A Deep Dive into Hawaii's Seafood Industry: Reducing Fish Processing Waste

By

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Executive Summary

This report examines potential strategies to reduce fish processing waste (FPW) in Hawaii's seafood industry, with a central focus on seafood distributors. Two methods of research were employed: (i) a survey of Hawai‘i-based seafood distributors and (ii) a document analysis of the Iceland Ocean Cluster (IOC), supplemented by interviews with representatives from global ocean clusters.

The key findings of the Hawai‘i-based seafood distributor survey highlight the current management strategies and waste rates regarding FPW. The estimated amount of seafood processed by nine respondents totaled to 1,128,200 pounds per month, while the total amount of fish processing waste across eight respondents equated to 245,680 pounds per month. Averaging the waste rates of each distributor company revealed an approximate waste rate of 36.6 percent.

The most commonly cited waste management practices were landfill disposal and compost production. The two primary barriers to sustainable waste management include financial burden and labor capacity. Distributors emphasized the need for financial resources, equipment, access to a database of companies willing to accept the waste, and information on value-added products, among other resources, to effectively reduce FPW.

Insights from the Iceland Ocean Cluster and other relevant case studies revealed successful models of collaboration, value-added product development, financing opportunities, technological innovation, and market development. Collaboration between stakeholders is identified as a pertinent strategy to reduce FPW. Informal networking opportunities, similar the IOC's weekly coffee events, would allow Hawai‘i-based distributors and other stakeholders to share knowledge and expertise, promoting innovation in the industry. In addition, distributors

should partner with other entities such as local universities and non-profit organizations to advance value-added product development and seafood innovation entrepreneurship.

Value-added product development would enable increased revenue generation and waste reduction. Products such as fish dips, smoked seafood, and pet treats have gained traction in Hawai‘i and can be further produced to minimize waste and maximize revenue. Non-food value added products, such as fish leather and health supplements, can offer new opportunities for Hawai‘i-based distributors. By conducting further research, including market analyses, cost/benefit analyses, and pilot projects, distributors can ensure the success of new value-added products created from FPW.

Hawaii’s geographical location and emerging role in the US Blue Economy offers the potential of establishing an ocean innovation cluster to drive economic growth and environmental sustainability in the region. Collaborating with other industry stakeholders to form a coalition that advocates for the establishment of an ocean cluster can demonstrate support and drive this initiative forward. Advocating for government support could also contribute to the creation of Hawaii’s own ocean cluster.

The recommendations outlined in this report provide a roadmap for navigating challenges and identifying opportunities to drive sustainability and profitability in Hawaii’s seafood industry through the reduction of fish processing waste.

Introduction

In response to the escalating global population and rising demand for seafood, the seafood industry is facing increasing pressure to embrace sustainability and cultivate a circular economy. Up to 50 percent of raw fish material, including scales, muscle trimmings, skins, fins, bones, heads, viscera, and blood, is discarded as fish processing waste (FPW) (Aronson, 2019). This waste has the potential to generate excess amounts of nutrients in the environment, an overconsumption of energy and resources, and high levels of greenhouse gas emissions (Environmental Protection Agency, n.d.). Waste may also lead to missed revenue opportunities, lost nutritional value, and missed employment opportunities (Environmental Protection Agency, n.d.).

Since recognizing the potential of these often discarded by-products, the global seafood industry has initiated a shift towards circular economy principles. The circular economy is defined by the World Economic Forum as a strategy to produce and consume materials in a way that reduces the use of the world's resources, cuts waste, and reduces emissions, which is often achieved through repairing, recycling, and redesigning processes (Masterson & Shine, 2023).

The global population is projected to exceed 9 billion people by 2050, which will lead to a significant rise in the demand for food products, estimated to increase by 59 to 98 percent (Alkaya & Demirer, 2016). A 2017 study determined that fish contributes approximately 17 percent of the global intake of animal protein, demonstrating its critical role in global nutrition and food security (FAO, 2020). Fish also significantly contribute to the global intake of nutrients as a rich source of vitamin B12, D, A, iodine, zinc, selenium, and calcium (Cardinaals et al., 2023). However, seafood nutrient availability is projected to be cut by approximately 30 percent in tropical low-income countries by 2100 due to climate change (Cheung et al., 2023).

Studies suggest that fish consumption specifically will increase by over 80 percent by 2050, and the total weight of the world's fish harvested, including shells, guts, bones, and other by-products, could potentially double (Naylor et al., 2021). The commercial seafood processing industry generates significant quantities of fish processing waste, including fish bones, skins, fins, heads, and viscera, which are often discarded in landfills. With the rising seafood demand and consumption, the absence of strategies to reduce processing waste will lead to a substantial increase in waste from seafood production.

The United Nations Sustainable Development Goal number 12 centers on ensuring sustainable consumption and production patterns (United Nations, n.d.). In alignment with this objective, the United States has established its own target for food loss and waste reduction. The U.S. Department of Agriculture and Environmental Protection Agency enacted a national goal to cut food loss and waste in half by 2030, from 328 pounds per person to 164 pounds per person (*United States 2030 Food Loss and waste reduction goal*, 2024). These ambitious targets demonstrate the global and national commitment to promote sustainability and address the growing global challenge of food waste.

Incentives for Waste Reduction

The economic loss from fish processing waste has not been widely studied in the literature, although multiple sources identify waste as being a major economic loss (Coppola et al., 2021; M.D et al., 2023). Economic loss from FPW can be determined by considering the disposal costs, missed revenue opportunities, environmental impact costs, potential job creation loss, and the costs to produce more resources.

In addition to the economic loss, seafood processing waste contributes to environmental issues as well. Processing waste is not only taking up valuable space of the limited landfill

capacity, but also releasing methane, a greenhouse gas. A quarter of global greenhouse gas emission is attributed to food production (Ritchie, 2023). Food loss contributes to eight percent of greenhouse gas emitted, which exceeds levels emitted by all animal agriculture in the US (Mitloehner, 2020). The waste of food products is not only a loss of sustenance, but also a waste of the energy and resources used to produce it. Cutting down on food waste has the potential to decrease human-induced greenhouse gas emissions by approximately six to eight percent (*Fight Climate Change,* n.d.). By demonstrating environmental sustainability, seafood distributors have the potential to meet consumer sustainability demands and enhance the company's image.

Potential for FPW

Recent research indicates that the processing and packaging stages of the seafood value chain holds substantial potential for recovering lost waste, offering both economic and environmental benefits (Cooney et al., 2023). Currently, a substantial portion of the world's seafood processing waste is used in low profitability products such as fishmeal, fertilizers, and fish oil (Coppola et al., 2021). In this report, we will explore the possibilities of transforming FPW into high-quality and high-value products, providing product recommendations for Hawai‘i-based seafood processors.

Seafood processing waste contains an abundance of underutilized high-value compounds such as proteins, peptides, vitamins, amino acids, collagen, chitin, enzymes, gelatin, glycosaminoglycans, polyunsaturated fatty acids, minerals, and more (Cooney et al., 2023). These compounds can offer potential applications in numerous industries such as food, agriculture, cosmetics, pharmaceuticals, and nutraceutical industries (Cooney et al., 2023).

In addition to industrial uses, various parts of the fish have been traditionally utilized in many native and Indigenous cultures, including Hawai‘i. For example, Native Hawaiians have

utilized various parts of the fish for bait, lua implements and weapons, fertilizer, healing practices, fuel, and sustenance. This paper will further explore specific product recommendations, considering both modern applications and the preservation of traditional practices.

Challenges and Barriers to Reducing FPW

A critical challenge in seafood waste recycling is the consumer acceptance of seafood waste as secondary products (Cooney et al., 2023). To overcome the negative connotations associated with waste recycling, effective marketing, consumer education, and food labeling have been identified as key strategies for retailers and producers to employ (Cooney et al., 2023). Research has suggested that consumers may hesitate to purchase and use products that might be considered "waste" and may consider the product unappealing or unsafe (Altintzoglou et al., 2021). However, consumers with higher levels of guilt and a more positive self-image were found to exhibit a greater acceptance of such products (Peschel & Aschemann-Witzel, 2020). Recent consumer studies suggest a growing acceptance of waste-to-value food products, nutritional supplements, and cosmetics (Altintzoglou et al., 2021). Researchers emphasize the importance of reframing perceptions of what is considered waste, highlighting that this shift not only reduces resource losses but also opens new revenue streams within the seafood sector (Cooney et al., 2023). Acceptance of new food products, especially ones using by-products, largely depends on the consumer's trust in the food system (Coderoni & Perito, 2019). Engaging in focus groups, product testing, and market assessments can contribute to addressing the challenge of negative consumer perceptions.

Another noteworthy challenge identified by researchers in utilizing seafood by-products is food safety. During the collection and processing of by-products for human consumption, by-

products must meet food-grade standards (Cooney et al., 2023). For example, the creation of food and health supplements from calcium extracted from fish bones or omega-3 fatty acid-rich oils from fish livers must meet stringent food safety requirements (Cooney et al., 2023). If by-products are intended to produce food ingredients, they should be treated on-site as food-grade (Cooney et al., 2023). Alternatively, if further processing is managed by approved animal by-product operators, by-products should be treated as feed-grade (Cooney et al., 2023).

Within the seafood processing sectors, waste can be attributed to several factors including inadequate equipment (i.e., refrigeration systems), insufficient processing control (i.e., staff removing inadequate amounts from fish frames), limited use of packaging materials, or inadequate processing capacities (Cooney et al., 2023). To reduce loss in the supply chain, processors can improve process control and supply chain management operations (Cooney et al., 2023).

Hawai‘i Case Study

While waste management in the seafood industry is a global problem, it is one that is context-specific, varying based on geographical, economic, political, and cultural factors. Therefore, adopting a case study approach can provide valuable insights into addressing waste management challenges based on these factors. While the insights may not be directly generalizable to all fisheries, they can inform fisheries with similar considerations and contribute to broader strategies for sustainable seafood production and waste management.

Given the context-specific nature of the seafood industry, Hawaii’s unique geographical and environmental circumstances, along with economic, social, and cultural considerations, demonstrate the particularly important need for addressing the issue of waste in the state through a case study. These considerations include Hawaii’s remote location, high export and import

costs, limited landfill capacity, and ecosystem vulnerability. Hawai‘i was chosen as a case study due to its status as an island economy heavily reliant on seafood production, which plays a role in both local consumption and export. The context of Hawai‘i can provide valuable insights into the challenges and opportunities to transition to a circular economy for island regions with similar economic and ecological characteristics.

The population in Hawai‘i is projected to rise by approximately 300,000 people by 2040, leading to increased pressure on the local food industry (Lynch, 2018). Currently, only 13 percent of the state’s food supply is locally sourced, with the remaining 87 percent imported (Lynch, 2018). In addition, 55 percent of seafood is sourced locally (Lynch, 2018). The anticipated population growth will require an increase in seafood catch and production, leading to an increase in fish processing waste. A 2015 study estimated that wild-capture fisheries in Hawai‘i were modeled to meet 55% of the expected 2040 seafood demand, but this figure has recently decreased to 45% or less (Teneva et al., 2018). Improving the seafood supply chain and management strategies to reduce the amount of processing waste discarded has the potential to alleviate the impact of a growing population on Hawaii’s food security.

A report conducted by the Western Pacific Regional Fishery Management Council in 2014 found that 8,792,000 pounds, or 4,396 tons per year of FPW were generated by the commercial fishing industry in the Hawaiian Islands (Dominy et al., 2014). This was a decrease from the 2011 DLNR study that found 6,463.1 tons of FPW being generated in the state (Dominy et al., 2014). Notably, Kauai County, Maui County, and Hawai‘i Island experienced an increase in total estimated FPW, while only Oahu decreased in the amount of FPW generated (Dominy et al., 2014). The study found that on the outer islands, including Molokai, Maui, Kauai, and Hawai‘i Island, processors were disposing of FPW either in landfills through commercial haulers

or wholesale companies (Dominy et al., 2014). Some companies opted for composting, either through dumping or collection by farmers for composting or as pig feed (Dominy et al., 2014). On Oahu, the majority of FPW was collected by companies transforming it into commercial commodities, such as pet food, or transporting waste to commercial farms for composting (Dominy et al., 2014).

Initiated in 2014, the Aloha+ Challenge represents a "statewide public-private commitment to achieve Hawaii's social, economic, and environmental goals by 2030" (*Aloha+ Challenge,* n.d.). Solid waste reduction is one of the identified Aloha+ goals. However, the 2021 scorecard developed by the initiative revealed that the solid waste diversion goal needed improvement, with 27 percent of solid waste being diverted from landfills, while the target was set at 70 percent (*Annual Sustainability Scorecard*, 2021). With 2.3 million tons of solid waste generated in 2014 at the start of the Aloha+ Challenge, solid waste generation has increase to 2.9 million tons produced in 2021 (*Annual Sustainability Scorecard,* 2021). Recycled and composted materials accounted for 695,931 tons of material in 2021, a decrease since the 2014 start of the initiative when 845.6k tons of waste were diverted (*Annual Sustainability Scorecard*, 2021).

In addition to the solid waste diversion goal, the Aloha+ Challenge has also recognized the need to improve health, nutrition, and access. The initiative identified 11.5% of households in Hawai‘i faced food insecurity, and 18.2% of children experienced a lack of access to sufficient nutrition in 2021 (*Annual Sustainability Scorecard,* 2021). While the household food insecurity rate aligns with the national average, there is a recognized need for enhanced access to healthy and nutritious foods, with further data needed to support these insights (*Annual Sustainability Scorecard,* 2021).

To achieve a more sustainable future, collective efforts are required to optimize seafood supply chains, reduce processing waste, and align with overarching environmental and social objectives. The complex relationship between population growth, waste management, and food security emphasizes the importance of comprehensive and collaborative approaches for the sustainable development of Hawaii's fisheries and food systems.

Current Regulations

The current regulations of seafood processing waste in Hawai‘i are primarily overseen by the Board of Health (BOH), a regulatory body a part of the Hawai‘i Department of Health. In accordance with BOH mandates, fish wholesalers and retailers are required to store their processing waste in cold storage facilities to prevent odor and pest issues while ensuring regular disposal (Dominy et al., 2014). Attempts at disposing of waste through free pickups by crop and pig farmers have proven inconsistent, conflicting with the BOH regulations (Dominy et al., 2014). Furthermore, bins used for pickup were also often returned without proper sanitation, violating BOH guidelines (Dominy et al., 2014). Currently, the most reliable and consistent disposal service is the commercial garbage disposal companies who take the processing waste to the landfill (Dominy et al., 2014).

In Honolulu, Ordinance, Chapter 9, Section 9-3.5 requires that owners of food manufacturers or processors occupying 5,000 square feet or more of floor area must either (a) arrange and provide for the separate collection of food waste and its recycling at a recycling facility in the city or (b) separate food waste from all other solid waste generated by the food establishment and deliver the food waste to a recycling facility (City of Honolulu Ordinance Food Waste Recycling, 2022). It is important to note that this legislation mandates the recycling

of all food waste at the required facilities within Honolulu but is not yet enacted in other regions of Hawai‘i.

Contextual Framework and Research Objectives

This Master's Project aims to address critical questions surrounding fish processing waste in Hawai‘i, with a broader goal of contributing to global efforts to reduce FPW. Hawai‘i serves as a unique case study due to its geographical location and marine resource-reliant economy. By investigating seafood waste management in this context, insights gained have the potential to inform strategies for island states facing similar challenges. Furthermore, findings may offer valuable lessons for addressing the global problem of seafood waste. This study aims to provide an overview of waste generation, potential utilization, and management strategies specific to Hawai‘i that could potentially be applied in diverse contexts.

The project is focused on answering the following questions:

1. How much seafood processing waste is being discarded in Hawai‘i?
2. What are potential sustainable uses and products from seafood processing waste?
3. What are best management practices to reduce seafood waste in Hawai‘i?

The first research question attempts to gain an understanding of the quantity and composition of waste generated to assist in determining effective management strategies from environmental, economic, and logistical perspectives. The second question aims to find potential uses and products from waste to foster a circular economy approach, generate more revenue for distributors, and reduce the environmental impact. Lastly, the study attempts to identify best management practices with the goal of mitigating waste generation and promoting resource efficiency. Effective waste reduction strategies, informed by the specific challenges and opportunities of Hawaii's seafood industry, can serve as a blueprint for other island regions

looking to reduce fish processing waste. By sharing knowledge and fostering collaboration, coastal communities worldwide can work together to minimize waste generation, maximize resource efficiency, and mitigate environmental impacts of seafood production.

I. Methods

To answer the proposed research questions, I focused on the seafood industry throughout all the Hawaiian Islands to gain a comprehensive understanding of the current state of processing waste management in the state. Given the limited availability of recent data on FPW in Hawai‘i, the research adopts an approach centered on interviews with key informants from seafood distributors across the main Hawaiian Islands to determine current waste rates, challenges, and management strategies, supplemented with a document analysis of successful strategies in other regions.

To answer question (1), how much seafood processing waste is being discarded in Hawai‘i, fourteen seafood distributors across the four main Hawaiian Islands who met the selection criteria (refer to the following section, Survey Methods and Analysis, for selection criteria) were identified to participate in the survey. To answer question (2), what are potential sustainable uses and products from seafood processing waste, the surveys with Hawai‘i-based seafood distributors along with a qualitative document analysis of global ocean cluster literature were employed. The objective of the document analysis was to conduct a comparative analysis of the Hawai‘i case study with more established waste reduction initiatives globally, in hopes of utilizing insights and determining recommendations for the Hawai‘i seafood industry. The survey determined current successful sustainable uses of FPW by Hawai‘i-based distributors, while the document analysis determined transferrable solutions from successful waste reduction

initiatives employed by global ocean clusters. To answer question (3), what are best management practices to reduce seafood waste in Hawai‘i, the results from the survey and document analysis were compiled and analyzed to determine practices that should be used to effectively reduce seafood processing waste across the Hawaiian Islands.

II.I Survey Methods and Analysis

To identify suitable survey and interview respondents, a twofold approach was utilized. I referenced the appendix of companies included in a Western Pacific Regional Fisheries Management Council study, “Fish Processing Waste: A valuable Co-Product of the Fishing Industry”, to identify potential respondents, and supplemented this by consulting staff at the local office of Conservation International Hawai‘i (CI Hawai‘i). Companies in Hawai‘i were selected based on specific criteria: processing local seafood products in Hawai‘i, sourcing from wild-caught fisheries, and selling products wholesale. Since the study is focused on FPW in Hawai‘i, targeting processors that produce local seafood processing waste ensures relevance to the research objectives. Processors sourcing from wild-caught fisheries have a significant impact on the local marine ecosystem. By targeting these processors, the study can determine the impact of wild-caught fishery waste on the environment and economy of Hawai‘i. And finally, processors operating at a wholesale are likely to generate higher amounts of waste compared to retail-focused operations. Surveying wholesale processors will provide a more comprehensive understanding of waste generation and management. Fourteen companies meeting these criteria were identified in Hawai‘i and were contacted via email or phone to request their participation in the study. Ten companies responded, with seven providing complete responses and three offering partial responses.

Three primary methods were used for data collection: online Qualtrics survey, in-person interviews, and phone interviews. All respondents were administered the same questions regardless of collection method, but in-person interviews allowed for a more semi-structured approach. The survey was administered from July to August of 2023. Three companies responded by phone or virtual interviews, one responded via the online survey, and six responded through an in-person interview.

To ensure alignment with the study's objectives, survey questions were developed based on the research questions. Relevant survey questions also emerged based on a review of relevant literature and identifying key themes and gaps within the literature. Finally, questions were developed based on a similar study conducted in the Asia-Pacific region by Conservation International. The questions were further refined through collaboration with CI Hawaii's Sustainable Seafood Manager and a seafood distribution company partnering with CI Hawai‘i.

Qualitative and quantitative data were collected. Qualitative questions focused on the company's current practices to manage seafood processing waste and challenges and barriers to manage processing waste. Quantitative data collected includes how much seafood the company is processing, what types of waste are generated the most, and what percentage of waste is converted into value-added products. One limitation of this data collection is that some responses were estimates provided by respondents.

Responses were analyzed using quantitative and qualitative methods. For quantitative responses, data were summed and visualized as descriptive statistics of seafood use and waste to answer the research questions. Qualitative data were analyzed using a conceptual content analysis to determine themes of strategies employed by companies to reduce processing waste.

II.II Document Analysis Methods

With recent advocacy from US lawmakers for the creation of more ocean innovation clusters, examining successful models becomes imperative (Strout, 2023). Hawaii's geographical location positions itself as a key player for the U.S. in the Blue Economy and has the potential to serve as an innovation hub for the Pacific region. Hawai‘i is a strong candidate for the establishment of the next ocean innovation cluster. To determine potential sustainable uses and products along with best management practices to reduce seafood waste, a document analysis of regional case studies was conducted. A document analysis can be defined as a qualitative research method in which text is analyzed and interpreted to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009). Cases, with a primary emphasis on ocean clusters, were chosen due to their focus on FPW reduction. Iceland Ocean Cluster revealed to be the only cluster with adequate literature, greater than 10 documents specifically mentioning the cluster and "waste" or "value-added products" in the title or abstract, to conduct a document analysis. The Iceland Ocean Cluster has a central focus on fish waste reduction and runs the 100% Fish initiative. The information was then supplemented by interviews with representatives from the IOC and the Oregon Cluster Initiative. Other ocean clusters were contacted without response.

Initially, Duke's Library search was used to find any scholarly literature, however, no results were found. Thus, Google Scholar was then employed using the search string "'Iceland Ocean Cluster' AND seafood waste," resulting in 61 documents found. These documents were then further screened by considering the title and abstract having Iceland and waste or value-added products mentioned, leading to a total of twelve documents. One document was removed from analysis after further review due to a lack of relevance to the codes.

Next, these documents were coded in NVivo for the following themes: value-added product development, technological innovation, financial opportunities, and market development. A deductive content analysis approach was utilized to develop codes, with codes chosen based on the needs found through the Hawai‘i-based distributor survey responses. Value-added product development was chosen to identify potential revenue-generating, high value products that could be produced in Hawai‘i, while technological innovations were coded to understand successful technology that could assist in reducing FPW in Hawai‘i. Financial burden emerged as the primary challenge for Hawai‘i-based distributors, revealing the need for strategies to overcome financial challenges. Given that financial burden is a significant challenge for Hawai‘i-based seafood distributors, an effective market development strategy can contribute to economic sustainability. Thus, there is a need to explore and understand the strategies employed in identifying, accessing, or creating markets for seafood processing waste products. As shown in the survey, Hawai‘i distribution companies are overwhelmingly in favor of collaborating with other stakeholders such as entrepreneurs, other distributors, non-profits, etc. Ocean clusters demonstrate successful collaboration, forming industry networks. The aim of this study is not comprehensive, but to provide a purposeful review of examples that may offer generalized lessons that may be used across Hawai‘i.

II. Results

III.I Survey Results for Hawai‘i-Based Distributors

To understand the variety of seafood processed at the facilities, respondents were asked to report the types of fish they process. All ten respondents reported processing wild caught fish, eight process farm-raised fish, seven process shellfish, and two process echinoderms. This

information is crucial for identifying potential products and markets for value-added items created from seafood processing waste. Seven of the nine distributors surveyed reported that tuna was their most popular product, with yellowfin, bigeye, and aku specifically mentioned. Other responses included mahi mahi, fresh fish, and one noted that everything sells. All surveyed distributors reported to sell their products wholesale, with over half reporting to sell both wholesale and retail.

The average amount of seafood processed per month varied among respondents, ranging from 4,000 to 600,000 pounds. The known amount of seafood processed by nine respondents totaled to 1,128,200 pounds per month. The total amount of processing waste generated by eight distributors equated to 245,680 pounds per month, with a range of 1680 pounds to 140,000 pounds. One key informant's estimate of processing waste came with a statement of uncertainty during an in-person interview, while no such statement was given by seven of the respondents. Two companies chose not to report the amount of FPW generated per month due to uncertainty. When asked the average amount of processing waste sent to the landfill monthly, four companies reported zero, two were unsure, one reported 4,900 pounds, and another reported only 50 pounds since their opening.

Waste records

Companies surveyed were asked if they kept records of the amount of waste generated. Three of the companies keep record of the waste generated, primarily through tracking the number or weight of bins sent off for compost or fertilizer. Those that tracked waste generated were companies who process at least 50,000 pounds of seafood a month. One of those companies also mentioned that they track waste through tracking their yield in addition to the number of bins picked up. The seven companies who did not track waste were asked if they would be

interested in keeping records of the amount of waste. Only three of the seven companies reported being interested in tracking waste amounts.

Current Management Strategies

Companies were asked how they currently manage their processing waste (results shown in Figure 1). Four companies used more than one method of managing their processing waste. Four out of ten use landfill disposal, two donate to food banks or charities, three donate to local farmers, four compost their waste, two utilize value-added products, and three have waste converted to a fertilizer. Other methods mentioned were using waste as bait or selling it to an out-of-state agriculture industry from the company's out-of-state processing facility.

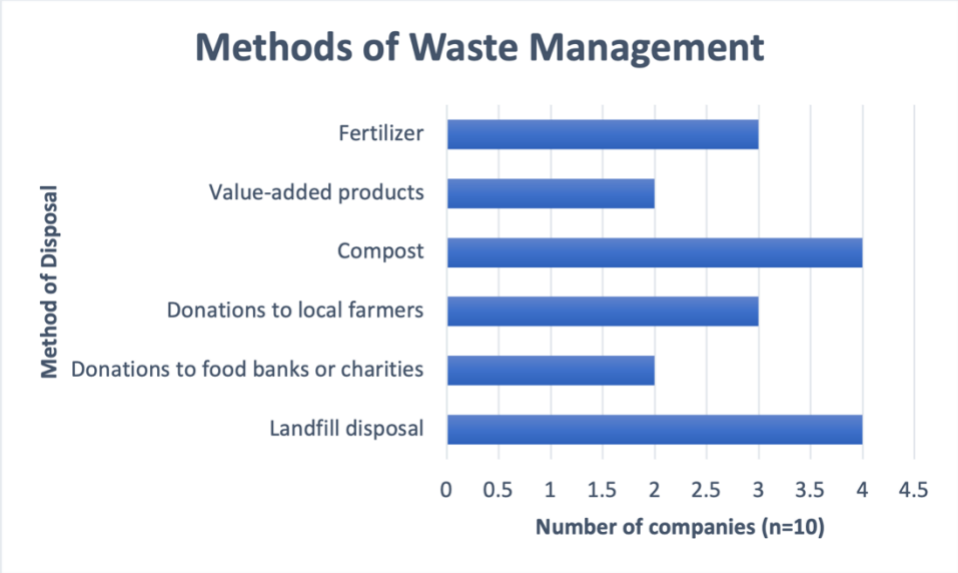

Figure 1 Methods of Waste Management employed by Hawai'i-based seafood distributors (n=10)

Four out of five companies who process over 40,000 pounds of seafood per month were found to utilize bin pickups from companies who either compost or create fertilizer from the waste, except for one company. One company who processes 30,000 pound per month also identified that all their waste is composted. Three smaller companies who processed less than 10,000 pounds of seafood per month identified that their waste goes either to the landfill or

donations to farmers, food banks, or charities. One of the small companies hopes to convert their waste into fertilizer in-house but have not been able to implement this strategy yet. This demonstrates how smaller companies struggle to find an avenue for their processing waste.

Company size	Method of disposal
>40,000 lbs./mo. (with one exception)	Bin Pickups for fertilizer or compost
10,000-30,000 lbs./mo.	Compost
<10,000 lbs./mo.	Landfill or donations to farmers, food banks, or charities

Figure 2 Comparison of company size (determined by the amount of seafood processed per month) with methods of disposal (n=9).

Companies have implemented various strategies in reducing seafood processing waste, including investments in new technology. Technologies that were exceptionally helpful according to respondents include grinders, poke cutting machine, vacuum seals, FoodTouch paper, and dehydrators. Companies were asked on a scale of 1 to 5, how likely they would be to invest in new technology to reduce processing waste, as shown in Figure 3, resulting in a mean

of 3.71. Along with technologies, improving inventory management, staff training and value-added products were identified as other strategies.

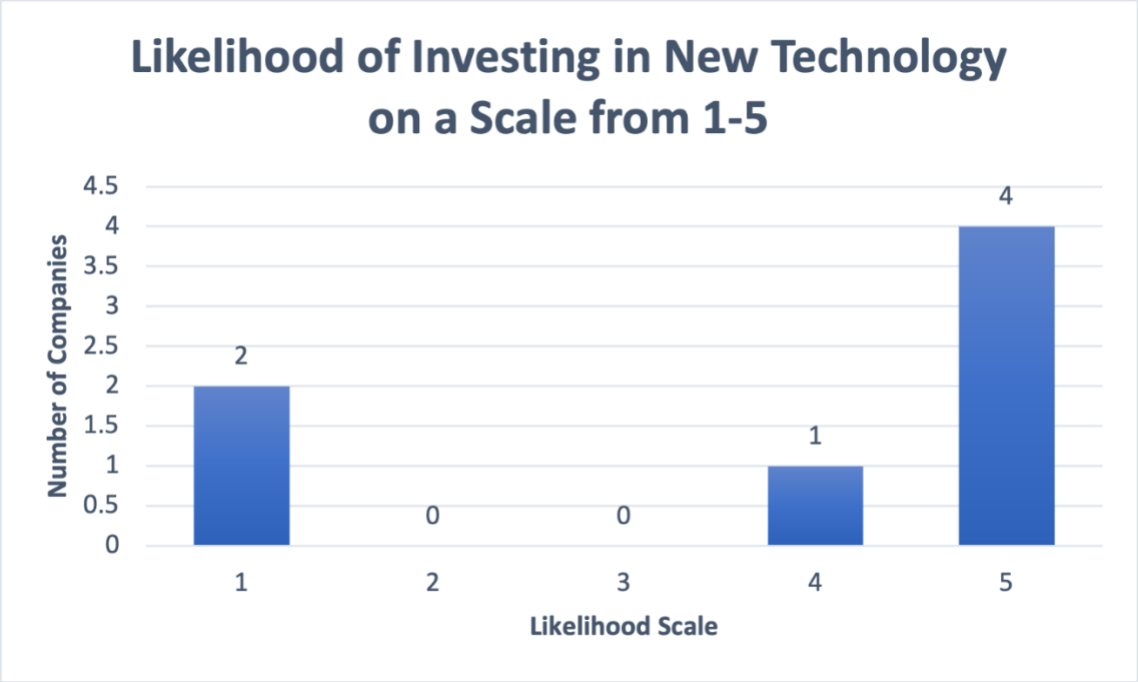

Figure 3 Likelihood of Companies Investing in New Technology to Reduce Processing Waste (n=7)

Value-added products are used as a strategy to reduce processing waste. A mean of 36.11 percent of processing waste is converted into value-added products, with six out of nine companies using waste for value-added products. It was observed that only two respondents explicitly mentioned utilizing value-added products when previously asked about their waste management practices. This discrepancy was likely due to the survey design, where compost and fertilizer were provided as separate choices from value-added products in the prior question. However, compost and fertilizer are considered under the category of value-add for this question.

Value-added products created and sold in-house include ahi collar, tail, and belly, salmon belly, bones, and heads, Hamachi collar, smoked marlin, fish dip, dried ahi and aku, pet treats, soups, bone broth, jerky of ahi bones, and smoked ahi. Two distributors noted that heads and bones are given to neighbors or restaurants to make soup. Five companies outsource their

processing waste to be converted into value-added products, mainly for fertilizer and compost with pet treats also being identified in the past. One company sells their waste to a local farmer for animal feed. Only one of two companies who do not currently produce value-added products were interested in exploring the production of value-added products for this survey.

Types of Processing Waste and their Potential

In response to the question regarding the most prevalent type of processing waste generated at the surveyed facilities, a diverse range of waste types was reported. Bones were the most frequently mentioned, with nine respondents, constituting about 27 percent of the total. This highlights the significance of bone waste in seafood processing. Heads were another substantial type of waste, identified by seven respondents, making up about 24 percent of the total. Skins and fins were noted by four respondents, which accounted for about 12 percent of the total. Innards and offal were mentioned three times, amounting to nine percent of the total. Other waste types such as muscle trimmings, viscera, scales, and blood were noted once, each accounting for six percent of the total.

When asked which waste types have the highest potential to be utilized in value-added products, bones were deemed to have the most potential with seven mentions, making up an estimate of 32 percent of the total. This is interesting to note with respondents also identifying bones as the most produced waste type. Skins and fins were identified as having the second highest potential for value-added products, while blood, innards and offal, and heads were all mentioned twice, each constituting about 9 percent of the total. Other waste types such as muscle trimmings, viscera, and scales were noted once, each accounting for 4.55 percent of the total. Other types of waste specified once to have the highest value-added potential include collars and all the waste grinded into a paste.

In addition, companies were asked to rate the potential of different industries to purchase FPW. The results are shown in Figure 4. Notably, the agricultural industry was believed to have the highest potential to purchase waste.

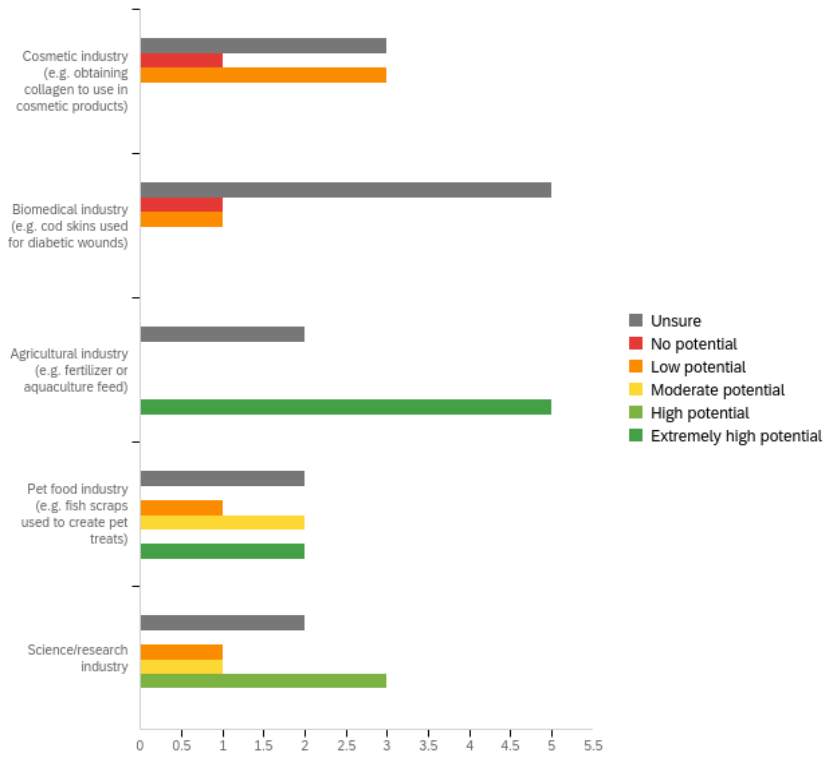

Figure 4 Potential of various industries to purchase FPW from seafood distributors (n=7)

Challenges

Surveyed distributors were asked what challenges and barriers they face in managing seafood processing waste. The primary challenge mentioned by respondents was the financial burden. Labor capacity was the second most mentioned barrier for managing processing waste in Hawai‘i, with infrastructure and storage space falling behind that. The financial burden was mentioned five times, with Hawaii’s remote location contributing to this burden. Labor capacity was identified as a barrier for four distributors, while infrastructure and storage space were mentioned by three distributors.

Collaboration Opportunities

An important takeaway from the survey is that all respondents are extremely willing to work with non-profit organizations, entrepreneurs, government agencies, fishers, other seafood distributors, and other industries, to manage seafood processing waste. This indicates the potential of creating an ocean innovation cluster network in the state.

Many companies have established partnerships or collaborations with other companies and organizations to address seafood processing waste, including retailers, customers, agricultural businesses, out-of-state canning facilities, accelerator programs, non-profit organizations, and other seafood distributors. Six out of seven respondents confirmed their collaborations with other stakeholders, however, two respondents noted they are no longer working with their collaborators.

Resources Needed

Financial resources and equipment were identified as a top need for distributors to reduce processing waste, followed by labor, employee trainings, and stakeholder workshops. When asked on a scale of 1 to 5, with 5 stars indicating extreme likelihood and 1 indicating not likely at all, how likely the company would be to invest in staff capacity, the mean was 3.43. Other identified needs include establishing a database of companies willing to accept the waste, securing consistent partners for waste collection, enhancing value-added information, improving product quality, acquiring third-party assistance, and addressing challenges related to land, time, infrastructure, and marketing.

III.II Document Analysis of the Iceland Ocean Cluster

Collaboration

The analysis of the Iceland Ocean Cluster (IOC) reveals a diverse landscape of collaborations within and outside of the participating cluster members. The core objective of the

IOC is to foster connections among ocean-related companies, and this study dives into the complexities of these collaborations. Collaboration is viewed as the key component of success for the IOC in using every part of the fish (Refsgaard et al., 2021).

The study highlights several dimensions of collaboration within the IOC. The geographical proximity of firms within the Ocean Cluster House (OC House), the headquarters of the IOC, facilitates frequent interactions and collaborations (Den Hollander & Thorsteinsson, 2020). Approximately 70 percent of the companies in the OC House have engaged in collaborative efforts (Den Hollander & Thorsteinsson, 2020). A specific collaboration effort identified as successful is the weekly coffee event which allows tenants to expand their networks (Den Hollander & Thorsteinsson, 2020).

Additionally, the cluster has relations with blue economy clusters worldwide, such as the clusters in Massachusetts, New England, and Nordic countries (Den Hollander & Thorsteinsson, 2020). These relationships have been established through connections between IOC's management and principal individuals in other clusters (Den Hollander & Thorsteinsson, 2020). IOC has even joined and facilitated innovation through the North Atlantic Ocean Cluster Alliance (NAOCA) which includes a network with Western Canada, Denmark, Faroe Islands, Finland, Greenland, Norway, and a few non-NAOCA members (Mattos-Hall, 2014).

Finally, collaborations with universities have been instrumental in facilitating innovation. Universities have collaborated with the IOC to facilitate events such as fish leather workshops (Palomino, 2019). Academic institutions also collaborate on biotechnology and innovations for residual raw material use (Saviolidis et al., 2020). The findings underscore the importance of personal connections in fostering successful collaborations within the cluster.

Financing Opportunities

As a for-profit organization, the IOC does not receive monthly grants from government funds, but the IOC has received government grants to work on specific projects (Den Hollander & Thorsteinsson, 2020). Additionally, membership fees, rental agreements, OC House food-halls, and consultancy projects have generated revenues for the cluster (Den Hollander & Thorsteinsson, 2020). This demonstrates the cluster's non-traditional methods of generating revenue. Another potential option identified for funding clusters is through crowd funding platforms (Mattos-Hall, 2014). The platforms allow users to create a project, invest in a project, or offer a service for a particular project (Mattos-Hall, 2014). In addition, the platforms allow for networking and referrals (Mattos-Hall, 2014). The research also identifies challenges in financing the cluster, such as the cost of investment and uncertain returns, particularly in the biotech industry (Saviolidis et al., 2020). Additionally, a lack of expertise in innovation, particularly in pharmaceutical and cosmetic applications, hinders investment in value-added products (Saviolidis et al., 2020).

Market Development

Iceland's market relies heavily upon exports to various countries including the United Kingdom, France, Spain, Norway, the United States, Germany, Japan, and more (Finger et al., 2021). One study highlighted that almost 99.9 percent of seafood production is exported out of the country (Den Hollander & Thorsteinsson, 2020). A separate study in 2018 attributed exports of seafood at 76 percent. This highlights the global reach and marketability of seafood and value-added products (Finger et al., 2021).

Another key point found in this study is the demand for sustainable fish. Trends such as population growth, the rise of the middle class, and the rising demand for healthy and sustainable food products, present opportunities for market growth (Saviolidis et al., 2020). Certifications,

such as the Marine Stewardship Council (MSC) certification, are used to gain access to markets, increase transparency, and attain higher prices (Saviolidis et al., 2020). Marketing strategies such as improved branding and product diversification provide the opportunity for value-added products (Saviolidis et al., 2020). An industry expert noted that competition on the island among producers is recognized as having enough market share for everyone (Den Hollander & Thorsteinsson, 2020).

Technological Innovation

The analysis of coded references reveals a dynamic environment of technological innovation within the Icelandic Ocean Cluster. Iceland leads the industry in fish processing technology solutions, and the country is recognized as an innovative society which continues to create cutting-edge technology in the seafood industry (Finger et al., 2021). The new domestically produced automated technologies have given rise to a competitive advantage in the international market (Bjornsdottir et al., 2021). Technologies such as on-board automated processing and improved packaging techniques have allowed for more value-added opportunities from seafood processing waste (Bjornsdottir et al., 2021). The extensive knowledge in biorefinery and biotechnological applications has led to using almost all the raw materials from cod (Björnsdóttir et al., 2018). Biotechnology such as bioprocessing, bioharvesting, bioprospecting, and bioremediation have applications to produce products for industries such as health, food, cosmetics, aquaculture and agriculture, biomaterials, biofilms and much more (Mattos-Hall, 2014). Furthermore, innovations from other industries, such as the extraction of collagen from fish skin, have been applied to the Icelandic seafood industry (Den Hollander & Thorsteinsson, 2020). Another innovative technology utilized is automatic water jet robots, which have been employed to remove pin bones from fillets (Bjornsdottir et al., 2021).

Regarding the production of fish meal, high heat results in lower quality proteins and lipids (Bjornsdottir et al., 2021). Thus, methods such as membrane filtering and spray drying have been implemented to better preserve the composition, resulting in enhanced nutritional value and higher value products (Bjornsdottir et al., 2021). These are just a few examples of how technology is aiding in value-added product development that were revealed through this study.

Investments in these technologies have increased the efficiency of the seafood industry (Den Hollander & Thorsteinsson, 2020). Companies and consultancies within the cluster play a crucial role in aiding the innovations in ocean technology (Den Hollander & Thorsteinsson, 2020). Across the value chain, innovation and automation have significantly increased the throughput in processing (Bjornsdottir et al., 2021). The adoption of new technologies is evident, with fisheries adopting the technologies when opportunities arise (Den Hollander & Thorsteinsson, 2020).

Value-Added Product Development

From products such as fish leather to the extraction and utilization of collagen, the IOC has pioneered the value-added product landscape in the seafood industry. Coding revealed a diverse number of value-added products from FPW including animal or pet feed, cosmetics, collagen, enzymes, fertilizer, fish leather, fish meal, food products, fuel, medicinal applications, oil, silage, and supplements. The most discussed products in the literature were fish leather, food products, medicinal applications, and supplements. This highlights the most researched value-added products within the IOC.

Food products created from FPW often involve drying, freezing, or canning. Iceland has exported seafood goods, including dried fish, to foreign countries since the 14th century (Bjarnadóttir, 2020). Fish heads are often sold dried, although it is noted that the market for dried

fish heads has recently decreased (Björnsdóttir et al., 2018). Fish faces, tongues, and cheeks can be sold separately, salted, or frozen (Björnsdóttir et al., 2018). The extraction of fish protein hydrolysates is used as flavor enhancers, salt and monosodium glutamate (MSG) replacer, and protein enrichment (Björnsdóttir et al., 2018). Fish roes are sold fresh, frozen, and salted, while fish livers are often chilled, frozen, or canned (Björnsdóttir et al., 2018; Finger et al., 2021).

Besides the use of FPW for food products, there has also been success in Iceland in using by-products for medicinal applications. Fish viscera are being utilized to produce valuable enzymes for wound and diabetes-related injuries (Mattos-Hall, 2014). Products such as Cod Doc, Penzim Fel, Penzim Lotion, and Zo Pure Serum droplets utilize these enzymes for treatments related to softening joints and muscles, treating acne, and moisturizing skin (Mattos-Hall, 2014). A common cold medication, PreCold, produced by Zymetech, has also been produced using enzymes from fish viscera (Björnsdóttir et al., 2018). Infection resistant anti-microbial peptides are being produced by the Icelandic company, Stofnfiskur, with North Atlantic salmon eggs (Mattos-Hall, 2014). Raw materials can further be broken down from proteins into peptides, which are increasingly being used for antihypertensive, antioxidative, anticoagulant (blood clots), and antimicrobial components in nutraceuticals and pharmaceuticals, aiding in the treatment or prevention of diseases (Björnsdóttir et al., 2018).

Fish skins, another by-product of fish processing, are being utilized for the production of collagen and gelatin, along with high-value tissue regenerating medical products and textiles. (Finger et al., 2021). From fish-skin wound treatment to beauty products, start-up companies have found value in collagen for diverse application potential (Minelgaite et al., 2020). The Icelandic company, Kerecis, processes cod skin to be sold as skin plasters for wound treatment (Björnsdóttir et al., 2018). Collagen can be further processed into hydrolysates and utilized in

supplements, cosmetics, and nutraceuticals (Björnsdóttir et al., 2018). Collagen was also noted to produce food glue and food supplements (Den Hollander & Thorsteinsson, 2020).

Fish skins can also be employed for other high-value applications such as fish leather. Fish skin is identified by many studies as an innovative and sustainable alternative material to conventional leather. Notably, companies such as Atlantic Leather are at the forefront of the fish leather industry, transforming skins into diverse leather products (Palomino et al., 2020). Atlantic Leather successfully renewed the historic Icelandic tradition of creating shoes from fish skins, incorporating ancestral tanning techniques and securing new employment opportunities for the community (Palomino et al., 2020). The use of fish skins to produce wallets, bags and shoes requires minimal capital which makes it ideal for small businesses (Palomino, 2019). One study noted that this model can be duplicated in seafood industries across the globe, particularly in regions which consume a lot of fish and countries with ancestral fish leather practices (Palomino, 2019). Not only can fish skins be used for fish leather, but companies have made advancements in transforming fish skins into skin plasters for wound treatment and in extracting collagen for a multitude of uses (Björnsdóttir et al., 2018).

Other uses of FPW discussed in the literature include pet and animal feed, fertilizer, silage, oil, and fuel. These topics were mentioned less than other uses of FPW but are still relevant to note in the discussion of value-added products. The Icelandic pelagic industry has moved away from animal feed towards freezing more for human consumption (Bjornsdottir et al., 2021). Viscera are used for feed and fertilizer, and fish skins are often dried for feed (Finger et al., 2021). Other side streams, including cut-offs, frames, and backbones, are also used to produce feed, but it is noted that these by-products have the potential to be processed into higher-value products (Finger et al., 2021). Some Icelandic companies process fish viscera into fish

silage but is primarily sold to Norway for additional processing. Furthermore, oils, including Omega-3, are produced by Iceland and are often exported to foreign countries (Mattos-Hall, 2014; Bjarnadóttir, 2020). Fish offal has the potential to be used for biofuel and methane production (Björnsdóttir et al., 2018), although none of the literature delves into whether or not this is a current practice in Iceland.

III. Discussion and Recommendations

The findings of the survey on FPW in Hawai‘i offer valuable insights into the composition of the waste generated by local distributors, current management strategies and challenges faced by distributors. By examining the predominant types of waste and identifying potential value-added products, the survey demonstrates the importance of innovation to reduce waste and maximize resource utilization in the seafood industry. By drawing parallels with successful waste reduction initiatives in global ocean clusters such as the IOC, this discussion highlights key implications for Hawai‘i-based seafood distributors, including recommendations focused on the previous coding themes: collaboration, financing opportunities, market development initiatives, technological innovation, and value-added product development. This discussion aims to provide actionable recommendations for Hawai‘i-based distributors to address waste management challenges and opportunities within the state’s seafood industry.

Implications of Hawai‘i Survey

The survey findings reveal the composition of seafood processing waste which can assist in developing tailored management strategies. The predominant types of waste generated by Hawai‘i-based distributors include bones, heads, skins and fins. Bones have potential for value-added products such as soups, fish stock, fish meal, and biotechnological products including calcium and bioactive peptides. Similarly, heads may be dried and used for soups or processed

for fish oil extraction (Sifusson, 2020). Fish oil is rich in omega-3 fatty acids such as docosahexaenoic acid (DHA) and are highly valued for their health benefits (Bonilla & Hoyos Concha, 2018). Skins offer numerous value-added opportunities including collagen, gelatin, fish meal, pet treats, and sustainably sourced leather (Sifusson, 2020). Moreover, the survey identified tuna as the most popular product for distributors.

The OCI and newly launched Pacific Island Ocean Cluster (PIOC) have identified tuna as a starting point for reducing processing waste. Laura Anderson, founder of Local Ocean Seafood and member of Oregon Cluster Initiative, stated, “We are looking to tuna to really be a good fish for us to start pushing the envelope with on some of these capacities.” The PIOC has created “The Incredible Tuna Value Machine” graphic seen in Figure 5 to demonstrate the numerous ways in which tuna by-products can be utilized. Similar to products produced in the Iceland seafood industry with cod and salmon, tuna by-products can be used to produce omega oils, enzymes, collagen, proteins, dietary supplements, skin replacement, and leather. With the most popular product in Hawai‘i identified as tuna in the survey, there is potential to utilize tuna as the same starting point for value-added product development.

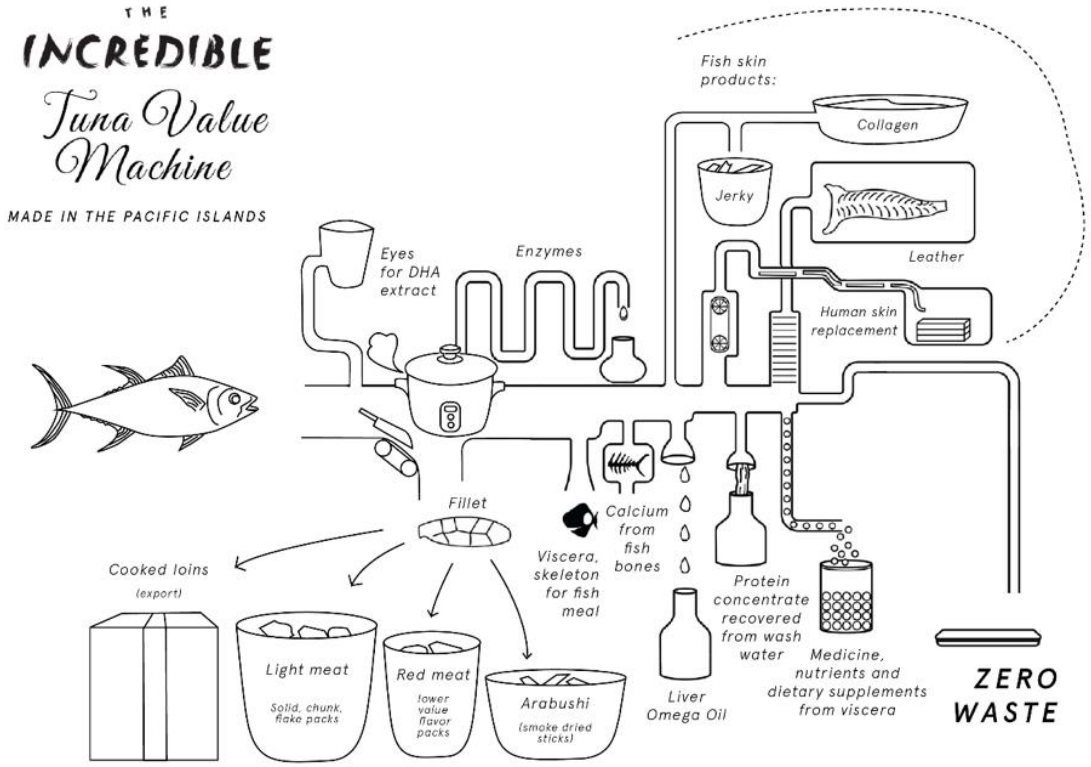

Figure 5 The Incredible Tuna Value Machine (Source: ©The Pacific Islands Ocean Cluster))

Furthermore, the survey also reveals the need for scalable and adaptable management strategies. While larger companies were shown to be more likely to adopt composting or fertilizer conversion methods, smaller companies faced challenges in finding effective waste management solutions and often utilized landfill disposal. Smaller companies likely lack sufficient raw material to partner with external companies for waste pickup and conversion. This demonstrates the need for strategies that can accommodate varying capacities of companies.

Financial burdens, labor capacity constraints, and infrastructure limitations were identified as key challenges faced by Hawai‘i-based distributors in managing processing waste. Funding opportunities and policy support can assist in addressing these challenges. Policymakers can address barriers to sustainable waste management by implementing supportive policies, such as providing tax incentives for waste reduction initiatives, eliminating barriers to feeding food

scraps to animals, providing funds for infrastructure and technology advancements, and streamlining the permitting processes for value-added product development (*Policymakers,* n.d.). By creating an enabling environment for sustainable waste management, policymakers can empower distributors to adopt innovative solutions and make progress towards waste reduction goals.

Lessons Learned from Ocean Clusters

While the preceding document analysis centered on ocean clusters, the findings hold relevance for Hawai‘i-based seafood distributors operating outside of a formalized cluster. The lessons from the IOC and other regional clusters can offer valuable insights to enhance innovation and collaboration among these companies. Comparisons can be drawn from Iceland to Hawai‘i as shown in Figure 6.

	Iceland	**Hawai‘i**
Collaboration	• Key component of success. • Informal gatherings enhance collaboration. • Strong connections with global blue economy clusters. • Collaborations with universities, entrepreneurs, separate industries, and fisheries.	• Respondents identified as extremely willing to collaborate to reduce waste. • Some existing partnerships with non-profits, entrepreneurs, and other distributors.
Financing Opportunities	• Generate revenue through membership fees, rental agreements, OC House food halls, consultancy projects, and government grants • Potential to use crowd funding platforms.	• Identified financial burden as a primary challenge.
Market Development	• Heavily reliant on seafood exports to various countries. • Opportunities for market growth through certifications and branding.	• Need to explore export opportunities to international markets.

		• Need to develop marketing strategies to promote value-added seafood products.
Technological Innovation	• Leading industry in fish processing technology solutions. Innovation in automated processing, improved packaging techniques, and biotechnological applications. • High adoption rates of new technologies in fisheries.	• Some companies have adopted technologies such as grinders, vacuum seals, and dehydrators. • Willingness to invest in new technology was identified as a 3.71 out of 5.
Value-Added Product Development	• Diverse range of value-added products, including fish leather, collagen, enzymes, fertilizer, medicinal applications, fish leather, and food products.	• Utilization of value-added products such as ahi collar, tail, and belly, smoked marlin, fish dip, and pet treats. • Waste converted to low value-added products including compost and fertilizer.
Geography	• Volcanic island geography, heavily reliant on imports and exports, located close to European countries and Greenland.	• Volcanic island geography, heavily reliant on imports, a part of the U.S. economy. • Potential to become a key player in the Pacific Ocean blue economy.

Figure 6 Comparison of Iceland and Hawaii based on the document analysis themes

Collaboration

The document analysis suggests that collaboration is one, and likely the primary driver, for successful waste reduction in Iceland. Since Hawai‘i does not yet have an ocean cluster, it is crucial for distributors to establish partnerships with non-profit organizations, entrepreneurs, government agencies, fishers, and other distributors, as demonstrated by the IOC. The survey results reveal that all respondents are extremely willing to collaborate with outside entities to reduce FPW. Informal networking opportunities, similar to IOC’s coffee events, may be instrumental for Hawai‘i-based seafood distributors to collaborate with others to develop innovative solutions. Organizing events would provide a platform for distributors to introduce

their businesses, exchange ideas, and build relationships in an informal setting. Opening the doors to other entrepreneurs could facilitate the expansion of the industry's network and capabilities. Forging collaboration agreements would be the "low-hanging fruit" for Hawai'i seafood distributors providing the opportunity for resources, funding, and expertise for reducing FPW.

Leveraging personal connections is a great way to start the conversation, as demonstrated by the IOC. During a conversation with Dr. Alexandra Leeper, Managing Director at the IOC, she emphasized, "one thing that has been key from the beginning is strong personal networks, but also really finding those one or two case studies to start with. It doesn't need to be this big network of startups to begin with, but one or two where you can also help them tell their story, talk about what they're doing and that kind of momentum that brings then other startups to the table as well."

A major resource that the IOC and Oregon Cluster Initiative have utilized, and that the Hawaiian seafood industry could adopt, are educational institutions. The IOC has implemented a summer school program in collaboration with universities where students apply with a start-up idea and work on it throughout the summer (Den Hollander & Thorsteinsson, 2020). If the idea is viable by the end of the summer, the students are offered the opportunity to continue working with the IOC in the OC House as a start-up (Den Hollander & Thorsteinsson, 2020). Establishing a similar program in Hawai'i has the potential to spark sustainable seafood entrepreneurship in the community. In a separate example, the OCI has worked with Oregon State University to facilitate industry training and collaborates with the Food Innovation Center, which focuses on providing "technical, creative, and educational service to food industry, entrepreneurs, and Northwest communities, with a focus on quality, safety, and sustainability" (*College of*

agricultural sciences, n.d.). An opportunity that Hawai‘i-based distributors may be able to leverage is partnering with the UH Sustainable Community Food Systems and Fashion Design & Merchandising.

The long-term goal of establishing an ocean cluster would provide additional resources and networking opportunities for seafood distributors (see Appendix III for potential innovative collaborators in Hawai‘i). The founder of the Iceland Ocean Cluster, Thor Sigfusson, stated, “The most famous clusters in the world were not created by government or government policy….but the main drivers were businesses and universities which valued cooperation, and small companies realized soon that clustering is sensible and profitable” (2018). He goes on to state that the principal role the government can provide is the same opportunity as institutions, non-governmental organizations, universities, and startups to compete for government funding (Sigfusson, 2018). Distributors initiating a knowledge-sharing network within Hawaii’s seafood industry will first initiate the conversation to create an ocean cluster with the hope of garnering support from government grants and policies.

Financing Opportunities

Hawai‘i-based seafood distributors can address financial challenges identified in the survey by exploring alternative funding sources for product development. The experiences from the IOC demonstrate that distributors can accumulate funding through options such as government grants, consultancy projects, and crowd funding platforms tailored to sustainable initiatives. Government and private grants are likely the primary source of funding for distributors. A list of potential grants for reducing FPW can be found in Appendix IV.

Market Development

To enhance the market for value-added products from FPW, Hawai‘i distributors should first explore local market opportunities, collaborating with local restaurants, retailers, entrepreneurs, and farmer’s markets to help create demand for these products. Forming partnerships with government agencies, non-profit organizations, and educational institutions can facilitate market development initiatives and raise awareness of the importance of reducing FPW. These initiatives can include market research such as focus groups, surveys, and cost/benefit analyses of new products.

Furthermore, exploring international markets offers the potential for expansion of the products. Similar to the IOC, targeting countries with established seafood consumption cultures including Japan, the United States and European nations, can provide profitable opportunities for Hawai‘i distributors to export value-added products. Additionally, sustainable seafood certifications, such as MSC certification utilized by the IOC, can provide access to additional markets. This study shows that investing in branding and marketing efforts have been shown to enhance consumer perception and drive product demand.

Technological Innovation

Technological innovation has been proven to play a pivotal role in enhancing efficiency, reducing waste, and creating value in the Iceland seafood industry. Based on the survey results, Hawai‘i distributors are generally willing to invest in technological advancements to address waste management challenges. Out of the seven survey respondents for this question, five expressed their willingness to invest in new technology, while two indicated they were not willing to do so. Technologies such as grinders, vacuum seals, and poke cutting machines, were highlighted as beneficial by survey respondents.

Like some Hawai‘i distributors, the Oregon Cluster Initiative has found value in a commercial dehydrator. The goal is to produce dog snack treats from fish skins. In addition, the cluster partners plan to use a grinder to create crab bait disks, with Laura Anderson stating, “It doesn’t necessarily create the highest value, but it does create some and bait is expensive.”

Adopting automated systems and robotics in seafood processing can improve precision, leading to higher quality product and lower waste generation. For instance, automatic water jet robots can efficiently remove pin bones from fillets, maximizing the amount of fish meat obtained. Notably, however, automation has resulted in fewer jobs within the Icelandic fishing industry but has also created new entrepreneur, startup, and technology-focused jobs (Bjornsdottir et al., 2021). Another limitation to automation is its current inability to address a multi-species seafood industry, such as Hawai‘i. In addition to processing equipment, advancements in packaging technologies can preserve products and reduce waste. Investing in vacuum seals can extend the shelf-life of seafood products.

A major component of the IOC is the development of biotechnological applications. Hawai‘i seafood distributors can explore emerging biotechnological applications to valorize FPW and create new, high-value products. Biorefinery processes, such as bioprocessing, bioharvesting, bioprospecting, and bioremediation, can extract valuable compounds from FPW such as collagen and enzymes, for use in various industries. Outsourcing FPW to external biotech companies could be the most effective approach considering knowledge gaps and capacity limitations within distribution companies. Therefore, distributors should actively collaborate with biotech firms and support research and development initiatives focused on biotechnological innovation. This partnership has the potential to unlock new markets and revenue streams for distributors, while also reducing FPW.

Overall, by embracing technological innovation across all facets of operations, Hawai‘i-based seafood distributors can drive efficiency, sustainability, and competitiveness in the global market while also addressing waste management challenges and maximizing revenue from processing waste. Collaboration with technology providers, research institutions, and industry partners can facilitate the adoption and integration of innovative solutions, positioning Hawai‘i as a leader in sustainable seafood processing and distribution.

Value-Added Product Development

Value-added product development presents a major opportunity for Hawai‘i distributors to transform FPW into high-value products. Many challenges come with creating a new product. Laura Anderson underscores the difficulty in inspiring entrepreneurship, stating, “What does it take to spark that entrepreneurial spirit? That’s the hard part.” While she suggests there is no shortage of ideas or capital, she goes on to say, “finding people to do the work has been undoubtedly the biggest challenge…especially for small communities or island communities, like Hawai‘i.” Dr. Leeper of the IOC stated, “In terms of inspiring ideas…storytelling, for example, it's really important to tell those good stories that you've mentioned, the [fish] skin leather in Hawaii and workshops,” referring to CI Hawaii’s ongoing efforts to spark a fish leather industry in Hawai‘i.

Many value-added products require the expertise and capital that distributors might not have, and therefore, Hawai‘i seafood distributors should first prioritize the development of value-added products that align with their capacity, consumer preferences, and market trends. Products such as fish dips, smoked seafood, jerky, soups, and pet treats, identified in the survey, have gained traction on a small scale in Hawai‘i. By expanding their product offerings to include these value-added items, distributors can minimize waste and maximize revenue.

In addition to traditional food products, Hawai‘i seafood distributors can explore opportunities in the development of non-food value-added products derived from processing waste. For instance, fish skins can be processed into sustainable leather alternatives for the fashion industry, offering environmentally friendly materials for apparel, accessories, and footwear. Collaborating with local artisans and fashion designers can facilitate the creation of innovative and marketable fish leather products that appeal to consumers seeking sustainable and ethically sourced materials. The IOC has successfully collaborated with educational institutions to implement fish leather workshops, and CI Hawai‘i has begun to facilitate fish leather workshops with local artisans and seafood entrepreneurs with great success. Distributors can contribute to this new movement in Hawai‘i by supplying these workshops with fish skins that would otherwise be discarded, as well as partnering with local artisans and universities to facilitate this movement further.

Medicinal applications and supplements are other high-value products that may be produced from FPW. However, the technological feasibility of extracting these compounds plays a significant role in its success. Distributors can collaborate with manufacturers to supply them with raw materials from FPW to create these products.

Further research is needed for value-added product development in Hawai‘i, including cost/benefit analyses of new products, market analysis, and pilot projects. Conducting market studies to determine emerging trends and consumer preferences for value-added FPW products can inform product development strategies and identify opportunities in the market. Pilot projects would offer distributors an opportunity to test, learn and refine new product developments.

IV. Conclusion

Throughout this study, we have explored various facets of the seafood industry in Hawai‘i, with a focus on waste rates and management, value-added product development, technological innovation, market development, collaboration, and financing opportunities. By drawing comparisons with successful models such as the Iceland Ocean Cluster (IOC) and the Oregon Cluster Initiative (OCI), we gained valuable insights that could offer Hawai‘i-based seafood distributors a roadmap to better their waste management and contribute to a more sustainable and profitable industry.

Reflecting on the research questions presented at the start of the study, we can address them through the following key findings. First, the amount of processing waste produced by the survey respondents totaled to 245,680 pounds per month, generated from 1,128,200 pounds of seafood processed. Dr. Alexandra Leeper highlighted the initial step of mapping out quantities and types of waste. She goes on to state, “this will determine what makes both environmental, economic, and logistical sense,” regarding the appropriate management of the waste. Further studies are needed to determine large-scale implementation, particularly the economic perspective of value-added products from waste.

Second, sustainable products and uses of processing waste were discussed throughout the report, with the most promising high value-added products including fish leather, medicinal applications, dietary supplements, pet treats, and food products. Other effective products, while low in value addition, include animal feed, fish meal, fish silage, compost, and fertilizer (Figure

7). To ensure the success of these products, market research and pilot projects can help identify consumer preferences and market demand before scaling up production.

Figure 7 Value-added pyramid for seafood waste products (Sigfusson, 2020)

Lastly, best management practices to reduce seafood processing waste include the adoption of effective value-added and waste reduction technologies such as grinders and dehydrators. These technologies require minimal effort and can be more easily adopted by companies, while biotechnology and automated processing may require more significant investment and implementation efforts. Outsourcing waste to biotechnological companies presents an opportunity to further value-added product development. Distributors should also explore local and international market opportunities for value-added products from FPW. This involves collaborating with local restaurants, retailers, and farmer's markets to build the demand for these products. Exploring the potential for exporting byproducts or value-added products to international markets with established seafood consumption cultures offers further market growth for distributors.

Collaboration emerged as a cornerstone of successful best management practices, with this study highlighting the importance of partnerships with entrepreneurs, non-profit organizations, government agencies, fishers, and other distributors. Informal networking could spark collaboration, in turn, fostering innovation and knowledge sharing within the industry. In addition, aligning with local non-profit organizations, and other industry stakeholders, as well as lobbying government agencies, could encourage the creation of Hawaii's own ocean cluster. However, the industry's self-organization is critical to a successful cooperative.

By implementing the recommendations outlined in this report, seafood distributors can work towards minimizing waste and maximizing profit, while also promoting a sustainable seafood industry.

Study Limitations and Compliance with Ethical Standards

A limitation of this study pertains to the reproducibility of the project's methodology. Various qualitative data methods, including semi-structured interviews were used, which results in a level of subjectivity for the interviewer and participant. This poses challenges in replicating the study's findings. In addition, some survey responses were provided with varying levels of certainty, which could lead to discrepancies in replicated studies.

This project was conducted in compliance with ethical standards, including consultation with the Duke University Campus Institutional Review Board (IRB). Since the project did not align with the IRB's definition of research involving human subjects, it was decided that the project did not require an IRB review or approval. Furthermore, a level of anonymity was kept to maintain the privacy of Hawai‘i-based seafood distributors.

Bibliography

Alkaya, E., & Demirer, G. N. (2016). Minimizing and adding value to seafood processing wastes. *Food and Bioproducts Processing*, *100*, 195–202. https://doi.org/10.1016/j.fbp.2016.07.003

Aloha+ Challenge. (n.d.). https://alohachallenge.hawaii.gov/

Altintzoglou, T., Honkanen, P., & Whitaker, R. D. (2021). Influence of the involvement in food waste reduction on attitudes towards sustainable products containing seafood by-products. Journal of Cleaner Production, 285, 125487. https://doi.org/10.1016/j.jclepro.2020.125487

Annual Sustainability Scorecard. Aloha+ Challenge. (2021). https://alohachallenge.hawaii.gov/pages/2021-annual-sustainability-scorecard

Bjarnadóttir, B. (2020). *The tone was set in the past: Sustainability in new product development within the Icelandic marine industry* (thesis). *Skemman*. Retrieved December 15, 2023, from http://hdl.handle.net/1946/37021.

Björnsdóttir , B., Geirsdóttir, M., Guðmundsdóttir, E., Þorkelsson , G., Jónsdóttir , R., Þórðarson, G., Groben, R., Knobloch , S., Hauptmann , A., Vang, J., Gunnarsdóttir, I., Jóhannsson, R., Schönemann-Paul, L., & Smáradóttir, S. (2018). *Biorefining and biotechnology opportunities in the West Nordic Region*. Matís. https://www.matis.is/media/matis/utgafa/03-18-Arctic-Bioeconomy-II.PDF

Bjornsdottir, B., Reykdal O., Þórðarson G., Valsdóttir Þ., Jonsdottir R., Kvalvik I., Svorken M., Pleym I., Natcher D., and Dalton M. (2021). *Blue Bioeconomy in the Arctic region*.

Nofima. https://nofima.brage.unit.no/nofima-xmlui/bitstream/handle/11250/2733654/BBAR_final+2021.pdf?sequence=1

Bonilla, J. R., & Hoyos Concha, J. L. (2018). Methods of extraction, refining and concentration of fish oil as a source of omega-3 fatty acids. *Ciencia y Tecnología Agropecuaria*, *19*(3). https://doi.org/10.21930/rcta.vol19_num2_art:684

Bowen, G. A. (2009a). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*(2), 27–40. https://doi.org/10.3316/qrj0902027

Cardinaals, R. P., Simon, W. J., Ziegler, F., Wiegertjes, G. F., van der Meer, J., & van Zanten, H. H. (2023). Nutrient yields from global capture fisheries could be sustainably doubled through improved utilization and management. Communications Earth & Environment, 4(1). https://doi.org/10.1038/s43247-023-01024-9

Cheung, W. W., Maire, E., Oyinlola, M. A., Robinson, J. P., Graham, N. A., Lam, V. W., MacNeil, M. A., & Hicks, C. C. (2023). Climate change exacerbates nutrient disparities from seafood. *Nature Climate Change*, *13*(11), 1242–1249. https://doi.org/10.1038/s41558-023-01822-1

City of Honolulu Ordinance Food Waste Recycling, 98, Section 9-3.5 (2022)

Coderoni, S., & Perito, M. A. (2019). Sustainable consumption in the circular economy. an analysis of consumers' purchase intentions for waste-to-value food. Journal of Cleaner Production, 252, 119870. https://doi.org/10.1016/j.jclepro.2019.119870

College of agricultural sciences. College of Agricultural Sciences. (n.d.). https://fic.oregonstate.edu/

Cooney, R., de Sousa, D. B., Fernández-Ríos, A., Mellett, S., Rowan, N., Morse, A. P., Hayes, M., Laso, J., Regueiro, L., Wan, A. HL., & Clifford, E. (2023). A circular economy framework for seafood waste valorisation to meet challenges and opportunities for intensive production and Sustainability. *Journal of Cleaner Production*, *392*, 136283. https://doi.org/10.1016/j.jclepro.2023.136283

Coppola, D., Lauritano, C., Palma Esposito, F., Riccio, G., Rizzo, C., & de Pascale, D. (2021). Fish waste: From problem to valuable resource. *Marine Drugs*, *19*(2), 116. https://doi.org/10.3390/md19020116

Den Hollander, N., & Thorsteinsson, T. V. (2020, August 27). *A systematic approach to analyze industrial clusters: A case study of the Iceland ocean cluster*. DIVA. https://www.diva-portal.org/smash/record.jsf?dswid=-9836&pid=diva2%3A1461792

Dominy, W., Sato, V., Ju, Z. Y., & Mitsuyasu, M. (2014). *Fish Processing Waste: A Valuable Co-Product of the Fishing Industry* . Western Pacific Regional Fishery Management Council. November 12, 2023, http://www.wpcouncil.org/wp-content/uploads/2019/05/Dominy-et-al.-2014.-Fish-processing-waste-report-s.pdf

Environmental Protection Agency. (n.d.). *Sustainable Management of Food Basics*. EPA. https://www.epa.gov/sustainable-management-food/sustainable-management-food-basics

FAO. (2020). *The State of World Fisheries and Aquaculture 2020*. Food and Agricultural Organization of the United Nations. https://www.fao.org/3/ca9229en/ca9229en.pdf

Finger, D. C., Saevarsdottir, G., Svavarsson, H. G., Björnsdóttir, B., Arason, S., & Böhme, L. (2021). Improved value generation from residual resources in Iceland: The first step towards a circular economy. *Circular Economy and Sustainability*, *1*(2), 525–543. https://doi.org/10.1007/s43615-021-00010-7

Hansen, E., Holthus, P., Allen, C. L., Bae, J., Goh, J., Mihailescu, C., & Pedregon, C. (2018, February). OCEAN / MARITIME CLUSTERS: Leadership and Collaboration for Ocean Sustainable Development and Implementing the Sustainable Development Goals. World Ocean Council.

Lynch, M. (2018, May 31). *To feed itself, Hawai'i must make sea change, study finds*. Conservation International. https://www.conservation.org/blog/to-feed-itself-hawaii-must-make-sea-change-study-finds

Masterson, V., & Shine, S. (2023). What is the circular economy, and why does it matter that it's shrinking? World Economic Forum. https://www.weforum.org/agenda/2022/06/what-is-the-circular-economy/

Mattos-Hall, J. (2014). *Strategy Under Uncertainty: Open Innovation and Strategic Learning for the Iceland Ocean Cluster* (thesis). *Skemman*. Retrieved December 8, 2024, from http://hdl.handle.net/1946/18109.

M.D, S., Balange, A. K., Layana, P., & Naidu, B. C. (2023). Harnessing value and Sustainability: Fish waste valorization and the production of valuable byproducts. *Advances in Food and Nutrition Research*, 175–192. https://doi.org/10.1016/bs.afnr.2023.08.001

Minelgaite, I., Bjarnadottir, B. B., & Kristinsson, K. (2020). Walking the talk? sustainability in new product development projects in the Icelandic Seafood Industry. *Lecture Notes in Management and Industrial Engineering*, 137–149. https://doi.org/10.1007/978-3-030-60139-3_10

Naylor, R. L., Kishore, A., Sumaila, U. R., Issifu, I., Hunter, B. P., Belton, B., Bush, S. R., Cao, L., Gelcich, S., Gephart, J. A., Golden, C. D., Jonell, M., Koehn, J. Z., Little, D. C., Thilsted, S. H., Tigchelaar, M., & Crona, B. (2021). Blue food demand across geographic and temporal scales. *Nature Communications*, *12*(1). https://doi.org/10.1038/s41467-021-25516-4

Palomino, E. (2019). Introducing Fish Skin as a Sustainable Raw Material for Fashion. *Science for Sustainable Societies*, 229–246. https://doi.org/10.1007/978-981-32-9927-6_15

Palomino, E., Phiri, E., & Káradóttir, K. (2020). *Indigenous Fish-Skin Craft Revived Through Contemporary Fashion* (1–). https://oaks.kent.edu/node/10451

Peschel, A. O., & Aschemann-Witzel, J. (2020). Sell more for less or less for more? the role of transparency in consumer response to upcycled food products. Journal of Cleaner Production, 273, 122884. https://doi.org/10.1016/j.jclepro.2020.122884

Policymakers. ReFED. (n.d.). https://refed.org/stakeholders/policymakers/

Refsgaard, K., Kull, M., Slätmo, E., & Meijer, M. W. (2021). Bioeconomy – a driver for regional development in the Nordic countries. *New Biotechnology*, *60*, 130–137. https://doi.org/10.1016/j.nbt.2020.10.001

Ritchie, H. (2023, December 28). *Food production is responsible for one-quarter of the world's greenhouse gas emissions*. Our World in Data. https://ourworldindata.org/food-ghg-emissions

Saviolidis, N. M., Davíðsdóttir, B., Ilmola, L., Stepanova, A., Valman, M., & Rovenskaya, E. (2020). Realising blue growth in the fishing industry in Iceland and Norway: Industry perceptions on drivers and barriers to blue growth investments and Policy Implications. *Marine Policy*, *117*, 103967. https://doi.org/10.1016/j.marpol.2020.103967

Sigfusson, T. (2018, March 10). *Role of government in Clusters*. LinkedIn. https://www.linkedin.com/pulse/role-government-clusters-thor-sigfusson/

Sigfússon, T. (2020). *The New Fish Wave: How to ignite the Seafood Industry*. Leete's Island Books.

Teneva, L. T., Schemmel, E., & Kittinger, J. N. (2018). State of the plate: Assessing present and future contribution of fisheries and aquaculture to Hawai'i's Food Security. *Marine Policy*, *94*, 28–38. https://doi.org/10.1016/j.marpol.2018.04.025

World Wildlife Fund. (n.d.). Fight climate change by preventing food waste. WWF. https://www.worldwildlife.org/stories/fight-climate-change-by-preventing-food-waste

United Nations. (n.d.). *Goal 12 | Ensure sustainable consumption and production patterns*. United Nations. https://sdgs.un.org/goals/goal12

United States 2030 Food Loss and waste reduction goal. EPA. (2024, April). https://www.epa.gov/sustainable-management-food/united-states-2030-food-loss-and-waste-reduction-goal

Appendix I. Companies who pick up FPW In Hawai‘i

- Aloun Farms
- Island Commodities
- Aloha Harvest
- EcoFeed Inc.
- A&A Specialty Services

Appendix II. List of Ocean Innovation Clusters (Hansen et al., 2018)

Ocean/Maritime Cluster	**Website**
Alaska Fisheries Development Foundation (Previously the Alaska Ocean Cluster Initiative)	https://afdf.org
Arctic Maritime Cluster	Website not found
Asian Seafood Improvement Collaborative	http://www.asicollaborative.org
EU Blue Economy	https://blue-economy-observatory.ec.europa.eu/eu-blue-economy-sectors_en
Blue Legasea	http://www.legasea.no
Blue Maritime Cluster	http://www.bluemaritimecluster.no/
Centre of Expertise Programme	Website not found
Cleverland Water Alliance	http://www.clevelandwateralliance.org/
Cluster Excellence Denmark	http://www.clusterexcellencedenmark.dk/

Dubai Maritime City	http://www.dubaimaritimecity.com/
European Network of Maritime Clusters	http://enmc.eu/
GCE Subsea	http://www.gcesubsea.no
International Maritime Center	http://www.mpa.gov.sg/
Irish Maritime and Energy Resource Center	http://www.imerc.ie/
MARCOD- Maritime Centre for Operations	Website not found
Marine South East	http://www.marinesoutheast.co.uk/
Gujarat Maritime Cluster	https://maritimecluster.org/
Maritime Cluster Funen (Fyns Maritime Cluster)	Website not found
Maritime Cluster Northern Germany	http://www.maritimes-cluster.de/
Maritime Technology Cluster FVG- mareTC FVG	http://www.marefvg.it/en
Nagasaki Maritime Industry Cluster Promotion Association	https://noa.nagasaki.jp/en/team/
NCE Maritime CleanTech	https://maritimecleantech.no
NCE Seafood Innovation Cluster	http://www.seafoodinnovation.no
Nederland Maritiem Land	http://www.maritiemland.nl/

Nelson Mandela Bay Maritime Cluster	https://saimi.co.za/site/uploads/resource/final_draft_-_nmbmc_framework_plan_2019.pdf
New England Ocean Cluster	http://www.newenglandoceancluster.com/#neoc
Norwegian Innovation Clusters	http://www.innovationclusters.no/english
Oceans Advance	http://www.oceansadvance.net/
Pôle Mer Méditerranée	https://polemermediterranee.com/
Smart Ocean Initiative	https://www.marine.ie/
Technopole Maritime du Québec	http://www.tmq.ca/
Foro Maritimo Vasco	www.fmv.eus
French Maritime Cluster	http://cluster-maritime.fr/en
Iceland Ocean Cluster	http://www.sjavarklasinn.is/en
The Maritime Alliance	http://www.themaritimealliance.org/
Maritime Development Center	https://maritimecenter.dk/
Ocean Technology Council of Nova Scotia	http://otcns.ca/
Vancouver International Maritime Centre	https://vmcclimate.ca/
Vinnväxt	https://www.vinnova.se/m/vinnvaxt/

Appendix III. Finding Innovative Collaborators

Company	About	Website
Ocean Era (formerly Kampachi Farms)	A mariculture technology startup focused on environmentally responsible seafood.	https://ocean-era.com/
Maui Food Technology Center	The nonprofit organization is committed to fostering and supporting entrepreneurs in various fields, including value-added products, agriculture, cultural practices, food, environmental sustainability, technology, and economic diversification.	https://mauifoodtechnology.org/
Kuehnle AgroSystems, Inc. (KAS)	A biotechnology company that researches and develops specialty chemicals and raw materials including cosmetic and skincare products using microalgae.	https://www.kuehnleagro.com/old-home
Common Ground	A hospitality and lifestyle company that aims to invest in circular economy initiatives within the food sector and provide distribution channels for local products.	https://commongroundkauai.com/
Pono Pacific	A privately-owned conservation company specializing in land management, restoration services, sustainable agricultural development, and eco-asset development. They operate across the state, catering to both large and small-scale projects.	https://www.ponopacific.com/about-us/experience/
Oceanit	Oceanit is a pioneering "Mind to Market" company that develops new technology to solve current problems.	https://www.oceanit.com/about-us/
UH Sustainable Community Food Systems	SCFS program trains the next generation of food industry professionals, working to solve real-world problems in agriculture, planning, business, research and more.	https://westoahu.hawaii.edu/academics/degrees/applied-science/sustainable-community-food-systems/
UH Fashion Design & Merchandising	The FDM program at UH focuses on the fashion world in Hawai'i and across the globe. There may be potential to collaborate on fish leather startups.	https://cms.ctahr.hawaii.edu/Majors/FDM
CTAHR Cooperative Extension Food Systems Initiative	Cooperative Extension serves as an outreach branch of the UH Manoa's College of Tropical Agriculture and Human Resources. CE focuses on supporting local food systems, fostering youth development, and advocating for the stewardship of natural resources to benefit future generations.	https://manoa.hawaii.edu/ctahr/getlocal/foodsystems/
Transforming Hawaiis Food System Together	Transforming Hawai'i' Food System Together is a statewide initiative to create a more sustainable and resilient food system.	https://transforminghawaiifoodsystem.org/
Hawai'i Good Food Alliance	The Hawai'i Good Food Alliance brings together community leaders who produce and distribute food. The goal of the organization is to build community food systems.	https://hawaiigoodfoodalliance.org/
Hui Na Mea 'Ai Hawai'i	Hui Na Mea Ai' Hawai'i is a non-profit organization focused on empowering Hawaii to become a leading force in agricultural technology and culinary innovation. Their mission includes sharing the richness of Hawaii's food and culture on a global scale.	https://huinameaaihawaii.org/
Emerald Nutraceutical	Emerald Nutraceutical is a leading provider of private label supplements in Hawaii and nearby regions. They specialize in formulating and manufacturing supplements within their own clean rooms and GMP certified facilities in Hawaii.	https://www.emeraldnutra.com/manufacturing-near-me/hawaii/
Hawaii Nutrition Company	The company specializes in Hawaiian grown botanicals to develop nutritional supplements.	https://hawaiinutrition.com/pages/about-us
Nutrex Hawaii	Nutrex Hawaii utilizes microalgae to produce nutritional supplements and is commited to environmental sustainability.	https://www.nutrex-hawaii.com/pages/about-us
Cyanotech	The parent company to Nutrex Hawaii, Cyanotech provides high quality microalgae products for health and human nutrition, with an emphasis on environmental sustainability.	https://www.cyanotech.com/our-purpose/
Hawaii Ocean Science & Technology Park	This innovative green economic development park serves as an ocean science hub in Kailua-Kona, bringing togetther emerging technologies and sustainable solutions.	https://www.hostpark.io/
Hatch Blue	Hatch Blue is an aquaculture and alternative seafood specialist that combines venture funds for seafood entrepreneurs.	https://www.hatch.blue/

Appendix IV. Funding Opportunities

Funding Resource	Application Dates	Funds ($)	Elligibility	Description	Website
EDA Build to Scale	Check back for 2024 funding	Not specified	Venture Challenge: intermediary organizations such as accelerators, universities, municipal governments, and non-profits supporting new business ventures Capital Challenge: startups, organizations with a goal to expand capital deployment in a community, programs that practice equity-base investing, technology startups that foster the growth of a regional technology cluster	The Build to Scale program aims to assist entrepreneurial innovators in accessing knowledge, capital, and networks to develop products using emerging technologies. The program also looks to foster cross-sector partnerships, demonstrate the importance of diverse and inclusive entrepreneurial ecosystems, and address structural barriers that impede access to equity capital.	https://www.eda.gov/funding/programs/build-to-scale?q=/oie/buildtoscale/
FY2023 Ocean-Based Climate Resilience	Check back for 2024 funding	$50,000 - $250,000	Private institutions of higher education Nonprofits having a 501(c)(3) status with the IRS, other than institutions of higher education State governments Native American tribal governments (Federally recognized) City or township governments Public and State controlled institutions of higher education Small businesses County governments Native American tribal organizations (other than Federally recognized tribal governments) Special district governments	The NOAA Climate Resilience Accelerators funding opportunity focuses on funding accelerator entitities that assist businesses in navigating avenues for commercializing ocean-based climate resilience solutions.	https://www.grants.gov/search-results-detail/349164
USDA Partnerships for Climate-Smart Commodities	Check back for 2024 funding	$3.1 billion for 141 projects	County, city or town governments. State governments. Small businesses For-profit organizations other than small businesses Federally recognized Native American Tribal governments Native American Tribal organizations other than Federally recognized Tribal governments Nonprofits that have a 501(c)(3) Nonprofits that do not have a 501(c)(3) Private institutions of higher education Public and State-controlled institutions of higher education	This programs hopes to broaden markets for climate-smart commodities, leverage the greenhouse gas advantages of climate-smart commodity production, and provide direct benefits to production agriculture, including for small and underserved producers.	https://www.usda.gov/climate-solutions/climate-smart-commodities
NOAA Fisheries Saltonstall-Kennedy Grant Competition	Check back for 2024 funding	no less than $25,000 and no greater than $500,000, for up to a 2-year period	U.S., Republic of the Marshall Islands, Republic of Palau, or the Federated States of Micronesia citizens Corporations, partnerships, associations, or other non-federal entity, including non-profit	The goal of the S-K Program is to enhance U.S. fisheries by aiding the fishing community in addressing marketing and research needs. The FY24 invitation seeks applications that fall into one of the three main priorities: -Promotion and Marketing -Development, Infrastructure, and Capacity Building -Science or Technology that Enhances Sustainable U.S. Fisheries	https://www.fisheries.noaa.gov/grant/saltonstall-kennedy-grant-competition
Cliff Bar Family Foundation, Operational Support	March 1 and August 1	Not specified	By invitation only	The program aims to fund projects that strengthen food systems, promote equitable community health and protect the environment and natural resources.	https://cliffamilyfoundation.org/grants-program

Funding Resource	Application Dates	Funds ($)	Elligibility	Description	Website
Regional Food System Partnerships	14-May-24	$100,000 to $1,000,000	Agricultural businesses or cooperatives, producer networks or associations, community supported agriculture networks or associations, food councils, local governments, nonprofit corporations, public benefit corporations, economic development corporations, regional farmers market authorities, and tribal governments.	The RFSP program supports collaborations between public and private entities to develop local or regional food systems. The program funds partnerships that develop relationships between local and regional producers, processors, intermediaries, and institutional markets or food service operations.	https://www.ams.usda.gov/services/grants/rfsp
USDA Community Food Projects Competitive Grants Program	Check back for 2024 funding	$25,000 - $400,000	Public food program service providers, tribal organizations, or private nonprofit entities	The objectives of CFPCGP include: meet nutritional needs of low-income individuals, increase the self-reliance of communities, enhance responses to local food or nutrition issues, meet specific state, tribal, local, or neighborhood food needs. The program is requesting food loss and waste efforts.	https://www.nifa.usda.gov/grants/funding-opportunities/community-food-projects-competitive-grants-program
USDA Food Safety Outreach Program	February 13, 2024 Check back for 2025 funding	$75,000 - $1,000,000	1. The Cooperative Extension Service for a U.S. state or territory; 2. Non-government organizations and/or community-based organizations representing owners and operators of farms, small food processors, or small fruit and vegetable merchant wholesalers that has a commitment to public health and expertise in administering programs that contribute to food safety; 3. Federal, State, local, or tribal agencies; 4. An institution of higher education or a foundation maintained by an institution of higher education; 5. A collaboration of two or more eligible entities.	Awardees of this program will generate and implement food safety education, outreach, and technical assistance projects that address the needs of owners and operators of small to mid-sized farms, beginning farmers, socially-disadvantaged farmers, small processors, or small fresh fruit and vegetable merchant wholesalers. Grant applications will be solicited directly from those in local communities to include those from community-based organizations, non-governmental organizations, food hubs, farm cooperatives, extension, and other local groups.	https://www.grants.gov/search-results-detail/351306
USDA Farmers Market Promotion Program	14-May-24	Capacity Building: $50,000 to $250,000 Community Development Training and Technical Assistance: $100,000 to $500,000	Agricultural businesses and cooperatives Community Supported Agriculture (CSA) networks and associations Food Councils Economic development corporations Local governments Nonprofit and public benefit corporations Producer networks or associations Regional farmers' market authorities Tribal governments	The Farmers Market Promotion Program (FMPP) funds projects that "develop, coordinate and expand direct producer-to-consumer markets to help increase access to and availability of locally and regionally produced agricultural products by developing, coordinating, expanding, and providing outreach, training, and technical assistance to domestic farmers markets, roadside stands, community-supported agriculture programs, agritourism activities, online sales or other direct producer-to-consumer (including direct producer-to-retail, direct producer-to-restaurant and direct producer-to-institutional marketing) market opportunities."	https://www.ams.usda.gov/services/grants/fmpp
Blooming Prairie Foundation Grant	March 1, 2024; check back for 2025 funding	Not specified	503(c)3 status or conduct any of the following activities: Developmental, research and education efforts in the organic industry and the cooperative community; The development of organic and natural products or services; Cooperative development in the natural products or organic industry.	The Blooming Prairie Foundation is funding projects that enhance the development of natural and organic products. The organization aims to improve the health of people, the planet, and the cooperative business model by supporting development and research efforts.	http://www.bloomingprairiefoundation.org/apply
USDA Local Food Promotion Program	14-May-24	Not specified	Agricultural businesses and cooperatives. Community Supported Agriculture (CSA) networks and associations. Food councils. Economic development corporations. Local governments. Nonprofit and public benefit corporations. Producer networks or associations. Regional farmers' market authorities. Tribal governments.	The Local Food Promotion Program (LFPP) provides funding to projects that develop and expand regional food businesses that "engage as intermediaries in indirect producer to consumer marketing to help increase access to and availability of locally and regionally produced agricultural products." Grants can be used for the planning stages of establishing or expanding food business enterprise or to improve food businesses that support regionally produced products by assisting in feasibility studies, market research, training and technical assistance.	https://www.ams.usda.gov/services/grants/lfpp

Funding Resource	Application Dates	Funds ($)	Elligibility	Description	Website
Good Food Institute Research Grant Program	23-May-24	Not specified	Any sector (academia, government, industry, nonprofits)	The program aims to fund innovative projects that advance the science and technology of the plant-based, fermentation-derived, and cultivated meat industries. “Meat” includes seafood such as fish and shellfish. Each RFP identifies priorities for research and can be submitted from any sector (academia, government, industry, nonprofits, etc.).	https://gfi.org/researchgrants/?gclid=Cj0KCQiAoKeuBhCoARIsAB4Wxtc8W62jZXqgcy5DXZHn6sWuzWj85IdhKA31InhDavsRLShD6Oo1LLoaAhHvEALw_wcB
NSF 24-525: Future Manufacturing (FM)	April 11, 2024 January 13, 2025	$28,000,000 split between 16 awards	Higher education institutions non-profit and non-academic organizations, for-profit organizations, state and local governments, tribal nations	Future Manufacturing hopes to support fundamental research, education, and training of a future workforce to overcome scientific, technological, educational, economic, and social hurdles to accelerate new manufacturing capabilities.	https://new.nsf.gov/funding/opportunities/future-manufacturing-fm/nsf24-525/solicitation#awd_info
Agriculture and Food Research Initiative Competitive Grants Program: Foundational and Applied Science Program	Varies by program area Novel Foods and Innovative Manufacting Technologies: September 26, 2024	Varies by program area	State Agricultural Experiment Station Colleges and universities (including junior colleges offering associate degrees or higher) University research foundations Other research institutions and organizations Federal agencies National laboratories Private organizations or corporations Individuals who are U.S. citizens, nationals, or permanent residents	The AFRI Foundational and Applied Science Program supports grants across six priority areas to advance knowledge in both fundamental and applied sciences important to agriculture. The six priority areas include: Plant Health and Production and Plant Products; Animal Health and Production and Animal Products; Food Safety, Nutrition, and Health; Bioenergy, Natural Resources, and Environment; Agriculture Systems and Technology; and Agriculture Economics and Rural Communities. *Please check the RFA to identify the best program area for your specific project as well as the due date. *Novel Foods and Innovative Manufacturing Technologies may be most relevant to seafood distributors	https://www.nifa.usda.gov/grants/funding-opportunities/agriculture-food-research-initiative-foundational-applied-science
Meat and Poultry Processing Expansion Program	Check back for 2024 dates	$250,000 - $10,000,000	Entities that engage in meat and poultry processing, including private, non-profit, tribal, cooperative, state or local government, among other entities.	The Meat and Poultry Processing Expansion Program (MPPEP) offers grants to assist eligible processors expand their processing capacity, enabling new and improved processing options for meat and poultry producers.	https://www.rd.usda.gov/programs-services/business-programs/meat-and-poultry-processing-expansion-program
Small Business Innovation Research and Small Business Technology Transfer Programs Phase I	Check back for 2024 dates	$125,000 - $175,000	Small businesses	The USDA SBIR/STTR programs aim to translate scientific breakthroughs into products and services that have commercial potential and/or societal benefit. The programs support small businesses in the creating of innovative technologies and enable the application of research innovations to markets. The STTR program facilitates technology transfer through cooperative R&D efforts between small businesses and nonprofit research institutions.	https://www.nifa.usda.gov/grants/funding-opportunities/small-business-innovation-research-small-business-technology-transfer
Value-Added Producer Grants	April 11, 2024; check back for 2025 dates	Maximum: Planning Grants $75,000; Working Capital Grants: $250,000.	Independent producers (includes harvesters and steering committees), agricultural producer groups, farmer- or rancher-cooperatives, and majority-controlled producer-based business ventures, as defined in the program regulation, are eligible to apply for this program.	The Value-Added Producer Grant (VAPG) program assists agricultural producers beginning value-added activities to innovate new products, create and expand marketing opportunities, and boost producer income.	https://www.rd.usda.gov/programs-services/business-programs/value-added-producer-grants/hi#overview
Seeding The Future Global Food System Challenge	Check back in June for 2024 submission dates	$25,000 - $250,000	National or international universities, research institutions, non-profits, and small or early-stage for-profit businesses	The Challenge provides three levels of awards incentivizing transformative food system innovations in different development stages: Seed Grants, Growth Grants, & Seeding the Future Grand Prizes	https://www.ift.org/food-system-challenge/grants-and-awards