	
Basin	.8	.7	
Contents	.6	.5	
Setting	.6	.6	
Total	2.0	1.8	Final Rating: 1.90

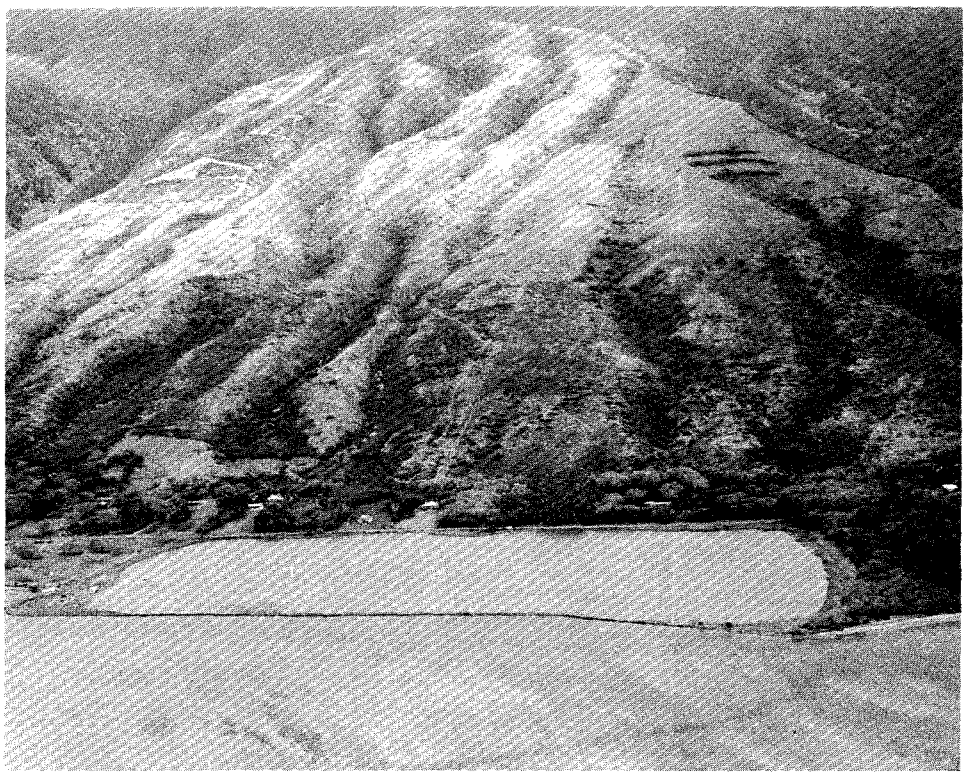


Fig. 14 Ni'auhala pond, Feb. 20, 1971. Neg. # Photo by George Bacon 10, 2/20/71 pond 42.

D43 NI'AUHALA, at Kalua'aha, Moloka'i
USGS Quad: Halawa
Tax Map Key: 5-6-08-8
Acreage 34 (?)
Ownership: Private

Type Ia

Kuapā was 1975 feet long; possibly 2 makahā; offshore wall, now underwater.

Ratings:	Apple	Kikuchi	
Basin	.5	.7	
Contents	.6	.6	
Setting	.6	.6	
Total	1.7	1.9	Final Rating: 1.80

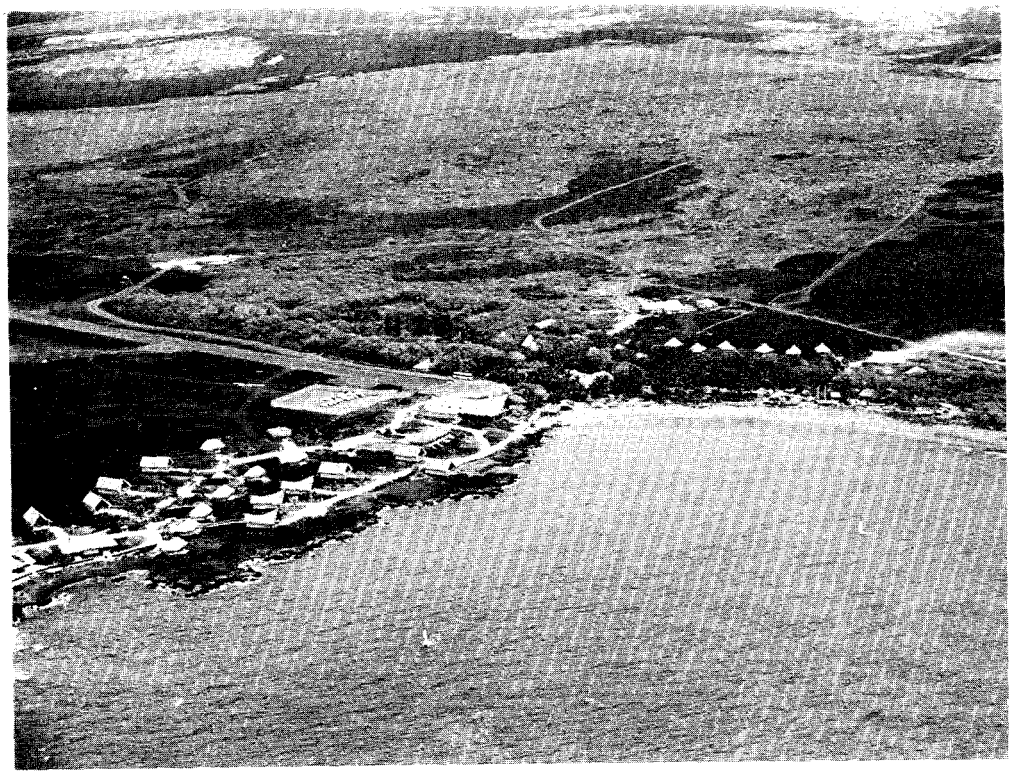


Fig. 15 Setting of nameless pond at Ka'upulehu. Neg. # NPS - Hawai'i 4-16.

H28 nameless, at Ka'upulehu, Kona, Hawai'i
USGS Quad: Kiholo
Tax Map Key: 7-2-03-2
Acreage 2 (?)
Ownership: Private

Type II

Ratings:	Apple	Kikuchi	
Basin	.9	.8	
Contents	.4	.5	
Setting	.8	.2	
Total	2.1	1.5	Final Rating: 1.80

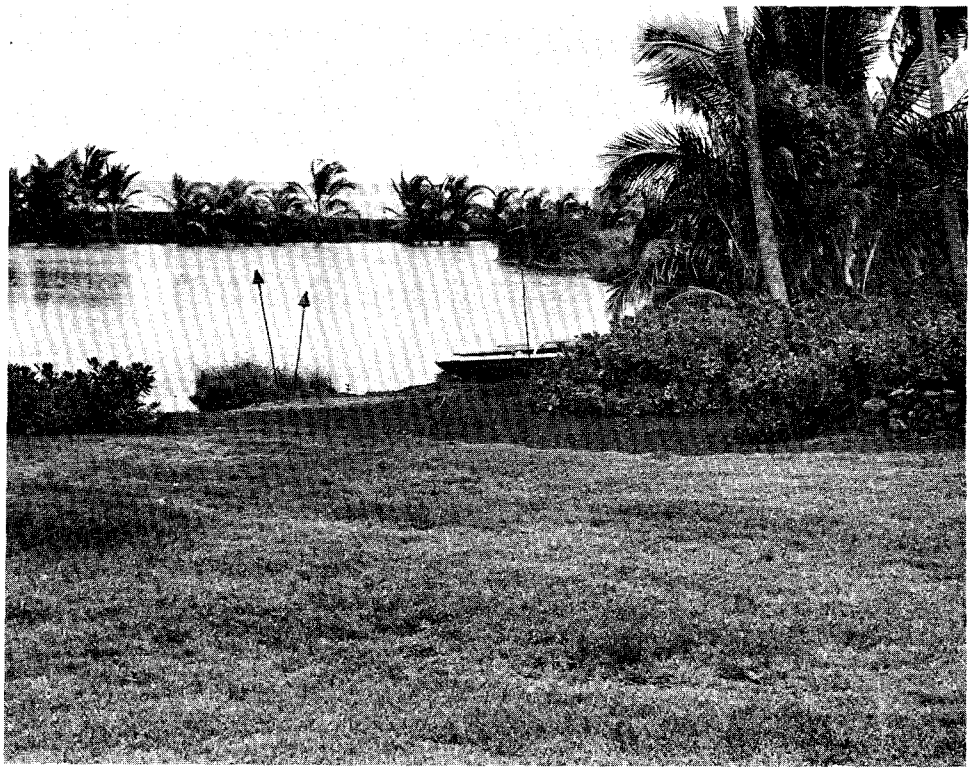


Fig. 16 'Ilo'i pond, June 25, 1974. Neg. # NPS - Hawai'i 5-8.

H19 'ILO'I, at Punalu'u, Ka'ū, Hawai'i
USGS Quad: Punalu'u
Tax Map Key: Portion of 9-5-19-11
Acreage
Ownership: Private

Type II

Dredged in 1973.

Ratings:	Apple	Kikuchi	
Basin	1.0	.3	
Contents	.9	.7	
Setting	.4	.2	
Total	2.3	1.2	Final Rating: 1.75

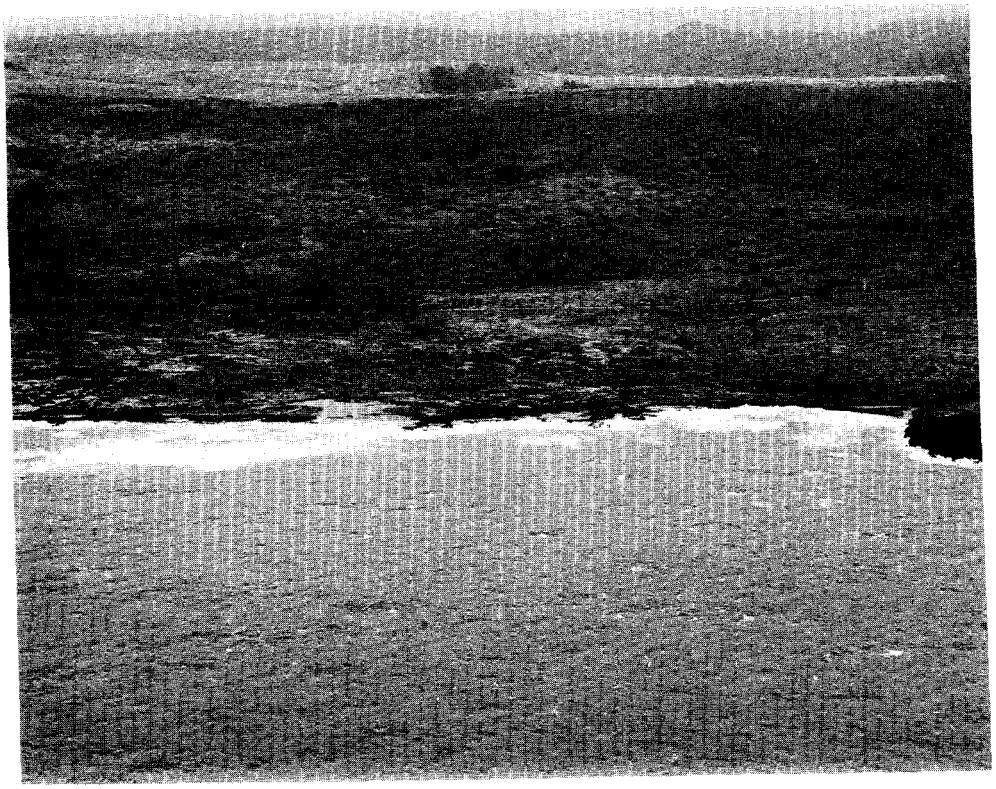


Fig. 17 nameless pond at Kawa'a. Neg # NPS - Hawai'i 2-31A.

H29 nameless, at Kawa'a, Ka'ū, Hawai'i
USGS Quad: Naalehu
Tax Map Key: 9-5-16-32
Acreage 2 (?)
Ownership: State of Hawai'i

Type II

Had 1 Ku'ula shrine; 1 unnamed mo'o.

Ratings:	Apple	Kikuchi	
Basin	.1	.6	
Contents	.5	.7	
Setting	.9	.7	
Total	1.5	2.0	Final Rating: 1.75

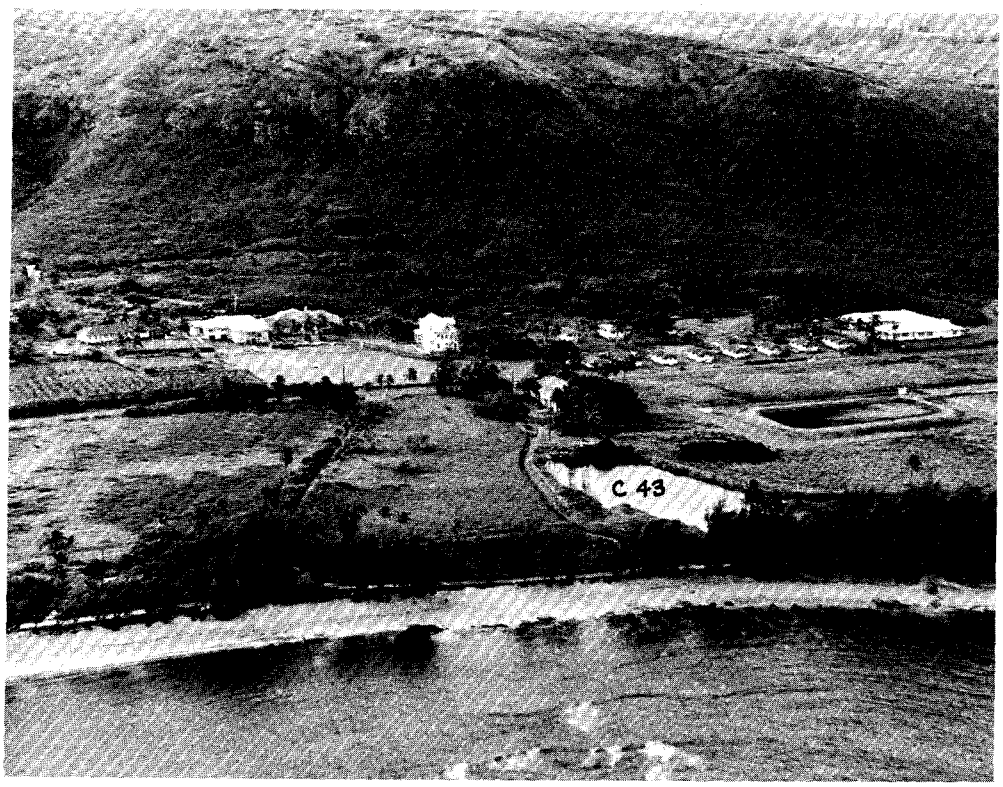


Fig. 18 Kalouwai pond, May 1, 1974. Neg. # NPS - O'ahu 3-20.

C43 KALOUWAI, at Waiale'e, Ko'olau Loa, O'ahu
USGS Quad: Waimea
Tax Map Key: 5-8-01-55
Acreage 1 (?)
Ownership: State of Hawai'i

Type IIIa

2 demigods, Malae Kahana and Laleikawai; they formed pond where a fishhook dug into ground; retaining wall was 4 feet high; Kane stone nearby; Konohiki named Kaluhi.

Ratings:	Apple	Kikuchi	
Basin	.8	.3	
Contents	.6	.6	
Setting	.7	.4	
Total	2.1	1.3	Final Rating: 1.70

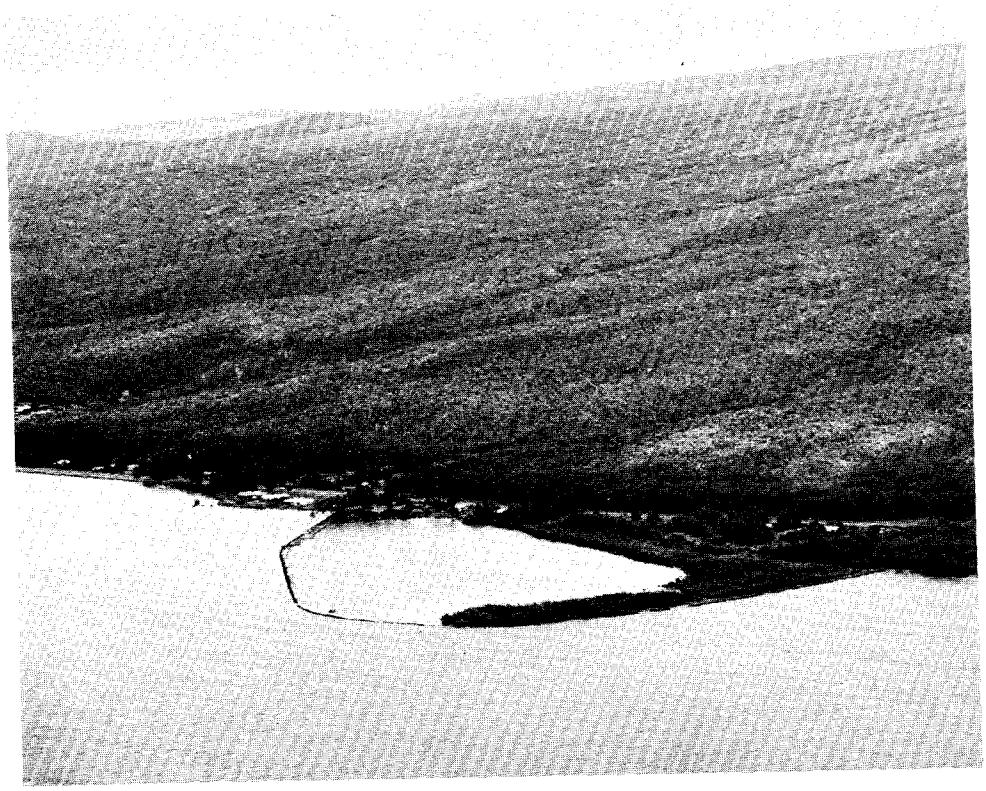


Fig. 19 Ali'i pond, May 22, 1974. Neg. # NPS - Moloka'i 0-23.

D2 ALI'I, at Makakupaia I, Moloka'i
USGS Quad: Kaunakakai
Tax Map Key: 5-4-06-23
Acreage 27 (?)
Ownership: Hawaiian Home Lands

Type Ia_1

Kuapā was 2,700 feet long, 4 feet wide and 3½ feet high; 1 makahā.

Ratings:	Apple	Kikuchi	
Basin	.4	.6	
Contents	.4	.7	
Setting	.5	.8	
Total	1.3	2.1	Final Rating: 1.70

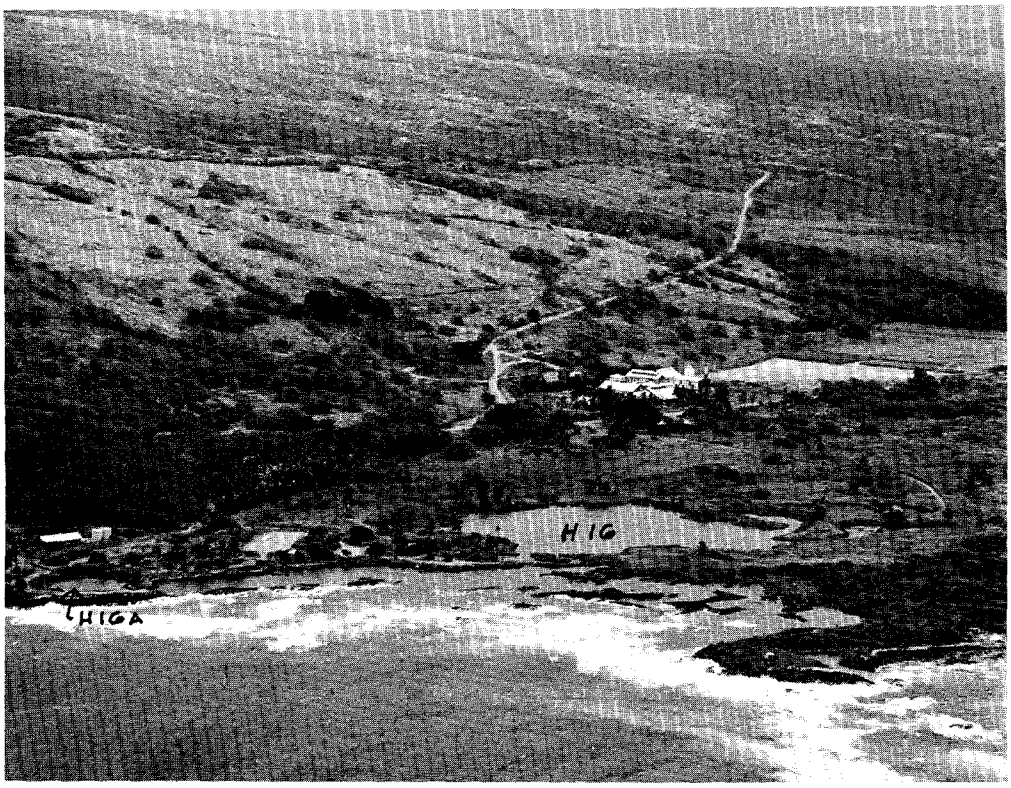


Fig. 20 nameless pond at Honu'apo (16) and nameless pond (16A), May 22, 1974. Neg. # NPS - Hawai'i 2-34A.

H16 nameless, at Honu'apo, Ka'ū, Hawai'i
USGS Quad: Naalehu
Tax Map Key: Part of Sea
Acreage 10 (?)
Ownership: State of Hawai'i

Type Ib

Ratings:	Apple	Kikuchi	
Basin	.7	.4	
Contents	.8	.4	
Setting	.7	.4	
Total	2.2	1.2	Final Rating: 1.70

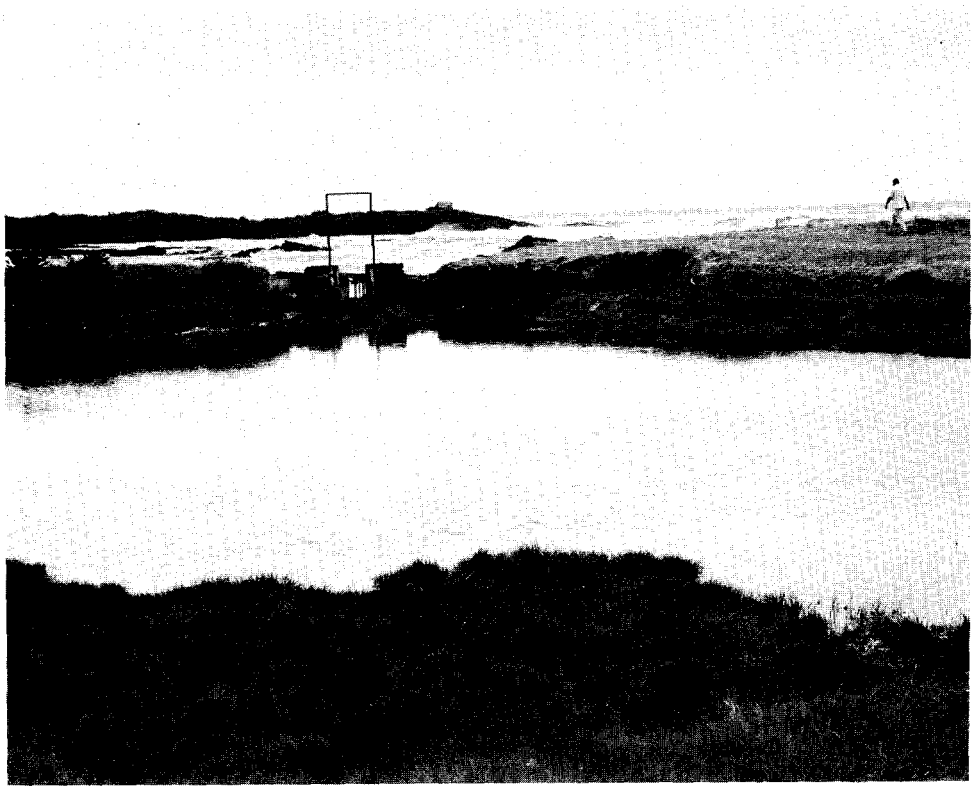


Fig. 21 Modern makahā in H16A, June 25, 1974. Neg. # NPS - Hawai'i 5-22. See figure 20 for aerial view of H16A.

H16A nameless, at Honu'apo, Ka'ū, Hawai'i
USGS Quad: Naalehu
Tax Map Key: Part of Sea
Acreage 3 (?)
Ownership: State of Hawai'i

Type Ib

Ratings:	Apple	Kikuchi	
Basin	.8	.4	
Contents	.7	.4	
Setting	.7	.4	
Total	2.2	1.2	Final Rating: 1.70

Fig. 22 Ninole and associated pond H53, May 22, 1974. Neg. # NPS - Hawai'i 2-28A.

H52 NINOLE, at Ninole, Ka'ū, Hawai'i
USGS Quad: Punaluu
Tax Map Key: 9-5-19-12
Acreage 4 (?)
Ownership: State of Hawai'i

Type Ib

Kuapā was 5 to 6 feet wide and 3 feet high, destroyed in A.D. 1954; connected to and includes H53 nameless.

Ratings:	Apple	Kikuchi	
Basin	.8	.4	
Contents	.6	.4	
Setting	.9	.2	
Total	2.3	1.0	Final Rating: 1.65

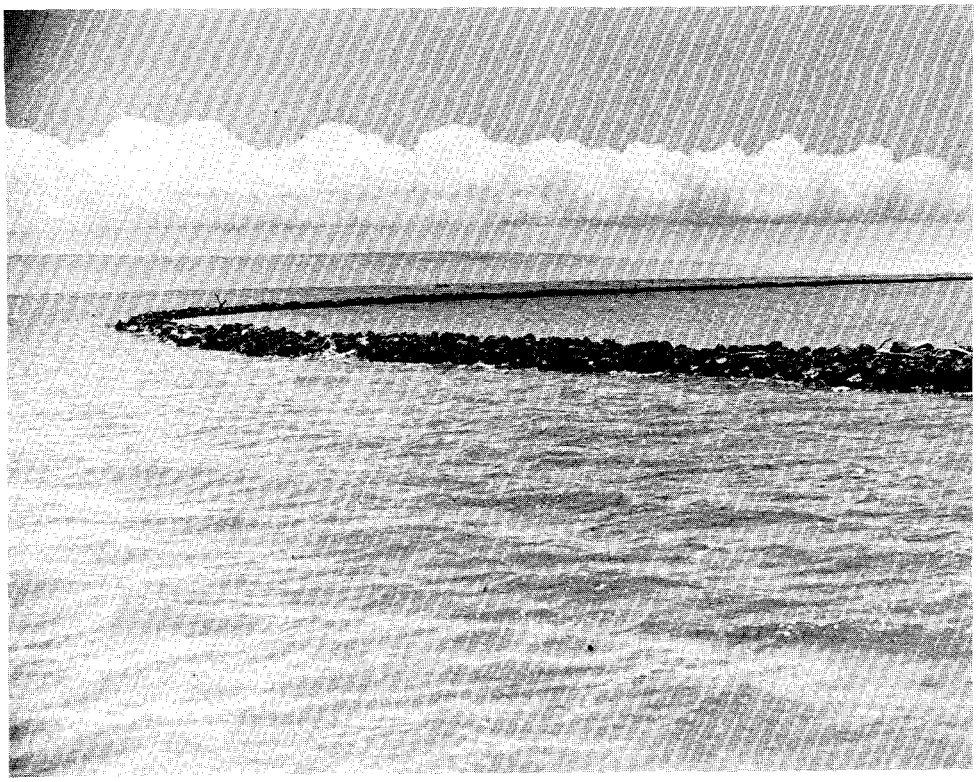


Fig. 23 Kuapā of Ka'ope'ahina pond, July 29, 1974. Neg. # NPS - Moloka'i 3-33A.

D29 KA'OPE'AHINA, at Kalua'aha, Moloka'i
USGS Quad: Halawa
Tax Map Key: 5-7-09-1
Acreage 19 (?)
Ownership: Private

Type Ic

Kuapā was 1770 feet long, 4-7 feet wide and 5-8 feet high; no makahā. Menehune built pond.

Ratings:	Apple	Kikuchi	
Basin	.3	.7	
Contents	.3	.7	
Setting	.5	.7	
Total	1.1	2.1	Final Rating: 1.60

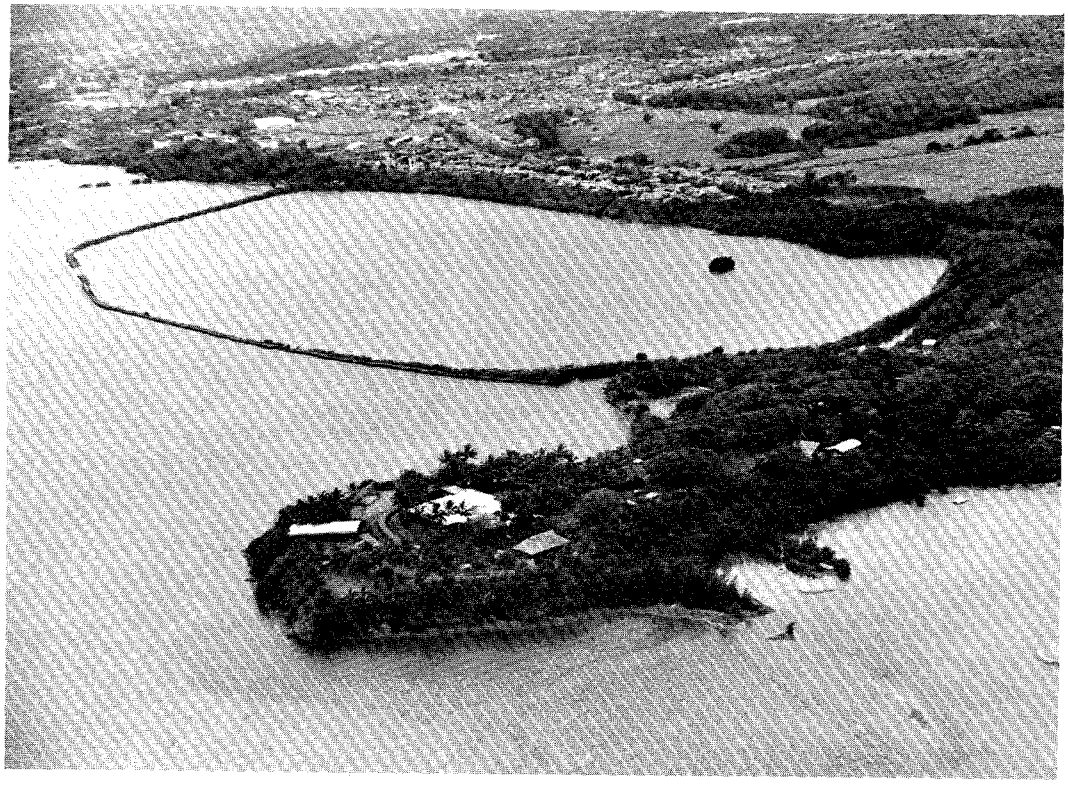


Fig. 24 He'eia'uli pond, May 1, 1974. Neg. # NPS - O'ahu 4-16.

C15 HE'EIA'ULI, at He'eia, Ko'olaupoko, O'ahu.
USGS Quad: Kaneohe
Tax Map Key: 4-6-05-1
Acreage 88 (?)
Ownership: Private

Type Ia

Dirt filled kuapā 5,000 feet long, 12 feet wide; 5 makahā; 4 hale kia'i.

Ratings:	Apple	Kikuchi	
Basin	.7	.5	
Contents	.3	.7	
Setting	.6	.3	
Total	1.6	1.5	Final Rating: 1.55

Fig. 25 Loko-nui pond, Feb. 27, 1975. Neg. # NPS - Maui 10-4.
See figure 26 Loko-iki.

F3 LOKO-NUI, at Maui
USGS Quad: Hana
Tax Map Key: 1-4-08-2
Acreage 11 (?)
Ownership: Private

Type Ib

Many hale kia'i on kuapā; several makahā. The mo'o was named Kihawahini. Kamehameha the Great rebuilt pond. Inundated by 1946 tsunami.

Ratings:	Apple	Kikuchi	
Basin	.8	.1	
Contents	.6	.4	
Setting	.9	.3	
Total	2.3	.8	Final Rating: 1.55

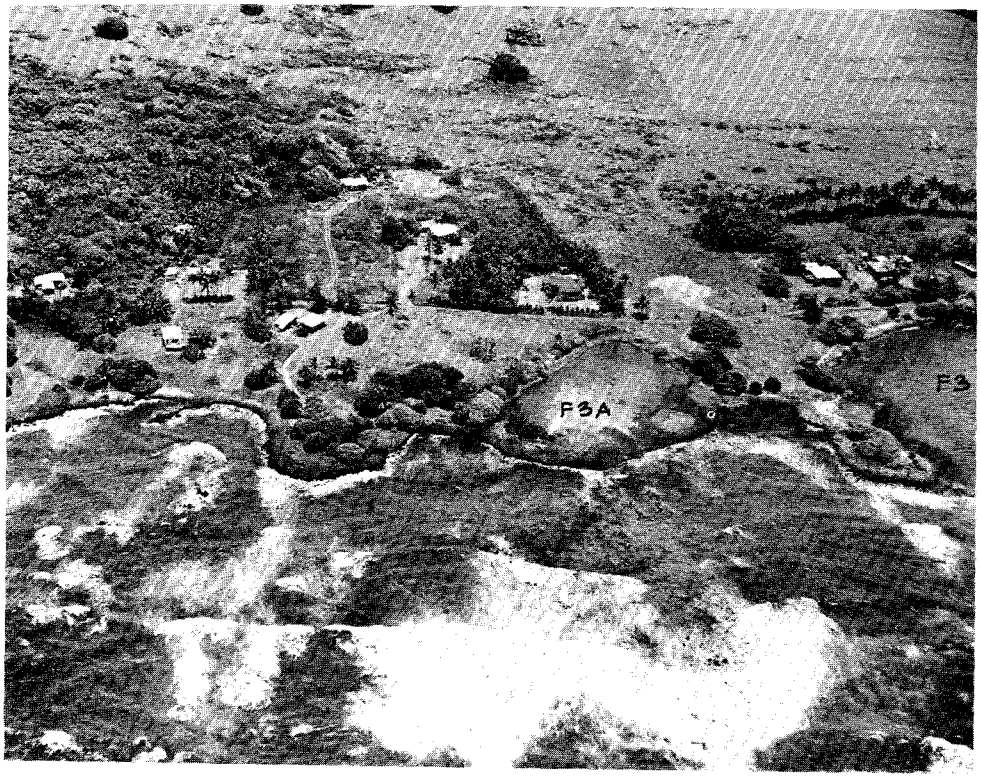


Fig. 26 Loko-iki pond, June 19, 1974. Neg. # NPS - Maui 5-8A.

F3A LOKO-IKI, at Maui
USGS Quad: Hana
Tax Map Key: 1-4-08-4
Acreage 2 (?)
Ownership: Private

Type Ib

One makahā in 'auwai-kai. Inundated by 1946 tsunami.

Ratings:	Apple	Kikuchi	
Basin	.8	.1	
Contents	.6	.4	
Setting	.9	.3	
Total	2.3	0.8	Final Rating: 1.55

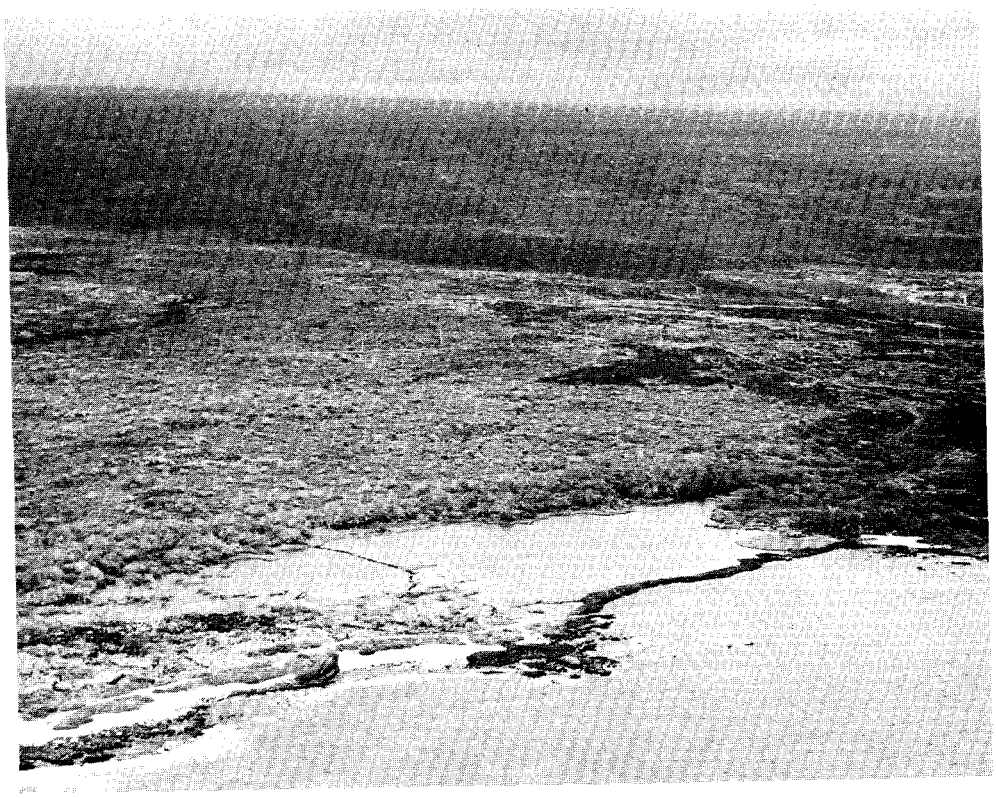


Fig. 27 Kaloko pond, May 22, 1974. Neg. # NPS - Hawai'i 4-12.
Note secondary walls.

H24 KALOKO, at Hawai'i
USGS Quad: Keahole Point
Tax Map Key: 7-3-09-2
Acreage 11 (?)
Ownership: Private

Type Ib

Kuapā was 750 feet long, 35 feet wide, 6 feet high; 3 secondary walls; 2 makahā; unnamed mo'o. Dredged in 1973.

Ratings:	Apple	Kikuchi	
Basin	.5	.3	
Contents	.8	.2	
Setting	.6	.6	
Total	1.9	1.1	Final Rating: 1.50

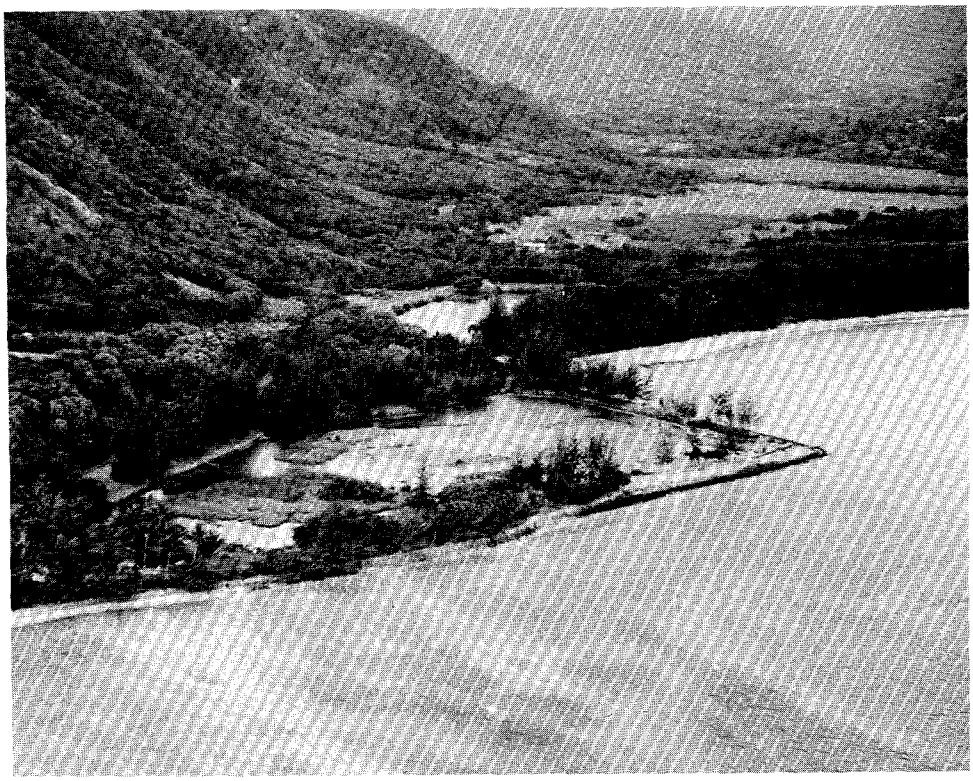


Fig. 28 Huilua pond, May 1, 1974. Neg. # NPS - O'ahu 3-31A.

C18 HUILUA, at Kahana, Ko'olaupoko, O'ahu
USGS Quad: Kahana
Tax Map Key: 6-2-03-2
Acreage 14 (?)
Ownership: State of Hawai'i

Type Ia_1

1 makahā with adjacent koa shrine; built by Menehune; shark 'aumakua.

Ratings:	Apple	Kikuchi	
Basin	.7	.5	
Contents	.3	.2	
Setting	.6	.6	
Total	1.6	1.3	Final Rating: 1.45

Fig. 29 Pūkoko pond, July 5, 1974. Neg. # NPS - O'ahu 7-11.

C144 PŪKOKO, at Kahana, Ko'olaupoko, O'ahu
USGS Quad: Kahana
Tax Map Key: Portion of 5-2-03-6
Acreage 1 (?)
Ownership: State of Hawai'i

Type IIIb

Ratings:	Apple	Kikuchi	
Basin	.7	.3	
Contents	.6	.4	
Setting	.6	.3	
Total	1.9	1.0	Final Rating: 1.45

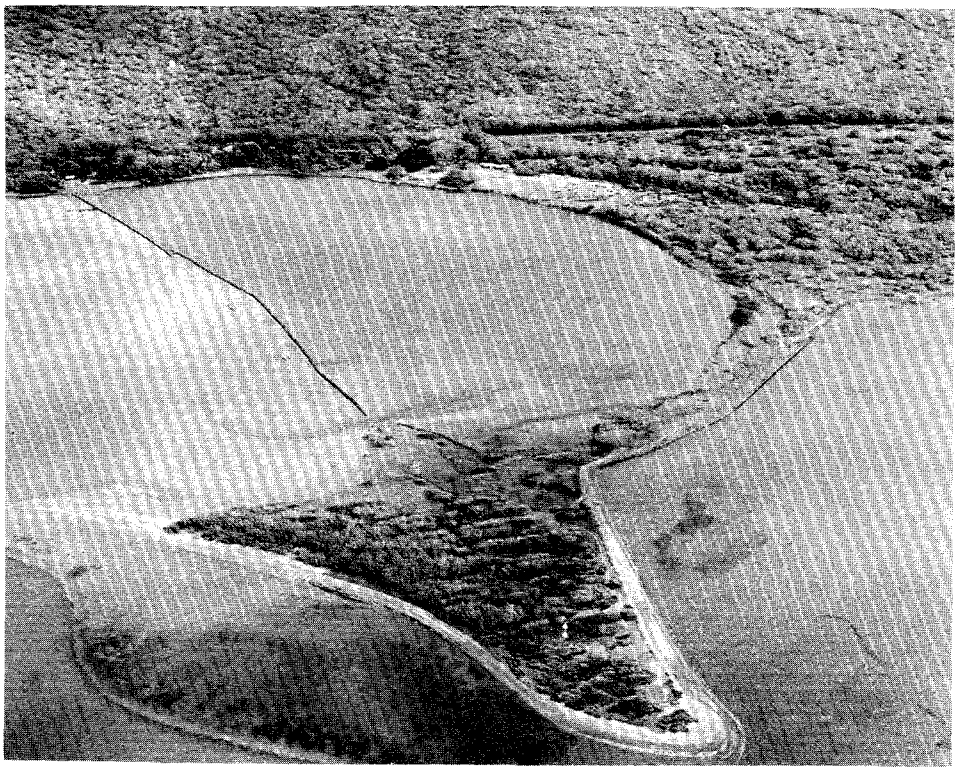


Fig. 30 Keawanui pond, Feb. 20, 1971. Neg. # Photo by George Bacon 19, 2/20/71 Pond 32.

D34 KEAWANUI, at Kalaeloa, Keawanui, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-6-06-8
Acreage 54 (?)
Ownership: Private

Type Ia_1

Kuapā was 2,000 feet long; 1 makahā. Lohelohe built pond ca. A.D. 1575. Konohiki at time of Pohano was Hekilika'aka'a.

Ratings:	Apple	Kikuchi	
Basin	.3	.5	
Contents	.4	.2	
Setting	.8	.7	
Total	1.5	1.4	Final Rating: 1.45

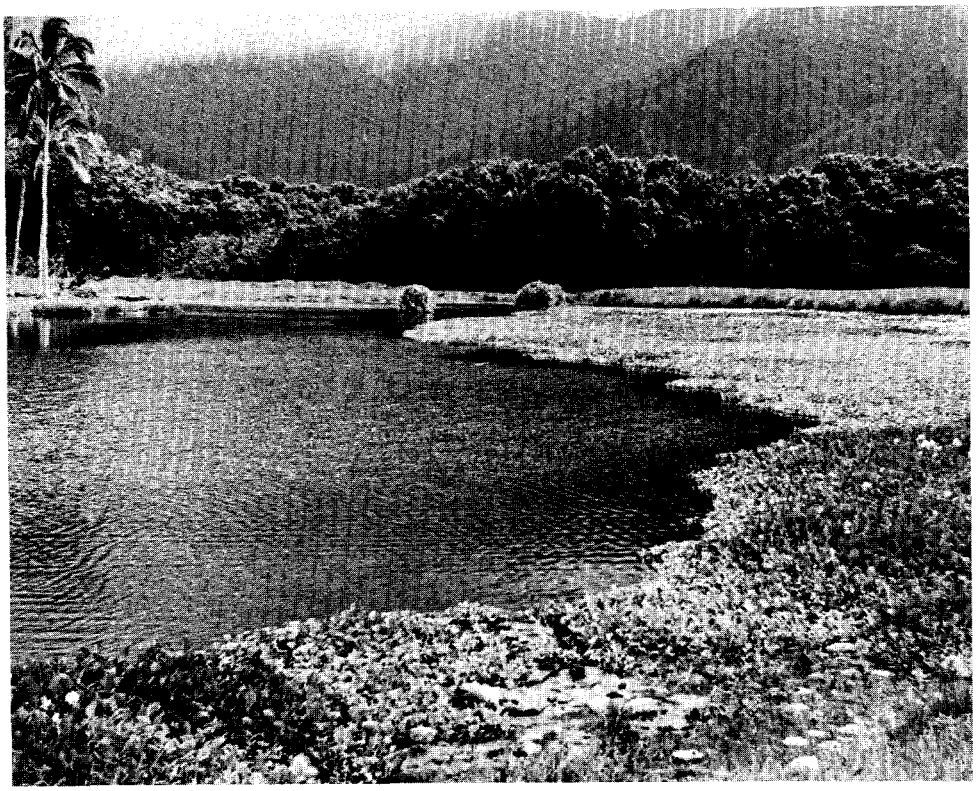


Fig. 31 Kanoa pond, June 21, 1974. Neg. # NPS - Kaua'i 5-28A.

B4A KANOA, at Hanalei, Kaua'i
USGS Quad: Hanalei
Tax Map Key: Portion of 5-5-01-2
Acreage 4 (?)
Ownership: Private

Type IIIa

Ratings	Apple	Kikuchi
Basin	.9	.3
Contents	.4	.2
Setting	.7	.2
Total	2.0	0.7

Final Rating: 1.35

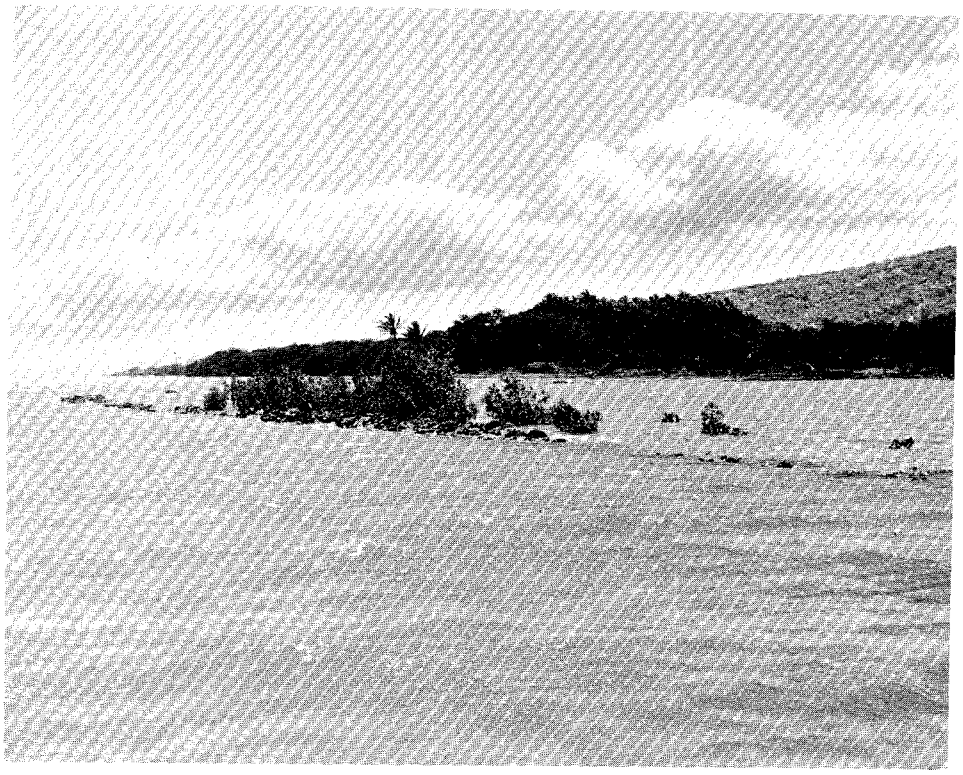


Fig. 32 Open water and mangrove, Kuapā awash, Pahiomu pond, July 29, 1974. Neg. # NPS - Moloka'i 5-33.

D49 PAHIOMU, at Keonoku'ino, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-5-01-10
Acreage 20 (?)
Ownership: State of Hawai'i

Type Ia

Kuapā was 1770 feet long; 1 makahā.

Ratings:	Apple	Kikuchi	
Basin	.4	.3	
Contents	.4	.2	
Setting	.7	.7	
Total	1.5	1.2	Final Rating: 1.35

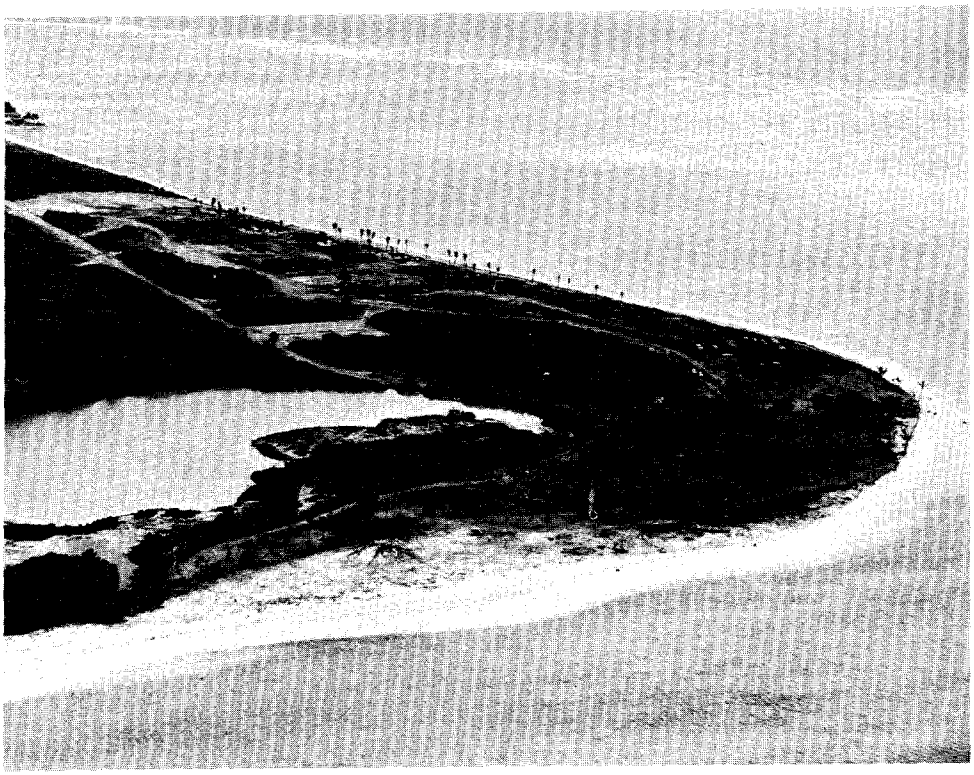


Fig. 33 Koholālele pond, May 1, 1974. Neg. # NPS - O'ahu 4-7.

C82 KOHOLĀLELE, at Kualoa, Ko'olaupoko, O'ahu
USGS Quad: Kahana
Tax Map Key: 4-9-04-1
Acreage 2 (?)
Ownership: State of Hawai'i

Type II

Ratings:	Apple	Kikuchi	
Basin	.8	.3	
Contents	.4	.2	
Setting	.5	.3	
Total	1.7	0.8	Final Rating: 1.25

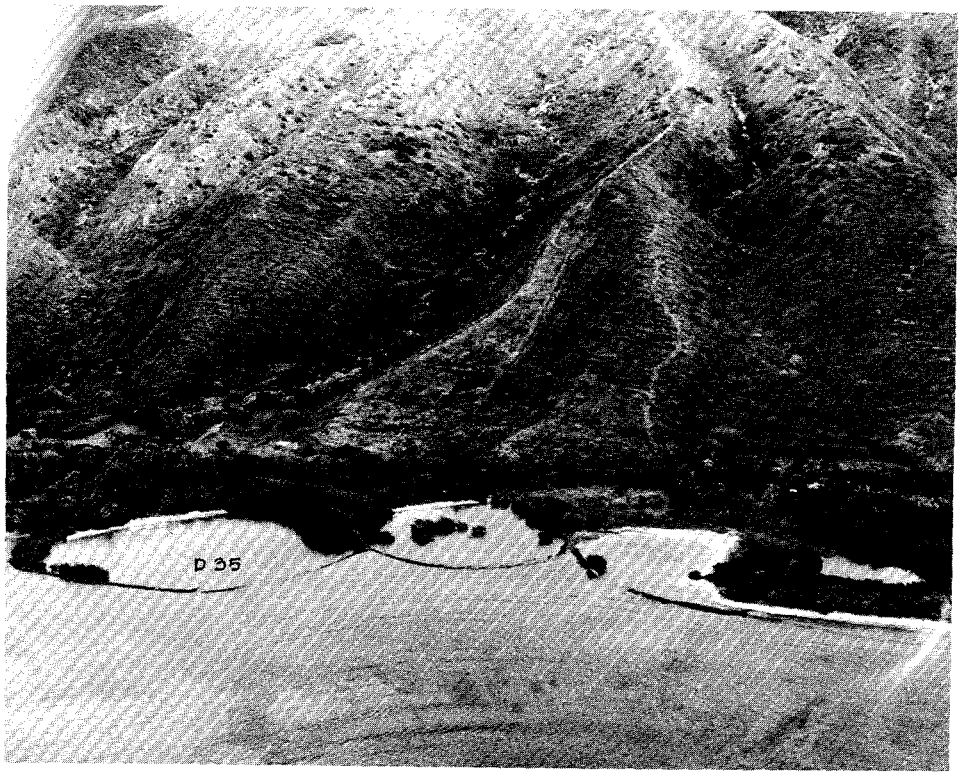


Fig. 34 Pond on left in Kihaloko, Feb. 20, 1971. Neg. # Photo by George Bacon 5, 2/20/71, Ponds 47, 48, 49.

D35 KIHALOKO, at Aha'ino II, Moloka'i
USGS Quad: Halawa
Tax Map Key: Portion of 5-7-06-22
Acreage 5 (?)
Ownership: Private

Type Ia

Ratings:	Apple	Kikuchi
Basin	.3	.4
Contents	.2	.5
Setting	.4	.7
Total	0.9	1.6

Final Rating: 1.25

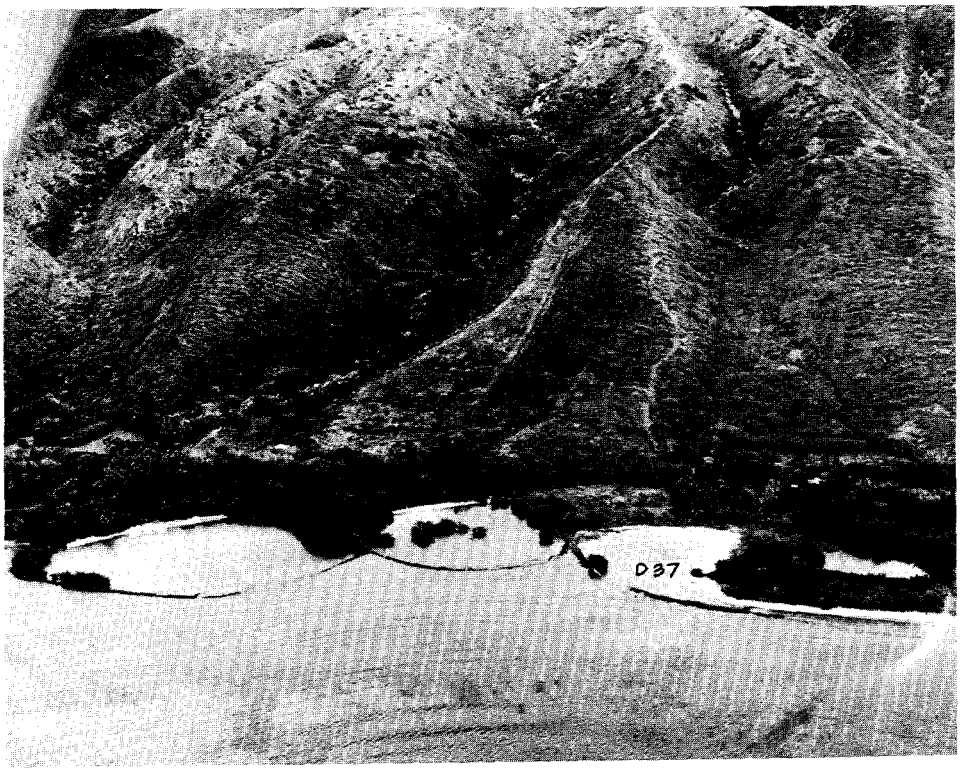


Fig. 35 Pond on right is Kula'alamihi, Feb. 21, 1971. Neg. #
Photo by George Bacon 5, 2/21/71, Ponds 47, 48, 49.

D37 KULA'ALAMIHI, at Honomuni, Moloka'i
USGS Quad: Kamalo
Tax Map Key: Portion of 5-7-04-34
Acreage 4 (?)
Ownership: Private

Type Ia

Ratings:	Apple	Kikuchi	
Basin	.3	.4	
Contents	.2	.5	
Setting	.4	.7	
Total	0.9	1.6	Final Rating: 1.25

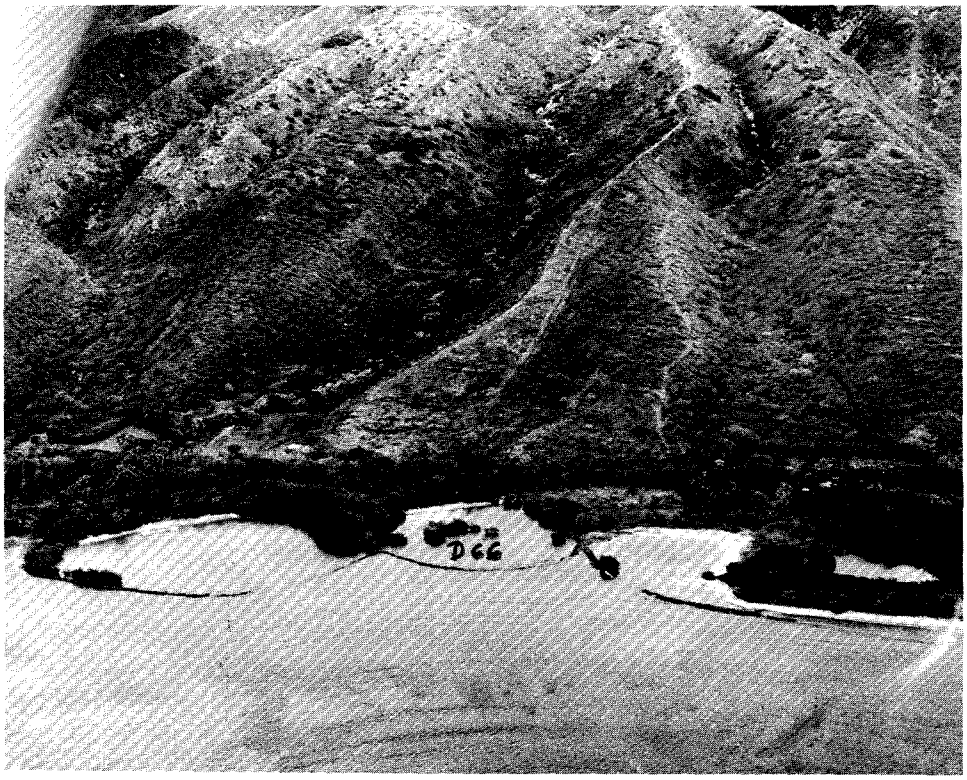


Fig. 36 Pond in center is Waihilahila, Feb. 20, 1971. Neg. #
Photo by George Bacon 5, 2/20/71, Ponds 47, 48, 49.

D66 WAIHILAHILA, Ka'ili'ula, Moloka'i
USGS Quad: Halawa
Tax Map Key: Portion of 5-7-06-27
Acreage 4 (?)
Ownership: Private

Type Ia_3

Ratings:	Apple	Kikuchi	
Basin	.3	.4	
Contents	.2	.5	
Setting	.4	.7	
Total	.9	1.6	Final Rating 1.25

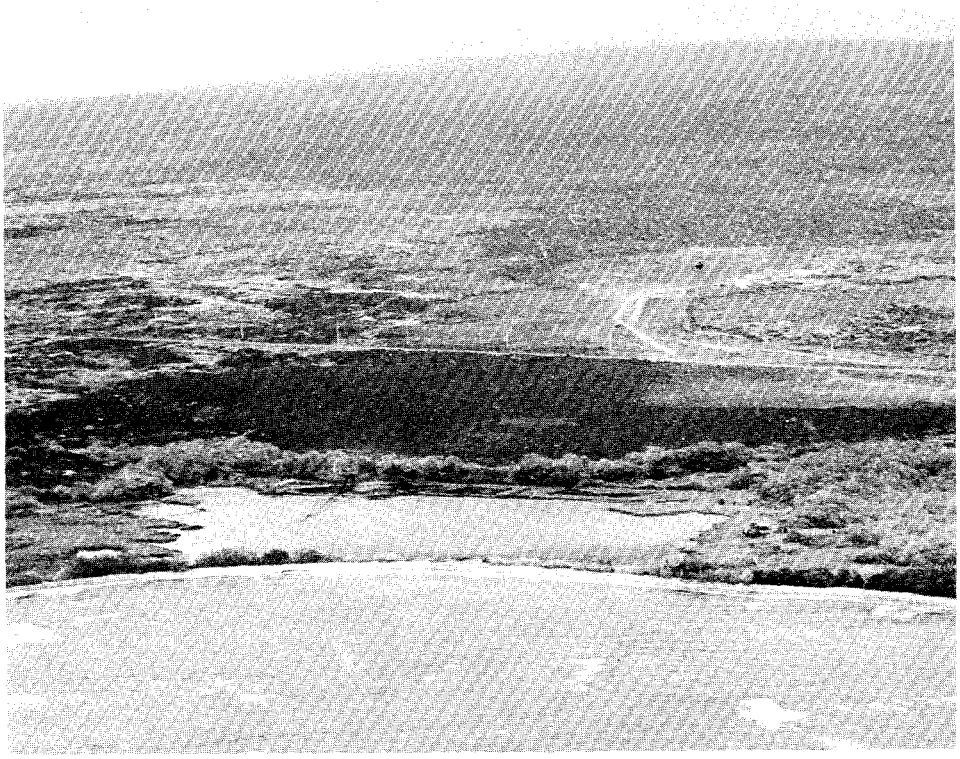


Fig. 37 'Aimakapa'a pond, May 22, 1974. Neg. # NPS - Hawai'i 4-10.

H1 'AIMAKAPA'A, at Honokohau II, Kona, Hawai'i
USGS Quad: Keahole Point
Tax Map Key: Portion of 7-4-08-10
Acreage 15 (?)
Ownership: Private

Type II

Ratings:	Apple	Kikuchi	
Basin	.8	.3	
Contents	.2	.3	
Setting	.5	.4	
Total	1.5	1.0	Final Rating: 1.25

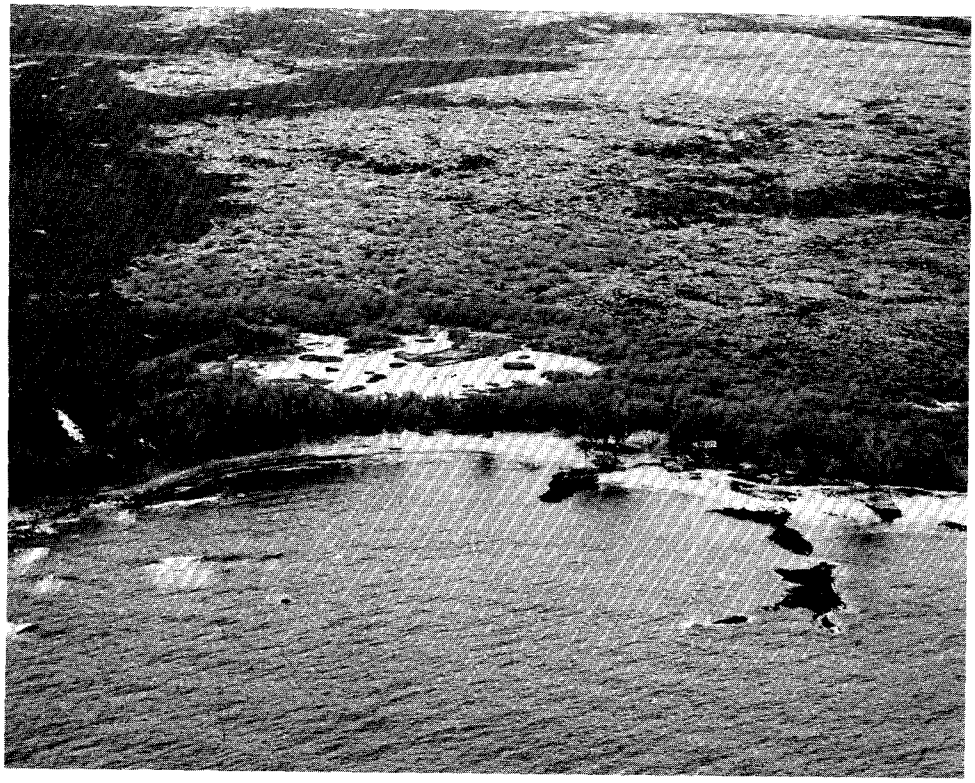


Fig. 38 'Opae'ula pond, May 22, 1974, Neg. # NPS - Hawai'i 4-13.

H54 'OPAE'ULA, at Makalawena, Kona, Hawai'i
USGS Quad: Makalawena
Tax Map Key: 7-2-04-1
Acreage 7 (?)
Ownership: Private

Type II

Ratings:	Apple	Kikuchi	
Basin	.7	.1	
Contents	.2	.1	
Setting	.8	.6	
Total	1.7	.8	Final Rating: 1.25

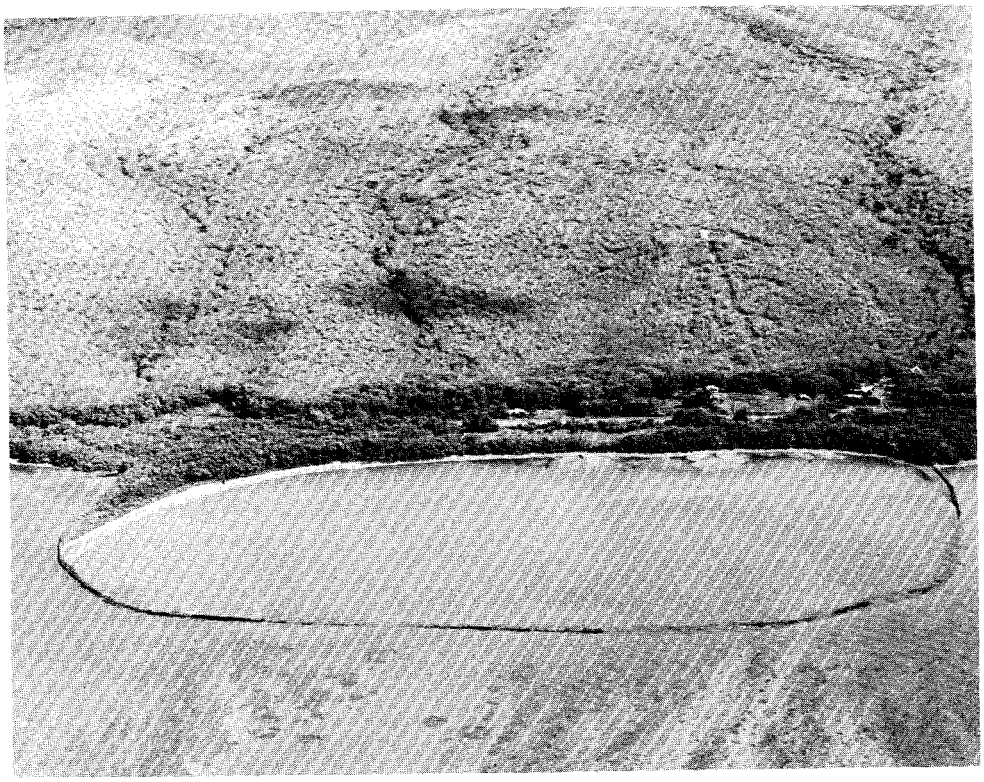


Fig. 39 Kanoa pond, Feb. 20, 1971. Neg. # Photo by George Bacon 2-9, 2/20/71 Pond 18.

D24 KANOA, Kawela, Moloka'i
USGS Quad: Kaunakakai
Tax Map Key: 5-4-03-23
Acreage 50 (?)
Ownership: Private

Type Ia

Kuapā was 2860 feet long; 2 makahā.

Ratings:	Apple	Kikuchi	
Basin	.3	.3	
Contents	.4	.5	
Setting	.5	.4	
Total	1.2	1.2	Final Rating: 1.20

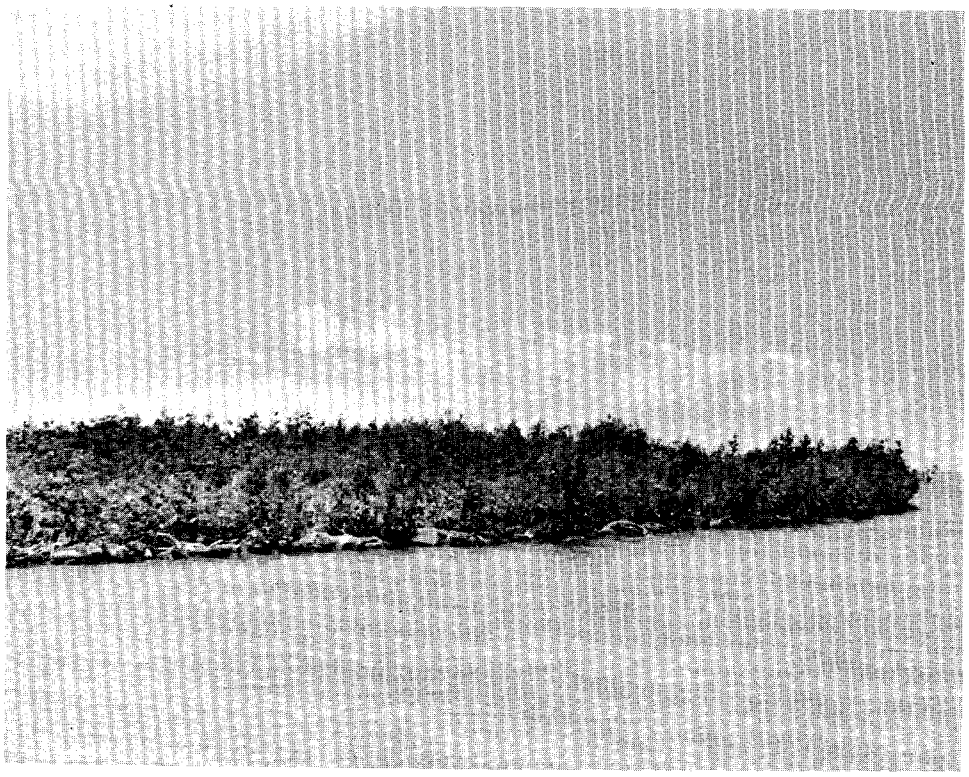


Fig. 40 Silt and mangrove in Kipapa pond, July 29, 1974. Neg. # NPS - Moloka'i 5-28. See Fig. 1, Chapt. II, for aerial view of Kipapa.

D36 KIPAPA, at Keonoku'ino, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-5-01-8
Acreage 10 (?)
Ownership: State of Hawai'i

Type Ia

Kuapā was 1371 feet long; 1 makahā.

Ratings:	Apple	Kikuchi	
Basin	.3	.2	
Contents	.2	.1	
Setting	.7	.8	
Total	1.2	1.1	Final Rating: 1.15

Fig. 41 nameless pond at Lāwa'i-kai, June 21, 1974. Neg. # NPS - Kaua'i 5-6.

B15 nameless, at Lāwa'i-kai, Kaua'i
USGS Quad: Koloa
Tax Map Key: Portion of 2-6-02-1
Acreage 2 (?)
Ownership: Private

Type IIIb

Kuapā was 400 feet long; pond inundated by 1946 Tsunami.

Ratings:	Apple	Kikuchi	
Basin	.3	.2	
Contents	.3	.1	
Setting	.8	.4	
Total	1.4	0.7	Final Rating 1.05

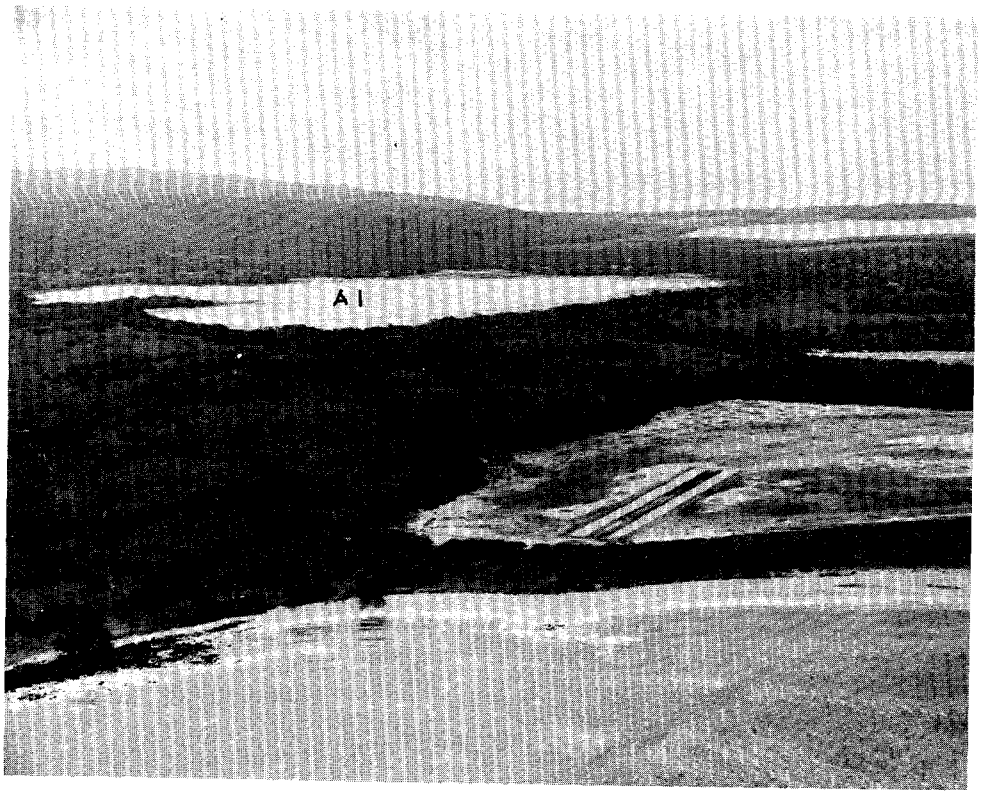


Fig. 42 nameless pond A1 (Halulu Lake), May 15, 1974. Neg. # NPS - A1-18A.

A1 nameless, at Halulu (lake), Ni'ihau

Tax Map Key: 1-1-01-1
Acreage 371 (?)
Ownership: Private

Type IIa_1

Ratings:

Final Rating: Less than 1.00

Fig. 43 nameless pond at Ho'ai, June 21, 1974. Neg. # NPS - Kaua'i 5-9.

B6 nameless, at Kuhio Park, Ho'ai, Koloa, Kaua'i
USGS Quad: Koloa
Tax Map Key: 2-6-06-2
Acreage 4 (?)
Ownership: Private

Type II

Ratings:

Final Rating: Less than 1.00

Fig. 44 Ke'e pond, May 15, 1974. Neg. # NPS - Kaua'i 2-21A.

BIOD KE'E, at Wet cave area, Hā'ena, Kaua'i
USGS Quad: Haena
Tax Map Key: 5-9-01-22
Acreage 3 (?)
Ownership: State of Hawai'i

Type IIa_1

Ratings:

Final Rating: Less than 1.00

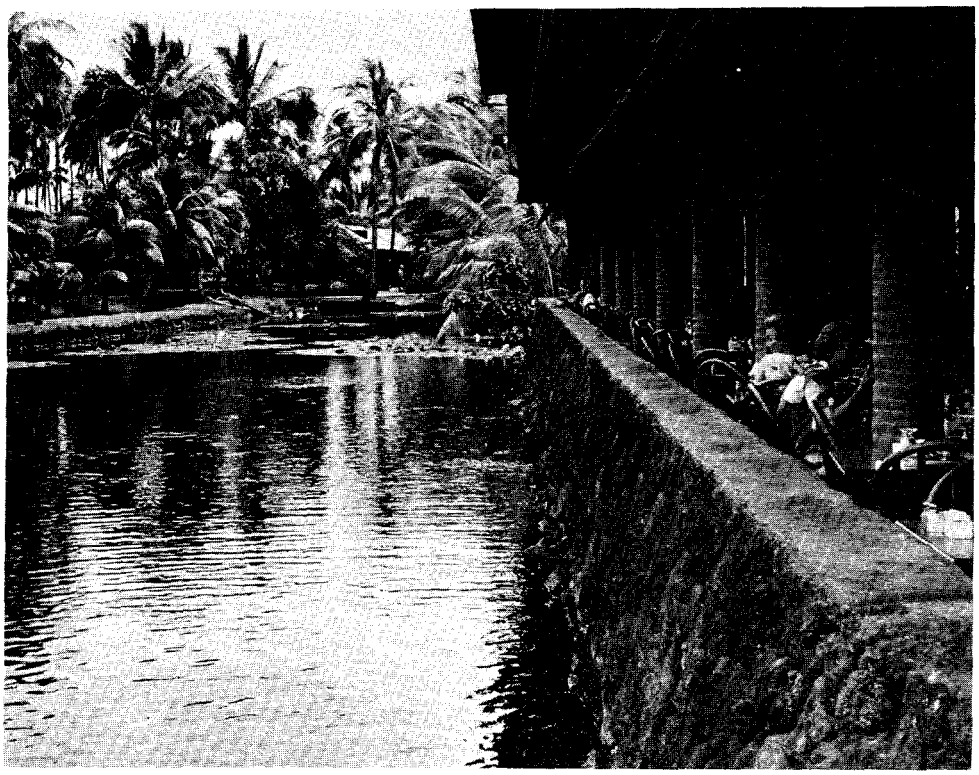


Fig. 45 nameless pond (B22A) at Wailua, June 22, 1974. Neg. # NPS - Kaua'i 6-35.

B22 nameless, at Coco Palms Hotel, Kaua'i
USGS Quad: Kapaa
Tax Map Key: Portion of 4-1-03-16
Acreage 3 (?)
Ownership: Private

Type II

Once belonged to Deborah Kapule. Two ponds included - "A" is pond mauka of dining area; "B" is small detached pond to south.

Ratings:

Final Rating: Less than 1.00

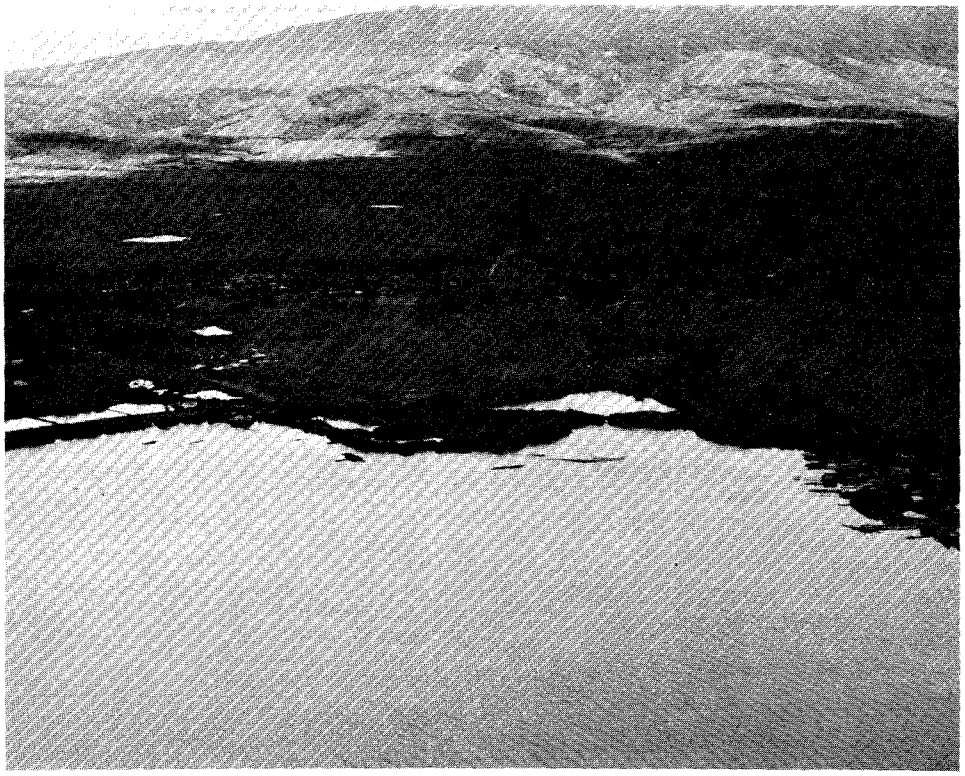


Fig. 46 Ka'auku'u pond, May 1, 1974. Neg. # NPS - O'ahu 2-22.

C21 KA'AUKU'U, at Waikele, Pearl Harbor, O'ahu
USGS Quad: Waipahu
Tax Map Key: 9-4-01-12
Acreage 4 (?)
Ownership: Private

Type Ia_2

Ratings:

Final Rating: Less than 1.00

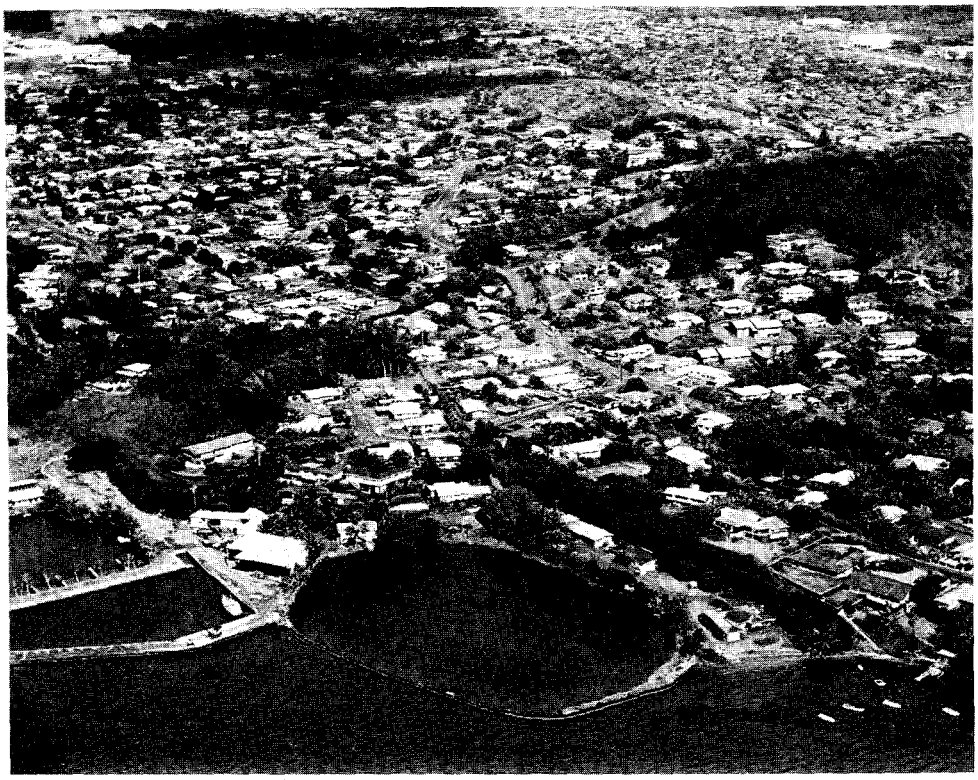


Fig. 47 Kanohulu iwi pond, July 23, 1974. Neg. # NPS - O'ahu 10-33.

C50 KANOHULU IWI, at Kane'ohe, Ko'olaupoko, O'ahu
USGS Quad: Kaneohe
Tax Map Key: 4-5-57-1
Acreage 3 (?)
Ownership: Private

Type Ia_2

Base of kuapā was 9 feet wide.

Ratings:

Final Rating: Less than 1.00

Fig. 48 Laulaunui pond and island, May 1, 1974. Neg. # NPS - O'ahu 2-20A.

C93 LAULAUNUI, at Honouliuli, Pearl Harbor, O'ahu
USGS Quad: Puuloa
Tax Map Key: 9-1-17-15
Acreage 5 (?)
Ownership: United States of America

Type Ia

Ratings:

Final Rating: Less than 1.00

Fig. 49 Okiokilepe pond, May 1, 1974. Neg. # NPS - O'ahu 1-18A.

C117 OKIOKILEPE, at West Loch, Pearl Harbor, O'ahu
USGS Quad: Puuloa
Tax Map Key: Portion of 9-1-01-1
Acreage 6 (?)
Ownership: United States of America

Type Ic

Kuapā of coral blocks and was 1,000 feet long, 6 feet wide and 4 feet high. No makahā.

Ratings:

Final Rating: Less than 1.00

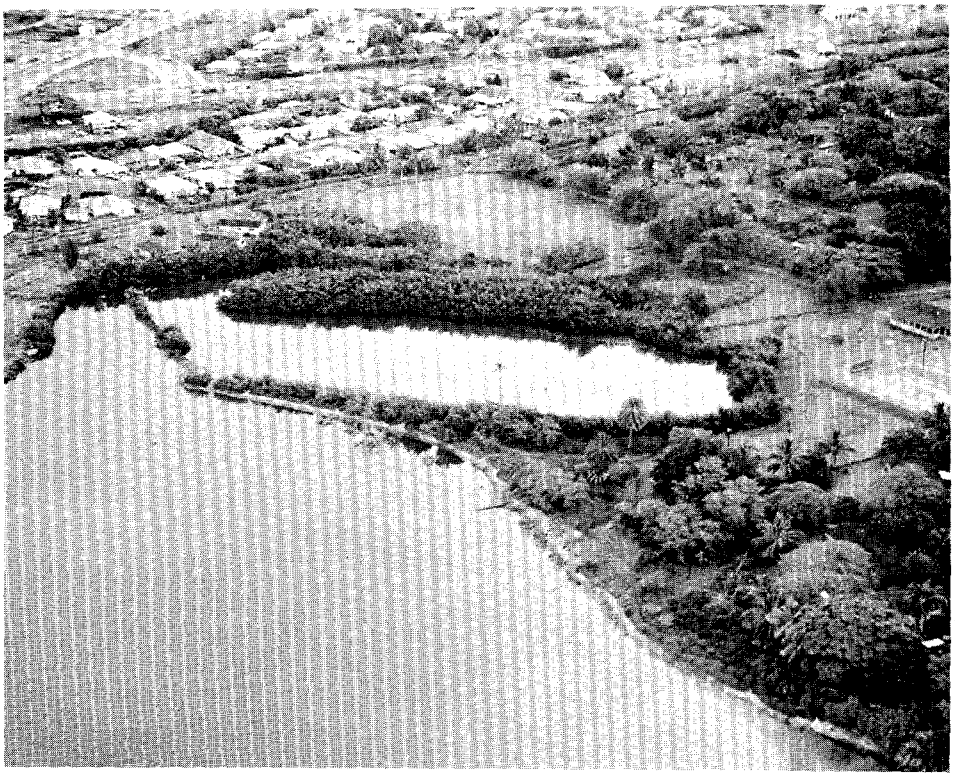


Fig. 50 Pa'aiau pond, May 1, 1974. Neg. # NPS - O'ahu 1-5.

C123 PA'AIAU, at McGrew Point, Kalauao, Pearl Harbor, O'ahu
USGS Quad: Waipahu
Tax Map Key: 9-8-19-3
Acreage 3 (?)
Ownership: United States of America

Type Ib

Kalaimanuia built pond ca. A.D. 1550. Kuapā was 600 feet long, 3 feet wide, 2 feet high; 1 makahā.

Ratings:

Final Rating: Less than 1.00

Fig. 51 "Paiko" pond, May 1, 1974. Neg. # NPS - O'ahu 5-21A.

C130 "PAIKO", at Kuliouou, Honolulu, O'ahu
USGS Quad: Koko Head
Tax Map Key: 3-8-02-2/13/21/22/24/25/26/27/28/36/37
Acreage 2 (?)
Ownership: Private

Type II

Ratings:

Final Rating: Less than 1.00

Fig. 52 Waikalua pond, July 23, 1974. Neg. # NPS - O'ahu 9-4A.

C153 WAIKALUA, at O'ahu
USGS Quad: Kaneohe
Tax Map Key: Portion of 4-5-30-1
Acreage 11 (?)
Ownership: Private

Type Ib

Kuapā was 1420 feet long, 9 feet wide and 9 feet high; 3 makahā; outer face of kuapā was large stones; inner face of pebbles.

Ratings:

Final Rating: Less than 1.00

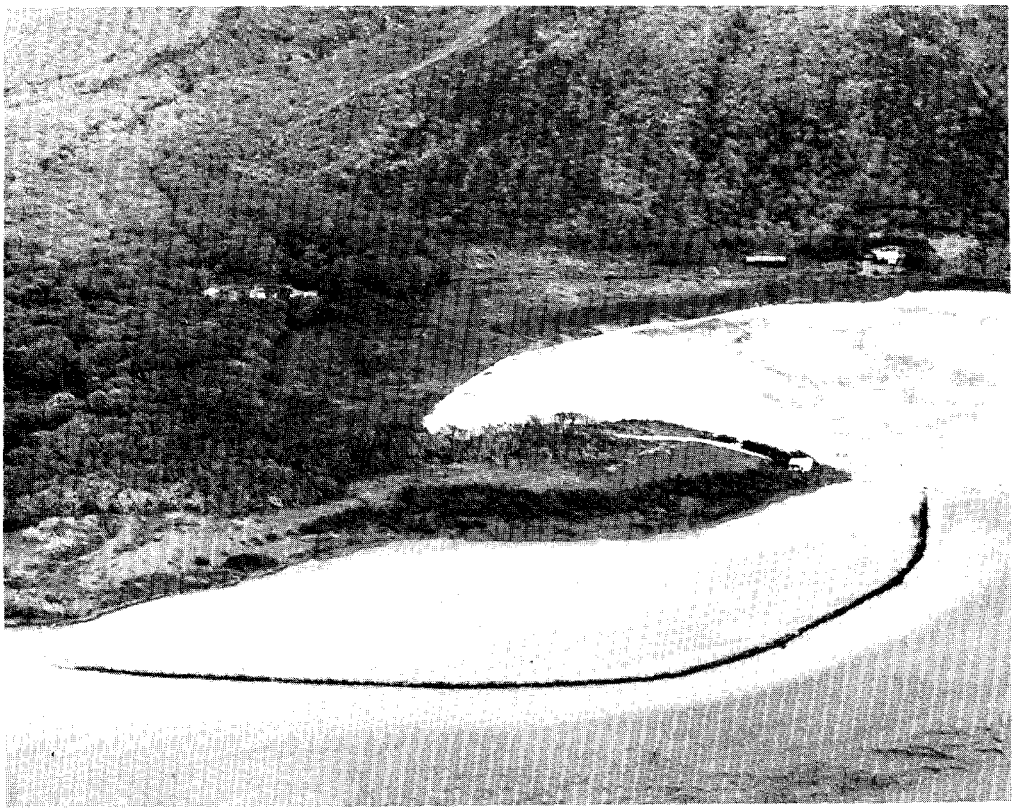


Fig. 53 Kaloko'iki pond, Feb. 20, 1971. Neg. # Photo by George Bacon #23, 2/20/71 Pond 28.

D16 KALOKO'IKI, at Wawaia, Moloka'i
USGS Quad: Kamalo
Tax Map Key: Portion of 5-6-08-20
Acreage 6 (?)
Ownership: Private

Type Ia

Kuapā was 1600 feet long.

Ratings:

Final Rating: Less than 1.00

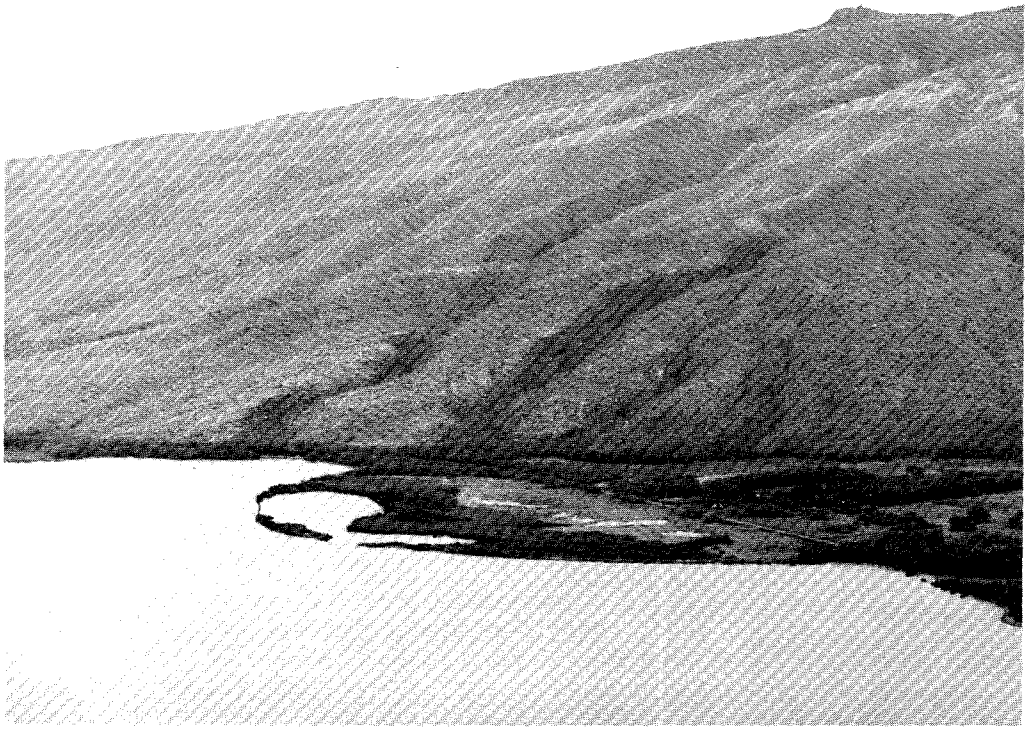


Fig. 54 Kamahu'ehu'e pond, May 22, 1974. Neg. # NPS - Moloka'i 0-18.

D22 KAMAHU'EHU'E, at Kamalo Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-5-02-5
Acreage 37 (?)
Ownership: Private

Type Ia

Kuapā was 3470 feet long; 2 makahā.

Ratings:

Final Rating: Less than 1.00

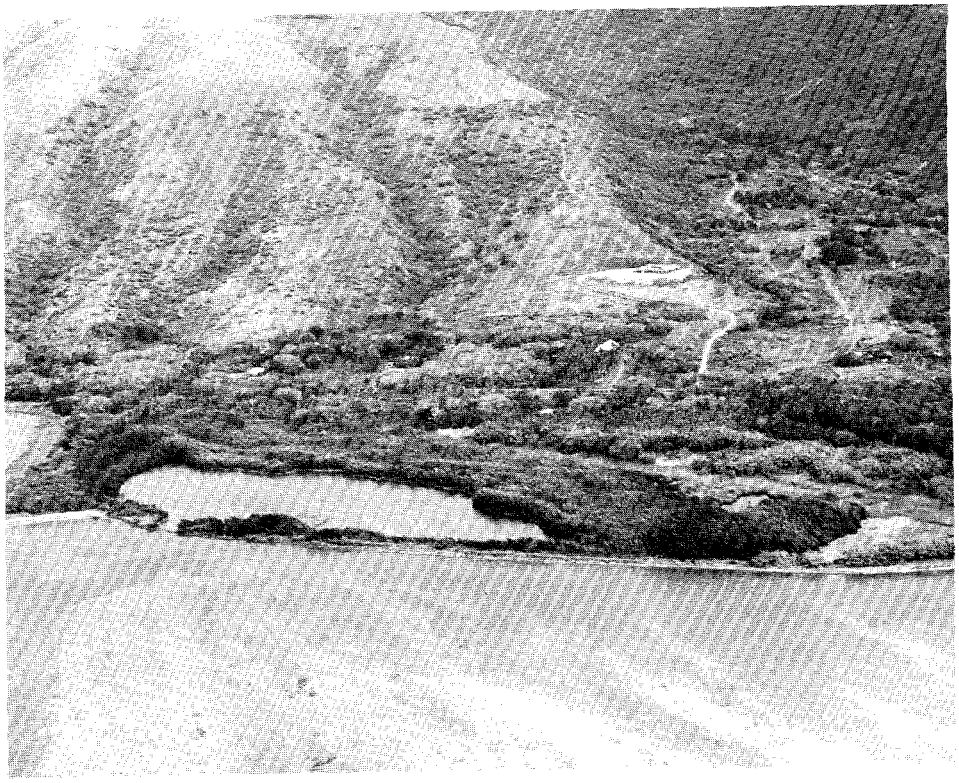


Fig. 55 Pi'opi'o pond, Feb. 20, 1971. Neg. # Photo by George Bacon 9, 2/20/71 Pond 43.

D56 PI'OPI'O, at Mapulehu, Moloka'i
USGS Quad: Halawa
Tax Map Key: 5-7-08-77
Acreage 17 (?)
Ownership: Private

Type Ia_2

Kuapā was 1156 feet long; 1 or more makahā.

Ratings:

Final Rating: Less than 1.00

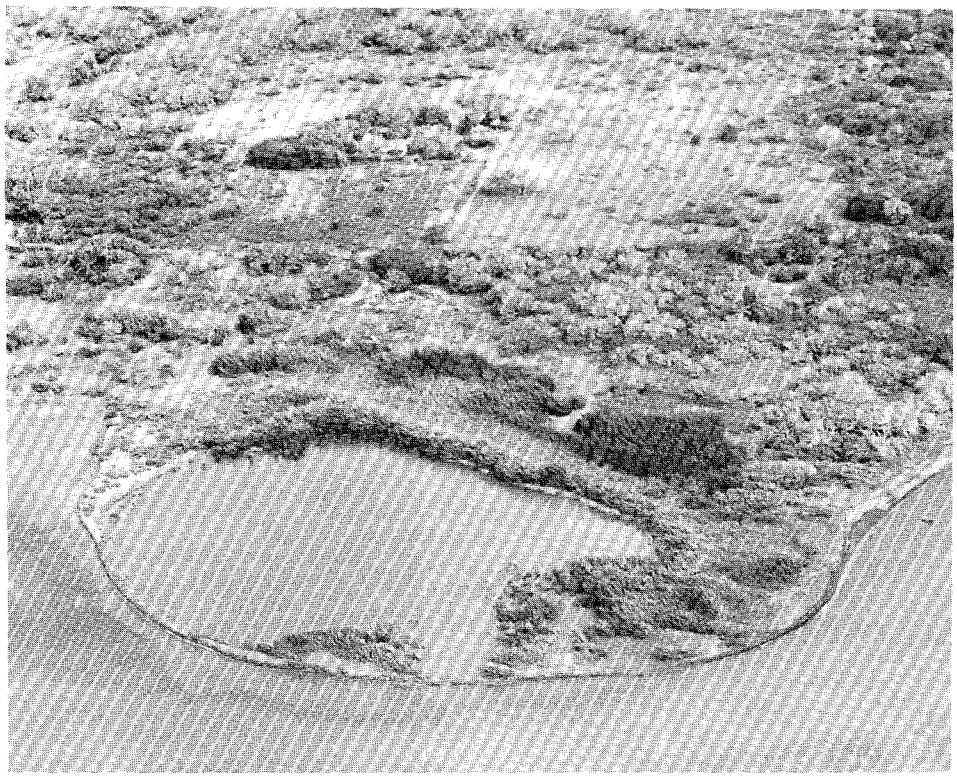


Fig. 56 Pūhāloa pond, Feb. 20, 1971. Neg. # Photo by George Bacon 16, 2/20/71, Pond 36.

D57 PŪHĀLOA, at Manawai, Moloka'i
USGS Quad: Kamalo
Tax Map Key: 5-6-04-29
Acreage 6 (?)
Ownership: Private

Type Ia

Kuapā was 1245 feet long; 2 makahā.

Ratings:

Final Rating: Less than 1.00

Fig. 57 Lokowaka pond, May 22, 1975. Neg. # NPS - Hawai'i 1-30. Note Hilo airport runway in background.

H45 LOKOWAKA, at Hawai'i
USGS Quad: Hilo
Tax Map Key: Portion of 2-1-16-1
Acreage 51 (?)
Ownership: State of Hawai'i

Type II

The mo'o was named Waka.

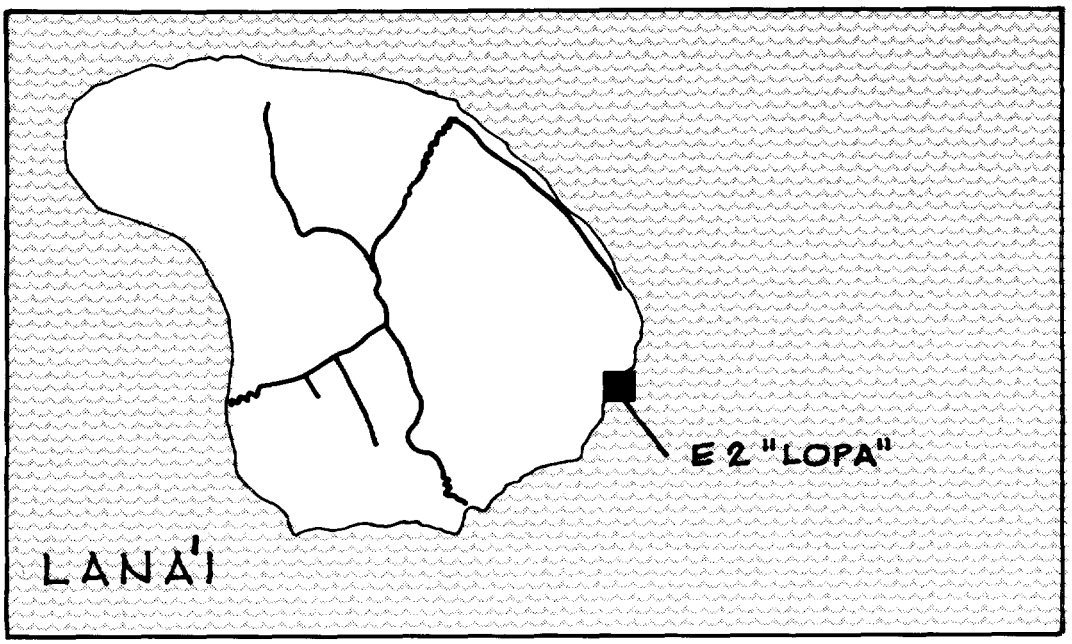
Ratings:

Final Rating: Less than 1.00

APPENDIX A

The following royal fishpond remnants, identified by island, are believed to meet the criteria outlined by the National Register. Further, they contain sufficient physical features and artifactual identity to warrant nomination to the National Register of Historic Places.

ID #	Type	Name, location	
		Lana'i Island	
E2	II	nameless	Lopā, Kaohai
		(Plate 5)	
		Ni'ihau Island	
A1	IIa_1	nameless	Halulu (lake)
		(Plate 5)	



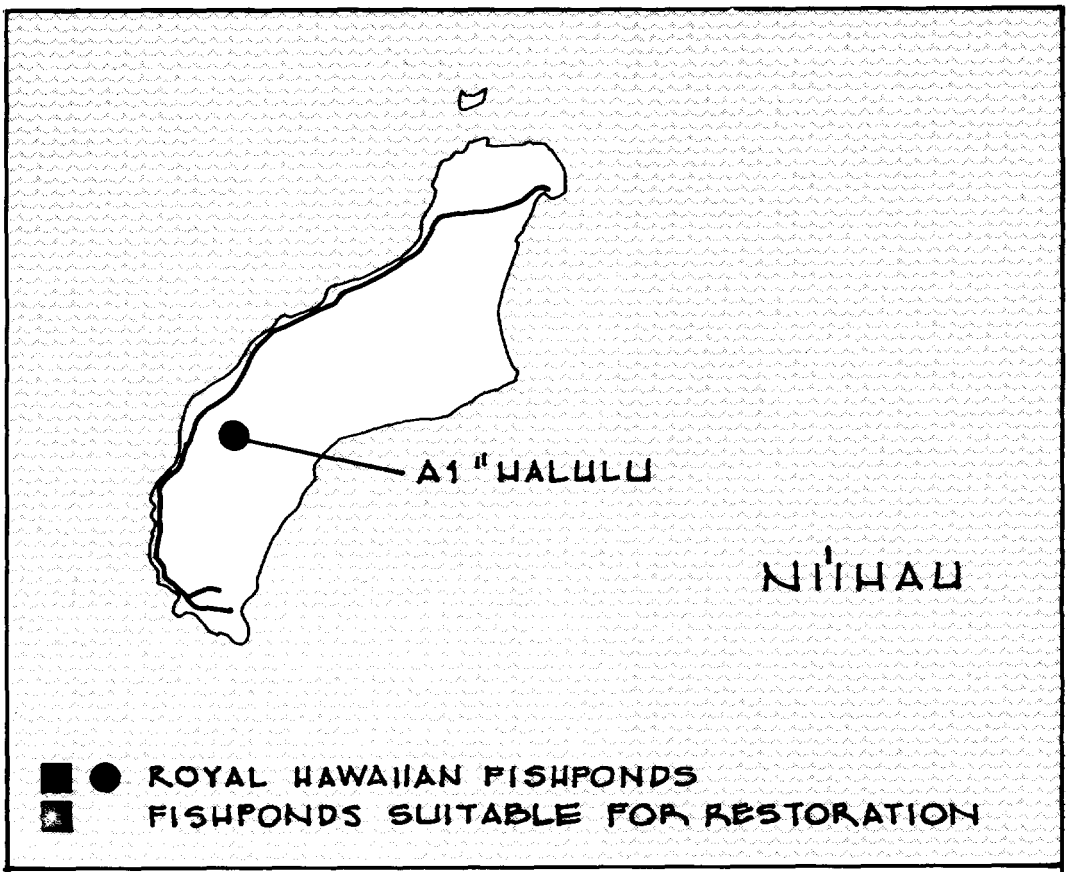


PLATE no. 5 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

Kaua'i Island

B18	IIIc	Nomilu	Kālaheo-kai
B2	IIIb	Alekoko	Nawiliwili
B4A	IIIa	Kanoa	Hanalei
B15	IIIb	nameless	Lāwa'i-kai
B22A,B	II	nameless	Coco Palms, Wailua
B6	II	nameless	Kuhio park, Ho'ai, Koloa
B10D	II	Ke'e	Wet cave area, Hā'ena

(Plate 6)

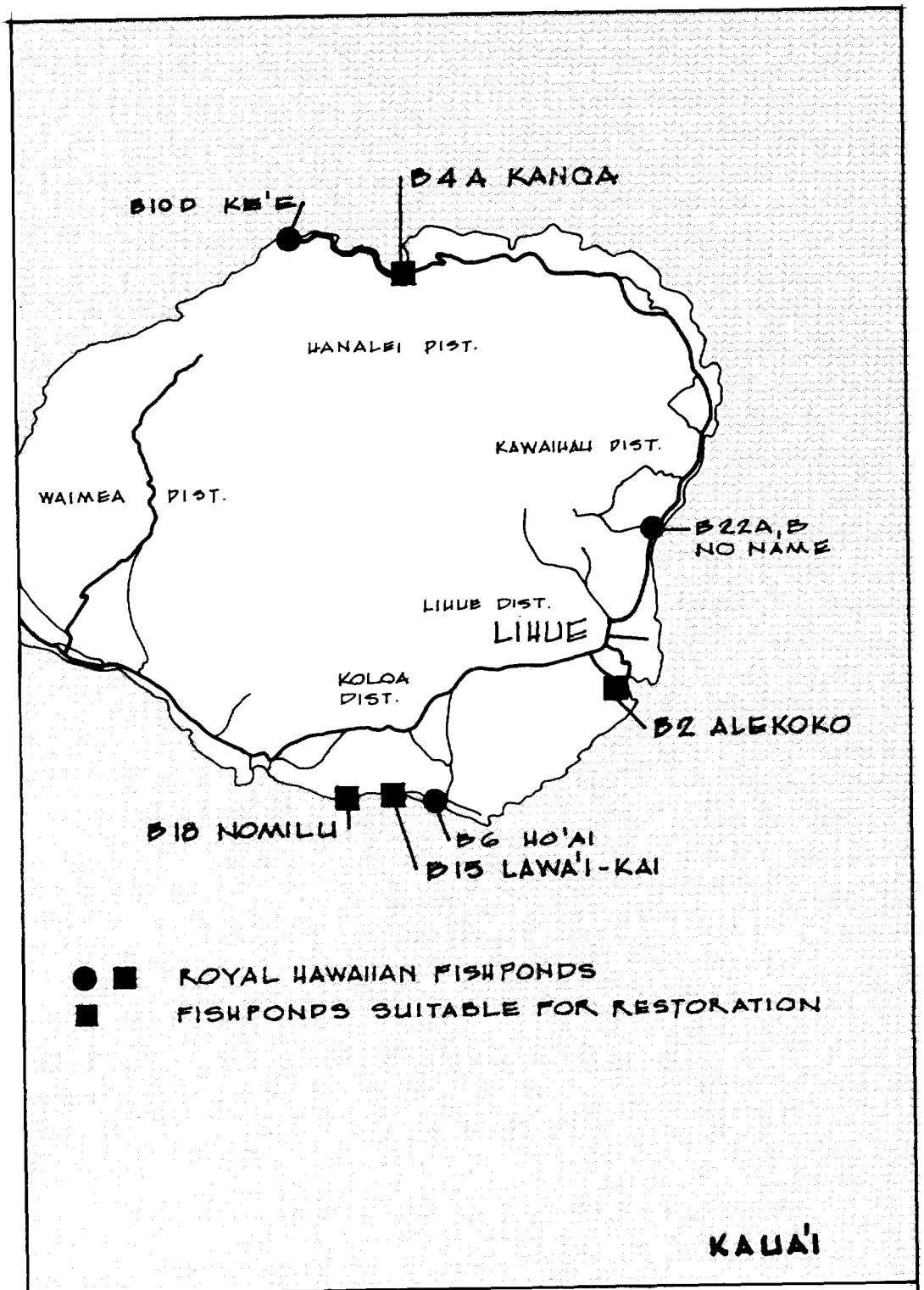


PLATE no. 6 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

O'ahu Island

C112	Ia_1	Mōli'i	Kualoa, Ko'olaupoko
C43	IIIa	Kalouwai	Waiale'e, Ko'olauloa
C144	IIIb	Pūkoko	Kahana, Ko'olaupoko
C82	II	Koholālele	Kualoa, Ko'olaupoko
C15	Ia	He'eia'uli	He'eia, Ko'olaupoko
C18	Ia_1	Huilua	Kahana, Ko'olaupoko
C93	Ia	Laulaunui	Honouliuli, Pearl Harbor
C21	Ia_2	Ka'auku'u	Waikele, Pearl Harbor
C117	Ic	Okiokilepe	West Loch, Pearl Harbor
C123	Ib	Pa'aiau	Kalauao, Pearl Harbor
C153	Ib	Waikalua	Waikalua, Ko'olaupoko
C50	Ia_2	Kanohuluiwi	Kane'ohe, Ko'olaupoko
C130	II	"Paiko"	Kuliouou, Honolulu

(Plate 7)

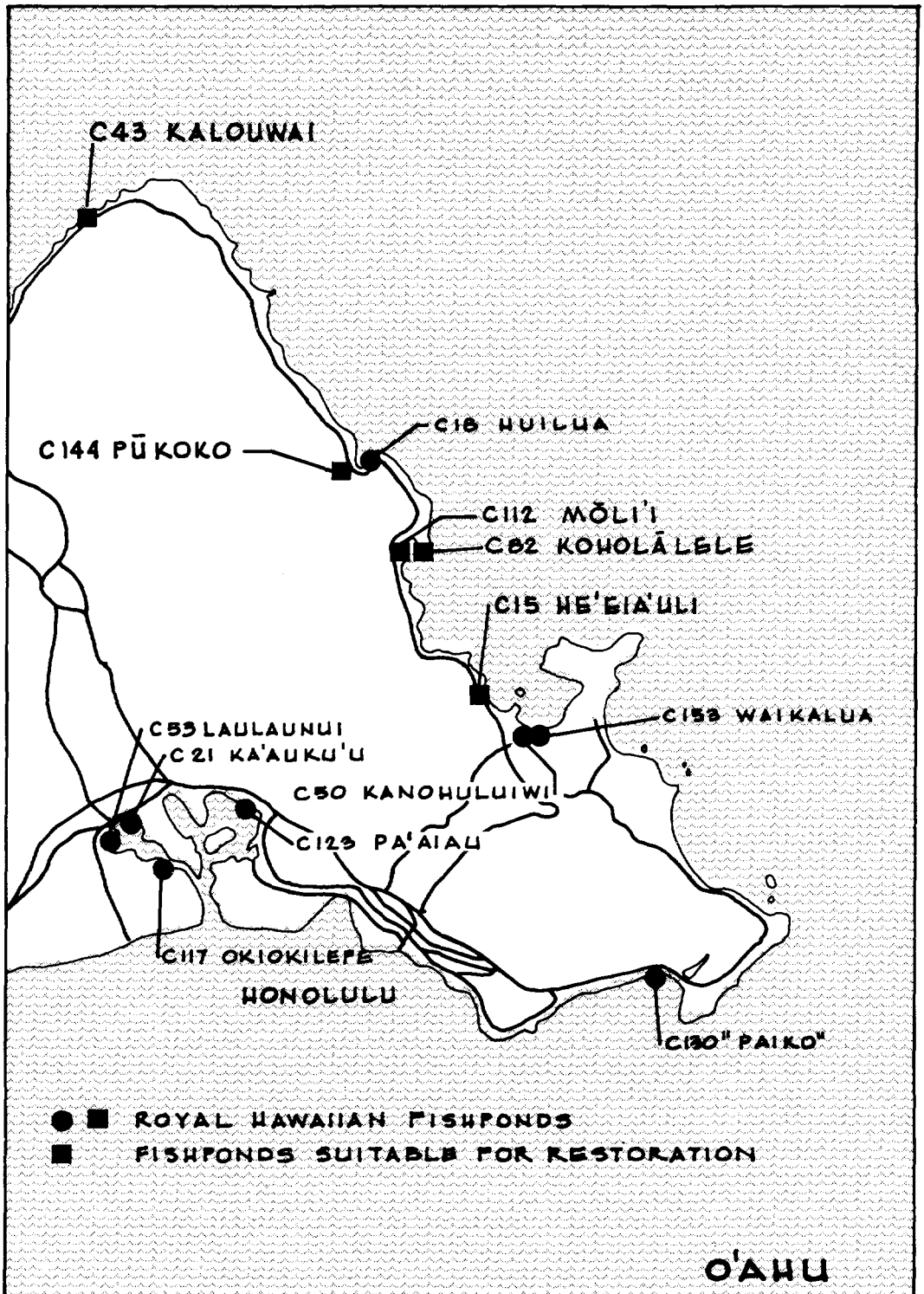


PLATE no.7 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

Moloka'i Island

D12	Ia_1	Kaina'ohe	Ka'amola
D61	Ia	'Ualapu'e	'Ualapu'e
D15	Ia	Kaloko'eli	Kamiloloa
D38	Ia_1	Kupeke	Kupeke
D43	Ia	Ni'auhala	Kalua'aha
D34	Ia_1	Keawanui	Kalaeloa, Keawanui
D49	Ia	Pahiomu	Keonoku'ino
D2	Ia	Ali'i	Makakupaia I
D24	Ia	Kanoa	Kawela
D36	Ia	Kipapa	Keonoku'ino
D29	Ic	Ka'ope'ahina	Kalua'aha
D16	Ia	Kaloko'iki	Wawaia
D35	Ia	Kihaloko	Aha'ino II
D37	Ia	Kula'ahamihi	Honomuni
D66	Ia_3	Waihilahila	Ka'ili'ula
D22	Ia	Kamaku'ehu'e	Kamalo
D57	Ia	Pūhāloa	Manawai
D56	Ia_2	Pi'opi'o	Mapulehu

(Plate 8)

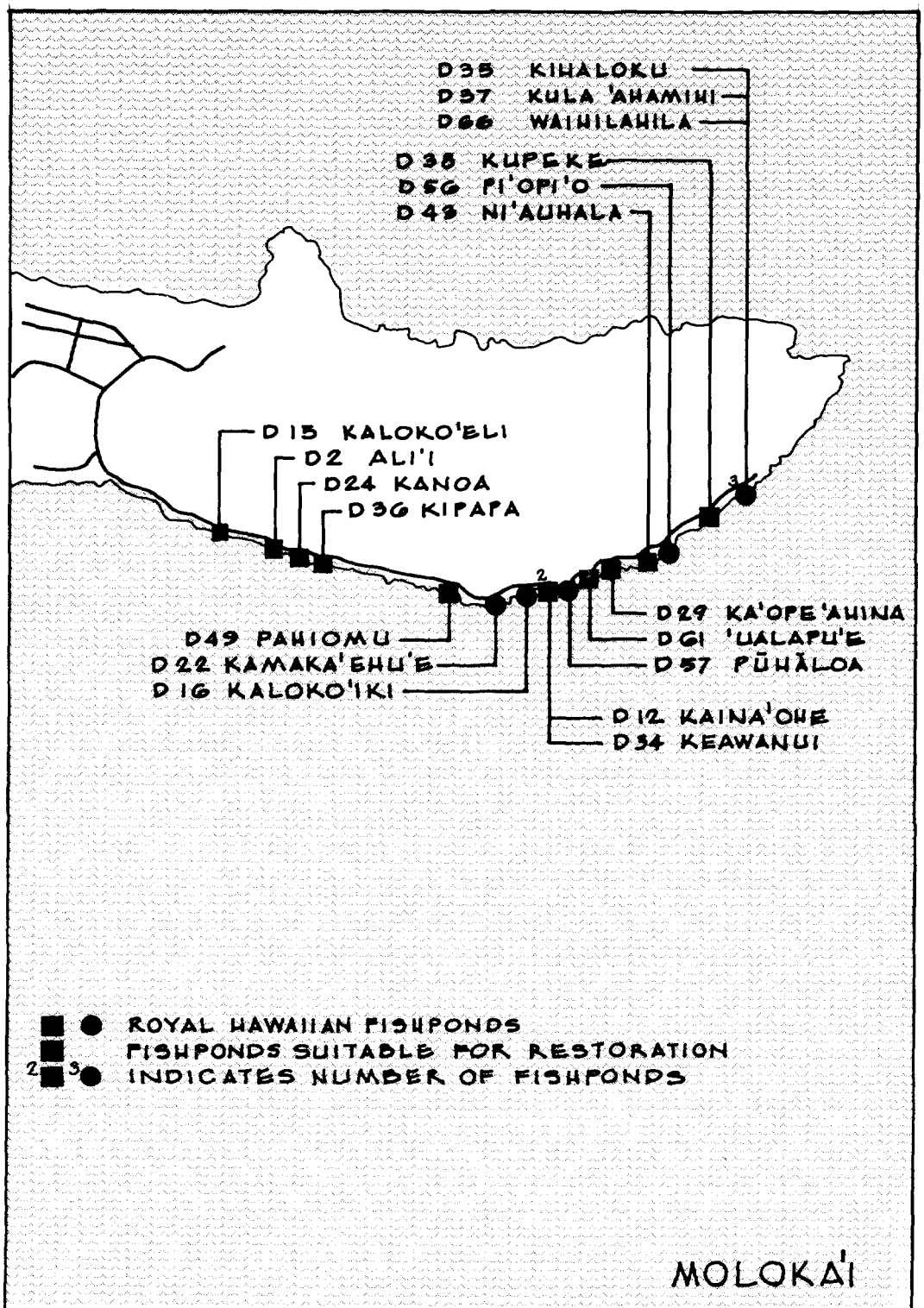


PLATE no.8 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

Maui Island

F3	Ib	Kaloko-nui	Haneo'o, Hana
F3A	Ia_1	Kaloko-iki	Haneo'o, Hana

(Plate 9)

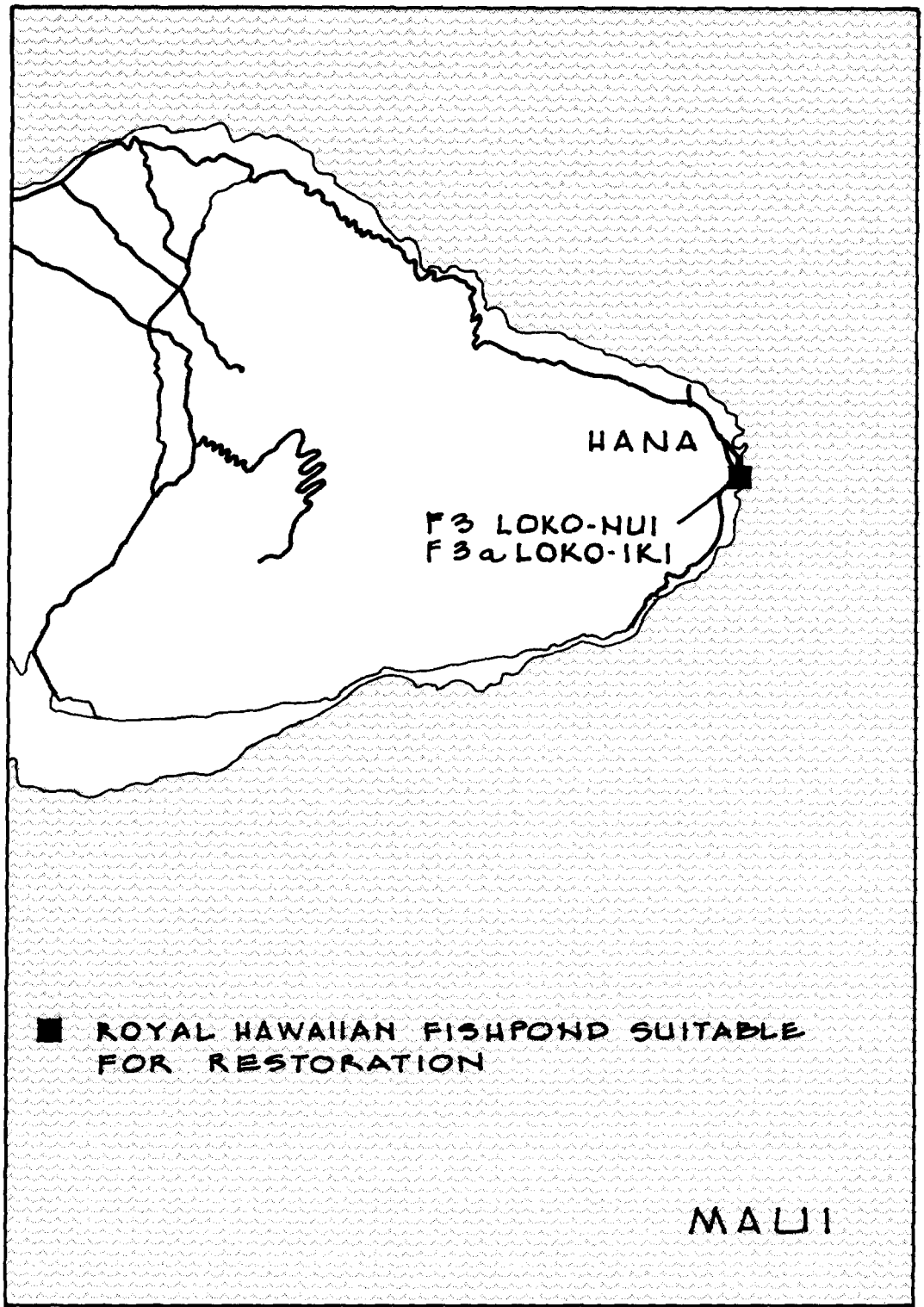


PLATE no. 9 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

Hawai'i Island (Western)

H41	Ib	Lahuipua'a*	Kalahuipua'a, Kohala
H21	II	Kahapapa**	'Anaeho'omalu, Kona
H2	Ia_1	'Aiopi'o	Honokohau I, Kona
H28	II	nameless	Ka'upulehu, Kona
H34	II	Kiholo	Pu'uwa'awa'a, Kona
H24	Ib	Kaloko	Kaloko, Kona
H54	II	'Opae'ula	Makalawena, Kona
H1	II	'Aimakapa'a	Honokohau II, Kona

(Plate 10)

* includes H17, Hopeaia; H20, Ka'aipio; H22, Kahinawao; H49, Manoku; H70, Waipuhi.

** includes H40, Ku'uali'i.

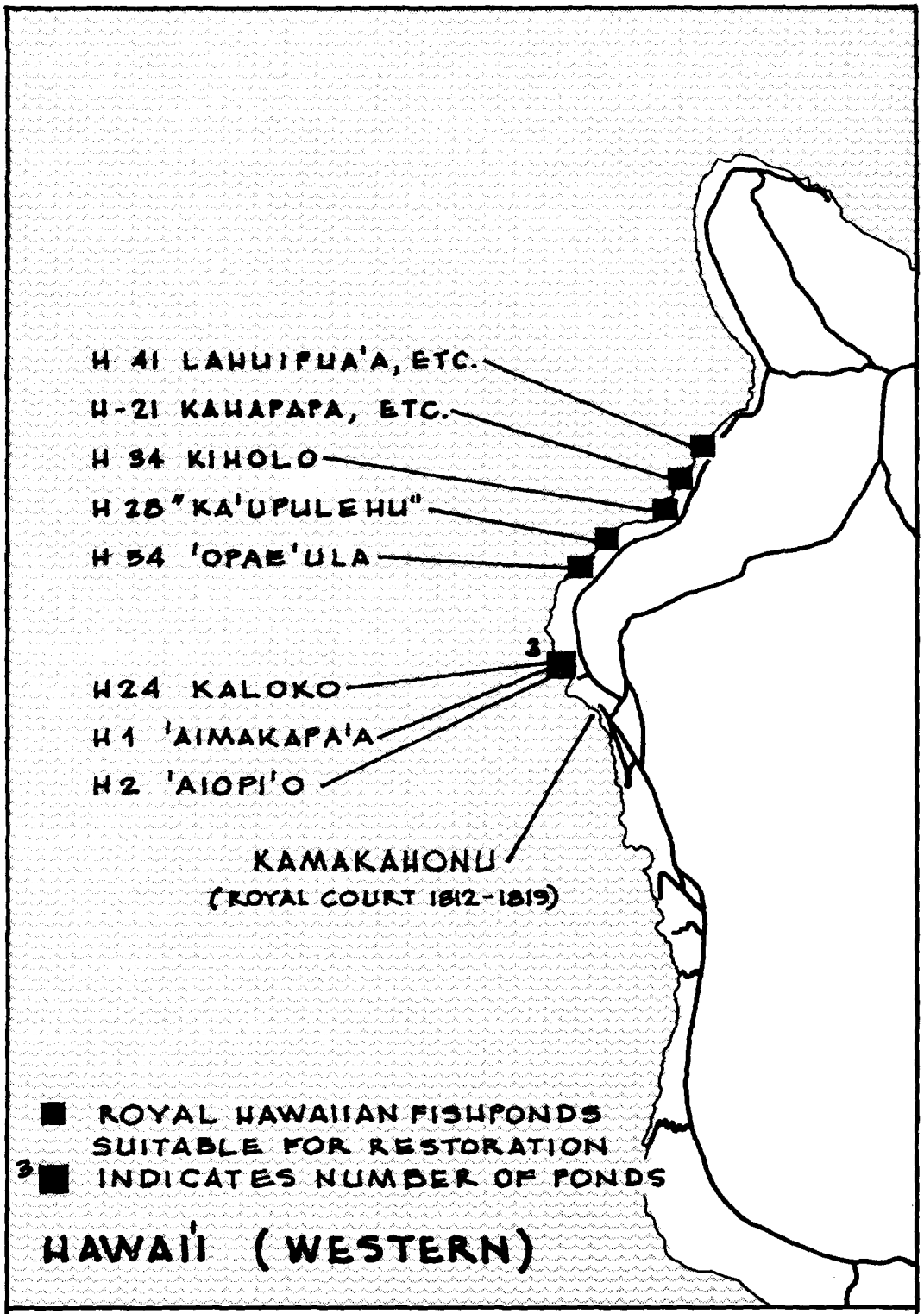


PLATE no.10 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

Hawai'i Island (Eastern)

H19	II	'Ilo'i	Punalu'u, Ka'ū
H52	Ic	Ninole*	Ninole, Ka'ū
H16	Ib	nameless	Honu'apo, Ka'ū
H16A	Ib	nameless	Honu'apo, Ka'ū
H45	II	Lokowaka	Keaukaha, Waiakea, Hilo
H29	II	nameless	Kawa'a, Hanai, Ka'alaiki, Ka'ū

(Plate 11)

* includes H53, nameless.

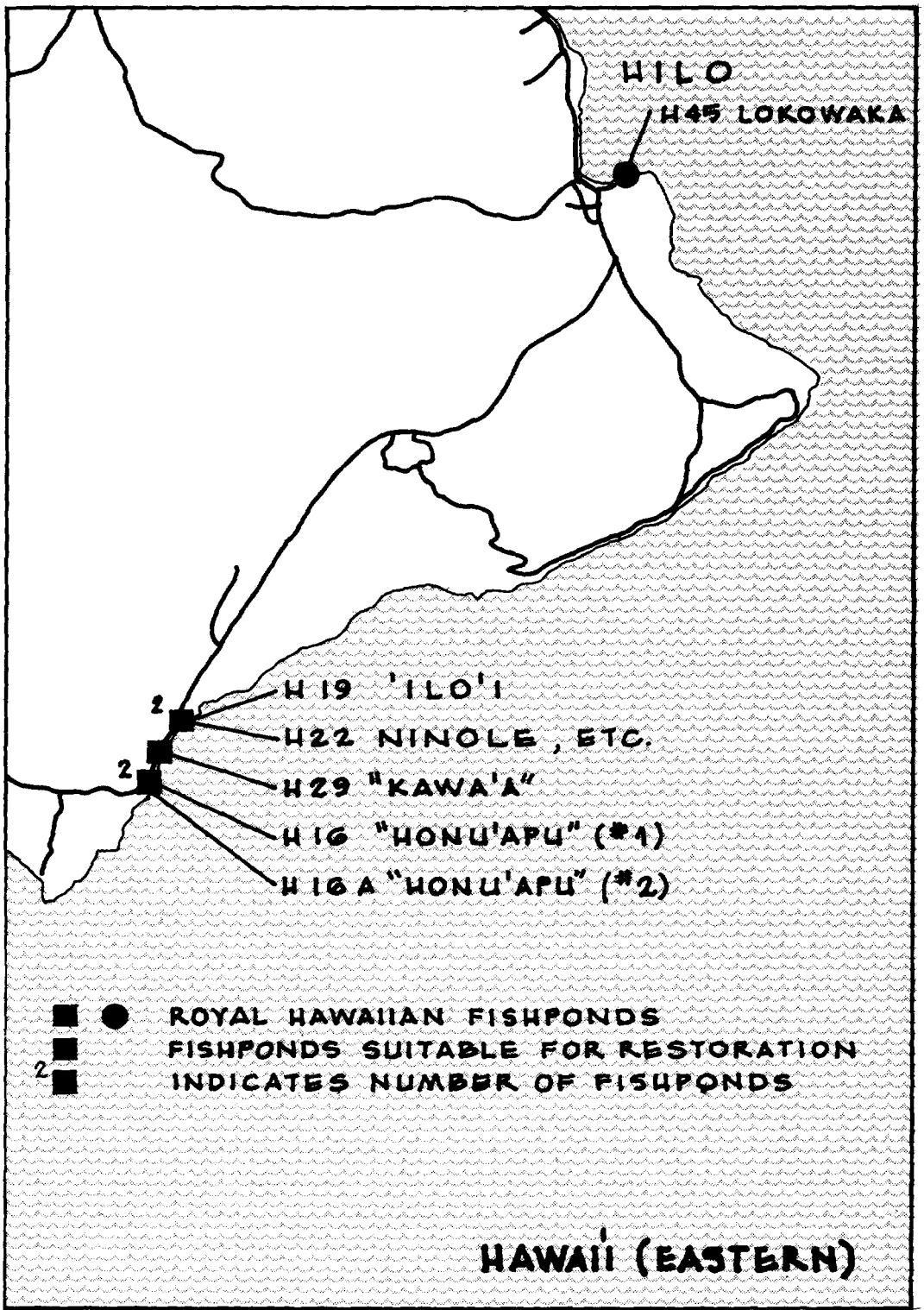


PLATE no. 11 GENERAL LOCATION OF SELECTED FISHPOND REMNANTS

APPENDIX B

Fishtraps Recommended for Preservation

Lana'i Island*

E1	V	Ka'a (2 outward lanes)	Palawai

Moloka'i Island**

D32	V	Kaunahiko'oku (2 inward, 9 outward lanes)	West Ohia
D40	V	Mikiawa (16 inward, 9 outward lanes)	Ka'amola
D67	V	nameless (4 inward, 4 outward lanes)	Wawaia
D27	V	Kunukunukuawa (6 inward, 7 outward)	Kapuaoko'olau

* see USGS map "Island of Lanai"

** see USGS Topographic Quadrangle "Kamalo"

Note: All fishtraps are in disrepair and not operating. Ka'a on Lana'i Island is in best condition. The fishtraps on Moloka'i Island have walls in 1975 that are below water. These five fishtraps are believed to have the best surviving structural integrity of this type of Hawaiian aquacultural device.

GLOSSARY

a'a	clinker-type lava
'Ai'ai	son of the fishgod Kū'ula-kai and fish goddess Hina; also a fishgod himself
'aoa	fishing shrine associated with a royal fishpond
ahupua'a	principal land division, usually extending from the uplands to and including adjacent offshore waters
ali'i	high royalty, humans related to the major gods
'aumakua	family or personal god, often in form of owl, shark, eel
'auwai	sluice
'auwai-kai	ditch which connects a fishpond to the sea
'auwai o ka makahā	sluice which contains a makahā
'awa	root of the Piper methysticum prepared with ritual as a drink to be offered to the gods through a high chief
hale kia'i	guard house on the kuapā of a fishpond, usually adjacent to a makahā
haku-'ohana	senior male head of a large extended family of commoners
Hina	major goddess of fishermen, worshipped in the afternoon
'ili	land section, usually a subdivision of an ahupua'a
Kanaloa	one of the four major gods. The 'ama'ama (mullet) followed him from Tahiti to Hawai'i

Kane	One of the four major gods. The 'ama'ama (mullet) followed him from Tahiti to Hawai'i
kapu	taboo, prohibition, sacredness, forbidden. Violation usually punished by death
kauwā	pariah, outcast, caste which lived apart and often drawn upon for human sacrifices; slave
kia'i loko	keeper of a royal fishpond
ko'a	fish shrine
kō'ele	royal garden, farmed by a tenant for a chief. Land and products taboo to commoners
konohiki	resident land manager of an ahupua'a, appointed by landlord chief
kope'ohe	weighted bamboo rake, towed behind canoe to stir bottom sediments
kuapā	also pā, seawall, or any wall which separates fishpond waters from sea or river
Kū'ula-kai	major god of fishermen, worshipped in the morning
Ku	one of the four major gods, in the form of Kū'ula-kai was a god of fishermen
lepo	decomposed rock, earth, dirt
loko	generic term for any type of pond
loko haku'one	see loko pu'uone
loko i'a kalo	also loko lo'i kalo, Type IV, a fishpond which utilizes an irrigated taro plot
loko kuapā	Type I, a fishpond of littoral waters whose side or sides facing the sea consist of a stone or coral wall usually containing one or more makahā

loko lo'i kalo	see loko i'a kalo
loko pu'uone	also loko haku'one, Type II, an isolated shore fishpond usually formed by the development of barrier beaches building a single, elongated sand ridge parallel to the coast and may contain one or more ditches and makahā
loko 'ume'iki	Type V, a fishtrap similar to a loko kuapā and has numerous stone-flanked lanes which lead fish into netting area with the ebb and flow of the tide
loko wai	Type III, an inland fresh water fishpond which is usually either a natural lake or swamp, which can contain ditches connected to a river, stream, or the sea, and which can contain makahā
Lono	one of the four major gods
makahā	sluice grate
mana	spiritual, supernatural and divine power
menehune	mythical, supernaturally endowed dwarfs
moku	district, usually containing numerous ahupua'a
mo'o	supernatural lizard, always female, frequently a fishpond guardian
pā	see kuapā
pahoehoe	ropy, molasses-like lava surface
pohaku	generic term for any type of rock from boulder to pebble
taro	kalo, Colocasia esculenta, Hawaiian staple, starchy corm cooked, mixed with water and eaten as poi

'ula-pa'a	preadolescent child of either sex, ceremonially pure
waihau	a temple for fish and fishing with major geographical influence

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