Socio-Economic & Environmental Analysis

of Great Lakes 100% Fish Initiative

PREPARED BY

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Contents

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Executive Summary

TriNav Fisheries Consultants (TFC) was engaged by the Conference of Great Lakes St. Lawrence Governors and Premiers (GSGP) to assess the economic and environmental benefits of the 100% Great Lakes Fish Initiative. Building on two earlier reports that explored value-added uses for fish byproducts, this analysis offers a comprehensive overview of the benefits that could result from widespread adoption of full fish utilization across the region's commercial processing industry.

Today, a significant portion of each fish harvested in the Great Lakes is discarded—sent to landfill or low-value uses. The 100% Great Lakes Fish Initiative seeks to change that by developing markets for heads, bones, skins, viscera, milt, and other byproducts. The potential benefits are substantial and span multiple dimensions. As illustrated in this table, economic benefits are estimated at over $50,000,000 (CAD) and environmental benefits are estimated at 7.9 million lbs. of CO_2 reduction and 265,000 lbs. of CH4 reduction, in addition to other environmental benefits.

	Type of Benefit	Description
Economic Benefits	Cost Savings from Disposal	Redirecting byproducts from landfill will save processors approximately **$295 (CAD) per ton** of waste.
	Direct Revenue to Processors	Diverting byproducts to value-added uses could generate over **$4 million (CAD) annually** for processors.
	Revenue Generation from Finished Goods	Converting fish material to value-added finish goods that are sold to consumers may generate over **$30 million (CAD)** annually.
	Job Creation	Implementation of the 100% Fish Initiative could create **over 30 jobs directly** utilizing the material or at the processor level, and **over 60 jobs indirectly**, and over **$7 million (CAD) in employment income**.
	Season Extension	Freezing and storing byproduct could **extend plant operating seasons**, supporting stable employment and economic activity.
Environmental Benefits	Emission Reductions	Diverting fish waste from landfill could avoid the release of up to **7.9 million lbs of CO_2 as well as 265,000 lbs of CH4** annually at full implementation.
	Landfill Impact	Removing fish waste from organic waste streams **reduces methane emissions** and **improves worker safety** in waste handling.
	Soil and Water Health	Using fish byproducts in compost and fertilizer **restores nutrients to the soil** and **helps prevent nutrient runoff and algal blooms** in nearby water systems.

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Introduction

TriNav Fisheries Consultants, Inc. was retained by the Conference of Great Lakes St. Lawrence Governors and Premiers (GSGP) as part of the 100% Great Lakes Fish initiative to conduct a comprehensive analysis of economic and environmental impacts of potential value chains that could be established through the initiative.

This is the third report in a series describing various value chains that could make use of the fish byproduct generated by the Great Lakes fishing industry. Previously, the following industries were identified:

i. Commercial Pet Food
ii. Pet Treats
iii. Fish Leather
iv. Collagen and Gelatin
v. Fertilizer
vi. Compost
vii. Fishing Bait
viii. Fish Meal and Oil
ix. Biomedical

These industries were assessed to determine the volumes, capacity and logistics required to participate. Based on the findings the potential revenues were quantified. This follow-up report is meant to describe the potential benefits of the 100% Great Lakes Fish Initiative in a more comprehensive manner, focusing on the total economic and ecological gains possible rather than just at individual industry level.

The primary focus of this report will be describing the benefits to both the processors and the Great Lakes St. Lawrence region that can be realized through the implementation of the 100% Great Lakes Fish Initiative. The economic loss associated with sending byproduct to landfill at a fee was compared against the revenues that could be realized by redirecting the byproduct to relevant identified industries. Employment benefits, such as the creation of new jobs and extension of the working season, were considered as well. Environmental factors such as reductions in greenhouse gas emissions and lessening pressure on vulnerable fish stocks were other factors of note.

Economic Impact

The Great Lakes commercial fishery is a major revenue generator and source of employment in the region. Annually, the commercial fishery generates approximately $420 million (CAD) and supports nearly 3,000 jobs, according to the Great Lakes Valuation Report released by the Great Lakes Fishery Commission in 2022. However, inefficient and costly disposal of fish byproducts detracts from the overall value of the industry, and the underutilization of potentially valuable fish parts represents a major source of unrealized financial opportunity.

Currently, a large portion of byproduct is destined for landfill, which incurs significant tipping fees which have been increasing steadily over the past several years. Beyond the tipping fees, the byproduct must be stored and transported prior to its disposal, which incurs additional costs.

Overall, this represents a net loss for both the processors and the regional economy. The 100% Fish Initiative is a pathway to reclaiming these losses and converting a money losing cost into a potential revenue generating activity.

Status Quo & Economic Loss

Due to a lack of established supply chains and business relationships, utilization of fish byproduct from the Great Lakes region is limited. With limited exceptions, every processor that was surveyed indicated that removal of byproduct was a cost. However, the development of the 100% Great Lakes Fish Initiative has made substantial progress in laying the necessary groundwork to establish these value chains that can unlock increased economic and social opportunities.

Based on data collected from processors in the region, a significant portion of the byproduct produced is currently destined for landfill, compost, and fertilizer. Information collected indicates that each ton of waste costs approximately $295 (CAD) to remove. Note that due to the lack of more in-depth monitoring of where and how processors dispose of their byproduct, more specific information is limited. For the sake of this report, it was assumed that disposal costs are uniform and that the “status quo” represents the current situation, where approximately 75% of the volume of byproduct material is utilized in very low-margin industries with the remaining 25% sent to landfill.

The Great Lakes region produces over 9,070 t (20 million pounds) of byproduct annually resulting in an estimated dumping cost of approximately $2.7 million (CAD) annually for the entire industry. As landfills are often publicly funded and operated by either municipal or State/Provincial governments, they are not profit generating businesses, and the cost of operation is often paid for by taxpayers. In total, it is estimated that the overhead, transportation and disposal of byproduct amounts to a cost of approximately $0.14 (CAD) /lb, total. Note that this figure is relatively consistent with the reported disposal costs from surveyed processors, regardless of if the byproduct was destined for landfill, fertilizer, or compost.

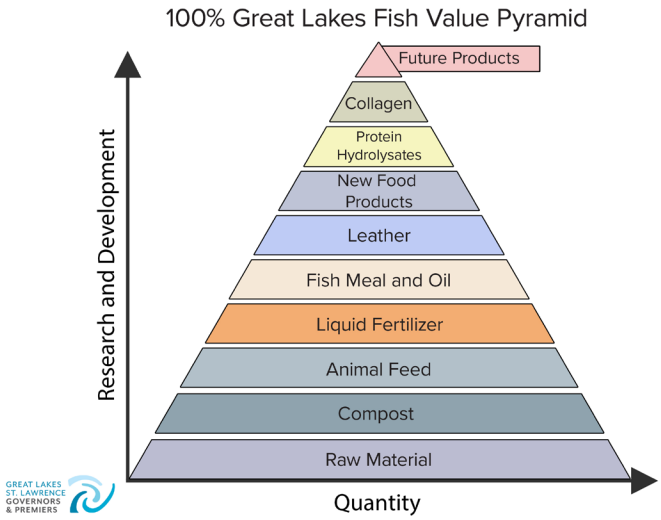
In addition to the cost of disposal, this represents an unrealized opportunity for additional revenue generation. For example, if Great Lakes processors were able to sell the entirety of their byproduct for a net revenue of only $0.10/lb (CAD), that would represent a revenue gain of $2.0 million (CAD).

Based upon conversations with processors, sorting product adds little additional labor or overhead costs. Freezing byproduct for the short-term is also an achievable goal for most processors, as their freezers are typically not filled entirely to capacity. This would not incur any additional energy costs as the freezers are already powered for the chilling of the main products. Processors without additional capacity to freeze byproduct are likely limited to accessing industries that have less strict requirements for fresh materials, such as fertilizer and compost. These are low margin industries, and in the case of composting may even charge a tipping fee. TFC’s ongoing research has demonstrated that composting facilities are generally unwilling to pay anything for raw material as they have very thin margins. Through discussions it was found

that the maximum a fertilizer company will pay for byproduct is roughly between $0.07-0.10/lb (CAD), though actual transactions are typically completed at amounts less than this.

Low Margin Value Chains

The initial implementation of the 100% Great Lakes Fish Initiative will likely focus on lower margin value chains due to the relative ease of access. These industries can accept large volumes of material and require limited extra handling (i.e. freezing). Industries such as commercial pet food and fertilizer have supply chains that are also well-established, whereas more complicated industries such as fish leather or the biomedical field are still in the process of developing infrastructure and cultivating a reliable consumer base. As a result, until these more profitable industries become more established, low-margin industries are the best solution for immediate redirection of fish byproduct.



Depending on the specific industry, the amount that processors may receive will likely vary between $0.00/lb (no revenue, no loss) to $0.20/lb. At $0.10/lb, this would result in an annual increase in industry revenue by approximately $2,000,000 (CAD). At $0.20/lb, this figure would increase to $4,000,000 (CAD). The most likely outcome for processors is a variety of value chains with different price points, with some product sent to pet food or fertilizer with the remainder sent to compost for no revenue or a modest tipping fee.

The finished goods for these value chains sell for a moderate price on a per pound basis. For example, a 21-pound bag of dog food made from fish (along with other necessary ingredients) sells for approximately $105 (CAD) at PetSmart, or approximately $5.00/lb (CAD). If 5 million pounds of this type of dog food is created through sourcing Great Lakes fish byproduct, that results in $25 million (CAD) in economic activity. Fertilizer and compost typically sell for less than pet food but would still result in modest economic gains.

Generally, these industries (pet food, fertilizer, gelatin and collagen, fish meal and oil) are volume driven, and already utilize substantial amounts of material. The amount provided by the Great Lakes processors would not represent a massive increase in those industries' intake of raw material. Consequently, there would likely be little change in employment.

High Margin Value Chains

Certain value chains require much lower volumes and support much higher buying prices. TFC's previous report found that the pet treat and fish leather industries are two examples of high margin value chains that may represent a significant revenue potential, exceeding $0.50/lb (CAD) in some cases. One of the drawbacks of these industries is that they cannot support high volumes, meaning that only a portion of the byproduct generated by Great Lakes processors can be sent to these value chains. However, the significantly higher prices that high margin value chains are willing to pay result in the potential revenues being equivalent to or even higher than those that can be achieved in low margin chains even with significantly greater volumes.

The revenues that can be generated from these industries are considerably higher, exceeding $0.50/lb in some instances. Compared to the $4,000,000 (CAD) that low margin industries can generate, at 100% utilization the high value industries could generated an additional $10,000,000 (CAD) for processors in the Great Lakes region (at $0.50/lb). Realistically, the full volume of byproducts would initially not be destined for the high margin industries, and the likely

outcome would be a mix of high and low margin destinations for Great Lakes fish byproduct.

Unlike pet food, fertilizer, and compost, products such as fish leather goods can sell for an extremely high price to the consumer. At the artisan scale, some products incorporating fish leather sell for hundreds of dollars utilizing a single strip of fish leather. Shoes with fish leather produced at larger scales may sell for several hundred dollars per pair. Pet treats are another high value product that can be produced at smaller local and regional scales, with products often selling for more than $15/lb (CAD). Despite having a reduced capacity for raw material, the high value of these products means that only limited amounts of raw material are necessary to generate significant added value and economic activity. Due to the variety in type, price range, and lower levels of industry volume capacity, it is difficult to project the revenues that are potentially achievable. What is important to understand is that the revenues that these finished goods are capable of generating are significant, potentially tens of millions of dollars annually.

Collection Center

One of the most significant obstacles to implementing a successful strategy for byproduct utilization at an industry scale is the relative low volumes produced by any one processor. While collectively the Great Lakes fishing and processing industry produces a significant amount of fish "waste" material, individual processors often do not generate enough of this material to supply industries that may have an interest in it. For example, commercial pet food, fertilizer, collagen, and meal and oil require vast volumes of fish material on an annual and even monthly basis. A single processor does not have the volume to adequately supply these industries year-round.

A potential solution would be the establishment and operation of a byproduct collection center. This facility (or facilities) would be established in the most productive regions of the Great Lakes, to which multiple processors would have easy access. This facility would purchase the raw material directly from the processers. It would then handle the sorting, handling, and freezing requirements for the byproduct before selling and shipping the byproduct to the target industries, such as pet food or fish leather. This would remove the need for processors to significantly change their operations and provide an easy and profitable way to remove byproduct from their facilities. During TFC's discussion with processors, an easy and quick solution to byproduct utilization was strongly preferred over more complicated efforts that require changing how these processing facilities operate (for example, removing the fish skins from the fillet).

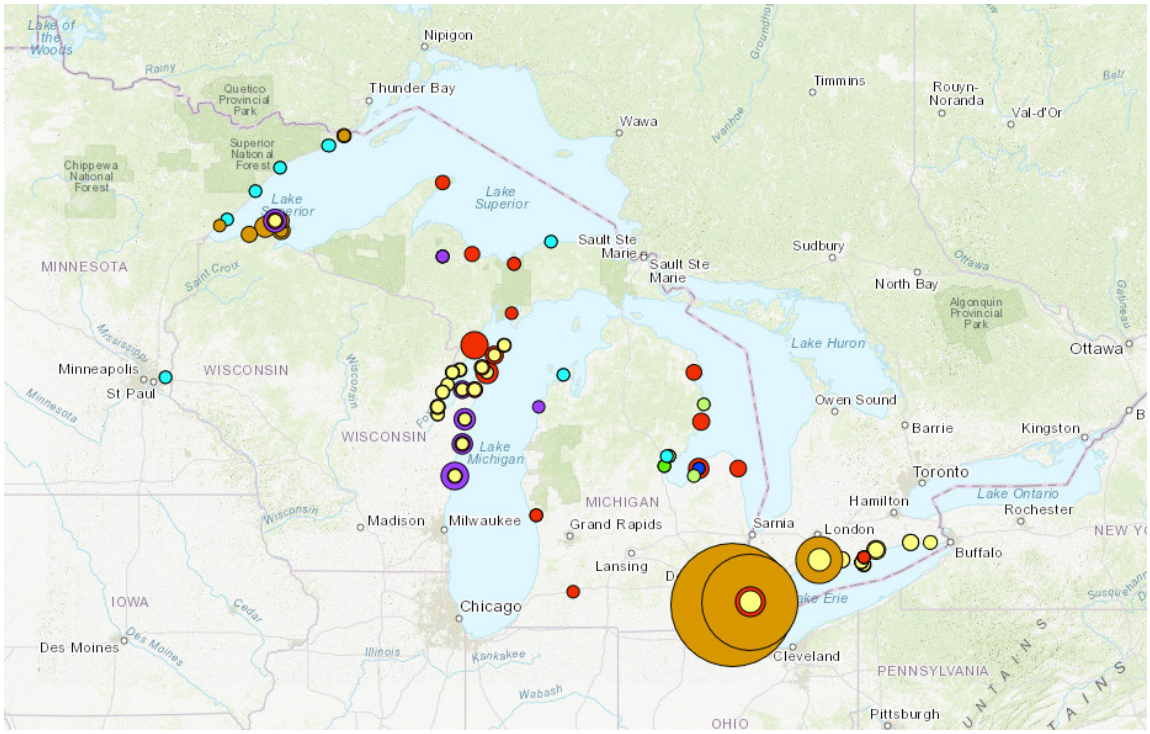
A collection facility would solve some of the issues related to providing the byproduct to more volume-based industries, as it would be sourcing raw material from multiple processors. The facility would also be able to hold material for longer term, in comparison to fish processors which prefer to remove byproduct quickly, so it doesn't obstruct storage for their fillets.

If new construction was required, the upfront cost of building a cold storage facility would be a major, but not insurmountable obstacle. A cold storage facility with 3,000,000 lbs of capacity would cost approximately $2.2 million (CAD) to construct. Generally, the cost to construct is approximately $150 (CAD) per square foot. This cost could potentially be avoided by utilizing an existing facility. In either scenario, the cost of the power and utilities required to keep the facility operational is approximately $100,000 (CAD) annually.

Transport of material would be another cost that the collection center would need to consider. It is important to establish the collection center in a location that is central to the processing activity of the fisheries in order to minimize transportation

costs and time. The most sensible locations for the facility would be in the vicinity of southwestern Lake Erie and western Lake Michigan, where the bulk of the processing activity takes place.

Figure 1. Estimated concentration of fish byproduct produced in the Great Lakes region. Larger circles denote higher volumes of waste. Full map available at: https://gsgp.org/projects/100-great-lakes-fish/map-average-weight-by-port-and-species/



Employment Benefits

As discussed in the previous sections, the implementation of the 100% Fish Initiative in the Great Lakes region would likely result in a modest increase in employment opportunities. High volume industries are unlikely to account for any increase in employment as these value chains can easily absorb the material from the Great Lakes fisheries without requiring additional labor to do so. The creation of additional employment opportunities is most likely to occur at the regional or artisan level. Pet treats, regional-scale pet food, and fish leather are the industries most likely to see employment increase through the 100% Great Lakes Fish Initiative in the near term.

An example that suggests this may be possible is Totally Raw Pet Food based in Nova Scotia. While Totally Raw utilizes a variety of protein sources, seafood fish byproduct and bycatch accounts for approximately 60,000 lbs of its production annually. Totally Raw operates three retail stores in the Halifax area, employing several people at each location. A similar operation exists in Alaska (AlaSkins) that specializes in pet treats derived from fish skins. These businesses demonstrate that the Great Lakes region could potentially be established with the fish byproduct as the main selling point. The establishment of such a business in the Great Lakes region could create 5-10 jobs depending on the scale of the operation. Assuming an annual wage of approximately $60,000 (CAD) per job, this would generate $300,000 to $600,000 (CAD) in employment benefits. The high population concentrated in the Great Lakes region could likely support multiple pet treat establishments, and the creation of 20-30 jobs for this specific industry is very conceivable.

Fish leather at the artisan scale is typically a one- or two-person operation and would likely represent a part-time form of income. Currently the artisan fish leather industry is not well developed, and it is difficult to generate a profit, with current practitioners describing it as a hobby rather than a real source of livelihood. A lack of widescale knowledge of fish leather

products along with the labor-intensive nature of the process are currently major obstacles to more widespread adoption. However, major apparel companies have begun releasing experimental products utilizing fish leather and the overall awareness of fish leather is beginning to grow.

The establishment of a collection facility represents another avenue for increasing employment opportunities utilizing fish byproduct. This would likely be a modest increase, possibly between 5-10 positions to sort the material in the facility, handle the logistics and financials, and market the service to interested industries. At an expected wage of $60,000 (CAD) per job per year, this equates to between $300,000 and $600,000 (CAD) in additional employment revenue.

An additional employment benefit would be the potential extension of the working season for the processing plants. During the peak of the fishing season, processing plants are typically near or at capacity and are focused on the primary revenue generators, typically the fillets sold for human consumption. Byproduct could be frozen and stored for later usage so long as there is adequate freezer space. Once the fishing and processing season slows down, the plant could shift towards handling and preparing the frozen byproduct, extending the season and creating additional work for plant employees. The amount of additional labor hours created would depend on the species, size of the plant, number of employees, and efficiency of the plant processing line, and is therefore difficult to estimate in concrete numbers.

In some cases, the sorting and handling of byproduct may require additional labor, resulting in the creation of new jobs. This would be more relevant in situations where additional, previously underutilized, species were incorporated into the production lines, such as gizzard shad, as the volumes for the currently harvested commercial species are unlikely to increase significantly in the near future.

Beneficiaries and Expansion

Initially, the primary beneficiaries of the 100% Fish Initiative will be the high volume, low margin industries that can easily accept the volumes produced in the Great Lakes region with minimal disruption to their currently existing operations. Pet food, fish meal and oil, and fertilizer producers are each volume-reliant industries that have relatively well-established processes and should be able to accept significant quantities of byproduct from fish processors with minimal additional required labor or resources. Composting operations may also be capable of taking larger volumes; however, this is less ideal due to the associated tipping costs processors may have to pay,

Processors operating on the western side of Lake Erie have the largest volumes of fish waste, primarily associated with the walleye and yellow perch fisheries. These processors are the most likely to be able to divert significant quantities of fish byproduct to volume-focused industries such as pet food and fertilizer. Other significant concentration of fish waste is generated on the western coast of Lake Michigan and the southwestern portion of Lake Superior.

More geographically isolated processors operating in areas of lower landings and production will likely rely on smaller, less volume-focused industries initially. The pet treat industry requires much smaller volumes than traditional pet food, and the margins for these products are typically significantly higher. This might help to mitigate the impact of the costs associated with the transportation of the byproduct.

As the various lower margin value chains are activated over time, there will be prospects to expand into higher margin value chain opportunities. Industrial scale fish leather and biomedical applications for fish waste are showing promising signs of growth, and while not currently able to accept significant volumes, these industries represent potentially profitable future opportunities.


Photo Credit: OCFA

Economic Scenarios

It is unlikely that the Great Lakes fishing industry will be able to generate revenue from 100% of its fish waste immediately, and utilization of byproduct will be an iterative process that scales up over time. Certain value chains are more easily accessible, while other industries that may utilize fish byproduct may not yet have the capacity to handle a large influx of material. The most likely scenario in the near term is that a significant portion of the byproduct produced in the Great Lakes region is sent to high volume industries at low margins. Eventually, there will be opportunities to scale up and diversify as new value chains are activated and developed. Table 1 below includes a variety of revenue scenarios based upon total utilization and value chain activation. Note that these are estimates and the achievable revenues and employment gains may differ. The following assumptions were utilized:

i. Total available volume of byproduct would remain static at 20 million lbs.

ii. Based on discussions with various industries, the average $/lb achievable for high volume, low margin industries that utilize fish byproduct is $0.05/lb (CAD). This was chosen to retain an element of conservatism in the estimates.

iii. Based on discussions with various industries, the $/lb achievable for low volume, high margin industries that utilize fish byproduct is $0.50/lb (CAD).

iv. Salaries and wages were estimated at $60,000 (CAD) annually per created job to maintain an element of conservatism.

v. Dumping costs (tipping fees) are estimated at $0.13/lb (CAD).

vi. Finished goods from low margin value chains sell for $5.00/lb (CAD).

vii. Finished goods from high margin value chains sell for $10.00/lb (CAD).

viii. For finished goods, a multiplier of 0.3 was incorporated to adjust the raw material weights for water, which is typically removed prior to the creation of the finalized product. Fish material is typically comprised of 70-80% water.

Table 1 illustrates the possible economic gains under a scenario in which the industry initially sends only a portion of its byproduct to low margin industries before scaling up and diversifying to more profitable industries over time.

Table 1. Economic scenarios based upon varying utilization levels. All currency $CAD.

	Current Stage Year 0-2	**Early Stage** Year 3-4	**Intermediate Stage** Year 5-9	**Late Stage** Year 10+
Total Available Volume (LBS)		20,000,000		
% of Total Volume to Low Margin Industries	75%	95%	85%	65%
Quantity (LBS) to Low Margin Industries	15,000,000	19,000,000	17,000,000	13,000,000
Revenue from Low margin industries @ $0.05/lb	$750,000	$950,000	$850,000	$650,000
% of Total Volume to High Margin Industries	0%	5%	15%	35%
Quantity (LBS) to High Margin Industries	-	1,000,000	3,000,000	7,000,000
Revenue from High margin industries @ $0.50/lb	$-	$500,000	$1,500,000	$3,500,000
Total Annual Revenue to Processors	$750,000	$1,450,000	$2,350,000	$4,150,000
Estimated Regional Direct Jobs Created	0-10	10-20	20-30	30-40
Max Estimated Employment Wage Generation @ $60,000 per Job	$600,000	$1,200,000	$1,800,000	$2,400,000
Estimated Regional Indirect and Induced Job Creation	0-20	20-40	40-60	60-80
Max Estimated Indirect and Induced Employment Wage Generation @ $60,000 per job	$1,200,000	$2,400,000	$3,600,000	$4,800,000
Finished Goods Revenue (Low Margin @ $5.00/lb * 0.3)	$9,000,000	$28,500,000	$25,500,000	$19,500,000
Finished Goods Revenue (High Margin @ $10.00/lb *0.3)	$0	$3,000,000	$9,000,000	$21,000,000
TOTAL ECONOMIC GAIN	**$11,550,000**	**$36,550,000**	**$42,250,000**	**$51,850,000**

Recommendations

The fish byproduct currently generated by the Great Lakes fishing industry represents an unrealized economic opportunity. The following recommendations can help accelerate progress.

Issue	Description of Issue	Possible Solution	Description
Lack of Concentrated Volume	The relative lack of concentrated volume from the Great Lakes commercial fisheries compared to the East and West coast fisheries in North America creates difficulties in accessing high volume margin chains.	Establish collection center	The construction of a collection center for fish byproduct that is near major sources of raw material would allow processors to easily divert their fish waste. Aggregating the waste to one or two central facilities would increase accessibility to industries that require higher volumes
		Target Artisan industries	For processors with smaller volumes or who are more geographically isolated, target selling to artisan buyers who can accept smaller volumes.
		Utilize waste from recreational fisheries and aquaculture	Developing infrastructure for recreational fish cleaning stations in order to refrigerate or freeze fish waste generated at these stations may create an additional, significant source of raw material that could be used to bolster the volumes available for possible usage in industries such as pet food, fertilizer, etc. The aquaculture sector is also an additional source of volume that should be tapped in order to bolster volume of raw material available.
Unfamiliarity with 100% Fish Products	Products made from fish byproduct are relatively unknown to the average consumer. Some industries that utilize fish byproduct are unfamiliar with the Great Lakes fish species.	Create prototypes to demonstrate to consumers and industry	Developing different physical prototypes of various possible products (a pet treat, bait product, wallet made of fish leather, etc.) will allow consumers and industry participants to get hands-on experience with these products. This will help to raise awareness of the possible usage of the fish byproduct.
Lack of Knowledge of Processor Capacity	The capabilities of the Great Lakes processors in terms of storing and freezing byproduct are currently poorly understood.	Perform inventory and survey to determine processor capacity	Gaining a better understanding of the freezing and storage capacity of the processors in the region will help to better narrow down which industries should be targeted. For example, certain industries require freezing (ex. bait) or additional steps (ex. removing skins from fillets for fish leather) in handling.

Environmental Impact

The 100% Great Lakes fish Initiative aims to maximize the use and hence economic potential of fish harvested from the Great Lakes region. However, in optimizing the economic benefit, it is also important to consider the environmental impacts of the various value chains identified. This section evaluates the environmental implications of various value chains by examining their estimated energy usage and greenhouse gas emissions. By quantifying the environmental impacts of these industries, it is possible to identify the most sustainable pathways for utilizing fish raw materials, reducing waste, and supporting circular economy models within the Great Lakes region. Currently, disposal of excess fish waste entails collecting the product from fish processors in sealed bins or totes to limit odor and spillage. It is typically treated as organic municipal solid waste and may be mixed with other municipal waste, buried directly in landfills, or co-disposed with cover materials to suppress odor and pests. In Canada, waste disposal is regulated provincially and requires permits for environmental guidelines. Improper disposal of fish waste includes illegal dumping in forests and roadsides, disposal in sewer or wastewater systems, and leaving waste in unsealed bins on-site to decay. As of today, 75% of total fish byproduct in the great lakes is being utilized away from landfills and into low margin value chains. There is ongoing improvement to reach 100% byproduct utilization by the end of the calendar year. Table 2 on page 14 is a summary of the environmental benefits and potential factors that could result due to mismanaging proper disposal of fish waste.

Photo Credit: OCFA

Table 2. Summary of environmental impacts and potential negative impacts on the environment of each value chain.

Value Chain	Positive Environmental Impacts	Potential Negative Environmental Impacts
Fishing Bait	• Reduces pressure on wild fish stocks • Low Energy usage and GHG emissions	• Potential pathogen transfer • Could create anoxic patches in benthic ecosystems
Gelatin/ Collagen	• Creates value-added product that is removed from landfills • Reduces pressure on wild fish stocks	• Relatively high energy usage and GHG emissions • Risk of chemical pollution if not handled properly
Fish Meal/Oil	• Heavily reduces reliance on wild pelagic fisheries, so this is ideal to eliminate pressure on those stocks • Moderate energy and GHG emissions	• Industry historically relies on wild fisheries so requires sustainable harvest amounts
Pet Food	• Low energy and emissions overall • Eliminates partial bovine and poultry ingredients, reducing emissions released from farming	• Pet food processing releases 64 million tons of CO_2-equivalent greenhouse gases into the atmosphere every year in the United States alone
Fish Leather	• Lower GHG and energy to be created • Reduces reliance on bovine skin for leather, reducing farming emissions • Clean tanning methods emerging to reduce emissions and chemical pollution	• Some tanning methods use chemicals that, if mismanaged, can pollute small water bodies • Worker health risks in some unregulated countries
Fertilizer	• Natural alternative to synthetic fertilizers • Low energy and emissions • Benefits rural/local farmers	• Risk of eutrophication, algal blooms, and runoff from increased nutrients in the soil if improperly managed
Compost	• Very low energy and emissions • Improves overall health of soil via slow-release nutrients which increase plant growth and reduce runoff	• Odor and pests can be a concern in local/ rural areas • Potential contamination if not managed properly
Medical	• Sustainable alternative to synthetic products	• Very high energy use and very labor-intensive • Costly and small scale, could take years before profitable or before a difference is made

Table 3 below demonstrates greenhouse gas (GHG) emissions based on different utilization scenarios. Currently we have successful avoided 100% of waste being disposed of in landfills and have achieved nearly 75% utilization.

Table 3. Environmental scenarios based upon varying utilization levels.

	Current Stage Year 1-2	**Early Stage** Year 3-4	**Intermediate Stage** Year 5-9	**Late Stage** Year 10+
Total Available Volume (LBS)		20,000		
% of Total Volume to Low Margin Industries	75%	95%	85%	65%
Quantity (LBS) to Low Margin Industries	15,000,000	19,000,000	17,000,000	13,000,000
GHG Emissions from Low margin industries (kg CO_2e)	1,012,500	1,282,500	1,147,500	877,500
% of Total Volume to High Margin Industries	0%	5%	15%	35%
Quantity (LBS) to High Margin Industries	0	1,000,000	3,000,000	7,000,000
GHG Emissions from High margin industries (kg CO_2e)	0	97,500	292,500	682,500
Quantity (lbs) of landfill volume	5,000,000	0	0	0
GHG Emissions from Landfill (non-utilized material)	907,000	0	0	0
Total Annual GHG Emissions	**1,919,500**	**1,380,000**	**1,440,000**	**1,560,000**

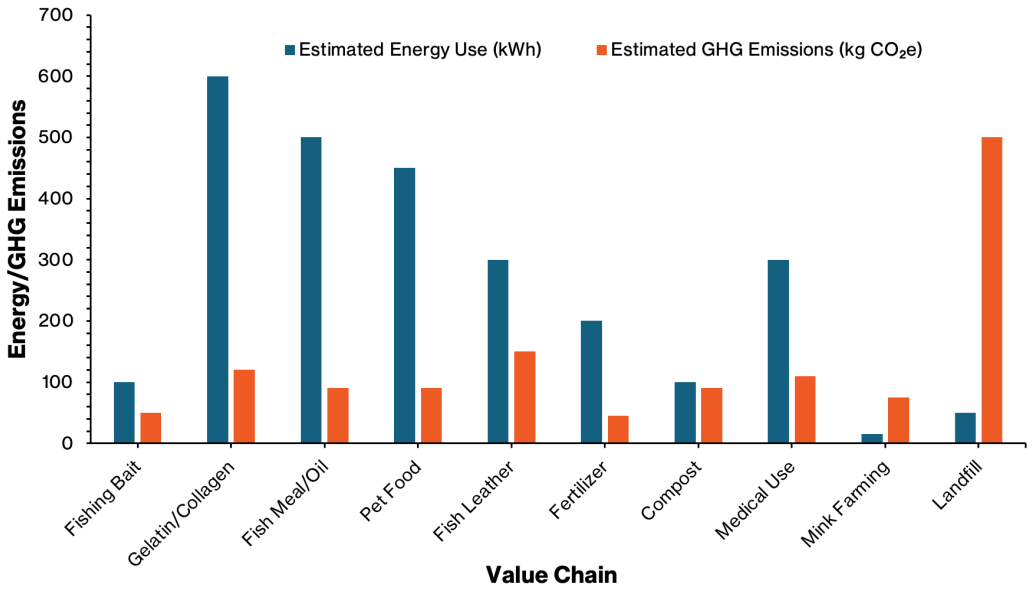
Table 4 below shows estimated energy consumption for each value chain, as well as predicted emissions based on an input of 1,000kg of fish material.

Table 4. Estimated energy use (kWh) and greenhouse gas emissions (lbs. CO_2e) associated with the conversion of 1,000 kg (2,204.62 lbs.) of fish waste into various products.

Process	**Inputs**		**Outputs**
	Fresh or Frozen Fish (lbs.)	Energy (kWh)	GHG Emissions (lbs. CO_2e)
Fishing Bait	2,204.62	50-150	16.5-50
Collagen	2,204.62	500-800	165-264
Meal and Oil	2,204.62	450-700	148-231
Pet food	2,204.62	300-600	99-198
Fish Leather	2,204.62	300	264-396
Fertilizer	2,204.62	150-300	49-99
Compost	2,204.62	50-100	99-198
Medical	2,204.62	200-300	220-242
Landfill	2,204.62	20-50	661-1102

The degree of energy required to create products from fish waste is an ideal way to compare the industries and their energy usage requirements for value added products. By establishing energy usage and greenhouse gas emissions for 1,000kg of fish waste for each product, they can be compared side by side to determine which have the greater environmental impact. It is worth noting that lower energy requirements or greenhouse gas emissions don't necessarily make an industry a more environmentally friendly solution, as other forms of pollution must be considered. This can be seen in Figure 2.

Figure 2. Estimated energy use (kWh) and greenhouse gas emissions (kg CO_2e) per 1,000kg of product processed for each value chain compared to landfill.



Upon full utilization of diverting fish from landfills, roughly 7,000-8,000 metric tons of CO_2-equivalent emissions are eliminated per year. Additionally, fish processing leftovers are essentially organic matter that, if landfilled, decompose anaerobically into methane. By using 100% of byproducts instead of dumping them, the initiative would eliminate these emissions entirely. According to EPA analysis, each 907 metric tons of food waste in a landfill produces about 34 metric tons of fugitive methane, equal to ~838 tons CO_2e released to the atmosphere. Extrapolated to ~8,200 metric tons of fish waste, this means roughly 300+ tons of methane emissions can be avoided annually. Over a 100-year timeframe methane has 25-28 times the climate warming impact of CO_2, so this reduction is roughly 7.5-8 thousand tons of CO_2 not emitted each year.

Utilizing byproducts as feed will relieve demand on wild fisheries used for fishmeal and oil. A fully utilized Great Lakes fishery can produce substantial quantities of fish meal and fish oil from frames, heads, and viscera which can substitute for traditional fishmeal/oil made from wild-caught forage species like anchovy, sardine, and mackerel. Globally, about 40% of fishmeal is still made from whole wild pelagic fish. By contributing alternative feed ingredients derived from waste, the Great Lakes region can help offset the need to harvest additional wild baitfish from the oceans. For instance, if Great Lakes fishmeal production replaces some volume that would otherwise come from Peruvian anchoveta, that eases fishing pressure on those wild stocks. Experts emphasize that utilizing fishery byproducts is a key strategy to "reduce pressure on wild fish stocks."

Improved soil health and reduced water pollution through organic fertilizer/

compost use is another positive environmental outcome of 100% utilization. A major outlet for fish waste under full utilization is organic fertilizer or compost, which yields direct environmental benefits when applied to land. Fish-based compost or hydrolysate fertilizer is rich in nutrients and organic matter, which enriches soils – improving soil organic carbon, structure, and fertility. Unlike synthetic fertilizers, these organic amendments release nutrients slowly and enhance soil moisture retention and microbiology, thereby boosting plant growth naturally. Replacing some chemical fertilizers with fish-derived compost also means avoided emissions from manufacturing those chemicals and less risk of nutrient runoff. Nutrients in compost are less prone to leaching, so using fish compost helps protect water quality – it prevents excess nitrogen and phosphorus from washing into waterways and causing issues like algal blooms and eutrophication. Additionally, the circular reuse of nutrients from fish remains (which originally came from the lake ecosystem) is a more sustainable loop, returning elements to regional soils rather than letting them become pollution. In an optimistic scenario, hundreds or thousands of tonnes of high-quality organic fertilizer could be produced annually from the fish leftovers, improving farm and garden soils across the region and reducing reliance on petrochemical fertilizers. Healthier soil also means better water infiltration and less runoff, creating a virtuous cycle of soil and water conservation.

Chemical management and byproduct disposal are critical to minimizing environmental harm within these value chains. If not managed correctly, residual chemicals or organic byproducts from the process can lead to nutrient loading, eutrophication, or toxic buildup in surrounding ecosystems. Implementing strict protocols for the storage, handling, and neutralization of chemicals ensures that any discharge complies with environmental regulations. For example, the hydrolysis process, commonly used to break down fish material into products such as hydrolysates, fish meal, and oil, can involve the use of acids, bases, or enzymes to facilitate protein breakdown. Advanced treatment systems such as pH neutralization units, filtration, and anaerobic digestion can effectively treat effluents before they are released or repurposed. Solid byproducts can be safely processed into compost, provided contaminants are within acceptable limits. Table 5 below demonstrates value chain inputs and outputs in terms of energy use and greenhouse gas emissions.

Table 5. Value chain inputs and outputs, as well as environmental concerns and comparisons of each industry to landfill.

Process	Inputs		Outputs
	Fresh Or Frozen Fish (lbs)	Energy (kWh)	GHG Emissions (lbs CO_2e)
Fishing Bait	2,204.62	50-150	16.5-50
Collagen	2,204.62	500-800	165-264
Meal and Oil	2,204.62	450-700	148-231
Pet food	2,204.62	300-600	99-198
Fish Leather	2,204.62	300	264-396
Fertilizer	2,204.62	150-300	49-99
Compost	2,204.62	50-100	99-198
Medical	2,204.62	200-300	220-242
Landfill	2,204.62	20-50	661-1102

Transportation

A separate environmental concern is transportation distances, costs, and total emissions. To analyze emissions, boundaries must be defined and transport scenarios analyzed. Key variables include freight type, (e.g. refrigerated truck vs van), shipment size, distance, vehicle fuel use, and weight. For consistency, this report assumes:

i. Freight trucks with cold storage are being used.

ii. CO_2 is the primary emissions considered (as it represents 95%+ of transport-related climate impact)

iii. Refrigerant leakage is excluded from calculations, but should be acknowledged that it can increase actual emissions

Table 6 includes an example of calculated emissions from transportation.

Table 6. Total Emission calculations for transport vehicles.

Distance	Weight	Total Ton-Miles	Emissions Factor	Total Emissions	Total Emissions (MT)
1,000 miles	20 Short Tons	1,000 x 20 = 20,000	161.8 grams of CO_2/ ton-mile	3,236,000 grams of CO_2	3.24 MT of CO_2
750 miles	13 Short Tons	750 x 13 = 9,750	161.8 grams of CO_2/ ton-mile	1,577,550 grams of CO_2	1.58 MT of CO_2

Although data-heavy, this method yields precise results. An alternative calculation method, the spend-based approach estimates emissions based on money spent rather than activity. It is less accurate but easier to implement where some data is unavailable. However, for general processors, the activity-based method is more suitable and aligns with the goals of this report. More information can be found in The Green Freight Handbook, online.

Refrigerated truck ("Reefer") rates typically range from $2.05-$2.44 (CAD)/mile equating to roughly $200-$240 (CAD)/100 miles. Rates can vary by cargo type, distance, route, fuel prices, insurance, permits, and service type. Refrigerated or hazardous materials tend to cost more due to regulatory requirements. Carriers may also apply surcharges for fuel, special handling, or urban deliveries.

Summary

For decades, the Great Lakes commercial fishing industry has grappled with the cost and environmental burden of disposing of fish byproducts—much of which have gone to landfills due to a lack of consistent, high-volume reuse markets. As disposal costs rise and consumer demand for sustainability grows, processors now have an opportunity to turn waste into value. Constructively utilizing only a portion of byproducts in just the low margin value chains in the short term could generate more than **$11 million (CAD)** annually through a combination of direct revenue to the processors and secondary revenue generation through the creation of finished goods such as pet food or fertilizer. Full utilization and diversification into high margin value chains could unlock over **$50 million (CAD) per year** as a conservative estimate, while also supporting new business development and job creation. The establishment of higher margin value chains could potentially see this estimate increase further, through both the direct revenues generated by the processors, increased wages via new job creation, and production and sale of final products. Early estimates suggest that activating these value chains could conservatively create **40–60 new jobs**, with greater potential as industries like fish leather and biomedicine mature. The number of jobs created indirectly through this initiative could **exceed 100**, based upon results seen in Iceland scaled to the size of the Great Lakes region. Beyond new job creation, the utilization of fish byproduct may provide the opportunity to extend the operational season for processors, which benefits employees and the processors' bottom line.

Beyond economics, the environmental benefits are substantial. Redirecting fish waste from landfills reduces methane emissions, while using bycatch and invasive species for fish meal or bait reduces pressure on at-risk forage fish, like herring and mackerel. Sectors such as pet food and fertilizer offer immediate outlets for sustainable reuse.

Inspired by Iceland's proven success, the Great Lakes region can realize similar gains. Processors should begin collaborating now—pooling volumes, identifying partners, and testing new markets. Adoption will be incremental, but every step builds momentum toward more sustainable, profitable fisheries.

Photo Credit: Presteve Foods

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