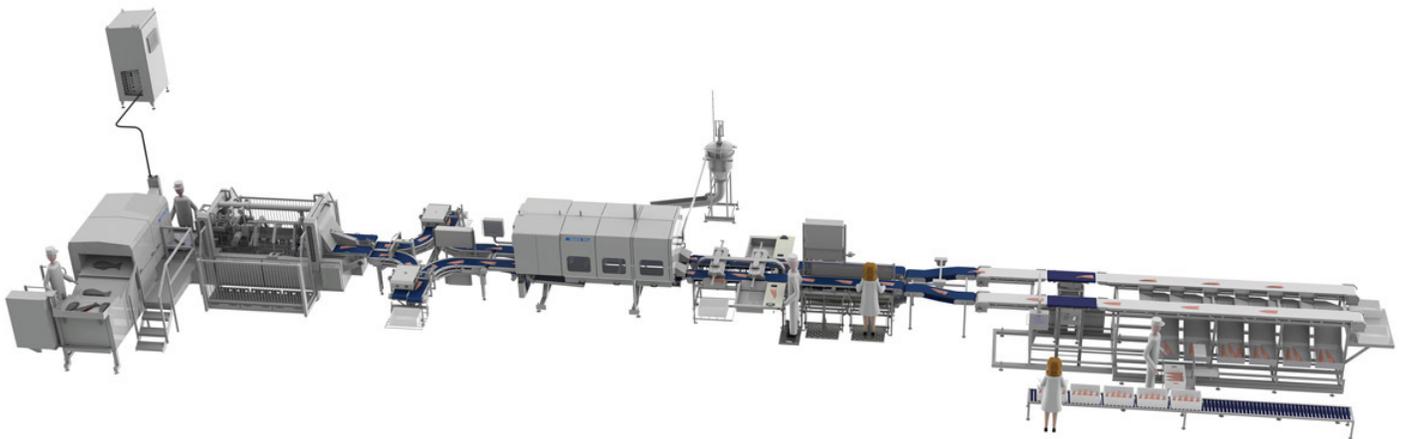


Technology Utilization in Atlantic Canada's

SEAFOOD PROCESSING INDUSTRY

September 2018



SECURING CANADA'S
FISH + SEAFOOD
WORKFORCE

Food Processing Skills Canada



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The opinions and interpretations in this publication are those of the author and do not necessarily reflect those of the Government of Canada.

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EXECUTIVE SUMMARY

FOOD PROCESSING SKILLS CANADA (FPSC) IS UNDERTAKING A COMPREHENSIVE STUDY OF THE CANADIAN SEAFOOD PROCESSING SECTOR IN ATLANTIC CANADA (FPSC, 2017).

The intent of the study is to gather information on the scope of the human resource (HR) challenges and determine the best human resource practices that will help employers meet their labour force needs. As a supplement to this larger report, FPSC requested that the Centre for Aquaculture and Seafood Development (CASD) prepare an analysis of the seafood processing sector in Europe and the United States, specifically the level of technology used and the labour market practices. The assessment included an extensive literature review, industry consultations, and site visits to selected fish processing facilities and research organizations in Norway, Iceland and the Faroe Islands. This report takes a closer look at the factors impacting the utilization of technology and automation in the Atlantic Canadian seafood processing industry and the associated HR challenges as compared to Europe and the United States.

Generally, non-Canadian fish and seafood processing companies appear to face similar issues as their Canadian peers – supply of raw material, cost of technology, and labour shortages. However, non-Canadian companies are much better at extracting more value from their fisheries resources than Canadian firms. European countries such as Iceland, Norway, Denmark and Germany are considered leaders not only in the use of automation and robotics in fish and seafood processing but also in the development of such technologies (especially Iceland and Norway). The United States, although not typically known for developing fish processing technologies, is considered among the top-leading countries with respect to the adoption of automation and robotics.

All European organizations visited report challenges with demographics and recruitment of young people into the industry. Some companies report employing seasonal workers for processing and others report investment in and reliance on international worker programs, as interim solutions to labour shortages. Longer-term strategies include: diversification into other species, including aquaculture, to provide year-round employment opportunities; vertical integration to ensure year-round access to high quality raw materials; a focus on value maximization to promote full utilization of raw materials and the development of higher value products; and investment in innovation, science and technology to develop advanced processing and automation technologies.

In the United States, there is a heavy reliance on foreign workers, which in 2015 accounted for 62.8% of the workforce in the seafood processing industry. However, challenges with access to H-2B visas have caused some processors to look for alternatives to meet their labour challenges. Such alternatives include: (1) advocating for a dedicated “seafood visa”; and (2) turning to advanced processing technologies and the incorporation of robotics into their processing lines.

Globally, Canada is a relatively small player in the supply of groundfish, pelagics, farmed salmon, and shrimp. Other countries that are larger producers of these species (e.g. Iceland, Norway) have developed new processing technologies for them. Canada, however, is a big player in lobsters and crab. Therefore, if Canada needs better technology for processing these species, Canadian processors

are unlikely to find it elsewhere. Regardless of species, there is no concerted or sustained effort in Canada to develop the technologies needed for Canadian companies to be competitive with European or American processors.

The results of this assessment suggest that Canadian seafood processing companies are generally risk averse and reluctant to invest in technology research and development (R&D) hence they want off-the-shelf solutions. However, technologies developed elsewhere are not necessarily applicable to Canada due to differences in processing volumes, diversity of species, availability of skilled labour, and the product forms produced. Development of new technologies must come from the technology sector or R&D organizations. Canadian technology companies however do not see the fishery as an attractive market and government support for R&D organizations has been unreliable and difficult to access (e.g. Atlantic Fisheries Fund). Ultimately, circumstances in Canada do not support investment in automation technologies, even if they were available.

The Atlantic Canadian seafood processing industry faces a great deal of uncertainty. There is uncertainty about the state of the resource, the ongoing impacts of climate change, the resource management regime (e.g. MPAs, the recent surf clam decision), and the supply of labour from both local and temporary foreign workers. This uncertainty reduces investment, returns are unclear and consequently it is difficult for industry to raise capital. Other factors complicating technology utilization and adoption in the Atlantic Canadian seafood processing industry arise due to the diversity of species, sizes, product forms and the number of producers. In contrast to the highly specialized European processing plants visited, most plants in Atlantic Canada are multi-species, offer seasonal employment, lack specialization and process a single or limited number of product forms. This has resulted in many species being processed to minimal requirements (e.g. whole frozen or H+G), a general lack of investment in state of the art processing technologies, and a short seasonal, yet labour-intensive industry.



ACRONYMS

CAD	Canadian Dollar
CASD	Centre for Aqua culture and Seafood Development
CCFI	Canadian Centre for Fisheries Innovation
CNA	College of the North Atlantic
DAL	Dalhousie University
DFO	Fisheries and Oceans Canada
DKK	Danish Kroner
EEA	European Economic Area
EFTA	European Free Trade Association
EU	European Union
FAS	Frozen at Sea
F&S	Fish and Seafood
FFAW	Fish, Food and Allied Workers
FPSC	Food Processing Skills Canada
H + G	Headed and Guttled
HOG	Head On Guttled
HR	Human Resources
ISK	Icelandic Kroner
MAP	Modified atmospheric packaging
MI	Fisheries and Marine Institute
MPAs	Marine Protected Areas
NOAA	National Oceanic and Atmospheric Administration
NFI	National Fisheries Institute
NL	Newfoundland and Labrador
NOK	Norwegian Kroner
OCI	Ocean Choice International
RSW	Recirculated seawater
R&D	Research and Development
SVCRT	Seafood Value Chain Roundtable
US	United States of America
VAP	Value Added Products

/01 INTRODUCTION

ACCORDING TO THE FPSC, THE CANADIAN SEAFOOD SECTOR EMPLOYS APPROXIMATELY 17,000 INDIVIDUALS, WITH A GROSS OUTPUT OF \$7.9 BILLION AND APPROXIMATE EXPORTS MORE THAN \$5.9 BILLION (2015). BY REVENUE VALUE, APPROXIMATELY 30% OF THE SECTOR IS BASED IN NEWFOUNDLAND, APPROXIMATELY 30% IN THE MARITIME PROVINCES AND THE REMAINDER IS LOCATED ELSEWHERE IN CANADA.

Throughout Atlantic Canada, the processing sector generally consists of many independently owned and operated plants operating with a lesser number of vertically integrated companies. Most plants conduct primary processing on commercial fisheries or aquaculture products while a limited number of operations conduct secondary processing. Typically, the number of employees per plant is less than 500; however, for a large company with multiple plants, total employees may exceed 500. For many of the commercial capture fisheries, processing plants are seasonal employers whereas for the aquaculture sector the processing season may be extended or plants may even operate year-round.

Currently, the seafood sector is in a state of transition and there are several factors impacting the industry and its associated value chains. Both the harvesting and processing sectors are experiencing a consolidation in the number of individuals or companies engaged in the industry. Fluctuations in quota and declining resources are increasing consolidation within the sector and decreasing quotas are negatively impacting the ability of organizations to invest in its operation or secure funding for technology investment. While consolidation can improve profitability, due to economies of scale, it is happening slowly. In the harvesting sector, fishers buy up licenses but there is a limit to how many they can buy, due to the Fish Food and Allied Workers (FFAW's) opposition in NL for example, and

Fisheries and Oceans Canada's (DFO's) renewed emphasis on the owner-operator policy. In the processing sector, consolidation is largely happening as participants find it difficult to continue based on the current industry management structure and access to resources more so than because one company takes over another. Processing companies generally don't need more plants or equipment. They need access to raw material and labour supply but a company wanting to exit the sector can't guarantee being able to transfer those things to a new owner.

All the above factors are having an impact on the human resource (HR) dynamic of the Atlantic Canadian seafood processing industry. The industry is largely a seasonal employer and recruitment and retention is being challenged by both the demographics (aging workforce) and competition from other industries who are offering higher wages and longer term employment. Strategies such as recruiting foreign workers, engaging Aboriginal communities and transitioning to greater automation are being considered as possible solutions to the HR challenges.

In recognition of the transition and challenges, Food Processing Skills Canada (FPSC) is undertaking a comprehensive study of the Canadian seafood processing sector in Atlantic Canada. The study is intended to gather information on the

scope of the human resource challenges and determine the best human resource practices that will help employers meet their labour force needs.

As part of this larger initiative, the study will investigate four major themes or components:



LABOUR SOURCE PROFILES



LABOUR SOURCE ANALYSIS (LOCAL SOURCES, ABORIGINAL PEOPLE, INTERNATIONAL LABOUR AND OTHER SOURCES)



OCCUPATIONAL ANALYSIS, WORKER COMPENSATION AND DEMAND PROJECTION

As a supplement to this larger report, FPSC has requested that the Centre for Aquaculture and Seafood Development (CASD) prepare an analysis of the seafood processing sector, specifically the level of technology used and the labour market practices for representative European countries (e.g. Iceland, Norway and the Faroe Islands) and the United States. The following report summarizes this assessment.

/02

METHODOLOGY

THE METHODOLOGY USED IN THIS STUDY CONSISTED OF THE FOLLOWING STRATEGIES FOR DATA AND INFORMATION COLLECTION.

Country Selection:

Countries were selected for this comparative analysis based on the following criteria: level of adoption of advanced processing technologies; investment in innovation, research and development; labour market practices; specialization of species processed (i.e. Salmonids, groundfish, and pelagics).

Literature Review:

The literature review and document analysis were derived from government and/or industry information (websites and other publications), conferences, peer industry reports and other publications.

Industry Consultations:

consultations with industry took place through email exchanges, telephone calls and personal communication.

Site Visits:

a series of site visits were conducted as part of direct technology transfer missions or through conference meetings in Norway, Iceland and the Faroe Islands. During these missions, researchers visited several fish and seafood processing facilities and met with individuals in these countries working with key research organizations involved in the seafood sector.



/03 COUNTRY ASSESSMENTS

THE ROLE OF TECHNOLOGY IN SEAFOOD PROCESSING HAS EVOLVED RAPIDLY IN THE LAST DECADE IN RESPONSE TO INDUSTRY'S NEED TO INCREASE OUTPUT VALUE, PROVIDE INNOVATIVE PRODUCTS, IMPROVE PRODUCTIVITY, AND OFFSET DECREASES IN THE LABOUR FORCE.

Process automation and advanced processing technologies have thus become increasingly important as seafood processors strive to remain competitive in global seafood markets. Other drivers of technology and innovation in the seafood industry stem from increasing consumer demands for sustainably harvested/produced seafood and natural health products. In this section, three European countries (Iceland, Norway, Faroe Islands) are profiled based on their use and development of advanced processing technologies. In addition, the United States is also profiled as it is considered a leader in its adoption of automation and robotics, and the US market accounts for more than 60% (by \$ value) of Canadian seafood exports



<https://www.canada.ca/en/fisheries-oceans/news/2018/03/fisheries-and-oceans-canada-releases-2017-trade-figures-canadian-fish-and-seafood-exports-continue-to-grow.html>



/3.1 OVERVIEW

DURING THE PAST SEVERAL YEARS CASD HAS BEEN ENGAGED AS THE ONLY NORTH AMERICAN PARTNER IN A EUROPEAN UNION (EU) HORIZON 2020 COLLABORATIVE RESEARCH INITIATIVE KNOWN AS PRIMEFISH.

The overall objective of the project is to develop an innovative market prediction toolbox to strengthen the economic sustainability and competitiveness of European seafood on local and global markets. Effectively the study is a comprehensive value chain analysis extracting data from all aspects of the seafood and aquaculture sectors (regulatory structure, harvesting, processing, marketing, etc.) related to the competitiveness and economic performance of key companies operating within the sector. Within the consortium there are 16 academic/industry partners (including CASD) and an industry reference group comprising 38 prominent European, Canadian and Vietnamese seafood and aquaculture companies, several of which are actively engaged in processing fish from capture fisheries and aquaculture.

As part of this collaboration, information relevant to industry challenges, level of technology investment, HR, and economics was shared among the project teams and in many cases, comparisons were drawn between the different countries to assess the level of competitiveness.

Some of this information was used in this report while additional information was gathered from site visits and technology transfer missions to Norway, Iceland and the Faroe Islands. During these missions CASD representatives visited several fish and seafood processing facilities and assessed the level of technology utilized and overall challenges related to the processing sector (HR, supply volume, etc.).

For this report, the country assessments focused on countries with facilities that processed both aquaculture and wild caught species, namely: aquaculture Salmonids (salmon and steel head trout), commercial Whitefish species (cod and haddock) and commercial Pelagic species (Herring, mackerel and capelin).

In terms of general impressions, depending on the species, fish were predominantly processed into

three main types of products fresh, frozen and salted. In general, most processing facilities focused on one main species and product form (e.g. salted cod) whereas others focused on a single species with multiple different product forms. This is a contrast to the plants of Atlantic Canada which are often multi-species and process a single or limited number of product forms. Our plants are not as specialized. It is partly due to our port market operations and partly due to our history of having a fish plant in every community. Competition for raw material means plants commit to buying everything a harvester catches. In Europe, port markets work differently. Specialization means being able to invest in specialized capabilities. Operating a multi-species plant inevitably means making compromises – you simply can't have state-of-the-art technology for every species. There is a similar problem in the harvesting sector, impacting on the quality of raw materials our plants receive.



As an example of the specialization observed in Europe, the Salmonid processing facility in the Faroe Islands, Bakkafrost, only processes farmed salmon, but in different retail forms from fresh (fresh whole gutted) to frozen products (frozen retail packages), as well as by-products (frozen belly flaps, salmon skin). All plants visited focused on full utilization of raw materials and as such processed their by-products into value added products such as dried heads, silage, or fishmeal and fish oil, for niche markets.

The European aquaculture industry (including Norway, Faroe Islands and Iceland) consists primarily of large vertically integrated companies which can control the supply of production into the processing facilities. For the commercial capture fishery, there is some variability as the fishery consists of a combination of independently owned and operated enterprises as well as large vertically integrated companies with mixed strategies for accessing product for processing. For example, in Iceland most of the quota is controlled by large, vertically operated companies who own their own fishing vessels and supply their own processing plants. Should they have insufficient product to process to meet the supply demands of its customers, these companies can purchase product from the smaller independent operators (typically <65-foot fleet) who sell product on the auction market. All companies reported challenges with demographics

and recruitment of young people into the industry. Some companies reported seasonal employment for processing and some companies reported investment in and reliance on international worker programs.

Technology utilized in the companies visited ranged from pick-and-place robots, automated heading and filleting machines, water jet cutters and flow-lines. One thing that was apparent when visiting these facilities was that Baader (www.baader.com/en), Marel (www.marel.com), and Skaginn 3X (www.skaginn3x.com) are the dominant suppliers of processing technology in Europe. Baader and Marel each host a significant annual trade show to showcase their existing and new technologies. These events attract a large global audience. A report published by KPMG LLP in 2014 stated that in general, European countries such as Iceland, Norway, Germany and Denmark are considered leaders in the adoption and development of advanced processing technologies such as automation and robotics in the fish and seafood (F&S) processing sector. The U.S., followed by Japan and Korea, are also considered among top-leading countries with respect to their level of automation and robotics. By contrast, Norsworthy (2015) reported that there is a general lack of investment in state-of-the-art processing technologies in Newfoundland and Labrador for a variety of reasons, such as the diversity of species processed.



GENERALLY, NON-CANADIAN F&S PROCESSING COMPANIES APPEARED TO FACE THE SAME ISSUES AS THEIR CANADIAN PEERS.



/3.1.1 THE FAROE ISLANDS

OVERVIEW

The population of the Faroe Islands in 2016 was 49,864 people. The nation has a strong history in fisheries and aquaculture and it is still today very important to the economy.

In 2015, FAO (Food and Agriculture Organization) ranked the Faroe Islands as 31st in wild capture production (FAO, 2017, p 9). A total of 751,000 tonnes were harvested in 2016 at a value of 867.8 million DKK (176.3 million CAD). Figure 1 shows the breakdown of landings by weight and Figure 2 value (Statistics Faroe Islands, 2017).

In 2016, the aquaculture industry harvested 68,271 tonnes (gutted weight) of salmon (Statistics Faroe Islands, 2017).

The total employment in 2016 for both capture fisheries and aquaculture was 3920 individuals. These numbers include people involved in both the primary and secondary sector. During that same year, the unemployment rate in the country was less than 3% (Statistics Faroe Islands, 2017).

The total number of immigrants into the country in 2016 was 1,622 of that 246 (15%) were from non-Nordic countries (Statistics Faroe Islands, 2017).

Citizens of Finland, Sweden, Norway, Denmark, Iceland and Greenland are free to work in the Faroe Islands. They do not need to apply for a work permit. EU-citizens from countries outside of Scandinavia must apply for a work permit to work in the Faroe Islands. Citizens from countries outside of the EU and Scandinavia must also apply for a work permit to work in the Faroe Islands (Taks, 2017).



2016 FAROE ISLANDS CAPTURE FISH LANDINGS (1,000 TONNES)

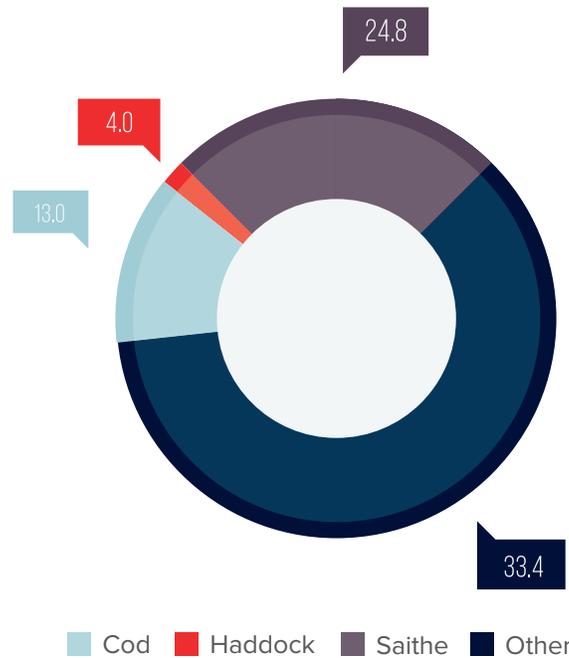


Figure 1. Total Volume (Tonnes) of the Faroe Islands Capture Fisheries.

2016 FAROE ISLANDS CAPTURE FISH LANDINGS (MILLIONS DKK)

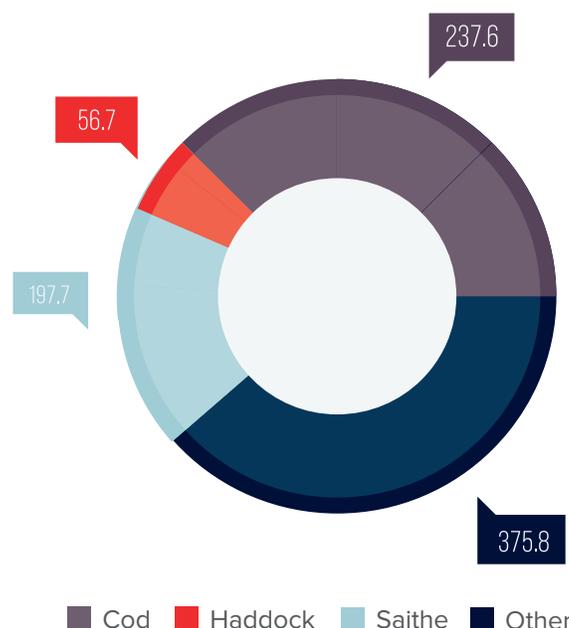


Figure 2. Total Value (Million DKK) of the Faroe Islands Capture Fisheries.

FACTORY VISIT: BAKKAFROST



BAKKAFROST

<https://www.bakkafrost.com/>

Bakkafrost is the largest aquaculture salmon producer in the Faroe Islands. It is a large vertically integrated salmon farming company and has full control of the value chain (Figure 3) from feed to finished value added products. This ensures unrivalled traceability and consistent high quality.

In 2016, Bakkafrost employed 1,000 + employees and had sales of 3,202.7 million DKK (651.0 million CAD).

In 2014 the company unveiled its capital investment plan for 2014-2020; committing millions (DKK) in new technology to enhance its processing facilities, wellboats, and smolt production. In 2016, Bakkafrost replaced 7 factories with one purpose built 4,000m² state of the art processing factory located in Glyvrrar, and constructed a new live well boat with 450 tonne transport capacity for transporting fish to and from their farm sites.

The processing facility has a daily production capacity of about 100 tonnes of value added products (VAP) for both retail and food service. Most of the technology within their new VAP processing facility was supplied by either Baader or Marel. At the end of the processing line they are using pick-and-place robotics for palletizing the finished products. A new electrical stunning system, improved cooling chain, automated gutting machines (e.g. Baader 144 salmon gutting machine), CIP cleaning, and the use of INNOVA traceability software by Marel, are among some of the new technologies that have been incorporated into the processing line.

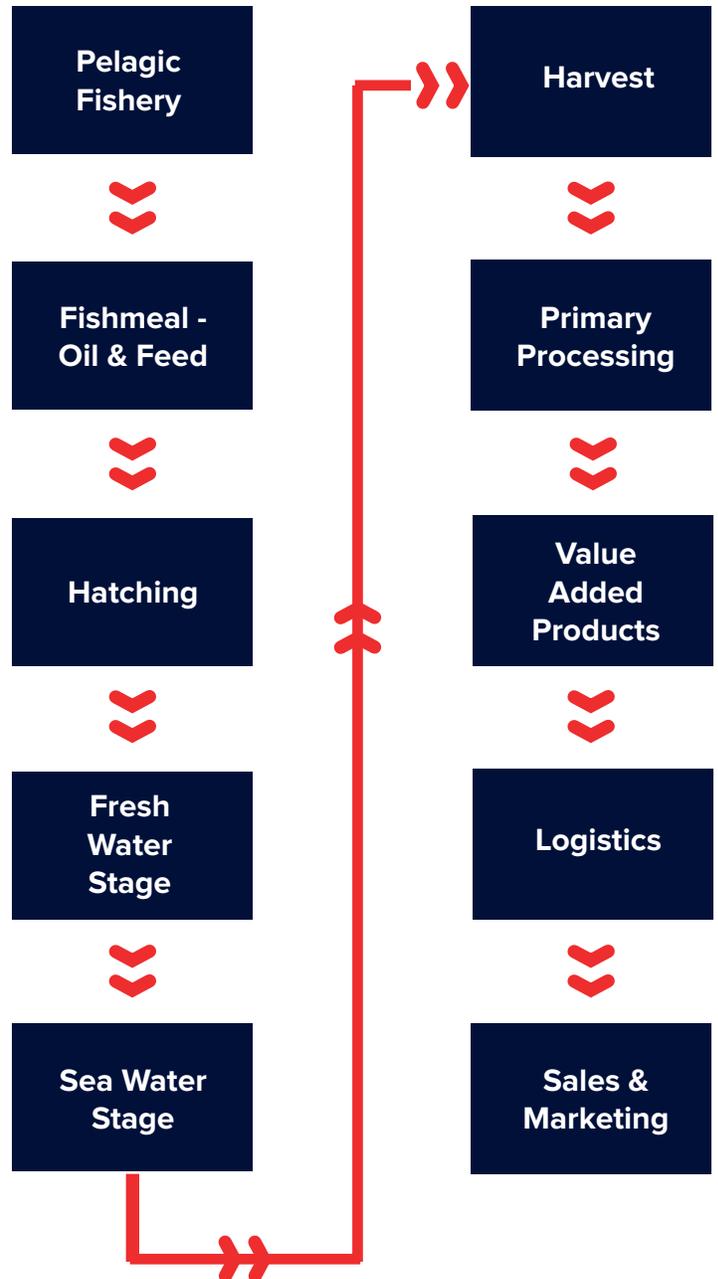


Figure 3. Bakkafrost's vertically integrated value chain



/3.1.2 ICELAND

OVERVIEW

The population of Iceland in 2016 was 332,529 people (Statistics Iceland, 2016). The nation has a long history in fisheries and it is a very important part of their economy. The Icelandic fisheries industry has a very strong focus on quality, by-product utilization and maximizing value.

In 2015, FAO ranked Iceland 19th in wild capture fisheries (FAO, 2018). A total of 1,319,395 tonnes at a landed value of 151,301,060,000 ISK (1.8 billion CAD). Figure 4 shows the breakdown of landings by weight and Figure 5 value (Statistics Iceland, 2016).

The total employment in 2015 for both capture fisheries and aquaculture was approximately 7316 individuals (Statistics Iceland, 2016). During that same year, the unemployment rate was 4 % (Statistics Iceland, 2016).

Nationality	Numbers	%
Iceland	304,806	92.6
Nordic Countries	1,578	0.5
Other European Countries (EU)	19,064	5.08
United States	567	0.2
Africa	396	0.1
Asia	2,058	0.6

Table 1. Citizenship in Iceland, by nationality (Statistics Iceland, 2016)

Table 1 shows the 2015 citizenship statistics for Iceland (Statistics Iceland, 2016). Citizens from the European Economic Area (EEA) and the European Free Trade Association (EFTA) states do not need a special residence permit to stay in Iceland, but must register with Registers Iceland (<https://www.skra.is/english/individuals/>). Information regarding the permanent stay of EEA and/or EFTA citizens can be found here. A foreigner from a country outside of the EEA and/or EFTA, who plans to stay in Iceland for more than three months, must have a valid residence permit (The Directorate of Immigration, 2018).



BREAKDOWN OF CAPTURE FISHERIES IN ICELAND

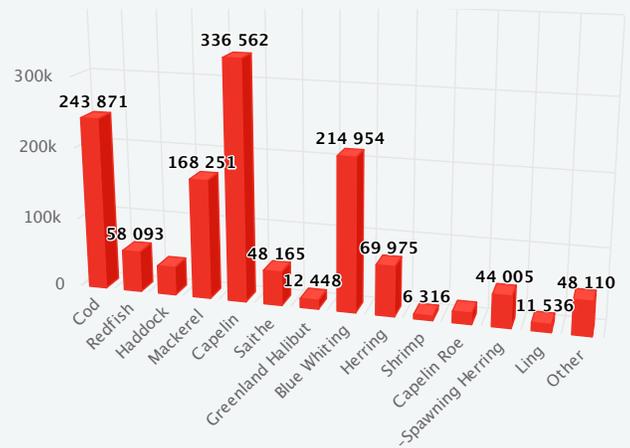


Figure 04. 2015 Iceland Fisheries Landings (Tonnes)

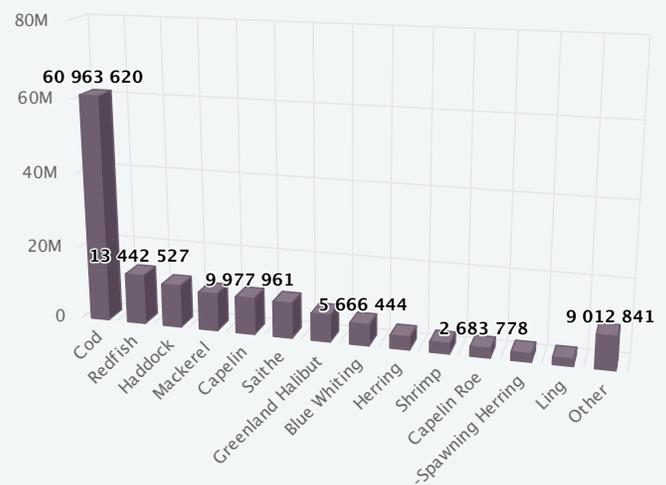


Figure 05. 2015 Iceland Fisheries Landed Value (1,000 ISK)



FACTORY VISITS

Site visits were conducted September 11-15, 2017 in three regions: Reykjavik in the west, Grindavik in the south west and Vestmannaeyjar in the Westman Islands in the south (Figure 6).

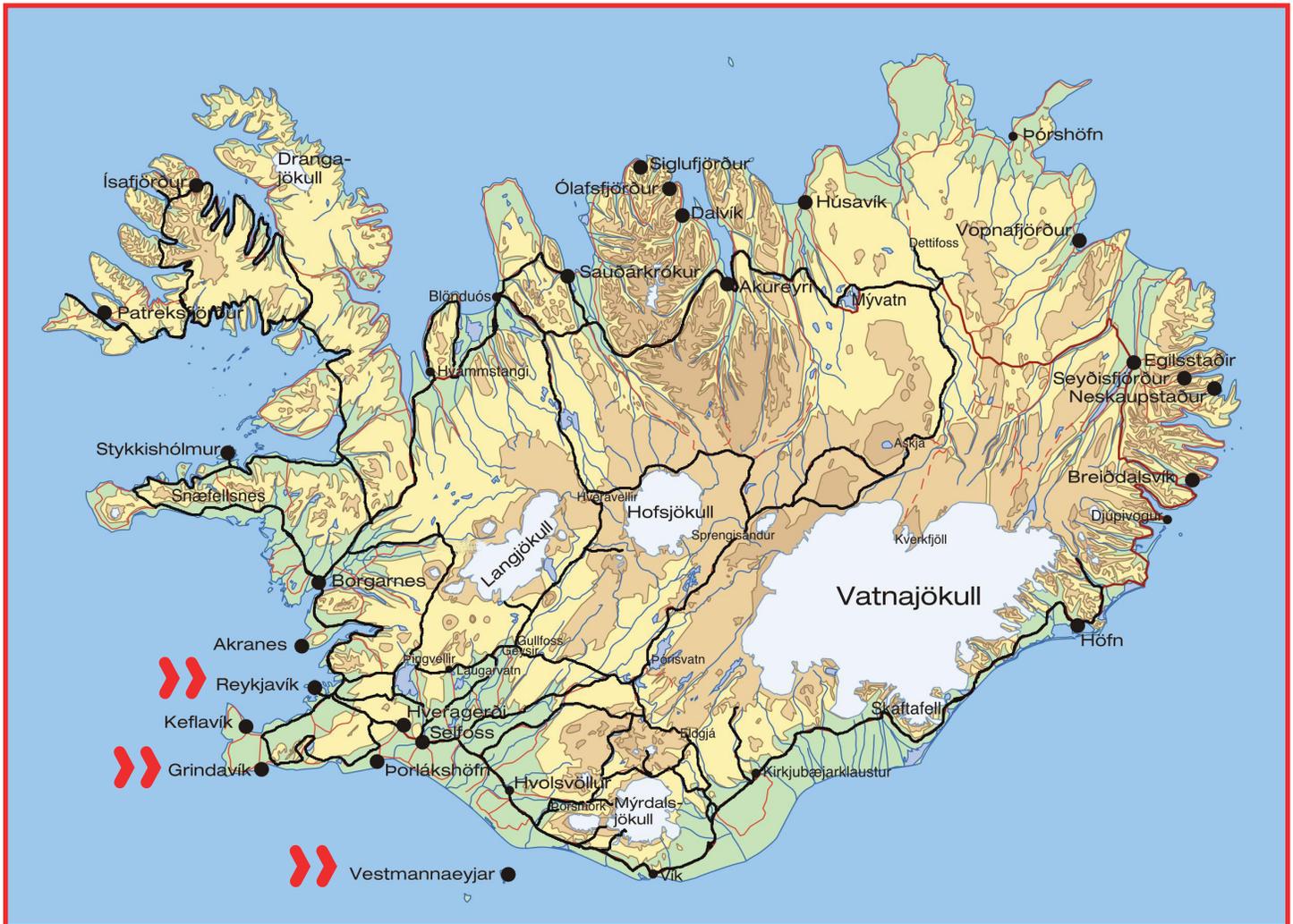


Figure 6. Map of Iceland



VIEW THIS MAP

<http://africatwin.com.pl/showthread.php?t=16182>



HB GRANDI



CORPORATE WEB SITE
<https://www.hbgrandi.com/>

HB Grandi hf. is one of Iceland's largest seafood companies with headquarters and its main processing facility located in Reykjavik. It is vertically integrated and is engaged in fishing, processing and marketing of groundfish and pelagic fish. HB Grandi employs about 800 people in its fishing fleet and processing plants. Due to labour shortages in Iceland, the company employs several foreign workers from 23 countries who live full-time in Iceland. Average wages for plant workers are \$4,250 (CAD) per month, while harvesters receive a percentage of the catch value.

Operating three factories in Iceland, as well as three factory freezer trawlers, four wet fish trawlers, and two pelagic vessels, HB Grandi has quotas for 45,487 tonnes of groundfish and 112,157 tonnes of pelagic fish. The company also operates a fish-meal plant, and two subsidiary companies, one for roe production and one for the production of value added secondary seafood products (e.g. prepared fish dishes, pate).

The company attributes its success to several factors which include its focus on: sophisticated fishing and processing technology (vessels and plants are mainly equipped with fish processing technology supplied by Icelandic companies Skaginn 3X, Valka and Marel); continuous product devel-

opment; the production of high-quality products from fresh wild fish caught in Icelandic waters; and respect for the marine environment. However, the company credits the commitment of its employees to delivering quality products as a key factor for its success.

HB Grandi had 3 new fresh fish trawlers built in 2017 each equipped with automated on board fish handling technology and increased processing system automation installed by Skaginn 3X, an Icelandic fish processing equipment manufacturer. The Engey Re 91 (Figure 7) is one of the most technologically advanced fishing vessels in Iceland, and has been fitted with better fish handling and processing technology (e.g. Skaginn 3X's award winning trademarked SUB-CHILLING technology), and new camera technology that categorizes every fish by size and species thus facilitating full traceability.



<https://www.seafoodsource.com/news/supply-trade/hb-grandi-trawler-eng-equip-with-skaginn-3x-processing-technology>

In April 2018, HB Grandi signed a contract with Marel for a Flexicut system and packing graders to be installed onboard its new freezer trawler.



<https://marel.com/fish-processing/news/flexicut-marine-to-be-installed-aboard-hb-grand/5474>

In May 2014, HB Grandi finalized their investment in a Revo Portioner system from Marel, which it had been trialing in their groundfish processing plant in Reykjavik.



<https://www.seafoodsource.com/news/supply-trade/hb-grand-trawler-eng-equip-with-skaginn-3x-processing-technology>

Figure 7. One of HB Grandi's newest fishing vessels, the Engey RE91, built in 2017





Vísir is an experienced yet innovative fishing company which operates exclusively 5 long-line vessels and runs a state-of-the-art processing facility in Grindavik with a daily production capacity of 100 tonnes of cod. The company processes 60 tonnes/day of fresh cod and 15 tonnes/day of salted cod (from 35-40 tonnes wet weight). The fresh processing line (Figure 8) employs 60 people per shift and is equipped with automatic heading, filleting, skinning and portioning equipment (i.e. Marel Flexicut system), and robotic pick-and-place systems for offloading fish tubs and end of line palletizing. Their state of the art processing facility is based on Icelandic ingenuity and design. Visir has collaborated with many Icelandic high-tech companies and research organizations (i.e. MATIS) that are at the forefront in the development and production of fisheries equipment at a global level.

Visir operates under the fundamental principle of using all raw materials to the utmost with the goal of utilizing 100% of its catch. The company strives to extract the highest value out of the ocean's resources. Heads and frames are collected and sold to Haustak, a fish drying facility located in Grindavik which Visir co-owns. Visir is also co-owner of Codland. Codland is building a collagen plant near the drying plant in Grindavik. Visir will supply fish skins to Codland for collagen extraction. The col-

lagen extracts are currently being incorporated into a health beverage "Marine Collagen Lemonade" (Figure 9) which was developed in collaboration with the Iceland Ocean Cluster house.



Figure 9. Marine Collagen Lemonade

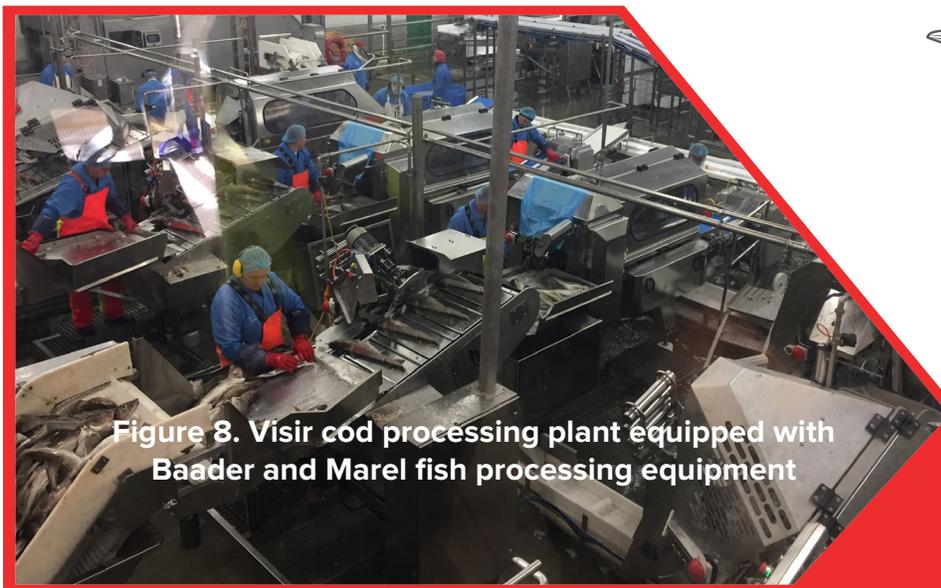
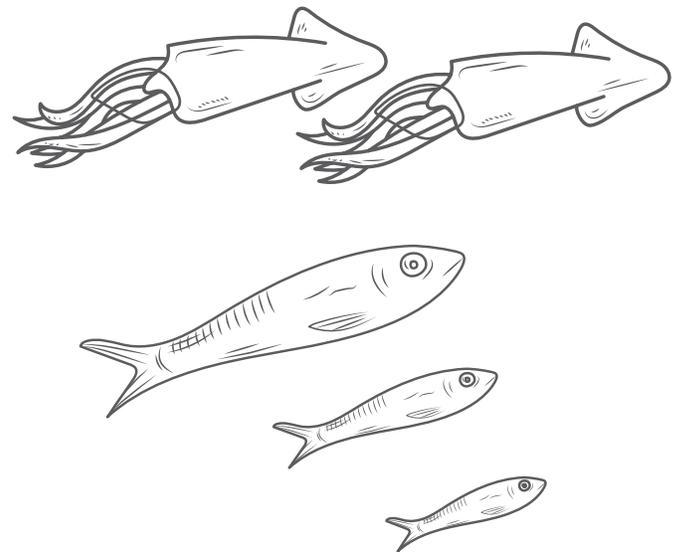


Figure 8. Visir cod processing plant equipped with Baader and Marel fish processing equipment



THORFISH



CORPORATE WEB SITE
<http://www.thorfish.is/>

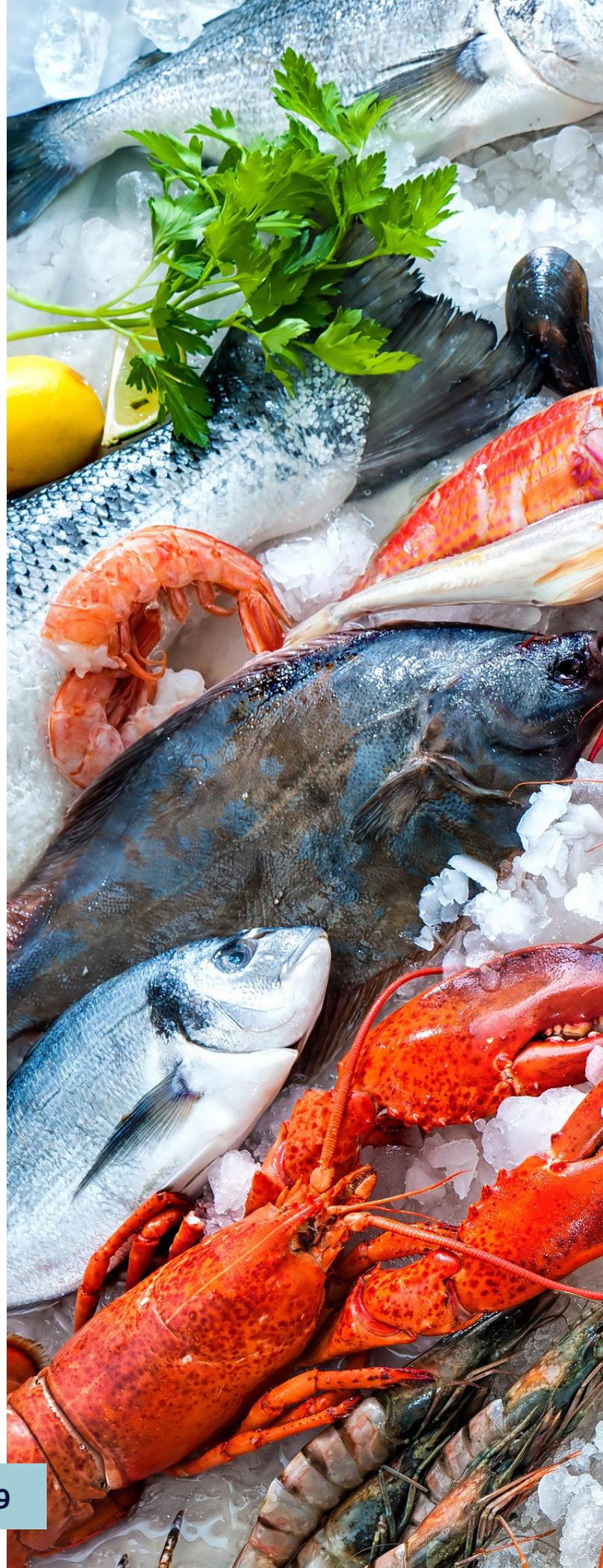
Thorfish is a medium sized vertically integrated fish processing company located in Grindavik, a small fishing town on the Southern Peninsula of Iceland. Thorfish produces mainly groundfish and pelagic species. The company owns 4 longliners and 3 freezer trawlers.

Thorfish has also been actively involved in the creation of several affiliated companies including:

- ☑ EHF – a Fishing Supplies Service created by merging Thorfish fishing gear department with SH fishing gear
- ☑ Haustak – Iceland’s largest fish drying company
- ☑ Salt Refinery – operated by Haustak which receives used salt from Thorfish Ltd’s bacalao making process. The salt is refined and sold for reuse such as road salt

Codland – R&D company focused on improving fish processing and raw material utilization

The production of wet saltfish is the focus of the organization but it also produces fresh and frozen groundfish as well as frozen pelagic species. Daily production averages 40 tonnes of salt cod (produced from 100 tonnes wet fish), and employs 45 people. The processing facility is highly automated and equipped with automated heading, filleting, brine injection, filling/layering, and protein skimming machines. There is some manual labour such as cod tongue removal, inspection and trimming. All by-products are collected and sold. Heads and frames are sold to Haustak for drying, while swim bladders are packaged and frozen for Asian markets. Skins are collected and supplied to Codland for collagen extraction.



HAUSTAK



CORPORATE WEB SITE
<http://www.haustak.is/>

Haustak is a very unique processing facility (Figure 10). Located in Grindavik, this plant specializes in dried fish by-products. It is owned by 2 local fish processors, Visir and Thorfish, which supply raw heads and frames for drying. Visir and Thorfish created Haustak specifically to take care of their fish by-products. The main product is dried heads and frames which is specific niche product for a large local tribe in Nigeria. The company operates year around and employs approximately 50 individuals. It produces 15,000 tonnes of dried fish by-products annually (~ 20% yield) from 75,000 tonnes of wet fish by-products.



Figure 10. Haustak fish drying plant in Grindavik, Iceland



Figure 11. Steam from geothermal plant in Grindavik that supplies power to the drying plant



Figure 12. Weighing and bagging of dried fish products at Haustak

Haustak takes advantage of the availability of steam power from a nearby geothermal plant (Figure 11) to operate its customized multi-stage drying technology. Heads and frames are manually sorted and placed on drying racks which are then loaded by pick-and-place robots onto a conveyor system which loads the racks into a pre-drying chamber where the heads and frames remain for 5-7 days. The racks of dried heads and frames are then moved to a post drying room for additional drying. At the end of the drying cycle the dried fish products are offloaded from the drying racks into large collection boxes (fish tubs) by pick-and-place robots which then stack the empty racks. The collection boxes are transported to the packaging/bagging area by forklift and packed into eco-friendly hessian bags using an automated weighing/bagging system (Figure 12). The filled bags are loaded into a hygienic shipping container using specially designed forklifts to stack the bags in rows of 6.



CORPORATE WEB SITE
<https://vsv.is/>

VSV is a vertically integrated company which was established in 1946 on Vestmannaeyjar, a small island off the coast of Iceland. VSV is involved in the harvesting, processing and marketing of both ground fish and pelagic species. The company operates four groundfish vessels and three pelagic fishing vessels (Figure 14), as well as a state-of-the-art processing facility (Figure 13) on the shores of the Vestmannaeyjar Islands.

The company employs 300 permanent staff year round, and additional temporary workers are brought in for seasonal work. VSV employs 7% of the island's workforce.

The plant processes capelin from February to May, and mackerel from June to September. It has a processing capacity of 400 tonnes/day.

The processing line for the pelagic species is highly automated for grading, packing, freezing and palletizing. The facility is equipped with an automated offloading system. Raw material is weighed into cartons lined with plastic, covers are placed

on the cartons by an automatic case topper. Pallets are stacked and shrink wrapped by robotics, then loaded using forklifts into a blast freezer prior to shipping.

VSV also produces fishmeal and fish oil from its pelagic processing by-products which are sold to fish feed producers in Norway, other European countries and Iceland. Female capelin are sold to Japan, while male capelin traditionally went to Russia but are now shipped to the Caribbean. The company also processes 10 tonnes of langoustines per year, but have not yet found a use for the by-product.

A major advantage for VSV is the proximity of the processing facility to the fishing grounds and landing port allowing VSV to catch and process fish within a few hours versus days for many other companies. The company also prides itself on its contributions to the community which include using excess heat energy from its processing facilities to provide energy to the hot water utility to heat half of the island's residential housing, and reducing its GHG emissions.



Figure 13. VSV Pelagics Processing Facility in Vestmannaeyjar



Figure 13. VSV Pelagics Processing Facility in Vestmannaeyjar



Figure 14. One of VSV's fishing vessels dockside - steps away from the processing plant

KEY OBSERVATIONS

- ☑ Iceland has a sophisticated, high-tech seafood processing industry focused on cod;
- ☑ Iceland is a leader in innovation with industry investing heavily in research and development
- ☑ Market driven strategy based on economic efficiency and value maximization
 - ☑ Everyone is focused on the target: quality, sustainability and 100% utilization to maximize output value
- ☑ Most of the industry is vertically integrated and operates year round
- ☑ The Iceland Ocean Cluster has been instrumental in developing and diversifying the seafood industry beyond traditional products and promoting value maximization (e.g. fish leather, collagen extracts)
- ☑ Significant government funding invested into R&D and technology enhancement

/3.1.3 NORWAY

OVERVIEW

The population of Norway in 2017 was 5,302,778 people (Statistics Norway, 2018). The nation has a strong history in fisheries and aquaculture and is still today very important to the economy. However, due to labour shortages, approximately 34% of those employed in Norway's seafood processing sector are foreign workers. In addition, only 19% of Norwegian fish is processed in Norway. Large volumes of fish are exported to Poland and China for further processing (NOFIMA, Pers. Comm.).

In 2015, FAO ranked Norway 9th in wild capture production (FAO, 2018). A total of 2,065,507 tonnes were harvested in 2016 at a landed value of 18,651 million NOK (2.9 billion CAD). Figure 15 shows the breakdown of landing by weight and value (Statistics Norway, 2018). About 25% of wild caught fish are converted to aquaculture feed, particularly pelagics (Williams, 2017). In 2010, there were 16,510 people employed in fishing and fish processing activities.

 **FAO COUNTRY PROFILE NORWAY**
<http://www.fao.org/fishery/facp/NOR/en>

In 2016, the aquaculture sector harvested 1,326,156 tonnes of which 93.0% was salmon and 6.6% was rainbow trout (Statistics Norway, 2018). In 2016, there were 7273 people employed in salmon and rainbow trout production of which 5627 were working in production of fish for food and 1646 were employed in hatcheries and fingerling production (Statistics Norway, 2018).

Norway's aquaculture sector is more globally competitive than its capture fishery. In fact, the global position of Norway's fishing and fish products cluster is largely built on the production of farmed salmon. Salmon farming began in Norway in the 1970s as a means for coastal (agricultural) farmers to sup-

plement their income. Since then, the aquaculture industry has evolved into an advanced modern industry, which has been significantly consolidated since 2000. Salmon output more than quadrupled since 1995 from a production volume of 277,600 tonnes to 1,326,156 tonnes in 2016. In terms of its competitors, Norway is much more advanced with respect to scale, sophistication (i.e. technology and innovation), and environmental sustainability. Norwegian companies (e.g. Marine Harvest, Grieg, EWOS, Skretting) are driving the development of salmon farming in other jurisdictions (Williams, 2017).

Norway's capture production however, has been declining since 2003, with cod being an exception. Norway's cod stocks are among the most abundant in the world. Norway's fishing fleet consists of small coastal boats (i.e. < 15 metres in length) and large industrial vessels which are typically trawlers operating offshore. While the coastal fleet has been shrinking for decades, the industrial fleet continued to grow until 2003. Challenges for Norway's capture fishery arise from several factors: (1) many other countries harvest the same species; (2) sector is volume driven and focused on cost minimization; (3) Norwegian salaries are high and workers are not interested in low paying jobs in seafood processing plants. To be competitive, Norway differentiates its capture fishery based on environmental stability, and quality due to effective distribution and/processing. Processing plants have also invested in process automation to offset labour supply issues (Williams, 2017).

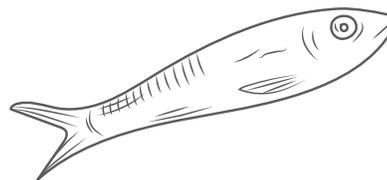
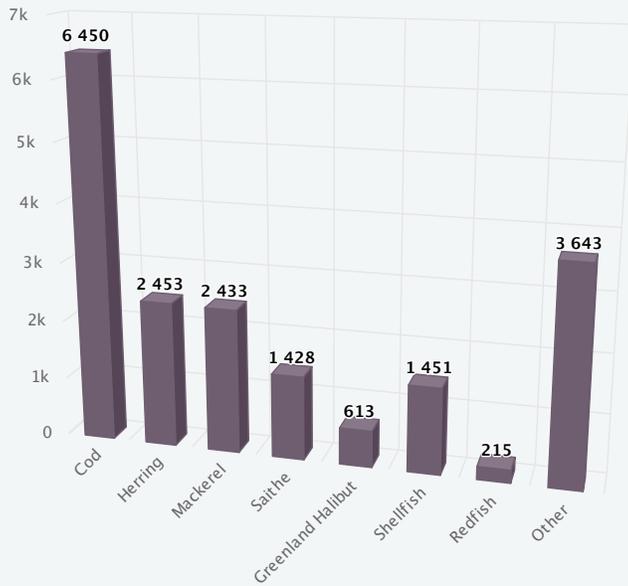
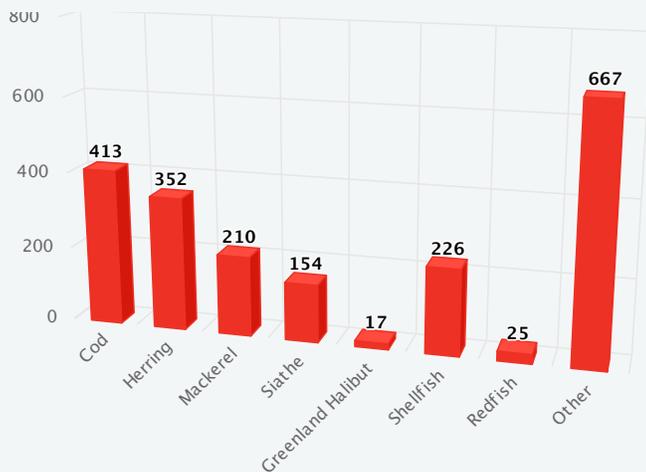


FIGURE 15: BREAKDOWN OF CAPTURE FISHERIES IN NORWAY



**2016 Norway's Capture Fish Landings
(Million NOK)**



**2016 Norway's Capture Fish Landings
(1,000 Tonnes)**

FACTORY VISITS

Site visits in Norway took place September 4-8, 2017 and began in the west with visits to SMP Marine Products (Bovagen) and Firda Seafood GS-roup AS (Byrknes). Visits were completed in the north with visits to BR Karlsen (Husoy) and Nergard AS (Senjahopen).

SMP MARINE PRODUCTS AS



CORPORATE WEB SITE
<http://www.smpmarine.no/>

SMP Marine Products (Figure 16) is a small salmon processing company located in Bovagen, Norway which produces fresh farmed salmon fillets and portions. The daily processing capacity is 20 tonnes of head on gutted salmon. The company employs less than 50 employees in total, and operates with 15 employees per shift. SMP purchases fresh bled and gutted salmon from independent salmon farms. The factory is fairly automated using mainly Baader equipment such as automatic headers, filleting machines, skinners, pin bone removal and multi-vac systems. However, they are not using any robotics. They operate on a zero-waste principle and as such all by-products are collected in sanitary fish tubs for BIOMEGA which uses the by-products to produce other food grade products such as salmon oil, salmon meal and peptides.



BIOMEGA WEB SITE
<http://www.biomega.no>



Figure 16. Headquarters and main processing facility for SMP Marine Products

FIRDA SEAFOOD GROUP AS



CORPORATE WEB SITE
<http://www.firdasea.no/>

Firda Seafood Group AS (Figure 17) is a family owned, vertically integrated salmonid aquaculture company. They farm salmon and trout in seven locations and are Global GAP certified. Operations span the full value chain and include: roe collection, production of fry, smolt and edible fish production, slaughtering, packing and export.

Firda's philosophy is that employees are their most important asset and therefore, the company is continuously investing in enhancing skills, upgrading facilities and developing new production methods (e.g. during our site visit the company was testing a new feed treatment for sea lice mitigation).

The feed control system used for feeding fish is centrally located at the main processing facility. It is monitored using video cameras and feeds 50 sites a day. Processing occurs at Firda's modern processing facility located in Byrknesov. Their processing facility is new and highly automated including the use of robotics at the end of line for palletization. The processing facility is equipped with Baader fish processing equipment and flow lines, a highly efficient automated bloodline removal system, and automatic weighing and monitoring systems.

The company also produces salmon from independent farmers. Products produced include fresh H+G salmon and well as fresh and frozen fillets and portions.

Firda Seafoods Group employs approximately 100 individuals. About 50 employees, work in the processing facility which operates year around.

By-products are collected daily and pumped directly into large silage tanks (Figure 18) for transport to BLOmega for further processing into salmon oil, fishmeal and peptides.



Figure 17. Firda Seafood Group AS main processing facility in Byrknesov, Norway



Figure 18. Silage tank located outside Firda's processing facility in Byrknesov, Norway

BR. KARLSEN



CORPORATE WEB SITE

<http://www.brkarlsen.no/om-gruppen>

B.R. Karlsen is a vertically integrated company specializing in red fish (i.e. farmed salmon) and white fish (i.e. groundfish from wild capture) processing. The organization owns a salmon hatchery, farms, vessels and a state-of-the-art processing facility with annual sales of 1 billion NOK (155.6 million CAD). The company also sources wild capture species from independent harvesters.

The organization is headquartered on the island of Husoy in Senja, Norway (Figure 19). It is made up of 10 subsidiary companies, and operates year-round employing 80-120 people. BR Karlsen employs >80% of the island's workforce. They produce a wide-ranging assortment of products including fresh H and G salmon, frozen salmon portions, saltfish, stockfish and many different by-products (Figure 20) for food and pharmaceutical use (e.g. salmon backs and belly flaps, dried cod heads, food and pharmaceutical grade cod liver oil).

Traditionally a cod and groundfish processor, established in 1932 producing salted and dried fish,

B.R. Karlsen diversified into cod fillets in 1960, and farmed salmon in 1990. The move to salmon farming and processing as a diversification strategy was implemented due to the continuing decline in cod stocks which started in the late 1980s. The company decided to expand into salmon farming and processing to provide year-round employment to the community. They currently produce 9000 tonnes of salmon annually and own 6 farm site licenses.

B.R. Karlsen was the first Norwegian company to produce organic salmon. The facility processes 20 tonnes of salmon a day employing 35 employees per shift. The salmon processing facility is highly automated. It is equipped with Baader heading, filleting and skinning machines, Marel and Scanvaegt portioning systems, filleting and pin bone removal machines (Figure 21), and uses ABB robotics for offloading fish containers and end of line boxing and palletizing (Figure 22). About 80% of its fresh salmon is sold to the United States in the headed and gutted form. The remaining 20% is sold in Europe as MAP fillets and portions.



Figure 19. BR Karlsen Headquarters and processing facility in Husoy, Senja, Norway



Figure 21. Filleting line and automated pin bone removal system at B. R. Karlsen



Figure 20. Collection of salmon frames for further processing at B.R. Karlsen



Figure 22. End of line robotics for palletizing at B.R. Karlsen

NERGARD



CORPORATE WEB SITE
<http://nergard.no/about-us>

Nergard is a large vertically integrated organization with headquarters located in Senjahopen, Norway (Figure 23). The organization is comprised of 10 subsidiary companies which are involved in the harvesting, processing and marketing of pelagic and groundfish species. The organization employs 350 people, and owns 5 vessels (4 freezer trawlers and 1 wet fish trawler).



WATCH VIDEO
<https://vimeo.com/231054078>

Nergard operates 9 processing facilities throughout northern Norway. It is one of the largest pelagic producers in Norway and has two of Norway's most modern pelagic factories located strategically for fishing during the pelagic season. Most of the factories operate year around. They use state of the art processing technologies such as water jet cutting, and automatic filleting machines with a capacity of processing 5,000 fillets per minute using 10 machines. ABB robots are used for boxing and palletizing.

The organization produces a wide range of products including frozen H+G groundfish and pelagics, fresh and frozen groundfish fillets, salted groundfish, stockfish as well as various by-products (e.g. sugar salted or frozen cod roe, cod livers, (Nergard, 2018).

Nergard's business strategy focuses on investment in new technology, community development, high quality products, and attracting and retaining young people in the seafood industry.

KEY OBSERVATIONS

- ☑ Processors have a key focus on innovation, science & technology, and well-being of employees
- ☑ Larger processing companies tend to be vertically integrated, year-round operations
 - ☑ Some companies have evolved to process both farmed and wild fish, focusing on a "red-white" diversification strategy in response to declining wild fish stocks
- ☑ Most plants process both dried/salted and fresh/frozen fish
- ☑ Brine injection is used in salt fish production
- ☑ Approximately 34% of the workforce are foreigners
 - ☑ Wages are too low for Norwegians
 - ☑ Reliance on young immigrants mainly from Poland
- ☑ Processing plants have high levels of automation and incorporate end-of-line robotics
- ☑ Minimal processing is done in Norway with about 20% processed in Norway and 80% exported to China and Poland for further processing
- ☑ Emphasis on full utilization of fish resources
 - ☑ Processors take care of their by-products which are sold for feed, food and pharmaceutical applications mainly to one large by-product processor, BIOMega



Figure 23. Nergard headquarters and main processing plant in Senjahopen, Norway



/3.1.4 UNITED STATES

OVERVIEW

The United States (US) has a population of ~ 327.1 million (Worldometers 2018) and is the world's largest importer of seafood (FAO, 2018), importing more than 80% of the seafood consumed in country (NOAA Fishwatch, 2018), valued at \$20 billion US in 2018 (FAO, 2018). It also ranked 3rd by FAO in marine wild capture production in 2016 producing 4,897,322 tonnes (FAO, 2018).

In 2016, commercial landings of fish and shellfish in the US amounted to 3,395,000 tonnes for human food and an additional 947,000 tonnes went to industrial use (Statista, 2018). In 2016, landings accounted for 75% of fresh/frozen production, 2.5% of canned and cured products, 19% went to fish meal and fish oil, while 3.2% was used as bait/animal food (NOAA Fisheries Statistics, 2016).

Over 88% of commercial landings are finfish, however, shellfish account for more than 50% of the total value. More than 50% of US landings are

caught by trawlers in the Pacific Ocean. Important commercial Pacific Ocean species include groundfish (e.g. Pacific cod, flounders, hake, ocean perch, Alaska Pollock and rockfishes), Pacific salmon, halibut, Dungeness, King and Snow crab, tuna and squid. Some of the most economically important species are harvested from the Atlantic Ocean and include scallops, lobster, clams, blue crab, oysters and herring. Other important fisheries include shrimp in the Gulf of Mexico and South Atlantic, and groundfish (butterfish, Atlantic cod, cusk, haddock, Atlantic Pollock) caught in the North Atlantic. The Menhaden fishery is an important fishery for bait and conversion and to fish oil and fish meal. As one of the largest importers of seafood products globally, the most important seafood products (by volume) imported to the US (Table 2) include shrimp, tuna and freshwater fish fillets. Other important imported products include salmon, groundfish species (e.g. cod, haddock, Pollock), crab and crab meat.



VIEW WEB SITE

<https://www.seafoodhealthfacts.org/printpdf/seafood-choices/overview-seafood-industry>

Seafood Products	Countries Imported From	Volume (tonnes) (NOAA, 2016)
Shrimp – fresh, frozen, canned	Thailand, Ecuador, Indonesia, China, Vietnam, Mexico	585,826
Tuna – canned, fresh, frozen	Thailand, Phillipines, Indonesia, Vietnam, Ecuador	297,820
Freshwater Fillets	Vietnam	311,689
Salmon – whole, fillets, steaks	Norway, Canada, Chile	323,315
Groundfish species (cod, haddock, Pollock) – fresh, frozen, fillets	Canada, Northern Europe	122,158
Crabs and crab meat	Southeast Asia	107,886

Table 2. Important seafood products imported to the United States in 2015

PROCESSING SECTOR

The US seafood processing industry consists of about 600 companies with combined annual revenue of about \$13 billion USD (~\$17 billion CAD). Major companies include American Seafoods, Bumble Bee Foods, Red Chamber, Tri Marine International and Trident Seafoods. The US seafood processing industry is concentrated with the 50 largest processors accounting for 70-75% of the segment revenue. Profitability of individual companies vary and depend on operational efficiencies. Typically, large companies have advantages such as vertical integration and economies of scale in purchasing and marketing. To be competitive, smaller companies specialize in niche markets (Business Wire, 2010; First Research, 2018).

Fresh and frozen seafood products account for 80% of processing revenue while canned and cured seafood make-up 12%. The remaining 8% comes from industrial products such as fish meal and fish oil, bait and animal feed (NOAA 2016). Frozen products such as cod and haddock are either battered or breaded, processed plain, cut into fillets or steaks, or formed into sticks (Business Wire, 2010; First Research, 2018).

600
COMPANIES
\$13.7 **BILLION**
IN REVENUE

ROLE OF FOREIGN WORKERS AND AUTOMATION IN THE US FOOD PROCESSING INDUSTRY

The seafood industry employs over 200,000 American workers. However, many of the jobs are labour intensive and repetitive making them unattractive to US born workers. Additionally, many of these jobs are in remote areas, offer seasonal employment and require long shifts working in a cold wet environment. In 2015, foreign workers accounted for 62.8% of workers employed in the seafood processing industry. Many seafood processors have availed of the H-2B visa, a visa which allows employers to hire foreign workers to fill temporary, non-agricultural jobs (USCIS, 2018). In 2015, US employers received 2,822 H-2B visas for meat, poultry, and fish cutter/trimmer position, but state that far more visas are needed. Other challenges with the H-2B visa is the cost and difficulty in obtaining such visas. In 2015, 126,000 visas were requested, however, there was a cap of 66,000 per year which suggests demand exceeds supply (New American Economy Research Fund, 2017). In 2017, this cap was increased and 83,600 H-2B visas were issued (Wikipedia, H-2B visa, 2018a). In recent years, the seafood processing industry has attempted to alleviate the situation by advocating for its own dedicated “seafood visa” to meet its demand for seasonal workers. Some facilities have turned to undocumented workers to fill vacant positions due to the lack of viable legal options (New American Economy Research Fund, 2017).

200,000
WORKERS
» 62.8% **FOREIGN WORKERS**
IN 2015

/04 TECHNOLOGY

IN THIS SECTION, WE DISCUSS SOME OF THE INNOVATIONS IN SEAFOOD PROCESSING TECHNOLOGIES THAT HAVE RECENTLY BEEN DEVELOPED AND ADOPTED BY VARIOUS SEAFOOD PRODUCING NATIONS.

The country overviews presented in section 3 provide insight into how Iceland, Norway, the Faroes and the United States are utilizing technology and innovation to address key issues facing the seafood processing industry such as labour shortages, the need to improve product quality and production efficiencies, and cost reduction. Many European processors are investing in existing technologies available from technology providers such as Baader and Marel (E.g. HB Grandi), while some European processors are partnering with technology companies and research centres (E.g. Visir, Iceland Ocean Cluster and MATIS) to develop new technologies that will improve processing efficiencies through automation and address labour shortages. HB Grandi, one of the largest fishing companies in Iceland, put great emphasis on using the latest advances in technology for fishing and processing, and as such has formed a collaborative partnership with Marel. Similarly, in the United States, fish processing companies in New Bedford are collaborating with researchers at Northern University to incorporate robotics into their fish processing operations.



/4.1 INNOVATIONS IN WHITEFISH AND SALMONID PROCESSING

IN RECENT YEARS, SOME TECHNOLOGY PROVIDERS HAVE BEEN FORMING STRATEGIC ALLIANCES WITH OTHER SUPPLIERS OF TECHNOLOGY (E.G. THE BAADER GROUP AND JBT CORPORATION) AND IN OTHER SITUATIONS THERE IS A CONSOLIDATION IN THE TECHNOLOGY SECTOR.

There are several companies developing various types of processing technologies for the fish and seafood processing industries (). Some organizations are developing single processing pieces (e.g. Curio), full lines and/or complete factories (e.g. Baader, Marel). In other cases, a company may develop technologies for specific species (i.e., whitefish, herring, shrimp, crab, etc.) and/or product type (i.e. salt fish, fresh or frozen fillets, cooked and peeled shrimp, etc.) (E.g. Martak, Valka).

In recent years, some technology providers have been forming strategic alliances with other suppliers of technology (e.g. The Baader Group and JBT Corporation) and in other situations there is a consolidation in the technology sector. While both strategies are undertaken to offer processors a one stop solution to their processing needs, there is also incentive for companies such as Baader and Marel to expand into other areas (e.g. poultry processing).

From the processing sector, the trend in Europe has been to invest in existing technologies and/or to partner with technology providers to develop new processing technologies that will improve efficiencies, automate processing steps, and offset labour shortages so that they can remain competitive in global markets.

Many of the suppliers of technology are investing in research and development to:

- ☑ Improve existing pieces to make them more efficient;
- ☑ Expand their product line into new technology;
- ☑ Expand their product line into new species.

Existing technologies are being used to automate the following processes in seafood processing plants: Stunning; Bleeding; Gutting; Heading; Filleting; Skinning; X-ray; Waterjet cutting; Portioning; Weighing; Visioning; Labeling; Data Management Software; Traceability Software; Palletizing.



Table 3 lists the major suppliers of fish and seafood processing technology. Many of the organizations identified have video clips on their website showing the operation of their equipment.



Company/Website	Species	Technology
Baader Food Processing Machinery http://www.baader.com/en/products/fish_processing/index.html	Many Species	Wide Ranging Complete Solutions
Marel https://marel.com/fish-processing	Whitefish Salmon	Wide Ranging Complete Solutions
Skaginn 3X Technology https://www.skaginn3x.com/	Many Species	Wide Ranging Complete Solutions Land and at Sea
Martak http://www.martak.ca/products.html	Shrimp Fish	Wide Ranging Material Handling
KM Machinery https://km-fish.dk/	Shrimp Fish	Wide Ranging Land and at Sea
Cabinplant https://www.cabinplant.com/solutions/fish-sea-food/	Pelagics Crustaceans	Wide Ranging Complete Solutions
Optimar https://optimar.no/products.html	Many Species	Wide Ranging Complete Solutions
Curio Food Machinery Limited https://curio.is/en/	Whitefish	Heading Skinning Filleting
Valka https://valka.is/	Whitefish Salmon	Wide Ranging Complete Solutions
Wisefish https://www.wisefish.com/	All Species	Software
Laitram Machinery www.laitrammachinery.com	Shrimp Crab	Shrimp grading, peeling, cooking and cooling Cool Steam Cooking
Ryco www.rycous.com	Crab Salmon Whitefish	Wide Ranging

Table 3. Major Suppliers of Technology for the Fish and Seafood Industry



4.1.1 BAADER

Figure 24 illustrates Baader's newest salmon processing line which includes stunning, bleeding and chilling equipment, gutting and fish distribution systems, filleting line, and packing conveyor system. This equipment will be showcased at the upcoming Baader Salmon processing workshop scheduled for September 27, 2018 at Baader's demonstration facility in Lubek, Germany (Figure 25).

In 2017, Baader hosted a whitefish demonstration workshop in Lubek to showcase its suite of on-board and in plant processing equipment (Figure 23). Key pieces of equipment included its onboard header and filleter the Baader 192, and the Baader 191 onboard gutting machine which replaces the Baader 190. Plant processing equipment included new equipment for processing larger fish such as the Baader 582 heading machine, the DSI 844 water-jet cutter, and the Baader 144 robotic cleaning system.

4.1.2 MAREL

Immediately following the Baader workshop, Marel will host a whitefish processing demonstration workshop September 28, 2018 at its demonstration facility in Copenhagen, Denmark. In 2017, the Marel workshop provided demos of the following technologies: Flexicut water jet cutting technology; Full processing line equipped with Flexicut, pre-trimming, robotic arm for portioning fish into packages, and SensorX bone detection; I-Cut Portion cutters for value added products; Grading and batching equipment with multi-head weighers and smartline graders; Bread and batter line (Roto Crumb, Value Spray); Packaging and labelling systems (Cryovac); Innova Virtual Software – for real-time monitoring and historical analysis of production data.

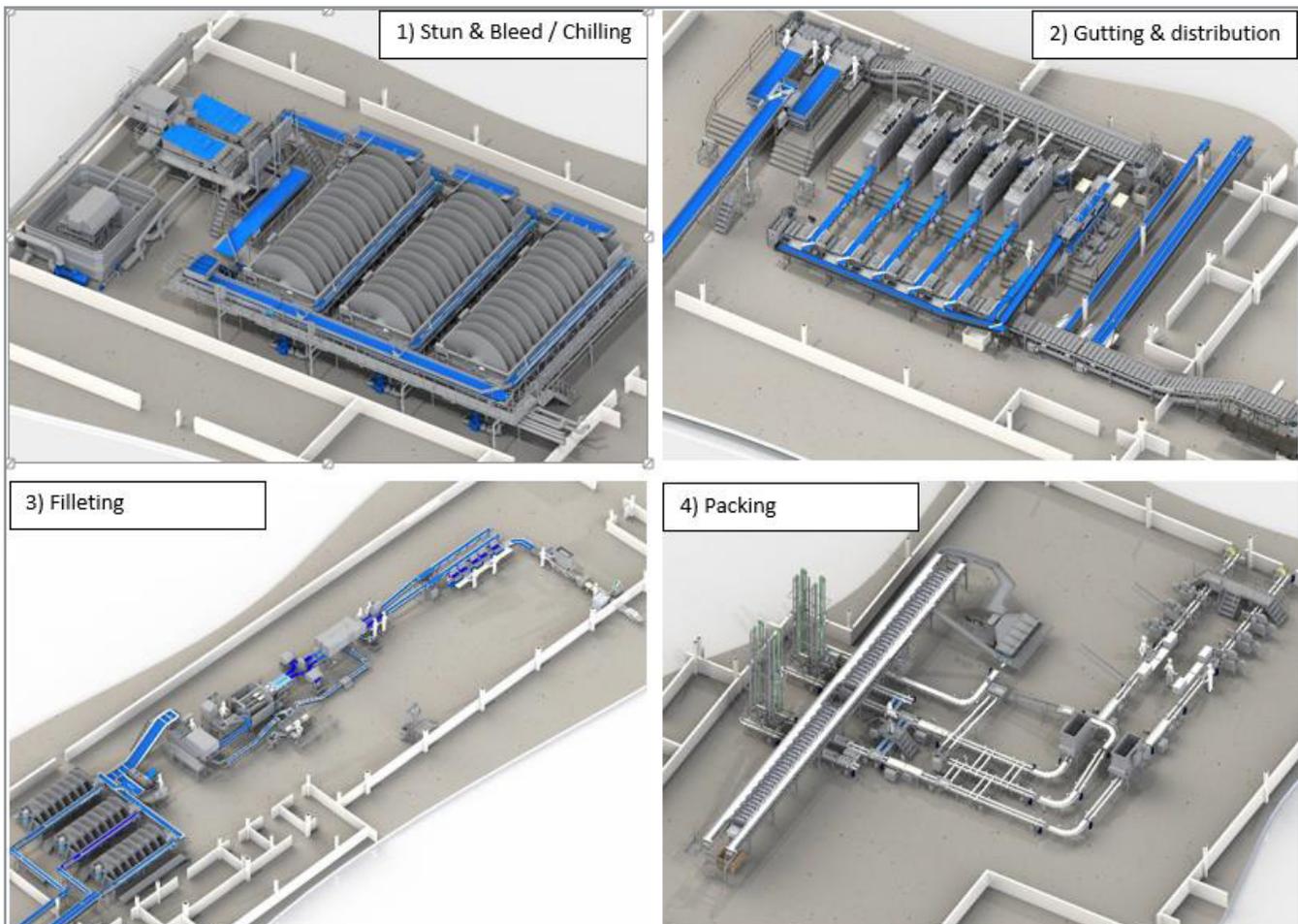


Figure 24. Conceptual layout of Baader's Salmon processing line (Source: Baader Canada)



Figure 25. Conceptual drawing of Baader whitefish processing line at the Baader demonstration facility in Lubek, Germany (Source: Baader Canada)

BAADER[®]

Food Processing Machinery

marel

/4.2 INNOVATIONS IN CRAB AND LOBSTER PROCESSING

CANADA IS A RELATIVELY SMALL PLAYER IN THE GLOBAL SUPPLY OF GROUND FISH, PELAGICS, FARMED SALMON, AND SHRIMP. OTHER COUNTRIES THAT ARE BIGGER THAN WE ARE IN THOSE SPECIES HAVE DEVELOPED NEW PROCESSING TECHNOLOGIES FOR THEM. CANADA, HOWEVER, IS A BIG PLAYER IN LOBSTERS AND CRAB.



If better technology for processing these species is needed, Canada will have to develop it. This could be challenging as there is no sustained effort in Canada to develop the technologies needed. Processing companies do not want to invest in technology R&D or take the risks. They want off-the-shelf solutions, but Canadian technology companies do not see the fishery as an attractive market, and government support for R&D organizations has been inconsistent and sporadic.

Several processing innovations have been developed to improve yield (i.e. meat extractability) and quality of crustacean products. This section first introduces examples of some of these technologies (e.g. ice slurry chilling technology, CoolSteam cooking, and High pressure processing) which are briefly discussed. We then take a more detailed look at specific challenges facing the lobster and snow crab processing industries, and discuss possible opportunities for process automation solutions.



4.2.1 ICE SLURRY SYSTEMS

For crustacean processing, chilling technologies are critical throughout the production process to ensure product quality and minimize deterioration. Traditionally, flake-ice and refrigerated sea water (RSW) systems have been employed for rapid chilling to decrease the final product temperature to just below 0° C. However, due to the highly perishable nature of crustaceans they must be rapidly chilled to subzero temperatures immediately after harvesting/butchering to prevent spoilage. Newer chilling systems have recently enabled the storage of seafood at subzero temperatures through the addition of salts or other compounds to ice-water mixtures which are usually referred to as “ice slurry systems”. Such systems have been receiving increasing attention for the storage and preservation of aquatic foods due to their faster chilling rate in comparison with traditional flake-ice or RSW, and reduced physical damage to the product (Manuel 2017). The spherical ice particles of an ice slurry mixture do less damage to aquatic food tissue than traditional flake-ice particles (Pineira et al 2004).



4.2.2 COOLSTEAM® COOKING

The CoolSteam® Technology developed by Laitram Machinery uses a forced convection method in which a low-temperature mixture of air and steam is constantly circulated inside the cooking chamber with uniform and efficient heat distribution. This provides a more consistent cook. Shrimp, crab and lobster processors in North America have been replacing older immersion cookers with the CoolSteam® cooking technology due to a number of advantages this technology provides over immersion cooking, namely: Improved quality, improved yield, cost and energy savings imparted by lower cooking temperatures and more efficient heat distribution (Manuel, 2017).

4.2.3 HIGH PRESSURE PROCESSING

High pressure processing (HPP) of foods was first commercialized in Japan in 1992 as a means of microbial inactivation in jams and fruit juices. HPP involves the application of high hydrostatic pressure to packaged foods, or whole raw shellfish (i.e. in the shell). Unlike thermally processed foods, HPP treated foods retain the appearance, flavor, texture and nutritional qualities of the unprocessed product (Smelt et al 2001; Murchie et al 2005; Hoover et al 1989). More recently, the technology has been applied commercially to bivalves (oysters) and crustaceans (lobster) to aid in raw meat removal from the shell (Manuel, 2017).

HPP technology provides clean separation of meat from the shell and facilitates a new approach to crab meat extraction (Figure 26). This offers potential to open up new markets and dramatically increase the value of crab products. Commercializing HPP technology involves developing new technology for crab meat extraction, and incorporating both the HPP and meat extraction technologies into a highly automated production system. Meat extraction is now done manually around the world, despite many efforts to find a better solution. It is for that reason it is done mostly in low-wage countries. The use of HPP enables easier meat extraction and potentially a greater degree of automation for the extraction process. Research is currently ongoing with respect to meat extraction automation for high pressure processed snow crab at Memorial University of Newfoundland through the Canadian Centre for Fisheries Innovation and the Centre for Aquaculture and Seafood Development (Manuel, 2017).

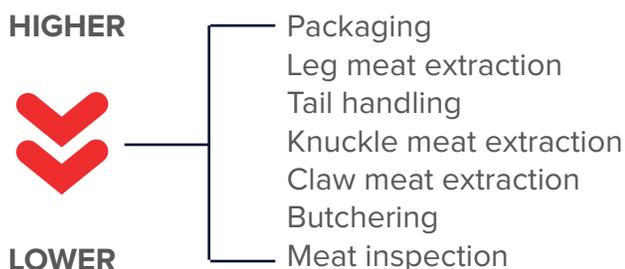


Figure 26. NC Hiperbaric Wave 6600 55L Horizontal High Pressure Processing System installed at the Fisheries and Marine Institute of Memorial University of Newfoundland

4.2.4 LOBSTER PROCESSING

Lobster is Canada’s highest value fishery resource (Gardner Pinfold, 2017). Despite its value, lobster processing remains a largely manual and labor-intensive operation. Heavy reliance on workers leaves the lobster industry particularly vulnerable to the shrinking labor supply, which is affecting all sectors of the Canadian fishing industry. There are two factors at work here. One is the substantial increase in lobster landings over the past 10 years that has made more raw material available for processing. The other is the aging and shrinking workforce in the Maritime Provinces. Temporary Foreign Workers helped fill the gap but they are no longer available in the numbers they once were (CBC, 2017).

Opportunities for automation exist at all stages in lobster processing including butchering, meat extraction, inspection, materials handling, and packing. A report by Enginuity Inc. (2014) identified and prioritized the steps in lobster processing where automation and implementation of new technology could provide significant labor savings. The report ranked the processes by priority as follows:



A major challenge when applying automation to processing tasks on natural products is the large variability from one individual to the next. Lobsters are a prime example, having an irregular shape, complex geometry, and appendages that shift position as they are handled. An automated system would need to handle these differences to be successful. Enginuity Inc. (2014) noted that trained workers can make rapid decisions using visual and tactile information and can make subtle adjustments to their grip and hand motions on the fly. Replicating this level of human skill and adaptability with technology is a daunting task.

Automating complex processes also requires long development cycles, and designs must go

through multiple iterations before they are ready for the production floor. This requires a significant financial investment and the risk of failure can be high. It can be difficult for a company to justify the risk based on potential benefits which may only be achieved years into the future.

Despite the challenges, several companies have developed technologies which provide some degree of automation in the meat extraction and inspection processes. Eastern Fabricators Inc. has developed an automated leg meat roller system, LMR 7200, for extracting the meat from cooked lobster legs. Charlottetown Metal Products Ltd. offers a claw scoring and extraction system (C3000), and a lobster knuckle and arm meat extraction system (KA3000). Lizotte Machine Vision has developed a cartilage finder to inspect lobster claw meat to reject those that contain cartilage, and a lobster grader for identifying the meat content and shell thickness of the lobsters. Both Lizotte machines use x-ray technology.

These developments represent a small portion of the overall potential for automation in the lobster processing industry.

A list of technology and solution providers for the lobster industry is provided in Table 4.

Atlantic Systems Man.	asmequipment.com
Avure Technologies Inc	avure-hpp-foods.com
C&W Industrial Marine Equipment	seafoodprocessingequipment.ca
Charlottetown Metal Products Ltd	cmpequipment.com
Cube Automation	cubefoodprocessing.com
Eastern Fabricators Ltd	easternfabricators.com
Enginuity Inc.	enginuityinc.ca
Hiperbaric USA	hiperbaric.com
Laitram Machinery	laitrammachinery.com
Lizotte Machine Vision	lizottemachinevision.com
South East Welding Ltd	southeastwelding.ca

Table 4. Technology and solution providers for the lobster processing industry (Enginuity Inc., 2014)

4.2.5 SNOW CRAB PROCESSING

Most of the snow crab landed in Canada is processed and packed manually. Specific to packing, in a typical plant, about twenty (20) people are required to pack snow crab sections at an industry normal rate of about 10,000 whole crab per hour (Pers. Comm. with various processing companies).

The workforce in the snow crab processing industry is aging and there are no young people entering the fishery. In the foreseeable future there will be a critical shortage of workers and plants will not have enough labor to remain viable. To maintain crab processing operations in Canada there is a need to automate those processing operations.

A review of existing technologies was undertaken by the Centre for Aquaculture and Seafood Development to determine the current state of the art in crab processing. Traditionally crab processing was a 100% manual process. Crab was butchered, cleaned, sorted, graded and packed all by hand. Technology has automated parts of the process including butchering, cleaning, sorting and grading. However, packing is still done manually by workers. The following sections describe the latest advances for each stage in the process.

BUTCHERING

Crab butchering is a labour-intensive process that requires skilled workers who remove the mandibles and the carapace from the crab prior to separating it into two sections from which the gills and viscera are subsequently removed. Due to a decreasing labour supply, snow crab processors have been seeking more effective, automated mechanical processes to complete this step in their production process (Manuel, 2017).

Technology for automatic butchering of crab has been available to industry for over 20 years although some plants still employ workers to manually butcher the crab. Two examples of butchering machines currently available are the Baader 2801 and the Ryco 260 (Figure 27) (Baader, 2014). Both of these technologies have been based on the principle patented in 1995 under US Patent 5401207, Crab Butchering Machine and have been continually refined. Whole crabs are loaded into clamping saddles on the machine by workers. The saddles move through multiple work stations inside the machine there the carapace, gills and viscera are removed and the crab split in half to create 2 sections. The butchering process is automated however loading the machine is still done manually.



Figure 27. Baader CB 2801 (top) and Ryco 260 (bottom)

SECTION CLEANING / BARNACLE REMOVAL

Automation also exists for cleaning the crab sections (Baader CS 602) and for removing barnacles (Baader CS 604) (Figure 28). This technology has also been available to industry for over 20 years. Crab sections are suspended individually from shackles and carried through a pair of rotating brushes. The CS 604 has a more aggressive brush with attachments for knocking off the barnacles. The cleaned sections are automatically ejected from the shackles at the exit end of the machines. Here again the process of cleaning and removing barnacles is automated but loading the crab sections must still be done by workers.



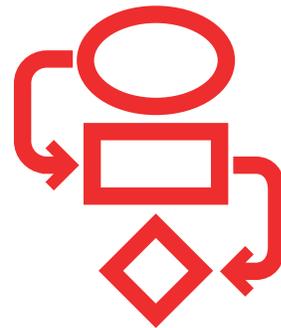
Figure 28. Baader CS 602/604

ROBOTICS

Recent work by a Newfoundland based research team which included CCFI (project lead), CASD (engineering design), CNA (engineering design) and OCI (industry partner) has introduced vision guided robotics to crab processing. Workers place whole crabs on a conveyor belt which carries them into the robotic work cell. A pick and place robot coupled with an imaging and lighting system identifies individual crabs on the belt and systematically picks up each one and places it on one of two clamping fixtures. Each fixture has its own camera and lighting system and its own 6-axis robot. An image is taken of the crab in the fixture and processed onboard the camera to generate a series of target points unique to each crab. These points are used to create a cutting path for the 6-axis robot to break the crab down according to one of two preselected recipes; traditional butchering into sections or leg removal. This technology rep-

SORTING / GRADING

Advances have also been made in automatic sorting and grading of crab sections. One recent development in automatic sorting and grading is the Skaginn 3X crab packing and grading line (Figure 29). Crab sections are placed on a belt that carries them through an optical scanner and automatic weighing unit. The sections are graded based on size, weight and quality. A series of moving mechanical arms divert each section to the appropriate packing station based on how it was graded. Workers then pack the crab in pans to be sent through a cooking process. The sizing, grading and sorting tasks have been automated but feeding the sections to the equipment and packing them at the end is still all done by hand.



resents the first time automatic picking and placing of whole crab has been demonstrated in industry and the first time robotics has been used to process crab, and to our knowledge, work directly on fish, other than packaging and palletizing.



Figure 29. Skaginn 3X Crab Packing/Grading Line

/05 RESEARCH

FOR EACH RESPECTIVE COUNTRY LISTED IN THIS REPORT, THERE ARE GOVERNMENT DEPARTMENTS AND/OR ACADEMIC INSTITUTIONS ACTIVELY ENGAGED IN AQUACULTURE AND FISHERIES RESEARCH AND DEVELOPMENT.

In addition, there are specific industry focused organizations (public/private) with a mandate to conduct research and advance all aspects of the fisheries and aquaculture value chains. The scope of research varies among the different organizations, but collectively they play a role in advancing both fisheries and aquaculture development.



/5.1 FAROE ISLANDS

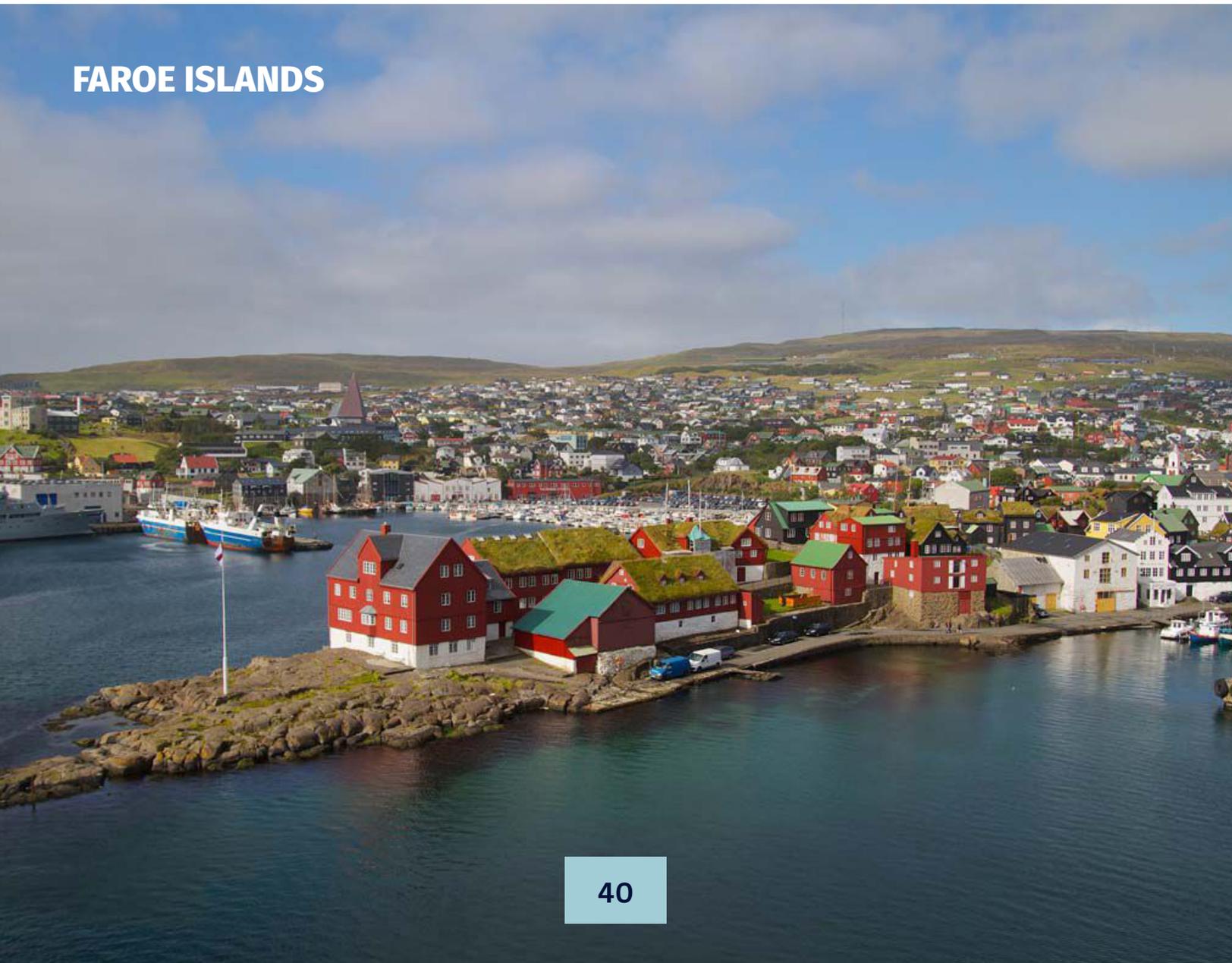


FISHERIES RESEARCH FUND OF THE FAROE ISLANDS

<http://www.wefta.org/default.asp?ZNT=SOT1O264>

The fund is intended to stimulate both scientific and industrial R&D projects in order to develop the Faroese fishing industry, harvesting, processing and trade sectors. The Programme also supports three small Fisheries R&D Centre for Fish Harvesting Technology, Fish Processing Technology and Marine Biotechnology. These Centres are supported by existing Faroese government infrastructure such as government agencies and public institutions and each centre is supported by a Programme Committee consisting of researchers and industry representatives. Within the Faroese government, seafood research falls under the Ministry of Fisheries and Maritime Affairs whereas aquaculture falls under the Minister of Trade and Industry.

FAROE ISLANDS



/5.2 ICELAND



MATIS

<https://english.matis.is/>

Matis is a government owned, independent research company that was founded in 2007 following the merger of three former public research institutes. The organization pursues research and development aligned to the food and biotech industries, as well as providing Iceland's leading analytical testing services for public and private authorities. Matis' vision is to increase the value of food processing and food production, through research, development, dissemination of knowledge and consultancy, as well as to ensure the safety and quality of food and feed products.

AVS R&D Fund of Ministry of Fisheries and Agriculture	<input checked="" type="checkbox"/> Supports value creation from F&S by awarding grants to individuals, enterprises, research, development or academic institutions, for their Fisheries and aquaculture-related projects.
The Icelandic Centre for Research (RANNIS)	<input checked="" type="checkbox"/> Provides professional assistance in the preparation and implementation of the national science and technology policy. <input checked="" type="checkbox"/> Administers funds in the fields of research, innovation, education, culture, and for strategic research programs. <input checked="" type="checkbox"/> Companies can apply for having access to this fund.

ICELAND



/5.3 NORWAY



NORWEGIAN INSTITUTE OF FISHERIES AND AQUACULTURE (NOFIMA)

<https://nofima.no/en/>

Norwegian Institute of Fisheries and Aquaculture (NOFIMA) is one of the largest institutes for applied research within the fields of fisheries, aquaculture and food research in Europe (Figure 30). The institute was established in 2008 through a merger of four institutes. It is owned by the Norwegian government under the Ministry of Trade, Industry and Fisheries (56.8%), Stiftelsen for landbrukets næringsmiddelforskning (33.2%), an Akvainvest Møre og Romsdal (10.0%).

NOFIMA provides internationally renowned research and solutions that provide competitive advantages along the complete value chain. NOFIMA has several laboratories and pilot plants, which are used for specific research in the fields of food, fisheries and aquaculture. The facilities make it possible for industries to carry out experiments and test production methods.



MARINE BIOPROSPECTING, ARCTIC UNIVERSITY OF NORWAY

https://en.uit.no/forskning/forsknings-grupper/gruppe?p_document_id=348358

Marine Bioprospecting, Arctic University of Norway is focused on better understanding marine molecules, and specifically bioactive secondary metabolites that have potential commercial applications. The research team strives to identify novel marine bioactive compounds, study the properties of these compounds, and identify uses of biotechnology in marine research and industry.



Figure 30. NOFIMA headquarters in Tromsø, Norway

SAMPLE PROJECTS

- ☑ Salmon Feed – using the correct raw materials in the feed gives high quality, firm fillets, and a salmon fillet that is suitable for various types of processing.
- ☑ Development of a scanner that uses spectroscopy and imaging technologies to automatically sort fish based on its quality properties.
- ☑ Development of the “How fresh is your fish?” app for iPhones and android phones which helps users check the quality of various types of fish. The app is free and has been translated into several languages.





FOUNDATION FOR SCIENTIFIC AND INDUSTRIAL RESEARCH (SINTEF)
<https://www.sintef.no/en/>



KONTALI ANALYSE AS
http://www.kontali.com/?div_id=22&pag_id=24

Foundation for Scientific and Industrial Research (SINTEF) was established at the Norwegian Institute of Technology in 1950 expanded rapidly in the following years. The organization’s Fisheries and Aquaculture division has a broad expertise and knowledge in utilizing renewable marine resources. The institute works with industry to find solutions to problems that challenge all aspects of the value chain such as biological aspects of marine production through aquaculture and harvesting to processing and distribution.

SINTEF also acts as an incubator for new industrial companies. In 2013, they were involved in the commercialization of eighty different technologies, through licensing agreements and the establishment of new companies.

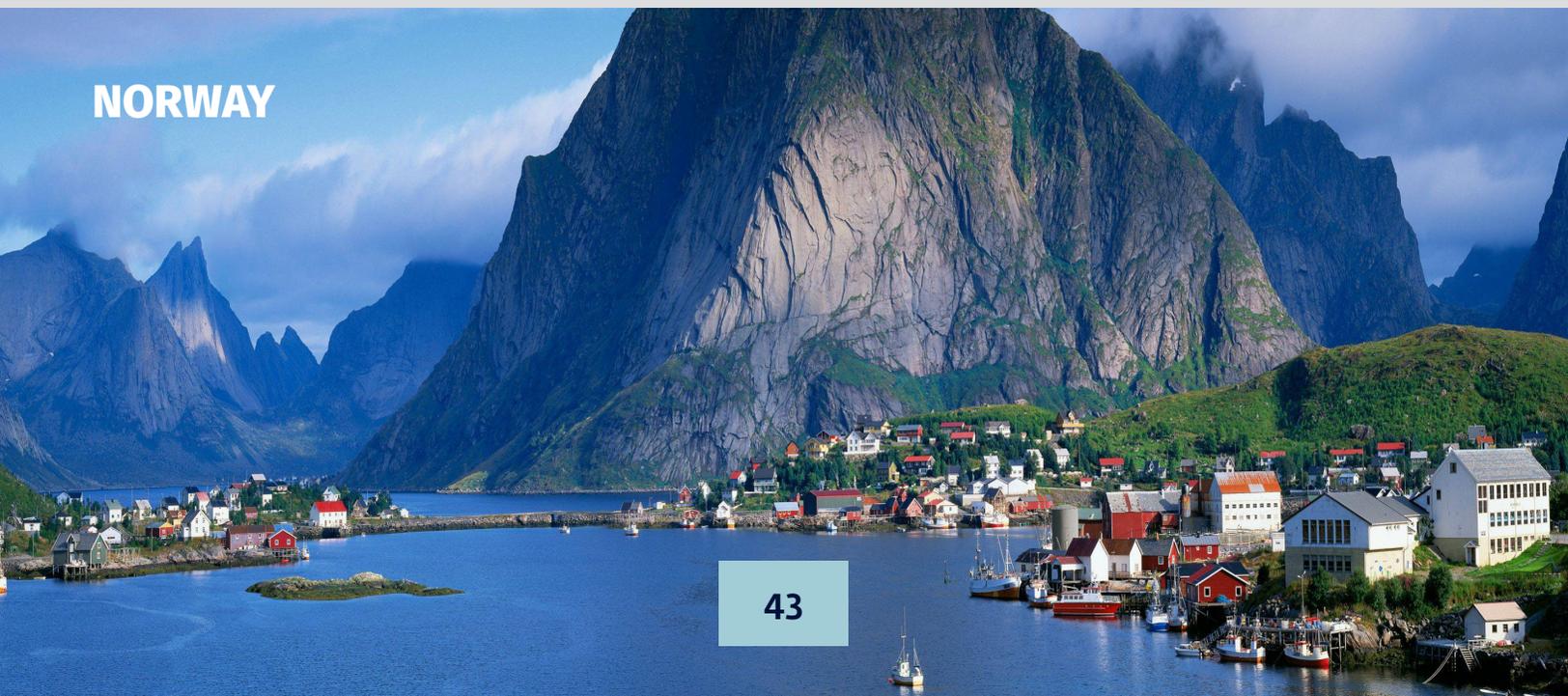


KONTALI is an independent, internationally recognized provider of aquaculture and commercial fisheries analysis. Kontali currently has the world’s most extensive private database which covers the value chain for aquaculture, commercial fish and crustaceans – a database which has been built up during many years of consultations with industry and collection of public and private data pertinent to the commercial species and sector. In addition to conducting comprehensive strategic positioning and value chain analyses the company also publishes a wide range of publications and special reports for the aquaculture and commercial fishery sector.

Norwegian Fishery and Aquaculture Industry Research Fund (FHF)

- ☑ FHF’s purpose is “to strengthen financing of research and development, to arrange for increased added value, environmental adaptation, adjustments and innovation in the fishery and aquaculture industry”.
- ☑ Financing agency that shall be utilized for industry-oriented R&D work.
- ☑ Aims at bringing financial support (including grants) to research programs and large projects.

NORWAY



/5.4 UNITED STATES



NATIONAL FISHERIES INSTITUTE (NFI)
<https://www.aboutseafood.com>

National Fisheries Institute (NFI) is a non-for profit industry trade organization representing the seafood industry in the US. Its members consist of organizations from all levels of business including vessels, processors and food service. NFI is dedicated to education about seafood safety, sustainability and nutrition. Sustainable oceans, responsible fisheries and ocean stewardship are core principles of NFI. Investment in oceans today, to ensure future generations have access to sustainable, healthy fisheries are a key objective of NFI and its members. The NFI also ensures that the public is informed of the recent facts or events that occur involving sustainability through the media.

NFI and its members support seafood and sustainability initiatives, such as studies of ocean bycatches by research scientists. It also endorses new initiatives such as certification of seafood importers and exporters, food safety and labelling regulations, and certification of labs for seafood testing that meet FDA guideline (Wikipedia, 2018b).



OREGON STATE UNIVERSITY SEAFOOD LAB
<https://osuseafoodlab.oregonstate.edu>

Oregon State University Seafood Lab is the only seafood experiment station on the West Coast of the United States. Its mission is to improve seafood through research and development, extension service to both the fishing and seafood processing industry, and graduate student research, training and instruction. The OSU Seafood lab offers facilities for research, product development and testing, and offers workshops related to seafood processing, seafood wastewater management, and surimi processing.



NATIONAL SEA GRANT COLLEGE PROGRAM
<https://seagrant.noaa.gov>

National Sea Grant College Program has three strategic focus areas: healthy coastal and marine ecosystems, sustainable fisheries and aquaculture, and resilient coastal communities and economies. The program offers competitive state and federal research awards, fellowship opportunities for graduate students, and community extension and outreach programs. It is part of a national network of 33 university-based programs funded and coordinated by NOAA.



THE VIRGINIA SEAFOOD AGRICULTURAL RESEARCH AND EXTENSION CENTER (AREC)
<https://www.arec.vaes.vt.edu/arec/virginia-seafood.html>

The Virginia Seafood Agricultural Research and Extension Center (AREC) provides information to help the seafood industry thrive in an increasingly competitive global market. Its mission is to research and create the most vital and current technologies and techniques in the seafood industry and to share that knowledge with the industry to help it succeed. It has modern, up-to-date facilities and is a global leader in seafood research, aquaculture and food safety.



/06 CANADA

CANADA'S SEAFOOD VALUE CHAIN ROUNDTABLE (SVCRT) VISION IS A PROSPEROUS AND COMPETITIVE CANADIAN SEAFOOD INDUSTRY THAT IS A WORLD LEADER AND THE PREFERRED SUPPLIER OF HIGH VALUE SEAFOOD, DOMESTICALLY AND INTERNATIONALLY.

Canada's Seafood Value Chain Roundtable (SVCRT) was established by Agriculture and Agri-food Canada to provide an opportunity for information sharing, discussion and strategizing on a national level about its key priorities: competitiveness, trade, human resources and market access issues. Its vision is a prosperous and competitive Canadian seafood industry that is a world leader and the preferred supplier of high value seafood, domestically and internationally. Its members include industry, provincial governments, and federal government representatives. The SVCRT has established several working groups and commissioned a few reports to help meet its objectives. Its most recent report "Extracting Maximum Value from Canada's Fisheries and Aquaculture Resources" was completed Gardner Pinfold Consultants Inc. in September 2017. This study evaluated how Canada could maximize the output of its fish and seafood, and sets a roadmap to show how industry can move forward to maximize value (Agriculture and Agri-food Canada, 2018).

Several studies related to the competitiveness of Canada's seafood industry in comparison to other seafood producing countries have been conducted in recent years. This section provides a summary of key results from selected studies specifically related to Canada's level of technology readiness and maximizing the value of Canada's seafood industry. This section also explores the research and technology support services that are available for Canada's fisheries and aquaculture industries.



/6.1 TECHNOLOGY READINESS OF CANADIAN SEAFOOD PROCESSORS

The international competitiveness of our processing sector has been steadily eroding for years. Part of the problem is that DFO does not consider the processing sector to be part of its constituency and makes resource management decisions without considering the needs and opportunities of the processing sector. This has been discussed at the SVCRT and will be discussed more at future SVCRT meetings. Canada still has a labour-intensive industry that can't compete with labour-intensive processing in low-wage countries and Canada does not have circumstances that support investment in automation technologies, even if they were available.

Innovation, Science and Economic Development Canada commissioned KPMG Advisory Services to conduct a national assessment on the technology readiness of automation and robotics for the fish and seafood processing sector in Canada. The KPMG report (2014) indicated that the processing sector is only partially automated with the level of adoption and development of automation and robotic technologies varying across sub-sectors and firms.



The report which consulted with 20 Canadian processing companies reported the following drivers and barriers to adopting automation and robotics in the Canadian F&S processing sector:

- ☑ Production related factors (including cost savings, increasing of margins, and improvement of efficiency of operations and of productivity) were most frequently considered as key drivers to the adoption of automation and robotics.
- ☑ Employee-related and competition-related motivations (mainly regarding decreasing labour supply and competition with low-labour-cost countries, respectively).
- ☑ Economic-related factors (costs of technologies).
- ☑ Several companies explained that the seasonality of operations was an important issue, as they have difficulties to justify more investment in automation or robotics whilst not operating all year round.

In addition, the report indicated, that in terms of investment in automation and robotics, F&S processing companies:

- ☑ Invest approximately 2% of revenue each year, with occasionally important year-over-year variations.
- ☑ While most of the interviewed companies considered that the annual investments targeting automation and robotics allowed for all necessary projects to ensure that their company remains competitive, most of them further expressed interest for additional funding.



Both the KPMG (2014) report and CCFI's Process Automation in Seafood Processing Workshop summary report (2017) cited several factors which are impacting the F&S processing sectors ability to invest in technology and automation. These include:

- 1 The business environment, the length of the operating season, fishing quotas, and policies limit the number of F&S products that can be processed in a plant in each year and as such hinder investments in automation and robotics (through decreased return on investment).
- 2 High availability of low wage labour (as in some developing countries) or low skilled labour availabilities are also factors that were documented to negatively impact the adoption of automation of robotics.
- 3 A fragmented industry marked by uncertain access to the fish harvested, poor quality of raw materials, and a shrinking abundance of some species, and economies of scale increase risk and do not provide circumstances that allow companies to make automation investments.
- 4 Industry is caught between low cost, low value products that are processed with minimal labour expense; and high value products that rely upon advanced, automated methods that required significant upfront investment.
- 5 Automation is not uniform among sectors; groundfish and pelagic processors could likely purchase equipment that has already been developed and proven elsewhere. For shellfish- the onus would be to work with producers to create automation solutions.
- 6 Current model is labour intensive with low wages.
- 7 Demographics are resulting in a decreasing labour supply.
- 8 Temporary workers have filled some of the gap for low cost labour; but the program is becoming restrictive.
- 9 Without adequate supply of low cost labour, the Canadian fish processing industry is facing increasing difficulty as it produces labour intensive products and is interested in finding ways to automate processes so it can do more with fewer people.



Financial support from government is also cited as an important factor for the adoption of automation and robotics by F&S processing companies. Support programs that have been developed in other countries can serve as examples for Canada (KPMG, 2014).

In terms of percent integration or usage of manual activity versus automation, the F&S processing companies interviewed by KPMG reported:

- ✓ 38% of all activities were mostly manual work done by hand labour
- ✓ 12% usage of mechanical machines operated by labour
- ✓ 23% usage of a combination of mechanical machines (either automatically or manually operated), integrated by conveyors and automated (or use of operator) control systems.
- ✓ 12% reported mostly automated, with little labour involved (e.g. quality/process control)

Further, the companies interviewed in the report, stated that:

- ✓ 59% of packing activity was considered mostly manual labour
- ✓ 42% of end-of-line activities were considered mostly manual labour
- ✓ 32% of initial processing (bleeding/gutting/heading/splitting) was mostly manual labour
- ✓ 29% of primary processing (filleting, portioning, mincing, packing, preserving) was mostly manual labour.

For initial and primary processing activities, many stated the use of mechanical machines operated by labour as well as a combination of mechanical machines.



The same companies when interviewed about the importance of adopting and developing automation and robotics, noted:

- ✓ Processing (filleting, portioning, mincing, packing and preserving) would be the most important activities to automate, particularly for the groundfish sector as it is considered the most time-consuming activity.
- ✓ Packaging materials and handling and sorting in general was listed as one of the most time-consuming activities for all species (groundfish, small pelagics, molluscs, crustaceans).
- ✓ Groundfish: While some technologies appear to be available, their level of adoption has remained relatively low. According to fact-finding discussions, processing activities were the most important to automate.
- ✓ Small Pelagics: The level of adoption and development of automation and robotics was relatively low for small pelagics, particularly for packaging and other activities. Technology for these sectors are not as readily available as for groundfish therefore they require more innovation versus adoption of off the shelf technology. While there are technologies available for small pelagics, Canada cannot adopt it because we do not have the volumes needed.

INDUSTRY CHALLENGE AND STRUCTURE

- ✓ The industry is fragmented (inconsistent supply, lack of vertical integration) and lacks consolidation among harvesters, processors and marketers which challenges processing companies from making the necessary investment in technology and automation.
- ✓ Industry structure does not support fewer, larger, plants that operate year-round with a consistent supply of year-round product (which is the Icelandic model) as vertical co-operation is limited in comparison to other countries.
- ✓ Canada produces large volumes of fresh fish in short periods of time and often at a time of the year that does not yield the highest quality product.

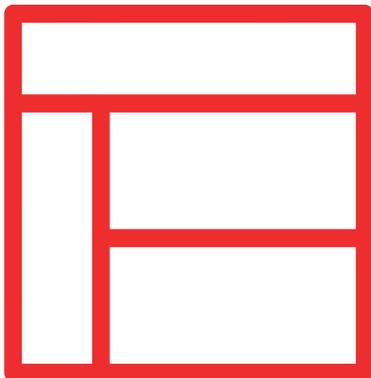
/6.2 COMPARISON OF TECHNOLOGY READINESS WITH OTHER COUNTRIES

In terms of the Newfoundland Seafood Value Chain, the NL Seafood Value Chain Infrastructure Benchmarking Assessment report by Pisces Consulting Limited (2015) reported that due to the diversity of species, sizes, product forms and number of producers, adoption of technologies to be internationally competitive is challenging. This has resulted in many species being processed to minimal requirements, whole frozen or H+G, and a general lack of investment in state of the art processing technologies. This is an indication of our weak competitiveness and loss of potential value.

In contrast, European countries such as Iceland, Norway, Denmark and Germany are considered leaders not only in the use of automation and robotics in F&S processing but also in the development of such technologies (especially Iceland and Norway). The US was also considered among top-leading countries regarding the adoption of automation and robotics. European countries do report having similar issues to Canadian processors, namely the cost of technology and the decreasing labour supply (Pisces Consulting Limited, NL Seafood Value Chain Infrastructure Benchmarking Assessment 2015; KPMG, 2014).

Access to government support and funding appears to be a major factor differentiating the Canadian and European processors. The Icelandic government provides the F&S sector with the most financial support (0.17% of its GDP), followed by Norway (0.08% of total GDP). In comparison the Canadian government's share is 0.05% of total GDP (KPMG, 2014).

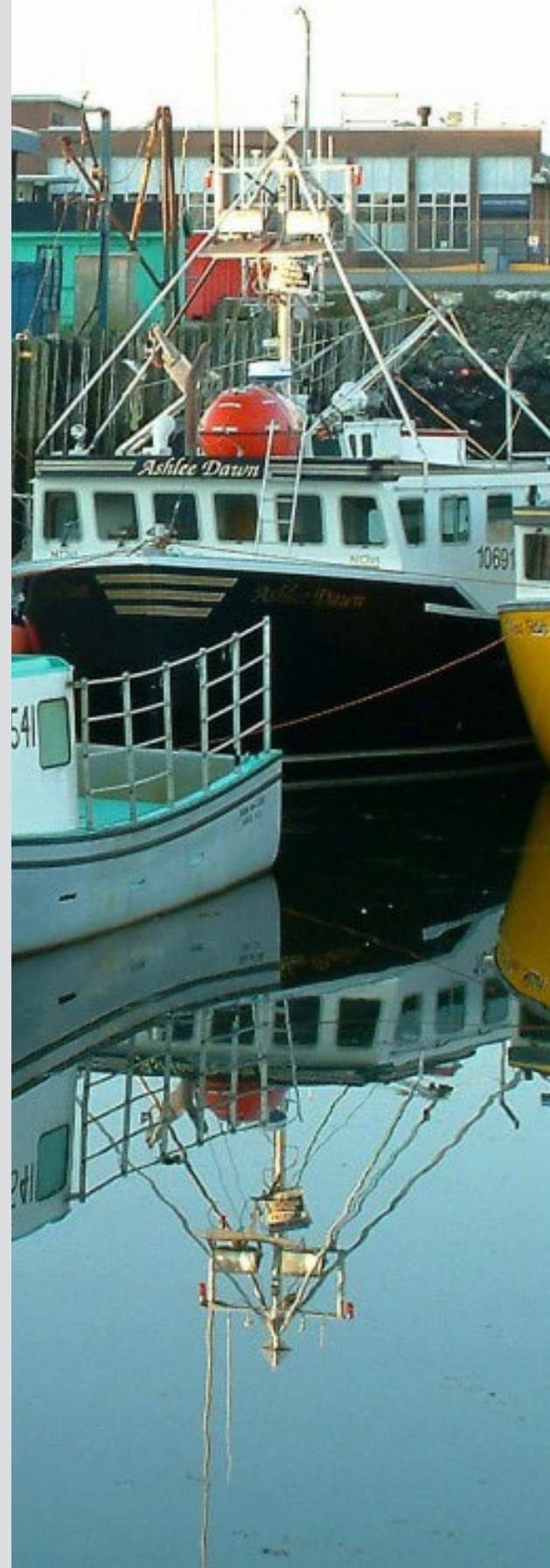
For countries such as Iceland and Norway the level of automation has increased significantly with fourth generation flow lines and water jet cutting machines being used. Specific to Iceland, trimming of the fillets are now minimal and is limited to cutting out defects that are on the fillets and removing parasites found in the filet. The pin bones are removed in the water cutter as well as belly flap and portioning of the fillets. This enables Iceland for example to pursue more advanced and complicated product mixes as well as more accurate cuts and sizes. In addition, robots are increasingly being used in packing and storing of the products. The increased level of automation in Icelandic processing facilities has resulted in the throughput per man hour increasing from 12kg/hour in traditional filleting production to approximately 80-100kg/hour in the most advanced production flow lines today. The drawback to increasing the use of technology and automated systems in fish processing in Iceland is investments in these systems require significant capital investment (Moret et. al., 2018).



The KPMG report also noted the following important factors when comparing Canada to non-Canadian countries:

- 1 Canadian and non-Canadian F&S processing companies revealed that generally, they have the same motivators for adopting automation and robotics namely production-related factors (improve margins and efficiency of operations, increase quality and consistency of products) and employee-related ones (decrease labour supply).
- 2 Non-Canadian companies also face the same challenges regarding costs of technologies/return on investment; technical issues and difficulties to find machines answering to their needs; decreasing labour supply.
- 3 Moreover, non-Canadian F&S processing companies explained that they typically do not invest in new automation and robotics, but rather in technologies already well tested and well known. According to them, this strategy helps to avoid major mistakes when investing in automation and robotics.
- 4 Norway F&S processing companies can avail of a development fund (paid by tax revenue) which funds R&D projects to foster the development and the adoption of automation and robotics.
- 5 Denmark has collaboration between processing companies and technology suppliers whereby the two parties work together to facilitate the development of automation and robotics, through specific projects. In that context, the technology provider would bring its knowledge and the processing company would provide the raw material (to test the technologies) and the space (its plants). Indeed, the technology provider would come to work in the processor's plants, from a few months to several years. Both parties would work together, and the technology provider would teach and train employees from the processing company to operate and maintain machines developed during the project.
- 6 Interviewed technology providers agreed on the high potential of the Canadian market for the development and adoption of automation and robotics for the F&S sector but feel the current structure of the sector (lack of vertical integration in the sector, lack of control/access of resource by processor) can be a major barrier for more investments in automation and robotics.
- 7 The shift from manual work to skilled jobs influences the interest for the sector for investing in automation and robotics, as these opportunities represent higher salaries, but also less physical jobs.

NOVA SCOTIA



/6.3 MAXIMIZING VALUE OF CANADIAN SEAFOOD

The market for fish and seafood is expanding rapidly, due to global population growth and changes in lifestyles with people seeking more healthy protein options.

Verge (2017) noted, while automation is a challenge, if action is not taken to automate the processing sector then it could resemble countries such as Norway where Canada would only supply unprocessed products or semi-processed raw materials to other countries for processing whereby the value of product leaving Canada would be diminished. Verge also stated that the output value that Canada obtains from its fish resources depends on how much processing can be done to add value to fish after they are harvested (Verge, 2017).

Canadian fish products face stiff competition in both export and domestic markets from products that originate in low cost developing countries with labour-intensive industries (e.g. China) and/or higher cost developed countries that focus on high value markets and use advanced technologies to produce high quality products and reduce labour costs (e.g. Iceland).

Verge (2017) noted that the Canadian fishery cannot compete in markets for low-priced commodity products, due to its cost structure; but Iceland's example could be followed by focusing on high-value markets, achieving full utilization of raw materials and adopting advanced technologies to enable these things to be accomplished with a diminishing labour supply.

In a 2018 report, Sackton noted in terms of value added - when a producing region is able to standardize a high-quality item, in the way that Norway has been able to standardize its farmed salmon

and Iceland its fresh cod fillets, then the market prices reflects a recognition for its overall quality.

The report "Canadian Cod Price Analysis in US and UK Markets" (Sackton, 2018) suggested that in terms of Canadian seafood (cod specifically) being exported into the US for example, unless cod fresh fillets are of consistent supply and quality the value or price paid for the product can be quite variable. Consequently, given the fragmented of this fishery in Canada, frozen products may be a better option until a more consistent supply/quality can be provided. Frozen fillets and loins and portions represent the highest value cod products at both retail and food service in the US with frozen fillets showing the most consistent and rapid growth in terms of import volume and percent of households consuming the product. The food service is heavily reliant on frozen cod as opposed to supermarkets and retail which are reliant on fresh product.

Iceland for example, is leading the cod fresh fillet market, because of stability/consistency of product and volume. Canada's inconsistent supply (often glut) and poorer quality is compromising the value. However, analysis of Canadian frozen cod loins and filets from a more modern processing facility noted that the products get the same competitive higher prices as Iceland (Sackton, 2018).



When looking specifically at the challenges in transitioning to an automated operation, the CCFI report, *Process Automation in Seafood Processing Workshop (2017)* notes the following:

- ✓ Processing sector participants noted that they often operate in circumstances that do not allow them to justify investment in advanced technologies for any of the main species groups because of shrinking abundance of some species, industry seasonality, uncertain access to fish harvested, raw materials that are often poor in quality, and inability to take advantage of economies of scale, due to fragmented industry structure
- ✓ Most industry participants want to buy off the shelf automation solutions; they are reluctant to invest in risky projects to develop such solutions
- ✓ The shrinking supply of labour, combined with the inability to adopt advanced technologies, mean that industries within the Canadian fishery are doing less and less processing of fish harvests and are increasingly becoming suppliers of unprocessed or semi-processed raw materials for others to process elsewhere (which allows them to capture much of the value from Canadian resources)
- ✓ Upscale, higher value products are almost always branded. There is no mechanism to brand unprocessed or semi-processed products. Similarly, many of the seafood industry benefits expected from the pending CETA agreement will not be realized by an industry focused on supplying raw material



These factors have an impact on the value of Canadian fish and seafood.

A recent report by Gardner Pinfold (2017) found that “Canada’s seafood industry, including capture fisheries and aquaculture, fails to extract maximum value from the resource”. The report stated several reasons for this, including the industry’s lack of full utilization of raw material to produce marketable products. Opportunities for value maximization have not yet been adopted and implemented in Canada’s seafood industry for a number of reasons which include, but are not limited to: unpredictable availability of raw material; quality of raw material; lack of capital to process by-products; weak economics; failure to develop industry-wide approaches.

The report proposes a 4-step strategy to maximize value from Canada’s fishery and aquaculture resources:

- 1 Full utilization of the resource
- 2 Focus on higher value products
- 3 Focus on obtaining maximum prices
- 4 Access the highest value markets and focus on market timing

For full utilization of the resource (i.e. Step 1 of the proposed strategy), Gardner Pinfold suggest the following approach:

- 1 Develop mandatory quality standards;
- 2 Research by-product opportunities;
- 3 Coordinate utilization by:
 - a Identifying prospective partners;
 - b Identifying logistical options;
 - c Conducting site selection;
 - d Implementing a pilot project.

“ The second step of the proposed strategy is to focus on the highest value products...” ”

The second step of the proposed strategy is to focus on the highest value products by: (1) allowing vertical integration so that processors could have better control over the quality of the raw material and the rate/timing of supply; (2) review/modify seasons to improve raw material quality; (3) enhance value through universal rights-based terms of access to fisheries.

To obtain maximum prices (step 3), Gardner Pinfold (2017) recommend that the harvesting and processing sectors gain better control over the value chain. This could be in the form of vertical integration, but does not have to be. It could mean better coordination of harvesting and processing operations to effect sufficient control over the timing, volume and quality of raw material supplied to processing plants. Product differentiation also makes the list of proactive steps that could be taken to achieve better prices. This would involve industry cooperation to develop sector-wide approaches to differ-

entiate Canadian products in the marketplace. The report also recommends that an industry funded organization with Canada brand development as its mandate to promote Canadian seafood could be beneficial and has worked in other jurisdictions such as Iceland, Norway and the UK.

Access to the highest value markets and a focus on market timing (step 4) could be improved by better accessibility to market intelligence, such as a standardized format for market reports issued by Canada's Trade Commissioner Service, for key export markets and up-to-date information on implementation of important trade agreements such as CETA. Other market access barriers (e.g. food safety issues) should also be flagged in such reports. Finally, the report recommends that issues impacting market responsiveness and timing availability of products to coincide with higher market demand/prices be dealt with at the company level.



/6.4 RESEARCH AND TECHNOLOGY

Dedicated research and technology support services for Canada's fisheries and aquaculture industries are perhaps best exemplified by Memorial University's (MUN) Fisheries and Marine Institute (MI) and the Canadian Centre for Fisheries Innovation (CCFI). Other institutions such as Dalhousie University, Prince Edward Island's BioFoodTech

Centre, New Brunswick's Valorēs (formerly Coastal Zone Research Institute), and MERINOV in Quebec also offer expertise in this area, however, MI of Memorial University has the most comprehensive fisheries, marine and seafood specific R&D centres across Canada.

6.4.1 FISHERIES AND MARINE INSTITUTE

The Fisheries and Marine Institute of Memorial University of Newfoundland (MI) is a world-class centre of advanced marine technology, education, and training. Initially conceived as the College of Fisheries, Navigation, Marine Engineering and Electronics in 1964, the Marine Institute has grown and developed to become Canada's leading fisheries and marine institute. Today, this progression can be seen in MI's superb facilities, strong education and training programs, and highly qualified and dedicated people.

Guided by its motto, "Ad Excellentiam Nitere - Strive for Excellence," the Marine Institute intends to continue moving forward. It has a substantial mandate which encompasses education and training, applied research, and technology transfer, that serves a client base drawn from St. John's, Newfoundland and Labrador, Canada, and worldwide.

The Marine Institute specifically recognizes its integral role within the province. The mission of the Institute is to foster economic development in strategic sectors of the Newfoundland and Labrador economy, particularly the fisheries and offshore (oil and gas), and to enable Newfoundlanders and Labradorians to participate in the marine industry nationally and internationally. This mission provides for the development of the Institute as an industrially relevant institution. Through its wide range of technical education and training courses, including short industrial response courses, diploma of tech-

nology programs, Bachelor's and Master's degree programs, as well as its participation in research and development, technology transfer, and public policy advocacy initiatives, the Marine Institute is actively involved in contributing to the economic development of Newfoundland and Labrador.

The Institute has three Schools – the School of Fisheries, the School of Maritime Studies and the School of Ocean Technology - and within these Schools a number of specialized centres and units, including: the Community Based Educational Delivery (CBED) unit, the Centre for Aquaculture and Seafood Development (CASD), the Centre for Sustainable Aquatic Resources (CSAR), the Centre of Marine Simulation (CMS), the Offshore Safety and Survival Centre (OSSC), the Safety and Emergency Response (SERT) Centre, the Centre for Applied Ocean Technology (CTec), Centre for Fisheries and Ecosystems Research (CFER), and MI International. These centres and units lead the Institute, both nationally and internationally, in applied research and technology transfer and in the provision of training to a variety of industry clients.

With its vision for the future to be a world oceans institute, setting the standard in education, training, innovation, and research, the Marine Institute is continuously shaping its goals and activities, strengthening its expertise, and advancing its reputation for ocean excellence.



SCHOOL OF FISHERIES

The School of Fisheries delivers education and training programs to students interested in entering the fishing, marine environmental, aquaculture and food industries. Academic programs offered by the School range from industry certifications to diplomas of technology, advanced diplomas, Master's and PhD degrees and post-graduate certificates.

The School is also heavily engaged in applied research and technology transfer activities which span the seafood value chain, through its three applied research centres: Centre for Fisheries Ecosystem Research (CFER), Centre for Sustainable Aquatic Resources (CSAR), and the Centre for Aquaculture and Seafood Development (CASD).

CENTRE FOR AQUACULTURE AND SEAFOOD DEVELOPMENT

The Centre for Aquaculture and Seafood Development (CASD) is a comprehensive industrial response unit located within the School of Fisheries at the Fisheries and Marine Institute. The CASD's mandate is to enhance the competitiveness and future growth of the aquaculture and seafood processing industries in Newfoundland and Labrador. The Centre has three main areas of research: seafood processing; aquaculture; and marine bio-processing.

The Centre operates 2 pilot plant facilities, an engineering design lab, a land-based recirculating aquaculture research facility and an analytical research lab. CASD has the largest pilot plant facilities (15,000 ft² = 1394 m²) in Canada dedicated to the advancement of the seafood sector and is equipped with more than \$10 million in research technology. The CASD employs 15 research and technical personnel who undertake contract research and provide technical support services for the seafood and aquaculture sectors.

The CASD is internationally recognized for its applied scientific and technical expertise, comprehensive research facilities and commitment to its industry clients. In recent years the Centre has grown its expertise in the development of advanced seafood processing technologies and marine bioprocessing research. The Centre is home to an experienced mechanical engineering team whose focus is to identify, design and develop advanced seafood processing solutions using process automation and robotics. The Centre has also developed applied R&D and graduate student programs in marine bioprocessing for the identification, extraction and production of novel marine bio-products from shrimp, crab, sea cucumber, salmon and cod.

PROJECT PROFILES

CASD's technical experts, graduate students and post-docs work directly with industry, and other organizations, to solve industry problems. For example, the CASD has worked closely with CCFI to: develop oysters as a commercial aquaculture species in NL; develop a patented sea cucumber eviscerating machine; develop a robotic system for butchering crab (currently being patented).

Other process automation/optimization projects that have been undertaken by CASD include: Design and development of an automated cod tongue cutting and cheek removal system; Design of an automatic feeding system for farmed cod; Develop-

ment of a novel fish skinning method; Development of pilot scale chemo-enzymatic, and non-chemical extraction methods for chitin/chitosan from crustaceans; Development of a pilot-scale process for the recovery of peptides from salmon by-products; Development of crustacean live transport and live holding technologies.

Other initiatives have included technical evaluations of advanced technologies for seafood processing such as: High Pressure Processing; Deep-Chill Ice Slurry Technology; CoolNova freezing and thawing technology; and Laitram CoolSteam® cooking technology.

6.4.2 CANADIAN CENTRE FOR FISHERIES INNOVATION (CCFI)

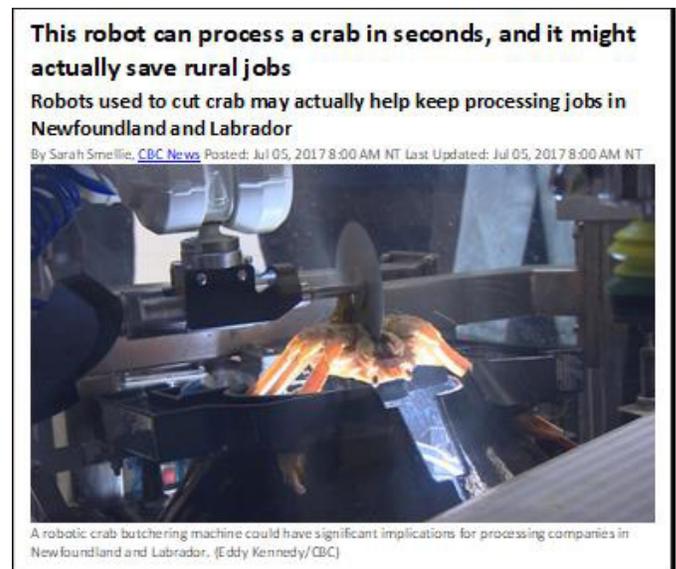
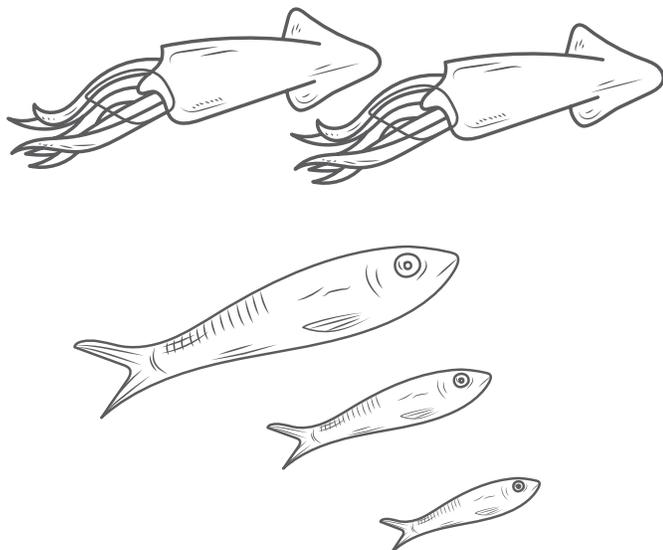
Founded in 1989, the Canadian Centre for Fisheries Innovation (CCFI) is a not-for-profit corporation owned by Memorial University of Newfoundland (MUN) that operates as a partnership between industry and academia.

As a corporation, CCFI has its own governance structure and is led by a board predominantly drawn from industry, to ensure it maintains a focus on industry needs and priorities. Memorial and other academic organizations provide expertise and facilities to address those needs and priorities. Since its founding, CCFI has worked with 24 different academic institutions.

CCFI helps participants in aquaculture, fish harvesting, and fish processing improve their international competitiveness, viability, and sustainability. Its mandate is to facilitate innovation in the different sectors, mostly through short-term problem-solving and longer-term research and development projects undertaken by project-specific partnerships of industry participants, academic institutions, and government funding programs. CCFI helps create the partnerships and formulate, finance, and manage the projects but most of the work is carried out utilizing the human resources and facilities of academic institutions, along with people, materials, and facilities provided by industry.

Projects can be initiated by industry or CCFI in response to clearly identified industry needs. CCFI helps clients by working with them to understand their opportunities and problems and then creating projects to address them. CCFI recruits people to do the projects and provides assistance in funding and managing them.

In short, CCFI provides a linking mechanism between industry participants who see the need and potential for innovation and academic institutions that can provide knowledge, facilities, and capacity those participants do not have. It also contributes and arranges financing to support the work and helps manage the risks involved in carrying it out. However, CCFI does not compete with the private sector.



PROJECT PROFILES

Through the projects undertaken, CCFI helps build and maintain industry-relevant research and development capabilities and capacities of the institutions it works with. And it encourages collaboration among local, national, and international businesses and academic institutions.

CCFI's main criteria for choosing projects are:

- ☑ importance to industry;
- ☑ potential impact;
- ☑ innovation; and
- ☑ likelihood of success.

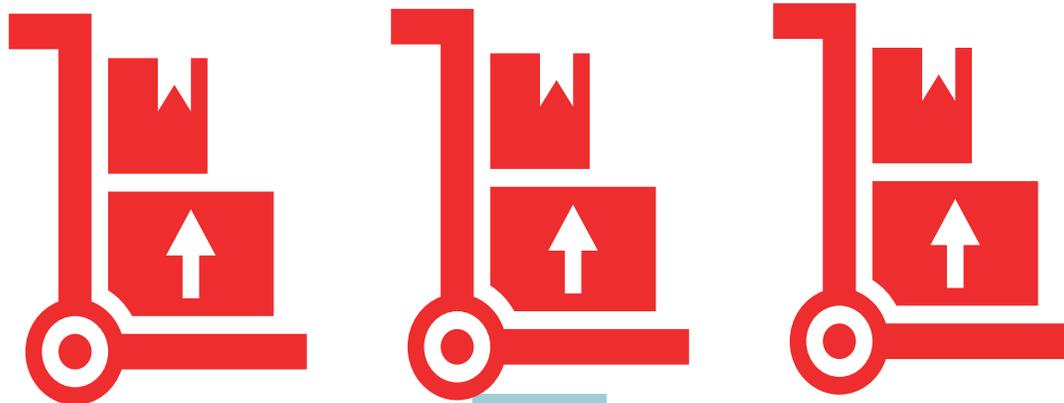
Over time, CCFI's activities have evolved in response to changing industry opportunities and needs. When CCFI began operations, the fishery in Atlantic Canada was predominantly based on cod and other groundfish but stocks were in decline and quotas were being cut. Aquaculture was still a very young, struggling industry. Subsequently, moratoriums were imposed on fishing many groundfish stocks and CCFI helped the industry make a transition from groundfish to shellfish. It also helped aquaculture become more stable and expand.

More recently, CCFI helped develop oysters as a commercial aquaculture species in NL, with the first crop soon ready for harvest. It helped develop a new fishery for sea cucumbers, by doing research on the stock, harvesting methods, and processing methods and developing a patented machine for

processing them. And it has developed a robotic system for butchering crab as part of a larger initiative to produce high-value crab meat products. Patenting of that system is now in progress.

Current projects are generally consistent with the following themes:

- 1 Aquaculture
 - a. Cleaner fish
 - b. Increased mussel production
 - c. Tools for monitoring environmental conditions
 - d. Cod ranching
- 2 Harvesting
 - a. Improved understanding of the marine ecosystem, to characterize fish habitat, assess fish stocks, and focus fishing effort
 - b. Species diversification
 - c. Gear improvements
 - d. Onboard handling systems
 - e. Improvements in fishing vessel design
- 3 Processing
 - a. Automation
 - b. Energy efficiency
 - c. By-product utilization
 - d. Packaging
- 4 Value chain improvements
 - a. Coordination of effort through the value chain
 - b. Improvements in transportation
 - c. Value maximization



6.4.3 DALHOUSIE UNIVERSITY



DALHOUSIE UNIVERSITY

<http://www.dal.ca>

Dalhousie University (DAL) located in Halifax, Nova Scotia was founded in 1818, and attracts over 18,800 students globally. Although DAL does not have a dedicated fisheries and seafood program, it does offer fisheries science and seafood processing research programs through its process engineering, environmental science and food science (minor) programs. DAL currently has a Tier II research chair in Integrated Ocean and Coastal Governance, as well as a Tier II research chair in Ocean Technology Systems. DAL offers academic programs covering a wide range of fisheries and marine science such as aquaculture, industrial engineering, environmental science, process engineering, food science, marine biology, and ocean sciences.

6.4.4 FOODTECH CANADA - FISHERIES AND SEAFOOD INNOVATION CENTRES



FOODTECH CANADA

<http://www.foodtechcanada.ca>

FoodTech Canada is a network of innovation and technology Centres from across Canada, committed to developing innovative products for the food and bio-industries. It has 12 member Centres, but only 1 Centre, Merinov, specializes in fisheries and aquaculture research, and the processing and development of aquatic products. Merinov offers technical assistance to industry in areas related to post-harvest quality and onboard handling techniques, as well as marine by-products valorization.

Established in 1979, CIFT is located at Dalhousie University as a specialized centre of advanced technology providing support to industry for research in food science and process engineering, with an emphasis on food fermentation and utilization of marine resources. Other seafood related research areas of CIFT include aquaculture development, fish/food process engineering, marine oils, and seafood biochemistry.

Prince Edward Island's BioFoodTech Centre, also a member of FoodTech Canada, was established in 1987 and is located on the premises of the University of PEI. Funded by the provincial government, it operates as a confidential, contract research lab and offers processing and analytical services to industry in the food and bioprocessing sectors, including seafood. The Centre operates various labs and pilot-scale equipment providing services that bridge the gap from concept to market.



MERINOV

<http://www.merinov.ca/en>



PEI BIOFOODTECH CENTRE

<http://www.biofoodtech.ca>



6.4.5 VALORĒS (FORMERLY COASTAL ZONE RESEARCH INSTITUTE)



VALORĒS

<http://www.valores.ca/>

Valorēs located in Shippigan, NB is a private non-profit organization dedicated to promoting the viable development of coastal zone resources. Valorēs has four key areas of research which include; aquaculture, fishery and marine products, peat and peatlands, and the sustainable development of coastal zones.

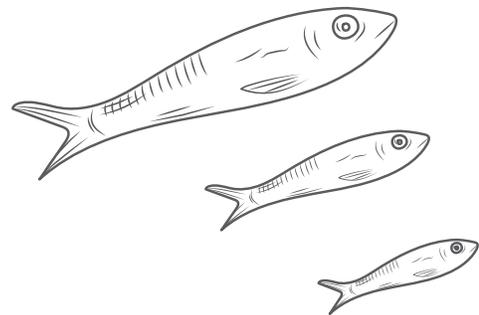
6.4.6 ATLANTIC FISHERIES FUND



ATLANTIC FISHERIES FUND

<http://www.dfo-mpo.gc.ca/fm-gp/initiatives/fish-fund-atlantic-fonds-peche/index-eng.html>

The Atlantic Fisheries Fund (AFF) (<http://www.dfo-mpo.gc.ca/fm-gp/initiatives/fish-fund-atlantic-fonds-peche/index-eng.html>) was officially announced on August 31, 2017. This \$400 million fund is intended to focus on growing opportunities and increasing market value for sustainably sourced, high quality fish and seafood from Atlantic Canada. This is a 70-30% federal-provincial fund shared between the federal government and the participating provinces.



The fund focuses on three key areas:

- 1 Innovative processes and technologies;
- 2 Infrastructure to improve fish and seafood product quality and sustainability;
- 3 Science Partnerships to better understand the North Atlantic marine environment and the changing oceanic conditions.



A COMPARISON OF VARIABLES AFFECTING THE SEAFOOD PROCESSING INDUSTRY IN ATLANTIC CANADA, ICELAND AND NORWAY IS PRESENTED IN TABLE 5 BELOW (KNUTSSON, 2018).

A comparison of variables affecting the seafood processing industry in Atlantic Canada, Iceland and Norway is presented in Table 5 below (Knutsson, 2018). This table summarizes the similarities and differences between the three countries with respect to their national strategies for maximizing value from the seafood industry, use of technology, and labour market practices.

While the structure of the Atlantic Canadian, European and United States seafood industries are quite different, the Norwegian and Icelandic models offer examples of how value maximization of fisheries resources can be achieved, largely through cooperation and coordination throughout the entire value chain.



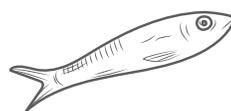
Table 5. Country comparisons – technology, value maximization and labour market practices

INFORMATION	CANADA	ICELAND	NORWAY
Value Maximizing Strategy - Legislation	<ul style="list-style-type: none"> • Conservation, community stability, stable resource access & allocation, sustainable resource use • Volume-driven model with independent processing & harvesting sectors, competitive quotas • Absence of “quality ethic” or standard - Same price paid regardless of quality of the catch • No national marketing strategy • Legislation restricts ability for industry to change – MPRs, restrictions on foreign company investment • Fleet separation policy, owner-operating policy 	<ul style="list-style-type: none"> • Economic efficiency • Value maximization • Management structure to support market-driven decisions – focus on quality, uniform system of ITQs, allow vertical integration, establish fish auction, invest in Icelandic brand 	<ul style="list-style-type: none"> • Resource sustainability, community stability, economic efficiency, safe working conditions • Limited vertical integration • Minimum raw material prices • Invest in Norway brand; Norwegian Seafood Council (NSC)
Cod Landings 2016	<ul style="list-style-type: none"> • 19,107 t • 16,217 t landed in NL (~85% of National total) 	<ul style="list-style-type: none"> • ~220,000t 	<ul style="list-style-type: none"> • ~340,000t
Number of Landing Sites	<ul style="list-style-type: none"> • NL: 400+ across the province 	<ul style="list-style-type: none"> • 80 harbors around 50 active 	<ul style="list-style-type: none"> • Approximately 400 landing sites
Frequency and timing of landings	<ul style="list-style-type: none"> • Majority of landings are not coordinated; independent vessels land at independent processing facilities • Small boats daily; weather affects when boats can fish • Season runs from approximately June-end of November with periods of inactivity during the season • Plants often deal with a glut of fish due to lack of coordination between vessels/plants 	<ul style="list-style-type: none"> • For trawlers and bigger boats fishing trip is max 5 days • Small boats daily • Landing close to fishing ground and then transferred by trucks to processing site • For vertically integrated firms, landings are decided based on need of the markets and production • Coastal fishing landings are from Monday to Thursday 	<ul style="list-style-type: none"> • Some degree of vertical integrated firms, but seldom utilized for smooth processing operation • Main season from January to April (approx. 80 %), which affects the processing activity • Klip fish processing, utilizing frozen fish, is to some degree shielded from this effect

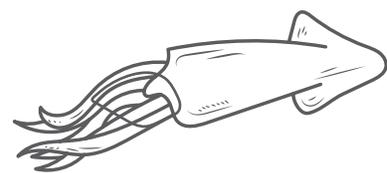
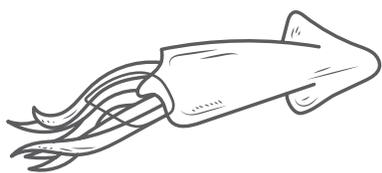


INFORMATION	CANADA	ICELAND	NORWAY
Degree of predictability	<ul style="list-style-type: none"> Low - Processing is linked to the opening/closing of the season which is determined annually; weather can impact participation; processing is not linked to market conditions such as highest demand or greatest commodity price; can create gluts at plant; too many landing sites with small volumes spread over a wide area 	<ul style="list-style-type: none"> High - TAC is clear for the year and companies can plan the year ahead according to markets conditions Less impacted by weather or other extrinsic factors 	<ul style="list-style-type: none"> Low, even though it is relatively known when the season appear Weather and biology (abundance) add uncertainty to this picture; can create gluts in plants
Number of Processing Facilities 2016	<ul style="list-style-type: none"> 728 licensed plants NL: 92 licensed processing plants of which 57 had a groundfish license 	<ul style="list-style-type: none"> In 2014, 200 licensed processing facilities 	<ul style="list-style-type: none"> In 2016, Approximately 230 (primary and secondary) ~180 plants producing dried fish
Nature of Processing Facilities	<ul style="list-style-type: none"> Mainly multi-species plants Small number of dedicated cod processing facilities; only 1 large state-of-the-art facility, others are smaller using old technologies from 1980s-90s Primarily independent operator; Minimal vertical integration 	<ul style="list-style-type: none"> Specialized in species and size of fish Rather large plants high degree of automation Small specialized plants in by-catch species low degree of automation Vertically integrated and independently operated 	<ul style="list-style-type: none"> Multi species (demersal) plants Heterogeneity – from small landing stations (transporting fish to processors) to large filleting plants Minimal vertical integrated, primarily independent Larger plants diversified to process both wild capture (whitefish, pelagics) and farmed species (salmonids) and are more likely to be vertically integrated
Type of Processing	<ul style="list-style-type: none"> Mainly primary processing Minimal value add/secondary 	<ul style="list-style-type: none"> Fresh fillets portions 5 kg box Bulk packing in most cases Packing for further packing abroad 	<ul style="list-style-type: none"> Heterogeneity (from fresh fish packing in tubs to relatively complex value added products; fresh fillet loins MAP-packed) Small share of consumer ready, value added products

INFORMATION	CANADA	ICELAND	NORWAY
Main product	<ul style="list-style-type: none"> Crab is main business for wild capture Cod <ul style="list-style-type: none"> Whole HOG Fresh fillets Frozen fillets Wet salted Salmon is main business for aquaculture <ul style="list-style-type: none"> Fresh HOG Fresh Fillets 	<ul style="list-style-type: none"> Fresh fillets & portions Frozen At Sea (FAS) IQ frozen fillets & portions Light salted fillets & portions Traditional salt fish Frozen at sea (decreasing) 	<ul style="list-style-type: none"> FAS H&G Whole fresh/frozen fish (H&G) Wet salted fish (bine injection) Dried fillets Frozen fillets Klip fish (dried, salted fish) Stock fish
Yield	<ul style="list-style-type: none"> ~35% for cod <ul style="list-style-type: none"> Additional yield extracted for tongues, cheeks ~80% for salmon <ul style="list-style-type: none"> try to fully utilize all parts of the fish ~62% for crab <ul style="list-style-type: none"> sold as sections in shell 	<ul style="list-style-type: none"> Fillets 50-52%; approximately 77% of total Additional yield from heads, frames, cheeks, tongues, gonads, livers, skin 	<ul style="list-style-type: none"> 35% for fillet yield; 54% from gutted and headed fish Additional yield extracted from heads, cheeks, tongues, gonads
Level of By-Product Utilization	<ul style="list-style-type: none"> Low (cheeks, tongues, trimmings) In NB, NS, PE most diverted to composting, fish-meal/oil, silage In NL, mostly disposed of as waste either at sea or in landfills <ul style="list-style-type: none"> One small company utilizing salmon silage and green crab for compost 	<ul style="list-style-type: none"> High (livers, gonads, skin, heads, frames) Increases overall yield to 75-80% of catch weight with significant increase in output value \$ Specialized facilities for utilizing by-products (E.g. Ocean Cluster House, Codland, Haustak) 	<ul style="list-style-type: none"> Medium (cod) - some skin, bones, livers, intestines ~90% by coastal fleet; 6% by offshore fleet Almost 100% in salmon plants – heads, frames, trimmings, belly flaps are used Large processor BIOmega utilizes most of the salmon by-product for feed, food and pharmaceuticals



INFORMATION	CANADA	ICELAND	NORWAY
Technology	<ul style="list-style-type: none"> Standard processing technology such as headers, skinners Technology is comparative to technology used 20 years ago Low to no investment in new innovative technology as there is no security of access to raw material for processors Baader and Marel largest technology providers for groundfish; Laitram Machinery largest technology provider for shrimp & crab processing 	<ul style="list-style-type: none"> Mixed from low automation to high High automation with water cutters, graders, robots in cutting & end of line handling Investment in new/innovative technology Marel & Skaginn 3X main technology providers 	<ul style="list-style-type: none"> Mixed from standard technology (i.e. old) to relative complex water-jet filleting equipment Investment in new/innovative technology Larger plants significant use of automation and end of line robotics Baader and Marel largest technology providers
Labour market practices	<ul style="list-style-type: none"> A work permit or authorization to work without a permit is required for a foreign national to be allowed to work in Canada under either of the following programs: <ul style="list-style-type: none"> Temporary Foreign Worker Program International Mobility Program (IMP) 1374 TFWs were approved in 2016 to work in Canada's seafood processing industry: 0 in NL; 444 in PE; 157 in NS; 773 in NB 	<ul style="list-style-type: none"> ~7.4% of total population are foreigners Citizens from the EEA and the EFTA states do not need a special residence permit, but must register with Registers Iceland A foreigner from a country outside of the EEA and/or EFTA, who plans to stay for more than three months, must have a valid residence permit Bring in temporary seasonal workers in some regions Commitment to employee well-being 	<ul style="list-style-type: none"> ~34% of total seafood labour force are foreigners Immigrants from Poland account for largest group making up 18% of Norway's foreign population (Norwegian Ministries, 2017) Focus on community development



/08 CONCLUSIONS

THE MAIN OBJECTIVE OF THIS STUDY WAS TO ASSESS THE CANADIAN SEAFOOD PROCESSING SECTOR, SPECIFICALLY THE LEVEL OF TECHNOLOGY USED AND THE LABOUR MARKET PRACTICES, IN COMPARISON TO REPRESENTATIVE FISHERIES IN EUROPE (E.G. ICELAND, NORWAY AND THE FAROE ISLANDS) AND THE UNITED STATES.

In the capture fishery in Canada, availability of fish, its quality and prices are highly variable. This is largely due to the independent harvester model under which the capture fisheries are operated. In this model harvesters operate independently of processors. The processing sector is challenged due to uncertainty of supply, seasonal availability, and variability in quality of the raw materials available. Historically, the harvesting and processing sectors have not agreed on objectives, and their efforts have not been coordinated. Consequently, the seafood value chain has not been optimized, and there has been little investment in science and technology, resulting in much of Canada's wild capture seafood being sold unprocessed or semi-processed (Verge 2018, Manuel 2018).

The international competitiveness of the Canadian seafood processing sector has been steadily eroding for years, due to the following factors:

- 1 DFO does not consider the processing sector to be part of its constituency and makes resource management decisions without considering the needs and opportunities of the processing sector.
- 2 Canada has a labour-intensive industry, however, the labour supply (both local and foreign) is not reliable. Canada can't compete with labour-intensive processing in low-wage countries.
- 3 To compete in global markets, advanced processing technologies and automation developed specifically for Canada, are needed. However, current circumstances do not support investment in the development of advanced processing/automation technologies.

The Norwegian and Icelandic models offer examples of how value maximization of fisheries resources can be achieved. This requires an industry-wide approach with significant cooperation and coordination throughout the entire value chain, between harvesters and processors, with all participants focused on the end goal – value maximization. A different fisheries management structure and a change in the national culture of the seafood industry are also key elements needed for success.

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