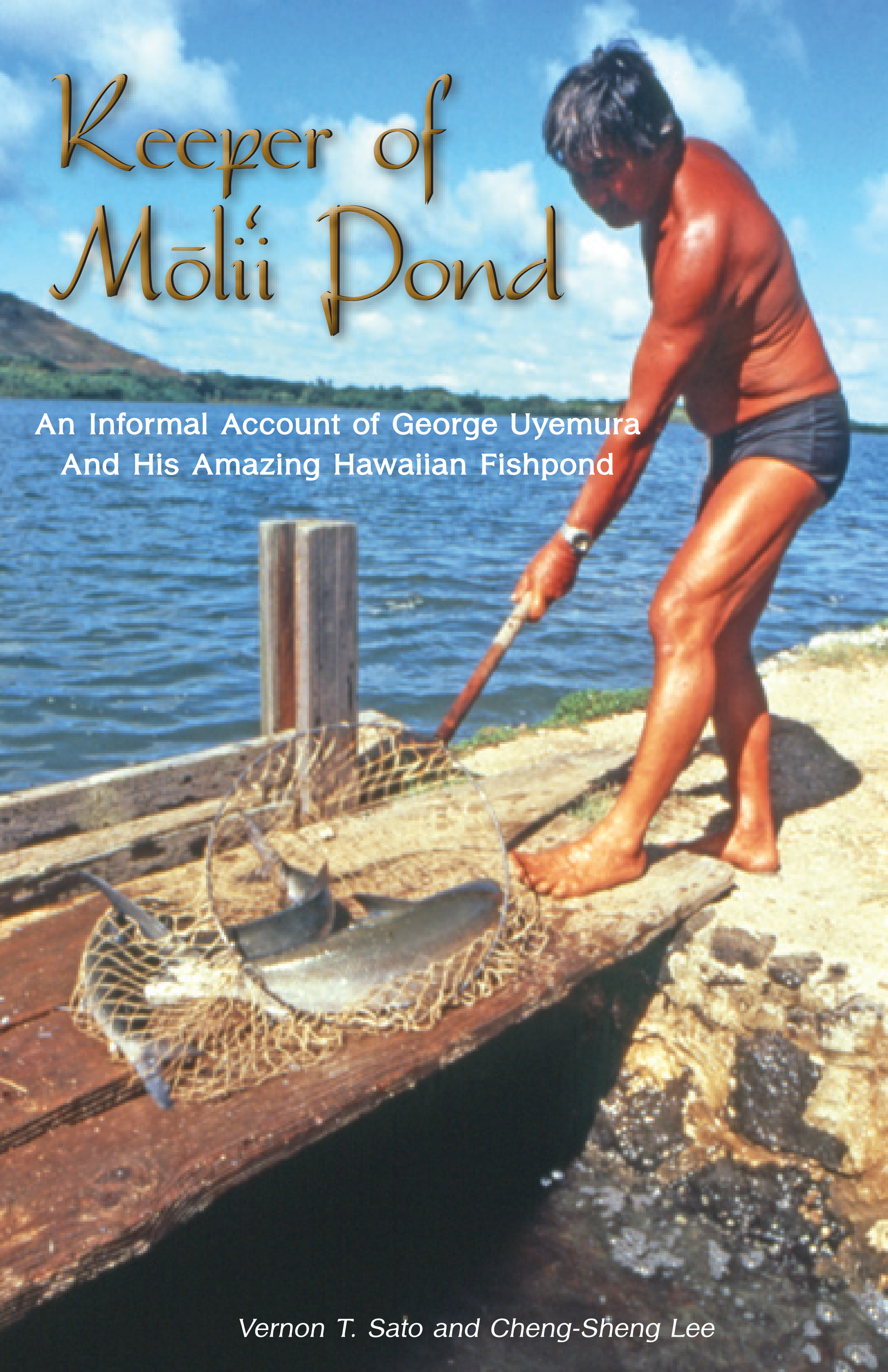
# Keeper of Mōli‘i Pond

An Informal Account of George Uyemura And His Amazing Hawaiian Fishpond



Vernon T. Sato and Cheng-Sheng Lee

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# Foreword

The *loko iʻa*, or fishpond, was a place of tremendous cultural and aquacultural significance for ancient Hawaiian people. Used for the fattening and storing of fish for the community, *loko iʻa* were also a source for *kapu* fish—species prized by royalty and reserved for their enjoyment. Though archaeologists have now identified the sites of 488 fishponds in these islands, only six of the ancient fishponds were still in operation in 1994 (Farber, 1997). Fishponds were a critical part of old Hawaiian culture, yet there were no written texts on the operation of Hawaiian fishponds until the 19th century. Recent interest in reinstallation of the fishponds has catalyzed a new demand for knowledge of ancient Hawaiian fishpond management.

In response, this book offers a look at the history and methodology of sustainable management of Hawaiian fishponds. It also documents the knowledge of a man whose life and experience will be topics of extraordinary interest to the generations of aquaculturists that will follow him: George Uyemura, the keeper of Mōliʻi Pond.

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# Introduction

Nestled at the base of the jagged emerald cliffs of Windward O‘ahu’s Kualoa Ranch, Mōli‘i Fishpond is the only *loko i‘a* in Hawai‘i that has been continually in operation for over 600 years. With more than six decades living right on Mōli‘i, managing the fishpond, observing its cycles, and learning its secrets, George Uyemura’s experiences might be especially welcome as a living document of fishpond management.

As he was interviewed for this book, Uyemura’s feelings about harvesting fish and animals to provide food for a community emerged as both compassionate and pragmatic.

In his childhood, Uyemura enjoyed visiting the zoo but always felt sorry for the animals locked in cages. Yet he grew to enjoy hunting and fishing. He harvested thousands and thousands of fish over the course of his career, but cared deeply about the changing habitats of aquatic animals and was terribly saddened by the disappearance of the mangroves, a nursery area for many of the ocean’s creatures, when they were shouldered out by urban development. He strongly believed that natural stocks must be diligently protected from illegal fishing methods and over-fishing. Though he has no Hawaiian blood, Uyemura learned to farm fish following the methods of ancient Hawaiians. He also employed modern management strategies, which enabled him to provide a constant supply of seafood to the market and to support a comfortable way of life for his family.

This book will be published in Mr. Uyemura's 87th year of life. He certainly has witnessed many changes, not just at Mōliʻi Fishpond but on every other path he has walked over the years. It is hoped that this little book can serve as a source of knowledge that might otherwise have been lost to the ages, and revive interest in the reinstallation and preservation of Hawaiian fishponds.

Chapter 1

# Origins of Hawaiian Fishponds

Historians and archaeologists have dated the origins of Hawaiian fishponds to 1000-1200 A.D. There are reports of pond walls being built or rebuilt as late as the early 1800s, but most of the work in maintaining these structures declined after the initial contact with Westerners in 1778.

Examples of fish traps can be seen in many parts of Asia and the South Pacific. It is believed that the tradition of trapping fish came to Hawai‘i with early Polynesian settlers. The fish trap or *loko ‘ume iki* was typically a walled structure built on shallow reefs. Other traps were constructed to block the flow of water in freshwater streams. Fishponds known as *loko kuapā* probably evolved from the trap designs.

Aquaculture systems that developed throughout most of the ancient world were based on production in freshwater ponds or natural lakes. While considered technologically advanced in their day, these systems generally consisted of stocking ponds with fish, and did not include any control or manipulation of fish lifecycles (Costa-Pierce 1987). Ponds built in Hawai‘i, however, represent unique advances in aquaculture technology comparable to advances made by the ancient Chinese.

Unlike other civilizations, however, the ancient Hawaiians did not leave any written records of the construction of the ponds, how they were managed, or the amount of fish they produced. After Western contact was established in 1778, some of this information was collected, interpreted, and published, but much of the knowledge of fishpond management possessed by the ancient Hawaiians was simply lost.

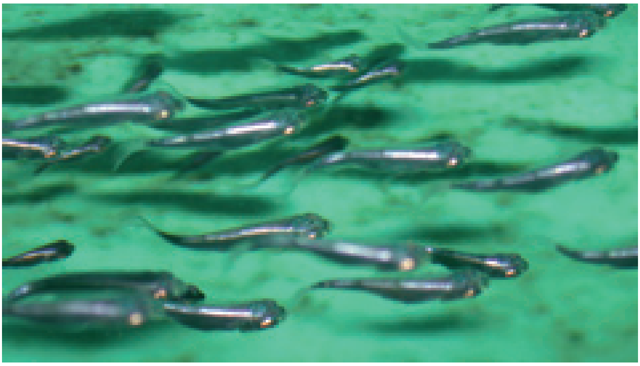


FIGURE 1: MULLET FRY

These ancient Hawaiians understood the attraction of land and freshwater to *pua* (fry or juvenile fish) returning to shore and into the protection of shallow water. Large migrations of *pua* along the shore eventually led these earliest islanders to the estuaries, where freshwater and nutrients from the mountain-fed waters mixed with saltwater to create a rich nursery ground that protected and fed the juvenile fish until they returned to the ocean.

FIGURE 2: *ʻAMAʻAMA*

The *ʻamaʻama* (striped mullet, *Mugil cephalus*) was an important food fish for the ancient Hawaiians, so much that they gave distinct names to its different life stages and banned its harvesting during the winter months. When the fish came to shore in great schools, they were called *pua ʻamaʻama* as they entered the nursery grounds and *ʻoʻola* when they grew to the length of a human hand. Years later, they returned to the ocean as *ʻanae* (full-size mullet, 12 inches or longer) to spawn and reproduce.

An important concept to understand when studying the management of the Hawaiian Islands' natural resources is the system of *kapu* (traditional rules and laws that guided daily behavior), which was established by the Hawaiian *aliʻi* (chiefs). The *kapu* regarding fishing were passed orally from one generation to the next, and historians have concluded not only that the ancient Hawaiians had detailed knowledge of the lifecycles of fish, but that they also made efforts to conserve these renewable resources. *Kapu* protected each species according to its own specific life history and the critical habitats required for optimum growth. Most importantly, *kapu* banned the harvesting of designated species during spawning migration, when they were most vulnerable. Most fish are in prime condition at this time, and very tempting to fishermen. Spawning schools were often easily located and captured, and the roe of many species were highly prized. These sophisticated rules suggest that ancient Hawaiians had developed a concept of fisheries management that focused both on providing for the present and also on meeting the needs of future generations.

Fishponds were considered to be a part of the *ahupuaʻa* that extended from the mountains to the ocean. These land divisions were under the control of the *konohiki* (*ahupuaʻa* headmen who controlled fishing rights and supervised the building of the fishponds). In contrast to fishing, harvesting from fishponds did not come under the restrictions of *kapu* and could be done at any time of year. Fishponds belonged to the *aliʻi* and could only be harvested by their order. As civil projects, ponds were there to benefit the community, and the *aliʻi* who were respectful of their people considered the ponds as living food pantries to be used to provide for the *makaʻāinana* or commoners during periods of poor fishing or other food shortages.

Applying their knowledge of the natural habits of the fish, the Hawaiians constructed *loko kuapā* (walled ponds) along the shorelines to capture the rich runoffs that attracted the young fry into the pond. The *mākāhā* is a channel opening through the *kuapā* that contains stationary grating. Traditionally, the grating systems were made of straight sticks positioned upright and spaced within the openings in the rock walls. Ancient Hawaiians referred to their stationary sluice grates as *mākāhā*; the sluice channels themselves were called *'auwai o ka mākāhā*. The moveable weir is a modern-day modification, probably added by Asians. The movable gates were adjusted with the ebb and flow of the tides to manage water quality, to stock the fishpond with fry and to harvest mature adults. Today, pondkeepers tend to refer to the entire system as *mākāhā*. We will follow suit in this book.

FIGURE 3: *'AUWAI O KA MĀKĀHĀ*

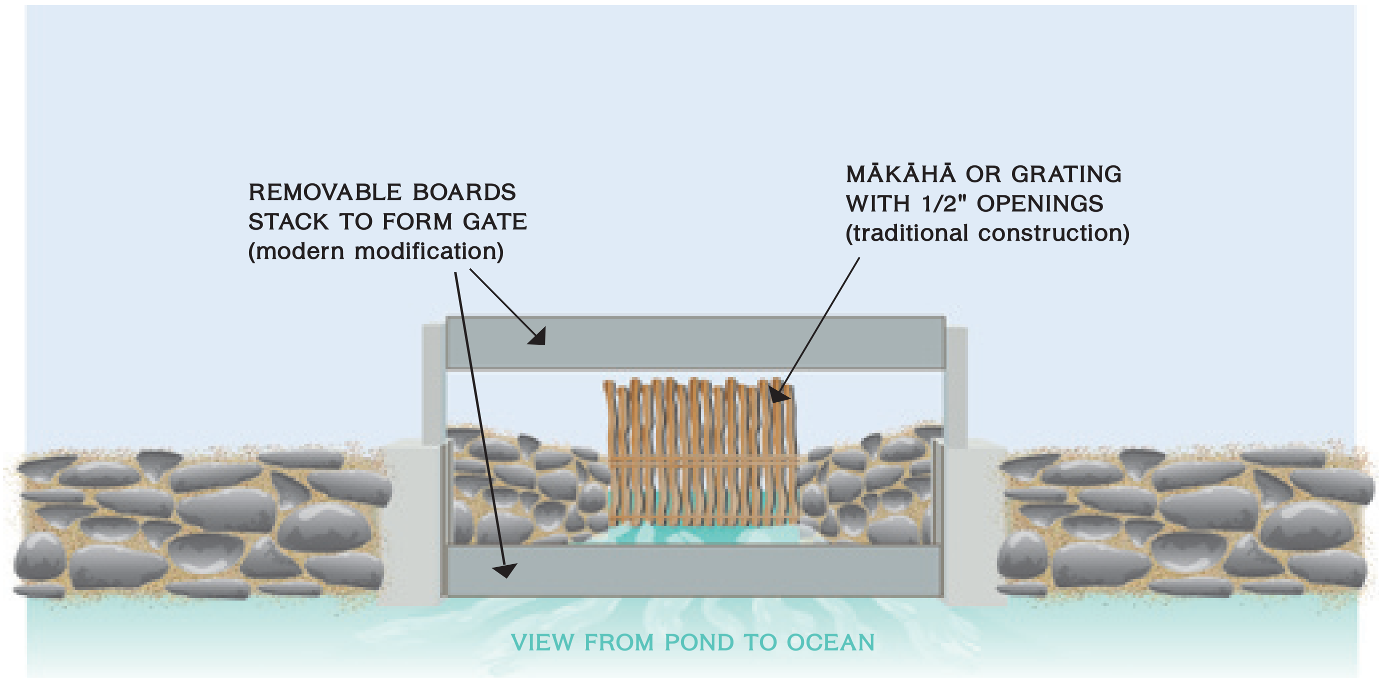



FIGURE 4: MOVEABLE WEIR AND GRATE

Figure 5: Mōli‘i Pond

The pond provided all food needed by these important fish, a group that consisted primarily of herbivores such as *ʻamaʻama* and *awa* (milkfish or *Chanos chanos*). A few predators helped to keep the population in check and contributed to a healthy and balanced ecosystem. Although the *kia ʻi loko* (daily caretaker who maintained the fishpond and protected it from poachers) occasionally fed the fish and enriched the pond, the system was nearly self-sustaining. Each species that entered the pond was harvested in its own time, which was determined by nature.

FIGURE 6: *AWA* SHOWN WITH 12 INCH RULER

The *loko kuapā* is the largest type of Hawaiian fishpond. *Loko kuapā* were constructed by building *kuapā* (walls) of basalt rocks or coral out onto a reef, and enclosing a portion of the reef to protect it from the full force and influence of the ocean.

The walls were sturdy structures that extended above sea level. Channels or *ʻauwai* that allowed seawater into and out of the pond were created by leaving openings in the walls at strategic locations, and spacing between sticks in the *mākāhā* controlled the movement of small fish into, and out of, the pond. *Loʻi* (irrigated terraces) for raising taro and artesian springs located along the shore fed freshwater into the ponds and changed the enclosed ecosystem from a saltwater reef to a more estuarine, brackish water environment.

The progression of these changes, however, and the time required to completely change the nature of the enclosed reef flat, are not known. The successful operation of these ponds required an understanding of the cycles of nature and superior management skills that were probably modified over the centuries to optimize production.

Although the traditional Hawaiian fishpond was protected from the direct impact of ocean waves, it was open to the changing tides, and some flow of water and organisms into and out of the pond occurred throughout the year. As long as the nearshore environment remained healthy, there was no negative impact on the fishpond production. The *loko kuapā* provided a stable ecosystem that was seldom affected by minor flooding after seasonal rains. Ponds were impacted because the freshwater runoffs usually brought nutrients to the pond that stimulated the bloom of phytoplankton. Therefore, in many cases the impact was a positive one for the overall health of the pond. The animals generally remained unaffected by minor events because they were usually species that were tolerant of slight salinity changes.

FIGURE 7: *MĀKĀHĀ* FROM POND LOOKING OUT TO THE BAY.

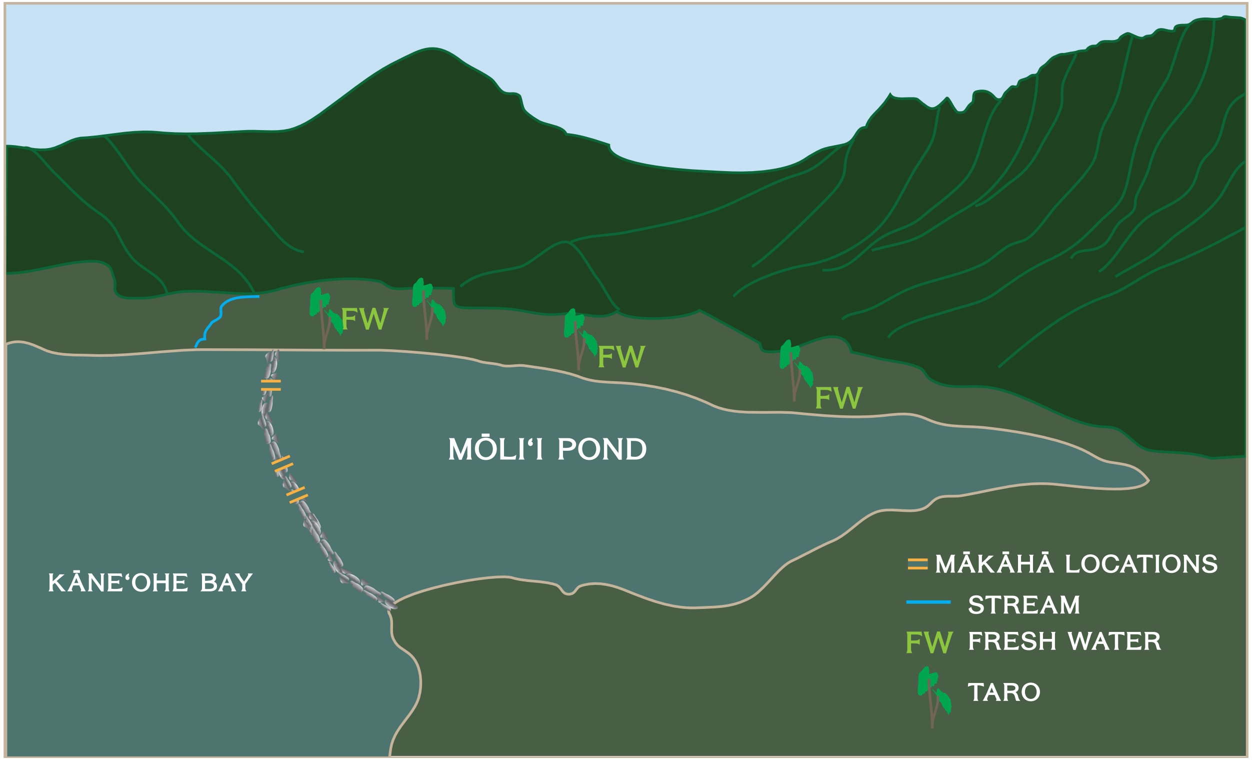



FIGURE 8: DRAWING OF MŌLI‘I POND AS IT MAY HAVE LOOKED PRIOR TO THE BUILD-UP OF SAND ALONG THE *KUAPĀ*. TRADITIONAL SOURCES OF FRESHWATER WERE FROM STREAMS, WATER FROM *LO‘I* AND FROM SPRINGS ALONG THE EDGE OF THE POND. THE *‘AUWAI* SHOWN ON THE WESTERN END OF THE *KUAPĀ* REPRESENTS THE THREE *MĀKĀHĀ* THAT HAVE REMAINED FUNCTIONAL.

The pond's estuarine environment proved to be a highly productive, excellent nursery ground for many species of aquatic life. Within a short period of time, the fish grew and became too large to swim out of the pond through the *mākāhā*.

The ingenuity of the Hawaiians is most apparent in the brilliant construction of the fishponds, and the fact that they were virtually self-harvesting during the prime periods for each of the fish species they contained. As fish entered their spawning periods, they swam to the *mākāhā* and collected in the sluice channels, following their instinct to return to the ocean to reproduce. The *konohiki* directed the harvesting of fish that were needed with nets or other devices. Fish not harvested were released back to the pond and then returned to the *mākāhā* during the next spawning season.

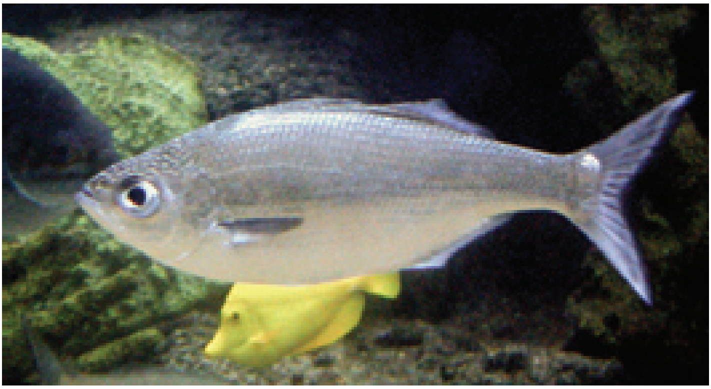


FIGURE 9: *ĀHOLEHOLE*

The *ʻamaʻama* swam to the *mākāhā* during the late fall and winter. *Āhole*, or mature Hawaiian flagtail (*Kuhlia sandvicensis*) went to the *mākāhā* in the winter months. *Āholehole* (younger flagtail) sought to enter the pond in the spring, and *awa* and *moi* (*Polydactylus sexfilis*) swam there during summer. There are natural cycles of "feast and famine" in nature, and supplemental stocking of fry was sometimes necessary. As long as the ponds were stocked regularly each year, and predators were managed properly, fish would be available for harvesting throughout the year.

FIGURE 10: *MOI*

As mentioned earlier, it is believed that the tradition of trapping fish came to Hawai‘i with ancient Polynesians. The *kuapā*-style fishpond was a uniquely Hawaiian invention but the *mākāhā* was the innovation that made the Hawaiian fishpond stand out from all other ancient aquaculture systems.

# Chapter 2

## Life Around The Ancient Hawaiian Fishpond

In early Hawaiʻi, island districts were called *moku* and all of the land was considered to be the property of the *mōʻi* who was the most senior of the *aliʻi* or ruling class. The *moku* were further divided into *ahupuaʻa*, land districts which were awarded to the lesser *aliʻi* to rule.

Fishponds in ancient Hawaiʻi were a part of the *ahupuaʻa*. They were considered valuable assets that added to the richness of the land (Kamakau, 1991). The building and maintenance of fishponds were civil projects involving all of the families that lived in the *ahupuaʻa*.

The society of Hawaiʻi prior to Western contact in 1778 is sometimes compared to the European feudal structure. *Makaʻāinana* (commoners) could be called upon by the *aliʻi* to build and repair ponds, irrigation channels and work on other projects for the overall benefit of the community. Everyone who participated in these labors had a right to share in the benefits of the work.

A lower ranked *aliʻi* might serve as *konohiki* or overseer of the land. The *konohiki* controlled food production, collected taxes, and recruited labor when necessary. He also functioned as a game warden, controlling the amount of fishing in his district in order to maintain healthy fish populations (Clifford 1991). The system for fishery management was fairly sophisticated, evidence that early Hawaiians recognized the danger of overfishing and believed in protecting the stocks of fish in the wild.

The *kia ʻi loko* was the actual keeper of the fishpond. He lived at the pond and was responsible for its day-to-day care, feeding the fish and monitoring them closely. When the *aliʻi* or *konohiki* requested it, the *kia ʻi loko* was responsible for harvesting the fish. One of his most important functions was to patrol the wall of the pond, for he was responsible for protecting the fish that belonged to the *aliʻi* from poachers.

It is often reported that poaching from the pond belonging to the *aliʻi* was punishable by death. Though this is true, the relationship between *aliʻi* and *makaʻāinana* is believed, for the most part, to have been mutually beneficial. First, they were all descendants of the same family. The original settlers of Hawaiʻi, who probably first came from the Marquesas Islands between 300 and 500 A.D., were likely members of a few founding families, and chiefs were believed to be descended from the heads of these family groups. The higher-ranked *aliʻi* descended from the *hiapo* (firstborn) of those with superior status. The *makaʻāinana* were descendants of the same families, but from a line of lower ranking *aliʻi*.

Secondly, although the *aliʻi* controlled the labor force, they generally did not produce any foodstuffs on their own, but depended on their *konohiki* to manage the production in their *ahupuaʻa*. The *konohiki*, in turn, relied upon the *makaʻāinana* to be productive on their land.

Third, the *aliʻi* were responsible for looking out for the best interests of the *makaʻāinana*, and were not allowed to abuse them (Clifford 1991). Commoners were free to move to other *ahupuaʻa* if they chose, and *aliʻi* knew that the loss of human resources would impact productivity and reduce taxes that could be collected. Therefore, *makaʻāinana* were considered to be valuable resources of the land and to the *aliʻi*, who knew it was in their best interest to treat their people well.

While the *aliʻi* did not produce anything on their own, they did have resources that were reserved only for chiefs. Some cultivation was done on designated land or *kōʻele*, and this production was reserved for the *aliʻi*. Fish ponds were regarded as aquatic *kōʻele*. The *aliʻi* would designate by *kapu* that certain fish be reserved strictly for their use.

According to Kelly (1975), all other fish were available to those who worked on the pond. Maintenance of the pond required replacing stones from the *kuapā* that were dislodged by high surf and storms. The accumulation of silt was also a problem. The *konohiki* would recruit *maka'āinana* to help rake the pond bottom and move the silt and sediment near the *mākāhā* where it could be flushed out. Ponds sometimes became overgrown with algae. The *maka'āinana* would wade into the pond, break the *limu* (algae) off the bottom and twist it together to form a ring. Fish caught in this tangle of *limu* belonged to the commoners. In this way, they were paid for their labor.

FIGURE 11: POND WALLS

The *kuapā* maintained the integrity of the pond and held the water inside. In some ponds, the walls were not completely watertight, but they were still adequate to maintain the water level within the pond between high tides. The *mākāhā* functioned, in many ways, to keep the pond alive. *Mākāhā* controlled the flow of seawater into and out of the pond. When ponds were located near freshwater streams, additional *mākāhā* could allow the flow of stream water as well. This flow-through system could be used to more effectively exchange water in the pond.

Seawater flowing into the pond brought the baby fish or *pua*. As they came into season, each species entered the pond through the *mākāhā*. For the two most important species, the mullet fry or *pua ʻama* came during the winter and early spring; the milkfish fry or *pua awa* came into the ponds during the summer months. Dozens of other fish species and a wide variety of sea creatures came into the pond as well, creating the ecosystem that supported the growth of these fish.

The microscopic plants and animals that provided food for all of these different organisms came through the *mākāhā* on each

FIGURE 12: MULLET READY TO SPAWN GATHER AT THE GATE OF THE *MĀKĀHĀ*

rising tide. Outgoing water carried a rich soup of microorganisms that was food for the reefs surrounding the ponds. After three years the *pua ʻama* were fully grown. During the winter months, they began to sense the oceanic water coming through the *mākāhā* at each rising tide, and to gather there instinctively, waiting to swim back into the ocean to spawn.

The *kapu* protected fish during their spawning seasons and banned their capture in the ocean. This kind of *kapu* was aimed at protecting the resources in nature. The *loko kuapā* were considered a part of the *ahupuaʻa*, the land division. In royal fishponds, the fish within the pond were treated like other resources within the *ahupuaʻa*. They were the property of the *aliʻi* and he could place a *kapu* on his favorite species. All harvests of *that* species from that pond were reserved for the *aliʻi*, regardless of season. The *aliʻi* could place a *kapu* on, for example, *ʻamaʻama* and feast on them during their vulnerable winter months when they came to the mākāhā, seeking to spawn.

Within several decades of Western contact, the fishponds became less traditional in operation and function. A great many changes occurred that hastened the decline of the fishponds. The social and cultural structure that guided the Hawaiian people for centuries slowly collapsed with the introduction of Western ideas and a different way of life. A need for laborers brought in other cultures that further eroded the Hawaiian lifestyle. The system of *kapu* broke down.

The final separation of the *makaʻāinana* from the land or *ʻāina* occurred with the Great *Mahele* (Division) of 1848, the land redistribution act that legalized private land ownership by non-Hawaiians. All privately-owned fishponds were deeded to native Hawaiians, primarily the *aliʻi*; in time, some would be transferred to non-Hawaiians.

Apple and Kikuchi (1975) estimated that there were approximately 350 ponds in operation in 1800. A study of the fisheries of Hawaiʻi from June 1901 to June 1904 noted the productivity of only 158 active fishponds known to be in operation since 1870. A series of reports from the beginning of the new century (Cobb 1902, Cobb 1903) provided some of the earliest published accounts of Hawaiian fishpond status and production, and discussed changes that had taken place since contact with Western civilization. The *kapu* and other restrictions on social behavior began to break down as the population embraced aspects of the Western lifestyle. The *ali'i* began to lose power over their people and to experience a decline of their influence in the social and political world.

| YEAR | NUMBER OF PONDS | PERCENTAGE REMAINING | REFERENCE |
|---|---|---|---|
| Total Sites | 488 | | DHM, Inc. 1990 |
| 1800 | 350 | 71.72% | Apple and Kikuchi, 1975 |
| 1900 | 99 | 20.29% | Cobb, 1900 |
| 1903 | 86 | 17.62% | Cobb, 1903 |
| 1997 | 6 | 1.22% | Farber, 1997 |
| Class I Ponds Remaining | 25 | 5.1% | DHM, Inc. 1990 |

Table 1: Decline in number of fishponds: "Total Sites" include historical sites that were once believed to be fishponds. The actual total number may never be known. The "# of Ponds" were ponds known to be in commercial operation during that year. "Class I Ponds Remaining" are ponds that are in operation or the physical structures are sufficiently intact that they are considered to be the easiest to restore.

Overfishing was a problem at the turn of the century, but the areas it affected were localized. Transportation was not readily available and though ice was obtainable, it was too expensive to be used to preserve catches of fresh fish. Therefore, as fishing served the local economy, only the areas that immediately surrounded Hawai'i's growing population centers were overfished.

As Jordan and Evermann (1902) reported, the number of ponds that were successfully operating was declining, especially on Moloka'i and the Big Island of Hawai'i. Many ponds on O'ahu had already been filled up and converted to other uses. Still, in 1902, Cobb noted that Hawai'i was the only place in the United States where fishponds were being used to produce large amounts of fish and other seafood. He also noted that less than half of the fishponds that had been in production in 1870 were still in production in 1900.

Cobb recognized the role of fishponds in feeding the people of Hawai'i and recommended the preservation of this resource.

Fish, he noted, could be harvested from ponds when other food resources were unavailable. Fish in Hawaiian ponds relied on the natural food chain and therefore cost almost nothing to grow to market size. When market prices were unfavorable, the fish could be held until prices improved at very little cost. It was suggested that fishponds could supplement the declining shoreline fisheries.

Still, the number of fishponds that remained in production continued to decline. Lava flows, as it was later documented, actually filled in a pond on the island of Hawaiʻi. On Oʻahu and in other areas of population growth, ponds were being filled in for the sake of development. As new roads were built along the coastline, and the island's railroad began to service some of the less accessible parts of Oʻahu, fishermen could freely overfish previously untapped resources. Fishponds continued to be an underutilized resource.

Some ponds with access to a good supply of fresh water were converted to agricultural uses, such as the production of rice or taro. Many of the smaller ponds were not of great interest; these were filled in, converted to private ponds, or simply incorporated into the landscape. The greatest loss, however, came about because of the social and cultural changes that were taking place in Hawaiʻi.

Diseases resulted in a decline in the population of native Hawaiians. This reduction in the available work force spurred the need for imported laborers, who came primarily from Asia. Changes in land ownership removed many Hawaiian people from their *ahupuaʻa* and from their connection with the *aliʻi*. The *konohiki* no longer had access to the *makaʻāinana* and could no longer compel them to maintain the ponds. In time, many native Hawaiians who maintained ownership of the ponds simply gave up direct control by leasing them and eventually transferring ownership to non-Hawaiians.

A healthy nearshore fishery was important in maintaining production in the fishponds. Though local fisheries were being depleted, the untapped areas around the major islands helped to maintain adequate spawning populations of the important fish species, so that the ponds were well-stocked through the early 1900's. Because the number of active fishponds in the Hawaiian Islands continued to decline, the competition for fry was also decreasing. Therefore, remaining fishpond operators could still maintain good production in well-managed ponds.

Apple and Kikuchi (1975) estimated that the average production of the ponds in ancient times was around 350 pounds per acre per year. Based on Cobb's 1902 estimates for production in the ponds that remained in 1900, the yield was between 175 to 275 pounds per acre per year (Farber 1997, Wyban 1992). By 1900 there were only about 100 ponds in active production and they provided about 10% of the fish that came to market.

The main native species being produced in the early 1900s was the *'ama'ama*, a special fish often reserved by *kapu* for the *ali'i*. In 1900, *'ama'ama* was very popular with Westerners. A number of other exotic species were already being cultured as well, due to non-Hawaiian influences. These included common goldfish (*Cerassius auratus auratus*), carp (*Cyprinus carpio carpio*) and a species referred to as "Chinafish," which may have been the Chinese catfish (*Clarias fuscus*), or the snakehead (*Channa striata*), as both were introduced into Hawai'i before 1900. The exotics were cultured in freshwater and, sometimes, brackish water ponds. Within 90 years, only 13 Hawaiian fishponds were listed as being in use: five for aquaculture, and the remaining eight in various stages of preservation, restoration, or conservation (Wyban, 1992).

Chapter 3

# Loko I‘a Today

The changes that accompanied Hawai‘i’s transition from an agrarian, subsistence economy to one whose growth is driven by market demand has now dulled the significance of the fishponds. To some, they now seem little more than quaint reminders of life in ancient Hawai‘i.

Recently, there has been renewed interest in the ponds. Without question, Hawaiian fishponds face a number of challenges if they are, once again, to become productive. Assuming that all legal and financial challenges are overcome, and that there is sufficient community support for the project, biological issues threaten all projects involving the cultivation of traditional species. The nearshore fisheries have changed drastically over the past seventy years, and though the pua are still attracted to the ponds, there may not be enough fry available in nature to restore *‘ama‘ama* and *awa* as the dominant species.

Sadly, none of the ponds in operation today are able to produce traditional species in a traditional manner. Ponds remaining in operation, or at least partially restored, have often been forced to incorporate recent aquaculture technologies, as maintenance, restoration and reconstruction can be very expensive and time-consuming. Rocks used in the *kuapā* and *mākāhā* have, in some instances, been set in place using concrete or other modern materials. This helps the structures to better withstand the forces of waves, flooding and tsunamis. Some ponds that attract large numbers of visitors have also been made safer with the construction of better paths.

The greatest changes to the ponds, however, remain largely unnoticed by visitors. These are the changes that have upset the balance of the ecosystems of Hawaiian fishponds.

*ʻAmaʻama* and *awa*, both herbivores, were two of the more important species that inhabited many of the ancient fishponds. They fed low on the natural food chain and survived on phytoplankton (microscopic algae) and *limu* (the larger algae that grows on rocks and other surfaces). They were also food for predators that occasionally entered the pond. Though predators might eat their share of *ʻamaʻama* and *awa*, they still were unable to severely impact the total population of a balanced pond system.

Natural populations of *ʻamaʻama* have drastically declined over the past two centuries, but the impact on pond production became most noticeable after the 1950s. Accompanying this decline has been an increase in the numbers of introduced species that have been able to compete for niches in the pond ecosystem. Eldredge (1994) cites a study by Maciolek (1984) in which 80% of the mullets caught in a Kauaʻi estuary were Australian mullet (*Valamugil engeli* [=*Chelon engeli*]) and not *ʻamaʻama*. Randall (1987) stated that the Australian mullet is difficult to distinguish from the *ʻamaʻama* and that it was being stocked in ponds by mistake. Because of these problems, the supplemental stocking of *pua ʻama* from natural sources may be a waste of time without a simple sorting of the Australian mullet from the *ʻamaʻama*. Though no supporting data exists, there have been additional reports of similar situations on Maui, Molokaʻi and the island of Hawaiʻi.

The problem with introduced species does not end there. *V. engeli* competes with the *ʻamaʻama* for the same niche in the pond ecosystem. The blacktail snapper or *toau* (*Lutjanus fulvus*) has been observed to be a voracious predator of *ʻamaʻama*, and is capable of drastically impacting the population of mullet and other fish less than five inches in length. While the *toau* does get a good price in the market, it is difficult to catch in quantities that would allow the *ʻamaʻama* to again dominate the Hawaiian fishpond. A number of other exotic species have found their way into the fishponds, but none have had as devastating an impact as *V. engeli* and *toau*. The tilapia, now a nuisance species that inhabits freshwater and brackish-water ponds and streams, has not become as great a problem for the *kuapā* ponds.

FIGURE 13: AUSTRALIAN MULLET

FIGURE 14: *ʻAMAʻAMA* OR STRIPED MULLET

The degradation of nearshore fisheries is a problem that fishpond operators must deal with, but there isn't much they can do to improve it. The responsibility for managing fisheries resources falls upon the state and federal agencies that monitor activities and have the authority to manage its use. Pond operators who want to raise *ʻamaʻama* and *awa* are competing for the same resources that would eventually develop into fish for the recreational and commercial fishermen. *Pua* collected by pond operators would become a marketable commodity in a few years. If left in the wild, a small number of *pua* grow to a larger size and are captured by fishermen. Most, however, would serve as food for predators; and some of those would also become the targets of fishermen. The question of how to best manage fisheries' resources is not an easy one to answer. Are fry collectors taking away from what will be available to fishermen in the future? Or are fry collectors being unfairly blamed for the depleted nearshore fisheries? Is there a solution that will benefit all of the users of Hawaiʻi's ocean resources? It appears that much of what has been done up until recently has resulted in disappointment for many groups.

The reality for pond operators who primarily want to raise *ʻamaʻama* and *awa* may be the inclusion of newer hatchery technologies in their plans. This would remove them from the competition for dwindling resources. More importantly, the impact of future changes in the nearshore fisheries would be diminished.

The Hawaiʻi community has been one of the more effective factors in protecting the remaining fishponds. Farber (1997) describes a number of instances in which concerned citizens on Molokaʻi, Oʻahu and the Island of Hawaiʻi have voiced opposition to developments that would impact or eliminate fishponds. Community expression has been instrumental in keeping the ponds intact and accessible. Community-based restoration of fishponds on Molokaʻi has been successful, though the process has been slow, and a decade or more may pass before restoration is complete and trained personnel are in place to operate a pond.

Mōliʻi Pond, under the management of the Uyemura family, has had the distinction of one of the longest records of continuous operation in the State of Hawaii and may be the only pond that has been in continuous operation since ancient times. Oral history says it was built by *menehune*, the legendary race of small people who worked at night, building fish ponds, roads, and temples. Written documents that came into existence after Western contact may be used to trace ownership of the pond through modern times. However, details of its operation, and of the operation of hundreds of other ancient Hawaiian fishponds, remain largely unrecorded, except in a very few instances in which the oral history has been documented and, in some cases, made public.

We have had the opportunity to record some of the experiences related to the recent history of Mōliʻi Pond, as well as the privilege of working with George Uyemura and his wife Jane to document the changes they have experienced in seventy years of living and raising their family at the pond. The challenges they faced represent only the beginning of the obstacles that tomorrow's Hawaiian aquaculturists will have to overcome if other ponds are to be brought back into production.

Figure 15: Hakipuʻu & Kualoa, NOAA satellite photo

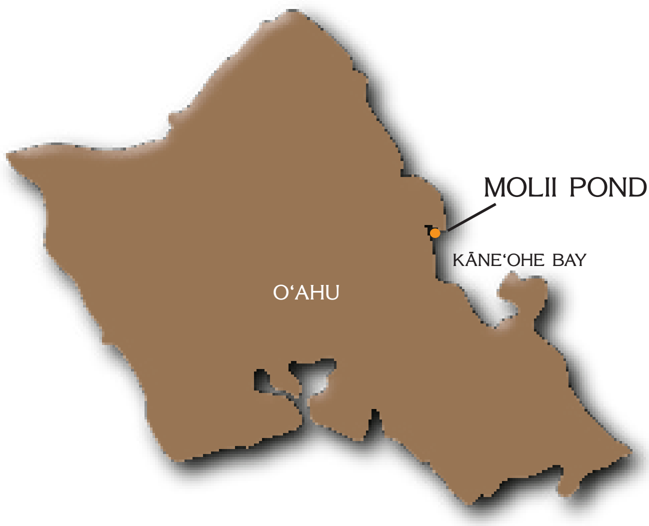



Figure 16: Pond location

Throughout its long history, Mōli‘i Pond has functioned as a type of microcosm. Seawater from the ocean, and the aquatic life within it, flow through the pond's *mākāhā*, interacting with the water held within the *kuapā* and creating a balanced ecosystem that supports the growth of many different kinds of aquatic life. Over the years, this ecosystem has mirrored the changes that have taken place in Kāne‘ohe Bay.

The fact that Mōli‘i Pond has been able to remain productive for so long can be attributed to three primary factors. First, the pond is well-built and located in a relatively protected part of what has been a productive bay. Secondly, from the days of the *ali‘i* through modern times, the pond has always been in the hands of people who were dedicated to its preservation, and to protecting the natural beauty of the area.

Finally, as a royal pond in ancient times, Mōli‘i was tended by trustworthy *konohiki* and dedicated *kia ‘i loko*. This tradition of responsible stewardship has continued well into modern times, as Mōli‘i came under the purview of a conscientious manager and caretaker who dedicated his life to keeping the pond productive.

# Chapter 4

# The Early Days of George Uyemura

Harumi "George" Uyemura, born on May 11, 1920 in Waikīkī, was the second of three children and the first son of Genzo and Mizue Uyemura. Genzo and Mizue were *issei*, first generation immigrants from Japan. George spent much of his childhood on Sans Souci Beach near the Honolulu Zoo and the Waikīkī Aquarium, which he visited regularly; he awoke every morning to the roars of the lions in the zoo.

As a boy, Uyemura developed great respect and tremendous empathy for animals, and he loved seeing them in the wild. Given the opportunity, he might have pursued a career as a veterinarian. Though he grew up to become an avid hunter and fisherman, he never liked to see animals being kept in cages or performing in a circus. And his love of fish and fishing began at a young age. He taught himself how to fish off a pier at Sans Souci, with hooks made from his mother's pins. His first fishing line was a No. 10 thread, and *pipipi* snails were all he needed for bait. Fish was plentiful at the end of the pier.

As Uyemura remembers, his father, Genzo, worked as a cook for Judge Hatch; the Uyemuras lived on the judge's property. When Judge Hatch passed away, Genzo had to find a new life for himself and his family. He loved animals and considered moving to Maui to work with horses owned by the Baldwin family, or working with dogs in the Castle family's O'ahu kennels. Why he chose to take on responsibility for the fish at Mōli'i Pond in Hakipu'u remains a mystery to Uyemura to this day. Whatever the reason, Genzo managed to acquire the lease to the pond, and he moved there in 1928.

Life in Hakipuʻu did not start out smoothly. Waikīkī, where the Uyemuras had lived, was part of the growing city of Honolulu and had many of the modern conveniences of the day. But the Windward coastline was still very much "country." Though a road going out to Kualoa and beyond had been built, there was no electricity and no running water on the property. Seemingly worst of all, the previous lessee had harvested almost all the fish from the pond, leaving little to sell over the coming months. There was much to learn about managing Mōliʻi Pond. The family settled in and tried to make the best of things.

As it turned out, they didn't need to worry about their empty pond. The reefs along Kualoa and Hakipuʻu were rich with fish. In fact, the abundance of fish within Kāneʻohe Bay, and the attraction of the bay to fry, would provide more than enough fish to stock the pond. Ultimately, the size and design of Hawaiian fishponds made it nearly impossible to remove all of the fish without totally draining the pond; some always remained.

George was eight when his family moved from Waikīkī to Hakipuʻu. He boarded in Honolulu and continued his education at Makiki Christian School during the school year, coming home to Mōliʻi Pond on weekends and working with his father during the

Figure 17: Uyemura home located along the shores of Mōliʻi Pond

summer, learning to manage the pond. Years later, he confesses that he was a bit lazy, in that he wanted to find an easier way to do some of the tasks associated with managing the fishpond. He had many ideas that he wanted to try, and he often talked with his father about them.

Young George was a keen observer of nature and the things he saw around the pond. As a self-styled scientist, he was able to test some of his ideas, observe the results and implement and fine-tune the successful ones. Some ideas worked, others did not, but the seeds of a lifetime commitment had been planted. The things he learned through trial and error would keep Mōliʻi Pond productive over the next 70 years.

One of the first tasks assigned to Uyemura was cleaning and maintenance of the *mākāhā*, or sluice gates. The *mākāhā*, as we have learned, is important to a fishpond for several reasons. All water to and from the ocean moves through it. Pure seawater flows through the *mākāhā* into the fishpond, bringing baby animals that will grow to maturity there, as well as the food organisms needed to keep the pond rich and productive. Within the pond, fresh water mixes with the ocean water. Together, they stimulate the growth of the food organisms contained within the walls or *kuapā*. The size of the grating, and the width of the spaces between the *mākāhā*'s poles, determines which organisms can enter or leave the pond. The gate's openings must be kept clear in order to ensure and maximize the pond's health. The walls of the sluice channel containing the *mākāhā* must also be cleaned regularly, to keep the gate safe and functional.

Cleaning the *mākāhā* was tricky, as the boy learned. It required going into the sluice channel to scrape off encrustations on the grating and walls. Stubborn organisms like oyster shells and barnacles had to be broken or pounded to dislodge them. Cuts from the sharp edges of these organisms were often deep and painful. His hands and knuckles were often scraped raw.

The reef surrounding Mōliʻi Pond was filled with different aquatic life. Lobsters were abundant and their "horns" could be observed in every crack and crevice on the reef. Uyemura often caught lobsters and brought them home for his family, to the point that they finally grew tired of eating them. When his mother asked him to stop bringing them home, he decided to put them in the *'auwai*, to keep them as pets and to hold them until his family was ready for more. When he returned to check on the lobsters Uyemura observed that the barnacles and oysters were gone! He had found an easier way to do his job by letting nature take its course.

This was only the beginning. This process of observation, experimentation, more observation and assessment would lead to continued improvements in production. Life at Mōliʻi Pond was not easy, but it was getting better.

In the early days of the Uyemura family's tenure at the pond, fish could be sold in two ways. Fishermen and pond operators with transportation could take their harvests to the fish merchants in downtown Honolulu. For others, fish brokers would drive along the coast and pick up any product that fishermen and farmers had to sell. At Kualoa, a taxi driver would make his way up the Windward coastline to the sugar mill in the early morning, blowing his horn at different points along his route. This was a signal for people to bring products to the roadside for him to pick up on his return down the coast. He would sell the products in downtown Honolulu and return in the next day or two with money from the sales and items ordered by the sellers.

The greatest challenge for fishpond operators was trying to figure out how much fish to take to market and still get the best price. The supply of wild mullet was not a concern, as there was a *kapu* on the taking of *ʻamaʻama* during their spawning season, but it was important to have an idea of how much other pond operators were able to harvest. The fish markets were controlled by Chinese merchants who had their own gentlemen's agreements to keep prices within a certain range. They would lower the prices they paid for fish if the harvests were greater than expected, but it was nearly impossible to get them to pay more, even when supplies were limited. Therefore, Genzo had to anticipate his maximum harvest on any given day. He could only hope that other pond managers weren't glutting the markets on the same day.

The harvesting of fish at Mōliʻi Pond was hard work, but with proper preparation, it wasn't complicated. Long-handled scoop nets were repaired and made ready a day before the harvest was to take place, and the *mākāhā* was checked and the weir boards adjusted in preparation. In the winter months, the *ʻamaʻama* would come to the *mākāhā* on the rising tide and accumulate within the sluice channel or *ʻauwai*.

In the beginning, Genzo did all the work around the pond, taking care of the harvests. He drove a boat from his home across the pond and docked at the *mākāhā*. As he drove, he assessed the *ʻamaʻama* that were gathering. Rough estimates ran through his mind as he began harvesting. The nets were used to scoop up the fish in the *mākāhā*, and then they were transferred directly into the boat. Ice was expensive and not readily available, so once harvesting began, Genzo was committed to finishing as quickly as possible; the fish must be delivered fresh to the market in Honolulu. If there were more fish than was needed, the weir boards would be moved into place, to keep additional *ʻamaʻama* out of the ʻ*auwai*.

When the harvest was complete, Genzo would drive the boat back to the house, where the fish were sorted, weighed and placed in wooden boxes. Boxes of mullet were stacked in back of the truck and covered with newspaper to prevent them from drying out on the long drive to Chinatown, and to keep debris from falling on the catch. The delivery of fish to market was usually done by George's mother Mizue, who would pick up supplies on her trips to town. In the meantime, Genzo would prepare for the next harvest. Nets had to be repaired and the weir boards adjusted with each tidal change.

Genzo died of the flu in 1938, the same year that George graduated from high school. Antibiotics were primitive and not readily available, so illnesses considered common and benign today were life-threatening at the time. As the oldest son, George, at age 18, took over the management of Mōliʻi Pond. He hoped to one day to continue with his college education, but that was not to be.

When Genzo passed away, Mizue continued to help around the pond. Because he wanted to get to know the merchants, George took on some of the responsibility for deliveries, and his role increased over time as his mother got older. It was on one of his delivery trips that George met Jane Akimoto. Their friendship began in a Chinatown restaurant owned by her family; soon, George began making it a point to stop by after his deliveries were completed. In 1952, Jane became his wife and full-time partner at Mōliʻi Pond.

For as long as he managed the pond, George was unfailingly loyal in his dealings at the fish market. In all the years he operated, he worked with only one dealer. He did not believe in switching to get a better price. In return, he expected his dealer to accept all of his deliveries, and to pay the best price each time. Over the years, this made his work at the fish market much simpler, as he didn't have to spend time trying to negotiate a better deal or finding someone to take his extra fish when he had a larger-than-expected harvest. In time, Jane began to take on some of this responsibility, just as George's mother had done years before.

# Chapter 5

## Keeper of the Fishpond

Without question, Uyemura learned a great deal about managing the pond as he worked with his father. Because he wasn't a native Hawaiian, however, he didn't have the benefit of the oral history and traditions that had been passed from generation to generation. Uyemura's neighbors provided valuable insights and told stories of the history and folklore of Mōli‘i Pond. By far, however, his wisest mentor was a man simply called *Kahuna*, a word that in Hawaiian means both "expert practitioner" and "sorcerer."

All of the children in the community were afraid of *Kahuna*, but when he was ten or so, Uyemura discovered somehow that the old man was a great fisherman. His fears were overcome by fascination as he got to know the man, heard his stories of Hakipu‘u and Mōli‘i Pond, and learned how to be a better fisherman.

In those abundant days, though the reefs of Kualoa and Hakipu‘u were still teeming with fish, octopus and lobsters, *Kahuna* would often tell George that the area was being overfished. The boy found it almost impossible to believe what *Kahuna* was saying. Many years later, George realized his old friend had seen great reduction in the numbers of fish and marine animals over his long lifetime.

As Uyemura developed his skills, he learned from *Kahuna* about how the Hawaiians observed the fish and their behaviors in order to become better fishermen. He learned of the Hawaiian system of fishery and resource management, the traditional *kapu*. Armed with this knowledge, the insights of experienced men and his own youthful but enthusiastic approach to problem-solving, Uyemura was as ready as he would ever be to become full-time manager of Mōliʻi Pond.

The years leading up to World War II, and the period just after, proved to be pivotal for Mōliʻi Pond. Many changes were being made to the areas in and around Kāneʻohe Bay. A military facility at Mōkapu Peninsula was being developed and it was necessary to bring some big ships into the bay to support the construction. The barrier reef surrounding the bay entrance was too shallow for tankers and other large ships to enter, so in 1938, the U.S. Navy dynamited the coral reef in northern Kāneʻohe Bay and dredged a channel. Large numbers of fish that did not die immediately were so disoriented that they were easily harvested.

Portions of Kualoa Ranch were taken over by the military. Fortifications were built to serve as observation posts and house machine-gun nests; some of these structures can still be seen along the coast. A small airfield with radio towers was also built at the ranch. There were some restrictions on activities as the military presence increased. With the attack on Pearl Harbor in December 1941, however, life at Mōliʻi Pond would change drastically.

Local officials realized that the economy and function of the Territory of Hawaiʻi would be severely impacted if Japanese-Americans were rounded up and placed in detention camps, as had been done on the mainland United States. They decided to place some limits on the activities of these citizens, but to allow life to continue pretty much as normal. As with many Japanese-Americans, the nisei or second-generation American tends to feel more affinity for the country and society of his birth than for the home country of his parents.

George thought about joining the 442nd Infantry Regimental Combat Team, which was made up primarily of Japanese-American volunteers. But the responsibility placed on a Japanese family's first-born son to continue with his father's work also had to be considered. In the end, he chose to continue managing Mōliʻi Pond.

A number of wartime restrictions limited George's ability to do his work around the pond. He could not operate his boat. This limited his ability to fish, and to capture fry. He could not work at night, which was a serious handicap. Tides shift every six or seven hours, and adjustments needed to be made at the *mākāhā*, depending on the season and nature of the tidal change. George was terribly frustrated, but he obeyed the restrictions. There were machine gun nests located at different points along the Kualoa coastline; one was planted right at the edge of the pond. While the guns were pointed out over the ocean, it would not be wise to test the gunners' reactions to unauthorized activity out on the *kuapā*.

By the summer of 1942 George had become frustrated, but rather than becoming reactive to his frustrations he became contemplative, looking for insights and resolution. He had to figure out how to continue his work at the pond in spite of the restrictions that were being placed on him and his family. As he often liked to do, he went to the *mākāhā* to sit and think. By stopping to think, he learned to observe.

On this particular day, he noticed movement in the water. He always had coconut oil on hand, to smooth out the surface of the water when he looked for *he'e* (octopus). George spread some on the water just outside of the *mākāhā* and noticed some clear, wiggly bodies with two large, black eyes. They were swimming along the shore, headed towards the *mākāhā*. He asked his mother to make a fine-meshed net and later returned to catch some of these unusual creatures.

When he got them home, George put them in a bucket and prepared to watch them grow. After three weeks they developed into *awa*. In George's own words, that was the beginning! He came to realize that every creature would come into the pond through the *mākāhā*. Sometimes he would go out at night and hold a light near the *mākāhā*. Sure enough, when the tide was right, a multitude of other creatures flowed with the currents into Mōli'i Pond.

In a time that was chaotic and disruptive for everyone, George was able to step back from the confusion and uncertainty. He stopped his activities, but he did not stop his thinking. He was able to observe nature and learn the secrets and ancient Hawaiian techniques Mōli'i Pond seemed to be trying to reveal. George realized that the pond would continue to work in spite of what he or anyone else did, as long as the fisheries remained healthy and the pond structure was properly maintained. He could now begin to learn the natural cycles of the pond in order to keep it productive.

While Uyemura was not a formally trained scientist, he was developing skills that enabled a scientific approach to solving problems. In time, this helped him to become more efficient at pond management. Though family members helped out from time to time, and friends helped with repairs after big storms, the work was mostly done exclusively by Uyemura, and, later, his wife Jane. Out of necessity, he had to be tremendously efficient.

FIGURE 18: WEIR BOARDS TRAPPED THE *ʻŌIʻO* IN THE *ʻAUWAI* MAKING IT EASY FOR GEORGE TO CAPTURE THEM IN THE NET.

The Uyemuras maintained their lease arrangement with Kualoa Ranch, Ltd. until 1998, when George and Jane formally retired. They had taken on the enormous task of managing Mōli‘i Pond using many traditional techniques. Like the ancient Hawaiians, Uyemura was largely self-taught, observing the fish and their behavior over many years to develop the insight he needed to make his fishpond successful. By his own admission, he made mistakes along the way. Sometimes, fish died. And some years, the harvests weren't very bountiful. But this was a life that George and Jane loved, and they were good at what they did.

Uyemura's dedication was rewarded with the same knowledge and finely-honed instincts developed by the *kia ‘i loko* of ancient times, stewards of the fishponds for the *ali‘i*. Each fish species George raised had its own lifecycle. Eventually, he was able to understand the signals and cues particular to each species. Each time he came to the pond, he had to absorb new information, process it against what he knew, and decide what he had to do that day to keep the pond healthy and help it thrive.

With his first step in the direction of his fishpond, a good aquaculturist will begin processing his observations. Often he will know what has to be done by the time he reaches the shore. It is not always possible to put these insights into words, but the information shared by George Uyemura provides an important starting point for future aquaculturists wanting to learn traditional Hawaiian methods for pond management, as other ponds are restored and brought back into operation.

# Chapter 6

## Ahupua'a: The New Land Division

Western contact had a tremendous impact on Hawaiian society, culture and resources. Changes in the traditions of land ownership, and the resulting growth and modernization, created the circumstances that allowed Mōliʻi Pond to come under private ownership. One hundred and fifty years later, these changes would lead to the relocation of the Uyemura family to Hakipuʻu.

Hawaiian society was controlled by a system of rules and laws known as *kapu*. The structure of society, and the rules that controlled it, were much more complicated than can be presented here. Broadly stated, these rules controlled all aspects of society for many centuries. All natural resources in the mountains and the ocean were protected in an effort to preserve a way of life for future generations.

The abolishment of the *kapu* system in 1819 left the people of Hawaiʻi without a traditional system of rules to guide their behaviors. The confluence of Western and Eastern cultures further added to the confusion between their traditional values and those of the new and evolving culture. Under the system of *ahupuaʻa* or land division, the mountains, coastline and ocean were considered a balanced and integrated unit. With the end of *kapu*, these areas were no longer protected. In time, the districts would be divided up and managed separately without regard to the overall health of the system. Rules enforced under the *kapu* to protect fish during their spawning seasons could now be ignored without the fear of punishment. The *aliʻi* were losing command over the *makaʻāinana*, who were desperately needed to maintain Mōliʻi Pond and hundreds of other fishponds, and other resources.

As mentioned in chapter 2, changes in land ownership in Hawaiʻi began in 1848 with the Great Mahele. Under the traditional feudal system all land was owned by the *aliʻi*. The right to live on or use the land could be awarded and removed at the whim of the *aliʻi*. Beginning in 1848, when the laws changed to allow for land ownership by foreigners, some prominent families in Hawaiʻi were successful in acquiring landholdings.

The Kuleana Act of 1850 was intended to allow commoners to obtain plots of land for subsistence living. The concept of land ownership was alien to the *makaʻāinana*. Therefore, many native Hawaiians entitled to lands did not apply. It is estimated that 70% of Hawaiians did not receive lands under the Kuleana Act of 1850. Additionally, tracts given to commoners were often not prime agricultural land, or they were otherwise lacking resources available in the traditional *ahupuaʻa*.

According to Kanahele (1995) and Farber (1997), all of the fishponds were awarded to Hawaiian families, primarily the *aliʻi*, in the 1850's. This would have protected the fishponds from development and exploitation, if only the traditions of maintaining the ponds had continued through the generations that followed.

But managing a pond was a full-time job, and the workforce needed to maintain the ponds was no longer available to the *aliʻi*. Diseases introduced by explorers and traders had taken a toll on the Hawaiian population. Hawaiians who did not receive lands under the Kuleana Act needed to find a way to make a living.

Those who *did* receive lands sometimes found it easier and more profitable to work at outside jobs. Some found it possible to make more money by converting their land and ponds to other uses. Others found it possible to make money from their ponds by leasing them to interested operators. The Chinese, who originally came to Hawaiʻi as traders and to work on the sugar plantations, were branching out into new territory. They were already doing business as fish merchants; obtaining rights to operate the Hawaiian fishponds provided them with another source of fresh fish for their markets. According to Kanahele (1995), once the Hawaiian owners began leasing the ponds to non-Hawaiians, the Hawaiian landowners "… gave up their management rights as well as this traditional link to the Hawaiian culture." In time, the Chinese came to control the fish markets and many of Honolulu's restaurants.

The 622-acre Kualoa *ahupuaʻa* was acquired by Dr. Gerritt P. Judd on November 20, 1850 from King Kamehameha III. The parcel included the island known as Mokoliʻi, often referred to as Chinaman's Hat. Judd attempted to develop a sugar plantation on his land in Kualoa, clearing land with one Mr. S.G. Wilder to plant sugarcane. A mill was built for the processing of the sugar cane; remnants of this structure can still be seen along Kamehameha Highway. Within a few years it was determined that the soil was too poor for sugarcane production, and the business was closed.

On December 19, 1870, portions of Hakipuʻu, Kaʻaʻawa and additional portions of Kualoa were acquired by Dr. Judd from S.G. Wilder. Kualoa Sugar Plantation finally closed as a business in 1871. In 1880, after the death of Queen Kalama, additional portions of Hakipuʻu were sold to Charles H. Judd, son of Gerritt Judd (Kelly 1998).

Collectively, this property officially became known as Kualoa Ranch, Ltd. on May 31, 1927. One of the country's oldest cattle ranches, Kualoa is still owned by the same family: John Morgan, great-great-great grandson of Dr. Gerritt Judd, is president and general manager of the hauntingly beautiful 4,000-acre estate (Carroll 2001).

# Chapter 7

## Spirits and Protectors

The gods *Kū* and *Hina* are often associated with traditional Hawaiian fishponds. According to Kawaharada (1992), the god *Kanaloa* “was the god of the ocean and the patron of fishing in the Marquesas and Society Islands.” This association changed in Hawaiʻi with regard to fishponds. Traditionally the god of war, *Kū* came from the South Pacific with the original settlers. Historians have discovered the great significance of *Kū* to *Kamehameha* in his great quest to unite the islands of Hawaiʻi under one rule. It was believed that the power of the chiefs came through *Kū*. By association, the land, fishing rights, fishponds and other resources obtained through conquest were also a part of the *mana* of *Kū*.

During times of peace, *Kū* retained these resources and remained god of the pond. His wife, *Hina*, was often associated with the gathering of seafood. She was often asked by the *kahuna* to bring fish in from the seas to the traps. She is also the goddess of growth and procreation, a verdant symbol of the productivity and richness found in ancient Hawaiian fishponds.

A *heiau* or shrine to *Kū* may often be found along the eastern end of Hawaiian fishponds, where early islanders made offerings and asked the god for protection of the fishpond and control of the fish. *Kū* is worshipped in the morning, and his shrines are always positioned to greet the sun as it rises. The goddess *Hina*, worshipped in the afternoon, represents the growth, production and procreation of the fish.

Fishponds often have their own *ʻaumakua*. The *ʻaumakua* are ancestral deities of the family and may also be thought of as the spirit of a place, as its guardian angel. In the case of Mōliʻi Pond, the *ʻaumakua* is giant *heʻe* or octopus. The reef flats along Kualoa and the reef patches within Kāneʻohe Bay have, traditionally, been very productive *heʻe* grounds. While the octopus in Hawaiʻi is shy, timid and non-aggressive, he can also be quite clever in his ability to survive and escape. Large octopuses are very strong. In close encounters with divers, they've been known to tear off masks, scuba mouthpieces and snorkels!

The *heʻe* is a clever creature, capable of solving complex problems related to its survival. There are stories of *heʻe* sacrificing one or two arms to moray eels, so they can escape. And the miracle of the *heʻe*: those arms are actually capable of regeneration! The *heʻe* is soon back to normal.

Ancient Hawaiians, in recognizing the *heʻe* as the protector of Mōliʻi Pond, might also have realized that this pond needed an *ʻaumakua* who was clever at solving problems, if the pond was to survive and flourish. Development on Oʻahu, population growth on the Windward coast, changes in the nearshore fisheries and competition for existing resources would result in changes that would greatly impact the productivity of Hawaiian fishponds. By the 20$^{th}$ century, fishponds had become less and less able to self-stock, requiring clever and adaptive management strategies in order to maintain production.

# Chapter 8

## The Physical World of Mōliʻi Pond

Mōliʻi Pond is a 128-acre *loko kuapā* that, according to Hawaiian legend, was built in one night by the *menehune*. A part of the Hakipuʻu *ahupuaʻa*, it has been in existence for over 600 years.

According to Sterling and Summers (1978), this fertile and productive area was included in lands given by the *aliʻi* to the *kahuna*. The adjacent *ahupuaʻa* of Kualoa was considered one of the most sacred places on the island of Oʻahu. The newborn children of chiefs were brought here, raised by foster parents, and trained in the art of war and the ancient traditions. The land was described as "very rich" in the old days, "because of the running schools of mullet from Kaihuopalaʻai, the *awa* fish and mullets that had been kept and fattened in ponds."

According to Handy et al. (1972), *haki puʻu* means "broken hill." Hakipuʻu Stream and a few smaller streams run through this *ahupuaʻa.* In 1935, a dozen *loʻi* had been created along Hakipuʻu Stream, with another dozen or so producing taro in the upper valleys. The freshwater needed to support the *loʻi* was provided by these streams, by Kailau Spring on the hill above the fishpond, and by rain channels. This water was also important in attracting young fish to the shoreline and into Mōliʻi Pond. Over the last century, much of the water has been diverted from the Waiāhole Ditch to Leeward and Central Oʻahu to support agriculture, as well as commercial and residential developments.

FIGURE 19: MŌLIʻI POND AERIAL PHOTO SHOWING LOCATION OF REMAINING, FUNCTIONAL *MĀKĀHĀ*. DETAILS IN DOTTED LINES SHOWN AT RIGHT.

The northern section of Kāneʻohe Bay, where Mōliʻi Pond is located, is protected by a large barrier reef. Man-made channels in the reef allow for the passage of larger boats. The *menehune* built the *kuapā* solidly, in a double-walled fashion with basalt rocks. Fill between the walls consists of smaller rocks, coral fragments and soil. The walls are approximately 10.8 feet (3.3 meters) wide, and stand an average 5.6 feet (1.7 meters) above the outer shoreline. Rocks were placed on an existing reef flat that connects two points of land. The wall itself is approximately 4,000 feet (1,220 meters) in length (Apple and Kikuchi 1975). The pond's total area has been reported as between 120 and 135 acres. Its depth measures from four feet to over thirty feet in some places.

The most important tool for stocking and harvesting fishponds was the *mākāhā*, the grate set in the sluice channel through which water flows in and out of the pond. When the fishpond was originally built at Mōliʻi, seawater flowed in and out of the pond through five *mākāhā*. Beckley (1883) describes the *mākāhā* as straight sticks held together by two or three crossbeams. According to Kamakau (1976) it was traditionally made of the wood of *ʻōhiʻa ʻai* (Mountain apple tree, *Eugenia malaccensis*). Straight pieces were lashed

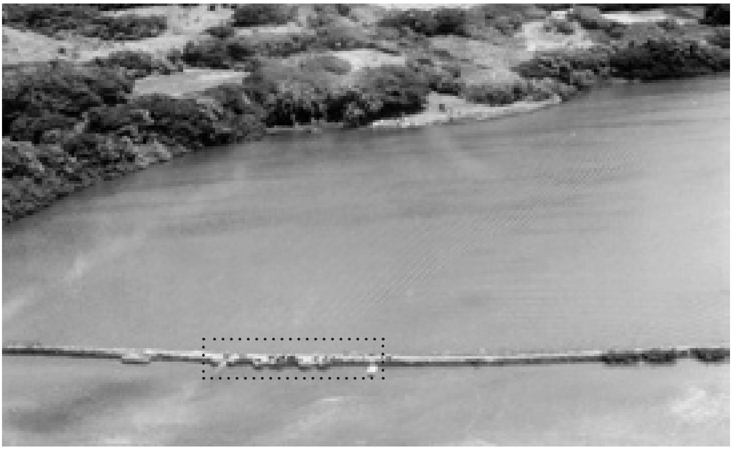


Figure 20: Mōli'i Pond aerial photo, circa 1960
Details in dotted lines shown in the next two figures

Figure 21: november 2007 view from kāne'ohe bay to pond where mangroves and accumulated sand have camouflaged the *mākāhā* .

Figure 22: Closer view of fig. 21, from Kāne'ohe bay to pond showing *mākāhā*.

together with cords made from *‘ie*, or woody vines (*Freycinetia*), to create the half-inch openings between wood slats. The spacing of the wood was adjusted to allow fry to enter and leave the pond freely, but prevented adult fish from returning to the sea. Traditionally, foundation stones were placed to frame the *mākāhā*, and pebbles were poured in to lock it in place. The traditional *mākāhā* was immobile and had to replaced every few years.

In modern times, other materials have been used: redwood, steel rebar, galvanized pipes, mesh screens. Though these modern materials are functional, they all deteriorate after a few years. In some cases, the mesh or grating is mounted in a removable frame so that it can easily be cleaned or changed. Maintaining the sluice channel and *mākāhā* is critical, as this complex system controls the movement and stocking of fish in the pond, and traps them at the time of harvest. A weakened or poorly built *mākāhā* may not be able to hold back hundreds of pounds of fish struggling to leave the pond *en masse*, as they follow their instincts and return to spawn in the ocean.

In modern times, even wrought iron used by some pond operators for the *mākāhā* did not last very long, usually for a

FIGURE 23: A SCREEN MESH ON TOP OF THE WEIR BOARDS FILTERS WATER DURING HIGH TIDES.

FIGURE 24: CLOSE-UP OF SCREENING

maximum of about two years. George experimented with various materials. He tried applying zinc to slow down the electrolysis of the iron, but it was not effective. Galvanizing the gate actually shortened its life to about six months! He never did find a better material, but through experimentation he proved to himself that the best strategy was to replace the grates regularly. This he did, until his retirement.

Within the sluice channel is a second gate that serves as a weir and is used to stop the flow of water through the sluice. This gate is usually movable and adjustable. In the case of Mōliʻi Pond, boards four to eight inches high were stacked upon one another to stop the flow of water, and could be removed or adjusted to allow water to enter or leave the pond.

When set in place, this gate acts as a solid barrier capable of cutting off most of the flow through the *mākāhā*, retaining the water mass within the pond. This was done during a falling tide, in order to maintain depth within the pond and to prevent fish from returning to the ocean. Because there are usually two low tides and two high tides during each twenty-five hour period, the gate may have to be adjusted with each change in the tidal cycle, and should be checked about every six to seven hours.

FIGURE 25: LIFTING THE GATE

Though most fishponds appear "sealed up," they are actually highly porous. Water can seep around the gates within the sluice channel. There are usually small openings along the base of the *kuapā* that allow the flow of small streams of water. This creates many microhabitats within the walls that can serve as shelter for eels, shrimp, crabs and fish. This adds to the diversity of the pond, making it a much more complex ecosystem than one might imagine.

In modern times, some ponds have rocks placed strategically and cemented with concrete. This helps stabilize the structure of the

FIGURE 26: *'AUWAI* SHOWING WEIR OR MOVABLE GATE SYSTEM

Figure 27: Close-up showing grooves for boards

*kuapā*, creating a wall that can better withstand high waves, storms and tsunamis. When concrete is used for this purpose, however, it may restrict the flow of water that allows the pond to "breathe" throughout the day. Smaller caves and microhabitats within the *kuapā* may be eliminated, creating an ecosystem that is not as diverse and healthy as it might be if the pond's devices were built with traditional techniques and materials. The ecosystem can also be negatively impacted if too much of the fill material falls and clogs the passages between the rocks at the base of the wall.

The five *mākāhā* of Mōliʻi Pond required regular maintenance. They must always be kept clear of debris so that water could flow freely through the grate. Conscientious caretakers performed simple visual inspections as the tides changed, fishing out leaves, branches and—in modern times—plastic bags.

Figure 28: Spiny lobster

Fouling organisms had to be removed from the *mākāhā* and walls of the sluice channel. Uyemura's experience using lobsters to control the biological growth in the sluice channel and *mākāhā* is only a part of the story. In the 1930's, *uhu* (*Calotomus sp.*) were annually recruited into Mōli'i Pond. When they grew to weigh about a pound, the Uyemuras would catch them with the intention of offering them for sale. Uyemura observed that *uhu* fed on the barnacles and oysters that grew on the rocks. Because of this, the *uhu* served two purposes at Mōli'i Pond: they helped keep the *mākāhā* clean, and they provided income for the business.

After about fifteen years, the *uhu* stopped coming into the pond. The creation of a channel in the barrier reef surrounding the entrance to Kāne'ohe Bay in preparation for World War II may have impacted the population, or perhaps there was simply more commercial and recreational fishing taking place in the bay as the Windward Coast became more accessible. Large schools of baby *uhu* in Kāne'ohe Bay, George remembers, were once common sights, but they all but disappeared in the 1960s.

Lobsters were also becoming harder to find. As the population on O‘ahu grew, the depleted localized fisheries began spreading out from the main population centers. Areas along the Windward coastline that had once been considered “country” became more accessible as roads were improved. The expansion of military activity just before World War II along the Windward coast required that roads be built and improved to handle the heavier traffic. This made the reefs along Kualoa accessible to commercial fishermen who could harvest fish and lobsters during the evening and early morning hours and still make it to the fish markets when they opened. As Uyemura learned, the balloonfish (*Arothron hispidus*) liked to eat some of the same fouling organisms as *uhu* and lobsters, and so became the next sea creature to serve in that capacity at Mōli‘i Pond.

Sand and sediment had to be cleared away as they accumulated along the entrances to the sluice channel. Light flocculent sediment accumulated rapidly as a natural course of biological productivity. Though heavy rainstorms could sometimes deliver large amounts of heavier sediment that actually decreased the depth of the pond, much of the lighter material would flush out with the outgoing tides. Some of the ancient ponds were said to have a unique flow pattern that allowed fresh seawater to enter through one *mākāhā*, and flush out debris and sediment through another.

The role of the *mākāhā*, and the *kia ‘i loko’s* own knowledge of his fishpond, were critical to the pond’s productivity. Monitoring the tidal patterns and managing the flow of water through the *mākāhā* were extremely important functions in maintaining the health of the pond, and cannot be overemphasized when discussing this process.

Sand deposited on the reef flats along the outer walls of the ponds presented another problem for Uyemura. Over time, sand that collected along the outer wall of Mōli‘i Pond created an extension of the beach at Kualoa Beach Park. This problem may have been exacerbated when, in an effort to improve Kualoa, the City and County of Honolulu brought in additional sand to widen the beaches along the shoreline. This sand eventually eroded and exposed the retaining walls that had been erected, ironically enough, to minimize erosion. This sand may have migrated along the shore, eventually blocking some openings to Mōliʻi Pond, and it had to be cleared out in order to keep the *mākāhā* functional.

As the build-up of Kualoa Beach continued, it became more and more difficult to keep the *mākāhā* cleared. New problems arose with curious beachgoers, who had begun venturing over to the other side of the *kuapā* to see what was going on. This created additional problems of security, safety and poaching. Once the beach grew a certain size, it was no longer possible to keep the channel clear and open. By the time Uyemura retired, he was depending primarily on the three sluice channels, located closer to the western end of the *kuapā*.

# Chapter 9

## ʻAmaʻama, Humble and Harassed

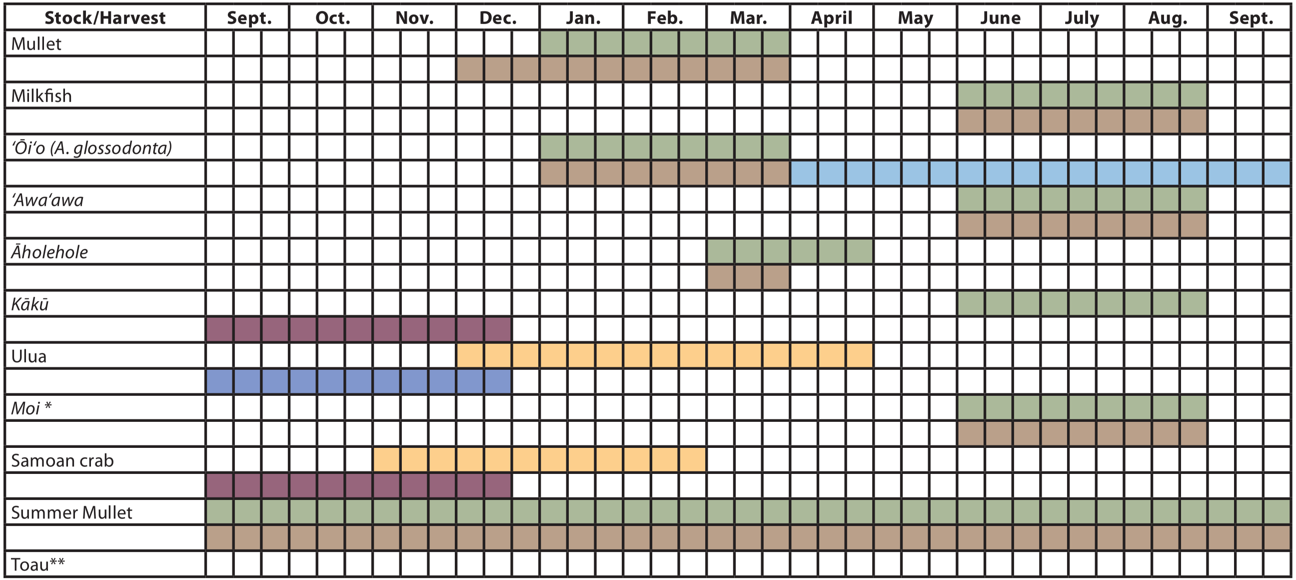
The stocking and harvesting of the *ʻamaʻama* and *awa* were important milestones each year in the operation of Mōliʻi Pond. George noted the normal periods for harvesting at the *mākāhā* and fry collection for these species, and a number of others that proved important in this ecosystem. (See Table 2.)

The primary species cultured at Mōliʻi Pond was the *ʻamaʻama* or striped mullet. Historically, this species produced the greatest biomass in the typical *loko kuapā*. After Western contact and the development of commercial markets, the *ʻamaʻama* generated the greatest income for fishponds still in operation. The *awa* or milkfish was usually the second most important income-producer.

Trailing behind, in terms of production numbers, were a dozen or so other species. Fishponds were productive because they were complete systems, and when properly tended, they were able to maintain their own ecological balance. Hence, while other species might have lower production numbers and less commercial value, they all contributed to the delicate balance that helped sustain healthy populations of *ʻamaʻama* and *awa* through centuries of operation.

Uyemura had great compassion for the mullet. He observed with sympathy that the fish were singled out for harassment at every stage of their lives. As young fry, they were chased by *ulae* or lizard fishes (*Saurida sp.*). George would watch them jumping out of the water as the ambushing predators chased them from the

Table 2: Pond Stocking and Harvest




stocking

harvest at gate

These species never come to the gate for harvesting

No information on recruitment into Mōli'i Pond

*Pa'opa'o* grow well in Mōli'i Pond. More difficult to capture. Do not regularly come to the gate. Sometimes caught on hook and line.

Harvests occur throughout the year with hook and line.

* *Because the Moi li'i are wider than the screen openings, they must be caught with nets and stocked into the pond.*

***George believes that the toau are spawning within Mōli'i Pond.*

Note: The actual date for when each species comes to the *mākāhā* or begins to appear as fry can vary by one month or more. This is dependent on a number of environmental factors that are recognized in modern times as an "early summer" or a "late winter". The knowledge and skills of the *kia 'i loko* was very important in managing the pond and making the adjustments necessary to optimize the recruitment of fry and the harvesting of adult fish. When that knowledge was successfully passed on to the next generation it was possible maintain production in the ancient ponds over many centuries.

sandy bottoms of the reef flats. Along the sandy beaches, many *keiki* (children) learned to chase and catch the mullet when they saw schools along the shoreline. In the ultimate harassment, the mullet would be harvested at the peak of their lives, while in prime condition for spawning and reproduction.

*Pua ʻama*, the mullet fry that made it into Mōliʻi Pond, were perfect prey for predators like the barracuda. Larger barracuda ate larger mullet. Avid fishermen who visited Mōliʻi Pond were always thrilled to hear the splashing of fish jumping, followed by the sight of a large *ulua* (jack) or *kākū* (barracuda) attacking a school of *ʻanae* (large adult mullet). To see the *ʻanae* jumping out of the water, followed closely by the mouth of a large predator breaking the surface, was simply amazing.

Though considered a trash fish in some parts of the world, the *ʻamaʻama* was important to the *aliʻi* in ancient Hawaiʻi, and the most important species produced in fishponds.

The early writings that describe the stocking of *pua ʻama* in *loko kuapā* further attest to the importance of the mullet in ancient Hawaiʻi. According to Kamakau (1976) the traditional method for stocking a fishpond was to simply leave it alone. After five or six months, fish would begin to appear in the pond. Though the ancient Hawaiians had nets that could be used to collect additional fry to stock a pond, it wasn't usually necessary. The natural resources of freshwater, the protective habitat along the shoreline, and the design of the ponds made it attractive for the mullet to move closer to shore and into the *loko kuapā* during their early lifestages.

In 1883, Beckley wrote about the methods being used by Chinese lessees to stock the ponds. The *nae* is a fine mesh net with about ¼-inch mesh. A six-foot square of this netting was used to create an *ʻupena pua*, which was then used to catch the young mullet fry. The netting was framed on two sides with two sticks or *kuku*. A bag, four inches in diameter and two feet deep, was created from the same material and sewn into the center of the mesh. This created a basic net unit which could be manipulated along the shore, trapping *pua* in the bag.

To surround larger schools of *pua* along a greater shoreline, fifteen to twenty feet of double twisted *convolvulus* vines were typically added to the *kuku*. When the twisted vines were extended from the central netting, an area nearly forty-five feet wide could be enveloped, and nearly all of the *pua ʻama* would be herded into the mesh bag.

According to Uyemura, mullet were grown on a three-year cycle: fry that entered the pond were fully grown and sexually mature after three years. Therefore, there would be little or no mullet to harvest for the first two years of the life of a new pond. A poor season for *pua* would not become evident in the harvest until three years later. However, because not all the mullet are harvested each year, there were always some that were four or five years old when finally harvested.

FIGURE 29: MULLET

The Uyemuras also described a few rare occasions in which they observed adult mullet swimming to the *mākāhā* from the ocean, trying to enter Mōliʻi Pond. This would sometimes happen after heavy rainstorms, and it is assumed that the fish were trying to return to familiar protective habitats on shore. It might also have been that the *ʻanae*, after completion of their spawning season, were compelled to return to the ponds and rivers so they could begin feeding for the next season of reproduction.

The use of the *mākāhā* for harvesting is a unique event. Mullet spawn primarily during the winter months. Starting in December, hundreds of mullet may come to the gate each day, mature and ready to spawn. Generally, mullet will not spawn within the *loko* *kuapā*. Instead, they must migrate back into the ocean, where they form large schools offshore as the females reach their final stages of maturation. During this period, they are extremely susceptible to predation and net fishing. The ancient Hawaiians recognized this fact and placed a *kapu* or ban on harvesting mullet from the ocean between December and February.

Mature mullet came to the *mākāhā* on rising tides. When the mullet attempted to leave Mōliʻi Pond, they were trapped within the sluice channel. Beckley (1883) described pond keepers using nets as wide as the channel in order to scoop out as much fish as was needed. Similarly, the Uyemuras used a large scoop net to harvest the mullet. Smaller mullet would be returned to the pond. The large mullet would be placed directly into the boat for transport across the pond and delivery to the fish markets in Honolulu. Sometimes, Uyemura closed the gate to prevent more mullet from coming into the sluice channel, further congesting the *mākāhā*. These mullet would return instinctively at the next rising tide, trying to return to the ocean.

In Uyemura's early years, an average harvest of mullet was 300 to 400 pounds per day. Taking more mullet to the market at any one time might force a drop in the price for that harvest, and could impact the price for future harvests. Therefore, the Uyemuras and other pond keepers had to manage their supplies to maintain the optimum price each season. Fish not taken to market on one day would return to the *mākāhā* at the next harvest. Similarly, fish not harvested one year would be available for harvest the following year. Because of this, the pond was thought of as a living refrigerator in which fish could be kept alive until needed.

The total harvest of mullet in any one season varied considerably, based on the amount of *pua* stocked three years earlier, the amount of predation that occurred during those three years, and the current price the market would pay for mullet that year. In better years, the Uyemuras were able to harvest between 7,000 and 10,000 pounds of mullet in a three-month season.

Predators, while never abundant in the pond, certainly did consume their share of mullet at all stages of life. (Figures 30 & 31)

*Kākū* and *ulua* never came to the gate during their spawning seasons; therefore there was no easy method for harvesting them from Mōliʻi Pond. In order to control the predator population, Uyemura implemented a steady regimen of fishing for barracuda and *ulua*. He also had to actively fish for the younger *kākū* in order to minimize them, as larger *kākū* were capable of eating larger mullet. When mullet fry were abundant, the presence of these predators was not as big a problem. However, as *pua* became scarce, it was important to keep the predator population under control.

FIGURE 30: GEORGE HOLDING LARGE *KĀKŪ*

Beginning in the 1950’s, mullet fry were not as abundant as before. Fry collection outside of Mōliʻi Pond was a year-round activity for Uyemura. He did not believe that the pond could be overstocked, as there were always predators that fed on excess fry, and nature would do its part to maintain proper balance within the pond. Fisheries already in a state of decline in the early 1900’s continued to decline, to the point that natural recruitment was insufficient to maintain the stocks of mullet and other species within Mōliʻi Pond.

Initially George would collect fry from the shoreline areas adjacent to Mōliʻi Pond. Kahana Bay to the north, and Waiāhole and Waikāne Valleys to the south, had freshwater flows that attracted *pua ʻama*. George and the other pond operators knew of these spots, and they all left their ponds to get enough fry each year.

Fishpond operators were required to apply for a special license that allowed them to use smaller mesh nets to collect fry for stocking the ponds. Competition among fishpond operators was

Figure 31: George holding a large *ulua*

not a problem; a "gentlemen's agreement" among fry collectors kept everyone on friendly terms. Whoever was at a site first would be allowed to finish collecting his fry without disturbance from other pond operators. There was always enough fry to satisfy everyone so this was usually not a problem. The greater competition came from commercial tuna or *aku* boats.

Nets used by sampan-style *aku* fishing boats were similar to those used by pond keepers, though longer and deeper. They were used to collect baitfish, primarily *nehu* and *ʻiao*. When a sufficient supply of bait had been collected, the boats would head out to sea where the fishing for *aku* took place. The baitfish was used to attract the tuna to the stern of the boat. As *nehu* became less abundant in the 1950s and 1960s, *aku* fishermen would use any other available species, including mullet. *Aku* boats would enter their favorite collecting areas, such as Pearl Harbor and Kāneʻohe Bay, and then send out their skiffs to locate and surround schools of baitfish. Huge schools of *pua ʻama* were collected from different parts of the bay, leaving less and less for fishpond operators.

As other fishponds shut down their commercial operations, there was less competition for the limited fry that were available. However, the remaining *aku* boats continued to visit Kāneʻohe Bay to collect bait. Officials of the Territory of Hawaiʻi became aware of this problem, and the Division of Fish and Game brought in a number of exotic species they hoped would become established in Hawaiian waters, addressing the baitfish needs of the *aku* industry. The outcome of these and other resource management efforts would eventually result in changes in the nearshore fisheries around Oʻahu and the other Hawaiian Islands. Because Mōliʻi Pond was so dependent on the productivity of Kāneʻohe Bay, these efforts would also impact its production.

# Chapter 10

## Exotics Invade The Fishpond

Over a period of many decades, and with the best of intentions, the Division of Fish and Game of the Territory of Hawai‘i looked into solutions to the problem of declining fisheries. The availability of *nehu* (*Stolephorus purpureus*) and *‘iao* (*Praenesus insularum*) were critical to the success of the sampan fisheries.

In 1932, a small population of California anchovy, *Anchoa compressa*, was released in Kāne‘ohe Bay on O‘ahu. According to Randall and Kanayama (1972), the anchovies did not become established. Beginning in 1955, the Marquesan sardine (*Harengula vittata*) was collected from the Marquesas Islands and brought to O‘ahu for release (Brock 1960). In the late summer of 1958, some juvenile sardines were captured, which suggested they were reproducing in Hawaiian waters. Additional recoveries of small sardines were made on Kaua‘i, Maui and Hawai‘i. It was later discovered that these sardines were of a species new to science. As Randall and Kanayama (1972) reported, the species was named *Sardinella marquesensis* Berry and Whitehead, 1968. While *S. marquesensis* did become established, the species was not able to prevent the decline of the sampan *aku* fishing industry.

The greater impact to Hawaiian waters came with an unintentional species introduction that occurred with *S. marquesensis*. The Australian mullet, also called Kanda or summer mullet (*V. engeli*), was also present in the shipments of the Marquesan sardine to O‘ahu. This species easily established itself here, and has now been reported in many areas inhabited by *‘ama‘ama*.

Australian mullet can grow up to 12 inches in length. Because of their smaller size, they do not command as high a price as *'ama 'ama*. Their fry is often mistaken for *pua 'ama*. This can lead to disappointing results for pond managers who find, after waiting for three years, that their *'anae* harvests do not meet their expectations. Uyemura observed that they came to the *mākāhā* throughout the year, suggesting that they may be year-round spawners. This would also suggest that their fry are being recruited into the pond throughout the year. Recent anecdotal comments suggest that Australian mullet is gaining some popularity in the markets, but it is still not as popular as locally-raised *'ama'ama*.

Kanayama (1967) reported that groupers and snappers were poorly represented in the nearshore fisheries around Hawai'i. To supplement these fisheries, the Division of Fish and Game implemented a program of species introductions. The successful introduction of the *taape* or blue-lined snapper (*Lutjanus kasmira*), and its subsequent impact on nearshore fisheries, is well known.

In 1955, and again in 1956, the *toau* or black-tailed snapper *(Lutjanus fulvus)* was introduced into Kāne'ohe Bay from Moorea, Society Islands. It never became as well-established as the *taape*, but the *toau* has been reported from O'ahu, Kaua'i, Maui, Lanai and Hawai'i.

Figure 32: *Toau* or black-tailed snapper

To the unfortunate detriment of the mullet population of Mōliʻi Pond, the *toau* became well-established in the pond. *Toau* could grow up to 40 cm. in length and were voracious piscivores. Their population grew until they had become the major predators of *ʻamaʻama* at Mōliʻi Pond. Uyemura observed them actively feeding at night on the surface of the water. When their gut contents were examined, they were often filled with small fish. Uyemura believed they were reproducing within the pond, as they did not come to the gate at any time of the year to migrate back to the ocean to spawn. He also believed that they fed on most of the mullet and milkfish fry that stocked the pond.

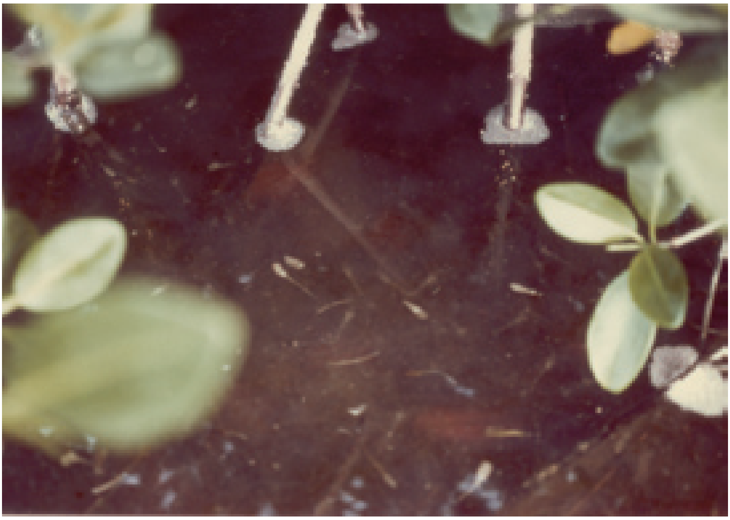


Figure 33: Close-up of mangroves

*Toau* were difficult to harvest. They did not come to the *mākāhā* during spawning season, but preferred sheltered areas and lived among mangrove roots or in rocky crevices. They learned to avoid seine nets. Uyemura attempted to hunt them by firing a bang stick into the mangroves. The *toau* learned to avoid the impact simply by swimming away when a diver was in the area. The only good thing about the *toau* was that they fetched a decent price at the market. However, because it was so difficult to capture them, their population could not be controlled.

George always leapt to take on challenges and develop workable solutions. He found such challenges exciting and stimulating to his creativity. Because the *toau* could not be eliminated from the pond, George tried to improve on mullet production, holding fry in nursery ponds until they were five inches in length. At this size, they were large enough to escape predation by the *toau*. The nursery period was about one year. This additional effort did help improve the production of *‘ama‘ama*, but there was one other problem to overcome.

FIGURE 34: NURSERY POND

# Chapter 11

## Awa in a Changing Pond

Kualoa Ranch had hosted Hollywood production companies for a number of years, and many of its spectacular vistas had appeared in major motion pictures. The Morgans decided to implement a plan to diversify the ranch's business. This attracted many visitors to Kualoa Ranch and to Mōli‘i Pond, where the visitors would play in and around the water.

Not surprisingly, increased motorboat activity nearby affected the behavior of the fish. George was concerned that the mullet would be scared away from the *mākāhā* because of the increased boat traffic. When the problems of lower recruitment were factored in, the net result was that fewer and fewer mullet came to the *mākāhā* at harvest. Facing predation by *toau*, and competition from the Australian mullet, the pond's *‘ama‘ama* population was in a state of decline. George recognized that production of this most important species was in jeopardy. By the time he retired in 1998, he had all but given up on mullet production.

Economically, the *awa* or milkfish was the second most important fish produced at Mōli‘i Pond. Like the *pua ‘ama* (mullet fry), the *pua awa* (milkfish fry) entered the pond with rising tides. *Awa* are fast-growing fish and may reach a weight of 1.5 pounds in a year. Harvesting is done at the *mākāhā* when the *awa* are mature and ready to spawn, after four or five years. The *awa* are summer spawners and begin to accumulate at the *mākāhā* in June, waiting to return to the ocean to reproduce. Their larvae have a three-week cycle. By late June, they can be observed returning to shore and moving into streams and estuaries for their nursery growth period.

This was the phenomenon George saw firsthand in the summer of 1942, one that helped him understand how Mōliʻi Pond had been productive for over 600 years. Like the mullet, the *pua awa* simply find their way into Hawaiian fishponds on their own.

The most successful fry recruitment for *pua awa* was preceded by periods of heavy rain during the winter and spring months. The consistent relationship between fresh water and fry recruitment helped George to understand the factors that impacted production at Mōliʻi Pond. He realized that species like the *awa* and mullet depended on freshwater to lead them to habitats that would provide food they needed to grow, and the shelter to protect them from predators. In Hawaiian fishponds, those habitats were recreated on well-developed coral reefs. Fresh water came from streams or artesian springs that flowed along the shoreline. These springs were charged with rainwater being accumulated and stored in the mountains of the *ahupuaʻa*. The fresh water brought the *pua awa* back to shore. During the rising tides, schools of *pua awa*

FIGURE 35: SEINING FOR FRY

would migrate along the shoreline to estuaries like Kahana Bay, or to Kāneʻohe Bay. When the fry came to Mōliʻi Pond, they would enter the pond just as they might enter a stream. The estuarine habitats provided food and shelter for the fry, and a safe place for their juvenile growth stages.

One particularly memorable season for fry collection took place after the flooding in 1965. Hawaiʻi experienced devastating rainstorms that caused major flooding on Oʻahu, much like the storms that flooded the islands in February and March 2006. What followed, that summer, was one of the best recruitments of *pua awa* that George and Jane Uyemura had ever seen.

During normal years, George and his family would be able to catch about a half-pound of *pua awa* in a day of collecting. The measurement used was about two tablespoons of *pua awa* per each scoop of the net, or about one thousand to two thousand fry per day. The tiny fry would normally be stocked in nursery tanks for sorting.

If the winter was dry and the island was going through a period of drought, then there would be very little freshwater seeping out along the shoreline. In dry years, the Uyemuras might only catch ten or fifteen fry in one scoop, amounting to maybe a few hundred per day. These would also be put in a nursery tank for sorting.

The fry collection season of 1965 was like none that George had ever seen. The pond was still recovering from the flooding that had occurred earlier that year. Freshwater collected in the mountains was still seeping out along the shoreline. The Uyemuras did not have to go far to collect the fry: just outside the pond were huge numbers of *pua awa*. There were so much *pua awa* that George's nursery tanks could not accommodate them. The contents of a single scoop of George's net would be passed up the wall to Jane, who would place the *pua awa* directly into the pond. As much as two or three pounds were collected every day for several days!

George's experiences in the summer of 1942 helped him develop some important insights into Mōliʻi Pond's natural, self-sustaining productivity. By collecting the fry, placing them in a tank, and observing them, he came to understand the natural cycles of the pond and how to better manage them. He also developed a nursery system for *pua awa* by purchasing old bathtubs for about a dollar apiece, placing different batches of fry in different tubs and leaving them there through their clear, late-larval stages, until they became pigmented. Through this process, George actually discovered the presence of another species in the collections.

FIGURE 36: GEORGE'S NURSERY SYSTEM

The fry of the *awa‘awa* or ladyfish (*Elops hawaiiensis*) also have a transparent late larval stage, which makes them difficult to distinguish from the *pua awa*. The *awa‘awa* has two black eyes on a transparent body, is slightly larger than the *pua awa*, and its behavior, while swimming, is similar to that of an eel. George came to realize that the *pua awa* had to be sorted out of the collections because they were being eaten by the *awa‘awa* who, if left alone, would consume all of the milkfish before they were large enough to stock into the pond.

The daily process of sorting consisted of scooping some larvae into a glass jar to see if *awa‘awa* were present. The tricky part was removing them without damaging the *pua awa*. Over a period of about three weeks, the *awa* became silvery, further distinguishing them from the *pua awa*. Most (though not all) would be removed, helping to improve the production of *awa* at Mōli‘i Pond over the next four or five years.

*Awa* have a faster growth rate than mullet and may reach a weight of 1.5 pounds in a year. They do not, however, come to the *mākāhā* until they are sexually mature, after four or five years in Mōliʻi Pond. At this time they may weigh up to ten pounds. Fish as large as thirty pounds have been harvested there!

The harvesting of *awa* can be challenging. They are large, and can be difficult to handle. When they are crowded into the fishpond's sluice channel, they begin to jump. These ten-pound flying torpedoes can be devastating to unwary pond keepers. Once caught, they must be quickly subdued to minimize bruising before they are delivered to market.

The *awa* has many small bones and is not terribly popular as a table fish, though its flesh is white and delicious. According to Titcomb (1977), whenever the supply of *awa* was poor, the precious fish was reserved strictly for chiefs as a delicacy. Today, it is still popular among the Asian populations in Hawaiʻi, selling well when it is available. It is sometimes used in the preparation of fishcake.

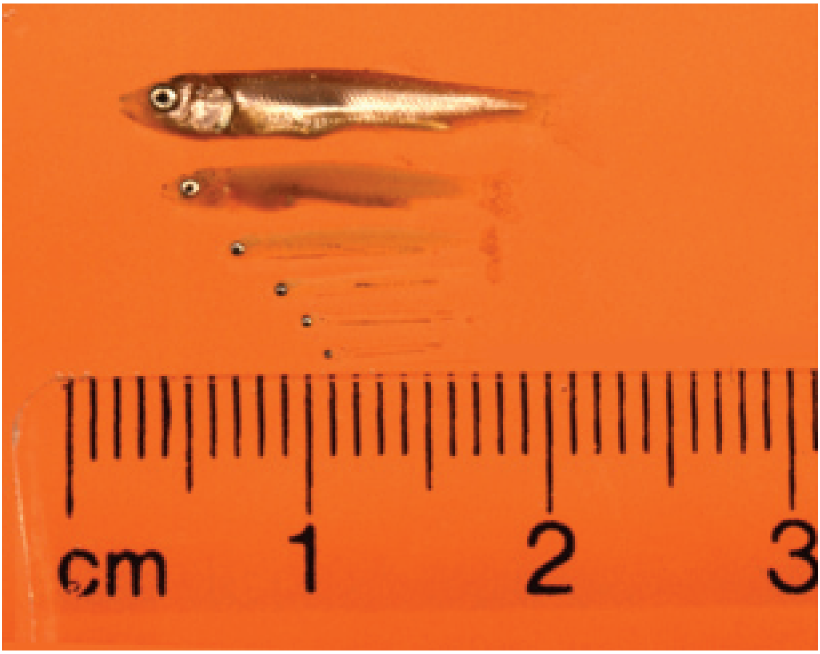



FIGURE 37: TRANSFORMATION OF TRANSPARENT AWA LARVAE TO A FULLY PIGMENTED (SILVERY) JUVENILE.

*‘Ama‘ama* and *awa* were the major species produced by Mōli‘i Pond. Their needs determined the cycles of activities that took place each year, an ancient protocol that survived through George and Jane Uyemura’s years as keepers of the pond. Many other species were also important to the health of the remarkable pond, and some even generated income, but none, with the possible exception of the Samoan crab, brought as much revenue as *‘ama‘ama* and *awa*.

Their greatest role, however, may have been as defenders and custodians of the ecological balance within the pond, a function subtly and far more important than their cash value. In the absence of natural disasters, a well-balanced pond in a healthy ecosystem was capable of generating thousands of pounds of fish each year. Disruptions to this balance, as illustrated in the example of the unfortunate *‘ama‘ama*, could result in problems that were difficult to overcome.

# Chapter 12

## Two Species of ʻŌiʻo

The *ʻŌiʻo* or bonefish of Mōliʻi Pond were not abundant and did not command a high price when George tried selling them at the fish markets. Still, because they came to the gate in the winter, they were easily harvested and provided a bit of extra income to the Uyemuras. As the flesh of the *ʻŌiʻo* contains many tiny bones, it wasn't terribly popular as a table fish. However, the *ʻŌiʻo* redeems itself as one of the favored species for the preparation of *lomi ʻōiʼo*, a raw fish paste that can be eaten raw or used for making fishcake.

As their spawning season begins in November and December, *ʻŌiʻo* rush to the gate. In the wild, adult *ʻŌiʻo* migrate to sandy channels where the spawning takes place. Their larvae grow in the ocean and migrate back to shore near the end of their leptocephalus stage. As young fry, they enter the pond in the early spring with the mullet.

For years, both biologists and pondkeepers believed that the bonefish species found in Hawaiʻi's fishponds was *Albula vulpes*. In 1981, Shaklee and Tamaru reported evidence of two distinct species of *ʻŌiʻo* in Hawaiʻi. When George learned of the discovery, he decided to assess the truth of the report for himself. He had already made mental notes on his observations of the bonefish in Mōliʻi Pond, and also from specimens caught from the ocean. He had experience capturing fingerlings to supplement the stock in his pond. He began to sort through his information, wondering if he had evidence of two species of *ʻŌiʻo* in Hawaiʻi.

FIGURE 38 AND 39: TWO TYPES OF *ʻŌIʻO: A. GLOSSODONTA* (ABOVE), *ALBULA VULPES* (BELOW)

According to FishBase (*http://fishbase.org*), *Albula vulpes* is described as "more or less pelagic," (belonging to the upper layer of the sea) and a benthic (bottom) feeder. This species can be found in shallow coastal waters, estuaries and bays with sandy or muddy bottoms.

FishBase describes *Albula glossodonta* as inhabiting mudflats, turbid reefs, mangroves and shallow lagoons. It also is a benthic feeder and uses its snout to find food. Its most distinguishing characteristic is a small dark patch of pigment on the underside of its snout. Other characteristics are not as easily observed. Shaklee and Tamaru (1981) used biochemical tests to distinguish the two species. They further described *A. glossodonta* as having a rounder snout and *A. vulpes* as having a more pointed snout.

George saw that *ʻŌiʻo* caught in his pond were rounder and stockier than *ʻŌiʻo* he caught in the ocean. *ʻŌiʻo* from Mōliʻi Pond were a greenish color; the *ʻŌiʻo* he caught in Kāneʻohe Bay were gray. At the fish market, he was told that the flesh of the pond *ʻŌiʻo* was quite firm, and could not be "spooned" or rolled until it had been stored in the refrigerator for several days. *ʻŌiʻo* caught from the ocean could be used for fishcake the day after it was caught. He noted that fish from his pond had dark patches on the underside of their snouts, which were rounder than those of the *ʻŌiʻo* he caught in the ocean. Though convinced of the presence of *A. glossodonta* in his pond, George was compelled to do a couple of experiments.

With careful study, George determined when and where he could collect pua *ʻōi'o*, bonefish fingerlings. He noted their delicate structure; they were difficult to handle and many did not survive transport to his pond for stocking. Once they entered the pond, however, the fingerlings grew very well. They also became easier to handle as they got older and larger.

In one memorable *ʻŌiʻo* experiment, George found a school of juvenile *A. vulpes* along the shoreline near the pond, fin-clipped thirty-three fingerlings, and released them. Later that year he recaptured two of them up the coast in Kaʻaʻawa. They had never entered the pond. In another experiment, he clipped the fins of *A. vulpes* juveniles and stocked them into Mōliʻi Pond. They never reappeared in any of the harvests. He assumes that they did not survive in the pond.

George's studies yielded valuable information about how to distinguish between the two very similar *ʻŌiʻo* species. The schools of *A. vulpes* juveniles were gray, and separate from the green-hued schools of *A. glossodonta* juveniles in the same area. They were never observed in a mixed school containing both species.

# Hawaii's Deadly ʻOʻopu Hue

The *ʻoʻopu hue*, or white-spotted puffer, has a unique place among the fish that inhabited Mōliʻi Pond. They were one of the important fish that helped keep the *mākāhā* clean. Also known as the balloonfish, in Latin as *Arothron hispidus*, and in Japan as the *fugu*, the flesh of *ʻoʻopu hue* is a deadly delicacy. In old Hawaiʻi, as in Japan today, these fish were consumed with delight (and, occasionally, fatal consequences) by thrill-seeking gourmands.

Figure 40: White-spotted Puffer

According to Titcomb (1977) and Beckley (1883) Hawaii's *'o'opu hue* had a good flavor. The more toxic specimens could be distinguished from milder fish by their yellower teeth. It was believed that those caught in the open ocean were more poisonous than those obtained from fish ponds.

To prepare the balloonfish for eating, three poison sacs had to be removed intact. The skin was also removed as it was slightly poisonous. The flesh that remained was white and described by Beckley (1883) as delicious. This was George Uyemura's favorite fish.

In Hawai'i's early years, it was legal to sell balloonfish in the markets. The main customers for this very special delicacy were the Japanese teahouses in Honolulu. All the other fish caught in Mōli'i Pond and taken to market were harvested during their spawning seasons, captured at the *mākāhā*. The balloonfish, however, always came to the *mākāhā* to feed, and could be harvested throughout the year. At night and in the early morning hours, George could hang a light over the sluice channel and scoop up the slow-swimming balloonfish as they swam by. The market was small and very limited, but balloonfish was one of the few species George was able to harvest on demand, according to the needs of the market. It was a good income producer.

George was an expert at cleaning the balloonfish; he began eating it when he was six years old. This is one of the few things he misses terribly about Mōli'i Pond. Because of the potential for poisoning, the sale of balloonfish was banned in Hawai'i. This, however, did not prevent George, his family, and occasionally some close friends, from enjoying *fugu sashimi*.

Figure 41: George holding a puffer fish with a *mākāhā* in the background

# Chapter 14

## The Samoan Crab

Samoan crabs were introduced into Kāneʻohe Bay by the Territory of Hawaiʻi between 1926 and 1935, with the intention of creating a fishery. Other releases took place on the islands of Molokaʻi and Hawaiʻi. The Samoan crab slowly reproduced and by the 1940s was considered to be firmly established in the state's rivers and estuaries. In the early years, crabs were protected by laws prohibiting their capture and sale, particularly of egg-carrying females. While never overly abundant, Samoan crabs occasionally showed up in the catches of recreational fishermen in the 40s.

Interest in the crabs increased as larger and larger specimens turned up; photos were even printed in the local newspapers. Larger specimens grew scarcer as the general public became aware of the delicious Samoan crab and recreational fishermen began targeting them. Over the years, their numbers increased considerably at Mōliʻi Pond, but George caught them only for his family's personal consumption, as fishing regulations prohibited him from selling them in the public market.

The Samoan crab was actually the first animal to disrupt the delicate balance at Mōliʻi Pond. It was an introduced species, initially low in numbers. But as it proliferated, George realized he had to do something to curb the population. Luckily, George's parents had a friend who was able to help. Fred Makino was founder and editor of the *Hawaiʻi Hochi*, a Japanese-language newspaper printed in Hawaiʻi. He was a frequent visitor to Mōliʻi Pond, coming there often to relax. When he heard of the pond's Samoan crab surplus, he asked the territorial legislature to readdress the regulations. The laws were changed.

Samoan crabs were caught using lobster nets. They had to be removed from the nets, and their pincers immobilized, before they were taken to market and sold, usually to seafood brokers. The market that finally developed for the crab was relatively small. At five dollars a pound, however, the tasty crustaceans were a nice source of income. Their relative scarcity helped keep their price high (and made them inviting targets for poachers).

Three other species of crabs at Mōli'i Pond were caught for market. They were all popular at the time. Once the Samoan crab was made available for sale, however, it became the only species fish markets wanted more of. Today there is no closed season for Samoan crabs. Only male crabs can be caught; the taking of female Samoan crabs is prohibited.

The biology of the Samoan crab is an interesting one. Crabs spend most of their lives inshore in streams and estuaries. The berried females, bearing eggs, will migrate to offshore waters for a few weeks until their eggs hatch. The tiny offspring's larval cycle is spent in the ocean, and the baby crabs must migrate back to their inshore habitat.

Figure 42: Samoan Crab under George's foot, the typical way to manage the crab

George had many, many nighttime encounters with Samoan crabs climbing the wall of Mōliʻi Pond to migrate to the ocean. When he walked on the wall he would hear their large pincers clacking on the rocks. On more than one occasion, they managed to latch onto his toes.

# Chapter 15

## Other Inhabitants of Mōliʻi

Predators created a paradoxical problem for Hawaiian fishponds. In small numbers, they helped eliminate weaker and diseased fish, playing an important role in keeping ponds healthy and in balance. But when their numbers grew, they could disrupt the pond's equilibrium. Fishing for predators was a constant activity for George, always mindful of protecting the *ʻanae* and *awa* as they neared market size. Predators usually got a good price at the fish market so they were a good source of additional income. Unlike the harvests at the *mākāhā*, however, capture of the large, predatory fish couldn't be counted on, so income from them was sporadic.

The *kākū* or *Sphyraena barracuda* was the most voracious of the predators in Mōliʻi Pond. It didn't take long for George to realize that the *kākū* had to be controlled to protect the *ʻamaʻama* at all stages of development. He watched as the *kākū* came in with *pua awa*, drifting into the pond with the tide, appearing as tiny sticks floating near the surface.

By observing the young *kākū's* behavior, George was able to devise a method that allowed *pua awa* to enter the pond while most of the *kākū* were tricked into remaining behind in the ocean. During certain parts of the tidal cycle George would lift some of the weir boards, allowing water to enter the sluice channel from the bottom of the water column. Weir boards remained in place at the surface so that the water flowing through the *mākāhā* did not come from the surface. Because the *kākū* remained near the surface, most of the fish that entered the channel were *awa* and *ʻawaʻawa*.

This method didn't eliminate all of the baby *kākū*, but it did reduce the numbers that entered Mōliʻi Pond.

FIGURE 43: *KĀKŪ* OR BARRACUDA

By maturity, *kākū* in Mōliʻi Pond would often grow to over 40 pounds. They often looked like logs floating near the surface of the water.

They did not startle easily, but when they noticed someone nearby, they'd slowly drift away and sink deeper into the water column, eventually disappearing from view. Visitors to Mōliʻi Pond would sometimes see large fishing poles set up, as George waited for a *kākū* to strike.

Whenever the *kākū* were available, they commanded a good price at the fish markets. George and Jane had many friends who particularly enjoyed eating *kākū*; it provided a nice treat for guests when they came to visit. One of their favorite methods for *kākū* preparation was Chinese style with *tausi*, black bean chili sauce.

*Ulua* also became popular in the fish markets over the years. The word *ulua* generally refers to the larger adult stages of jacks or *carangids*. Titcomb (1972) used the term *pāpiopio* to refer to the jack's younger stages; this term has been shortened to *pāpio*. The term for its intermediate stage is *pau uʻu*, sometimes shortened to *pauʻu*. The *ulua paʻopaʻo* was the *carangid* most commonly found in Mōliʻi Pond.

In the ocean, the juvenile *paʻopaʻo* can sometimes be observed swimming among the tentacles of jellyfish, or among flotsam at the surface of the water. Juvenile *paʻopaʻo* entered Mōliʻi Pond with the rising tide. They were distinguishable from other *ulua* by the darker

Figure 44: Day's catch shows a large number of smaller barracuda caught in one day's fishing.

vertical bars on their bodies, which were sometimes gold-tinged with yellow ventral and caudal fins.

While this *ulua* does feed on small fish, its primary diet consists of crustaceans and other invertebrates found at the bottom of the pond. George could often see the tails of the *pa'opa'o* sticking out of the water as they foraged along the pond floor. He and Jane enjoyed the *pa'opa'o* as a very good eating fish. Titcomb (1972) describes it as the best species of *ulua* to eat raw.

Figure 45: *Pa'opa'o*

The *āholehole* or Hawaiian flagtail (*Kuhlia sandvicensis*) was also another noteworthy resident of Mōli‘i Pond. This species is known to eat smaller fish, but it generally prefers crustaceans. *Āholehole* spawn during the winter months and their young were frequently found mixed in with schools of *pua ‘ama* in the early spring. Popular when available in the markets, they command a good price. They are also useful in aquarium-keeping because they help to control parasites.

George was often astonished by the richness and abundance of Mōli‘i Pond. He seemed to be able to find markets for all the fish. During the spring and fall, as he went about his daily work, he noticed juvenile fish falling out of the plankton and searching for habitats on the reef. He watched many of them approach the *mākāhā*; some even entered the pond and established territories for themselves. Young *manini (Acanthurus triostegus)* and other surgeonfish would appear as transparent post-larvae. As they fed and grew, their pigment would deepen, and they would begin to look like adults. When they got larger, they extended their feeding range out onto the reef flat.

Wrasses, damselfish and other species would also congregate around the entrance to the fishpond, feeding on zooplankton as they were flushed from the pond during low tides. Chicago’s Shedd Aquarium placed a standing order for several aquarium species, and he was easily able to fill those orders each year.

Many other species were present only at certain times in the history of Mōli‘i Pond. When he was still alive and managing the pond, George’s father had managed to get hold of some Japanese surf clams or *hokegai (Spisula sp.)*. In the 1930s, control over the import of exotic species was not as strict in Hawai‘i.

The clams were caged to prevent them from getting away, and also to protect them from the crabs. The cage was placed into the pond. When the Uyemuras sampled a crop from this planting, they found the clams very tasty. Unfortunately, the crabs also found them to be delectable; they managed to enter the cage and eat all of the remaining clams.

The problem of introduced species has been described as a major factor in the decrease of *ʻamaʻama* production. Some introduced species, like the *hokegai*, simply did not survive in Mōliʻi Pond. Uyemura's great fear was that the tilapia, which managed to survive in freshwater, brackish water and marine habitats in Hawaiʻi, would begin to take over the pond. This never happened. Tilapia could be found in Mōliʻi Pond, but not in great numbers. They occupied some of the same habitats as *toau* and were perhaps simply out-competed by them. It was possible that the *kākū, ulua* and *āholehole* were feeding on the tilapia fry. Adult tilapia are not voracious piscivores, and may have had the greatest impact on the pond's shrimp populations.

Figure 46: Glass shrimp

Shrimp of various species were abundant in Mōliʻi Pond. The clear glass shrimp or *ʻōpae* (*Palaemon debilis*) was a popular bait for *akule* fishing. For many years, a large sign could be seen on Nimitz Highway near Iwilei, across from the fish markets, hawking LIVE SHRIMP BAIT for sale. Much of that shrimp came from Mōliʻi Pond.

*Akule* or big-eyed scad (*Trachurops crumenophthalmus*) were a popular food fish caught by nets or hook-and-line fishermen. The *akule* caught by hook got a better price because the fish received better handling after they were caught, and their flesh was considered to be of better quality. Therefore, fishermen were willing to pay for live bait whenever it was available. These shrimp made their home among the *limu* or in the crevices of the *kuapā*. They were, at one time, abundant in the pond and could be easily caught.

Another shrimp species found at Mōliʻi Pond was the *ʻōpae lolo*, a pink penaeid shrimp, *Melicertus marginatus (Penaeus marginatus).* In today's popular literature it is sometimes referred to as the "Aloha prawn". These shrimp grew much larger than the *ʻōpae* and were easily attracted to light, so George hung a lantern at the *mākāhā*, where he easily captured the *ʻōpae lolo* with a long-handled scoop net. A single night's haul usually wasn't much, so it was rarely seen in the markets. Most of what was caught was converted into succulent shrimp tempura by Jane Uyemura, who delighted in sharing it with family and friends.

Researchers who have experimented with spawning and rearing this species of shrimp found they did not reproduce easily in captivity, so other species were preferred for large-scale aquaculture. They were not very hardy, and didn't grow well in ponds and tanks. While *ʻōpae lolo* may have some potential for culturing, especially as a native species in restored Hawaiian fishponds, there is much work to be done before that will be possible.

## Chapter 16

# Jane Uyemura and Hospitality at Mōliʻi Pond

In the 1970s, modern aquaculture began to get a lot of attention in Hawaiʻi. At the time, one of the world's leading aquaculture experts, Dr. John Bardach, was director of the Hawaii Institute of Marine Biology (HIMB) in Kāneʻohe Bay, often referred to as Coconut Island. As part of the University of Hawaiʻi, HIMB provided research facilities for graduate students and researchers. Commercial aquaculture production was also being established and commercial production was viewed as a growth industry for Hawaii. The lifecycle of the Malaysian prawn (*Macrobrachium rosenbergii*) was closed and brought to commercial production by Takuji "Fuji" Fujimura and Henry "Opu" Okamoto of the State of Hawaii's Division of Fish and Game. Businessman Taylor A. (Tap) Pryor, a former senator in the state legislature, was developing a land-based oyster culture system in Kahuku. Hawaiʻi was becoming a focal point of tropical aquaculture, and the State established the Aquaculture Development Program (ADP) to assist with the development of this new industry.

At this point in time, the Uyemuras had been harvesting fish from Mōliʻi Pond for more than 40 years. Visiting researchers and commercial producers often came to Hawaiʻi, either as consultants or observers, and Mōliʻi Pond was often included on their tours as an example of the state's 600+ year history of aquaculture production. Government officials from the U.S. Mainland and from other countries would visit Hawaiʻi to learn about recent developments in aquaculture; they, too, were introduced to the centuries-old fishpond tradition. In 1988, the World Aquaculture Society hosted its annual international meeting in Hawai‘i, and hundreds more enthusiasts were able to see traditional Hawaiian aquaculture at work.

Jane and George tried to accommodate requests for visits whenever possible. When visitors came in smaller groups, it was possible to sit down and talk with them. Jane would prepare snacks and, if time permitted, guests could sit and learn more about the history of Mōli‘i Pond. In conversations with others who got to know the Uyemuras in this setting, their remembrances include the food and hospitality that followed an afternoon touring the pond with George.

One such visitor was the late King of Tonga, His Majesty Taufa‘ahau Tupou IV, whose entourage included the United States Secret Service. A tour was planned, followed by a snack in the Uyemuras' dining room. Before the visit, George was briefed on protocol, which dictated that the king be seated higher that everyone else at the table. But the Uyemuras' dining room was designed for family meals, and not to host state dinners. The king, George replied, would have to sit around the table just like everyone else. His Majesty greatly enjoyed his visit, and later invited the Uyemuras to come to Tonga as his guest, in order to return the hospitality that he had experienced in Hawai‘i.

George was introduced to Fijian Prime Minister Ratu Sir Kamisese Mara by a mutual friend in Hawai‘i. The Prime Minister was interested in the potential of aquaculture in Fiji, and wanted to visit some sites to get a better idea of what would be appropriate for his country. It was the beginning of a lifelong friendship. The Prime Minister visited Mōli‘i Pond whenever he could, sometimes requesting that his Secret Service detail remain in the background so that he could relax a bit with his friends. He even helped to coordinate their trip to Tonga, so that the Uyemuras could visit him in Fiji.

Visitors who enjoyed the Uyemuras' hospitality at Mōli‘i Pond never forgot it. In the 1980s, researchers from the Finfish Program at the Oceanic Institute worked closely with George to collect *‘ama‘ama* and *awa* broodstock from his pond. Once larval rearing techniques were developed, the Finfish Program needed sites at which they could plant these fish and compare their behavior and growth with wild fry. George, once again, came to the rescue and made the facilities at Mōliʻi Pond available.

Though the researchers came to the pond to work, Jane saw to it that they were well-fed. While there may be three or four researchers working at the pond Jane knew that there was additional staff working at OI. She would even prepare dishes for the researchers to take back to other staff at the Institute. The Finfish Program staffers would eagerly anticipate their trips out to Mōliʻi Pond, trying to guess what culinary treats Jane might prepare on that day. Visitors still remember some of their favorite dishes, and Jane has provided some of the recipes in an appendix at the end of this book.

# Chapter 17

## The Story Of Matilda

In the Uyemura Family's early years at Mōli‘i Pond, green sea turtles or *honu (Chelonia mydas)* managed to find their way into the pond. George saw that they didn't seem to harm the fish, so he let them stay, and soon they seemed like pets. They did pull their own weight around the pond, eating the jellyfish that sometimes accumulated. After a few years, some of the *honu* had grown to over 300 pounds. Whenever they came near the *mākāhā*, they scared away any fish that had congregated. If it was time to replace the gates in the *mākāhā*, George could release the turtles through it, but otherwise he was forced to lift them out over the wall or put them in a boat and onto his truck and take them to a nearby beach. The *mākāhā* was stationary and could only be opened when it came time to replace the grates.

The Uyemuras were particularly fond of one particular turtle, a big creature George had named Matilda. She lived in the pond for many years, until George felt it was time to release her back into the ocean. Though he never saw her again, he occasionally heard stories about a large *honu* in the area, and he always suspected it might be Matilda.

When an outbreak of jellyfish occurred some years later, George wanted to get another *honu* for his pond. Unfortunately, they were now protected; he could not legally obtain another one. In time, however, another *honu* made its way into the pond. George called researchers at Coconut Island, where he'd heard they were studying the green sea turtle. When he told them about the turtle, George was told that he was not allowed to have a *honu*, so he asked them to come and remove it.

The researcher came on a Saturday. Throughout George's life, he had enjoyed chatting with scientists, fishermen, other pond operators—anybody whose interests were similar to his own. But the researcher was different. When George tried to engage him in conversation, the researcher appeared upset that his weekend was being interrupted. Though he willingly transferred the *honu*, George was very sad that the researcher had been indifferent about his honesty and desire to do the right thing.

FIGURE 47: *HONU* OR GREEN SEA TURTLE

# Chapter 18

## Day-To-Day Pond Management

As with all aquaculture systems, the activities and tasks required to manage Mōliʻi Pond varied, sometimes greatly, from one day to the next. Certain routines were part of the daily schedule. The *mākāhā* must be inspected and cleaned every day. Weir boards must be checked and adjusted as appropriate. The flow of water into and out of the pond was adjusted as necessary, an activity directed by the high and low tide peaks that shifted by about an hour each day. What might need to be adjusted in the morning this week could become an evening adjustment in two weeks. This directly impacted harvesting, as the fish moved into the sluice channel with the high tides. The walls of the ponds were carefully inspected every day. Experienced managers such as Uyemura were able to see when rocks were out of place, and knew to reset them immediately in order to protect the integrity of the wall. All other activities took place around these tasks.

Beckley (1883) described the stocking of ancient Hawaiian fishponds as a natural process. In a newly-build pond, he said, constructed with ancient methods, one might see fish within a few weeks, and it would be fully stocked with little or no effort over the following couple of years. When there was a shortage of fish in a pond, the Hawaiians would use small meshed nets to collect fry to supplement what was already there.

Though the previous tenant of Mōliʻi Pond had harvested almost everything that could be caught by the time Genzo and Mizue Uyemura moved there in 1928, the pond was still able to produce some fish during their first year in Hakipuʻu. Many years later, in 1965, a storm flushed out or killed all of the fish, except for some tilapia. The storm appeared to wipe out everything from the pond. However, Uyemura noted that within a few days, hundreds of fish, large and small, were coming to the *mākāhā* in an attempt to enter Mōliʻi Pond. The fertility of the Hawaiian fishpond and its ability to attract fish was legendary.

FIGURE 48: 1965 FLOOD DAMAGE

As with any Hawaiian fishpond, managing Mōliʻi Pond was never the same from one day to the next, as its cycles were governed by the tides, the weather, the time of year, and the requirements of the season, the day, the moment. Uyemura, like the ancient Hawaiians, took a logical, pragmatic approach, with patient observation as a key element, to develop his strategies and techniques, refining and improving his strategies over the years. He realized the water gates were the most important feature of fishpond operation, and he was diligent about their maintenance. He also understood the importance of freshwater in Hawaiʻi's nearshore fisheries, and the health of Mōliʻi Pond; has remained an active proponent for restoring freshwater to the Windward coast.

High surf is a natural occurrence in Hawaiʻi during certain times of the year. Somewhat protected by Mokoliʻi Island and a wide reef flat, Mōliʻi Pond was not exposed to full frontal assault by storm surges and tsunami. Storms from the east, however, sometimes generated waves that were destructive to the rock walls. After every major storm, extensive repair work was required to maintain the walls, because once a wall was breached, it always seemed to keep breaking. Mōliʻi Pond survived intact because George and Jane, regardless of fatigue or illness, made every effort to repair compromised walls as soon as it was safe for them to do so. The *aliʻi* had had the *makaʻāinana* to maintain their *kuapā*. Though George and Jane had friends and family who could help out in a crisis, most of the time they maintained the pond by themselves.

# Chapter 19

## Stocking The Pond

The stocking of Mōliʻi Pond was a full-time, year-round activity. When the *mākāhā* was properly maintained, natural recruitment provided all the fry that was needed to keep the pond properly stocked and in balance. The *mākāhā* was kept clear to ensure the fry could move freely into the pond. Adjusting the sluice gates with the changing tides was important to keep the fry inside the pond, and to maintain the water level. Pond maintenance, and those critical daily adjustments, were important factors in achieving a proper natural stocking.

In some ways, George was spoiled by the productivity of Kāneʻohe Bay and the production he was able to attain in the early years. Perhaps his most valuable personal quality as an aquaculturist was his ability to adapt to the bay's changes and still maintain a healthy and productive pond.

At various times in George's career, he worked with The Oceanic Institute (OI) and researchers with the State of Hawaiʻi, providing broodstock for their projects. Mōliʻi Pond was one of a few sources for broodstock used in research to develop maturation and spawning methods for the *awa* and *ʻamaʻama*, both important sources of protein throughout southeast Asia and along the African coast. Researchers hoped to cultivate these species to alleviate food shortages in the impoverished regions. Even as the State was facing various challenges associated with the restoration of Hawaiian fishponds, researchers at OI hoped the restored ponds would once again produce these species in great abundance.

Mōliʻi Pond was selected as a test site to see how hatchery-reared *awa* and *ʻamaʻama* would behave and grow in a Hawaiian fishpond. After George accepted the fish, he took the time to observe their behavior and growth. The *ʻamaʻama*, he noticed, behaved quite oddly. They tended to remain in tight schools in the pond, as if still being held in a round tank. This made them highly susceptible to predation.

George and Jane also noticed that the *awa* from OI had a tougher skin than the wild fish. Some of the dishes Jane prepared used raw *awa*, but the hatchery-reared fish could not be included as an ingredient because the texture of the skin was too tough and the slices of flesh were too chewy. Based on his experiences with OI's stock, George knew he preferred wild-caught fry for production. He still teases those researchers, who have remained close friends, about their *"crazy ʻamaʻama"* and the tough-skinned *awa*.

George believes in wild fry. His application of the natural recruitment process made Mōliʻi Pond successful at producing mullet and milkfish for many decades, in spite of the drastic changes that took place in the nearshore fisheries in Kāneʻohe Bay. Based on reports from other parts of Hawaiʻi, however, the availability of wild fry may be inadequate for the production of *ʻamaʻama* and awa in the future.

When the mullet harvest declined, he explored the possibility of stocking the pond with more predators; *pāpio, kākū, moi*—any species that would take a hook. Given time, George would likely have been able to develop new ways to keep Mōliʻi Pond productive. "Fee fishing" at Mōliʻi Pond might have been successful. His loyalty, however, remained with the *awa* and the *ʻamaʻama*.

When considered with data from other fishpond operators, George's fry collection and pond harvest reports, regularly submitted to the Division of Aquatic Resources over the years, show how the fisheries have declined over the years. As a retired pondkeeper, his observations and experiences may be valuable to three groups: aquaculture researchers, pondkeepers wanting to do stock enhancement, and pond managers seeking additional insights on resource management.

Table 3. Comparison of fish species cultured in restored Hawaiian fishponds.

| SPECIES | HERBIVORES | | CARNIVORES | | |
|---|---|---|---|---|---|
| | *'Ama'ama (Mugil cephalus)* | *Awa (Chanos chanos)* | *Moi (Polydactylus sexfilis)* | *Ulua (Caranx ignobilis)* | *Kākū (Sphyraena barracuda)* |
| Source of fry | Wild sources available. May require extensive fry collection efforts. | | May require large-scale fry collection efforts seasonally each year. | | |
| Availability of fry | Spring | Summer-Fall | Fall. Rarely available in large numbers at the end of summer. | (*Pāpio*) Fall | n.r.[a] |
| Hatchery technology | Available | Available | Available | Being developed | Not available |
| Nursery | 1 year (depends on presence of predators in the pond) | 3 months (depends on presence of predators in the pond) | Problem with cannibalism for first 3 months | n.r. | n.r. |
| Feed | Natural. Little to no supplemental feeding required. | | High protein feeds required, which may affect water quality. | | |
| Harvest | Come to gate in winter | Come to gate in summer | Come to gate in summer | Do not come to gate. Must be "fished" from the pond. | |
| Market[b] | \$4.95/pound. Market for locally grown fish may increase if product is consistently available | \$2.95/pound | \$8.95/pound. Price may drop as more production becomes available from sea cages | \$2.95/pound | \$4.43/pound |

[a]n.r., not recorded.

[b]Market values (except *kākū)* based on retail prices at Tamashiro Market, Honolulu, May 2007.

The ability of Hawaiian fishponds to produce traditional species will continue to be dependent on the overall management of the nearshore fisheries around the State of Hawaii. If the trends of the past continue, traditional production may not be possible without the intervention of modern hatchery technology. Table 3 lists the major native species that have been important in the history of Molii Pond. The *ʻamaʻama, awa*, and *moi* are still desirable in Hawaiian fishponds. George Uyemura and other cooperating fishpond operators had a hand in developing the hatchery technology for these species by providing broodstock and providing space for growing out the fry. WIth this technology, it will be possible to provide adequate stocking for restored fishponds

At the present time there is no reliable hatchery technology for the *kākū* and *ulua* although that may become available in the future. The nearshore fisheries for these species may have declined to the point that they will not become a problem in the ponds.

The role of all of the other species that were present in Mōliʻi Pond is not well understood. While most of the discussion has focused on the organisms that represented some economic value to the pond there were many other organisms that were naturally recruited and kept the pond in balance to the benefit of the *'ama'ama* and *awa*. Recreating that balance with a changing nearshore fishery will be an even greater challenge in the future.

# Chapter 20

## Feeding

Generally, feeding the fish in Hawaiian fishponds was not necessary. There are reports that the *kia ʻi loko* in ancient Hawaiʻi would occasionally feed the fish, but this was not done on a scale practiced in modern aquaculture.

George Uyemura was an active reader who enjoyed meeting with aquaculturists from around the world. Because Mōliʻi Pond was one of the few remaining ponds in operation on Oʻahu, it became a popular stop for visiting researchers. Faculty from the University of Hawaiʻi, and staff from OI and the Aquaculture Development Program, often included Mōliʻi Pond as a stop on their tours when they hosted visitors from the Mainland and abroad. Jane Uyemura was the ultimate hostess, and visitors were treated to sights, sounds and foods unlike anything they had previously experienced. Not surprisingly, many people who visited Mōliʻi Pond decades ago still have great memories of their time spent with the Uyemuras.

In social situations, George naturally liked to talk about the pond. He was also a good listener. He often discussed pond management with people from different parts of the world, and researchers would frequently send him their papers that might relate to his own work. He was frequently able to obtain and absorb scientific and popular literature from researchers he'd worked with, and from other available sources.

George's own experiments taught him a great deal, and he generously shared his findings with researchers. Over the years, he attempted a number of feeding and enrichment methods at Mōliʻi Pond. He knew about feeding practices in southeast Asia, where keepers use fertilizer, fish feeds and leftovers to enrich their ponds. Formulated feeds were expensive to obtain, and the use of fish food in a 128-acre pond was not thought to be practical. At one point, George tried to use outdated dairy and bread products to supplement food for the pond's inhabitants. When he saw gasses coming out of the mud in the area, he suspected he might be polluting the water. The experiment was halted.

On another occasion, George placed *aku* heads on a wire rack suspended above the pond. He had heard that fish farmers in parts of Asia did this. The maggots that grew on the carcasses of the fish would fall into the pond and be eaten. Sure enough, as the *aku* head decomposed, the *āholehole* were there to eat anything that fell. This was a messy process. Over time, it turned out to be an interesting experiment, but nothing more.

Many of George's experiments provided a means of testing new aquaculture methodologies and strategies he'd heard about, and sometimes they yielded surprises he hadn't anticipated. Always, however, if something worked well, he might implement it at his own pond.

At one point, for example, George tried fertilizing Mōliʻi Pond with a 10-5-5 inorganic fertilizer. The plants—in this case, phytoplankton—grew quickly and created a rich brown soup, which he maintained with additional doses of fertilizer. He later noticed white clouds rising from the sediment. About three months later, while wading in the pond, George felt crunching under his feet. He realized that he was walking on tiny clams; the white clouds he had seen earlier were adult clams in the process of spawning.

The mollusks were Japanese clams *(Tapes philippinarum)* planted years earlier in Kāneʻohe Bay by the State of Hawaiʻi. George believed they began to reproduce because of the additional food made available after he fertilized the pond. They became very, very prolific. When a few friends in New York heard about the new crop, they sent clam rakes to George and Jane for the harvest!

As the young clams grew, they continued to eat the phytoplankton. Maintaining the bloom became a problem, because the clams ate the algae faster that it could be produced. Additional fertilization wasn't enough to maintain the bloom. As the *'ama'ama* and *awa* fed on the same phytoplankton, George became concerned that the growing population of clams would affect fish production. He decided to stop fertilizing the pond.

In time, the clam population returned to a normal balance. A number of the bi-valves remained in the pond, and some of the Uyemuras' friends enjoyed collecting them for their own consumption. One day, a couple of friends who were frequent diggers showed up at the pond. The wife was proudly wearing a brand-new diamond ring. Harvesting clams generally requires digging up a pile of mud, placing it in a wire mesh box, washing off the mud and collecting the clams that remain. A simpler method requires the harvester to simply feel around in the mud with bare hands and bring up any clams that are found.

At the end of the day, the wife realized her new ring was missing. She and her husband returned many times with sieves and buckets to look for the ring. They even came with a metal detector, hoping they could find the ring electronically. However, because George often used buckshot to scare away predators, the sediment on the bottom of the pond was filled with pellets, which made the metal detector return many false readings. To this day, a diamond ring may be buried in the sediment at Mōli'i Pond.

# Chapter 21

## Natural Disasters

In 1965, a devastating rainstorm pounded the island of Oʻahu. It was reported as a once-in-125-years event. On the Windward coast, some areas were prone to flooding and sediment runoff because they had been cleared for housing development. Flooding from the Keapuka subdivision of Kāneʻohe, for instance, overwhelmed Kamooaliʻi Stream, with tragic results. Kāneʻohe Bay, whose waters were once referred to as "coral gardens" because of their abundant reef life, was inundated with runoff from the cleared hillsides. Huge amounts of sediment were deposited in the bay, contributing to the suffocation of the reef flats at its southern end.

Although it went unreported in the news, the 1965 rainstorm had a catastrophic impact on Mōliʻi Pond, where it rained for 20 hours. The owners of Kualoa Ranch were in the process of clearing land along the slopes of Kānehoalani Ridge to create pastures for grazing cattle. When the rainstorm hit, there was no forest or established grassland to slow the flow of water running off the mountains. A rain gauge at Mōliʻi Pond registered 17 inches of rising water before the flood swept it away, along with huge amounts of mud, sediment, rocks, and boulders. Some of the debris ended up in the Uyemura's house; some remained in the yard. Everything else flowed into the pond, filling it before continuing over the wall into northern Kāneʻohe Bay.

This was one of the few times, over the decades of the Uyemuras' tenure, that everything at Mōliʻi Pond came to a complete halt. Three years' worth of *ʻamaʻama* production was literally flushed out into the bay. After a good cry, George and Jane sat down and assessed what they had to do, in order to bring everything back to normal.

The salinity of Mōliʻi Pond was now zero, indicating that no saltwater remained, even the deepest parts of the pond. Over the next several days, George saw many dead fish floating in the water along the *kuapā*. The only survivors were a few tilapia. To remove as much sediment as possible, George removed the weirs and let it flush out with each low tide. In time, the salinity increased. Remarkably, some *ʻanae* came to the *mākāhā* as Kāneʻohe Bay started to recover. Diligently, George and Jane caught these fish and returned them to the pond.

Needless to say, the harvest that year was not very good. However, there were still fish that could be harvested and sold. Where these fish came from, and how they managed to survive, is unknown. This story is a perfect illustration of one of the most powerful attributes of Hawaiian fishponds: they are quick to recover from disaster, and they can do it on their own.

Heʻeia Fishpond, located in a more central part of Kāneʻohe Bay, experienced much more destruction after that terrible storm in 1965. The valley above Heʻeia Fishpond is huge, capable of collecting and funneling much more water into the bay. A large section of Heʻeia's *kuapā* was blown out by the flood. As of 2007, over 40 years later, the wall is finally being restored.

George attributes the survival of his own *kuapā* to the presence of mangroves at Mōliʻi Pond. Though mangroves are an introduced plant species, they did, in this instance, provide some benefits. Mangroves are able to grow among the rocks, and they helped stabilize the wall as the flood waters built up in the pond. When part of the *kuapā* collapsed, George, his family and friends were able to restore the wall by collecting rocks scattered along the reef nearby.

The subject of mangroves is controversial in Hawaiʻi. The ancient ponds did not have these plants to help stabilize their *kuapā*. Therefore, this plant may not have a place in restored ponds whose managers wish to recreate traditional environments. George and Jane thought of the mangroves as a living fence that kept poachers out. Their tangled branches were difficult to cut through and required a lot of effort before the poachers could even get near the water's edge. Once, on a trip to Fiji, George got to see firsthand the abundance of sea creatures who made the mangroves their home. It was an unforgettable experience. All this compelled the Uyemuras to appreciate the presence of mangroves at Mōliʻi Pond.

Figure 49: Mangroves, a living fence

# Chapter 22

## A Closer Look At The Water

Water quality generally was not a problem at Mōliʻi Pond. “What can you do about a water quality problem in an area that covers 128 acres?” George would say. “Not much!”

The rise and fall of the tides were the only real tools available to the traditional pond manager. In modern times, pumps and aerators are sometimes useful in smaller ponds, if one has a water source to pump from, and electricity for power. But in George’s day, the option of pumping water from a stream or from the ocean through a pond usually wasn’t available to managers. The key, therefore, was to manage the pond ecosystem so that critical water quality issues were avoided. George was successful at doing just that for seventy years. Over the course of his tenure at Mōliʻi Pond, only one major problem required him to take immediate and drastic action.

Serious potential problems with water quality in Hawaiian fishponds generally occur during the early fall months, particularly in September. The problem originates not with fish, but with phytoplankton that grows in the ponds. Low dissolved oxygen (DO) occurs in ponds when conditions are just right. During most of the year, Hawaiʻi’s tradewinds, the moderate and constant breezes from the northeast, help keep pondwater moving. As water moves across the ponds with the wind, a vertical mixing that helps replenish oxygen in the deeper parts of the pond also takes place. This wind action, with the tidal flushing, helps keep the pond healthy and well-oxygenated.

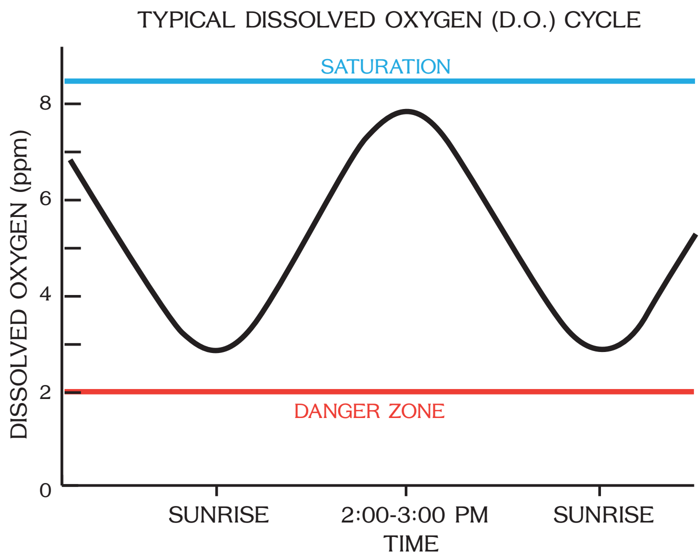



TABLE 4: DISSOLVED OXYGEN CYCLE UNDER NORMAL BALANCED POND CONDITIONS. RISE IN D.O. IS DUE TO PHOTOSYNTHETIC ACTIVITY. D.O. LEVELS DROP AS POND RESPIRATION INCREASES. SUPERSATURATION CAN OCCUR WITH HIGHER ALGAL BIOMASS AND INCREASED SUNLIGHT. D.O. REACHES CRITICALLY LOW LEVELS WHEN THERE IS HIGH RESPIRATION IN THE ABSENCE OF SUNLIGHT.

Conversely, when the winds are light or calm, there is no vertical mixing of the water. At the air-water interface, carbon dioxide is released into the atmosphere and oxygen dissolves in the water but this oxygen does not mix into the deeper water. Fish may be able to come to the surface to take advantage of this, but the problem is further complicated when high densities of phytoplankton are also consuming the oxygen.

During the late fall, winter and early spring, the limited availability of sunlight and lower temperatures help keep the growth of phytoplankton under control. During the summer, however, this can change and disrupt the balance within the pond.

Summer conditions bring stronger sunlight, a longer photoperiod and warmer temperatures. While this is good for fish growth, it also stimulates additional phytoplankton growth. This isn't a problem as long as the tradewinds are present to keep the pond well-mixed, but the end of the summer often brings Kona winds from the Southwest, and “flat” days, with little or no wind, heat and humidity, and sometimes even stormy weather. Those flat, windless days are most dangerous to the health of the fishpond.

Warm sunny days stimulate the growth of phytoplankton. During the day, phytoplankton produces oxygen; at night, they respire and consume oxygen, just like the fish, crabs and shrimp. It is when the winds die down during the evening hours that a dangerous situation may occur. The absence of winds, and a “glassy” pond surface, are signs that dissolved oxygen levels in the pond may be dropping. While these conditions may occur at any time of the year, the most dangerous time for them is in August and September.

In a typical scenario, the pondkeeper would observe two or three cloudless days with intense blooms of phytoplankton. In some ponds, he might observe the color changing from a light or medium brown to a dark chocolate color, as oxygen levels can reach supersaturation during the day.

At night, the phytoplankton continues to grow and divide on its reserve energy, and oxygen levels may drop to their lowest point just before sunrise. Once photosynthesis can begin, the oxygen levels begin to rise. In a normal pond, oxygen might drop to 3 to 4 ppm at night, but not much lower because of the mixing by the wind. If the wind stops, however, oxygen in the water near the bottom can drop to below 2 ppm, even though surface DO levels may be acceptable. This is very dangerous for the fish, crab, shrimp and any other organisms that live on the bottom.

During the first two nights of this hypothetical scenario, phytoplankton density is not high enough to create oxygen stress in the deeper parts of the pond. A third day of intense sunlight, however, may increase the phytoplankton biomass so much that they are able to reduce DO levels to below 2 ppm. If this were to occur at around 2:00 AM, it might still be another three hours or more before photosynthesis will begin. When oxygen is near critical levels, the fish will come to the surface to get more.

One of the earliest signs of a fish kill is the unsettling sight, beginning around midnight, of fish swimming and gasping at the surface of the water—a sight which must not be confused with that of *toau* feeding on small fish at the surface of the water. The fish’s unsettling behavior usually lasts until just before sunrise, and it is possible that no dead fish may be visible in the light of day.

If the day remains cloudless, the cycle repeats with another night of fish gasping at the surface. It may even begin earlier in the evening. In the morning, the first dead fish, possibly casualties of the first night's anoxia, may be observed at the leeward end of the pond.

During the day, fish behavior may be odd. Predators may cease actively feeding when food is thrown into the water. The pond might even get through the second day without any visible signs of a fish kill, but a third night of distress will very likely claim most of the remaining fish, crabs, shrimps, clams—virtually everything. At this point, the remaining fish may be too weak to come to the surface to gulp oxygen and the pond manager may falsely believe the crisis has passed. The reality will be visible the next day, when large numbers of dead fish from the first night of distress are seen floating on the surface of the pond or accumulating against the *kuapā*.

The actual duration from the first windless night to the visual proof of a fish kill can vary. It may be shorter or longer than the scenario presented. The solution? A method of adding oxygen to the water, such as a paddle wheel or an outboard motor, should be readily available for times when a pond's oxygen level falls below 2.5 ppm. At the earliest sign of a crisis—a bright, sunny day, low winds and an intensifying bloom of phytoplankton—the pondkeeper should check the DO throughout the day and at night.

Low DO is one indicator. If the DO continues to drop below 2.5 ppm some action is required. The pond operator does not want conditions to get to the point that fish can be seen gasping for oxygen at the surface of the water. Organisms on the bottom may already be dying at that point. If the DO is low, it may be time to start the aerators. Depending on the pond's size, several paddle wheels may be needed. At Mōliʻi Pond, George would run a small motorboat through the night. Were he still a pondkeeper today, he would likely get a Jet Ski and ride it through the pond. The idea is to add oxygen and create some vertical mixing.

In summary: three days of intense sunlight, strong phytoplankton blooms and windless nights are the beginning indicators of potential problems with dissolved oxygen. The pond manager should increase monitoring on the first night, and prepare to take action if conditions continue on the second night. Monitoring with a DO meter should take place at different parts of the pond and at different depths. A level of 2.5 ppm is critical, but the idea is to prevent the DO in any part of the pond from going any lower. Turn on the paddlewheels, run the motorboat, and ride the Jet Ski earlier rather than later! It will take a while before there is sufficient mixing to make 128 acres of water safe for all of the pond's inhabitants.

## Chapter 23

# Preserving the Hawaiian Fishpond

Operating a Hawaiian fishpond in modern times is a tremendous challenge. Fishponds in ancient Hawaii were successful because they were supported by healthy nearshore fisheries, yet the status of fisheries around the Hawaiian Islands continues to decline. Unlike the *kia ʻi loko* of ancient times, modern fishpond operators must comply with regulations that affect all aquaculture operations in the state. They must have the financial means to operate despite rising costs, and they must make careful, informed decisions about pond management in an increasingly complex and bewildering world.

Each fishpond has its own characteristics and quirks, requiring thoughtful management specific to its environment and culture species. Storms, mudslides, tsunamis, and other catastrophic natural events require the development of an immediate response strategy, so the integrity and functionality of the pond are protected and preserved. Slow but continual changes in existing nearshore fisheries will require adaptive management of the fishpond on an ongoing basis.

Though George remains a strong proponent of stocking ponds with wild fry, it may not be possible to depend solely on that source in the future. Technology exists for producing *ʻamaʻama*, *awa* and *moi* from captive broodstock. In order to provide sufficient numbers of *pua* to stock a pond, it may be necessary to develop systems for handling hatchery-produced fry. To improve the likelihood of their survival, future pond managers may have to incorporate nursery ponds or tanks as a first stage in culturing fish before releasing them into the pond. If George's observations and instincts are correct, these fish may have to be trained to evade predators in the nursery phase of growth. If the pond contains a large population of predators, the manager may consider utilizing net pens or cages to keep predators away from the *pua*. These technologies are available and it will be up to the pond manager and the unique characteristics of the pond to decide which ideas are appropriate.

At present, no commercial hatcheries in Hawaiʻi produce the traditional species grown in Hawaiian fishponds, nor is there sufficient demand to support a hatchery capable of producing these species on a regular basis. The cost of building a hatchery, however, might be offset by larger harvests of these fish at the end of the culture cycle, which would accurately represent the yields from a traditional Hawaiian fishpond. Hence, the construction of new hatcheries will likely be dependent on the demands of aquaculture and fishpond managers. (see Table 3, page 103)

As Uyemura's experiences prove, many of the traditional methods of fishpond management developed by ancient Hawaiians still work in modern times. To develop a better understanding of Mōliʻi Pond, he adopted a scientific method of observing, identifying a problem, attempting corrective action, and analyzing the results of his actions. Uyemura managed to keep Mōliʻi Pond productive by adapting to changes in the specific environment that affected the pond. Therefore, some of the practices he employed may not work well in other ponds and at other locations. New pond operators are encouraged to emulate his approach of observation, experimentation, and evaluation of the results, and to look for unique ways to make things work.

**BE AN OBSERVER:** Learn to observe everything, taking special note of cause-and-effect relationships. Learn to filter out (but never discard) non-relevant observations.

Though hard work was a necessary part of Mōliʻi Pond's everyday operations, some of Uyemura's greatest breakthroughs occurred when he took the time to observe what was happening in the pond. When he put lobsters in the sluice channel, he observed that they solved some of the problem of keeping it clean. When restrictions were put on his activities during World War II, he recognized an opportunity to closely examine the behavior of milkfish at the *mākāhā*. His acute observations of all of the aquatic life in Mōliʻi Pond each day helped him formulate his decisions and resulted in successful management of the fishpond.

**BE PATIENT, COMMITTED, CONSISTENT, AND REALISTIC:** Like a good bottle of Scotch, a pond operator's ability to manage a fishpond should improve with age. Fishponds benefit from constant and consistent management, and only the most dedicated individuals are successful at making them productive. Even a 30-year commitment may not be sufficient.

To keep Mōliʻi Pond productive, Uyemura had to respond to numerous challenges that arose over the years: fry collection from outside the pond, and the need to go increasingly farther to collect sufficient numbers; the need to incorporate a nursery stage to improve survival of the fry; and after 60 years, the realization that mullet culture at Mōliʻi Pond was no longer viable.

**BE ADAPTABLE:** In the world surrounding a fishpond, changes are constantly taking place. These changes can sometimes impact the pond's health. Acute changes require immediate response, so the pondkeeper must be wise enough to recognize them as early as possible. Changes that occur more slowly may not be noticed right away, and might also require adaptive strategies to be taken. Daily observations help the aquaculturist detect minor changes in the condition of the pond over time, and allow time for adjustments in routines as needed to keep the pond healthy.

For example, blacktail snapper feeding on smaller fish at night is not generally considered an acute problem, though adaptive strategies must be taken to prevent the *toau* from decimating other species. Action must be taken but the desired outcome may not occur immediately. Like weeding a garden the first pass only gets rid of some of the more obvious weeds. The process of weeding continues for many years.

In contrast, fish gulping air at the surface of the water at night is a sign of low dissolved oxygen, an acute problem capable of killing most of the fish and invertebrates in a pond within hours. Signs that indicate the decrease of dissolved oxygen levels require an immediate response. Failure to respond could result in a collapse of the entire pond ecosystem and the loss of nearly all of the fish. The responses to a dissolved oxygen problem at different stages have been previously discussed. The pond manager must be able to clearly identify when a problem is acute and requires immediate action as compared to a problem that is to be brought under control over a long period of time. Managers like George Uyemura have learned where to focus their energies and the limited time and resources that they have. The successful managers have learned not to panic and have become masters at identifying a problem and targeting the most effective solution.

**BE SCIENTIFIC:** To successfully operate a well-balanced Hawaiian fishpond using traditional species and methods in the 21st century, some experimentation is required. Nearshore ecosystems around the Hawaiian Islands have undergone extensive changes, and ponds may not produce according to expectations. Knowledgeable people are not always available when problems occur, and even experienced fishpond operators may not be able to quickly and accurately diagnose problems.

Uyemura tried several methods of enriching Mōliʻi Pond by adding nutrients he had read about, but results were unsatisfactory. The best strategy turned out to be maintaining a balanced ecosystem within the pond. Uyemura experimented, observed the short- and long-term effects of the modifications he made, and implemented further adjustments as needed, to come up with the best solution for Mōliʻi Pond.

# Chapter 24

## The Keeper Retires

A significant validation of the George Uyemura's skill as keeper of the fishpond came from Frank Morgan, the Judd descendant who owned Kualoa Ranch at the time.

For decades, the Uyemuras had leased the fishpond from the ranch in a formal lease agreement. At some point in the 1970s, George went to the ranch to renegotiate the lease. Morgan said he didn't feel a lease was necessary; eventually, he simply told the Uyemuras that they could stay at the pond for as long as they wanted. After John Morgan took over the family business, he honored his father's agreement with the Uyemuras, who were allowed to stay.

When George announced his retirement in 1998, there was immediate general concern among his friends within the aquaculture community that his accumulated knowledge would be lost. A number of discussions about capturing his oral history and documenting his experiences at Mōliʻi Pond took place, and there were several attempts to obtain funding for such a project. There was no formal transition between George and the next pond manager, so a real possibility existed that his knowledge might be lost. Different individuals made a few false starts when it looked like funding might be available. The work for this book was initiated in the belief that it was important to begin even without the commitment of funding.

Three interviews were conducted with George and Jane Uyemura. They took place on July 29, August 4 and August 18 in 2005. Additional shorter sessions took place through 2007.

On May 15, 2007, George sat down with members of the Hawaiian fishpond community to talk about his experiences. He and Jane have remained supportive of the restoration of Hawaiian fishponds and willing share their knowledge with all who are interested.

Now that they're retired, life is quiet and relaxed. Jane is still the ultimate hostess; the authors greatly enjoyed her hospitality when they visited the Uyemuras at home. George still enjoys fishing and occasional hunting. They like to pass their days spending time in their garden, playing with their dogs and sharing their knowledge and experiences with their grandchildren.

Figure 50: George holding a large red snapper

# Epilogue

We believe strongly that Hawaiian fishponds should be protected as archaeological and historical sites. Operational fishponds with functional traditional methods have tremendous cultural significance. Partnership with the State of Hawaiʻi is essential for projects designed to help ensure the future of Hawaiian fishponds. Supporting the ponds' restoration and operation would help the state assess the impact of policies and regulations governing its fisheries.

The Division of Aquatic Resources routinely requires fishpond operators to report on their harvests. These reports, along with data from commercial and recreational fishermen, should show what the trends in the nearshore fisheries since data reporting was initiated. Once the data is analyzed, the greater challenge will be in developing models that can reasonably predict the outcome of different management strategies on the future status of fisheries resources, and in implementing, monitoring, and improving those management strategies.

If the Uyemuras' experience is any indicator, an adaptive management strategy will be necessary. Competition for access to limited and finite resources by a myriad of user groups has only increased over the years, a trend that is expected to continue into the future. Whatever approach is taken, the desired outcome is more fish, and more of the right kinds of fish, for all.

# Glossary

## Hawaiian

| Word | Definition |
|---|---|
| *āhole* | Hawaiian flagtail |
| *āholehole* | young Hawaiian flagtail, *āhole* (*Kuhlia sandvicensis*) |
| *ahupua‘a* | Land division usually extending from uplands to sea |
| *‘āina* | land |
| *aku* | Bonito, skipjack (*Katsuwonus pelamis*) |
| *akule* | big-eyed scad (*Trachurops crumenophthalmus*) |
| *ali‘i* | chiefs, kings, ruling class |
| *‘ama‘ama* | striped mullet, *Mugil cephalus*, between 20-29 cm. |
| *‘anae* | full-size ‘ama‘ama mullet fish, 12 inches or longer |
| *awa* | milkfish (*Chanos chanos*) |
| *awa‘awa* | ladyfish, Hawaiian tarpon (*Elops hawaiensis*) |
| *‘aumakua* | ancestral deities |
| *‘auwai, ‘auwai o ka mākāhā* | sluice channels |

## Hawaiian

| WORD | DEFINITION |
|---|---|
| *ʻiao* | Silversides (*Pranesus insularum*), a fish 5-8 cm. long, used as bait for *aku* and others |
| *ʻie* | woody vine (*Freycinetia*) |
| *hakipuʻu* | broken hill |
| *heʻe* | octopus (*Polypus sp.*), also known as squid |
| *heiau* | shrine, place of worship |
| *hiapo* | firstborn |
| *Hina* | goddess associated with the moon, the ocean, and healing; associated with growth, production and procreation of fish |
| *honu* | green sea turtle (*Chelonia mydas*) |
| *kahuna* | expert practitioner, sorcerer (plural *kahuna*) |
| *kākū* | barracuda (Sphyraena barracuda) |
| *Kanaloa* | Hawaiian god of the ocean; patron of fishing in the Marquesas and Society Islands |
| *kapu* | taboo or prohibition |
| *keiki* | Children |
| *kia ʻi loko* | keeper of the fishpond: a daily caretaker who maintained a fishpond and protected it from poachers |
| *kōʻele* | small land unit farmed by a tenant for the chief. Also: a small pond, reserved for a chief, where fish were kept alive until needed |
| *konohiki* | headmen of the land divisions, or ahupuaʻa, who controlled fishing rights and supervised the building of the fishponds |
| *Kū* | Hawaiian god of war and protector of fishponds |
| *kuapā* | wall of a fish pond |
| *kuku* | sticks |
| *Kuleana Act of 1850* | law designed to allow commoners to obtain plots of land for subsistence living |
| *limu* | larger algae that grows on rocks and other surfaces |

## Hawaiian

| Word | Definition |
|---|---|
| *lo'i* | irrigated terraces |
| *loko 'ume iki* | fishponds |
| *loko i'a* | fishpond |
| *loko kuapā* | largest type of Hawaiian fishpond, made by building a wall on a reef; possibly evolved from trap designs |
| *lomi 'Ōi'o* | fish paste that can be eaten raw or used for making fishcake |
| *mahele* | division; land division of 1848 (the Great Mahele) |
| *maka'āinana* | commoner |
| *mākāhā* | sluice gates. In modern times, the entire system—gates, channels, moveable weirs—is often collectively called a *mākāhā* by pondkeepers |
| *mana* | authority, power, might |
| *manini* | young reef surgeonfish (*Acanthurus triostegus)* |
| *menehune* | Legendary race of small people in Hawai'i who worked at night, building fish ponds, roads, temples. Work not finished in one night remained unfinished |
| *mō'i* | most senior of the ali'i or ruling class |
| *moi* | Pacific threadfin (*Polydactylus sexfilis*) |
| *moku* | island districts |
| *nae* | fishing net with small meshes |
| *nehu* | anchovy, bait fish (*Stolephorus purpureus*) |
| *'o'olā* | young fish |
| *'ōhi'a 'ai* | mountain apple tree (*Eugenia malaccensis*) |
| *'Ōi'o* | Ladyfish, bonefish (*Albula vulpes*) |
| *'o'opu hue* | White-spotted puffer; balloonfish (*Arothron hispidus*) |
| *'ōpae* | clear glass shrimp |

| | |
|---|---|
| *ʻōpae lōlō* | Brackish-water shrimp or prawn (*Penaeus marginatus*) |
| *pāʻāʻū* | Second stage in the growth of *ulua*, a fish. Also *pāpio*. |
| *pipipi* | general name for small mollusks, including *Theodoxus neglectus* |
| *pua* | fry; baby fish |
| *pua ʻama* | mullet fry; juvenile fish |
| *pua ʻamaʻama* | mullet that come to shore in great schools |
| *pua ʻŌiʻo* | bonefish fingerlings (*Albula vulpes*) |
| *pua awa* | milkfish fry |
| *uhu* | parrotfish (*Calotomus sp.*) |
| *ulae* | lizard fish (*Saurida sp.*) |
| *ulua* | a species of jackfish (*Caranx speciosus)* considered superb for eating raw |
| *ulua paʻopaʻo* | younger jackfish (*Caranx speciosus*) |
| *ʻupena pua* | fish net |

## Other Polynesian

| Word | Definition |
|---|---|
| *taape* | blue-lined snapper (*Lutjanus kasmira*), introduced from the Marquesas Islands by the state of Hawaiʻi in the 1950s |
| *toau* | blacktail snapper (*Lutjanus fulvus*) from Moorea, the Society Islands |

## Japanese

| Word | Definition |
|---|---|
| *hokegai* | Japanese surf clams (*Spisula sp.*) |
| *issei* | first-generation immigrants from Japan |
| *fugu* | ʻoʻopu hue; white-spotted puffer; balloonfish (*Arothron hispidus*) |
| *nisei* | second-generation Japanese; Japanese-Americans |

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# Jane Uyemura's Recipes

As mentioned in Chapter 16, visitors to Mōli‘i Pond were often treated to spectacular dining experiences that often included the "catch of the day" from the pond itself. Jane Uyemura was a gracious, creative, gifted hostess whose delectable dishes left a lasting impression on her guests. Jane relied upon a number of locally-published cookbooks for the dishes she prepared regularly. One of her favorites is *Favorite Island Cookery*, a series of six volumes compiled by the Honpa Hongwanji Buddhist Temple. Other recipes came from her family or from George's mother. Jane's approach was to take a recipe that looked interesting and to make adjustments, depending on the ingredients available. Here is one of her favorite basic sushi recipes:

### SUSHI (*MAMA*)

*In Japanese, the universal word "mama" is often used for something that is "same as usual." It was written thusly on Jane's recipe card, and we assume it was her mother's or George's mother's recipe, as the card appeared older than the others in her collection.*

1 cup vinegar
½ cup sugar
2 tsp. salt
1 tsp. *ajinomoto* (MSG), optional
5 cups cooked rice

One of the dishes Jane made for the Finfish Program at The Oceanic Institute was *awa* sushi. Milkfish or *awa* fry were occasionally taken by Finfish Program staff members to Mōliʻi Pond, so that George could compare their growth and behavior with the wild *pua awa* he normally stocked in his pond. Once the trial was completed, Jane used some of these fish to make *awa* sushi. The average fish weighed less than a quarter of a pound, and thin fillets could be taken from each side. The recipe for the preparation of the *awa* is based on Jane's recipe for *Pickled Āholehole*.

### PICKLED *ĀHOLEHOLE* (USED FOR PICKLING *AWA*)

1-1/4 cup sugar
2 cups Japanese vinegar
Salt fish (large *āholehole*, though Jane also used 10" *awa*)
Fresh ginger (chopped)
*Ajinomoto* (MSG), optional

Boil the vinegar to dissolve the sugar. Allow mixture to cool. Prepare salt fish as follows: Remove all scales. Cut the fish from the top along the backbone to the gut cavity. Clean the fish. Cut along the other side of the spine to remove the center bone from the head to the tail. Sharp fins and spines can be removed at this time. Head can be left on for presentation. Salt the body heavily. Ginger and MSG are added to the cooled sugar-vinegar mixture. Soak the salted fish in this sauce for several hours. (Small *awa* rib bones can be sharp but should soften when soaked in vinegar.) Fish prepared before lunch may be adequately pickled in time for dinner.

### *AWA* SUSHI

Jane prepared sushi rice and pickled *awa* according to several recipes. In one presentation, she stuffed sushi rice into the cavity of the whole *awa*. In another, she placed slices of the pickled *awa* filet over mounds of sushi rice prepared *nigiri*-style.

One day, after visiting Mōliʻi Pond to check on the fish, one of the Finfish Program researchers returned to OI with a large platter of sushi. Everyone got a taste of the fish they had produced in the hatchery several months earlier. As Jane and George warned, the skin of hatchery-reared *awa* was tougher than the skin on his wild-caught fish.

Jane modified another popular recipe to use with the Samoan crabs caught in Mōliʻi Pond.

### HAWAIIAN CURRY

*In Jane's recipe, shrimp may be substituted for Samoan crab.*

3 cups cooked shrimp (*ʻōpae lolo* or, if available, Samoan crab)
6 tbsp. butter
6 tbsp. flour
1½ tsp. salt
1 cup fresh coconut milk
2 cups milk
2 tsp. chopped ginger
1 medium onion, chopped fine
2–3 tsp. curry powder

Melt butter. Add flour and salt. Blend thoroughly; add milk and coconut milk, stirring constantly. Simmer until thick and smooth. Add the shrimp (or cooked Samoan crab) and serve with rice.

*Condiments to be served with curry:*
Mango chutney
Peanuts or macadamia nuts
Eggs
Coconut
Bacon
Green pepper
Green onion

*Preparation of coconut milk:*
Pour 1 cup boiling water over the meat from one large, grated coconut. Let stand for 20 to 30 minutes. Squeeze out in cheesecloth. Serves six.

Desserts were popular. Jane would prepare different dishes when she knew Finfish Program staff would be working at Mōliʻi Pond. Then she would send the desserts back to OI for the rest of the staff to enjoy.

## FRESH MANGO PIE

Three steps: crust, cream cheese filling, and mango topping.

*Crust:*
2 cups flour
½ cup powdered sugar
2 blocks butter

Roll into dough, place in pie pan, bake at 350° for 20 to 25 minutes.

*Cream Cheese Filling:*
8 oz. cream cheese
½ cup sugar
1 tsp. vanilla
8 oz. whipping cream

Mix and fold into stiffly-whipped cream. Pour over crust and chill.

*Topping:*
2 pkg. unflavored gelatin
1 cup cold water
1 cup boiling water
1 cup sugar
¼ tsp. salt
4 tbsp. lemon juice
5 cups firm mangoes, diced

Layer over the chilled cream cheese filling.

## CUSTARD PIE

4 eggs, slightly beaten
½ cup sugar
½ tsp salt
1½ cups milk
1½ cups cream
1 tsp. vanilla
¼ tsp. nutmeg

Pour into 9" pie crust (see recipe for *Mango Pie*) and bake at 425° for 10 minutes or 350° for 30 minutes.

## BUTTER MOCHI

4 cups *mochi* rice flour
5 tsp. baking powder
4 cups milk
3 cups sugar
4 eggs (beaten)
2 tsp. vanilla extract
1 quarter-lb. block of butter

Blend all ingredients with a mixer. Pour into greased 9x13" pan. Bake in 325° oven for one hour or until done. Slice the baked mochi into ½" by 2" long strips or bite-sized blocks, and dust with a mixture of *kinako* (a powder made from roasted soybeans) and sugar, if desired. The coating keeps the slices separate and easy to handle as finger food.