Assessing the Feasibility of Using Value-Added Products to Reduce Seafood Waste in Hawai‘i

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Abstract

Our project, sponsored by Conservation International – Hawai‘i, delves into transforming fish waste into value-added products such as fish leather and broth, addressing seafood waste's environmental and economic challenges in Hawai‘i. Our findings highlight fish leather’s appeal due to its unique characteristics and sustainability and fish broth’s untapped market. This study demonstrates the potential of fish leather and broth to mitigate fish waste and generate increased value, suggesting a promising future for these products in Hawai‘i’s market.

Executive Summary

Seafood waste presents a substantial financial burden for the seafood industry in Hawai‘i. In particular, fish waste disposal costs are the “greatest concern” for all the seafood dealers and processors throughout the state and “a critical cost issue for their business.” Fisheries and wholesalers spent an estimated $820,000 in 2014 combined to dispose of fish waste on the island of O‘ahu alone. Given inflation, the rising cost of fuel, and considering Hawai‘i’s five other islands, the seafood waste disposal cost only increases. It is now estimated that well over $1 million is spent annually. This trend underscores the importance and urgency of a sustainable fish waste management solution to alleviate the economic pressure on Hawai‘i’s fishing industry.

Most Hawaiian seafood distributors who handle fresh, local seafood incur significant operational costs when disposing of fish waste through fish disposal companies. There is great interest in finding optimal utilization for this waste. However, seafood is highly perishable, and the byproducts are discarded due to limited space, a lack of demand, difficulty with processing, and a lack of cross-sector connections and collaborations. Creating additional value-added products from seafood, such as processed or specialized products, will increase the overall value generated for Hawai‘i's seafood producers. Investing in developing new types of value-added seafood products for the market may increase revenues and profitability. It can help maximize the economic benefits of Hawai‘i’s seafood industry.

This report analyzes the potential benefits, challenges, and market opportunities associated with fish leather and broth production, focusing on applications within the local Hawaiian market. Through an in-depth feasibility and market analysis, these products can effectively create value from waste. We investigated sourcing, market, branding, and scalability strategies to develop a clear path for introducing these products in the local Hawaiian market. Throughout our research, we interviewed experts across the United States, Japan, New Zealand, and Canada. The findings of this report demonstrate the considerable potential for both fish leather and broth within the local Hawaiian market, offering avenues to mitigate waste and generate increased value.

Fish leather is a promising avenue to create value through fish waste. It offers several advantages over traditional leather materials, including its unique texture, durability, and sustainability. These characteristics make fish leather desirable for new entrepreneurs and established businesses to incorporate into their product lines. It poses as an attractive product for environmentally conscious consumers and the fashion industry searching for innovative materials. The fish leather market in Hawai‘i is small and new. With the global demand for sustainable and exotic materials, we believe fish leather has a significant market potential. Hawai‘i's strong culture, which is tied to its local fisheries, suggests that there will be strong support for fish leather. Many artisans, artists, and businesses are interested in naturally tanning and utilizing fish leather for their products, such as wallets and fishing gear, and were encouraged by the positive feedback on fish leather products from friends and customers.

The tanning stage represents the most challenging aspect of producing fish leather at scale, but efficient tanning and processing techniques lead to higher-quality fish leather. Tanning the fish skins with natural tannins and dyes is essential for the environment, while using chemicals like chromium harms the tanners and the environment. Proper sourcing practices and eco-friendly production address and combat the concerns of sustainability. As the industry

grows, increasing the scale of fish leather production introduces a few challenges. Keeping the skin under the proper condition and ensuring a consistent quality of leather across batches are among some of the concerns.

Leather makers should source fish skins from Honolulu fish markets as most wholesalers, such as Nico's Fish Market at Pier 38 and Pier 38 Fish Market, are willing to donate fish skins at no cost. This reduces the financial and logistical burden of starting a fish leather-making company, making fish leather a feasible business endeavor.

In researching fish broth, we focused on understanding its nutritional benefits and identifying challenges and opportunities for its incorporation into the market. The nutritional analysis determined that fish broth offers essential vitamins, minerals, and Omega-3 when enriched with vegetables. We believe the nutritional values of fish broth should be used as a competitive advantage when marketing it as a sustainable and healthy alternative to existing broths. However, our research also uncovered potential challenges to adopting fish broth in Hawai‘i. These include existing culinary traditions involving dashi powder, cultural barriers, established cuisines, and quality control. Despite existing products and Hawai‘i's small fish broth market potential, steps can still be taken to reduce fish waste through fish broth by creating fish broth packets and adopting new practices.

In summary, this report highlights the significant potential of fish leather and broth as value-added products in the leather and culinary industries. Fish leather offers an innovative and sustainable material in the fashion industry, offering an environmentally conscious substitute and social benefits for all stakeholders in the supply chain. Since Hawai‘i is one of the most abundant fisheries in the world, the state stands at a unique advantage to leverage this emerging trend. Artisans can diversify their products and increase their market size and revenue while contributing to sustainable practices in the fashion industry. Similarly, the increased adoption of fish leather can alleviate the financial burdens associated with fish waste disposal for seafood wholesalers. Fish broth holds potential for culinary innovation. Utilizing fish byproducts represents an opportunity to reduce fish waste while providing nutrient-rich broth and broth-based dishes. This approach not only supports environmental sustainability but also offers economic advantages to local fisheries and restaurants. Hawai‘i, being an abundant fishery, has the resources and motivation to position itself as a rapidly growing value-added fish product market.

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1 Background Research

The seafood industry in Hawai‘i plays a pivotal role in the state’s economy and cultural identity. However, the industry faces a significant challenge that extends beyond commerce and into environmental sustainability: the management of seafood waste. This background section explores the various levels and stages of seafood waste management in Hawai‘i.

The background begins by understanding Hawai‘i's seafood industry's cultural and traditional aspects (Section 1.1). We explore traditional fishing practices, the evolution of these practices, and how they connect with the local community’s livelihood and cultural expressions. Understanding seafood's historical context and cultural significance in Hawai‘i reveals industry dynamics and its role in the state’s economy.

Then, we address the critical issue of seafood waste, examining its environmental and economic repercussions. Section 1.2 explores the implications of Hawai‘i’s unique geographical context and discusses sources of seafood waste and supply chain dynamics.

In Section 1.3, we emphasize the critical importance of addressing seafood waste. This includes an exploration of the economic and environmental ramifications associated with seafood waste, highlighting why effective management strategies are essential.

Lastly, Sections 1.4 and 1.5 introduce the concept of value-added products derived from seafood waste, discussing their economic potential and sustainability benefits. These sections highlight how repurposing seafood waste can mitigate environmental impact and contribute to the state’s economic prosperity.

1.1 Why are fish and seafood important in Hawai‘i?

1.1.1 Culture and Tradition

Hawai‘i is well-known worldwide for its beauty, with flourishing green landscapes, pristine beaches, and active volcanoes. Along with surfing and hospitality, Hawai‘i has become renowned for its food. A central component of many famous Hawaiian dishes is fish. From reef fish to tuna from the Pacific, fish has been a staple of Hawaiian cuisine for centuries. The importance of fish and other Hawaiian ingredients stems from its deep roots in Polynesian tradition. When departing to embark on voyages to different islands, select foods could sustain voyagers and be caught, raised, or grown anywhere. Along with fish, these foods are “chicken, pig, dog, coconut, yam, sugar cane, breadfruit, mango, taro, and candlenut” ~~and fish~~ (Klieger, 2021, n.p.). Food was essential to the voyagers, as many foods were tied to specific deities. Women were even limited to the food they could eat if they were the symbol of a male god, but fish were a valuable part of everyone’s diet. (Klieger, 2021, n.p.)

One of the most important types of fish for a sustainable food source was ‘ahi, which is the Hawaiian word for yellowfin or bigeye tuna. ‘Ahi would store well when dried and salted, making it an ideal protein source for long trips across the Pacific (Kawaharada, 2006). Current-day Hawaiian food contains more than just traditional ingredients; it comprises many recipe structures due to foreign influence and a mix of cultures. These international influences are not only from the Americans who colonized the islands in the early 1900s, but also from Asian countries like Japan, making the food in Hawai‘i a mix of some of the best culinary forces in the world.

1.1.2 Fishing Industry

Japan has influenced Hawaiian cooking and the methods of catching fish used in Hawai‘i. In the early 20th century, Japan began an era of industrialization, leading to new nets and fishing techniques, which introduced an improved way to catch fish compared to traditional fishing. This industrialization in Japan occurred over many years, but people from the Japanese diaspora brought these new techniques to Hawai‘i between 1899 and 1920 (Ogawa, 2015). Before this time, traditional Hawaiian fishing techniques, such as Ulua fishing, were passed down from generation to generation. Two forms of Ulua fishing are Kau Lā‘au and Ma‘ama‘a. The first method uses hand baiting lines tied to a pole to catch fish, and the second involves casting line by hand overhead and pulling it in (Calamia, 2005), as shown in Figure 1.

Figure 1: Example of traditional Ma‘ama‘a fishing.

Image source: https://ediblehi.com/to-catch-uhu-hawaiian-fishing/r

These traditional ways of fishing, integrated with industrializing Japanese influences, have evolved into modern-day fishing in Hawai‘i. Today, fishing entails new techniques and ways to conserve fish to ensure the local population is sustained for the future. Sustainable

seafood is “wild-caught or farmed seafood that is harvested or produced in ways that protect the long-term health of species populations and ecosystems” (Sustainable Seafood | NOAA Fisheries, n.d.). The typical way fish in Hawai‘i are currently caught is commercially. Deeper seas and closer to reefs are targeted for seafood from ‘ahi to lobster. As fishing has advanced, regulations have been implemented to protect from overfishing. Hawaiian fisheries are held to a Code of Conduct for Responsible Fisheries, an assessment endorsed by the United Nations Food and Agriculture Organization (Hawaii-Seafood, 2015). Fishing a variety of fish is also helpful in preventing the targeting of specific species that may be more lucrative. It is vital to be conscious of responsible fishing in this area, as the Northwest Hawaiian Islands are recognized as a protected area (Kittinger, 2010). If the fishing industry can be sustainably focused on the front end of catching fish, it should be just as focused on the back end in disposing of waste.

1.1.3 Who Uses Fish Products Most?

Regardless of where the fish is sourced, it will always end up with the consumer. This includes people preparing fish independently and those ordering fish at restaurants (Figure 2). Figure 2 shows that the focus on fish waste does not involve only the fishing industry but also outlets that provide the fish to consumers. Most fish caught will go through wholesalers and retailers, making them significant focuses when finding ways to reduce fish waste. Fish disposal is expensive, as Hawai‘i is an island with limited land area, and dumping into large landfills is not sustainable. Finding new ways to dispose of fish remains that are the least impactful to the environment is essential. There will always be excess seafood that must be disposed of; however, finding alternative ways to reuse or use parts of the discarded fish would be the most effective way to deal with fish waste.

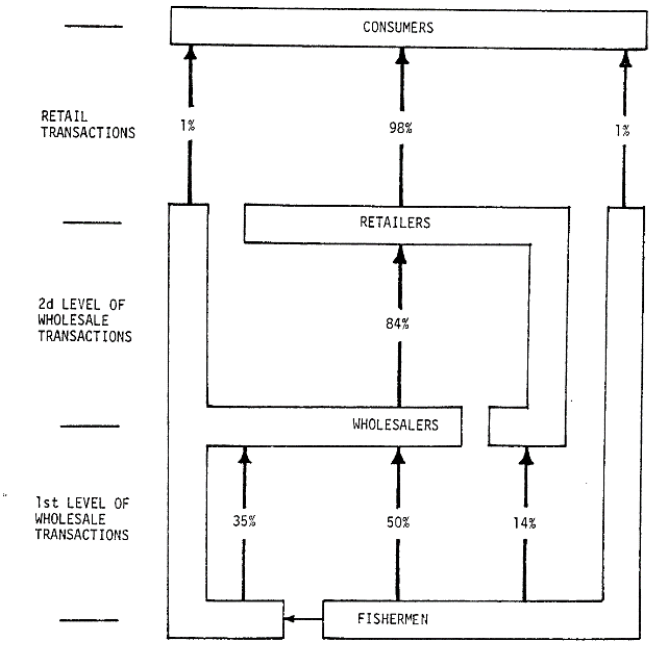

Figure 1.--Distribution of sales at two levels of wholesale transactions and one level of retail transactions in the Oahu Island fresh fish market for all species, 1975-80.

Figure 2: Distribution of Sales.

Image source: Competition and Market Structure in the Hawai‘i Fish Industry (Adams, 1981)

1.2 Introduction to Seafood Waste and Overview of Hawai‘i’s Seafood Industry

The Department of Health defines fish or seafood waste as “organic materials from commercial or recreational fish cleaning or processing operations. Fish waste may include, but is not limited to, particles of flesh, skin, bones, entrails, or liquid stick water” (Department of Health, 2021). Stick water is defined as “a by-product in the wet process of manufacturing fish meal and fish oil by cooking the fish with steam and pressing” from the Merrian-Webster Dictionary (Merriam-Webster, n.d.). Hawai‘i faces a significant challenge in managing seafood waste due to its reliance on fishing, with approximately 40% of the commercial catch ending as waste (Loke & Leung, 2015). Understanding the scope and definitions of seafood waste in Hawai‘i is vital to improving local ecosystems, communities, and long-term industry viability.

This introduction will set the stage for a comprehensive exploration of seafood waste in Hawai‘i, delving into its significant contributors, disposal methods, and broader implications for companies, people, and the environment.

1.2.1 Seafood Catch and Fish Product Waste Contribution

Table 1 below presents the catch data for different species in Hawai‘i from the Division of Aquatic Resources Department of Land and Natural Resources State of Hawai‘i, showcasing the weight of each species of fish landings caught in pounds from 2019 to 2021. Fish landings are “catches of marine fish landed in foreign or domestic ports” (OECD, 2018). The total landed fish caught decreased from 34,897,804 pounds in 2019 to 29,242,379 pounds in 2021, indicating the industry’s susceptibility to external factors such as the COVID-19 pandemic.

Table 1: Breakdown of landed fish caught in Hawai‘i (2019-2021).

Species Group (lbs.)	2019	2020	2021
‘Ahi	23,247,875	20,594,492	22,193,279
Billfish	5,434,048	3,169,926	3,322,172
Misc. Pelagic	5,082,805	2,789,663	2,866,648
Deep Bottom fish	322,169	258,016	264,221
Akule/‘ōpelu	370,084	345,267	323,987
Inshore fish	237,298	261,716	198,848
All others	203,524	85,635	73,225
Total fish caught	34,897,804	27,504,716	29,242,379
Estimated FPW	13,959,121.60	11,001,886.40	11,696,951.60

Image Source: (Division of Aquatic Resources Department of Land and Natural Resources State of Hawai‘i, 2019)**;** (Akizuki et al., 2020)**;** (Akizuki et al., 2021).

As shown in Table 1, ‘ahi emerges as the predominant species in Hawai‘i in terms of weight and its contribution to fish processing waste. This finding underscores the significance of ‘ahi in the seafood industry while highlighting the associated challenges of managing its processed waste. This prominence shows the importance of effective waste management strategies for tuna and suggests a potential area of focus for developing value-added fish

products (VAFP). This insight leads us to the supply chain dynamics of Hawai‘i’s seafood industry, exploring the stages of seafood processing.

1.2.2 Supply Chain Dynamics

The seafood industry in Hawai‘i operates in a complex supply chain consisting of several distinct stages, each contributing to the production of seafood waste. From the initial catch to the final consumer, every stage plays a role in the accumulation of waste. Post-harvest waste encompasses losses or spoilage (Loke & Leung, 2015). According to the Food and Agriculture Organization (FAO), retail and consumer waste refers to wholesale, edible material intended for human consumption that pests discard, lost, degraded, or consumed at any point in the Food Supply Chain (FSC).

Table 2: Stages of seafood waste in Hawai‘i (2010)

Seafood Waste	Post-harvest	Distr./Retail	Consumer	Aggregate
Waste (mil kcal)	110.3	3,198.50	11,550.60	14
Waste (US$ mil)	0.45	29.65	107.06	137.15
Waste (%)	0.30%	8.60%	30.90%	39.80%

Source: Loke, M. K., & Leung, P. (2015). Quantifying food waste in Hawai‘i’s food supply chain. Waste Management & Research, 33(12), 1076–1083. **https://doi.org/10.1177/0734242X15607427**

Table 2 above, sourced from a 2015 study by Loke and Leung, provides a quantitative breakdown of seafood waste in Hawai‘i across different stages. The data encompasses post-harvest, distribution and retail, and consumers, culminating in the aggregate waste. The values are expressed in million kilocalories, US dollars, and percentages, offering a comprehensive view of seafood waste's scale and economic impact on Hawai‘i's supply chain. This data serves as a foundational reference for understanding the dimensions of waste and informs subsequent discussions on waste management strategies.

Hawai‘i’s unique geographic isolation significantly impacts its economy by increasing shipping costs to and from the mainland US. For instance, the Jones Act mandates that goods transported between US ports use US-flagged vessels, amplifying costs (Akina, 2020). This regulation was intended to support domestic maritime commerce but inadvertently raised the price of living and operational costs for Hawai‘i. These economic pressures extend to the seafood industry, contributing to the high costs of seafood products and waste management. This brings us to our next focus: disposing of fish waste for companies. Waste management processes are shaped by the need to comply with regulatory requirements and address environmental concerns and economic efficiency in a state where every resource counts.

1.2.3 Process of Disposing of Fish Waste for Companies

Waste disposal includes several vital stages and unique challenges for companies occupying more than 5,000 square in Hawai‘i. Initially, fish waste products (FWPs) are stored in freezers or refrigeration units to prevent decomposition and maintain hygiene within facilities, minimizing issues like odors and flies (Dominy et al., 2014). Previous regulations mandated by the Board of Health strictly prohibited the disposal of FWPs in a manner that would cause odors or attract pests. However, in 2018, the Board of Health repealed this law, indicating that refrigeration of FWPs is no longer a regulatory requirement (Department of Health, n.d.).

After the initial storage phase, FWPs are moved to landfills, where they may be disposed of in designated areas for composting (Dominy et al., 2014). There are practices of repurposing FWPs as fertilizers or pig feed, fostering a more sustainable approach. However, this often occurs on a smaller scale, with farmers picking up FWPs from stores rather than wholesale sources.

Despite the efforts made by farmers, challenges persist, and improvements can still be made in seafood waste management. Small businesses, defined as those producing FWPs in less than 5,000 square feet of facilities, have different regulations, allowing them to use traditional disposal methods rather than specialized FWP disposal companies. Furthermore, the limitations of current disposal methods include high costs, especially in regions with limited available land. This situation highlights the pressing need for more innovative and sustainable fish waste disposal solutions, such as developing value-added fish products, to address economic opportunities and environmental concerns.

1.3 Importance of Addressing Seafood Waste

1.3.1 Economic Importance

The economic ramifications of seafood waste on the seafood industry are profound. The financial burden of large amounts of waste poses an immense setback to fishing industries. Dominy et al. shed light on the economic impact of fish processing waste disposal, revealing staggering figures. In O‘ahu, the cost of fish disposal can rise to $10,000 per month for some companies, with annual expenditures reaching as high as $100,000. Collectively, these figures translate to a substantial financial outlay of approximately $820,000 annually on fish disposal in O‘ahu alone (Dominy et al., 2014).

In addition to the direct costs associated with seafood waste disposal, Dominy et al. explored some companies' investments in fish grinders to address the challenge of containerized disposal. Given that FWP disposal companies provide services based on container loads, companies seek to optimize space and minimize cost by compacting FWPs. Notably, a common approach involves the adoption of in-house grinders. These grinders, however, come at a substantial cost, with some companies having to invest up to $40,000 to secure an industrial fish

grinder. Such investments constitute a significant financial commitment, posing challenges for many small companies in the industry.

1.3.2 Effects of Seafood Waste

Hawaiian locals rely on seafood and aquaculture for both nourishment and their culture. The amount of seafood used in Hawai‘i annually equals “36 pounds per person for the residents,” which is easily the highest rate in the United States (Lynch, 2018). Over half of the local seafood, 55%, comes directly from Hawai‘i, underlying how the state relies on the ocean as a persistent food source. There is a prominent issue with food insecurity in Hawai‘i that is affecting 48% of families. “Food insecure households are defined as those lacking enough food for an active, healthy life for all household members” (Pruitt et al., 2021). (Pruitt et al., 2021)The Hawaiian population is projected to increase significantly within the next 20 years, which will augment the demand for aquaculture (Lynch, 2018). Action must be taken to reduce the amount of seafood waste to prevent a food gap and a further depletion in food security.

New and better ways to manage the local fishing and seafood system must be analyzed to increase production. It is essential for fish waste to be reduced in all sectors, from distributors to consumers, to improve sustainability. A better understanding of the seafood supply chain will be beneficial in reducing seafood waste. Sourcing should be kept local in Hawai‘i to handle seafood production and the industry better. There should be more support for the traditional and local Hawaiian fishponds that produce millions of pounds of aquaculture per year and are sustainable if they are maintained healthily. Finding ways to reduce land waste and pollution directly impacting the oceans will help keep them clean and thriving for the fishing companies that depend on them (Lynch, 2018). Also, if Hawai‘i could reduce the number of areas fishermen are being forced out of due to tourism, this could lead to a better handle on the management and

support for the local fisheries that can produce mass amounts of aquaculture per year (Tubbs, 2023). With these efforts to prioritize local seafood production, there will be a better handle on seafood waste and food security in the upcoming years in Hawai‘i.

1.4 Value-Added Products

Value-added products are a way to take a by-product that is often wasted and not valuable and turn it into a new, profitable, and desirable item. A product would need to be physically changed, produced to enhance its value, and have a clear separation between itself and its value to be considered value-added (Iowa State University, 2023a). Value can be captured or created in an item, but either way, there is a potential to reduce waste, grow a market, increase profits, and have a successful business. Although there are many avenues through which a desire for a specific by-product can be generated, common options include creating and putting a new product on the market, lowering the cost, and simplifying the supply chain (Iowa State University, 2023b).

Food products have the potential to become value-added. This depends on the specific by-product, availability, location, cost, and economic risks. (Hargreaves et al., 2013). Due to its location, culture, and population, aquaculture use is essential in the food industry in Hawai‘i (Zilberfarb et al., 2023). On average, 30-70% of the fish is wasted, including the bones, skin, head, and eyes, as shown in Figure 3; yet, these products may easily have value and can be utilized in many different industries (Wood et al., 2021). For example, fish leather and broth are two value-added products made from these usually discarded fish parts that can potentially reduce the amount of waste in Hawai‘i.

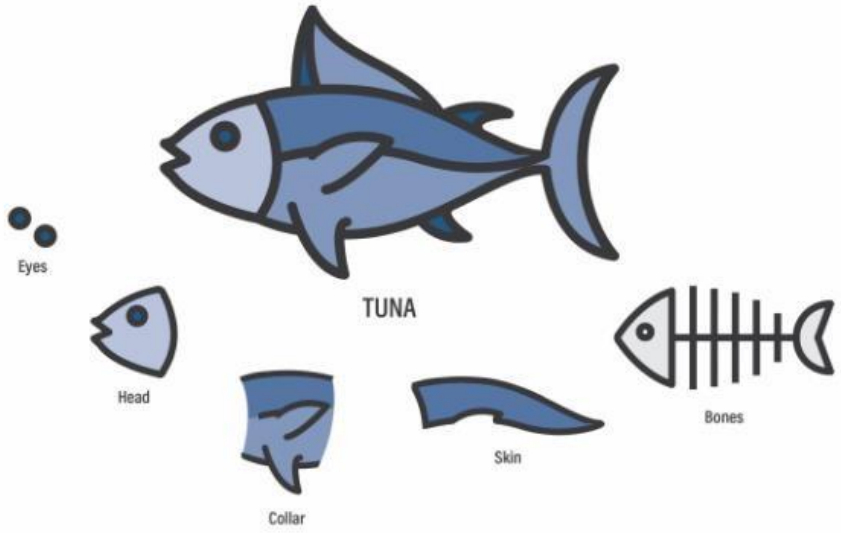

Figure 3: The parts of a tuna that are commonly wasted.

Image source: MENAFN. (n.d.). 5 Ways to Help Reduce Seafood Waste and Loss. Retrieved December 7, 2023, from https://menafn.com/1103024430/5-Ways-to-Help-Reduce-Seafood-Waste-and-Loss

1.4.1 Fish Leather

Fish skin is an abundant by-product of the fishing industry that is commonly wasted and has become an environmental pollutant; therefore, there is great interest in finding ways to utilize fish skin to reduce its waste. One use for fish skin is turning it into leather through tanning (Zilberfarb et al., 2023). Fish leather can be produced using a variety of fish species, including ‘ahi and other native Hawaiian fish.

Fish leather was first introduced by indigenous people who used it for clothing because it was a shared resource that was easily accessible (Alexander, 2023). As time progressed, fish leather became more expensive to produce and buy. After the industrial revolution in the … century, cheaper forms of leather from other animals emerged in the market. Currently, fish leather is not commonly utilized and is usually only employed by luxury clothing and accessories brands selling their products at a high price point (Alexander, 2023). Fish leather has the

potential to be transformed into a value-added product depending on the species it is made from, the tanning process it goes through, and the method of harvesting the skin.

Figure 4: A wallet, keychains, and sample pieces made from fish leather.

Image source: OHIRA, Y. (2023, April 20). *Fishing for fashion: Fish leather has become the latest sensation in the fashion world*. https://jstories.media/article/fishing-for-fashion-fish-leather-becomes-the-latest-sensation-in-the-fashion-world

Hawai‘i has many local fisheries, fish farms, and seafood restaurants that produce immense amounts of fish skin waste; typically, this is where fish leather producers source their

materials (Alexander, 2023). Finding a supply of fish skin in Hawai‘i for a fish leather value-added product would be easy and significantly reduce the amount of waste polluting the land and ocean environments, as seen in Figure 5. for a fish leather value-added product would be easy and significantly reduce the amount of waste polluting the land and ocean environments.

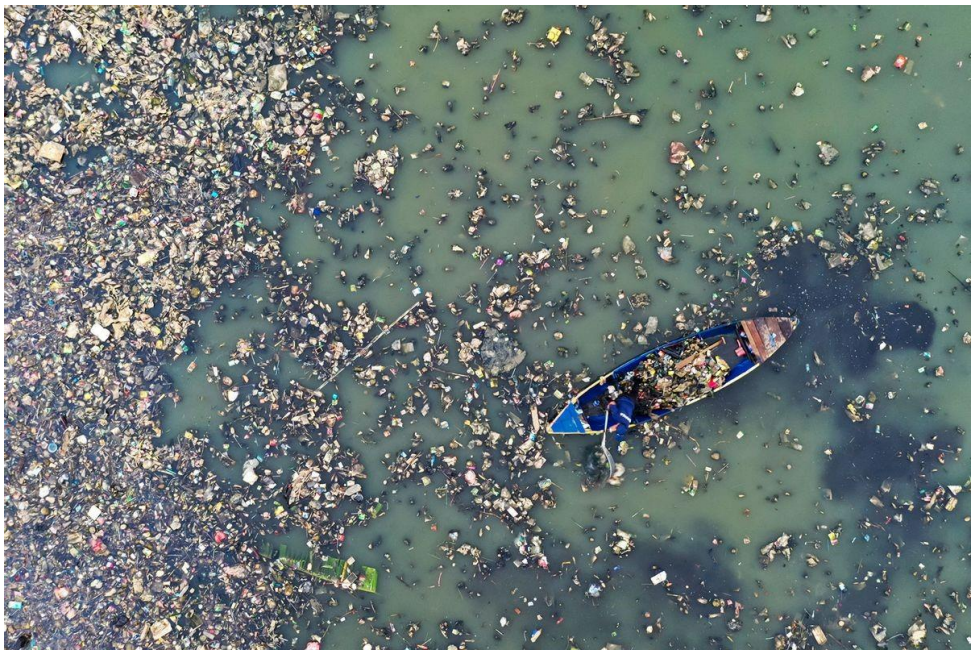

Figure 5: Waste in the Hawaiian waters from fishing and other land pollutants.

Image source: Rozsa, M. (2022, September 14). *Thanks to lax regulation, fishing waste has created a huge trash island in the Pacific*. Salon. https://www.salon.com/2022/09/14/fishing-regulation-trash-island/

1.4.2 Fish Broth

Fish broth is made from fish bones, heads, tails, and carcasses, which are often the most wasted parts of the fish. Simmering and then straining all these fish parts along with vegetables and herbs, as shown in Figure 6, creates a flavorful stock that can be used in various ways (Fear, 2023). There are many international cuisines, including French, Asian, Mediterranean, Italian, and Caribbean, which use fish broth in staple dishes. Fish broth can be made from an abundance of different species, including “white fish,” such as cod, haddock, and sole, and “oily fish,” like

salmon, mackerel, and tuna. Fish broth is highly versatile in terms of how it can be used. It can be a main ingredient when making soups and stew, creating sauces for different seafood dishes, and adding it to marinades and dressings. It cooks and flavors other foods and can be used for boiling pasta and steaming seafood. It can also be added to vegetarian dishes and other stocks and broths for flavor.

Cooking with fish broth has many benefits, including enhancing flavor profiles, increasing nutritional value, reducing waste, and being cost-effective (Billan, 2023). These wasted fish products can be easily accessible at local fish markets because stores tend to extract and sell the more desirable parts of the fish and throw all the other parts away. They can be bought directly from local seafood suppliers, i.e., the fishermen and the companies they work for (Fear, 2023).

Figure 6: Ingredients for fish broth with the wasted fish parts in a pot.

Image source: Bloor, A. (n.d.). Fish Stock Recipe. Retrieved December 7, 2023, from https://www.linsfood.com/fish-stock/

1.5 Market and Feasibility Background

1.5.1 Introduction to the Fish Broth and Fish Leather Market

With the primary objective of promoting wider adoption and awareness of fish leather and fish broth, our team researched the existing markets. Two key steps in completing this objective were conducting a brief market analysis and feasibility assessment of the two types of value-added products. We identified economic opportunities for local entrepreneurs in Hawai‘i who are trying to create sustainable products to help reduce seafood waste. An improved understanding of potential market opportunities can assist entrepreneurs in identifying sourcing strategies, equipment, and improvements to supply chains to utilize better-discarded fish by-products. This analysis and assessment can guide chefs and entrepreneurs looking to maximize the value of these by-products.

1.5.2 Fish Leather Industry

The fish leather industry is forecasted to grow substantially in the coming years because the demand for leather-related products continues to increase (Straights Research, 2023). Fish leather has many applications in fashion, such as clothing, footwear, wallets, and handbags, due to its high durability and wear-resistant characteristics. Leather is one of the most widely traded commodities in international markets, and Europe currently has the largest fish leather industry in the world. Despite this, fish leather products account for less than 1% of global leather sales (Timmins, 2019). Leather products play a critical role in the global economy, with an estimated value of USD 100 billion annually (Straights Research, 2023). Fish leather has the opportunity to contribute to this vast existing leather market.

There are many benefits and opportunities for entrepreneurs to enter the fish leather industry. First, The United Nations Food and Agriculture Organization (FAO) promotes fish leather to boost the income of fishing communities worldwide (Timmins, 2019). Additionally, the increased availability of fish leather could reduce the demand for snake skins, alligator skins, or other endangered species.

The fish leather industry can proliferate in Hawai‘i. Utilizing excess resources like exotic fish leathers of ‘ahi and marlin can create a local and global appeal for fish leather products. The wide range of uses for fish leather makes it a versatile material that has the potential to cover large markets. Nonetheless, prospective businesses looking to enter the fish leather industry face a few challenges, the most prominent being that cow leather makes up much of the leather industry. Cow leather production cannot necessarily be slowed down as it is intrinsically linked to the continuing demand for beef. Cowhides not turned into leather would become a 10-million-ton waste issue annually (Timmins, 2019). As such, the fish leather industry should not try to take over the leather industry but rather aim to become a significant part of it. A fish leather value-added product would reduce seafood waste, boost the income of local fishing communities, and create additional profits for entrepreneurs and stakeholders.

1.5.3 Fish Broth Industry

Fish broth has the opportunity to become an effective value-added product. The ingredients needed to make fish broth can come from a large portion of Hawai‘i’s seafood waste. Fish broth is not yet a typical food for locals and has not made its way onto the shelves of supermarkets. This allows an opportunity to campaign for fish broth products and to open the local market.

Fish broth can provide several benefits for the Hawaiian population. One substantial benefit is that using fish broth can improve food security. Since Hawai‘i is one of the most isolated archipelagos, it is almost impossible to become self-sufficient; therefore, Hawai‘i will continue to rely heavily on imports. (Lysak, Ritz, Henriksen, 2019). However, locally produced goods can improve food security by reducing Hawai‘i’s import dependency. Hence, fish broth can reduce the amount of seafood waste, increase food security, and boost the local economy by increasing profits and creating jobs.

To assess the feasibility of introducing these value-added products to reduce seafood waste and create more profits in Hawai‘i, we did a brief market analysis of where these current products are. In Hawai‘i, value-added products have been introduced before, so we looked at their successes and failures to provide the best chance for fish broth and leather to succeed. A study conducted and published in 2019 assessed consumer acceptance and willingness to pay for value-added products made from breadfruit in the Hawaiian Islands. (Lysak, Ritz, Henriksen, 2019). This study highlights “currently a limited selection of commercially available breadfruit products on the Hawaiian Islands.” This study investigated the consumer acceptance of new novel breadfruit products to increase its utilization and to ensure the successful future of breadfruit as a significant food source. Some of the key results from the study are that consumers would be more willing to pay for these products if they received product information (i.e., health benefits, what is it made of, how it is made, etc.) and that including additional product and label information improved consumer acceptance scores. This study concluded that consumers' overall assessment of a product depends on three factors:

1) The availability of information from their memory, either as a child or cultural memory.

2) Consumers' diagnosis of the information presented to them.

3) The relative accessibility of the information that is available to them (Lysak et al., 2019).

One of the most significant conclusions from this study is that symbolic or affective roles of value-added products, for example, where a product originates from, directly impact consumers' willingness to pay for a product. Entrepreneurs and chefs should consider Hawaiian locals' pride in their culture when deciding how to market fish broth to build their brand.

1.5.4 Branding and Marketing

There are many opportunities to build a strong fish broth and leather brand, starting with marketing them effectively. The study focused on introducing breadfruit-based value-added products described in the previous section (Lysak et al., 2019) underlines how building a high product acceptance among consumers is essential. Locals in Hawai‘i take pride in their culture and background, so leveraging where these value-added products come from and their impact on local life would be very effective for growing a strong brand. Three strong marketing points for fish broth and leather may be that the products are made from local Hawaiian fisheries, contribute to self-sustainable Hawai‘i, and support local businesses. Also, consumers will appreciate knowing that VAFP is environmentally friendly and contributes to reducing waste on the island. Entrepreneurs and chefs should market nutritional benefits and the potential to increase food security, specifically for fish broth. For fish leather, entrepreneurs could market exotic leather harvested from Hawaiian fish like ‘ahi and marlin. Marketing is essential to building solid brands around these two value-added products and will impact the success of these products by creating significant consumer acceptance. Businesses' success, in turn, will impact whether reducing mass waste through these avenues is feasible.

1.5.5 Local Challenges and Opportunities

There are several potential benefits to introducing these value-added products in the Hawaiian Islands. A fundamental benefit is that creating valued products can reduce seafood waste and create value for something previously considered waste.

Fish broth has the opportunity to improve Hawai‘i’s food security. Hawai‘i’s average weekly grocery bill for a family of four is $270, compared to the mainland’s average of $149 (Lysak et al., 2019). Increased food prices of up to 19% have been attributed to climate change. Hawai‘i is particularly vulnerable to such increases due to a high dependency on imported food. Around 90% of Hawai‘i’s goods are imported (How Much of Hawai‘i’s Food is Imported? 2023). Locally produced fish broth would cost less, reduce Hawai‘i’s import dependence, and decrease grocery bills. This makes the product a viable food option. Fish broth and fish leather products have the perfect opportunity to reduce seafood waste, increase food security, create jobs, and have the potential to increase profits for stakeholders.

We saw how there are numerous opportunities for fish broth and fish leather. However, many challenges are to be faced when developing these products. Building a successful brand, strong consumer and business relationships, physically producing the products, and competing with other products in stacked markets is challenging. Despite these potential challenges, we believe the potential of these VAFPs is great for chefs, entrepreneurs, and all of Hawai‘i.

2 Methodology

This section discusses how we achieved our project goal and used the objectives as a roadmap for our results. Understanding the consumers, market, cost, and businesses involved in making and distributing these fish products helped to determine their feasibility. It also helped

analyze the interest in these products and whether they will impact the reduction of seafood waste all around Hawai‘i. Our primary research method was to use semi-structured interviews with subjects ranging from major companies to individuals with experience making fish products to gain knowledge on all objectives. Additional desktop research was conducted to gain further information on the market and the cost of creating and distributing these products. Participant observations were incorporated into our research for hands-on experience on how these value-added products are made and their impact on those involved. With all these methods, abundant information and data were acquired to achieve the goal and produce viable information on the feasibility of creating fish leather and broth value-added products. This information was then used to create two different 2–3-page deliverables, one for fish leather and one for fish broth. These deliverables will help spread the information gathered by our team to businesses wanting to implement these VAFPs.

2.1 The Goal

Our goal was to assist Conservation International – Hawai‘i in determining the feasibility of using the value-added products fish broth and fish leather to reduce seafood waste and spending for businesses in Hawai‘i. The following objectives were used to help us achieve this goal:

1. Determine potential value-added product users, target audience, and possible market size and scope.
2. Assess the cost-effectiveness of fish broth and leather to enhance their marketability and viability.
3. Address challenges that small businesses, entrepreneurs, and other companies face in incorporating fish broth and leather products in their businesses.

4. Create 2–3-page deliverables for fish leather and broth to give businesses and entrepreneurs the information and recommendations they need to implement these products.

2.2 Summary of Methods

2.2.1 Objective 1

Our first goal was to determine the potential value of product users, product target audience, and the potential market size and scope. Through this objective, we planned to learn more about consumer behavior and the people utilizing fish broth and leather. We also planned to learn about the potential market size and scope of fish broth and leather. We must learn this information because it helps determine the future market based on what consumers seek. With this, we can show entrepreneurs what consumers are looking for and support our hypothesis that the fish leather and broth markets can be lucrative. We can also display the innovation of these products, which we hope will appeal to aspiring entrepreneurs and chefs.

2.2.1.1 Data Collection Strategy

We gathered data through semi-structured interviews and desktop research. We interviewed chefs, entrepreneurs, and industry experts with semi-structured interviews to gather broader perspectives, market trends, market demand, and strategic insights to enter the fish broth and leather industry. For each interview, the interviewee was given a consent form in Appendix A: Consent Form. Additionally, these interviews gave us insight into potential market value-added product users. This includes consumers, aspiring entrepreneurs, and established businesses, as each utilizes these products differently. We set out to understand what consumers want in value-added products like fish leather and broth and to gain insight into what they like

and dislike in fish broth and leather. This information gave us an understanding of how to increase product exposure and market fish broth and leather. We researched how large the fish broth and fish leather markets are today, the market demand for these products, and the forecasted trend of the fish broth and fish leather industry. We investigated other global practices to see why and how they successfully reduce seafood waste. This gave us insights into how we can guide entrepreneurs to run a successful business with fish broth and fish leather.

2.2.1.2 Challenges and Limitations

The most significant limitation of Objective 1 was our desktop market research capabilities. Since they are not yet prevalent, we could only find limited information on the fish broth and the fish market industry. Significantly less information was available about these markets in Hawai‘i. Determining the potential market size and scope of the fish broth and fish leather industry was essential, but data obtained from desktop research was extremely limited.

2.2.2 Objective 2

The second objective was to assess the cost-effectiveness of fish leather and broth. This assessment was critical in determining these products' sustainability and economic viability. We aimed to identify key factors influencing production costs, including raw material sourcing, processing, labor, and marketing expenses. Additionally, we explored the potential retail price range and market acceptance for these products. Understanding cost-effectiveness was crucial for ensuring these initiatives' economic viability. It also provided insight into aligning the products with consumer preferences and industry standards, maximizing their appeal and competitive advantage.

2.2.2.1 Data Collection Strategy

To thoroughly understand these factors, we conducted market research by interviewing industry experts who provided valuable perspectives on efficient production techniques, potential

cost-saving measures, and prevailing market trends. Our interviews gave us direct insights into price sensitivity and market demand. A detailed cost analysis of the fish broth and leather production process was analyzed, enabling us to identify the financial aspects and potential cost-saving opportunities at each production stage.

2.2.2.2 Addressing Challenges and Limitations

One of the primary challenges was obtaining detailed and accurate cost data for each aspect of production. Additionally, the unpredictability of market trends and consumer preferences, particularly for innovative products like fish broth and fish leather, posed a risk to the accuracy of our market research findings. There was the concern that initial cost-effectiveness assessments may not fully capture the scalability potential, a critical factor for long-term viability. Insights from industry professionals, while valuable, carried inherent subjective biases based on their personal experiences and interests. Resource limitations constrained the extent of our market research and cost analysis, affecting the depth of our findings. Furthermore, the variability in consumer acceptance and market dynamics across different cultural and regional contexts impacted the generalizability of our results. Despite these challenges, our methodology provided a structured and comprehensive approach to evaluating fish broth and leather's economic viability, considering both the market potential and production costs.

2.2.3 Objective 3

Our third objective was to address the challenges that small businesses, entrepreneurs, and other companies face in incorporating fish leather and broth products into their businesses. Our project aimed to help educate those on how to get involved in making value-added fish

products and implementing them into a business. This included possible ways to advertise, the target product audience, and ways to grow their business.

2.2.3.1 Data Collection Strategy

To complete this objective, we interviewed people who are currently in the business of making fish leather and broth. We asked the questions listed in Appendix B: Interview Questions for Fish Broth and Appendix C: Interview Questions for Fish Leather. Thanks to the interviewees who were comfortable sharing the financial aspects of their businesses, we gained an idea of the market size and scope; however, this information did not seem relevant when trying to help others start their businesses. We learned about the difficulties entrepreneurs encountered, how they dealt with them, and what advice they had to share with others. This objective required much information from those with experience in the industry, and the interviews we conducted resulted in an effective way to learn from them.

2.2.3.2 Addressing Challenges and Limitations

One downside to interviews is the large volume of information. Multiple group members took notes to gather data and condensed the interview information by coding. Selecting repeated or stand-out keywords helped inform people trying to enter the business of the biggest hurdles. We also devised a plan to spread the information gathered to the largest possible number of people looking to enter the business. The advice shared involved information about launching a business and the early stages that follow. Providing information on growing and expanding into larger corporations was challenging for such new industries.

2.2.4 Objective 4

The previous objectives aimed to gather information on how to join the fish waste product industry successfully. This objective aimed to effectively share these evidence-based

strategies with those looking to implement fish waste products. This information is being shared with prospective entrepreneurs using two separate 2-3-page deliverables for fish broth and leather. For fish broth, the document is accessible through the Chef Hui website. This non-profit organization consists of local chefs and food service providers working to connect the culinary world to their environment. The document is emailed to those who participated in fish leather workshops organized by Conservation International - Hawai‘i.

2.2.4.1 Data Collection Strategy

To complete this objective, we compiled our data, starting with deliverable outlines for fish broth and leather. These outlines can be found in Appendix D: Deliverable Outline for Both Fish Broth and Leather. The most important outcome of these deliverables was for businesses and entrepreneurs looking to incorporate FWPs to develop a market strategy using our advice, which covered business model and strategy, production process, marketing and branding, sustainability and environmental impact, etc.

2.2.4.2 Addressing Challenges and Limitations

One limitation we came across when creating these deliverables was missing information. We wanted our deliverables to be as specific and informative as possible, which required access to largely unavailable data. Although not all the details we would have wanted to include could be thoroughly researched, this did not affect our ability to create valuable deliverables that addressed clearly and concisely all critical topics and steps related to fish broth and fish leather.

3 Results

This section will discuss our general results and findings relating to the fish markets in Honolulu, Hawai‘i, fish leather, and fish broth. The initial results of our research on fish leather are promising: We found passionate artisans who create various products by hand and educators who want to teach others how to make fish leather. There is also a large potential market surrounding this value-added product. Some of the challenges in the industry include scalability, educating consumers, and getting artisans' new businesses off the ground. We found that the fish broth market differs vastly from that of fish leather, facing different challenges. Fish broth is utilized in other cultures and has proved possible to implement in the industry; however, cultural norms may make this problematic in Hawai‘i. We may need to look at different applications in other markets where fish broth can impact and succeed.

3.1 General Results

3.1.1 Abundance of Materials

Sourcing raw materials needed for fish broth and leather is inexpensive and can be done consistently. Here, we will discuss the sourcing of fish waste and how small businesses or companies can utilize this information.

At Nico's Fish Market at Pier 38, we interviewed a fish processing worker named Ricky Patacsil. During this interview, we found that wholesalers had abundant fish waste, including fish skin and carcasses. Wholesalers must pay to dispose of fish waste at a landfill or have it picked up by farmers for fertilizer. We also interviewed Christopher Alan Pabacal, a Pier 38 Fish Market retail salesman, who said his company used to pay to have their waste turned into fertilizer but has

since stopped. This could be due to farmers' lack of interest in fish waste fertilizer or cost-effectiveness.

The waste disposal process is a significant expense for wholesalers as they must pay waste management companies to take it away. Patacsil said they are willing to give away fish skins at no cost if people are willing to pick them up. However, the business or individual picking up the fish by-products would need to bring their own cooled storage container and provide the transportation for the raw materials. This interview confirmed our initial background research, where we found that fish processing businesses were required to pay to dispose of fish waste and were willing to donate it to any business at no cost.

The Pier 38 Fish Market provides a large majority of fish sold at auction. They own 22 fishing vessels and hold America's only fresh fish auction in-house. This is the company from which Conservation International – Hawai‘i obtained fish skins for their 2023 fish leather workshop. We could not contact Pier 38 management for more details on their waste disposal process. Still, they seem willing to continue providing free fish skins and possibly other less desirable parts. An existing fish leather company called Tototo sources their fish skins for free, and the link of their website can be found in Appendix E: Links and Resources. We spoke with the CEO, Tomohisa Noguchi, who founded the company in 2020. They still source fish skin for free from markets and make fish leather products from salmon, yellowtail, Japanese sea bass, and red sea bream. Tomohisa reported that while increasing the size and production of the company, there have been challenges, but sourcing fish skin has not been an issue.

Wholesale markets seem to be the best option for sourcing. Smaller fish markets, like Tomoshiro Market, do not supply as much waste, as they try to sell all parts of the fish. We spoke with the owner, Guy Tomoshiro, who said people often buy fish parts other than the fillet.

Tomoshiro told us that the center bone has been very popular and “will often sell faster than the fillets.” The fish waste discarded from Tomoshiro Market is often taken off the shelves due to its age and, as such, would not be desirable for fish broth. However, the market also sells whole fish. People who purchase these whole fish will likely have fish waste they could make into a broth. Guy Tomoshiro has made fish broth before and supports using all parts of the fish. However, he told us that he mainly uses dashi powder when making broths as it is a cheaper and more convenient option; this reflects the thoughts of others making fish stock. Finding alternate uses beyond fish broth for old fish waste from smaller markets may be more beneficial. Larger wholesalers will have a larger supply and more fresh waste.

3.1.2 Sustainability

The fisheries and fish markets in Honolulu, Hawai‘i, practice sustainability. Nico’s Fish Market, Pier 38 Fish Market, Tamashiro Fish Market, Fresh Island Fish, and Pacific Island National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) are critical players in the fish industry; we researched these markets and interviewed some of their employees during our time in Hawai‘i. Pier 38 Fish Market in Honolulu is the only U.S. fish auction selling fresh caught ‘ahi. This auction prices individual fish based on their actual value at the time of sale, which changes minute by minute based on market demands (Interview with John Kaneko, Hawai‘i Seafood Council | NOAA Fisheries, 2019). Many fish markets attend this auction up to 6 days a week to buy all the fresh fish they process and sell. These markets prioritize the freshness and sustainability of the fish they buy to benefit their environment and customers.

Sustainability is essential to the auction, fisheries, and fish markets. Sustainable seafood is “wild-caught or farmed seafood that is harvested or produced in ways that protect the long-term

health of species populations and ecosystems" (Sustainable Seafood | NOAA Fisheries, n.d.). The fisheries we interviewed and researched are considered "sustainable," following U.S. guidelines because data is collected for each fish. NOAA Fisheries are aware of the boat landings, species, weight, price, who purchased it, where it went, and the market channel for every fish caught and brought through the auction (Interview with John Kaneko, Hawai‘i Seafood Council | NOAA Fisheries, 2019). The Pacific Island NOAA Fisheries strives to support sustainable fisheries and the protection of marine life by leveraging new and improved science to inform management decisions in this dynamic environment. Their goals are to have fully sustainable fisheries and seafood and healthy marine environments for stable fishing resources by maintaining healthy stocks, abolishing overfishing, and rebuilding overfished stocks important for all types of fisheries (Pacific Islands Fisheries Management and Marine Life Protection | NOAA Fisheries, n.d.).

3.2 Fish Leather

Through our research, we can conclude that fish leather is a powerful value-added product with various applications. The first thing we looked for in our study of the fish leather industry is whether suppliers in Hawai‘i are willing to utilize it. Our research found significant interest from new artisans and established businesses in incorporating fish leather products into their product lines. This is apparent from the multiple interviews we conducted. The first interview we performed was with Samantha Hook, a knowledgeable leather artist who has previous experience working with cow leather. She participated in the 2023 fish leather workshop by Conservation International – Hawai‘i in Hilo and is starting her new fish leather business, Tidal Theory. In her interview, she continuously expressed excitement for the future of the fish leather industry. She has aspirations of producing and selling her fish leather products and has long-term goals of

opening a storefront and e-commerce website. She makes fish leather with other passionate artists looking to do the same. Through this interview, we concluded that there is interest in producing fish leather in Hawai‘i’s creative artisan community. This is significant because artisans see the value and creativity, and they can put into designing a fashionable and popular product. The first step for introducing any new product is to have suppliers produce fashionable items that excite consumers.

Through more interviews, we found that established businesses in the leather industry in Hawai‘i are also interested in incorporating fish leather into their product lines. We interviewed Michael Bluth, Founder of Open Sea Leather, who seemed confident that there could be a future for fish leather in Hawai‘i. He said that exotics like snake or alligator leather have done well, but they are often not ethically sourced. However, fish leather is a new niche material that can be an excellent option for him when designing new products. His shop is adamant about ethically sourcing its leather and ensuring the quality of its products. In sourcing the fish skins from the Honolulu Fish Market, we discovered that sourcing the raw materials required can be done ethically and utilizing them to make fish skin removes waste that would otherwise go to a landfill.

These suppliers face a few challenges. In Samantha Hook’s case, one of the more significant issues she encountered was the business aspect of launching her store. She is very creative and passionate about making her products but says she could use some assistance in marketing them. In Micheal Bluth's case, one of his biggest concerns is the quality and durability of fish leather. He does not want to offer his customers a product that will wear out quickly, and he is not sold on the durability of fish leather. One challenge we found across all interviewees is that tanning and dying fish skin is the most challenging part of the production process. Micheal

Bluth specifically said that he would only use fish leather if he could get a steady source of it from a leather wholesaler, as he was not willing to tan all the skins himself because the process is so time-consuming.

3.2.1.1 Recommendations

Our recommendation to help make the leather tanning process more worthwhile is to increase its scale. It does not make economic sense to tan skin in small batches at a time since it takes so long and requires much effort. Continuously going through the process of making small batches of leather would take more time than occasionally producing one big batch. Since the small fish leather community seems collaborative, artisans could work together every few weeks and mass-produce leather. Then, each artisan could take a share of the leather they make and work with it for the following weeks until they mass produce leather again. This could be done monthly or less frequently, depending on how much leather is needed.

Another possible solution would be to have a fish leather wholesaler. This can prove very lucrative as people like Michael Bluth from Open Sea Leather would only incorporate fish leather in their product line if they could get a steady source of tanned skin. Also, more people will be encouraged to experiment with fish leather if they can avoid the daunting task of tanning their fish skins. This wholesaler could also export to other markets outside Hawai‘i and the US. A wholesaler could appeal to different markets by getting tanned skins from fish like ‘ahi, mahi mahi, and various unique Hawaiian reef fish.

In general, fish skin is highly durable. Unlike cowhide, the fibers in fish skin run in different directions and cross over each other, like a basket weave. This gives fish skin, on average, a tensile strength of 90 Newtons, while leathers of the same thickness but from other sources have a tensile strength of 8 to 25 Newtons (Leather Neo, 2023). The durability of fish

leather depends on the fish: ‘ahi skin is thicker and more robust than the average reef fish, and salmon leather is up to 9 times stronger than traditional cow and lamb leather.

Fish leather can have many different applications. For example, a wallet made of fish leather is durable and will last for years. Since fish leather has a unique look, it can accentuate products like an iPhone case, a hat's brim, or a handle. An option to increase the thickness of fish leather and give a product a clean look is to stitch it over cow leather; this would allow artisans to make a product with the unique, stylish look of fish leather paired with the general thickness of cowhide.

3.2.2 Scalability for fish leather

As the fish leather industry in Hawai‘i grows more prominent over time, more fish leather needs to be produced. The most expensive and time-consuhpart of the fish leather process is tanning and dying the skin. Producing leather on a large scale will help with this issue. As discussed, obtaining raw fish skin is often free. The most significant expense in producing fish leather is for tools, tannins, dyes, and the labor and time needed. Since the tanning process has a set number of steps, adjusting the number of skins and labor hours makes the process more worthwhile. For example, if a batch of 20 skins takes seven days to tan from start to finish, and a batch of 100 skins takes eight days, it would make more sense to make the 100 skins in 8 days rather than 20 skins more often. This is why scaling up production as the market grows will be beneficial. To reduce the number of labor hours spent on the tanning process, people need to tan the leather in bulk. This would increase the number of usable leather skins they produce in less time. Increasing the scale of the fish leather produced at one time will also make it cheaper.

Our interview with Tasha Nathanson, founder of 7 Leagues Leather, gave insights into how difficult the scaling process is to mass-produce fish leather. She said producing a high-

quality product on a large scale is very difficult. This is because as the batches of fish leather get larger, it becomes more difficult to tan the skin evenly throughout. Moreover, fish skin must be in specific condition during the tanning process. For example, the fish skins must be kept at a low temperature to not spoil during tanning. Tasha Nathanson is dedicated to figuring out how to scale up the production of high-quality fish leather using all-natural methods. She mentioned that the 7 Leagues Leather is still in research and development, but she has made a large investment in making the process more automated, utilizing machinery and technology. In our interview, she stated her process is her trade secret, and rightfully so, as 7 Leagues leather has made a large investment to perfecting their strategy.

3.2.2.1 Recommendations

We propose a few ideas to improve the scalability of fish leather. One suggestion stated earlier is for all the local artists to gather every few weeks and mass-produce leather. Then, each artist can take a share of the leather made and work with it for the following weeks until the next mass production. Since the fish leather community is small and close-knit, folks can help each other until the industry grows stable. If a need for increased material arises as the industry develops, this could be a promising opportunity for a fish leather wholesaler to mass produce fish leather and sell it to artists in Hawai‘i and possibly to large corporations worldwide. This is the goal of 7 Leagues Leather in Canada and can be incorporated into the Hawaiian market.

Mass-producing fish leather has its challenges. Fish skin must be held at a specific controlled temperature so it does not rot. Also, processes like scraping the flesh from the skin are prolonged and tedious. A solution could be to automate the process. Machines already filet fish automatically, but they do not remove the amount of flesh from the skin required to start the tanning process. So, creating a new machine to scrape off most of the flesh automatically would

save many labor hours and allow a wholesaler to produce even more leather. Also, tanning the fish skin evenly and in a cooled environment can be done in a washing machine with cold water.

Our recommendation to scale fish leather production as it grows is again to have a wholesaler of fish leather. The primary way to scale up production would be to have larger equipment to process more. Creating new machines would also increase the speed at which fish leather can be processed, making the process more automated.

3.2.3 Process and Expenses

We interviewed Samantha Hook from Tidal Theory, Janey Chang from Janey Chang Art + Ancestral Skills, and Tomohisa Noguchi from Tototo about the process and expenses of creating fish leather. These artisans make fish leather and their final products by hand.

Samantha Hook makes leather by carefully removing the scales and flesh to prevent skin damage. She expressed that this can be done with a scaler tool, but she prefers using a seashell she can find at the beach in Hawai‘i because it is free and easily accessible. The next step is cleaning with natural soap, like certain dish soaps, to remove the fish smell. Turning the skin to leather is called tanning; the most common tannin Samantha Hook uses is black tea. Other tannins can be used, but this is the most cost-effective in her process. The last optional steps Samantha applies are oiling the leather for conditioning and dyeing it to achieve a specific color. When oiling, she uses a bee's wax mixture to enhance the shine and soften the texture of the leather. After getting a finished piece of fish leather, she turns it into a wallet by hand-sowing it together.

Janey Chang begins the fish leather-making process in the same way: scraping to remove the scales and the flesh, followed by cleaning to clear the fish scent. Next is the tanning process,

and Janey Chang has experimented with various tannins. She has used black tea, tree bark, egg yolks and oil, and fish roe. One specific tree bark currently being looked into is albizia trees, which are invasive in Hawai‘i. These trees have a tannin content of about 7-11% (Orwa et al., 2009). After tanning, Janey Chang washes and dries the skin before the final step, conditioning. With this fish leather, Janey Chang can make a wide array of products, including cardholder wallets, woven fish hats, roses, book covers, and book spines; she also uses fish leather to accent fiber baskets by adding it to buttons and beads.

Tomohisa Noguchi and his employees at Tototo in Himi City, Japan, use a different method when making fish leather. They begin by removing the flesh and scales and then preserving the skin in a salt solution. Next, they apply a bleaching process that takes about two weeks, using bleach powder detergent to turn the skin completely white. Next is the tanning process, where they use vegetable tannins to turn the skin into leather. Last is the dyeing process, which turns the white leather pieces into a bright color of their choice. They use vegetables and chemical dyes depending on the color they are trying to achieve. This leather is then made into small products like wallets, keychains, watch straps, and phone cases sold on their website. Tototo has been experimenting with other applications of fish leather, including making interior design products like ceiling lamps and adding accents to fashion pieces like the lapel of suit jackets.

Natural dyes and tannins are essential when making fish leather. Black tea has proven to be an effective way to tan leather and is relatively inexpensive. However, another option is using bark from albizia trees. This invasive species could be harvested and used due to the natural tannins in their bark. Botanical gardens are working to remove these trees from their property,

and some may be willing to supply the bark for free. Another possible invasive tree to use for tannins would be the acacia mearnsii.

The primary warning we received about the tanning process from everyone we interviewed was how detrimental it is to use chromium. Chromium tanning is harmful to humans and the environment because it is a known toxin and carcinogen (Development, n.d.). It accounts for about 90% of the leather-making industry today because of how cheap and fast it is to use. Chrome tanning is known to cause abundant solid waste, air pollution, and health risks to leather workers and consumers alike (Andina, n.d.). Leatherworkers like Samantha, Janey, and Tomohisa are aware of the harmful impact chromium tanning has and strive to make a change by using natural tannins in their products.

Fish leather can be made in many ways, from the tools to the products needed, and all choices impact the process's cost. Samantha Hook, Janey Chang, and Tomohisa Noguchi source their fish skins at little to no cost from either fisheries, friends, or family. This is because the skins that they use would otherwise be wasted and thrown in the landfill. The tannins and dyes are expensive depending on where they are sourced and used. Samantha Hook’s preferred tannin is black tea, and she buys it in bulk from Costco or Walmart for around $10-$15 to turn 4 to 5 skins into leather, about eight wallets. One concern these leather makers have is how long it takes to make a single product. Labor is considered the most expensive part of this process when produced by hand, from fish skin to a finished product.

3.2.4 Market Size/Scope

After learning that multiple new and established artists are encouraged to produce fish leather products, we investigated the existence of an excited consumer base. Our research found evidence through our interviews of a potential market for fish leather, but the size is unclear.

Through desktop research and interviews with parties in other parts of the world, existing markets suggest fish leather can be lucrative in Hawai‘i. However, most of the evidence we gathered is from artisans and businesses we interviewed; we know that their views may be biased since they are invested in fish leather working out.

However, many strong marketing attributes can increase the popularity of fish leather, and people who purchase products made from fish leather seem to fall in love with them. Samantha Hook receives frequent requests from friends for her fish leather wallets and is constantly out of samples to give. She has not started selling her fish leather products yet because she first wants to ensure their quality and longevity, but she is sure there is interest. Michael Bluth, of Open Sea Leather, also said people would likely buy fish leather products based on his experience with sustainable products in his shop. It is also clear that people want to purchase these products based on existing companies like Tototo and Teton Leather Co. Such companies sell their wallets for about $400 per item, and people are willing to buy them despite the considerable cost. Samantha Hook says her wallets will likely be priced at $60-70 each, which will be much more accessible for locals and tourists looking for souvenirs in Hawai‘i. Also, fish leather has strong markets in other parts of the world, especially Europe, so it is possible to see the same success in Hawai‘i with more education and marketing. One limiting factor of this claim is that we do not have consumer data. Surveys should be sent out for a more definitive answer on the potential market size and the variety of products that would be most appealing.

McLean, the owner of Pelagos Fly Rods, said he was confident that avid anglers would buy products that include fish leather. Some fly wallets are made with leather with sheep wool inside to hold the lures in place. Lining the outside with fish leather would be a stylish way to store flies. The fish leather could also be used on other fly-fishing merchandise, and the brand

could be displayed on a patch. Another possibility would be to make a fly rod sock out of fish leather. The sock is generally used to keep rods safe in storage. Concerns about the order of the fish leather are mitigated through the tanning process, which removes the fishy smell and leaves a leathery scent. As awareness of fish leather grows, concerns about the odor will diminish, making it more widely accepted.

It is encouraged that artisans be creative with fish leather. Fish leather is an innovative product with various characteristics that can span over a variety of different markets. It can provide a new and unique look to a multitude of fashion products. It can be used for a variety of different products in the outdoors and fishing industry. In addition, it can become a material people take as a souvenir. For example, there could be a special service to turn your own fishing catch into a leather product. It could be an attractive product to people who just caught their trophy fish. Through this idea, people can create a memory without having to pay for an alternative like a taxidermy project or nothing at all. There are many different avenues to incorporate fish leather, making it have a large market scope. The versatility that it has brings limitless possibilities, which is an encouraging attribute for creativity.

3.2.5 Business Model

Our research found that new artisans need assistance to kick-start their businesses. They may need guidance on the different possible business models that can be used or marketing strategies to grow their business. We researched different business models that apply best to the fish leather industry in Hawai‘i. It is important to note that these are not the only business models, and personal research is recommended before choosing a suitable option. Below are some business models that can be applied:

a. **E-commerce Model:**

i. Sell leather products through an online platform or website.

ii. Offer a wide range of products and generate revenue through online sales.

b. **Retail Model:**

iii. Establish physical retail stores to sell leather products directly to customers.

iv. Provide a showroom experience for customers to see and feel the products.

c. **Experience Model:**

v. Offer leather crafting workshops, events, or experiences to engage customers.

vi. Create a community around the brand and products.

b. Business 2 Business Model:

i. Target businesses such as fashion retailers, boutique stores, or corporate clients to sell them large batches of fish leather directly.

ii. Sell leather products in bulk to other businesses.

c. Business 2 Customer Model

i. Businesses sell their products or services directly to consumers through various channels, such as physical retail stores, e-commerce websites, mobile apps, or direct sales representatives.

Entrepreneurs can utilize many different and effective business models, and it is up to them to decide which model best suits their aspirations. Entrepreneurs can combine and adapt multiple models to fit their goals.

3.2.6 Fish Leather Recommendations

The purpose of the information gathered during this project is to share our findings to make the fish leather market more accessible to those who are interested. From our interviews, we gathered keen insights into the industry. Some of this information will be shared through our deliverables (Appendix F: Fish Leather Deliverable), but more can be done to expand these markets. This section will report what individual artists and entrepreneurs can do and how this research can continue to develop these industries.

3.2.6.1 Ways to Produce Fish Leather

Natural dyes and tannins are essential when making fish leather. Black tea has proven to be an effective and inexpensive way to tan leather. Albizia trees are another possible tannin source that can be harvested and used for the natural tannins in their bark. However, albizia must be further studied to determine if the tannin levels are adequate for producing leather.

An idea suggested during our interview with Janey Chang was running workshops for artists to make fish leather together. Making leather takes days, but working with others can shorten the process and increase the amount of leather produced. This will allow artists to spend less time making leather and more time creating products like wallets or keychains, strengthening the community of artisans and value-added product makers.

Figure 7: 7 Leagues Leather fish tanning process from their website.

Image source: https://www.7leagues.com/leather

Another possibility is to source fish leather from existing companies. 7 Leagues Leather does not yet supply fish leather as they are still a startup. However, sourcing from existing wholesalers or establishing a new fish leather wholesaler in Hawai‘i will give artisans more time to make products. An important aspect to remember when sourcing fish leather is to keep sustainability a top priority. Some wholesale companies use chemical chromium tanning to reduce the cost of their leather at the expense of the environment, workers, and consumers.

3.3 Fish Broth

In our investigation into the viability of marketing fish broth as a sustainable and nutritious product, we comprehensively researched its nutritional value from existing data and the

challenges of incorporating it into the market. The nutritional analysis of fish broth and seafood soup (derived from fish broth) reveals a rich profile of essential vitamins, minerals, and healthy fatty acids, especially when enhanced with various vegetables. However, our study also uncovered several potential obstacles to using and accepting fish broth in Hawai‘i due to East Asian cultures and ready access to fresh fish. Challenges include existing island preferences, dashi powder in local cuisine, and potential cultural barriers to introducing a new form of fish broth on the island.

Despite these challenges, there is a strong potential to reduce fish waste from fish broth. This applies to both home and restaurant settings, where adopting fish broth can significantly reduce fish waste. Emphasizing the enhanced nutritional content of incorporating vegetables into fish broth is a strong marketing point. We aim to synthesize and share our results with the Hawaiian community to help individual restaurants and entrepreneurs further develop the fish broth industry through our recommendations (Appendix G: Fish Broth Deliverable).

3.3.1 Nutritional Value

One primary reason fish broth is a valuable value-added product is its nutritional benefits. Nutritional values from Table 3 were extracted from the U.S. Department of Agriculture’s Food Data Central (USDA, 2019, 2022c, 2022d, 2022b, 2022a). Four variations of seafood soup may include specific vegetables such as carrots, broccoli, dark-green leafy greens, and potatoes. Figure SEQ Figure * ARABIC lists the base ingredients for seafood soup, excluding all additional vegetables and potatoes. According to the USDA, fish broth is considered a Standard Reference (SR) Legacy Food, i.e., the nutrients are derived from literature, and the food itself is the final release of the nutritional value (USDA, 2019).

The base ingredients for Seafood Soup without potatoes and specific vegetables are:

- Fish
- Celery, raw
- Parsley, fresh
- Peas, green, frozen, cooked, boiled, drained, without salt
- Fish broth
- Tomatoes, red, ripe, raw, year-round average
- Beans, snap, green, raw
- Corn, sweet, yellow, frozen, kernels cut off cob, boiled, drained, without salt
- Onions, raw

Figure 8: Base Ingredients for Seafood Soup without Potatoes and Specific Vegetables.

Image source: (USDA, 2022c)

Table 3: Nutritional value of different seafood soups and fish broth for 100g.

Nutritional Component	Seafood Soup w/o Potatoes & w/o Vegetables	Seafood Soup w/o Potatoes & w/ Vegetables	Seafood Soup w/ Potatoes & Vegetables	Seafood Soup w/ Potatoes, w/o Specific Vegetables	Fish Broth
Water (g)	90.3	90.2	89.3	89.4	96
Energy (kcal)	42	42	45	45	16
Protein (g)	4.63	4.54	4.41	4.49	2
Total Lipid (Fat) (g)	1.31	1.29	1.22	1.24	0.6
Fatty Acid, Total Saturated	0.226	0.221	0.21	0.214	0.133
Carbohydrates (g)	2.81	3.02	4.07	3.9	0.4
Fiber, total dietary (g)	0.6	0.7	0.8	0.7	0
Sugars, total including NLEA (g)	0.96	1.08	1.07	0.96	0.09
Calcium, Ca (mg)	30	30	29	29	30
Iron, Fe (mg)	0.37	0.37	0.41	0.41	0.21
Magnesium, Mg (mg)	8	8	10	9	1
Phosphorus, P (mg)	73	72	72	72	30
Potassium, K (mg)	155	161	181	177	86
Sodium, Na (mg)	170	168	158	160	200

Vitamin C, total ascorbic acid (mg)	3.2	3.2	4.1	4.1	0
Vitamin A, RAE (µg)	13	36	34	12	1
Vitamin E (alpha-tocopherol) (mg)	0.4	0.41	0.38	0.38	0.15
Vitamin D (D2 + D3) (µg)	0.1	0.1	0.1	0.1	0
Vitamin K (phylloquinone) (µg)	16.9	16.8	16	16	0.2
PUFA 20:5 n-3 (EPA) (g)	0.077	0.075	0.071	0.072	0.095
PUFA 22:6 n-3 (DHA) (g)	0.092	0.09	0.084	0.086	0.101
Cholesterol (mg)	8	8	7	7	0

Source: (USDA, 2019, 2022c, 2022d, 2022b, 2022a)

The analysis of various seafood soups and fish broth against the Recommended Daily Intake (RDI) incorporates categorizations of high (H), normal (N), and low (L) nutritional values. These values are deemed "low" when a serving contains less than 2% of the daily value, "high" when it exceeds 20%, and "normal" for values that fall in between these thresholds. 2% is derived from the Code of Federal Regulations of Food Labeling, where any vitamin or mineral can be stated as “Not a significant source of…” (USDA & USHHS, 2016a). 20% is derived from Title 21, Chapter 1, Subchapter B, Part 101, Subpart D, 101.54 (i) (b) where the terms “high, rich in or excellent source of…” can be used if the serving size is 20% or more of the RDI of the nutrient (USDA & USHHS, 2016b).

Table 4: RDI comparisons for various seafood soups and fish broth (1 cup serving size) high (H), normal (N), and low (L).

Nutritional Component	RDI Comparison w/o Potatoes & w/o Vegetables	RDI Comparison w/o Potatoes & w/ Vegetables	RDI Comparison w/ Potatoes & Vegetables	RDI Comparison w/ Potatoes, w/o Specific Vegetables	RDI Comparison Fish Broth	RDI for adults and children >= 4 years
Protein (g)	H	H	H	H	N	50
Carbohydrates (g)	L	N	N	N	L	275
Fiber, total dietary (g)	N	N	N	N	L	28

Sugars, total including NLEA (g)	N	N	N	N	L	50
Calcium, Ca (mg)	N	N	N	N	N	1300
Iron, Fe (mg)	N	N	N	N	N	18
Magnesium, Mg (mg)	N	N	N	N	L	420
Phosphorus, P (mg)	N	N	N	N	N	1,250
Potassium, K (mg)	N	N	N	N	N	4700
Vitamin A, RAE (µg)	N	N	N	N	L	900
Vitamin E (alpha-tocopherol) (mg)	N	N	N	N	L	15
Vitamin D (D2 + D3) (µg)	L	L	L	L	L	20
Vitamin K (phylloquinone) (µg)	H	H	H	H	L	120
Omega-3 Fats	H	H	H	H	H	1.35
Vitamin C, total ascorbic acid (mg)	N	N	N	N	L	90
Energy (kcal)	N	N	N	N	L	2000
Total Lipid (Fat) (g)	N	N	N	N	L	78
Sodium, Na (mg)	N	N	N	N	H	2300
Cholesterol (mg)	N	N	N	N	L	300

Source:(Institute of Medicine (US) Committee on Examination of Front-of-Package Nutrition Rating Systems and et al., 2010; NIH, 2023; USDA & USHHS, 2016a) Department of Health and Human Services & Food and Drug Administration 2016

A high level of Vitamin K is present in fish broth, surpassing the RDI threshold for adults and children over four years old. Vitamin K has been understood to be essential for blood clotting and mineralization of bone tissue (Weber, 2001). Furthermore, all soup variants and fish broth are rich in Omega-3 fatty acids, which support cardiovascular and endocrine systems (Cleveland Clinic, 2022).

While providing a range of minerals, fish broth is outmatched by seafood soups that include additional vegetables, suggesting a more robust mineral profile. This reflects the added nutritional value that vegetables contribute to soups to help offset some of the nutritional lows of fish broth. However, the protein content is consistently rated as normal or high across all variations compared to the RDI, signifying that these soups can be good protein sources.

The caloric content across all variations is rated normal, suggesting these products can be a part of a balanced diet without contributing to excessive caloric intake. Labeling regulations in the United States indicate that servings with less than 25g of fat per 100g and those with 25% or less sodium per serving can be marketed as low or reduced fat and sodium (USDA & USHHS, 2016d, 2016e). Products with 20 mg or less of cholesterol and less than 2g of saturated fatty acid per serving can be marketed as low in cholesterol (USDA & USHHS, 2016e). Products with less than 120 calories per 100g can be sold as low-calorie (USDA & USHHS, 2016c).

Adherence to the Department of Health and Human Services Food Labeling regulations is crucial when marketing such a product. These regulations guide the claims of nutrient content that can be made and can help appeal to health-conscious consumers. The nutrient composition is also recommended to substantiate health claims and comply with the labeling regulations outlined in Title 21, Chapter 1, Subchapter B, Part 101, Subpart D of the Code of Federal Regulations.

3.3.2 Fish Broth in Restaurants

Conservation International – Hawai‘i held impressive food showcases during Hawaiian Seafood Month in October 2023. Three notable chefs from restaurants in Hawai‘i were asked to construct menus using all parts of the fish during the showcase. This showed that it is possible to produce full-course meals sustainably; now, it is essential to spread this idea to restaurants that value this practice. Working in collaboration with Chef Hui, a non-profit organization for the community and chef network, we developed a deliverable to inform more chefs in Hawai‘i about the possibilities of incorporating fish waste in recipes (Appendix G: Fish Broth Deliverable).

3.3.3 Fish Broth Packets

A European company called Knorr manufactures different types of bouillon cubes. We have seen the beef, pork, and chicken stock varieties in markets in Hawai‘i, but not fish stock. Knorr's fish stock version can be found online, but stores seem uninterested in selling this item in Hawai‘i. The only fish broth we have seen on market shelves is Aneto Natural fish broth at Foodland Farms. With a small market and little interest, selling fish stock in stores is not the best option. Instead, fish broth packets could be advertised to hikers looking to pack a hearty meal. However, developing these packets would be intensive and challenging to implement below an industrial level due to the drying process. Instead, introducing fresh fish broth as part of recipes at home and in restaurants could be a more effective way of reducing fish waste from the distributors and restaurant industry.

3.3.4 Challenges

Our investigation included interviews with fish markets, participant observations in the Honolulu area, and desktop research on existing products. Our interviews and desktop research found multiple fish broth products already on the market. This can be flavored fish broth packets and fish soup derived from fish broth. However, we discovered little to no fish broth products in Honolulu.

Due to Hawai‘i’s strong Asian cultural influences, residents commonly use dashi powder to create dashi broth, a form of dried fish broth flavor packets. The deep-rooted tradition of using dashi in local cuisine could present a challenge to introducing a new variant of fish broth. In our interview with Guy Tamashiro, a fishmonger from Tamashiro Fish Market, we discussed his market opinion of fish broth in bouillon cubes or fresh broth. He uses dashi powder weekly and told us that “anything new sometimes is a little hard to get in because of old habits.” Another

concern is properly sourcing fish waste from fisheries and ensuring consistent grade and quality. Grading of a fish refers to the quality assessment based on specific criteria, such as flavor, odor, and compliance with U.S. Determination of Grade (NOAA, n.d.). U.S. Determination of Grade includes inspection of abnormal conditions, appearance defects, discoloration, dehydration, surface defects, cutting and trimming defects, and texture defects. Tamashiro's main concern about using fish waste to create fish broth is the quality and grade of fish used. He told us that "there are other grades that we normally do not even consider. I walk away from it at the auction." This indicates the possible challenges of properly sourcing quality fish waste for broth use.

4 Conclusions

This project aimed to assist Conservation International – Hawai‘i in conducting exploratory research on the feasibility of fish leather and broth. Our team conducted interviews and collected information from fish leather and broth industry experts to achieve this goal. Through these methods, we acquired a valuable understanding of every aspect of these fish waste products. The findings and the 2–3-page deliverables will help the smaller businesses and locals in the creative industries and potentially open a new direction for using fish leather and fish broth to improve sustainability. The results and information from this study can also be used to encourage entrepreneurs and more prominent companies by giving them the tools they need to introduce value-added products from seafood waste into their businesses.

In future project iterations, other value-added products from fish waste can be studied, researched, and analyzed to further reduce seafood waste in Hawai‘i. The more items can be made from these by-products, the more Hawai‘i and other places dependent on aquaculture will thrive and become increasingly self-sustainable. Value-added products are an effective way to reduce waste, grow businesses, and boost the economy.

Although a large amount of information was collected for this project, future research possibilities remain. Future expansions may include a sustainability impact assessment, fish broth product development, and integration of new fish waste processing and management technology.

No comprehensive evaluations exist to measure the environmental benefits of converting fish waste into value-added products such as fish leather and broth. Assessments of this project’s ecological footprint may include quantifying the reduction in fish waste, energy consumption, and greenhouse gas emissions. Moreover, our research indicates that further research and

development are needed to create new fish broth products, such as dry packets. Companies must develop new, sustainable, scalable practices in creating fish broth and leather as demand grows. This includes identifying new sustainable and effective tannins for making fish leather and ensuring these products' future environmental and sustainable viability.

5 Appendix

5.1 Appendix A: Consent Form

Informed Consent Agreement for Participation in Our Research Study

Investigators: Morgan Polinski, Nick Sloan, Sander Coscia, Kang Zhang

Contact Information: Morgan Polinski, Email: mlpolinski@wpi.edu

Title of Research Study: Value-added Fish Products in Hawai‘i

Sponsor: Conservation International Hawai‘i

Introduction

You are being asked to participate in a research study. Before you agree, however, you must be fully informed about the purpose of the study, the procedures to be followed, and any benefits, risks or discomfort that you may experience as a result of your participation. This form presents information about the study so that you may make a fully informed decision regarding your participation.

Purpose of the study:

The purpose of this study is to determine the feasibility of introducing fish leather and fish broth as value-added products into the markets in Hawai‘i. We are analyzing how these products can be made, sold, and bought to reduce the amount of seafood waste produced among the islands.

Procedures to be followed:

Our procedures include semi-structured interviews with one or up to three people to discuss either the production of fish leather and/or fish broth, the feasibility of making them, or the acceptance of them in a person's life. We will also be conducting surveys to analyze the viewpoints on fish leather and fish broth to improve sustainability of people living in Hawai‘i.

Risks to study participants:

If there are any topics relating to fish leather, fish broth, market analyses, sustainability, and/or seafood waste that the participant wishes not to discuss they can choose to opt out of the interview or survey at any time.

Benefits to research participants and others:

By participating in this study, you would be helping to spread awareness on the abundance of waste in the seafood industry. Your participation will also help with bringing new ideas on how to reduce this waste into fruition.

Record keeping and confidentiality:

During the interview one of the investigators listed above will be taking notes on the answers to the questions for later review.

The survey results will be sent to one of the investigators listed above for later review.

Records of your participation in this study will be held confidential so far as permitted by law. However, the study investigators, the sponsor or it's designee and, under certain circumstances, the Worcester Polytechnic Institute Institutional Review Board (WPI IRB) will be able to inspect and have access to confidential data that identify you by name. Any publication or presentation of the data will not identify you.

Compensation or treatment in the event of injury:

You do not give up any of your legal rights by signing this statement.

For more information about this research or about the rights of research participants, or in case of research-related injury, contact:

Morgan Polinski, Tel. 508-816-9379, Email: mlpolinski@wpi.edu

IRB Manager – Ruth McKeogh, Tel. 508-831-6699, Email: irb@wpi.edu

Human Protection Administrator – Gabriel Johnson, Tel. 508-831-4989, Email: gjohnson@wpi.edu

Your participation in this research is voluntary. Your refusal to participate will not result in any penalty to you or any loss of benefits to which you may otherwise be entitled. You may decide to stop participating in the research at any time without penalty or loss of other benefits.

The project investigators retain the right to cancel or postpone the experimental procedures at any time they see fit.

By signing below, you acknowledge that you have been informed about and consent to be a participant in the study described above. Make sure that your questions are answered to your satisfaction before signing. You are entitled to retain a copy of this consent agreement.

_____ Date:

Study Participant Signature

_____

Study Participant Name (Please Print)

_____ Date:

Signature of Person who explained this study

5.2 Appendix B: Interview Questions for Fish Broth

Fish Broth Restaurant Questions

1. **Current Usage and Motivation:**

a. Does your establishment currently utilize fish broth, or any products derived from fish waste or undesired fish parts?

b. If so, what motivated your decision to incorporate fish waste into your products?

2. **Production Process:**

    a. Could you describe the process you use to make fish broth?

    b. How do you source the fish or fish waste for your broth production?

3. **Quality Control and Standards:**

    a. How do you maintain the quality and consistency of your fish broth products?

    b. Are there specific standards or criteria that you follow during production?

4. **Sourcing and Materials:**

    a. How do you source the raw materials for your fish broth?

5. **Challenges and Market Response:**

    a. What challenges have you encountered in producing and marketing fish broth?

    b. How have customers responded to your fish broth products?

6. **Regulatory and Logistical Considerations:**

    a. Have you faced any regulatory or logistical hurdles in this process?

7. **Environmental and Sustainability Factors:**

    a. What environmental or sustainability considerations are considered in your production process?

    b. How do you address environmental concerns in your fish broth production?

    c. What steps do you take to ensure the eco-friendliness of your products?

    d. How do you report or communicate your sustainability practices related to fish broth production?

8. **Consumer Education and Awareness:**
    a. How do you educate consumers about the benefits and uniqueness of your fish broth?
    b. What marketing strategies have you found effective in raising awareness?
9. **Customer Feedback and Improvement:**
    a. How do you gather and incorporate customer feedback into your fish broth product development?
    b. Are there any specific customer suggestions that have significantly influenced your product?
10. **Collaborations and Partnerships:**
    a. Have you collaborated with any local fisheries, environmental groups, or other organizations in your fish broth production?
    b. How do these collaborations impact your business?
11. **Navigating Market Trends:**
    a. How do you stay informed about the latest trends in the fish broth market?
    b. How do market trends influence your product innovation and business strategy?
12. **Expansion and Future Opportunities:**
    a. Are you exploring or currently using any other value-added products from normally discarded fish parts?
    b. Would you consider donating fish skin for leather production instead of disposing of it?

The assumption is that a company or restaurant uses unpopular fish parts (or fish waste) in their products.

1. **Motivation for Utilizing Fish Waste:**
    a. What inspired your company to begin using undesired fish parts in broth production?
2. **Environmental Benefits:**
    a. Can you discuss the environmental benefits you've observed from repurposing these fish parts in this manner?
3. **Cost-Effectiveness:**
    a. Could you provide insights into the cost-effectiveness of producing fish broth from waste?
4. **Expansion into Other Products:**
    a. Are there other value-added products derived from seafood waste that your company is considering or has already started producing?
5. **Future of Sustainable Practices:**
    a. How do you envision the future of sustainable practices like these within your industry?

5.3 Appendix C: Interview Questions for Fish Leather

1. **Introduction and Background:**
    a. What initially attracted you to working with fish leather?
    b. How long have you been involved in the fish leather business?
    c. Can you share your ideas and vision for fish leather use?
2. **Product Range and Success Stories:**

a. What range of products do you create from fish leather?

b. Among these, which products have been the most successful or popular?

3. **Manufacturing Process:**

    a. Could you describe the process of making fish leather products?

    b. Do you handle the production in-house, or do you work with a warehouse or large-scale manufacturer?

4. **Sourcing Materials:**

    a. Where do you source the fish skins used for leather production?

    b. How do you ensure the sustainability of your sourcing practices?

5. **Challenges and Solutions:**

    a. What are some significant challenges you face in the fish leather industry?

    b. Are there specific supports or resources that could help you overcome these challenges?

6. **Plans and Opportunities:**

    a. Do you have plans to expand into new products or markets?

    b. What other opportunities do you see for fish leather in the market?

7. **Sustainability and Environmental Impact:**

    a. What environmental or sustainability considerations are considered in your production process?

    b. How do you address environmental concerns in your fish leather production?

    c. What steps do you take to ensure the eco-friendliness of your products?

    d. How do you report or communicate your sustainability practices related to fish leather production?

8. **Consumer Education and Marketing:**
    a. How do you educate consumers about the benefits and unique qualities of fish leather?
    b. What marketing strategies have proven effective in promoting fish leather products?
9. **Customer Engagement and Market Trends:**
    a. How do customers typically respond to your fish leather products?
    b. Have you observed any recent trends in consumer demand for sustainable materials like fish leather?
10. **Customer Feedback and Improvement:**
    a. How do you gather and incorporate customer feedback into your fish leather product development?
    b. Are there any specific customer suggestions that have significantly influenced your product line?
11. **Collaborations and Partnerships:**
    a. Have you collaborated with any local fisheries, environmental groups, or other organizations in your fish leather production?
    b. How do these collaborations impact your business?
12. **Product Development and Innovation:**
    a. How do you approach product design and innovation using fish leather?
    b. Are there any unique properties of fish leather that influence your product designs?
13. **Supply Chain Management:**

a. Can you describe the logistics of your supply chain for sourcing fish leather materials?

b. How do you ensure the traceability and ethical sourcing of fish skins?

14. Competitive Landscape:

a. How do you position your fish leather products in the competitive market?

b. What sets your fish leather products apart from traditional leather goods?

5.4 Appendix D: Deliverable Outline for Both Fish Broth and Leather

1. **Executive Summary:**
    - Overview of the fish broth and leather market.
    - Potential opportunities and benefits for new businesses.
2. **Introduction to Fish Broth and Leather:**
    - Definition and background of fish broth and leather products.
    - Current market trends
3. **Business Model and Strategy:**
    - Guidelines for setting up a fish broth or leather business.
    - Analysis of different business models (e.g., direct-to-consumer, B2B).
4. **Production Process:**
    - Detailed process for producing fish broth and leather.
    - Equipment and technology requirements.

5. **Sourcing Materials:**
    - Guidance on sourcing fish waste or skins.
    - Considerations for sustainable and ethical sourcing practices.
6. **Marketing and Branding:**
    - Strategies for marketing fish broth and leather products.
    - Branding tips to appeal to target markets, emphasizing sustainability.
7. **Cost Analysis and Financial Planning:**
    - Breakdown of initial investment and operating costs.
    - Financial planning for profitability and growth.
8. **Challenges and Risk Management:**
    - Identification of potential challenges and risks.
    - Strategies for risk mitigation and problem-solving.
9. **Sustainability and Environmental Impact:**
    - Analysis of the environmental benefits of fish broth and leather.
    - How to communicate these benefits to consumers.
10. **Case Studies and Success Stories:**
    - Examples of successful fish broth and leather businesses.
    - Lessons learned.

12. **Customer Engagement and Feedback:**

- Strategies for engaging with customers and collecting feedback.
- Importance of customer insights in product development and improvement.

13. **Future Opportunities and Trends:**

- Emerging trends in the fish product market.
- Opportunities for innovation and expansion in fish broth and leather products.

14. **Conclusion and Action Plan:**

- Summary of key takeaways for starting a fish broth and leather business.
- Recommended steps and action plans for interested businesses.

5.5 Appendix E: Links and Resources

Fish Leather Upcycling in Japan – from Tomohisa Noguchi

https://www3.nhk.or.jp/nhkworld/en/ondemand/video/3020018/?autoplay

Website with Japanese fish leather photos - https://jstories.media/article/fishing-for-fashion-fish-leather-becomes-the-latest-sensation-in-the-fashion-world

5.6 Appendix F: Fish Leather Deliverable

Link to fish leather deliverable.

Link to fish leather marketing deliverable.

5.7 Appendix G: Fish Broth Deliverable

Link to fish broth deliverable.

5.8 Appendix H: Final IQP Presentation

Link to presentation.

6 References

Table 5: List of companies we interviewed.

Interviewed	Company	Company Description	Interview Date
Ricky Patacsil	Nico‘s Fish Market at Pier 38	Fish Wholesaler	17-Jan
Christopher Alan Pabacal	Pier 38 Market	Fish Wholesaler	17-Jan
Samantha Hook	Tidal Theory	Fish Leather Product Company	22-Jan
Michael Bluth	Open Sea Leather	Leather Product Company	25-Jan
Kevin	Slow Fish America	Fish Network Company	28-Jan
Janey Chang	Janey Chang Art + Ancestral Skills	Fish Leather Instructor	30-Jan
Guy Tamashiro	Tamashiro Fish Market	Fish Market	2-Feb
Tomohisa Noguchi	Tototo	Fish Leather Wholesale and Product Company	5-Feb
Scott Macindoe	Kai Ika	Fish Broth Company	7-Feb
McLean	Pelagos fly fishing	Fly Fishing Product Company	7-Feb
Megan Tomino & Nick Erker	Chef Hui	Non-Profit Community and Chef Network	8-Feb
Tasha Nathanson	7 Leagues Leather	Fish Leather Product Company	8-Feb

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