100% Great Lakes Fish

Engagement Summary and Recommendations Fuqua Client Consulting Practicum



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Executive Summary

This report presents a comprehensive analysis by Duke University's Fuqua Client Consulting Program (FCCP) of opportunities to maximize the value of fish byproducts in the Great Lakes and St. Lawrence region. Guided by the vision of the Great Lakes St. Lawrence Governors and Premiers, the project identifies economically viable, environmentally sustainable uses for fish processing residuals or underutilized parts of the fish that typically amount to fish waste.

Project Overview

The objective of this project was to identify between 2-4 commercially viable products that would maximize the utilization of byproducts from Great Lakes-caught fish, aquaculture-farmed fish, and fish from the region's sport fishery. In addition to reducing waste, these products needed to be suitable for small-batch production within a 6-to 18-month timeframe. To achieve these aims, our team conducted 10 in-depth stakeholder interviews with fisheries, processors, and aquaculture operators across the United States and Canada. Additionally, we conducted a comprehensive market analysis of 18 potential product concepts, rigorously evaluating each through a custom weighted matrix that assessed market potential, operational feasibility, regulatory considerations, and financial viability. This approach ensured that our final recommendations are both actionable and closely aligned with the priorities of the Great Lakes and St. Lawrence region.

Approach and Methodology

The team's approach included:

- Reviewing existing literature and industry data
- Conducting interviews with key stakeholders, including processors, entrepreneurs, and researchers
- Establishing feasibility criteria based on market demand, technical viability, and sustainability
- Assessing and prioritizing product opportunities

Key Findings

The analysis identified pet treats and fish leather goods as the most promising opportunities.

- **Pet Treats:** Strong market demand, straightforward processing, and clear sustainability messaging make this a leading candidate.
- **Culinary Collaborations:** A viable option to collaborate with existing seafood restaurants with a commitment to local development and waste minimization without the additional

risk of creating a product from scratch and acquiring licensure from adequate commercial production kitchens.

• Fish Leather Goods: Emerging interest in sustainable fashion and artisanal products positions fish leather as a unique, high-value product. Workshops and collaborations can further enhance awareness and revenue streams.

There is growing momentum for circular economy solutions in the region. Culinary collaborations and creative partnerships are expanding public awareness and market interest in underutilized fish resources.

A range of other products-including animal feed, fish oil, fish meal, and pet food-were evaluated. While some show potential, they face greater technical, regulatory, market or profitability barriers. Products including anaerobic digestion, bait, beauty products, biofuels, bioplastics, collagen beverages & supplements, fertilizer & compost, and medical applications were deemed outside the current project scope or not feasible based on preliminary analysis.

Conclusion

The "100% Fish" project demonstrates that with targeted investment and collaboration, the Great Lakes and St. Lawrence region can lead in sustainable fisheries innovation. By transforming fish byproducts into high-value goods, the region can reduce waste, create new economic opportunities, and advance its reputation as a leader in the blue economy.

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Introduction

The Great Lakes St. Lawrence region accounts for 21% of the world's surface freshwater while supporting a nearly \$8 trillion (US) economy through critical industries including commercial fisheries and aquaculture. However, systemic inefficiencies persist as commercial fish processing operations typically discard 60% of each fish caught, representing both environmental liability and missed economic value.¹ The Conference of Great Lakes St. Lawrence Governors & Premiers (GSGP) launched the 100% Great Lakes Fish Initiative to transform this challenge into opportunity.² Duke University's Fuqua Client Consulting Program (FCCP) student research directly supports GSGP's mandate to minimize waste while creating value whether it is through creating single-chew pet treats, involving restaurants to diversify their menus, or partnering with small-scale sustainable clothing manufacturers. All currencies in this report are in U.S. dollars.

Background

Great Lakes and St. Lawrence Governors and Premiers

GSGP is a North American intergovernmental organization that brings together the chief executives of eight U.S. states – Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin – and the Canadian provinces of Ontario and Québec. Established in 1983, GSGP's mission is to foster economic growth in the region, which boasts a nearly \$8 trillion economy. The organization undertakes a broad portfolio of projects that collectively support the region's environmental health and economic vitality. Their initiatives span the protection and restoration of the Great Lakes, sustainable water management, and the prevention of aquatic invasive species. GSGP also advances regional economic interests through international trade promotion, tourism development, and efforts to modernize maritime transportation. Additional projects focus on maximizing the value of regional resources, such as promoting full utilization of Great Lakes fish. By addressing priorities ranging from ecosystem preservation to economic growth and cross-border cooperations, GSGP's work aims to ensure the long-term resilience and prosperity of the Great Lakes St. Lawrence region.³

¹ "About Us," Great Lakes St. Lawrence Governors and Premiers, <u>https://gsgp.org/about-us/</u>.

² "Hudson Valley Fisheries Joins 100% Great Lakes Fish Pledge," Great Lakes St. Lawrence Governors & Premiers, <u>https://gsgp.org/projects/100-great-lakes-fish/100-great-lakes-fish-news/hudson-valley-fisheries-joins-100-great-lakes-fish-pledge/</u>.

³ "About Us," Great Lakes St. Lawrence Governors and Premiers, <u>https://gsgp.org/about-us/</u>.

100% Fish

The 100% Great Lakes Fish Initiative, led by GSGP, aims to advance circular economy practices in the region's fisheries by identifying sustainable business opportunities that maximize the use of fish resources. Building on the Iceland Ocean Cluster's success in repurposing fish waste into high-value products, this project supports GSGP's mission to promote sustainable economic development and reduce environmental impact across industries.

The initiative centers on the goal of achieving full utilization of each fish caught, produced, or processed in the Great Lakes region. Up to 60% of a fish's biomass typically goes to waste; the project seeks to redirect this material into economically valuable uses.⁴ By integrating similar models in the Great Lakes region, the 100% Fish campaign not only aspires to enhance economic returns for local fisheries but also addresses critical environmental concerns, such as waste reduction and climate resilience. This effort represents a significant step toward creating a circular economy in the fisheries sector, where products are reimagined as inputs for new industries, driving sustainability and innovation across the supply chain.

FCCP Background

The Fuqua Client Consulting Practicum is a for-credit experiential learning course at Duke University's Fuqua School of Business. The goal of FCCP is to enhance students' business education by developing collaborative consulting engagements in which students assist organizations in addressing existing and emerging challenges.⁵ The FCCP student team engaged with GSGP on this project between December 2024 and April 2025.

Project Scope

The objective of this project was to identify 2-4 high-potential fish products, encompassing material generated by the Great Lakes commercial fishery, aquaculture sources in the region, and the region's sport fishery; and to develop high-level business plans that enable small-scale manufacturing and sustainable utilization of these fish resources over the next 6-18 months. The research focused primarily on the U.S. market due to policy uncertainty during the project.

⁴ "100% Great Lakes Fish Initiative," Great Lakes St. Lawrence Governors and Premiers, <u>https://gsgp.org/projects/100-great-lakes-fish/overview/</u>.

⁵ "About FCCP." Fuqua Client Consulting Practicum. Accessed April 21, 2025. <u>https://sites.fuqua.duke.edu/fccp/about/</u>.

The research sought to answer the following guiding questions:

- 1. What are existing fish products on the North American or international markets that can be manufactured at a small scale (e.g. pet treats, fish leather, etc.)?
- 2. What is the existing supply for these products and where is their raw material sourced?
- 3. What are other potential products that might not be on the market yet and could be manufactured on a small scale? What barriers are there to bringing these products to market?
- 4. From the questions above, what are 2-4 promising opportunities for fish products made from raw materials generated in the region?
- 5. What would a very high-level business plan look like, including the capital, equipment, transportation, labor, and other needs to get a small business or sole practitioner up and going with these new fish products?

Approach

The work was conducted over four project phases: conducting research, engaging stakeholders, evaluating potential products, and developing recommendations.

The research phase began by grounding ourselves in the context of the project and defining the project objective with GSGP staff. We collaborated with client representatives, David Naftzger and John Schmidt, to frame the problem so that it was not only about sustainability, but also about regional economic development and equity for small producers, tribal communities, and entrepreneurs around the Great Lakes region. Our initial research covered the Great Lakes region, circular economy in fisheries as well as other industries, and the Iceland Ocean Cluster 100% Fish model. We also examined existing companies using fish byproducts to understand potential products and business models.

Next, we conducted in-depth stakeholder interviews with 10 key stakeholder groups. More information about these interviews can be found in the section below.

The third step was to evaluate the suitability of 18 potential products for small-scale manufacturing within the next 6-18 months. To translate qualitative insights into actionable recommendations, we developed a custom feasibility evaluation matrix based on insights from our research and stakeholder interviews. Products were first ruled out by the feasibility of bringing them to market within 6-18 months based on regulatory and research & development requirements. The remaining product ideas were ranked against the feasibility criteria. More information about these criteria can be found in the Feasibility Criteria section below. From this rigorous evaluation process, we identified seven high-potential products which were further

compared on a scale of both "Profitability" and "Ease of Implementation". This helped us identify our final three recommended products.

For each of these three products, we developed high-level business plans, including startup cost estimates, revenue potential, key risks, legal considerations, and ideal distribution channels.

Stakeholder Interview Summary

We conducted in-depth stakeholder interviews with 10 key stakeholder groups to gather insights and expertise around utilizing fish waste and better inform our recommendations. We used semi-structured interviews to gather qualitative and quantitative insights around market demand, operational constraints, certification hurdles, consumer trends, and capital requirements. While most stakeholders worked within the Great Lakes region, we also spoke with individuals from other geographies to learn how similar topics are addressed elsewhere. Stakeholders represented each part of the fish waste value chain as shown below, except for consumers.

Exhibit 1: Fish Product Value Chain



The stakeholders interviewed are summarized below.

Exhibit	2:	Stakeholders	Interviewed
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Name	Organization/Role	Organization's Value Chain		
		Role		
Dr. Alexandra Leeper	Iceland Ocean Cluster, CEO	Industry Expert		
Audrey Comte & Dave	Freshwater Fish Market Corp,	Primary Production, Primary		
Bergunder	VP of Operations and VP of	Processing		
	Field Operations			
Doug Craven	Little Traverse Bay Bands of	Primary Production		
	Odawa Indians, Natural			
	Resource Director			
Eric Montagne	Locals Seafood, Director of	Secondary Manufacturing,		
	Production Operations	Distribution & Retail		
Joe Manthei	Fiskur Leather, Fish Leather	Secondary Manufacturing,		
	Entrepreneur	Distribution & Retail		

John & Everett Omstead	John O's Foods, Owners	Primary Production, Primary
		Processing
Dr. Martin Smith	Duke University,	Industry Expert
	Environmental Economics	
	and Marine Sciences	
	Professor	
RJ Taylor	Springhills Fish, Owner	Primary Production,
		Distribution & Retail
Sara Erickson	AlaSkins, Pet Treat	Secondary Manufacturing,
	Entrepreneur	Distribution & Retail
Seth Jenks & Will Herrington	TriNav Fisheries, Regional	Industry Experts
	Fisheries Consultants	

The takeaways from the interviews helped to frame the criteria we used to analyze product feasibility. The key takeaways are highlighted below:

Market Potential

 Consumer Demand - Consumer demand is one of the biggest limiting factors for scaling. Joe Manthei from Fiskur Leather shared that, "the products are easier to sell at art fairs than craft fairs," generally due to the higher consumer willingness to pay at an art fair.⁶ Consumer demand seemed to be a common hurdle amongst sustainable goods. Jarrett Schlaff, Co-founder and CEO of Pingree Detroit, which upcycles automotive leather into handcrafted goods, shared a similar message: "The greatest challenge for us has been demand for our products. We have more automotive waste than we can utilize so while we've diverted 48k lbs of waste from landfill, we could divert 10x (that) per year if we had demand for what we make. And we don't have a marketing budget to scale. That's been our greatest need."⁷

Operational & Technical

- Scalability Some products are easier to scale than others due to the production process required. When asked about products that can be produced at a small scale, Dr. Martin Smith from Duke University said, "High-value niche products offer strong margins but limited scalability and require high labor input."⁸
- **Seasonality** Byproduct supply is inconsistent throughout the year due to seasonality of commercial fishing. John Omstead from John O's Foods pointed out that, "If the small

⁶ Joe Manthei. Fiskur Leather, Online Interview, February 11, 2025.

⁷ Jarrett Schlaff, email message to author, February 13, 2025.

⁸ Dr. Martin Smith. Duke University, Online Interview, March 5, 2025.

manufacturers can handle frozen byproduct, they would ensure more consistent supply."⁹

 Volume – Sorting out small volumes of byproduct is often inconvenient for processors but necessary for the limited capacity of small-scale manufactures. Large-scale manufacturers often have minimum volume requirements that are difficult to meet. Dr. Alexandra Leeper, CEO of Iceland Ocean Cluster advised, "Don't be afraid of collaboration – it's too hard to do it alone, especially to reach those volumes."¹⁰

Legal

- Certifications Many byproduct markets require specific certifications so that the end product can be labeled or marketed a specific way. According to Audrey Comte of Freshwater Fish Market Corp, "Eco-certifications are critical for access to pet food and premium byproduct markets."¹¹ This can be a challenge for processors that handle fish from multiple locations or sources because of traceability.
- Local Zoning Local zoning and neighbor issues impact the feasibility of some products, such as composting.

Financial

- Equipment & Storage Costs There are high upfront costs for the equipment to process and store byproducts.
- Thin Margins The true cost of byproducts is often underestimated by byproduct purchasers, which often leads to low willingness to pay and small margins. However, processors must expend extra effort to prepare byproducts, especially at very small quantities. RJ Taylor from Springhills Fish highlighted the difficulty saying, "People often thought that the byproduct was free, so they were doing the fish farm a favor, but really it required more work for the fish farm to grind, store, move about, and treat the byproduct."¹²
- **Transportation Costs** Transportation is one of the highest costs in the value chain due to product weight, refrigeration requirements, and geographic distance. Transportation costs sometimes made otherwise promising uses for fish waste infeasible.

Feasibility Criteria

Products were assessed using feasibility criteria that we developed based on insights from our research and stakeholder interviews and then validated with GSGP staff. The criteria had four

⁹ John & Everett Omstead. John O's Food, Online Interview, February 12, 2025.

¹⁰ Alexandra Leeper. Iceland Ocean Cluster, Online Interview, March 18, 2025.

¹¹ Audrey Comte & Dave Bergunder. Freshwater Fish Market Corp, Online Interview, April 2, 2025.

¹² RJ Taylor. Springhills Fish, Online Interview, February 6, 2025.

key categories: market potential, operational & technical, legal, and financial. Each category had respective sub-criteria that are shown in the exhibit below.

Exhibit 3: Feasibility Criteria



Each category was assigned weights the following weight by GSGP staff:

- Market Potential 60%
- Operational & Technical 20%
- Legal 10%
- Financial 10%

Recommended Products

The team identified the following three products as feasible for small-scale manufacturing within the next 6-18 months: pet treats, lake to plate culinary collaborations, and fish leather goods and courses. A high-level business plan for each product is outlined below.

Pet Treats

Dehydrated pet treats and chews made from fish byproducts, such as skin, frames, and offcuts, offer a high-value, sustainable solution to reducing waste from Great Lakes fisheries. These treats are typically single-ingredient and minimally processed, often requiring only slicing, drying, and packaging. The most common products include fish skin jerky, dehydrated chews, and fish-based biscuit-style snacks. This category is attractive due to its simplicity, legal flexibility, and alignment with circular economy principles.

Product Benefits and Challenges

Pet treats have low start-up costs, support a circular economy, and have regulatory exemptions in some states. However, key challenges include food safety and supply chain variability.

One of the most compelling advantages of pet treats is their low start-up cost. Home dehydrators can cost as little as \$40¹³, while commercial units range from \$3,000 to \$8,000¹⁴, requiring no heavy processing or extrusion equipment. This affordability makes the business model scalable, even for operations with limited capital. Furthermore, upcycling local fish waste into pet treats supports environmental stewardship by reducing organic waste and creating a closed-loop economy. While each state has its own regulations about pet treats, several states, such as Michigan and Minnesota, offer exemptions for single-ingredient chews from full product registration, lowering regulatory barriers and making compliance more straightforward for early-stage businesses.¹⁵

Food safety remains a top priority, particularly when using raw fish byproducts, which can harbor biological hazards such as Listeria monocytogenes, Salmonella, or chemical contaminants like mercury and per- and polyfluoroalkyl substances (PFAS).^{16 17} These risks are heightened if inputs are sourced from polluted waters or handled without sufficient sanitary controls. To ensure shelf stability and safety, manufacturers must implement validated dehydration or freeze-drying processes that consistently achieve pathogen kill steps (e.g., temperatures above 160°F for dehydration) and use moisture-impermeable packaging to prevent rehydration and microbial growth.¹⁸

Another critical challenge lies in supply chain variability. Fish byproducts—used as a primary input in single-ingredient chews and high-protein pet treats—are often subject to seasonal availability and inconsistent supply quality. This inconsistency can disrupt production schedules

¹³ "Amazon.com: Elite Gourmet EFD319BNG Food Dehydrator, 5 BPA-Free 11.4" Trays Adjustable Temperature Controls, Jerky, Herbs, Fruit, Veggies, Dried Snacks, Black and Grey, 5 Trays: Home & Kitchen," Amazon.com. Spend Less. Smile More, accessed April 22, 2025, <u>https://www.amazon.com/Elite-Gourmet-EFD319BNG-Dehydrator-Temperature/dp/B0B64F8V7P?th=1</u>.

¹⁴ "Premium Commercial Dehydrators," Commercial Dehydrators America | Best Value & Service, last modified April 17, 2025, https://www.dehydratorsamerica.com/product/3-zone-30-tray-53-sq-ft-tray-area?.

¹⁵ "Exempt Pet Products," Minnesota Department of Agriculture, last modified July 29, 2024, https://www.mda.state.mn.us/exempt-pet-products.

¹⁶ Ali Hamade, "Fish consumption benefits and PFAS risks: Epidemiology and public health recommendations," *Toxicology Reports* 13 (2024), doi:10.1016/j.toxrep.2024.101736.

¹⁷ Jean C. Costa et al., "Listeria monocytogenes in aquatic food products: Spotlight on epidemiological information, bio-based mitigation strategies and predictive approaches," *Microbial Pathogenesis* 197 (2024), doi:10.1016/j.micpath.2024.106981.

¹⁸ "Food Safety for Dehydrated Pet Treats (U.S.)," Commercial Dehydrators America | Best Value & Service, last modified April 17, 2025, <u>https://www.dehydratorsamerica.com/post/food-safety-for-dehydrated-pet-treats-u-s?srsltid=AfmBOopU8TFBiRRZV2gHsohGR9F7LZnrANjL 8z9OBRem 8s1pgulZqC.</u>

and lead to variation in nutritional content, which complicates labeling compliance under statelevel feed regulations, such as those in New York and Ohio. Establishing partnerships with local fish processors, cooperatives, or cold-chain distributors may be necessary to secure a consistent raw material supply throughout the year.

Market Potential

The market for natural, sustainable pet treats is both niche and rapidly growing. Retail prices for fish chews, such as cod or walleye skin, typically range between \$25 and \$35 per pound,¹⁹ offering high margins for producers. The broader U.S. pet treat market is valued at \$45.47 billion as of 2024 and is projected to grow at a compound annual growth rate (CAGR) of 11.8% through 2034.²⁰ There is considerable room for innovative, regional brands to thrive within this segment by emphasizing local sourcing, wild-caught fisheries, and sustainable production methods as appropriate.

Marketing and Distribution

The target consumer segment for these treats consists primarily of eco-conscious pet owners, particularly Millennials and Gen Z, who are willing to pay a premium for transparency, sustainability, and natural ingredients. These customers are typically found on online marketplaces, at local farmers' markets, or through regional pet supply retailers. Effective marketing strategies should emphasize the "100% Fish" branding, highlight tribal heritage or Great Lakes storytelling, and avoid unsubstantiated nutritional claims to stay within regulatory boundaries.

Distribution can be achieved through a mix of direct-to-consumer (D2C) platforms like Etsy and PupJoy, as well as through retail partnerships with pet boutiques, subscription boxes, and coops. Retailers such as Kriser's or Top Dog Chews already cater to the natural pet product niche and may be receptive to regional suppliers offering unique, wild-caught treats.

Industry Landscape

Market competition adds another layer of complexity. Well-established companies like The Honest Kitchen, Polkadog, and Open Farm already occupy significant shelf space in premium pet food markets, both online and in physical retail. These brands have built consumer trust through transparency, sustainability claims, and third-party certifications, creating pressure for new entrants to establish a strong unique value proposition—such as traceable sourcing, novel

¹⁹ "Cod Skin Dog Treats," Polkadog, accessed April 22, 2025, <u>https://www.polkadog.com/products/cod-skin-tube-dehydrated-dog-treats?variant=718211713</u>.

²⁰ "Pet Snacks And Treats Market Size To Hit USD 138.73 Bn By 2034," Precedence Research - Market Research Reports & Strategic Consulting, accessed April 22, 2025, <u>https://www.precedenceresearch.com/pet-snacks-and-treats-market</u>.

protein use, or region-specific branding—to differentiate themselves in a saturated marketplace.

From an industry dynamics standpoint, the pet treat market is influenced by several key forces. Buyer power is increasing as consumers demand ingredient transparency and clean labeling. Supplier power varies by region and species availability. Threats of substitution exist, with plantbased or more traditional meat treats available, but the novelty and sustainability of fish-based options help differentiate the product. Entry barriers are low for basic chews, though scaling requires stronger quality controls, branding, and potentially licensing in multiple states. Industry rivalry is intensifying but presents the opportunity for authentic, place-based brands.

Legal and Regulatory Considerations

Despite its potential, the pet treat industry presents several challenges. Regulatory compliance remains a key concern; producers must adhere to Association of American Feed Control Officials (AAFCO) guidelines, and state-specific labeling, licensing, and Good Manufacturing Practices (GMP):

- Illinois: Pet food and treats manufactured in the state of Illinois require annual licensing by the Illinois Department of Agriculture. Additionally, each product made and sold must be registered and labeled under the Illinois Commercial Feed Act.²¹
- Indiana: Single-ingredient pet chews are regulated as commercial feed under the Indiana Commercial Feed Law and require a Commercial Feed License and product listing with the Office of Indiana State Chemist (OISC).²² Labels must include the product name, intended species, net quantity, guaranteed analysis (minimum crude protein and fat, maximum crude fiber and moisture), a single-ingredient statement, and manufacturer information. Additionally, all labels must be reviewed and approved by OISC before distribution. Claims like "human grade" are only allowed if strict human food production standards are met; CBD-containing pet chews are prohibited.²³
- **Michigan:** Pet food and treats manufactured in the state of Michigan require annual licensing by the Michigan Department of Agriculture and Rural Development (MDARD).²⁴

²¹ "Pet Food as a Business," Illinois Department of Agriculture, accessed April 2, 2025, https://agr.illinois.gov/animals/animalfeed/pet-food-as-a-business-.html.

²² "Pet Food - Resources," Office of Indiana State Chemist, accessed April 25, 2025, https://oisc.purdue.edu/petfood/resources.html.

²³ Ibid

 ²⁴ "Pet Food and Treats," Michigan Agriculture & Rural Development, accessed April 2,
2025, https://www.michigan.gov/mdard/animals/feed/pet-food-and-treats.

However, single ingredient chews need no licensing.²⁵ Pet foods and treats are also subject to inspections and applicable fees based on weight sold.²⁶

- Minnesota: Pet food manufactured or distributed in the state of Minnesota requires annual licensing by the Minnesota Department of Agriculture. Products are also required to abide by state-specific labeling laws and are subject to applicable inspection and registration fees. Single-ingredient pet chews that do not make claims about nutritional benefits are exempt from registration and licensing requirements.²⁷ Additionally, baked and dehydrated pet treats can be sold within the state or online under the Cottage Food Exemption, which requires registration as a Cottage Food Producer.²⁸ However, Cottage Food producers are capped at \$78,000 in annual sales.²⁹
- New York: Pet treats are regulated under Article 8 of the Agriculture and Markets Law, which mandates that all pet food and treats of nutritional value be registered annually at a fee of \$100 per product.³⁰ Labels must include the product and brand name, species designation (e.g., "dog treats"), net quantity, guaranteed analysis (minimum crude protein and fat, maximum crude fiber and moisture), ingredient list in descending order by weight, and the name and address of the manufacturer or distributor . Home-produced pet treats, such as non-perishable biscuits and cookies, are permitted if they are shelf-stable and not processed by specialized methods like dehydration or freeze-drying; however, these products cannot claim to be "human grade" unless produced in a commercial facility compliant with federal regulations.³¹
- Ohio: Pet treats are regulated as commercial feed and must be registered with the Ohio Department of Agriculture.³² Any claims regarding nutritional content or health benefits must comply with both state and federal regulations to avoid misleading consumers.³³ Single-ingredient pet chews must be labeled with the product name, intended species, net quantity, guaranteed analysis, and a complete list of ingredients in descending order

²⁵ Diane Longanbach, "Pet Treats and Chews," Michigan State University Extension, September 12, 2023, <u>https://www.canr.msu.edu/news/pet-treats-and-chews</u>.

²⁶ "Commercial Animal Feed Tonnage," MDARD, accessed April 2,

^{2025,} https://www.michigan.gov/mdard/animals/feed/commercial-animal-feed-tonnage.

²⁷ "Exempt Pet Products," Minnesota Department of Agriculture, accessed April 2,

^{2025, &}lt;u>https://www.mda.state.mn.us/exempt-pet-products</u>.

²⁸ "How to Start a Pet Food Business in Minnesota," Minnesota Department of Agriculture, accessed April 2, 2025, <u>https://www.mda.state.mn.us/how-start-pet-food-business-minnesota</u>.

 ²⁹ "Cottage Food Producer Registration," Minnesota Department of Agriculture, accessed April 2, 2025, https://www.mda.state.mn.us/food-feed/cottage-food-producer-registration.

³⁰ "New York," AAFCO, accessed April 24, 2025, <u>https://www.aafco.org/regulatory/state-information/new-york/</u>.

³¹ "Pet Food," Agriculture and Markets, accessed April 24, 2025, <u>https://agriculture.ny.gov/food-safety/pet-food</u>.

³² "Chapter 901:5-7 - Ohio Administrative Code | Ohio Laws," Ohio Laws, accessed April 24, 2025, https://codes.ohio.gov/ohio-administrative-code/chapter-901%3A5-7.

³³ "Frequently Asked Questions," AAFCO, accessed April 24, 2025,

https://www.aafco.org/resources/startups/starting-a-pet-food-business.

by weight. The use of terms like "100%" or "All" is restricted to products containing only one ingredient.³⁴

- **Pennsylvania**: Single-ingredient pet chews are regulated under the state's commercial feed laws. Manufacturers must obtain a feed license, and labels must include the product name, species designation, net weight, guaranteed analysis, ingredient list in descending order by weight, and the name and address of the manufacturer or distributor. Even for single-ingredient products, a guaranteed analysis is required.³⁵
- Wisconsin: Pet food and treats manufactured or distributed in the state of Wisconsin require annual licensing by the Wisconsin Department of Agriculture, Trade and Consumer Protection, and are subject to state-specific labeling laws and tonnage fees.³⁶

Implementation Plan

To successfully launch a fish-based pet treat product, small-scale fisheries and producers should adopt a phased implementation strategy that balances regulatory compliance, product development, and market entry. This approach ensures alignment with sustainability goals, operational capacity, and the resource constraints typically faced by regional or communitybased enterprises.

Phase 1: Feasibility and Resource Assessment

The first step involves conducting a comprehensive feasibility assessment to determine product viability. Producers should begin with a byproduct audit to identify which fish species and parts, such as skins, bones, and viscera, are readily available from local fisheries or processors. This inventory will help determine the most consistent and scalable raw material streams. At the same time, evaluating existing processing capabilities, including access to dehydration, baking, or freeze-drying equipment, is important. For producers without in-house capacity, shared commercial kitchens, food incubators, or contract co-packers may offer feasible alternatives. Legal feasibility is equally important in this phase; producers should research licensing, labeling, and registration requirements in their own and target distribution states, particularly Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. This includes reviewing standards from the Association of American Feed Control Officials (AAFCO) and relevant state agriculture departments.

³⁴ "What to Know About Pet Food and Treats," Ohio Department of Agriculture Division of Plant Health Grain, Feed, and Seed Section, accessed April 24, 2025,

https://dam.assets.ohio.gov/image/upload/v1742826412/agri.ohio.gov/PlantHealth/Pet_Food_Brochure.pdf. ³⁵ "Pet Food & Animal Feed," Commonwealth of Pennsylvania, accessed April 24, 2025, https://www.pa.gov/agencies/pda/food/pet-food-animal-feed.html.

³⁶ "Department of Agriculture, Trade and Consumer Protection," DATCP Home Livestock Feed and Pet Food, accessed April 2, 2025, <u>https://datcp.wi.gov/Pages/Programs_Services/LivestockFeedPetFood.aspx</u>.

Phase 2: Product Development and Prototyping

With foundational knowledge in place, producers can move into product development. It is advisable to begin with low-barrier, single-ingredient dehydrated treats, such as fish skin chews, which may be exempt from more rigorous registration in certain states like Michigan and Minnesota. To reduce infrastructure investment, small pilot batches can be developed using community kitchens or mobile production units. This phase also includes branding and packaging design, which should highlight key values such as sustainability, traceability, and local sourcing. Using compostable or recyclable materials will reinforce the product's alignment with circular economy principles and appeal to eco-conscious pet owners.

Phase 3: Licensing, Registration, and Compliance

Before products can be sold, producers must secure the necessary regulatory approvals. This includes registering the business entity and applying for any feed licenses and product registrations required in the production and target sales states. Producers should also develop standard operating procedures (SOPs) that reflect Good Manufacturing Practices (GMPs), ensuring proper handling, sanitation, and product consistency. Labeling should follow AAFCO and state-specific requirements, including guaranteed analysis, ingredient lists, net weight, and the manufacturer's name and address. Compliance in this phase is critical to reducing risk and enabling multistate distribution.

Phase 4: Market Entry and Distribution

Once regulatory steps are completed and production is underway, the business can enter the market through small-scale sales channels. Farmers' markets, pet expos, and online platforms provide low-cost, high-feedback environments for testing customer response, price points, and packaging appeal. As initial demand grows, producers should seek strategic partnerships with pet stores, fisheries cooperatives, or regional eco-conscious retailers to scale distribution. Building a robust online presence, including a dedicated website, brand story, and active social media marketing, will also be crucial for reaching sustainability-minded consumers and expanding the customer base.

Phase 5: Growth and Diversification

The final phase focuses on product refinement and business expansion. Producers should regularly collect and analyze customer feedback to improve product format, flavor, and packaging design. Over time, expanding the product line to include functional treats with added health benefits, such as omega-3 enrichment for skin and coat health, can attract a wider audience and build brand loyalty. In addition, pursuing regionally focused marketing claims or third-party sustainability endorsements can help differentiate the product in a competitive

marketplace, highlighting its environmental responsibility and local sourcing to strengthen consumer trust and brand appeal.

Lake to Plate Culinary Collaborations

Culinary collaborations are strategic partnerships between restaurants, chefs, and food producers aimed at fostering creativity, reducing waste, and driving innovation in the food industry.³⁷ By joining forces, especially in the Great Lakes St. Lawrence region, these collaborations enable seafood restaurants and their partners to leverage each other's strengths, share resources, and reach new audiences. This approach not only mitigates costs and lowers risk for small and medium-sized enterprises (SMEs) but also allows for easier implementation of new ideas and seasonal menu changes, supporting both sustainability and local economies.³⁸

The core of this initiative is creating seafood dishes that utilize underused fish parts and seasonal offerings tailored to fit local restaurant menus. Examples include seafood chowder or stews made from fish offcuts, burgers, or meatballs crafted from trimmings, and seasonal dips.

Instead of creating one dish or product recommendation, our approach was to provide individual chefs and restaurants with autonomy and flexibility to identify dishes that align with their customer base. This was influenced by chef Eric Montagne in Durham, North Carolina, who found successful dishes aligned with his customer base instead of more inventive ones like dried fish charcuterie boards.

By connecting with restaurants with strong preexisting relationships with signatories from the 100% Fish pledge, collaborations not only enhance visibility but also can contribute to the health of the broader Great Lakes ecosystem.

Benefits and Challenges

Implementing a zero-waste approach and finding creative ways to use underutilized parts of the fish on restaurant menus can deliver significant benefits and presents notable challenges. On the positive side, finding creative ways to incorporate underutilized parts of the fish to an existing establishment's menu potentially enhances a restaurant's reputation among increasingly eco-conscious diners, and attracts customers who value sustainability and are willing to pay a premium for such offerings.³⁹ Utilizing more of each fish-such as bones, skin, and offal-can also lower food costs, improve operational efficiency, and inspire culinary

³⁷ US Foods "Chef'Store" Blog. "How Collaboration Is Rebuilding the Restaurant Industry." Chef'StoreBlog, May 3, 2021. <u>https://www.chefstore.com/about/blog/how-collaboration-is-rebuilding-the-restaurant-industry/</u>.

 ³⁸ KCooper Brands. "The Power of Strategic Partnerships and Collaboration in Food Service." KCooper Brands Blog. <u>https://www.kcooperbrands.com/post/the-power-of-strategic-partnerships-and-collaboration-in-food-service</u>.
³⁹ DoorDash. "Low-Waste Kitchens: How Restaurants Can Cut Costs and Reduce Waste." DoorDash Merchant Blog. February 10, 2025. https://merchants.doordash.com/en-us/blog/low-waste-kitchens.

innovation, as chefs are challenged to develop new, flavorful dishes that stand out in a competitive market. ⁴⁰ These practices can ultimately support a circular economy and drive profitability by minimizing waste disposal fees and maximizing ingredient use.⁴¹

However, several challenges must be addressed for long-term success. Ongoing support and training for kitchen staff on the importance of zero-waste efforts are essential for consistently executing these practices. Adapting menus to include less-traditional fish parts also requires thorough research into local consumer tastes to ensure new dishes are accepted and enjoyed, rather than rejected due to unfamiliarity or cultural preferences.⁴² This is especially important because consumer willingness to try new or unconventional foods can vary widely.

On a macro level, the broader restaurant industry faces external pressures such as fluctuating food costs and changing consumer spending habits. Rising ingredient prices and economic uncertainty may drive more people to eat at home, impacting sales of both traditional and innovative menu items.⁴³ These market dynamics can make it riskier to invest in new menu development and staff training, especially if customer demand is unpredictable or declines. For these reasons, successful implementation of a zero-waste approach requires not only creativity and commitment but also robust staff engagement, ongoing consumer education, and careful adaptation to local market trends and economic realities.

Market Potential

The primary target market for this initiative includes seafood restaurants in the Great Lakes region that are deeply embedded in their communities and prioritize environmental stewardship.⁴⁴ Programs such as the Great Lakes Friendly Restaurants initiative highlight a growing network of restaurants actively seeking to reduce their environmental impact through sustainable sourcing, waste reduction, and community engagement.⁴⁵ Many of these restaurants already feature local species such as lake whitefish, walleye, and brook trout-fish

⁴⁰ Restaurantware. "Understanding Zero-Waste in Foodservice." Restaurantware Blog. April 4, 2025.

https://www.restaurantware.com/blogs/eco-friendly-solutions/understanding-zero-waste-in-foodservice. ⁴¹ Food & Wine. "The Most Exciting Food at Restaurants Starts in the Trash Bin." Last modified April 25, 2025. https://www.foodandwine.com/sustainability-zero-waste-restaurants-11721401.

⁴² The Food Institute, "Wading in Shallow Waters: New Seafood Challenges Consumers." April 3, 2024, <u>https://foodinstitute.com/focus/new-seafood-challenges-consumers/</u>.

⁴³ Talk Business & Politics. "Survey: Consumers Reduce Restaurant Visits, Eat More Meals at Home." May 7, 2024. <u>https://talkbusiness.net/2024/05/survey-consumers-reduce-restaurant-visits-eat-more-meals-at-home/</u>.

⁴⁴ ICSF, "US Seafood Restaurants Cast a Wider Net for Sustainable Fish," <u>https://icsf.net/newss/us-seafood-restaurants-cast-a-wider-net-for-sustainable-fish/</u>.

⁴⁵ Surfrider Foundation. "Great Lakes Friendly Restaurants" <u>https://greatlakes.surfrider.org/programs/great-lakes-friendly-restaurants</u>.

that are both abundant and culturally significant in the region.⁴⁶ The market for locally sourced Great Lakes fish is further supported by consumer preferences for transparency, traceability, and unique culinary experiences, as well as by the region's established infrastructure for commercial fishing and fish processing.⁴⁷

Given these factors, the target market size encompasses not only the current network of sustainability-focused restaurants but also those looking to differentiate themselves by adopting green practices and capitalizing on the growing interest in regional and underutilized fish species. As the 100% Great Lakes Fish program gains international recognition and interest, the potential for market growth is strong, particularly among restaurants eager to innovate and appeal to environmentally conscious diners.⁴⁸

There is a growing preference among younger consumers for processed fish and innovative seafood products, as documented by recent market research.⁴⁹ Chef-driven collaborations and creative menu offerings are also gaining traction, helping restaurants stand out in a competitive landscape.

Focusing specifically on the U.S. domestic market and the potential for culinary collaborations with Great Lakes restaurants, the opportunity is both significant and specialized. The Great Lakes commercial fishing industry in the U.S. generated \$151.4 million in economic activity in 2020, contributing \$78.5 million to GDP and supporting over 1,900 jobs.⁵⁰ While this figure reflects the value at the dock before processing or culinary innovation, it underscores a robust supply base for restaurant partnerships.

Culinary initiatives--such as collaborations between charter fishing operations and local restaurants, exemplified by Michigan's Catch & Cook program--demonstrate the value-added potential of bringing Great Lakes fish directly to consumers through creative restaurant offerings. With nearly 1.1 million licensed U.S. anglers fishing the Great Lakes and direct angler spending of \$3.8 billion in 2020, there is strong regional interest and a receptive customer base

⁴⁶ Jescovitch, Lauren N., and Elliot Nelson. "2020 Status of the Industry: Michigan's Commercial Fishing and Fish Processing Businesses." Michigan State University Extension, January 19,

²⁰²¹.<u>https://www.canr.msu.edu/news/2020-status-of-the-industry-michigan-s-commercial-fishing-and-fish-processing-businesses-msg21-jescovitch21-nelson21</u>.

⁴⁷ Iceland Ocean Cluster. *100% Great Lakes Fish Market Demand Report*. Prepared for Great Lakes St. Lawrence Governors and Premiers. January 2025.<u>https://gsgp.org/media/npxfepqb/2025-great-lakes-market-demand-report.pdf</u>.

⁴⁸ Ibid.

⁴⁹ MarketsandMarkets. *Fish Processing Market by Category Global Forecast to 2021* <u>https://www.marketsandmarkets.com/Market-Reports/fish-processing-market-203673625.html</u>.

⁵⁰ Jescovitch, Lauren N., and Elliot Nelson. "2020 Status of the Industry: Michigan's Commercial Fishing and Fish Processing Businesses." Michigan State University Extension, June 21, 2021,

https://www.canr.msu.edu/news/2020-status-of-the-industry-michigan-s-commercial-fishing-and-fish-processingbusinesses-msg21-jescovitch21-nelson21.

for local fish-based culinary experiences.⁵¹ Restaurants that focus on sustainable, locally sourced⁵² seafood are well-positioned to capture this demand, especially as consumers propensity for unique, environmentally responsible dining options grow.

The broader U.S. seafood market is valued at over \$35 billion annually, with the Great Lakes segment representing a distinct niche for restaurants aiming to differentiate themselves through local sourcing and sustainability.⁵³ While the commercial harvest in the region is smaller than coastal fisheries, the culinary market potential is amplified by the ability of restaurants to create premium experiences and menu items-such as whole-fish preparations, smoked fish, and dishes using underutilized cuts-that command higher margins and attract eco-conscious diners.⁵⁴

In summary, the U.S. Great Lakes seafood culinary market offers a multi-million-dollar opportunity for restaurants to innovate and grow, leveraging the region's strong fisheries, community ties, and consumer interest in local, sustainable food. Strategic partnerships and menu creativity can help unlock further value, positioning participating restaurants at the forefront of a growing movement in American dining.⁵⁵

Costs and Revenues

The financial structure of this recommendation is inherently flexible allowing for scalability based on the size and ambition of each partnership. Capital costs typically include recipe development and testing, ingredient sourcing-particularly for unique species-additional kitchen equipment, marketing, and personnel training. Costs depend on the number of participating restaurants and the complexity of the menu offerings. Ongoing operational costs may include ingredient procurement, staff hours dedicated to collaboration, and periodic marketing campaigns.

Revenue streams are equally diverse. Licensing fees for proprietary recipes and branded menu items can generate recurring income, while hosting educational workshops and cooking classes provides both direct revenue and valuable community engagement. Ingredient sales, especially for specialty or co-branded products, offer another avenue for profit-potentially extending into retail or online markets. Furthermore, collaborations with Native Tribes and sustainable aquaculture farms open doors to grant funding and sponsorships focused on sustainability and

⁵¹ Ibid.

⁵² Michigan Catch & Cook. "Welcome to Michigan Catch & Cook." <u>https://michigancatchandcook.com/</u>.

⁵³ Mordor Intelligence. "North America Seafood Market Size & Share Analysis - Growth Trends & Forecasts (2025–2030)." <u>https://www.mordorintelligence.com/industry-reports/north-america-seafood-market</u>

⁵⁴ Jescovitch, Lauren N., and Elliot Nelson. "2020 Status of the Industry: Michigan's Commercial Fishing and Fish Processing Businesses." Michigan State University Extension, June 21, 2021,

https://www.canr.msu.edu/news/2020-status-of-the-industry-michigan-s-commercial-fishing-and-fish-processingbusinesses-msg21-jescovitch21-nelson21.

community development. By sharing resources and leveraging existing infrastructure, these partnerships can achieve profitability more quickly than traditional standalone ventures, while also reducing financial risk for all parties involved.

Marketing and Distribution

The foundation of the marketing approach is in leveraging existing customer bases and reputations of partner restaurants and amplifying their stories through coordinated campaigns. Social media platforms, such as Instagram and TikTok, are ideal for showcasing behind-the-scenes content, chef interviews, and the creative process behind new dishes-especially those featuring unique, sustainable ingredients. Regular email newsletters and community bulletins keep loyal customers informed about upcoming menu changes, special events, and seasonal offerings.

In-person engagement is another key pillar. Hosting cooking classes, chef-led tastings, and popup events not only drive direct revenue but also foster a sense of community and excitement around the collaboration. Partnerships with local food influencers, environmental organizations, and culinary schools can further broaden reach and credibility. Strategic public relations efforts-including press releases, features in local food media, and participation in food festivals--help position the collaboration as a leader in sustainability and culinary innovation. The ultimate goal is to build a strong brand identity that resonates with environmentally conscious diners, adventurous eaters, and the broader community.

Industry Landscape

Notable domestic examples of restaurants incorporating creative seafood byproducts into their menu offerings include Seamore's (NYC), Black Salt (DC), Providence (LA) and Locals Seafood (NC). These restaurants have successfully implemented innovative dishes like fish cakes, bouillabaisse stew, and fish head ravioli by using underutilized parts of the fish. The limited number of restaurants currently embracing minimal-waste and byproduct-based seafood dishes suggests a relatively low barrier to entry for new collaborations. This niche approach can help participating establishments differentiate in a market where high-quality, creative seafood is in demand but not widely available in the Great Lakes region. We identified potential restaurant establishments with notable customer bases like *Manley's Fish Market* in St. Ignace, Michigan, that is well known for its smoked fish offerings, strong local partnerships and tourist customer base. By incorporating seafood restaurants into the community, greater consumer awareness would be promoted and could potentially draw greater attention to the 100% Fish pledge in the future.

Legal and Regulatory Considerations

Legal considerations include ensuring all partner kitchens meet local health and safety regulations. Implementing these collaborations with existing brick-and-mortar restaurants or small-stores reduces the initial capital requirements to obtain the necessary certifications or comply with local health & safety regulations for commercial kitchens to serve customers.⁵⁶ Collaborations involving Native Tribes or aquaculture farms may require additional agreements to respect tribal sovereignty and sustainability commitments.

Implementation Plan

The implementation plan involves identifying and vetting potential restaurant partners, developing pilot recipes in collaboration with chefs, and launching limited-time menu items to gauge customer response. Ongoing support includes staff training, marketing coordination, and regular feedback loops to refine offerings. Success will be measured by customer engagement, waste reduction metrics, and the scalability of the collaboration model.

Phase 1: Identify and Connect with Appropriate Seafood Restaurants

Identify a restaurant with an existing customer base in the Great Lakes region that consumes seafood. For example, a restaurant like *Manley's Fish Market* in St. Ignace, Michigan, with an established customer base and history of working with Great Lakes fisheries, or an upscale eatery like *Owamni* in Minneapolis, Minnesota, with public commitments to sustainability and local community efforts.

Phase 2: Review Equipment and Compliance

To successfully expand the restaurant's menu to feature more dishes utilizing various parts of the fish, even with existing seafood certifications and green labels like MSC, the restaurant may need to consider specialized equipment or additional staffing focused on menu development and seafood processing. To efficiently process and utilize more parts of the fish-including heads, bones, collars, and skin-beyond standard fillets, the following specialized equipment is recommended:

<u>Fish Scalers and Skinning Machines:</u> In instances where de-scaling and skinning are not possible by hand, these machines are helpful for preparing whole fish and making use of skin for dishes like crispy fish skin or fish chicharrón.⁵⁷

⁵⁶ GS1 US, *Case Study: Culinary Collaborations LLC*, 2023, <u>https://documents.gs1us.org/adobe/assets/deliver/urn:aaid:aem:4dd121cf-a785-4cad-83f9-e1534a89bc00/Case-Study-Culinary-Collaborations-LLC.pdf</u>

⁵⁷ Seafood Sherpa, "Equipment," <u>https://www.seafoodsherpa.com/equipment</u>.

<u>Fillet and Deba Knives</u>: High-quality, flexible fillet knives and heavier Deba knives are crucial for precise butchery, including breaking down heads, removing collars, and cutting through bones.⁵⁸

<u>Needle-nose Pliers or Fishbone Tweezers:</u> Necessary for removing pin bones from fillets and other cuts, ensuring a pleasant dining experience when using less common parts.⁵⁹

<u>Bone Saw Machine</u>: For cutting through larger bones and heads, especially if using frozen fish or preparing dishes like fish head soup or roasted collars.⁶⁰

<u>Kitchen Scissors</u>: Useful for trimming fins, cutting gills, or portioning smaller bones and cartilage for broths or crispy snacks.⁶¹

<u>Steamers and Specialized Cookware:</u> Commercial steamers and pots for preparing dishes like fish head stews, steamed collars, or bone broths.⁶²

<u>Oyster and Clam Knives, Lobster Picks, and Crab Scissors:</u> If expanding into shellfish byproducts or whole-animal presentations.

<u>Large, Dedicated Cutting Boards</u>: Preferably plastic for seafood, to accommodate whole fish and prevent cross-contamination.⁶³

Human Capital

Expanding the menu to creatively use more fish parts may require additional staff or dedicated roles, especially in menu development and seafood processing:

<u>Menu Development Chef or R&D Chef</u>: A culinary professional with experience in seafood and whole-animal utilization should be tasked with researching, testing, and developing new recipes that highlight underused fish parts. This chef will collaborate with the executive chef and kitchen team to ensure new dishes are feasible for service.

<u>Seafood Processing Specialist or Butcher</u>: An additional prep cook or seafood butcher may be necessary to handle the increased workload of breaking down whole fish and preparing specialized cuts. This person should be skilled in fish butchery and familiar with relevant equipment.⁶⁴

<u>Training for Existing Staff</u>: Current kitchen staff may require training sessions on new butchery techniques, equipment use, and safe handling of less common fish parts.

⁵⁸ Eating with the Ecosystem, "Tools for Preparing Seafood," <u>https://www.eatingwiththeecosystem.org/tools-for-preparing-seafood</u>.

⁵⁹ Ibid.

⁶⁰ OTN Machinery, "Top 5 Equipment Every Seafood Restaurant Needs," Last modified September 4, 2024. <u>https://www.otnmachinery.com/top-5-equipment-every-seafood-restaurant-needs</u>.

⁶¹ Eating with the Ecosystem, "Tools for Preparing Seafood," <u>https://www.eatingwiththeecosystem.org/tools-for-preparing-seafood</u>.

⁶² Ibid.

⁶³ Ibid.

⁶⁴ Seafood Sherpa, "Equipment," <u>https://www.seafoodsherpa.com/equipment</u>

Phase 3: Pilot Launch

Monitoring the initial implementation the new menu additions with the restaurant collaborators is key. Aspects to look out for include customer feedback, operational challenges, and the effectiveness of the new menu; and, assessing the quality and consistency of the dishes, staff readiness, and any supply chain issues. Regular communication with the participating restaurants will help identify areas for improvement and ensure the pilot runs smoothly. Collecting data on sales performance and customer satisfaction during this phase will provide valuable insights for future adjustments.

Phase 4: Set up Distribution Channels

In phase four, establishing efficient distribution channels is essential for scaling. Leveraging existing marketing resources and networks of the participating restaurants to promote the new fish dishes can help streamline logistics. We recommend teaming up with the restaurant marketing teams to use their social media platforms, email newsletters, and in-house promotions to reach a wider audience.

Phase 5: Refine and Grow

The final phase requires incorporating metric monitoring and providing ongoing support to the restaurants. Specifically, offering training sessions to kitchen staff around waste minimization or education around the importance of incorporating species into seasonal dishes to help improve lake health while minimizing an ongoing yearly demand for these products, can help optimize preparation. Maintaining open communication channels to address challenges promptly and share best practices among collaborators is important.

Fish Leather Goods and Workshops

Fish leather offers an opportunity for the Great Lakes fishing and artisan communities to collaborate and share this rich tradition. Leather goods like wallets, jewelry, belts, and bags can be made from tanned fish skins. Teaching workshops on fish leather tanning and leather crafting can increase the community's interest in fish leather as well as provide an additional revenue stream.

Fish Leather Goods

Goods made from fish leather provide not only a fashionable product but also a way to build more mainstream awareness for the 100% Fish project.

Product Benefits and Challenges

Fish leather was selected as one of the three recommended products for its ease of starting up, its resilience to seasonality, its limited legal regulations, and its large global growth. Compared to other products explored, tanning and sewing fish leather goods is very easy to start up. Procurement of fish skins is relatively easy because fish are often skinned during processing. Additionally, finished products can be sold directly to consumers and are not dependent on setting up contracts with downstream supply chain partners. Next, frozen fish skins are suitable for tanning, enabling tanning to occur year-round. There are also limited environmental regulations for home-scale tanning. Finally, driven by trends in sustainable consumption, the global fish leather market was estimated at \$46.01 million in 2024. It is expected to grow with an explosive CAGR of 19.9% and reach \$233.34 million by 2033.⁶⁵

However, several key considerations about fish leather are potential environmental hazards, product lead times, the suitability of Great Lakes fish, and the barriers to scaling tanning operations. First, chrome tanning can have negative impacts on the environment, but vegetable tanning has long been considered a safe alternative. ⁶⁶ However, vegetable tanning takes longer but is more durable, warranting a premium price.⁶⁷ The next consideration is the suitability of Great Lakes fish. While any fish can technically be tanned, Joe Manthei of Fiskur Leather pointed out that not all are suitable for it. For example, whitefish skin is too thin whereas sturgeon and walleye are very difficult to clean, each making for a difficult project.⁶⁸ Lake trout is suitable though not very large compared to other skins. Salmon is the most popular type of fish used for leather and while they are found in the Great Lakes, they are not native. ⁶⁹ In fact, resource management agencies released the salmon to manage invasive species and these agencies still run several salmon hatcheries across the Great Lakes to keep the lakes stocked.⁷⁰ The final consideration about fish leather is the barriers that come with scaling operations. Tanning fish leather can be done by hand but is quite a manual process. To scale operations beyond a certain point, investments need to be made in commercial scale tanning equipment and additional legal regulations apply.

https://www.globalgrowthinsights.com/market-reports/tanned-fish-skin-leather-market-107614. ⁶⁶ Zilberfarb, Achiad, Gali Cohen, and Elizabeth Amir. 2023. "Increasing Functionality of Fish Leather by Chemical Surface Modifications" *Polymers* 15, no. 19: 3904. <u>https://doi.org/10.3390/polym15193904</u>

⁶⁵ Tanned Fish Skin Leather Market Size, Trends, Growth: 2033 Report, April 7, 2025,

⁶⁷ Ruchi Naik, "The Difference Between Chrome-Tanned and Vegetable Tanned Leather," Vintage Leather Sydney, September 11, 2022, <u>https://www.vintageleather.store/blogs/vintage-leather-sydney/difference-between-vegetable-and-chrome-tanned-leather</u>.

 ⁶⁸ Duke FCCP Team and Joe Manthei. Fiskur Leather. Personal Interview, February 11, 2025.
⁶⁹ 100% Great Lakes Fish Market Demand Report, January 2025.

https://www.cglslgp.org/media/npxfepqb/20250206 great-lakes-market-demand-report.pdf.

⁷⁰ Schuitema, Emily. "How the DNR Supports the Great Lakes Salmon Population | Woodtv.Com." Wood TV, May 2, 2022. <u>https://www.woodtv.com/news/michigan/how-the-dnr-supports-the-great-lakes-salmon-population/</u>.

Market Potential

The North American fish leather market size was estimated to be \$8 million in 2024 with a 13.6% CAGR from 2025-2030.⁷¹ A one percent share of this market represents \$80,000. The global fish leather market is estimated to reach \$233.34 million by 2033 with an explosive CAGR of 19.9% from 2025-2033, signaling significant market opportunity.⁷² Global policy uncertainty may make the import of foreign fish leather and fish leather goods more expensive, increasing demand for domestically tanned fish skins.

Costs and Revenues

Fish leather generates a revenue of approximately \$36.00 per 0.8 square foot.⁷³

While startup costs are quite low and fish skins can be relatively cheap, labor costs are the most expensive input to tanning and crafting fish leather.

It is estimated that it costs a minimum of \$82.34 in materials to begin tanning which does not include the price of fish skins.

Exhibit 4: Sample Fish Leather Tanning Start Up Costs

Material	Cost Estimate
Tanning Chemicals	
Hydrated Lime	\$16.28/50 lbs
Oropon Enzyme	\$11.60/lb
• <u>Tannins</u>	\$3.50-\$8.85/lb (depending on type)
Ulu	\$45.00
Buckets	\$3.98/bucket
Bucket Lid	\$1.98/lid
Dyes	\$0 (if using natural foraged
	materials)
Total	\$82.34+

⁷¹ 100% Great Lakes Fish Market Demand Report, January 2025.

https://www.gsgp.org/media/npxfepqb/20250206_great-lakes-market-demand-report.pdf. ⁷² Tanned Fish Skin Leather Market Size, Trends, Growth: 2033 Report, April 7, 2025,

https://www.globalgrowthinsights.com/market-reports/tanned-fish-skin-leather-market-107614. ⁷³ 100% Great Lakes Fish Market Demand Report, January 2025.

https://www.cglslgp.org/media/npxfepqb/20250206 great-lakes-market-demand-report.pdf.

It is estimated that it costs \$40.68 in start-up costs for hand sewing materials or \$356.69 for machine sewing.

Evhihit 4	Ξ.	Sample	Fich	Leather	Craftina	Start	1 In	Costs
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Material	Cost Estimate
Awl (hand sewing)	\$32.99
Sewing Machine	\$349
Thread	\$7.69/25 yards
Total	\$40.68 (hand sewing)-\$356.69
	(machine sewing)

Marketing and Distribution

The target market for fish leather goods is eco-conscious fashion enthusiasts in North America. Rising awareness of sustainability in luxury fashion makes this segment an ideal target.⁷⁴

To market to this niche, products could be promoted using messaging about local craftsmanship, tribal heritage storytelling, sustainability, or 100% Fish branding.

In-person distribution methods should be prioritized because customers often want to touch and feel products before purchasing, especially products they are not as familiar with like fish leather.⁷⁵ Partnerships to sell goods at local boutiques, gift shops, and art galleries can give customers this opportunity and help to position the products as high-end. Art fairs are another potential in-person channel but require significantly more labor hours for travel, set up, and sales.

E-commerce is an opportunity to sell to individuals who maybe did not purchase the first time they saw the product in person or for those who want to make follow-up purchases. Social media, including Instagram, TikTok, and Facebook, can play a key role in product promotion to build awareness and help the product's story come to life.

⁷⁴ "Luxury Goods Market Size, Growth & Demand Report by 2033," Straits Research, accessed April 27, 2025, <u>https://straitsresearch.com/report/luxury-goods-market</u>.

⁷⁵ Dataintelo, "Fish Leather Market Report: Global Forecast from 2025 to 2033," Dataintelo, February 19, 2024, <u>https://dataintelo.com/report/global-fish-leather-market</u>.

Industry Landscape

The fish leather industry is primarily made up of large industrial tanneries, importers, small businesses, and fashion designers. The only industrial scale fish tanneries known in North America are Aquaborne in Sacramento, California⁷⁶ and 7 Leagues in British Columbia.⁷⁷ However, Atlantic Leather, located in Iceland, and Nova Kaeru, in Brazil, lead the industry as large tanneries.⁷⁸ When it comes to importers, Leatherbox is the largest known importer of fish leather to the US and sources from Iceland.⁷⁹ Existing small businesses in the space include Fiskur Leather and Moonrise Jewelry. Fiskur Leather, located in Minnesota, tans and crafts its own leather and sells online and at art fairs.⁸⁰ Conversely, Moonrise Jewelry imports leather from Iceland to craft and then sell in its store in Cape Charles, Virginia.⁸¹ Designers that have recently featured fish leather include haute couture design houses, such as Rick Owens, Burberry, Givenchy, Dolce & Gabbana, and Giorgio Armani that have sourced fish leather from Nova Kaeru.⁸²

Nova Kaeru provides an interesting case study as a sustainable fish leather tannery. It supplies sustainable leather, primarily with a focus on largest freshwater fish such as pirarucu, to the fashion industry, and work with fishing cooperatives in the Amazon to support communities' livelihoods and to ensure sustainable fishing practices.⁸³ One customer of Nova Kaeru is Piper & Skye, a luxury handbag and accessory maker. Piper & Skye is Butterfly Mark Certified and employs local artisans to craft its pieces.⁸⁴

Small businesses looking to enter the fish leather industry should be aware of several key market forces. The first is that there is a high threat of substitutes from other types of leather so consumer education is often required. Another key aspect is the competition within the industry. Marketing is extremely important as more and more well-known luxury fashion houses enter the fish leather goods market.

⁷⁶ Aquaborne, accessed April 28, 2025, <u>https://theaquaborne.com/</u>.

⁷⁷ 7 Leagues, accessed April 28, 2025, <u>https://www.7leagues.com/</u>.

⁷⁸ Dataintelo, "Fish Leather Market Report: Global Forecast from 2025 to 2033," Dataintelo, February 19, 2024, <u>https://dataintelo.com/report/global-fish-leather-market</u>.

⁷⁹ "Fish Leather," Leatherbox, accessed April 28, 2025, <u>https://leatherboxusa.com/collections/fish-leather</u>.

⁸⁰ Duke FCCP Team and Joe Manthei. Fiskur Leather. Personal Interview, February 11, 2025.

⁸¹ "Our Story," Moonrise Jewelry, accessed April 28, 2025, <u>https://moonrisejewelry.com/our-story/</u>.

⁸² "NOVA KAERU BR (@nova.Kaeru) • Instagram Photos and Videos," November 6, 2024, <u>https://www.instagram.com/nova.kaeru</u>.

⁸³ "About Us • Nova Kaeru • Exotic Sustainable BioFabrics," *Nova Kaeru* (blog), accessed April 22, 2025, <u>https://novakaeru.com.br/en/about-us/</u>.

⁸⁴ "Sustainability," Piper & Skye, accessed April 22, 2025, <u>https://www.piperandskye.com/pages/sustainability</u>.

Legal and Regulatory Considerations

The two main regulatory considerations for fish leather are related to tanning and sale of leather.

Fish leather licenses for tanning are generally related to the handling of tanning chemicals and the handling of animal products. Tanneries that discharge pollutants, such as chromium, are required to have a National Pollutant Discharge Elimination System (NPDES) permit and may be subject to state and local wastewater permitting as well.⁸⁵ Some regions may also have additional health and safety requirements. This is generally not applicable for home scale vegetable tanning but should still be considered as operations grow. Licenses required to tan animal products vary between states and have differing definitions of tanning and taxidermy. A summary of the Great Lakes states' regulations for tanning fish leather can be found below. However, producers should verify all requirements with their state's Department of Natural Resources.

- Indiana: Tanning for oneself does not require a license but tanning for others, even if not for compensation, could require a taxidermist license.⁸⁶ Taxidermy is not defined in the law so verification with the Indiana Department of Natural Resources is encouraged.⁸⁷
- Illinois: Fish leather does not currently fall within Illinois licensing requirements for a tanning or taxidermy license. Illinois requires a license for the tanning of fur-bearing animals as well as taxidermy. However, the state defines taxidermy as mounting animals to make them appear lifelike which is not the purpose of fish leather.⁸⁸
- **Michigan:** Michigan does not require animal tanning licenses and explicitly does not regulate the taxidermy of fish.⁸⁹
- Minnesota: A tanner's license is required in Minnesota if tanning for compensation.⁹⁰
- New York: New York does not require a license for tanning fish or taxidermy. However, a register is required to be kept when selling prepared fish skins.⁹¹

⁸⁵ "Leather Tanning and Finishing Effluent Guidelines," EPA, April 4, 2025, <u>https://www.epa.gov/eg/leather-tanning-and-finishing-effluent-guidelines</u>.

⁸⁶ Taxidermy licenses and Regulation, July 28, 2003, <u>https://www.in.gov/dnr/fish-and-wildlife/files/TaxidermyLicenseRegulations.pdf</u>.

⁸⁷ Taxidermy licenses and Regulation, July 28, 2003, <u>https://www.in.gov/dnr/fish-and-wildlife/files/TaxidermyLicenseRegulations.pdf</u>.

⁸⁸ "Illinois Taxidermy Laws," Illinois Department of Natural Resources - Office of Law Enforcement, May 2014, <u>https://dnr.illinois.gov/content/dam/soi/en/web/dnr/lawenforcement/documents/taxidermyhandbook.pdf</u>.

⁸⁹ "Taxidermy Permits Information," Michigan Department of Natural Resources – Law Enforcement, January 11, 2017, https://www.michigan.gov/dnr/-/media/Project/Websites/dnr/Documents/Forms/folder1/IC9161.pdf.

⁹⁰ "Sec. 97A.425 MN Statutes," Minnesota Legislature, accessed April 28, 2025, https://www.revisor.mn.gov/statutes/cite/97a.425.

⁹¹ "N.Y. Env't Conservation Law § 11-1733 – Taxidermy," New York State Sentate, September 22, 2014, https://www.nysenate.gov/legislation/laws/ENV/11-1733.

- **Ohio:** While Ohio does require a fur dealer permit to tan skins of fur-bearing animals, the state does not require licenses for tanning of non-fur-bearing animals.⁹² A license is also not required for taxidermy.⁹³
- **Pennsylvania:** Fish leather does not currently fall within Pennsylvania licensing requirements for a taxidermy license because the state defines taxidermy as stuffing animal skins to make them appear real which is not the purpose of fish leather.⁹⁴
- **Wisconsin:** A taxidermy license is required to sell preserved fish skins but is not required for hobby tanning.⁹⁵

Selling fish leather across U.S. borders requires an import/export license from the U.S. Fish & Wildlife Service. License fees are currently \$100 per year, and application processing takes approximately 60 days.⁹⁶

Implementation Plan

To successfully launch a fish leather business, small-scale fisheries and producers should adopt a phased implementation strategy to focus on local regulations, product development, and market entry. This approach ensures alignment with sustainability goals, traditional values, and market demand.

Phase 1: Feasibility and Resource Assessment

The first step involves conducting a comprehensive feasibility assessment to determine product viability. Producers should begin with an assessment to identify which fish species are readily available from local fisheries or processors and the average quality of their skins. This inventory will help determine the most consistent suppliers. Legal regulations should also be assessed at this point to understand local licensing and recordkeeping requirements. While none of the Great Lakes states require a license for hobby tanning, Minnesota, Wisconsin, and possibly Indiana require a license for the sale of tanned skins. Producers should research and verify applicable tannery regulations with their local environmental, health, and natural resources departments.

⁹² "Fur Dealer Permit," Ohio Department of Natural Resources, accessed April 28, 2025, <u>https://ohiodnr.gov/buy-and-apply/regulatory-permits/commercial-wildlife-permits/fur-dealer</u>.

⁹³ "Rule 1501:31-15-02: General Hunting and Trapping Provisions," Ohio Laws & Administrative Rules, January 1, 2025, <u>https://codes.ohio.gov/ohio-administrative-code/rule-1501:31-15-02</u>.

⁹⁴ "Apply for a Taxidermy License," Commonwealth of Pennsylvania, accessed April 28, 2025, <u>https://www.pa.gov/services/pda/apply-for-a-taxidermy-license.html</u>.

⁹⁵ "Professional and Occupational Licenses," Wisconsin DNR, accessed April 28, 2025, <u>https://dnr.wisconsin.gov/permits/professionalicenses.html</u>.

⁹⁶ "3-200-3A - Import / Export License for U.S. Entities." U.S. Fish & Wildlife Service. Accessed March 27, 2025. https://fwsepermits.servicenowservices.com/fws?id=fws_kb_view&sys_id=9f3283751b1790101f45dbdbe54bcb45.

Phase 2: Product Development and Prototyping

With foundational knowledge in place, producers can move into product development and learn how to tan and craft fish leather. Investments in tanning and/or sewing materials would occur at this point. To speed up the learning curve, producers could take a course or workshop. It is encouraged to experiment with different fish species and products. While continuous improvement should continue to occur, a key outcome of this phase would be to determine the initial product one will bring to the market. This phase also should include identifying a business name and developing branding.

Phase 3: Licensing, Registration, and Compliance

Before products can be sold, producers must secure the necessary regulatory approvals. This includes registering the business entity and applying for import/export licenses and other applicable local licenses. Producers should also set up a product registration system if required.

Phase 4: Market Entry and Distribution

Once regulatory steps are completed and production is underway, the business can enter the market through small-scale sales channels. Local boutiques and gift shops, art fairs, and online platforms provide low-cost, high-feedback environments for testing customer response, price points, and product appeal. Building a robust online presence, including a dedicated website, brand story, and active social media marketing, will also be crucial for reaching sustainability-minded fashion enthusiasts and expanding the customer base.

Phase 5: Growth and Diversification

The final phase focuses on product refinement and business expansion. Producers should regularly collect and analyze customer feedback to improve products. In addition, exploring certifications or third-party sustainability endorsements will help differentiate the products from goods made from other leathers or by large fashion brands. One key growth step that could occur at this phase is to begin offering workshops to grow the fish leather artisan community and provide an additional revenue stream. Fish leather workshops are detailed more below.

Fish Leather Workshops

Fish leather workshops were selected as complementary service to fish leather goods, as workshops educate the public on sustainability and the rich history that fish leather has in indigenous cultures. Fish leather workshops could entail teaching participants how to tan leather or making leather goods using fish leather that has already been tanned. These goods could include wallets, handbags, jewelry, hats, or even sewing workshops where participants can bring in an article of clothing that they would like to customize using fish leather provided. This option is geared toward an artistic individual that wants to use fish leather to create art and share that skill with others.

Product Benefits and Challenges

Fish leather workshops were selected for their ease of implementation, low start-up costs, yearround availability of fish skins, and lack of regulatory hurdles. Workshops are easy to implement as they can be offered in person or online. Starting up entails setting up relationships and contracts that can provide the platform to offer these courses, whether it is through an arts and craft store or online website, or through community centers to provide a large room to set up in-person workshops. Additionally, the start-up costs are minimal, particularly when paired with fish leather tanning, as supplies used for fish leather can be used for the courses and most of the costs will be associated with marketing the courses. Courses can be offered year-round since tanning can occur indoors and skins can be frozen prior to tanning in class. Alternatively, sewing workshops could use finished fish leather that participants could buy from the fish leather provider. There are not any regulations regarding fish leather workshops in the Great Lakes region.

However, this initiative presents some challenges including identifying the target audience and scaling limits. While both fish leather and sustainable fashion are emerging trends, both are still rather niche markets so identifying the appropriate target audience and finding unique ways to market to them will be challenging. Deep community ties will enable tapping into different networks to advertise classes to different customer segments. For example, offering non-degree seeking courses with colleges and universities might be a way to attract younger participants, whereas targeting an elder audience involves working with senior centers or retirement communities to offer courses at different levels. Once these connections are made, it is important to understand the best marketing method to attract the target audience. Last, scaling of the workshops may be limited depending on the number of instructors involved with this initiative, the student demand, or availability of locations to teach in-person workshops.

Market Potential

As mentioned previously, the global fish leather market is estimated to reach \$233.34 million by 2033 with an explosive CAGR of 19.9% from 2025-2033, signaling significant market opportunity.⁹⁷ As consumers awareness expands about understanding where their products come from and demanding more sustainable products, fish leather is an attractive product that

⁹⁷ Tanned Fish Skin Leather Market Size, Trends, Growth: 2033 Report, April 7, 2025, https://www.globalgrowthinsights.com/market-reports/tanned-fish-skin-leather-market-107614.

is more durable than its cowhide counterpart and can be traced.⁹⁸ Fish leather workshops offer a unique way to establish business-to-consumer relationships. Since this is a niche market, producers can highlight how their workshops are a part of the 100% Fish Pledge, support small fishing communities, and promote sustainability by using the fish skin waste to create a byproduct.

Currently, the Great Lakes market is small, but the advantage of offering workshops is to have first-mover advantage, meaning to be one of the first businesses in a certain area. This is advantageous because when consumers think about fish leather workshops or goods, they will associate it with the most popular brand, which is usually a business that has existed prior to the market expanding. Skill-leveled workshops are possible, where producers can offer beginner-, intermediate-, and expert-level workshops that could either be one-day or multi-day classes.

Cost and Revenues

Should the producer want to cross-sell the fish leathers, if they tan their own, to participants in their workshops, then the costs will mirror the costs highlighted in the fish leather section. However, producers will incur additional costs, such as marketing costs and video production costs. Fish leather workshops can range from \$100 per participant to \$400 per participant, and supplies are sometimes sold separately, and the producers will cross-sell the equipment with the workshop. Though not fish leather, cowhide leather making workshops charge between \$300 for half-day workshops versus over \$700 for full-day workshops.⁹⁹

Marketing and Distribution

In-Person Community

Creative partnerships provide a unique marketing opportunity to leverage an existing firm's audience. For example, Tidal Theory, a Hawaiian-based local handbag and accessory boutique, partnered with Janey Chang, a Canadian fish leather tanner, and offered a 5-day in-person workshop for \$400 per participant to learn how to make leather goods. These partnerships may be helpful when entering a new market, and the producers do not have an active following yet. Even if both parties have their own customers, this still provides an opportunity to expand beyond just the individual's customer base. Additionally, creative partnerships can help producers grow to differentiate and enter a new segment. The partnership does not have to be

⁹⁸ Research, Straits. "Fish Leather Market Size, Share | Growth Analysis [2033]." Accessed April 28, 2025. <u>https://straitsresearch.com/report/fish-leather-market</u>.

⁹⁹ Handmade Leather Goods. "Half Day Leather Workshop." Accessed April 28, 2025. <u>https://www.sullyandproper.supply/handmade-leather-goods/xf3abnyun1fqbn4pfuxwghb97yavp4</u>.

with another business but can also be partnering with community centers, art and crafts studios, art schools, local colleges and universities, museums, and libraries. If the producer chooses a library as a locale for their classes, the library could sponsor the event and some locations may allow charging a participation fee.¹⁰⁰ If the producer is located near a downtown area with office buildings, it could be interesting to market these services as a team building experience where team members could work together to create a fish leather good. Creating partnerships with different institutions allows producers to have a customer base from young adults to elderly adults who are interested in learning how to turn fish waste into products.

Another method is to attend arts and craft fairs. In Michigan, the Great Lakes Market hosts seasonal weekend art markets, where artists can apply for a booth, and, if approved, can showcase their products in a single or double booth that will cost between \$125-\$200.¹⁰¹ While producers may not be able to offer workshops at a fair, they can offer live demonstrations and it is an opportunity to sell their own leather goods and to market workshop offerings as well.

Online Community

Online stores are a popular way to market not fish leather goods and to showcase fish leather workshops. Michael's, a US-based craft store, allows third-party sellers to market and sell their crafts and offer workshops via their MakersPlace platform with low transaction and referral fees, and this platform is geared toward small-to-medium sized artisans.¹⁰² Etsy is a popular marketplace for small-sized artisans and producers can offer both products and workshops. Last, a YouTube channel or Patreon could be leveraged as well because producers can monetize their content by creating paid subscriber content.

Social Media

Different forms of social media, such as YouTube, TikTok, Instagram, Facebook, Snapchat, et al. can be used to market to broader audiences and highlight any partnerships. In fact, Monzo, a UK-based online bank, shared that there were over 5.1 billion TikTok views globally for embroidery videos, and an artist showcasing embroidery using fish leather to transform an article of clothing could be an interesting way to attract attention.¹⁰³

 ¹⁰⁰ "To Charge or Not to Charge? A Dilemma for Programming Librarians | Programming Librarian." Accessed April 28, 2025. <u>https://programminglibrarian.org/articles/charge-or-not-charge-dilemma-programming-librarians</u>.
¹⁰¹ The Great Lakes Market. "The Great Lakes Market." Accessed April 28, 2025. <u>https://the-great-lakes-market.squarespace.com</u>.

¹⁰² "Become A Seller | Handmade Crafts & More | MakerPlace by Michaels." Accessed April 28, 2025. <u>https://www.michaels.com/makerplace/sell</u>.

¹⁰³ Monzo. "Handmade businesses are booming. These are 2023's biggest British crafting trends." Accessed April 28, 2025. <u>https://monzo.com/business-banking/learn/handmade-business</u>.

Industry Landscape

Fish leather workshops are a niche market, and while there are existing competitors in North America, it is still small. Businesses like Fiskur Leather use their websites to offer courses and to sell fish leather and fish leather goods. Janey Chang, a Canadian fish leather tanner, offers online and in-person fish leather multi-day workshops.¹⁰⁴ June Pardue, an Alaska Native artist who taught herself how to make fish leather goods, teaches at museums, universities, and local schools about how to craft leather goods.¹⁰⁵

Besides fish leather tanneries and artists, local arts and craft groups have used fish leather for craft workshops. North Country Arts & Crafts Workshop in Minnesota hosts arts and craft workshops throughout the year and have offered several fish leather workshops.¹⁰⁶

Legal and Regulatory Considerations

Fish leather workshops are generally not subject to any additional regulations. However, the same legal considerations for fish leather goods are applicable for the workshops if fish leather tanning is involved.

Implementation Plan

Phase 1: Feasibility and Resource Assessment

Like fish leather goods, producers will have to assess which fish species are available in their locales, and research the feasibility of using these fish skins for workshops. Producers will want to research to understand the handling ease of working with fish skins to narrow down which skins would be the most ideal to work with for workshops. During this phase, producers could attend a fish leather workshop and/or interview fish leather workshop practitioners to learn more about their process, how they market their skills, and gauge the audience's response from attending a live class or online.

Phase 2: Product Development and Prototyping

After narrowing down a list of fish species, the producer should note their own process they undertake to create fish leather products. Then, use their own process to develop easy-to-follow instructions for the varying level of fish leather workshops they would like to offer. During this

 ¹⁰⁴ Janey Chang Art + Ancestral Skills. "About." Accessed April 28, 2025. <u>https://www.janeychang.ca/about</u>.
¹⁰⁵ Studebaker, Addie. "Salmon Skin: June Pardue Reinvents and Reclaims an Important Alutiiq Tradition,"

November 8, 2021. <u>https://ediblealaska.ediblecommunities.com/food-thought/food-thought-salmon-skin-june-pardue/</u>.

¹⁰⁶ "Crafts - Miscellaneous » North Country Arts & Crafts Workshop." Accessed April 28, 2025. <u>https://www.ncacw.com/crafts-miscellaneous</u>.

stage, producers should turn to family and friends with varying skill levels to trial their instructional skills and to see how they respond to the instructions. Additionally, this stage is usually used to figure out what product types are most appropriate for a specified skill level.

Phase 3: Licensing & Registration

Before products can be sold, producers must establish their business by setting up the legal structure. This includes registering the business entity and choosing a domain name should the producer decide to offer online services. Then, it will be necessary to set up different distribution networks, for example, on the producer's personal website and develop different social media pages across different platforms that can help reach broader audiences.

Phase 4: Market Entry and Distribution

In this phase, producers will focus on building partnerships with potential businesses that could host their workshops. It may be advantageous to start with local businesses and community organizations, such as community centers, art studios, camps, and libraries. Additionally, these spaces can also market the producers' workshops, so the producers will need to have marketing materials available whether through their website or via their social media platforms. Local coffee shops and community college usually have posting boards, where the producer can hang flyers with QR codes that will direct potential participants to their website to view more information and sign up for the course. During this stage, it is imperative to collaborate to build a loyal customer base.

Phase 5: Growth and Diversification

The final phase entails learning from mistakes made in the previous stages and possibly expanding to other cities or regions, or to build an art space dedicated to supporting artists and offering different types of workshops. Another possibility is to expand by adding instructors or potentially expand outside of North America via online platforms, but this will entail learning about those countries' regulations.

Alternative Products Not Selected

Animal feed, fish oil, fish meal, and pet food were analyzed using the feasibility criteria but were ultimately not selected based on our review of the ease of implementation and profitability. Each of these products are detailed below.

Animal Feed

Animal feed production from fish waste was ultimately not recommended due to its limited economic viability for small-scale producers. In many cases, fish waste is given away or sold at

negligible prices to local farmers simply as a means of disposal, especially when not processed at scale. This makes it an unattractive commercial option unless pursued in high volumes. Moreover, to legally market fish-based animal feed, producers must navigate a complex and stringent regulatory landscape. In the U.S., the FDA, and the Association of American Feed Control Officials (AAFCO) require approval of ingredients and labeling standards¹⁰⁷, and statelevel certifications often apply as well. These regulatory processes can be both time-consuming and costly.

For small tribal or community-based operations in the Great Lakes region, the high barriers to entry—combined with a limited revenue opportunity—make fish waste-based animal feed an impractical solution. While large commercial processors with established infrastructure and compliance systems might be able to pursue this route profitably, the costs of processing, safety testing, storage, and distribution outweigh the marginal gains for smaller players seeking nearterm, scalable impact.

Fish Oil

Fish oil extraction was not recommended due to the high technical and financial barriers associated with its production. While fish oil is a valuable product with strong demand in nutraceuticals, cosmetics, and animal feed supplements, producing high-quality oil from fish waste requires significant upfront investment in specialized extraction and purification equipment. Low-tech methods often result in impure oil with unpleasant odor, poor shelf life, and limited marketability, making the product unviable without industrial-scale refinement. Moreover, to sell fish oil for human or animal consumption, producers must comply with rigorous regulatory standards enforced by the FDA, USDA, state, and international quality control bodies. These include certification for food-grade production, traceability, and adherence to safety and hygiene protocols (FDA, AAFCO). For small-scale operators in the Great Lakes region, these requirements introduce substantial cost and complexity, particularly when working with variable-quality raw material like waste trimmings and viscera.

Exploring the option of selling fish waste or semi-processed oil to existing fish oil manufacturers also appears impractical in the short term. Large fish oil producers require certified, consistent, and traceable raw material in order to label their products with claims like "wild-caught" or "sustainably sourced." Small-scale producers typically cannot meet the strict certification requirements, minimum volume thresholds, or provide a consistent, year-round supply needed to secure contracting partnerships. Finding and establishing such relationships would likely take

¹⁰⁷ Commissioner, Office of the. U.S. Food and Drug Administration. Accessed April 28, 2025. <u>https://www.fda.gov/</u>

longer than 6–18 months and require operational reliability that emerging or community-led projects currently lack.

Given the lack of existing infrastructure, high capital requirements, supply chain limitations, and narrow profit margins unless produced at scale, fish oil was deemed an impractical option for near-term deployment by tribal and community-level stakeholders seeking accessible, low-barrier solutions.

Fish oil remains attractive for future exploration due to its high market value and growing demand in health and wellness sectors.¹⁰⁸ With proper investment in infrastructure and partnerships, it could offer strong returns. The research also highlighted the importance of quality control and certification, which are critical for market access. Scaling up through cooperatives or shared facilities could make this viable in the long term.

Fish Meal

Fish meal was not chosen due to the significant capital investment, regulations, and operational challenges it poses for small-scale producers. Producing high-quality fish meal requires industrial-grade drying and grinding equipment, along with proper waste handling systems. These facilities are expensive to build and maintain, especially for community-based or tribal operations with limited resources. Since fish meal is often used in animal feed, it is subject to the same state and AAFCO regulations as animal feed.

Additionally, fish meal production can be associated with strong odors, which often lead to local opposition and strict zoning regulations. Many municipalities restrict or outright prohibit such facilities near residential or mixed-use areas, making siting a major challenge.¹⁰⁹

We also considered the potential of selling raw or semi-processed fish waste to existing fish meal manufacturers. However, this was deemed impractical in the short term. Established processors typically require consistent, certified, high-volume inputs to meet quality and regulatory standards. Small-scale producers would likely struggle to meet minimum volume thresholds, maintain year-round supply reliability, and satisfy the strict traceability requirements needed to secure purchasing agreements. As a result, for producers in the Great

¹⁰⁸ Research, Persistence Market. "Fish Oil Market Set to Reach Strong Market Position by 2033 - Persistence Market Research." openPR.com, April 24, 2025. <u>https://www.openpr.com/news/3985426/fish-oil-market-set-to-reach-strong-market-position-by-2033</u>.

¹⁰⁹ "165.10 Residential Zoning District Regulations (R-1, R-2, R-3, R-4)." American Legal Publishing. Accessed April 28, 2025. <u>https://codelibrary.amlegal.com/codes/reinbeckia/latest/reinbeck_ia/0-0-0-3936</u>.

Lakes region looking for near-term, community-friendly, and scalable solutions, fish meal presented too many barriers relative to its potential returns.

Pet Food

Pet food, even though one of the most revenue-generating and profitable products, was not chosen due to the strict regulations and highly competitive industry landscape.

Pet food is subject to state, FDA, and AAFCO regulations around ingredient sourcing, processing, and labeling, especially for products intended for dogs and cats. Ensuring consistency, safety, and palatability from variable fish waste sources is challenging without industrial-scale facilities. Additionally, the cost of product testing, packaging, and distribution is often prohibitive for small community producers.

Moreover, the pet food market is heavily consolidated among a few dominant companies, and entering this space competitively would require major investment, brand building, and strong supply chain backing. We also considered the possibility of selling fish byproduct to existing pet food manufacturers. However, this approach is unlikely to be viable in the short term. Large pet food companies demand reliable, certified, and standardized inputs to maintain their quality claims and brand reputation. Small-scale producers would face significant hurdles in meeting minimum volume requirements, ensuring year-round consistency, and achieving the regulatory certifications necessary to become approved suppliers. Our stakeholder interviews revealed challenges securing buyers in this market–even for large processors. Consequently, selling into the existing pet food supply chain is not a practical pathway for small or community-based operations in the next 6–18 months.

The pet food market remains an attractive future opportunity, fueled by rising consumer demand for sustainable, protein-rich products. Interest continues to grow in eco-conscious and novel-ingredient pet treats, such as those made from insect protein, fish byproducts, or plant-based alternatives. Reflecting this shift, Petco announced in 2021 a commitment to increase its assortment of sustainable products to 50% by the end of 2025, reinforcing its broader pledge to corporate social responsibility and to preserving the health and wellness of pets, people, and the planet. This market momentum creates a favorable environment for new entrants. By leveraging strategic partnerships, co-manufacturing models, or shared processing facilities, as successfully demonstrated by emerging brands like Chippin and Wild Earth, companies can scale efficiently while maintaining strong margins and building a premium, environmentally

responsible brand identity.¹¹⁰ With the right partnerships, co-manufacturing models, or shared processing facilities, this segment could offer strong margins and brand potential.

Products Not Suitable for Project Scope

Anaerobic digestion, bait, beauty products, biochar, biofuel, bioplastic packaging & products, collagen beverages & supplements, fertilizer & compost, and medical applications were all explored as well but were found not to be suitable for the project's scope. A summary of each product can be found below.

Anaerobic Digestion

Anaerobic digestion is not a feasible option for small-scale manufacturers in the Great Lakes region to pursue over the next 6 to 18 months due to a combination of technical, financial, legal, and environmental challenges. Technically, fish waste presents significant complications for digestion due to its high lipid content and low carbon-to-nitrogen ratio, both of which can inhibit microbial activity and reduce biogas production.¹¹¹ From a market perspective, the volume of fish waste available in the region, approximately 17.9 million pounds annually from the commercial fishery,¹¹² yields only about 22,500 MMBtu/year of renewable natural gas (RNG), which may be viable for large-scale rural digesters but not practical or profitable for small-scale operations. Financially, the capital expenditure for a small digester ranges from \$400,000 to \$1.2 million, with annual operation and maintenance costs between \$11,000 and \$51,000--costs that are difficult to recoup given the limited energy yield and low-margin byproduct fertilizer sales.¹¹³ Legally, the permitting process is time-intensive and complex. In Michigan, for example, anaerobic digesters must obtain permits through the Department of Environment, Great Lakes, and Energy (EGLE), including compliance with air quality and wastewater regulations under NPDES.¹¹⁴ Even with recent legislative efforts to streamline approvals, permitting can still take 6 to 12 months or longer, delaying implementation.¹¹⁵ Finally, environmental, health, and safety concerns, such as the risk of methane leaks, toxic spills, or

¹¹² "100% Great Lakes Fish," accessed April 22, 2025,

https://www.arcgis.com/apps/dashboards/ba675d377f804f14b9281f50274d46

 ¹¹⁰ Glenn Polyn, "Eco-Conscious Consumers Shape the Future of Sustainable Pet Products," PetAge, last modified March 1, 2024, <u>https://www.petage.com/eco-conscious-consumers-shape-the-future-of-sustainable-pet-products</u>
¹¹¹ Abhinav Choudhury et al., "Anaerobic digestion challenges and resource recovery opportunities from land-based aquaculture waste and seafood processing byproducts: A review," *Bioresource Technology* 354 (2022): xx, doi:10.1016/j.biortech.2022.127144.

¹¹³ Biogasman, "Anaerobic Digestion Cost - Plus Gate Fees and and Other Rules of Thumb," IPPTS Anaerobic Digestion Community Website, last modified June 18, 2023, <u>https://anaerobic-digestion.com/anaerobic-digestion-cost-gate-fees/</u>.

¹¹⁴ Michigan Department of Environment, Great Lakes, and Energy, "Anaerobic Digesters – Permitting and CAFOs." ¹¹⁵ "Rep. Filler Introduces Plan to Support Anaerobic Digesters," MI House Republicans, last modified June 6, 2024, <u>https://gophouse.org/posts/rep-filler-introduces-plan-to-support-anaerobic-digesters</u>.

explosion hazards in confined spaces, add another layer of complexity and liability.¹¹⁶ Altogether, these barriers make anaerobic digestion an impractical and high-risk investment for small-scale manufacturers seeking near-term, scalable waste solutions.

Bait

Bait made from fish waste was not recommended because it performs poorly compared to synthetic or commercially available options. Research indicates that such bait has lower durability, reduced effectiveness in attracting target species, and shorter shelf life. These limitations make it less appealing for fishers, particularly when reliable and affordable alternatives already exist in the market. This makes bait made from fish waste unattractive to commercial fishing.¹¹⁷ The only exception to this general unattractiveness is fish heads used for commercial lobster or crab fishing. However, the lobster market fell in the U.S. in 2019 due to Chinese tariffs on U.S. lobsters and in 2020 due to the COVID-19 pandemic.¹¹⁸ While the market seems to have recovered, future policy uncertainty may lead to similar price volatility, shedding doubt on if the significant transportation distance is worthwhile. Finally, while fish waste can still be used as bait for leisure fishing, the market is much smaller and is fragmented.

Beauty Products

There are various beauty products that could use marine-based ingredients, such as collagen, gelatin, and polypeptide—an anti-aging ingredient. Beauty products were not selected because commercially caught Great Lakes fish species have not been studied for beauty applications so research and development would not only be costly but also extend past 6-18 months. For example, Cosmetic Design USA reported on a Thai study how Asian seabass skin is a great contender to use for hydrolyzed collagen based since the skin contains collagen type I, which is the same collagen found in humans.¹¹⁹ Another study used skins from salmon and Atlantic codfish and concluded that marine collagen is a suitable ingredient for beauty products.¹²⁰

¹¹⁶ "Biodigesters: Good or Bad for the Environment?," Power Knot, last modified September 26, 2022, <u>https://powerknot.com/2022/09/26/biodigesters-good-or-bad-for-the-environment/</u>.

¹¹⁷ <u>https://link.springer.com/article/10.1007/s41208-023-00625-7</u>

¹¹⁸ Amelia Shister, John Fry, and Alexander Melton, A Case Study of the U.S. and Canadian Lobster Industries, May 2022,

https://www.usitc.gov/sites/default/files/publications/332/working_papers/lobsters_industry_integration_final_05 22 .pdf.

¹¹⁹ Ana L. Alves et al., "Cosmetic Potential of Marine Fish Skin Collagen," *Cosmetics* 4, no. 4 (December 2017): 39, https://doi.org/10.3390/cosmetics4040039.

¹²⁰ "Researchers Successfully Develop Hydrolyzed Collagen Serum Derived from Fish Skin By-Products," CosmeticsDesign.com, February 16, 2023, https://www.cosmeticsdesign.com/Article/2023/02/16/Study-shows-fish-collagen-a-sustainable-source-for-cosmetics/.

Additional research should be undertaken to understand which Great Lakes fish would be the most suitable for beauty products.

One example of a promising beauty related research project is SUPREME, led by several Nordicbased researchers such as SINTEF Ocean and the Technical University of Denmark. SUPREME aims to reduce raw whitefish and salmon waste to help optimize the value chain they are developing by giving fishermen the best ways to preserve their catches.¹²¹ Researchers are working toward learning how to use whitefish skin to create fish-based gelatin, which is used in the pharmaceutical, dietary, nutrition, and cosmetic industries that can then be manufactured in different forms, such as jelly, powder, capsules etc.¹²² While this project is very promising and could be replicated in the United States, this would require an existing startup or company to process the raw waste that would then be used as ingredients for beauty products, which would require significant start-up costs.

Another possibility is to supply the fish waste to contract manufacturers. Sanford, a New Zealand-based fishery company, first partnered with Plant & Food Research, to develop the extraction process to extract collagen from fish skins.¹²³ This pilot proved successful after the product premiered at a Chinese beauty conference, and Sanford opened a new \$12.5 million plant, Sanford Bioactives, in 2022 to innovate extraction methods used in marine-based ingredients, particularly its supplement powders and eye masks.¹²⁴ Sanford supplies materials for eye masks to NanoLayr, a manufacturer who creates the eye mask fibers, to take Hoki fish skins and create collagen skin masks.¹²⁵ NanoLayr sells masks to various consumer beauty brands, such as Korean skincare brand actiVLayr and Chinese beauty brand POME.¹²⁶

¹²¹ "Circular Economy: New Tech Turns Fish Waste into Valuable Pharma and Cosmetic Ingredients - Responsible Seafood Advocate," Global Seafood Alliance, April 26, 2024, <u>https://www.globalseafood.org/advocate/circular-economy-new-tech-turns-fish-waste-into-valuable-pharma-and-cosmetic-ingredients/</u>.

¹²² Henriette Krogness Norwegianscitechnews.com, "Fish Residues Can Compensate for Raw Materials Shortages and Improve Our Health into the Bargain," SINTEF, April 24, 2024, <u>https://www.sintef.no/en/latest-news/2024/fish-residues-can-compensate-for-raw-materials-shortages-and-improve-our-health-into-the-bargain/</u>.

¹²³ "Marine Collagen for Beauty · Plant & Food Research," Plant & Food Research, accessed April 22, 2025, https://www.plantandfood.com/en-nz/article/marine-collagen-for-beauty.

¹²⁴ "Natural. Non-GMO. Certified Sustainably Managed Marine Inputs. - Sanford Bioactives," accessed April 22, 2025, https://sanfordbioactives.co.nz/marine-ingredients/.

¹²⁵ "Sanford Scales up Collagen Extraction from Fish Skin in Marlborough," RNZ, November 25, 2022, https://www.rnz.co.nz/news/country/479458/sanford-scales-up-collagen-extraction-from-fish-skin-inmarlborough.

¹²⁶ "Discover More," *DermaLayr* (blog), accessed April 22, 2025, https://dermalayr.com/discover-more/.

Biochar

Biochar production from fish waste is not a feasible venture for small-scale manufacturers in the Great Lakes region within the next 6 to 18 months due to limited market demand, high production costs, and lack of established infrastructure. Currently, biochar derived from fish waste is not widely recognized or utilized in the region, making it difficult for small producers to secure buyers or justify the investment without guaranteed end-use markets. Economic feasibility is further hindered by high costs associated with both feedstock preparation and the specialized pyrolysis equipment required for production.¹²⁷ Without significant policy incentives, subsidies, or established regional demand, small-scale operations would face considerable financial risk with limited short-term returns. As a result, biochar remains outside the practical scope for immediate deployment by local fisheries or fish processors.

Biofuel

Biofuel is not a viable option for small-scale manufacturers in the Great Lakes region to pursue within the next 6 to 18 months due to significant regulatory and adoption barriers.

Research has shown that fish waste can be turned into biodiesel. However, there remains to be a widely accepted methodology for doing so, something which has slowed commercialization.¹²⁸ Fish waste made up a mere 10 million of the 600 million gallons of biodiesel burned in the U.S. in 2020.¹²⁹ Producing biofuel requires significant investment and is subject to lengthy permitting timelines.

Our research was unable to identify if existing biodiesel producers within the Great Lakes region utilize fish waste and/or if they are willing to purchase it. However, we did identify that neither U.S. nor Canadian regulatory authorities have approved biofuels for use in the types of vessels commonly operating across the Great Lakes-St. Lawrence corridor.¹³⁰ This lack of certification restricts their legal use in regional shipping and poses a major obstacle to market entry. As a result, even if small-scale producers were able to develop biofuel from fish waste or other

https://www.wweek.com/news/2022/09/28/turning-fish-grease-into-diesel-fuel-could-solve-oregons-carbon-problem-why-are-enviros-so-queasy/.

¹²⁷ "Economics of Biochar," Great Lakes Biochar Network, last modified December 7, 2021, https://www.canr.msu.edu/news/economics-of-biochar.

¹²⁸ Vankara Anu Prasanna, et al. 2023. "Fish Waste: A Potential Source of Biodiesel" *Fermentation* 9, no. 9: 861. <u>https://doi.org/10.3390/fermentation9090861</u>

¹²⁹ Anthony Effinger, "Fishy Fuel: Turning Fish Grease Into Diesel Fuel Could Solve Oregon's Carbon Problem. Why Are Enviros So Queasy?," Willamette Week, September 28, 2022,

¹³¹ "Plants Are the New Plastic: Microplastics Are Not a Micro-Problem," fw_Inspiring, Siemens USA, accessed April 22, 2025, <u>https://www.siemens.com/us/en/products/financing/siemens-financial-insight-center/plants-are-the-new-plastic-microplastics-are-not-a-micro-problem.html</u>.

byproducts, they would face limited regional demand and uncertain returns. Without regulatory clarity or widespread adoption in the maritime sector, investing in biofuel production at this time would be premature and financially risky for small operations seeking near-term impact.

Bioplastics Packaging & Products

Bioplastics were not selected because we foresee that the advanced skills required to create bioplastics, the legal requirements and level of capital expenditure required for the research and development, and investing in manufacturing equipment would result in a long payback period and would not be feasible to set up within the 6–18-month implementation timeline.

While there are a variety of startups creating bioplastic packaging and products in the United States, these firms are primarily deriving bioplastics from plant-based products. PlantSwitch, a North Carolina-based manufacturing plant, works with farms to receive agricultural byproducts, such as rice hulls and wheat straw, to create compostable pellets that can then be used to create biobased plastic products, such as compostable cutlery.¹³¹ Additionally, its partnership with Siemens, a German technology conglomerate, provides the financial backing to support the research and development for equipment and embedding Siemens technology into PlantSwitch's manufacturing plant.¹³² This firm underscores the necessity to have a larger firm providing backing to scale production. Then, there is UK-based MarinaTex®, created by former graduate student Lucy Hughes, that partners with a local fish processing plant to receive the skins and scales that are then used to create bioplastics.¹³³ Hughes cited the challenges that she faces with her company, which include legal resources to obtain patents, costly research, acquiring more equipment to change the formulas, and acquiring the necessary certifications needed for food-safe packaging.¹³⁴

Collagen Beverages & Supplements

Collagen beverages and supplements were not selected because of the operational difficulties imposed by the seasonality of the Great Lakes commercial fisheries.

¹³³ "About," MarinaTex, accessed April 22, 2025, https://www.marinatex.co.uk/about-3.

¹³¹ "Plants Are the New Plastic: Microplastics Are Not a Micro-Problem," fw_Inspiring, Siemens USA, accessed April 22, 2025, <u>https://www.siemens.com/us/en/products/financing/siemens-financial-insight-center/plants-are-the-new-plastic-microplastics-are-not-a-micro-problem.html</u>.

¹³² "Plants Are the New Plastic: Microplastics Are Not a Micro-Problem," fw_Inspiring, Siemens USA, accessed April 22, 2025, https://www.siemens.com/us/en/products/financing/siemens-financial-insight-center/plants-are-the-new-plastic-microplastics-are-not-a-micro-problem.html.

¹³⁴ "MarinaTex," James Dyson Award, accessed April 2, 2025, <u>https://www.jamesdysonaward.org/en-US/2019/project/marinatex</u>.

Existing collagen beverage companies do not use any of the commercially caught Great Lakes fish species in their formulations, ruling out the possibility of supplying byproduct to an existing collagen manufacturer in the short-term. Even the aptly named Great Lakes Wellness uses marine collagen from other species, including Atlantic Cod, Blue Ling, Pacific Cod, and others. This sourcing enables them to label the product as "wild-caught".¹³⁵

Seasonality becomes a barrier to producing collagen beverages from Great Lakes fish. While supplements are not regulated by the FDA, product formulations must remain consistent for nutritional labeling and cost. If the type of fish in the product cannot be substituted, a consistent supply must be available year-round. There are several challenges to executing this. First sourcing from aquaculture prevents utilization of the "wild-caught" label which is used by most marine collagen beverages on the market. However, certain Great Lakes species, like Lake whitefish, are not available from aquaculture sources. While frozen byproducts of wild-caught fish could theoretically be used to have a year-round supply, this is very risky for a commercialized product. The lead time between when the amount of byproduct needed is determined and the next time the byproduct could be sourced in the future may be a very long time. It is possible to get stuck with too much or too little frozen byproduct and not be able to scale up or down to meet demand. As a result, we do not recommend collagen beverages for small-scale manufacturing at this time.

Fertilizer & Compost

Fertilizer and compost production from fish waste is not a feasible option for small-scale manufacturers in the Great Lakes region over the next 6 to 18 months due to high processing costs, limited revenue potential, and operational challenges. Data from the Little Traverse Bay Bands of Odawa Indians Natural Resource Department shows that composting 600,000 pounds of fish waste, ¹³⁶ assuming a 60% waste rate, yields only 150–180 cubic yards of compost annually. At a market rate of \$40 per cubic yard, ¹³⁷ this translates to \$6,000–\$7,200 in revenue. However, processing costs, even with a 50% subsidy, range from \$22,500 to \$43,500 per year, ¹³⁸ resulting in a net loss of \$15,300 to \$37,500. Breaking even would require selling compost at \$125 per cubic yard, which is significantly above standard market prices. Furthermore, fish waste composting presents additional hurdles due to its high moisture content and potential for

 ¹³⁵ "Daily Marine Collagen Peptides: Great Lakes Wellness Collagen Peptides," Great Lakes Wellness, accessed April
25, 2025, <u>https://greatlakeswellness.com/products/daily-marine-collagen-peptides?selling_plan=1241153671</u>.
¹³⁶ 2016-2017 Annual Harvest Report, (LTBB NRD, 2018), <u>https://ltbbodawa-nsn.gov/wp-</u>content/uploads/2020/11/Harvest-Report-2016-2017.pdf.

 ¹³⁷ "Emmet County Recycling and Disposal Serving Petoskey, Harbor Springs and Northwest Michigan," Recycling & Disposal | Emmet County Recycling, accessed April 6, 2025, <u>https://www.emmetrecycling.org/for-sale/compost</u>.
¹³⁸ Ibid

odor, which may require specialized handling and increased costs. While blending fish waste with municipal yard waste or targeting niche markets such as organic vineyards and hemp farms could improve long-term feasibility, ¹³⁹ these strategies require partnerships, infrastructure, and market development that are unlikely to materialize within the next 6–18 months.

Medical Applications

Medical applications were not selected due to the multi-year research and development required to create medical products to be used in the human body and the highly regulated environment. Medical products require navigating the lengthy and complicated approval process of the Food and Drug Administration (FDA). Since using fish waste may be considered a novel product, the FDA may require premarket approval, which at minimum takes 180 days to get approval and may take over a year.¹⁴⁰ In fact, getting FDA approvals is only the first step, as healthcare insurers and clinicians need data to prove that this technology is scalable and will help their patients¹⁴¹ before insurers cover the costs and healthcare providers purchase and allow clinicians to use on patients. Market implementation exceeds the shorter timeline of 6-18 months.

Kerecis, an Icelandic firm owned by Coloplast A/S, has patented the use of fish skins for skin grafts in the United States.¹⁴² Kerecis imports Atlantic cod fish from Iceland for skin grafts.¹⁴³ The firm applied for FDA approvals in stages starting in 2013.¹⁴⁴ As far as the Great Lakes region is concerned, there would have to be additional research to understand if Great Lakes fish species would be suitable.

Kerecis has been around since at least 2009 when it was raising money from investors.¹⁴⁵ Even though Kerecis has FDA approval, it has also had to navigate the complexity of the Centers for Medicare and Medicaid Services (CMS), the United States' Department of Health and Human Services agency that administers the Medicare program, which requires that medical

https://www.kerecis.com/fda-clears-fish-skin-technology-to-heal-human-wounds/.

 ¹³⁹ "La Valorisation Des Déchets De Poissons S'organise Grâce à La Reverse Logistic," Actu-Environnement, accessed April 6, 2025, <u>https://www.actu-environnement.com/ae/news/valorisation-dechets-poisson-35095.php4</u>.
¹⁴⁰ "Medical Device FDA Approval Process [+Timeline]," accessed April 22, 2025, https://www.greenlight.guru/blog/fda-medical-device-approval-process.

¹⁴¹ Dee Kolanek, "How to Get Nationwide Reimbursement for Novel Medical Technology," MedCity News, August 20, 2020, https://medcitynews.com/2020/08/how-to-get-nationwide-reimbursement-for-novel-medical-technology/.

¹⁴² "Overview - Kerecis," February 7, 2023, <u>https://www.kerecis.com/overview/</u>.

 ¹⁴³ "Patients and Caregivers - Kerecis," accessed April 22, 2025, <u>https://www.kerecis.com/patients-and-caregivers/</u>.
¹⁴⁴ "FDA Clears Fish-Skin Technology to Heal Human Wounds - Kerecis," November 7, 2013,

¹⁴⁵ "Kerecis to Present at the 10th Seed Forum Iceland Conference - Kerecis," September 30, 2009, https://www.kerecis.com/kerecis-present-10th-seed-forum-iceland-conference/.

applications must be considered "reasonable and necessary" for Medicare to cover.¹⁴⁶ While Kerecis is covered by Medicare, new firms will face the barrier of a postponed CMS policy that would have covered alternative skin grafts, and is postponed until January 2026.¹⁴⁷

Recommendations for Further Research

While many products highlighted in this report did not fall within the scope of the project's short time horizon, they still show potential for the long term. Several products highlighted below would be good candidates for further research.

- Anaerobic Digestion As noted above, building an anaerobic digester is extremely capital intensive and has many regulatory hurdles. However, there are currently 60 existing food waste digesters within the Great Lakes region and many more that handle manure and wastewater.¹⁴⁸ GSGP should conduct more research on the locations of existing digesters within the Great Lakes region and their proximity to waste landing locations as these existing digesters could serve as an alternative to landfilling or composting fish waste. While tipping fees may still be required, reducing transportation distance would reduce cost and greenhouse gas emissions. The Michigan State University Anaerobic Digestion Research and Education Center would be a good partner for this effort.¹⁴⁹
- Biofuels The biofuels market is expected to grow at a CAGR of 11.3% globally between 2024 and 2030.¹⁵⁰ While biofuels from fish waste are still in the early stages of commercialization globally, the Great Lakes Bioenergy Research Center would be a good organization for GSGP to connect with about potential research partnerships.¹⁵¹
- Bioplastics The bioplastics market is expected to grow at an impressive CAGR of 19.5% between 2025 to 2030.¹⁵² Given the explosive growth in this industry, GSGP should inquire about potential partnerships with regional universities that are already

¹⁴⁶ "Medicare Coverage Determination Process | CMS," accessed April 22, 2025, <u>https://www.cms.gov/medicare/coverage/determination-process</u>.

¹⁴⁷ Business Wire 3 min read, "CMS Delays Skin Substitute Policy, Intact Fish-Skin Grafts Remain Covered on Existing LCDs," Yahoo Finance, April 14, 2025, <u>https://finance.yahoo.com/news/cms-delays-skin-substitute-policy-145600949.html</u>.

¹⁴⁸ "Biogas State Profiles," American Biogas Council, November 6, 2024,

https://americanbiogascouncil.org/resources/state-profiles.

¹⁴⁹ "Anaerobic Digestion Research and Education Center (ADREC)," Michigan State University, accessed April 24, 2025, <u>https://www.egr.msu.edu/bae/adrec/about</u>.

¹⁵⁰ "Biofuels Market Size, Share & Growth Analysis Report, 2030," Grand View Research, accessed April 25, 2025, <u>https://www.grandviewresearch.com/industry-analysis/biofuels-market</u>.

¹⁵¹ "About," Great Lakes Bioenergy Research Center, November 13, 2017, <u>https://www.glbrc.org/about</u>.

¹⁵² "Bioplastics Market Size, Share, Growth Analysis Report 2030," Bioplastics Market Size, Share, Growth Analysis Report 2030, accessed April 24, 2025, <u>https://www.grandviewresearch.com/industry-analysis/bioplastics-industry</u>.

renowned for bioplastics research, including, Michigan State University's School of Packaging¹⁵³ and Purdue University.¹⁵⁴

- Beauty/ Skincare Products The GSGP team should consider researching the viability of Great Lakes fish for beauty/skincare applications. The global collagen market is expected to reach \$1.2 billion by 2032, which has been driven by increased consumer demand for anti-aging topical cosmetic products.¹⁵⁵ Should GSGP want to explore this further, Nutra Ingredient is an ingredient contract manufacturer based in Kentwood, Michigan.¹⁵⁶
- Medical Applications While the four main commercially caught Great Lakes fish have not yet been used in medical applications, the topic should be considered for a longterm investment initiative or research partnership. University of Pittsburgh researchers recently launched a startup, Zegenex, that uses zebrafish for medical applications and may be a good contact for GSGP to learn more about the research and commercialization process.¹⁵⁷ Additionally, Salmonics, a producer of biomedical products made from fish proteins, is based in Maine and is open to partnerships with aquaculture companies, researchers, and others.¹⁵⁸

Conclusion

The "100% Great Lakes Fish" project highlights the significant opportunity that exists when sustainability, innovation, and community-driven economic development intersect. Through a comprehensive evaluation of potential byproduct uses, we identified near-term viable options—pet treats, culinary collaborations, and fish leather goods and workshops—that align with the operational realities and entrepreneurial capacity of small-scale and tribal producers in the Great Lakes region.

¹⁵³ "MSU School of Packaging Researchers Make a Sustainable Plastic More Compostable," MSU Innovation Center, August 31, 2023, <u>https://innovationcenter.msu.edu/msu-school-of-packaging-researchers-make-a-sustainable-plastic-more-compostable/</u>.

¹⁵⁴ "Purdue Researchers Develop Sustainable, Biodegradable Superabsorbent Materials from Hemp." Purdue University, August 20, 2024. <u>https://www.purdue.edu/newsroom/2024/Q2/purdue-researchers-develop-sustainable-biodegradable-superabsorbent-materials-from-hemp/</u>.

¹⁵⁵ Market Research Future https://www.marketresearchfuture.com, "Fish Collagen Peptide Market Size, Share, Growth | Report, 2032," accessed April 6, 2025, <u>https://www.marketresearchfuture.com/reports/fish-collagen-peptide-market-32641</u>.

¹⁵⁶ Bryon Yang and President, "Nutra Food Ingredients," Nutra Food Ingredients, January 20, 2016, https://www.nutrafoodingredients.com/.

¹⁵⁷ Kiley Koscinski, "University of Pittsburgh Startup Wants to Innovate Wound Care with Zebrafish," 90.5 WESA, November 26, 2024, <u>https://www.wesa.fm/health-science-tech/2024-11-25/university-of-pittsburgh-startup-wound-care-zebrafish</u>.

¹⁵⁸ "Partner with US," Salmonics LLC, accessed April 25, 2025, <u>https://www.salmonics.co/partner-with-us/</u>.

Our research also surfaced important lessons for future efforts: while many high-value products like fish oil, pet food, and fish meal hold long-term promise, they require substantial investments in infrastructure, certification, and supply chain consistency that are not currently attainable for small producers within a 6-18 month window. Addressing these barriers over time through cooperative models, shared processing facilities, and investment in technical assistance will be critical to unlocking the full circular economy potential.

By focusing on accessible, scalable, and sustainable solutions today, the region can build momentum toward a future where 100% utilization of Great Lakes fish is not just an aspiration, but a standard practice—benefiting the environment, local communities, and regional economies alike.