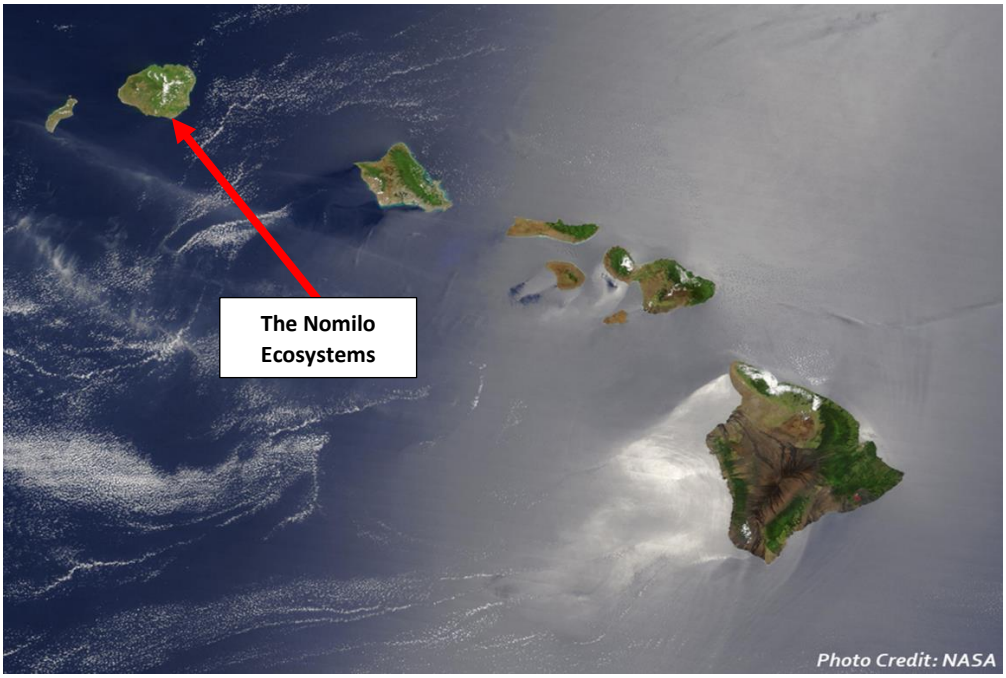
Welcome to Kauai Sea Farm

Kauai Sea Farm (KSF) of Kalaheo, Kauai, Hawai'i is a private company formed to produce more ocean foods for the Island of Kauai, restore Kauai's invaluable marine ecosystems, and to be a partner with other ancient restoration aquaculture fishpond communities and practitioners throughout the Hawaiian Islands. Over 95% of Kauai's foods are imported and oil powers its power grid. Seafoods in markets are largely imported and are increasingly out of the price range of most Island residents. This situation occurs amid a Hawaiian culture with one of the highest per capita demands for seafoods anywhere on Earth.

> Kauai is remarkable for its spectacular marine and terrestrial ecosystems…but the island is…from many indicators…a food…*especially seafood*…desert.



KSF was founded to reverse these alarming trends. KSF is developing a viable economic model to secure forever the destiny of the invaluable marine ecosystems of southern Kauai that include the Nomilo fishpond (see our YouTube by Lynn Maile Taylor, KSF President & CEO). Our global to local

> **The Mission of KSF is** to merge modern aquaculture techniques with traditional Hawaiian fishpond philosophy and knowledge to increase sustainable seafood production and promote non-tourism related jobs for Kauai communities.

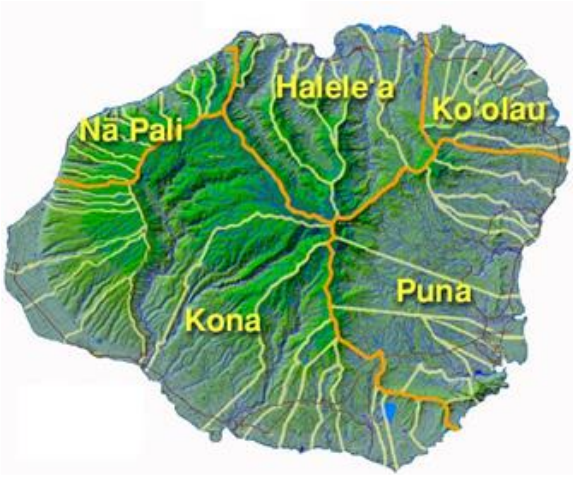
partnerships and ecosystem approaches are a socio-ecological-economic model that can be adapted to other Hawaiian fishpond communities. KSF engages with fishpond operators by being an active participant in the Kua'aina Ulu Auamo (KUA), the leading non-profit fishpond networking organization working throughout Hawai'i.

The Ancient Fishpond Ecosystems of Hawai'i

> The whole distance to the village of Whyeete is taken up with innumerable artificial fishponds extending a mile inland from shore, in these the fish taken by nets in the sea are put, and though most of the ponds are fresh water, yet the fish seem to thrive and fatten … The ponds are several hundred in number and are the resort of ducks and other waterfowl.
>
> T. Bloxam, a British naturalist on H. M. S. Blonde describing Waikiki in 1825

Hawaiian fishponds are some of the earliest known forms of marine aquaculture (Kikuchi, 1976; Costa-Pierce, 1987; Gon and Winter, 2019). Fishponds were treasured resources to the Hawaiian kingdom prior to Western contact. They provided seafood security and spiritual homes for Hawaiian communities for over 500 years.

The *ahupua`a* of Kauai



Marine and freshwater fishponds were part of sophisticated, integrated, watershed social-ecological systems (*ahupua`a*) that spanned all Hawaiian Islands (Gon and Winter, 2019). A social and political revival of Hawaiian culture is underway, but more investments are needed to uncover the traditional knowledge and restore these remarkable, globally important, land-water food and resource watershed management systems. Recovery of Hawaiian traditional knowledge systems in integrated aquaculture is underway as anthropologists and archeologists work as partners with Indigenous societies and investigate how aquaculture develops, evolves, and fits more deeply into narratives of human development from antiquity (Costa-Pierce, 2022). Jokiel et al. (2011) stated that, "Thousands of additional primary source documents and newspaper articles written…remain to be translated and studied and will one day reveal more than is known today". New partnerships have connected Hawai'i to Indigenous aquaculture communities throughout the Pacific. The Pacific Sea Garden Collective

(PSGC, 2022) has developed a beautiful interactive website of Indigenous fisheries and aquaculture innovations throughout the Pacific basin. PSGC is “a collective of Indigenous knowledge holders, community practitioners, university researchers, and artists working together to foster learning about sea gardens drawing from traditional and scientific knowledge with the vision of supporting their resurgence as adaptive strategies today.”

We are inspired and encouraged by these developments. However, the challenges we face daily at KSF are daunting. Over 150 years of colonization and more than 30 years of disuse has led to the deterioration of Nomilo and most of the fishpond/watershed *ahupua`a* ecosystems of Hawai’i. But we believe strongly in the words of Gon and Winter (2019) who stated that the fishponds and the traditional knowledge of the watershed management systems could lead a “renaissance that could save the World”.

The Nomilo Ancient and Modern Social-Ecological Ecosystems

The Nomilo fishpond is in an ancient caldera connected to the sea by a canal (*‘auwai*). Legends and oral histories of the elders (*kapuna*) place Nomilo as one of the most ancient of all Hawaiian fishponds (Kikuchi, 1976). Legends recant that Pele the Goddess of Fire and Volcanoes, who created the Hawaiian archipelago, was born in Tahiti, one of six daughters and seven sons born to Haumea (The Earth Goddess) and Kane Milohai (The Creator of Sky, Earth, Heavens). Pele came to Hawai‘i after being exiled by her father because of her fiery temper. Pele fought incessantly with her older sister Namakaokaha‘i the Water Goddess whose husband Pele had seduced. Upon arrival in her new Hawaiian home Pele thrust her digging stick (*o‘o*) into the earth to dig a pit for her home, which was Nomilo. Each time Pele tried to make a new home her sister, Namakaokaha‘i would flood the area, which created the Nomilo fishpond. When Pele decided to leave Kauai for Oahu

she left two supernatural eels named Puhi‘ula and Puhi’pakapaka to guard forever Nomilo from all dangers. These eels serve as the logo for KSF.

The Nomilo property was purchased from Hawaiian ownership by a sugar cane landowner in the mid-late 1800’s. It was reacquired by the Hawaiian Palama family in the early 1900’s and has been in the family ever since. The President & CEO of Kauai Sea Farm is Lynn Maile Taylor of the Palama family. The family has managed the property as a land trust for three generations and has created KSF as a modern seafood business based on traditional Hawaiian knowledge systems it continues to recover.

Our Progress and Our Needs

Most Hawaiian fishpond restoration efforts are funded through public grants and donations which are not sustainable long-term strategies. KSF was formed in 2017. To date approximately $750,000 has been invested alone by the Palama/Taylor family. Approximately $450,000 in applied scientific grants have been obtained.

Ecosystem Restoration and Sustainable Development

The ecosystems of the south coast of Kauai are under threat from unsustainable development but Nomilo and its miles of coasts and marine ecosystems are near pristine. Coral reefs, endangered Hawaiian monk seals and sea turtles abound on Nomilo’s beaches.

Water quality, ecosystem restoration and sustainable aquaculture developments are on-going at Nomilo. To assist and advise KSF a global to local scientific partnership between businesses, NGOs, universities, and community groups has been formed. Invasive mangroves lined the pond for decades, degrading the fishpond water quality. By the first quarter of 2022 mangroves were all removed from the ecosystem. Nomilo is remote with no power connections to the Island grid. A unique solar-powered hatchery was established in 2021 that we are expanding in 2022-2023. Our hatchery system is a model for other Pacific Island communities in similar situations.

Shellfish Production

Hard clams (Mercenaria mercenaria)

Hard clams were introduced to Hawai'i during the 1960's and were grown on a Kauai shrimp farm. They were also introduced to the Nomilo fishpond but died out after Hurricane Iniki in 1992**,** the most powerful hurricane to strike Hawai'i in recorded history. KSF re-established production of hard clams after purchasing the last remaining seed clams in Hawai'i from a now defunct hatchery. Production has yielded approximately 1,100 lbs. from 43,000 stocked seed for an estimated survival of 55-60%. A solar-powered hatchery has been established at Nomilo to expand clam production and is producing seed. The KSF hatchery plans to stock 1 million seed that will yield an estimated 50,000 lbs. annually.

Oysters

After an invasion of the mud blister worm (*Polydora spp.*) that destroyed our large-scale fishpond production of oysters in 2021, KSF has developed new land-based nursery and growout systems for oysters that will make growing oysters more efficient, cost-effective, and less susceptible to parasites. We are growing several varieties including *Crassostrea virginica* (Eastern), *C. gigas* (Pacific), and *C. sikamea* (Kumamoto) oysters.

KSF has a need to expand its shellfish hatchery and pumping systems to meet the high local market demands, and to partner with innovative shellfish breeding companies and programs.

Production of Seaweeds (*limu*)

Ogo is a very popular food in Hawaiian, Filipino, Japanese and Korean markets. *Ogo* in the wild has been overharvested throughout Hawai'i, and much of the *ogo* now consumed is imported. KSF produces the highest quality *ogo* in tumble culture on land. Our location on the undeveloped south coast of Kauai has very high quality seawater which is drawn directly by solar power to tanks.

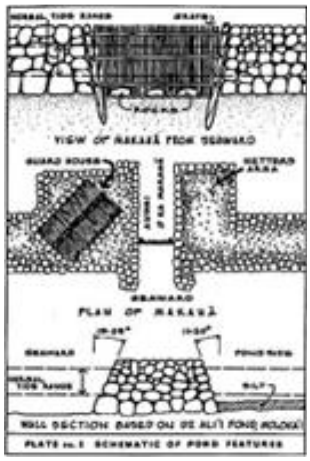
KSF has a need to expand its tank capacities and pumping systems to meet the high local market demands for *ogo*.

Production of Hawaiian Staple Fish Species

Milkfish and Mullet…called "The Tastiest Fish You've Never Tried"

Kikuchi (1976) estimated there were 488 fishponds in Hawai'i prior to western contact. In 1901 360 fishponds were mapped and 99 were active. The two most abundant fish species were the Hawaiian fish protein staples, mullet *('ama'ama)* and milkfish *('awa).* In 1901 the estimated annual production of '*ama'ama* was about 486,000 lbs. and '*awa* 194,000 lbs. Today, according to Vernon Sato, there's less than 5,000 lbs.

KSF intends to use the ancient wisdom of the *mahaka* dual gate system combined with modern engineering knowledge to harvest thousands of fish to meet the high local market demands for traditional fish.



Kikuchi (1976)

produced in all of Hawai'i. KSF has restored the ancient canal (*'auwai*) that connect Nomilo to the ocean but not yet the innovative dual gate fish harvest system (the *makaha* system) (Wyban, 1992). However, opening and cleaning the canal has allowed mullet and milkfish to repopulate Nomilo and recovery over the last year has been astounding as the marine ecosystems outside of the Nomilo are near pristine and produce thousands of juvenile fish that now can reenter Nomilo via the canal with the tides.

Production of Sea Cucumbers

An exquisite - and very valuable - native Hawaiian sea cucumber being developed for markets and restoration aquaculture by KSF (photo by David Anderson, 2022)

Sea cucumber aquaculture presents a tremendous opportunity for KSF and all other Hawaiian fishpond communities to engage in a type of restoration aquaculture that would produce a high value species that can consume the excess nutrients which have built up in the sediments of fishponds over decades.

A market study for Hawaiian grown sea cucumbers has been completed (Reynolds, 2022). Annually the US imports over 750,000 metric tons of sea cucumbers mostly from foreign sources and for consumption primarily by Asian ethnic groups.

KSF is the principal investigator on an ongoing National Oceanic and Atmospheric Administration (NOAA) Saltonstall-Kennedy project to investigate production of three native Hawaiian sea cucumbers utilizing fishponds throughout Hawai'i. The larval cycle for the high-value *Holothuria whitmaei* sea cucumber has been completed at the solar-powered KSF hatchery, and improved settlement methods and optimization of larval rearing research is underway. Investigations of sea cucumber production in Nomilo have demonstrated high survival and fast growth rates with minimal labor required to maintain sea cucumber enclosures. Long-term project goals are to create a vertically integrated cooperative of

KSF needs to expand its production capacity to investigate valuable native Hawaiian species of sea cucumbers. There is a need to expand our hatchery to supply cucumbers that are valuable and in demand for both food and restoration aquaculture in Hawai'i.

fishpond growers where KSF will produce juvenile sea cucumbers for production in fishponds throughout Hawai'i under a guaranteed buy-back program. Sea cucumber products will be processed and marketed through a shared facility offering a sustainable funding source for Hawaiian fishponds with very low cost of market entry.

Restoration Aquaculture

The period of neglect between the time when the Hawaiian kingdom was thriving to modern Hawai'i has led to a buildup of nutrients and detritus in fishponds. KSF needs assistance to recover the full productive water column of the fishpond and has the scientific expertise and partnerships to do so. Sea cucumbers are detritivores that consume sediments, bacteria and settled nutrients as they eat through sand and sediment helping to recycle materials and nutrients. Sea cucumber aquaculture is a rare opportunity for Hawaiian fishpond practitioners to grow a low trophic level, high-value species that may offer invaluable ecosystem services in addition to sustainable funding for practitioners.

KSF principals, advisors and scientists have been partners in restoration aquaculture internationally and in Hawai'i (TNC, 2021). As the production of sea cucumbers ramps up, KSF has the partnerships needed to distribute them. In addition, KSF can deliver not only sea cucumbers, but also juvenile fish and seaweed seeds to other fishpond cooperators. KSF plans to expand the hatchery and reproduce native sea urchins and corals which could be distributed to fishpond communities. KSF works closely with Kua'āina Ulu 'Auamo (KUA) who support the Hui Mālama Loko I'a (Hui), a network of Hawaiian fishpond practitioners and organizations. Expansion of our marine aquaculture restoration efforts will be accomplished by continuing our partnerships with these Indigenous leaders, federal and state agencies, NGOs and scientists locally and globally.

References

Costa-Pierce, B.A. (1987). Aquaculture in ancient Hawaii. *BioScience* 37, 320-331.

Costa-Pierce, B.A. (2022) The anthropology of aquaculture. *Frontiers in Sustainable Food Systems*, 6:843743. doi: 10.3389/fsufs.2022.843743

Gon III, S., and Winter, K. (2019). A Hawaiian renaissance that could save the World. *American Scientist* 107, 232-239.

Jokiel, P.L., Rodgers, K.S., Walsh, W.J., Polhemus, D.A. and T.A. Wilhelm. (2011). Marine resource management in the Hawaiian Archipelago: The traditional Hawaiian system in relation to the Western approach. *Journal of Marine Biology* 151682. doi:10.1155/2011/151682

Kikuchi, W.K. (1976). Prehistoric Hawaiian fishponds. *Science* 193, 295-299.

PSGC (Pacific Sea Garden Collective. (2022). Sea Gardens Across the Pacific: Reawakening Ancestral Mariculture Innovations. Version 1. Washington Sea Grant at the University of Washington. doi:10.6069/ZJB9-CG30

Reynolds, J. (2022). Market analysis of Hawaiian grown sea cucumbers *Stichopus horrens, Holothuria whitmaei* and *Actinopyga varians.* Graduate Program in Ocean Food Systems, University of New England, Biddeford, ME.

TNC (The Nature Conservancy: Alleway, H., R. Brummett, J. Cai, L. Cao, M. R. Cayten, B.A. Costa-Pierce, P. Dobbins, Y-w Dong, S.C. Brandstrup Hansen, R. Jones, S. Liu, Q. Liu, C.C. Shelley, S. Theuerkauf, L. Tucker, T. Waters, and Y. Wang). (2021). *Global Principles of Restorative Aquaculture*. The Nature Conservancy, Arlington, VA.

Wyban, C. (1992). *Tide and Current: Fishponds of Hawai'i*. University of Hawai'i Press, Honolulu.