Prehistoric Hawaiian Fishponds

Indigenous aquaculture influenced the development of social stratification in Hawaii.

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Ever since the discovery of the Hawaiian Islands by Captain James Cook in 1778, Polynesian and Hawaiian specialists have been intrigued by the factors that caused the development of the highly stratified chiefdoms found in the Pacific. The cultures of Hawaii, Tonga, Samoa, and the Society Islands were structurally complex, with well-defined status separating the high chiefs, chiefs, advisers, stewards, and commoners. Of these island groups, Hawaii had the most highly stratified society. If we assume that all of the cultures of Polynesia are ancestrally related and that they all share a common linguistic, technological, and agricultural base, then the question arises of why a high level of complexity was achieved in only these four island groups.

Wittfogel (*1*) claims that irrigation systems had a direct influence on the emergence of political power and on the development of a statelike government. Fried (*2*) states that in Hawaii the control of water resources was used to bolster control over the land. According to Sahlins (*3*), the control of water resources was achieved by restricting access to irrigation water rather than to the land. Sahlins attributes the evolution of political stratification to technological and environmental factors. All of these authors imply that the development of bureaucracy in the Hawaiian Islands resulted in part from the control of water sources, specifically, irrigation systems, rather than from the direct control of land.

The word irrigation implies agriculture. Of the many theories concerning the development of Hawaiian culture, most center around the productivity of the agricultural system. The system of ditches that fed and drained the taro (*Colocasia esculenta*) plots is always seen as proof of engineering and agricultural skills. I suggest, however, that there is another important area in the study of the complexity of Hawaiian culture. This is the aquacultural system, which I do not see as an entity in itself but as one end of a continuum of food production technologies (Fig. 1). The fishpond system paralleled the agricultural irrigation system in many ways; that is, it dealt with the access to, restrictions on, and management of water resources. In this article I attempt to place the fishpond into such a context—to describe both its technological and political roles in culture.

Strung along the southern shore of the island of Molokai are a series of prehistoric fishponds whose remains can still be seen within the calm shoal waters. These remnants are only a fraction of the extensive aquacultural system that was evident on all of the major inhabited islands of the Hawaiian archipelago around the turn of the 20th century. Over the years, the ravages of high seas, tsunamis, floods, earthquakes, lava flows, and tectonic activities have greatly altered most such sites. Quite recently, fishponds have been filled and destroyed by commercial and industrial development. Some of the sites are now fringed with houses and industrial parks—foreign and incompatible environments that exhibit these sites as oddities, fossils of the past. Nonetheless, in isolated regions of the Islands a few fishponds can still be found in a relatively pristine environment.

Origins

The date for the origin of Hawaiian fishponds will probably never be known. It certainly is not within the reach of traditional archeological dating techniques. Mythological and legendary sources are the only means currently available for gauging the antiquity and the nature of the origin of fishponds.

The builder of the first Hawaiian fishpond is traditionally acknowledged to be Kū-'ula-kai, who lived in an undated period of the Heroes and Gods. Kū-'ula-kai constructed the fishpond at Kaiwiopele in the district of Hana on the island of Maui (*4*). According to mythological sources (*5*), the fishponds of Alekoko and Nomilu on the island of Kauai were built during the period of the mythical Hawaiian dwarf-elves, the menehune. Associated with them is Chief Ola, whose historical placement remains unknown but who is alleged to have ruled in very ancient times. The fishpond is commonplace in legendary literature attributed to the 14th through the 19th centuries; therefore it can be conjectured that fishponds appeared in the Hawaiian Islands sometime prior to the 14th century A.D.

A survey (*6*) of aquacultural features in Oceania reveals a lack of true fishponds (that is, bodies of water primarily intended for the raising of fish), with the exception of ponds in the Gilbert Islands, where further study is needed. I propose that coastal fishponds in Hawaii evolved from irrigated agricultural plots, lo'i kalo, and became one end of a continuum of a basically agricultural, wet-plot system. On the basis of the barest and most questionable evidence from traditional material, I also propose that the fishpond was an independent Hawaiian innovation.

Typology

Four basic types of fishponds were developed by the prehistoric Hawaiians: loko i'a kalo, loko wai, loko pu'uone, and loko kuapā (Fig. 2). The prefix loko refers to any pool, pond, lake, or other enclosed body of water (*7*), while the suffixes denote the specific type of fishpond. Although there were many variations within each type, the Hawaiians do not seem to have used separate names to identify subtypes.

Loko i'a kalo were irrigated agricultural plots for the growing of selected fish (i'a), such as aholehole (*Kuhlia sandwichensis*) and 'o'opu (*Eleotridae* and *Gobiidae* families), and of taro (kalo). Like other irrigated agricultural plots, loko i'a kalo were fed and drained through a system of ditches. Some of the fishponds were simply agricultural plots in inland areas or along the shore where both taro and fish could tolerate the varying degrees of water salinity.

Loko wai were inland ponds and lakes, usually found close to the shore. Since they most often had natural connections to the sea by way of ditches or

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streams, these fishponds, although called freshwater (wai) by the Hawaiians, would have been partially brackish because of tidal action. Aholehole; 'o'opu; amaama, or mullet (*Mugil cephalus*); awa (*Elops machnata*); and awa'aua, or milkfish (*Chanos chano*), all tolerant of both fresh and brackish water, were some of the fish raised in loko wai.

Loko pu'uone were coastal bodies of water that had been either stranded because of eustatic sea-level changes or isolated through the formation, by sea action, of loose, irregular walls (pu'uone) of sand and coral detritus. The permeability of the walls allowed seawater to percolate through, while freshwater springs along the shore provided internal seepage. Because of their proximity to the sea and because of their water salinity, loko pu'uone resembled natural estuarine habitats. Their fish were preferred as delicacies because the native Hawaiians believed that brackish to salt water produced a more savory fish than did freshwater.

Usually located in shallow shoal areas along the coast were loko kuapā, fishponds whose primary isolating feature was a wall of stone, coral blocks, or both as the backbone (kuapā). The kuapā core, usually of stone, was purposely made permeable in order to effectively absorb the forces of its containing body of water (either the sea or a river) while allowing a limited amount of water to flow through to reduce stagnation. Where the core was of earth, such as that found in loko i'a kalo or loko wai fishponds, other means of allowing water circulation were needed because the earth prevented water from entering or leaving the pond.

Geomorphological Consideration

A positive correlation exists between the geography and geomorphology of an island and the type, size, shape, and location of a fishpond (*8*) (Fig. 3). The favorable geographical features sought by the ancient engineer-architects were shallow shore areas protected by long fringing reefs, natural bodies of water inland or along rocky rugged coastlines, barrier beaches with large bodies of water trapped behind them, and shore areas with seepage of freshwater through natural springs, streams, or rivers. A survey of the aquacultural system of prehistoric Hawaii (*6*) suggests that ancient Hawaiians utilized practically all sizable bodies of water for the construction of fishponds.

Architectonic Features

Each of the fishpond types had some distinguishing architectonic feature, for example, a primary wall, secondary walls (pā), or ditches ('auwai) and their accompanying sluice grates (makahā). All of these were permanent and nonmobile in nature. In a recent study of selected fishponds (*6*), the mean width and height of 37 pond walls was computed to be 2.02 meters wide by 1.17 meters high, and the average length and volume of 90 pond walls was determined to be 487.68 meters and 954.9 cubic meters, respectively (*6*). The volume of the most massive seawall (kuapā), that of Kaloko fishpond on the island of Hawaii, was calculated as 4248.08 cubic meters. In comparison, secondary walls were small and crudely constructed. While seawalls were intended to withstand the forces of erosion and to hold the fishpond intact over long periods of time, secondary walls served to partition the calmer interior waters into aquatic pens.

The Hawaiians made a distinction between ordinary ditches ('auwai) and those associated with the seawall ('auwai o ka makahā). 'Auwai were channels, usually a meter or two wide, that connected the fishpond with outside sources of water. These features served to allow circulation of water while introducing dissolved nutrients from without. 'Auwai o ka makahā, on the other hand, consisted of that short portion of the ditch that passed through the seawall; these were always associated with the makahā, or sluice grate. Sluice grates were stationary structures that consisted of spaced, vertically placed wooden sticks lashed to two or more horizontally placed sticks; these were placed in the ditch to act as a sort of filter for debris and large fish.

The number and location of sluice grates seems to have been a function of the size of the fishpond and of the prevailing current patterns. Most often there were two grates. A shelter for the caretaker, hale kia'i, was associated only with the loko kuapā type fishpond. These small rudimentary shacks were placed adjacent to the sluice grate area in order to provide the caretaker with some protection against the elements while he guarded against poachers.

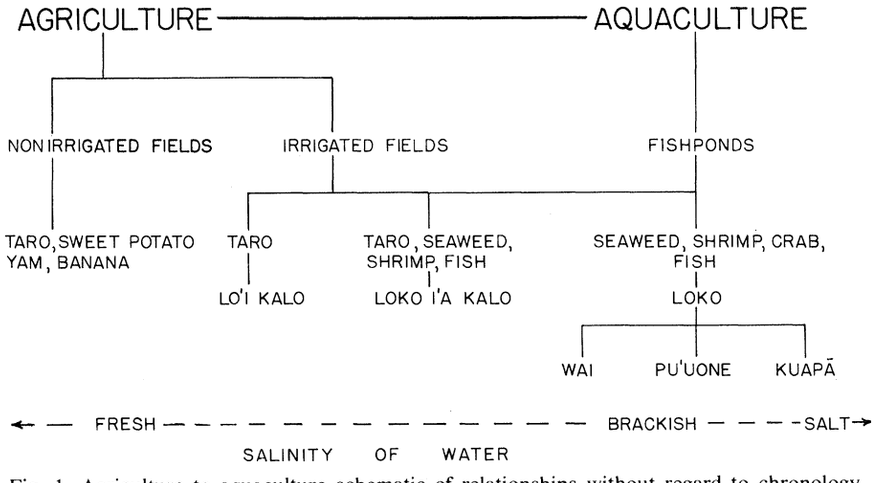

Fig. 1. Agriculture to aquaculture schematic of relationships without regard to chronology. The products of both systems are shown as a function of emphasis, with agriculture and aquaculture as extreme ends of resource management.

Cultural Significance

The prehistoric Hawaiian fishpond is an innovation not seen in other cultural areas of Oceania. Its evolution from a simple technological device into a symbol of status and power is significant from the vantage point of the development of stratified societies in the Pacific.

The universe of the native Hawaiian was a delicately balanced, tri-state system of the supernatural, the natural, and the cultural. Intertwined and integrated with one another, these three influences permeated every aspect of Hawaiian life. There were four "national" gods—Kū, Kane, Kanaloa, and Lono—who, with a multitude of demigods and guardian spirits, manifested themselves in every form of nature, from rocks and plants to atmospheric phenomena and running water. These served as constant reminders of the sanctity of all forms of earthly matter.

Complementing the gods were the

ali'i, or chiefs, whose status within the highly stratified order of nobility was determined by their genealogical proximity to the gods. Pedigree as well as privilege was correlated with individual linkage to both genealogy and the rights from conquest. Since each god had supernatural power, the human counterparts also possessed this mana, power bestowed directly or indirectly from a supernatural source (*9*), but in lesser degree.

There were two types of chiefs that were associated with fishponds: the ali'i-'ai-moku, or paramount chief, and the ali'i-'ai-ahupua'a, who were lower chiefs of land sections, or ahupua'a. All of the land with its resources and produce was owned by the paramount chief. Specific fishponds, in particular those noted for their antiquity or productivity, as well as all major temples, were also owned and controlled by the paramount chief as manifestations of his supreme rights, including his right of ownership and his right to rule. Other fishponds were feudalistically contracted to the chiefs of the various land sections, who, in turn, probably left control of the smaller fishpond-agricultural plots (loko i'a kalo) to the commoners. If this ownership pattern was in fact common in prehistoric Hawaii, a paucity of sites would be expected around fishponds.

A study (*6, 10*) was made of the published archeological surveys of ten fishponds and their surrounding archeological remains to determine the nature of the settlement pattern around them. These sites (*11*) are the only ponds left in the Hawaiian Islands which have not been denuded of their archeological sites during the course of historical coastal development. The features that are directly associated with fishpond activity and that are consequently to be expected around ponds are canoe sheds, net-drying areas, the caretakers' house sites, and burial platforms. The number of sites expected is small, and they should be widely distributed over the landscape.

Canoe sheds were discovered only on the inland side of Kaloko fishpond on Hawaii Island and were diagnostic of other structures with stored canoes. Enclosures and mounds lined with stone, common structures for the cultivation of sweet potatoes and yams, never occurred in large numbers but were scattered where the bedrock allowed soil and humus to collect. A total of 24 house sites was found at seven fishponds, for an average of more than three per pond. The mode was two, while the largest number of house sites found at one fishpond was seven. This is a very small number, in view of the fact that a typical Hawaiian house site was a complex usually composed of two or three separate structures. Other features found near the fishponds were platforms, burial mounds, shelters, and walls. Such features ranged from 12 to 20 per fishpond. Although no chronological relationships have yet been established for these sites,

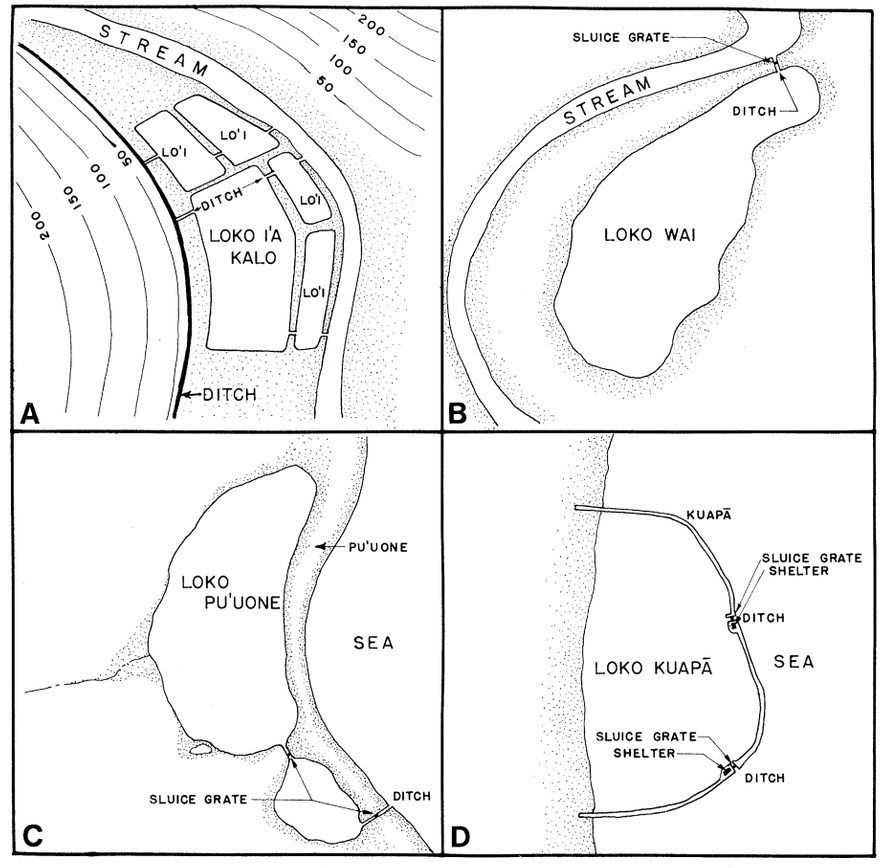

Fig. 2. The four basic Hawaiian fishpond types. (A) The loko i'a kalo, located in an inland area; (B) the loko wai, a natural lake artificially connected to a stream by a ditch; (C) the loko pu'uone, ponds created by coastal barrier beaches, artificially connected to each other, and drained by a ditch; and (D) the loko kuapā, two ditches and a seawall isolating a coastal body of water. No scale.

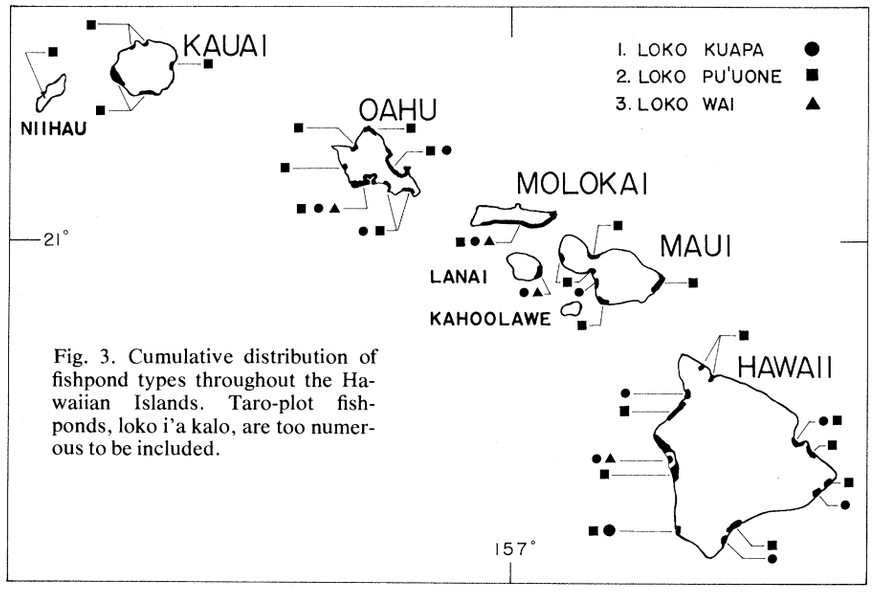

Fig. 3. Cumulative distribution of fishpond types throughout the Hawaiian Islands. Taro-plot fishponds, loko i'a kalo, are too numerous to be included.

there are not enough of them to have supported any sizable portion of the population even if they were all in use simultaneously. I expect that an effort was made to discourage settlement around fishponds, possibly to prevent poaching as well as to eliminate undue noise and sewage pollution.

Philosophically, fishponds were handled as if they were simple extensions of irrigated taro plots. That is, they were seeded (stocked with mullet fry) (*12*), fertilized (mulched with cut grass and pieces of mussel, clams, and seaweeds) (*13*), weeded (cleared of algae) (*14*), and harvested. The gods abhorred filth, sewage, and kitchen refuse, and, in historic times, even the use of chemicals was absolutely prohibited in fishponds and taro plots. This philosophy prevented fishponds from attaining optimum yield.

Unfortunately, the yield of Hawaiian fishponds in prehistoric times will never be known; native accounts tend only to exaggerate the abundance of fish. Only Cobb (*15*) took exact care in his documentation of the yield of Hawaiian fishponds. His study, made in 1901, is the only source available for use in making projections about prehistoric yield.

A tally was taken of all fishponds for which documented acreage is available (*6*). Out of a total of 360 ponds of all types, acreage is known for 304, giving a total of 5608.48 acres for an arithmetical average of 18.44 acres per fishpond. According to Cobb's figures for historic yield on the islands of Kauai, Oahu, Molokai, and Hawaii, the yield of preferred fishes (which would have constituted the major part of the total) from 99 ponds was 307,900.4 kilograms of fish per annum. This averages to 3063.8 kilograms of fish per pond, or 166.1 kilograms per acre per annum. (In comparison, modern southeast Asian fishponds yield approximately 1800 kilograms per acre per annum.) If we assume that 360 fishponds were used prior to Captain Cook's discovery of the Islands in 1778 and use the average size of 18.44 acres per pond and a yield of 158.6 kilograms of fish per acre per annum, it can be calculated that the annual fish production for all the Hawaiian Islands amounted to somewhere in the vicinity of 1,052,518.3 kilograms. At the time of discovery in 1778, the estimated population of the Islands was 300,000. On the basis of this figure, each individual could have been allotted a total of only 3.62 kilograms of mullet, tenpounder, and milkfish per year if the produce of fishponds had been open for public consumption. It can be readily ascertained that the fishponds would have been quickly depleted of their produce if they had served the entire community. But if fishponds were not designed to provide a significant source of protein for the populace, what was their role in that prehistoric society? It seems very likely that selected fishponds played an important symbiotic role in the nature and development of the chiefdom, in particular, of the royal court.

The Hawaiian court was centered about its ruling chief, and surrounding him was a large retinue of relatives, servants, specialists, priests, warriors, and entertainers. The court had no permanent seat of government but moved about from area to area. Although highly mobile, the court still had to be fed and have its supplies furnished. This was accomplished by tapping local sources of food throughout the realm of the chief. It is known that, within the agricultural system of the Islands, certain agricultural plots, kō'ele, were set aside strictly for the chiefs. It seems, then, that fishponds became the aquacultural equivalent of the kō'ele, offering an ever-ready, sufficient supply of food. These fishponds were exempt from the coastal restrictions on fishing during spawning times and could provide fish, crustaceans, and seaweeds at any time of the year, regardless of the vagaries of the weather. The court could freely tap its own resources without unduly burdening the commoners or stripping them of their supplies. As the power of the chiefs increased, and as the size of the court grew, the political and economic roles of fishponds probably took on different meanings in meeting the needs of the royalty.

In order to effectively maintain control and organization of his lands, the paramount chief established a bureaucracy of specialists whose status and role were firmly spelled out. The first of these was the priest-architect, kahuna. In all of the chief's projects, whether the alteration of a taro plot or the construction of a new loko kuapā pond, a priest was consulted to advise the chief on all related engineering matters, from selecting the location to determining the dimensions of the site. These kahuna-kuhikuhi-pu'uone (*7, 16*) were specialists who knew the geography of the land, the nature of the resident spirits of the site, and the total lore of the native religion. Only by maintaining concordance with the gods and the guardian spirits could the success of any project be ensured and productivity made possible.

Two further members of the bureaucracy connected with aquaculture were the land overseer, or konohiki, and the caretaker of a fishpond, the kia'i-loko. The land overseer was a male of chiefly status who served his superior by carrying out orders handed down to him. Superintendence duties surrounding aquacultural sites included instructing the tenants of the land when and where to construct, repair, and clean the different aquacultural structures. In many instances the konohiki also served as a warden to control poaching. Each loko kuapā fishpond apparently had one or more caretakers, kia'i-loko, who lived with their families at the site. These men patrolled the pond, cleaned it, and, when instructed to do so, harvested the fish.

In view of the statistics on the dimensions of fishpond walls, the amount of work involved in their construction and upkeep must have been considerable. Kamakau (*17*) estimates the manpower requirement for the reconstruction of several fishponds on the islands of Maui and Hawaii at around 10,000 men. The massiveness of even the shortest primary walls indicates that these construction projects were not based on the whim of commoners but were developed by individuals of status who could command and supply a large body of workers.

During interisland wars of conquest, invaders often destroyed the irrigation ditches that fed fishponds and agricultural plots (*18*) and tore down fishpond walls (*19*). The destruction of both agricultural and aquacultural systems effectively depleted the supplies of both commoners and elite for many years. Therefore, civil projects were necessary by both the conquered and the conquerors to reestablish their food sources. It was considered a commendable deed for conquering chiefs to spend time repairing breached fishponds.

Cultural and Religious Sanctions

Fishponds were protected by both cultural sanctions and religious restrictions. The paramount chief, through his overseer and caretakers, physically operated and guarded the fishpond and its environment. Proclaiming the sanctity of all of the chief's property was the kapu, a taboo that was made visible by tying strips of white barkcloth to stakes along the property boundary or along the shore, whichever the case might be.

Pollution in the form of sewage, rubbish, and offal not only dirtied the physical environment of the fishpond but insulted and violated both the chief's taboo and the religious sanctions guarding the

area. Religious controls in the form of traditional lore and mores were not directly manifested in the form of specific signs, such as taboo markers. Instead, their violation resulted in the disappearance of fish, crustaceans, and seaweeds and in sudden calamities such as floods, tsunamis, and storms.

All bodies of water, from the smallest pool to the largest fishpond, were the domicile of guardian spirits, mo'o, which manifested themselves in lizardlike or mermaid form. Their role was to protect their watery domain from man-made pollution in order to ensure an abundance and proliferation of aquatic foodstuffs. It was the duty of the caretaker of a loko kuapā to make offerings regularly to the guardian spirits at certain designated times of the lunar month; appeasement was likewise made through such offerings. Disrespect, in the form of verbal insults, of polluting the pond water with sewage, offal, or corpses, or of the presence of women in their menses, was considered sufficient cause for the spirits to denude a territory of its resources. Since famine was greatly feared, gross violation of cultural mores was punishable by death or by plucking out the eyes of the offender (*20*).

In order to restore a fishpond to a state of productivity, a ritual was performed to appease the guardian mo'o. This ceremony has been documented for Hanaloa (*21*) and Kuapā (*22*), fishponds on the island of Oahu. In each case, offerings were made at specific shrines near the ponds in the early dawn hours of the last phase of the moon. This night was the night of Kane, the god associated with life and with maleness, and thus with procreation.

Decline of the Fishpond

Discovery of Hawaii by Europeans in 1778 initiated tremendous changes in all aspects of Hawaiian culture. The greatest barrier to change fell in 1819 with the abolition of the kapu system. This effectively destroyed the Hawaiian religion and with it the chief's supernatural right to rule and his once undeniable control of the land and all its resources. From that time on, Western acculturation accelerated at a rapid rate, and money became the standard of exchange in place of the barter system. The fishpond was no longer a symbol of chiefly power, but rather had to compete economically in the local market as well as with imports of foreign foods. Because of its inherent inefficiency, its low yield, and its requirement for frequent and extensive maintenance, the indigenous aquacultural system was doomed to decline during the population decline of the 19th century. Today, fewer than a dozen prehistoric fishponds are still in use throughout the Hawaiian Islands. The majority of these are operated by their owners, while a few are contracted out to lessees. Unless these ancient sites are physically altered, their economic impact on the local market will remain minimal. It is only through complete modernization that significant profits from fishponds can be foreseen.

Summary

One of the important technological concepts that was developed in the Hawaiian Islands is that of the fishpond. From the 14th to the 19th centuries, these sites served as aquariums for the raising of selected fish. From its inception until the 1900's, the fishpond progressed little in design and function. Its rudimentary nature was a function of both technology and religion. Because of the open ditches, sluice grates, and permeable walls, neither the types nor the quantity of juvenile fish entering or leaving could be controlled. In addition, religious beliefs prevented experimenting with fertilization to increase yield. Although seemingly inefficient, the native aquacultural system was not intended to produce a great amount of fish but rather to yield selected fish on call. Fishponds became symbols of the chiefly right to conspicuous consumption and to ownership of the land and its resources. They were manifestations of the chief's political power and his ability to control and tap his resources. As soon as the native aristocracy changed to a Western-style kingdom, the fishpond's function changed, until, by the 1930's, the majority were simply archeological remains—mounds and walls of rock along a river or shore.

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