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Market Study on Biodegradable Products for Fishing Industry

PREPARED FOR



BY OVG CONSULTING INC.

1. TABLE OF CONTENTS

1. Table of Contents.....	2
2. Table of Figures.....	6
3. Table of Tables.....	10
4. Contact Info	11
Client	11
Consultant.....	11
5. Executive Summary.....	12
6. Introduction	14
7. Study Scope, Approach, Assumptions	15
8. Fish Feed and Packaging: Types, Uses, Performance and Features Desired by Aquaculture	17
9. Fish Tags and Gear Tags: Analysis of Types and Uses as Applicable to the Client.....	22
Fish Tags and Fish Tagging Programs.....	22
Types and Features of Fish Tags: From Spaghetti to Transmitters.....	22
Global Fish Tagging Programs. Dominance of Advanced Tags	24
Fish Tagging Programs in Canada: Plastic Tags Still Hold Grounds Among Rising Numbers of Wire Tags and Genotyping	24
Fishing Gear Tagging in Canada: Atlantic Fisheries Held Responsible	27
10. Fishing Lines: Examination of Different Types for Positioning a Biodegradable Alternative	29
Techniques of Line Fishing	29
History of a Fishing Line	30
Fishing Line Types and Their Features: Critical Values for Biodegradable Alternatives	32
Monofilament	34
Braided	35
Fluorocarbon.....	36
11. Fishing Nets: Analysis of Major Culprits in Ghost Fishing.....	38
Net Fishing Global Distribution by Types.....	38
Net Fishing Techniques, Contribution to Ghost Fishing by Type	39
Cast Net.....	39
Coracle Nets	40
Trawling.....	40
Drive-in Net	42

Gillnet and Tangle Nets.....	42
Haaf Net	43
Hand Net and Push Net.....	43
Landing Nets	44
Lave Nets.....	44
Lift Nets.....	44
Plankton Nets.....	45
Seine Net.....	45
Trammel Nets.....	46
Harvesting Shellfish with Different Nets.....	46
Dredge.....	46
Traps and Pots.....	46
Fyke net.....	47
12.Dangers of Ghost Fishing. Most Damaging Types of Fishing Gear	48
13.Government Initiatives on Ghost Gear Reduction.....	50
The Global Ghost Gear Initiative Looks for Options for Derelict Gear Reduction via Biodegradable Technology.....	50
Canadian Ghost Gear Initiatives: Objectives and Impact on Fisheries	52
Canadian Marine Life Conservation Programs Focused on Atlantic Coast Trappers.....	52
New Canadian Ghost Gear Fund Supports Mainly Gear Removal.....	54
Gear Innovation Summit – the First Ghost Gear Event in Canada to Feature New Technologies	55
14.Global Fishing Industry: Production and Trade	56
15.Canadian Fishing Industry’s Segments: Historical Analysis, Trends, Potential Positioning of Biodegradable Products.....	58
General Overview. Contribution to the Canadian Economy, Trade	58
Aboriginal Fisheries: Potential Support in Conservation and Preservation Efforts	63
Commercial Aquaculture: Growing Sector with British Columbia in the Leadership Position	64
Commercial Fisheries: Atlantic Dominance in Production and Fishnet Usage	68
History of Commercial Fisheries in Canada	68
Industry Monitoring	69
Production Levels on Canadian Commercial Fisheries	70
Fishing Gear in Canada.....	72
Residential Fishing: Inland Fishermen Lead in Investments in Industry.....	73
16.Outlook on Canadian Fishing Industry: Aquaculture to Grow, Fisheries Driven by Global Demand	76

17.COVID-19 Impact on Canadian Economy and Fishing Industry	80
Canadian Economy During COVID-19 Shows Varying Outputs.....	80
COVID-19 Impact on Canadian Fishing Industry is Mild	82
Specifics of Fishing Sector Response to COVID-19	84
Crab Production and Export Declined but Retail Picks up the Slack.....	84
Lobster and Other Luxury Items Market is Seriously Affected	85
Domestic Anglers are Getting Good Results.....	86
18.Plastic Pellets Market.....	88
Plastic Pellets Market Segmentation	88
Plastic Pellets Materials Market Size	90
Plastic Resin Pellets Market Drivers.....	90
Virgin Resin Production in Canada.....	91
Plastic Resin Manufacturing Industry in the USA	92
Current Prices.....	92
19.Biodegradable Plastics and Fishing Products: Production Driven by Environmental Concerns.....	95
Bioplastics Market Overview	95
Polyhydroxyalkanoates (PHAs) Use as a Biodegradable Plastic in Fisheries	98
Examples of Biodegradable Fishing Gear.....	99
Fishing Nets and Crab Traps are the First in Line for Required Degradation.....	99
Biodegradable Fishing Lines: Historical Failures	102
20.Manufacturers of Pellets, Nylon and Bioplastics.....	105
Plastic Pellets Manufacturers	105
Nylon Manufacturers are Stepping into Biodegradable Sector.....	107
Manufacturers of Nylon Fishing Gear	111
21.Estimation of the Nylon-based Fishing Gear Market Size	118
Market Size Forecast Approach	118
Global Nylon Market Composition by Product, Type, and Application	118
By Product.....	118
By Type.....	119
By Application	119
The Total Nylon Market Size	120
The Share of Fishing Gear in the Total Nylon Market.....	125
Market Distribution by Geography and Consumer Type.....	125

Regional Market Shares	125
Residential vs. Commercial Users	126
Assumptions and Input Data for Nylon Fishing Gear Market Size Forecast	126
Resulting Market Size Estimates	128
Future Nylon Market (Fishing Application) Size.....	128
Future Nylon (Fishing Application) Market Size by Region.....	128
Future Nylon (Fishing Application) Market Size by Consumer	129
Client's Market Share Forecast	130
22.Marketing Strategy	131
SWOT Analysis.....	132
Understanding Strengths	132
Mitigating Weaknesses	133
Market Opportunities	134
Mitigating Business Risks / Threats.....	134
Marketing Mix.....	135
Product.....	136
Price, Packaging	139
Place	141
Promotion	143
23.Conclusions and Recommendations.....	146
Multiple Product Lines Need Multiple Touchpoints	146
Get a Grip on Your Future with Analysis and Planning.....	148
Building Awareness is the Key to the Marketing Strategy for Market Disruptors.....	148
Succeed Through Joining the Environmental Movement: Help the World, Help Yourself.....	150
24.Appendix A: Fish Tag Colors.....	152
25.Appendix B: Recipients of Canadian Ghost Gear Fund	154
26.Appendix C: Statistics of Canadian Commercial Fish Landings.....	158

2. TABLE OF FIGURES

Figure 1: Fish Feed Types Used in Aquaculture.....	18
Figure 2: Fish Feed Packages Stored on Farm Sites.....	19
Figure 3: Examples of Fish Feeding Methods	20
Figure 4: spaghetti tag (Wikimedia, Des Colhoun / CC BY-SA 2.0).....	22
Figure 5: A Bull Shark receiving an archival tag (Flickr, Doug Adams / CC BY-ND 2.0)	23
Figure 6: A Ray gets tagged with a PSAT (Virginia Sea Grant / CC BY-ND 2.0)	23
Figure 7: Shark has been given a SPOT tag (Flickr, OCEARCH / CC BY 2.0)	23
Figure 8: A crew tagging fish in collaboration with Gray FishTag Research.....	24
Figure 9: Tagging of Atlantic Cod in NAFO Divisions 3Pn and 4RS. Credit: Philippe Schwab, DFO....	25
Figure 10: Pole and Line Fishing. Courtesy Marine Stewardship Council (MSC).....	29
Figure 11: Fishing with Longlines.....	30
Figure 12: Share of Annual Catch Using Different Gear, %	38
Figure 13: Total Global Catch Using Different Gear, Million Tons.....	38
Figure 14: Cast Net.....	39
Figure 15: Coracle Nets	40
Figure 16: Bottom Trawling. Courtesy Marine Stewardship Council (MSC).....	41
Figure 17: Midwater Trawling.....	41
Figure 18: Gillnets. Courtesy Marine Stewardship Council (MSC).....	42
Figure 19: Fixed Gillnet.....	42
Figure 20: Drifting Gillnet.....	42
Figure 21: Haaf Net	43
Figure 22: Hand Net.....	43
Figure 23: Push Net	43
Figure 24: Landing Net.....	44
Figure 25: Lave Net	44
Figure 26: Lift Net	44
Figure 27: Plankton Net.....	45
Figure 28: Beach Seine Net	45
Figure 29: Purse Seine Using FAD.....	45
Figure 30: Trammel Net.....	46
Figure 31: Dredging. Courtesy Marine Stewardship Council (MSC).....	46
Figure 32: Traps Courtesy Marine Stewardship Council (MSC).....	47

Figure 33: Fyke Net. Source: Wikipedia	47
Figure 34: Sunfish trapped in lost fishing net in Cap de Creus, Costa Brava, Spain © Reinhard Dirscherl/ullstein bild via Getty Images	48
Figure 35: Lost fishing net over a reef in Cap de Creus, Costa Brava, Spain © Reinhard Dirscherl/ullstein bild via Getty Images	49
Figure 36: Location of Ghost Fund International Focus	54
Figure 37: Nominal Fish Catches by Major Producing Countries, 2016-2018, Metric Tons, Live Weight	56
Figure 38: Canada GDP and Employment in 2000 - 2020, All Industries vs. Fishing	59
Figure 39: Canada's Fish and Seafood Production, Exports, Imports, and Consumption in 2017 (Thousand tons Live Weight)	59
Figure 40: Canada's Profile, Fish Production in 2017	60
Figure 41: Canadian Monthly Fishing Exports, January 2005 – January 2020	60
Figure 42: Canada's Fish Export and Import, 2017-2019	61
Figure 43: World Salmon Export Partners (\$Value, 2017- 2019)	61
Figure 44: World Salmon Exporter-Importer Trade Flows (\$Million, Jan-Dec 2019)	62
Figure 45: World Salmon Exporter-Importer Trade % Share of Total \$Value (Jan-Dec 2019)	62
Figure 46: Commercial Aquaculture Farm in Canada	64
Figure 47: Types of Aquaculture in Canada	65
Figure 48: Canadian Aquaculture Production Growth	65
Figure 49: Number of Aquaculture Establishments in Canada, 2018	66
Figure 50: Canadian Aquaculture Volume and Value of Fish Production, 2018	66
Figure 51: Aquaculture Production by Species in Canada, 2018	67
Figure 52: Canadian Commercial Fishing Vessel	68
Figure 53: Number of Fishing Vessels in Canada, 2018	70
Figure 54: Commercial Fisheries Landings in Canada, 2018	71
Figure 55: Commercial Sea Fisheries Landings by Species Groups and Region, 2018	71
Figure 56: Recreational Fisherman	73
Figure 57: Number of Active Adult Anglers in Canada, 2018	74
Figure 58: Number of Total Days in 2018 Fished by Anglers	74
Figure 59: Canadian Anglers' Direct Investments and Expenditures in 2018	75
Figure 60: Total Global Consumption of Fish and Seafood and Consumption as Food by Country (Million tons)	76
Figure 61: Global Supply from Aquaculture will Exceed Total Wild Harvest (Million tons)	77
Figure 62: Canadian Exports by Species Group (Billions CAD)	77
Figure 63: Canada's Net Trade by Species (CAD, Billions)	78
Figure 64: Canada and World Fish Export Price (CADD per ton) and Quantity (Million Tons)	78

Figure 65: Canada Will Remain the Largest Exporter of Lobster (\$, Billions)	78
Figure 66: World Demand for Salmon and Canadian Total Production (Million Tons)	79
Figure 67: Canadian GDP, Jan 2019 – Nov 2020	81
Figure 68: Canadian Employment, Jan 2019 – Nov 2020	81
Figure 69: Canadian Exports, Jan 2019 – Nov 2020	81
Figure 70: Canadian Import, Jan 2019 – Nov 2020	81
Figure 71: Canada Economic Indicators Forecast for 2020 – 2021	82
Figure 72: %age of Canadian Businesses Laid off 100% of the Workforce in Q1 2020 vs. Q1 2019 because of COVID-19	82
Figure 73: %age of Canadian Businesses Losing over 50% of Revenue in Q1 2020 vs. Q1 2019 because of COVID-19	83
Figure 74: Decrease in Demand for Products or Services in Canadian Businesses due to COVID-19	83
Figure 75: Cancellation of Services by Canadian Businesses due to COVID-19	84
Figure 76: Global Plastic Resin Pellets Materials Market by Application	89
Figure 77: Plastics demand distribution by resin types 2018	89
Figure 78: Distribution of Global Plastics Production	90
Figure 79: Global Plastics Production Distribution	90
Figure 80: Global Plastic Demand	91
Figure 81: Virgin Plastic Resin Production Demand and International Trade in Canada, 2016, kt	92
Figure 82: US Plastic Pellets Market Size	92
Figure 83: Plastics Exchange	94
Figure 84: Years for Plastics to Degrade	95
Figure 85: Different Classes of Polymers which are Bio-based and Biodegradable	96
Figure 86: Bioplastics Global Production Capacities, 2019, by Material	96
Figure 87: Global Production Capacities of Bioplastic, kt	97
Figure 88: 2019 Global Production of Bioplastics by Market Segment, kt	97
Figure 89: Global Production Capacities of Bioplastic by Region, 2019	98
Figure 90: Commercial PHAs	99
Figure 91: Thermal and Mechanical Properties of Commercial PHAs	99
Figure 92: Biodegradable Purse Seine with Radio Chip	100
Figure 93: Biodegradable Panels in Crab Traps	101
Figure 94: Biodegradable Bioline	102
Figure 95: FieldMate Fishing Line	103
Figure 96: Global Capacity of Nylon Market by Product, 2016	119
Figure 97: US Nylon Market Share by Product, 2016	119

Figure 98: Nylon Monofilament Market by Type, 2013.....	119
Figure 99: Global and US Nylon 6 Filament Yarn Market by Application, 2016.....	120
Figure 100: Nylon Monofilament Market by Application, 2014.....	120
Figure 101: Nylon Market Capacity by Region.....	125
Figure 102: Recreational Fishers	126
Figure 103: Nylon Market (Fishing Application) in 2021-2030.....	128
Figure 104: Nylon Market Size (Fishing Application) by Region, 2021-2030	128
Figure 105: Nylon Market Size (Fishing Application) by Consumer, 2021-2030.....	129
Figure 106: Nylon (Fishing Application) Market Share, \$Million.....	130
Figure 107: Schematics of Marketing Strategy and Tactics	131

3. TABLE OF TABLES

Table 1 : Exports by Principal Trading Countries, 2015-2017	57
Table 2: Commercial landings by gear type, marine fisheries, Canada, 2011, “000\$	72
Table 3: Summary of Federal, Provincial and Territorial Responsibilities, Management of Recreational Fisheries, Canada	73
Table 4: Plastic Pellets Prices	93
Table 5: Top Resin and Plastics Producers	106
Table 6: Big Nylon Market Players	110
Table 7: Top Nylon Fishing Gear Companies	117
Table 8:Nylon Market Future Size Estimates	124
Table 9: Nylon Market Share and Growth by Region	126
Table 10: 2018 Value of Atlantic & Pacific Coast Commercial Landings, by Province (thousand dollars)	158
Table 11: Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2018 (Nominal catches (Q) in tons, live weight. Values (V) in thousand dollars).....	159

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5. EXECUTIVE SUMMARY

This study investigates the current state of the market and its size for biodegradable plastic technology products invented by [REDACTED]. The company intends to introduce the products into the market in a staged approach starting with plastic pellets and followed by several products for the fishing industry: fish feed bags, fish bags, fishing nets and fishing lines. The key differentiator for all these products is their complete degradability in water, which is expected to provide some degree of mitigation to the problem of ocean pollution from derelict fishing gear (ghost fishing). The issue of ghost fishing is world-wide; Canada, with the longest coastline and a well-developed fishing industry, is a major culprit on the global stage.

Because each of the products intended for development by [REDACTED] will be utilized by a different sector of the fishing industry, this study examines these industry segments separately. These segments are aquaculture (fish farms), commercial fisheries, and residential anglers. The study examines each individual product, its place in industry operations, value to the users, and its contribution to ghost fishing, if any. This analysis is covered in sections Fish Feed and Packaging, Fish Tags and Gear Tags, Fishing Lines, Net Fishing.

Fish feed bags is an important component of the feeding process and an integral part of the food supply system in aquaculture. The study discovers that while biodegradable fish feed bags do not directly contribute to ghost fishing, they can help to contribute to the overall goal of reducing plastics pollution and can be especially valuable in fish farms specialized in raising bottom feeders (sturgeon, catfish); these farms typically immerse feed bags in fishponds to ensure the most efficient delivery of food to the fish.

Fish tags are typically used for scientific and conservation purposes, as well as for game fishing events. While the most modern and advanced tags are manufactured mainly of durable and non-destructive materials, most tagging activity is still based on conventional principals (spaghetti tags), which are plastic-based. These conventional tags, due to their low cost, are rather common in mass tagging programs. Biodegradable fish tags can be valuable for short-term research programs and gaming events: upon completion of these programs (events), fish will be freed from tags naturally.

Anglers (residential fishermen) are large in numbers but low in impact on the fishing industry economy when compared to aquaculture or commercial fisheries; their contribution to ghost fishing is also significantly lower than that of commercial fisheries. Meanwhile, as consumers of fishing lines, they do dispose of snagged fishing lines into rivers, lakes, and oceans in large volumes. Biodegradable fishing lines are a great solution to this pollution problem, as well as ghost fishing.

The main contribution to ghost fishing comes from fishing nets. Different types of nets, when lost, have a varying level of damage on marine life (addressed in section Dangers of Ghost Fishing). The study uncovered that the major contributors to this pollution are gillnets, and traps and pots commonly used by commercial fisheries. The loss of traps and pots is often linked to conflict with towed gears, other inshore water vessels, and even large marine mammals. Gillnets, on the other hand, have a wide range of mesh sizes and structures, thus the risk of entanglement with marine animals and seabirds is high. In modern commercial fishing, over [REDACTED]% of fish are caught with nets. Replacing conventional nets with biodegradable alternatives will have a positive impact on aquatic life.

Recently, governments have been putting more efforts into fighting ghost fishing (section Government Initiatives on Ghost Gear Reduction). The Global Ghost Gear Initiative, a joint venture of world nations, scientific organizations, and commercial enterprises, is the first initiative dedicated to tackling the problem of ghost fishing gear on a global scale. The Canadian government, as a member of this organization, has initiated several programs aimed at fighting the causes and removing abandoned fishing

gear. Ghost fishing is especially urgent in Atlantic Canada where abandoned gear has caused multiple whale deaths.

According to the historic and current analysis of the fishing industry in Canada (sections Global Fishing Industry, Canadian Fishing Industry), with the decline of commercial fisheries, salmon aquaculture has been occupying an increasingly important place in Canada, and British Columbia in particular. The industry forecast indicates that Canada will retain its current status as a dominating exporter of lobster, followed by crabs, while maintaining its somewhat modest position on salmon trading. With this in mind, it is likely that the potential demand in traps and pots for capturing crustaceans will continue to offer more opportunities for the Client's Product (biodegradable netting). The expectation to continue salmon farming will sustain demand in other types of Products, such as fish tags and fish food bags.

The pandemic lockdown that started in early 2020 has had a dramatic impact on economies worldwide. Within each individual industry and sector, this impact has not been uniform; some industries are facing irreparable damage and/or transformation while others have prospered. Fishing, as part of the Agriculture industry, remains the least affected compared to other sectors with about █% of businesses losing 100% of the workforce, the lowest level among all other industries in Canada (section COVID-19 Impact on Canadian Economy and Fishing Industry).

While there is no commercialized solution on the market at this time, there have been several published papers / announcements describing biodegradable fishing nets at different stages of development. Several attempts to introduce biodegradable fishing lines to the angler market have failed due to unreliable performance. There is currently no credible vendor in the North American market that manufactures biodegradable fishing gear.

The current size of the plastic pellets market exceeds \$█ billion (section Plastic Pellets Market). Examination of the nylon plastic market shows that biodegradable and bio-products are rising in prominence. Almost all major plastics manufacturers have already opened their production; the number of manufacturers and ecologically friendly products is constantly increasing.

The future nylon market of fishing gear is estimated to remain within the █ kt range in 2030, valued between \$█ (section Estimation of the Nylon-based Fishing Gear Market Size). Asia Pacific leads among all regions comprising more than half of the market. It is followed by Europe (█% of the world). The growth rate slightly differs among regions averaging █% of the total.

█ enters the niche of a mature market of fishing gear and fishing products with the established market players as a disruptor. In order to break through the existing barriers, the most immediate focus should be on building market awareness via education, with firm support from the government. Section Marketing Strategy outlines recommendations on approaching the market entry.

6. INTRODUCTION

[REDACTED]

The Client is the inventor of a modified biopolymer pellet that reacts to its surroundings in water and changes its behaviour in a way that extends the lifetime of the gear. This biopolymer is intended to be utilized for the development of a series of biodegradable products, such as fish feed bags, fish tags, fishing lines and fishing nets (the Products). When utilized in fishing gear, it will eliminate the environmental drawbacks of conventional gear by stopping the contribution to ghost fishing. It is 100% water biodegradable and environmentally friendly. Initial laboratory testing of the biopolymer pellet has shown that the pellet will degrade faster when left in water for extended periods of time but will not degrade when it is being used or is sitting on the shelf. The Client is still testing if the additional functionality of the gear affects the performance of the gear itself. The Client intends to deliver high-quality fishing equipment (equally comparable to traditional gear) to customers without the subsequent long-lasting consequences of non-biodegradable equipment. Key benefits to the customers are:

- Lessened negative impacts on the environment;
- Reduction of navigational hazards on water;
- Higher quality of fish yields due to the reduced volume of ghost fishing.

There is limited competition in the biodegradable fishing gear market because previous companies suffered market failure by not delivering a product that met customers' expectations. The Client believes that its Products will avoid the challenges faced by previous competition because they will have only controlled degradation, allowing for a better shelf life.

The Client's biodegradable products will be distinguishable in the following ways:

1. The Client is looking into developing multiple fishing gear products rather than just one;
2. Products will only have controlled degradation allowing for better shelf life;
3. Products will be accessible to everyone.

The Client plans to differentiate from non-biodegradable products in the following ways:

1. Providing biodegradable solutions, hence environmentally friendly;
2. Cost-effective solutions either via technology or government subsidies;
3. Leveraging government support in marketing.

The Client intends to execute a staged product development and market entry that will proceed in the following sequence: plastic pellets – fish feed bags – fish tags – fishing lines – fishing nets. The ultimate scope and the number of developed products depend on the government's funding support.

The Client has engaged the Consultant to conduct market research on biodegradable fishing gear.

7. STUDY SCOPE, APPROACH, ASSUMPTIONS

The Consultant followed the standard research project management approach. Below is the description of the scope, steps, assumptions, and data used for the development of the study.

Technology under study: biodegradable plastics

Products intended for developments:

- i. plastic pellets,
- ii. fish feed bags,
- iii. fish tags,
- iv. fishing nets,
- v. fishing lines.

Market segments utilizing these Products: aquaculture, commercial fisheries, residential anglers.

Geography: industry and regulatory analysis of the Canadian markets; the market size forecast to include other regions.

Study scope. The source of demand for the Client's Products can be tentatively divided into two groups: economic and regulatory drivers. Analysis of these drivers ultimately defines the scope of the study.

Economic drivers impact the demand coming from the fishing industry itself. Factors, which influence the growth or decline of industry segments under study, also have an indirect impact on the Products. For example, a decline in quotas issued to commercial fisheries to reduce the time spent in ocean and their usage of fishnets causes the potential demand in (biodegradable) nets to also decline. Hence, the examination of the state of each market segment's conditions, developments and future projections is important for understanding the level of the current and projected future demand for the products that are targeted to be replaced with the Client's technology.

Regulatory drivers can be loosely defined as primary drivers. Introduction of biodegradable fishing gear is not driven by operational necessity: biodegradability is not required and does not affect the operational performance of the gear. In fact, previous designs introduced to the market or designs that only reached the testing phase demonstrated faulty performance. While there are currently some technologies being tested worldwide, no mass market commercialization has yet emerged. Because of this, there is a reluctance from the market towards biodegradable products. Regulations requiring reduction of ghost fishing and governmental programs supporting the development of such technologies, as well as mandating their utilization by the fishing industry is the main determinant of demand for these products—at least at the first stage of the market cycle until market confidence in biodegradable products has been restored and confirmed by their reliable performance.

The Steps of the Study are summarized below.

1. Examination of the current market offering intended to be replaced by the Client's Products (fish tags, fish feed bags, fishing lines, fishing nets).
2. Overview of ghost fishing and its impact on the environment.
3. Overview of the global and Canadian government regulations and initiatives that target ghost fishing reduction and elimination of plastics pollution.

4. Examination of the historic state of the fishing industry with analysis of each segment (aquaculture, commercial fisheries, residential fishing), their current trends, drivers, impact from the COVID-19 pandemic, and projected future development.
5. Analysis of plastics markets including the biodegradable sector with examples of previously developed and marketed products.
6. Summaries of the top manufacturers of plastic pellets, nylon, and biodegradable products.
7. Future projections of the total market size and that to be potentially captured by the Client.
8. Recommendations on approaching the market entry.

Forecast Approach. The potential total market size is estimated in kt of the Nylon used by the fishing industry (fishing nets, lines, lures, tags, bags, etc.). The kt of Nylon is selected as a more reliable reference unit because manufacturers are located around the world and the cost of production differs, for example, in China vs. Germany. Market size in US\$ is also calculated for reference purposes. Forecasts are segregated by:

- Product: Nylon 6, Nylon 66, Others;
- Type: Monofilament, Multifilament, and Microfilament;
- Application: Fishing, Consumer Goods, Textile, Automotive, Sport, and Others;
- Sector: Commercial and Residential; and
- Region: North America, Asia, Europe, South America, Africa & Middle East.

The forecast period starts in 2021; however, any delay in R&D, demo, or a marketing campaign will shift the timeframe for the estimated Client's potential market share. Forecasts have been developed until the year 2030.

Estimations of the potential current and future market size for Low Case and High Case and Average reflect possible options for market conditions, solution development and market capture.

Data. All data for the study is public and acquired via online research.

Study limitations. The study is limited in its scope and excludes any consideration given to the Client's internal capacity in operational, HR, and financial stances.

8. FISH FEED AND PACKAGING: TYPES, USES, PERFORMANCE AND FEATURES DESIRED BY AQUACULTURE

Fish feed bags (packages) are typically used in aquaculture by fish farms (hatcheries). Feed is the key component of raising fish. **THE QUALITY OF THE FISH FEED DEPENDS NOT JUST ON ITS FORMULATION AND PROCESSING, BUT ALSO ON THE WAY IN WHICH IT IS PACKAGED, TRANSPORTED, AND STORED, AS WELL AS THE FEEDING MODE ITSELF.**

This section discusses fish feed that is utilized by aquaculture from the perspective of a fish farm and the value of the feed to the whole operational process. **PACKAGING IS VIEWED AS A COMPONENT OF THE FEEDING PROCESS AND IS AN INTEGRAL PART OF THE FOOD SUPPLY SYSTEM IN AQUACULTURE. UNDERSTANDING THIS PROCESS CAN BE USEFUL FOR THE CLIENT TO DISTINGUISH AMONG PRIORITIES OF THE FISH FARMERS AND WHERE THE PRODUCT FITS IN THE VALUE CHAIN. THIS KNOWLEDGE CAN BE APPLIED WHEN DESIGNING THE PRODUCT AND PREPARING A MARKET MESSAGE.**

As global aquaculture production increases to meet the need for seafood, there is a growing demand for feed supply. Fish farming is increasing in volume, particularly in Asia with warm water and more land availability, as well as a large and growing local market.

Due to the high conversion ratio of feed into final product (whether it is fish or crustaceans), the demand for feed is increasing faster than the production of the aquatic product. However, as the feeds used vary greatly between species and farming systems, feed is the single greatest resource being added to the farm and also the single greatest cost to farmers: feed can account for up to 10% of the cost of production. This makes it essential for farmers to focus on feed controls to get the most from the feed they buy and to choose the most appropriate feed for their production.¹

Combination of improved feed quality and improved feed management allows the best use of resources to be achieved on-farm. The clear impact of this is seen in the reduction in relative feed costs. With such improved feed management, farmers can find more benefits of the feed, especially where there are disease issues that can be alleviated by dietary means.

Fish Feed Development

Until the end of World War II, most fish hatcheries relied on raw meat. In the early 1950s, John E. (Red) Hanson, while working for the New Mexico Game and Fish Department, began experimenting with dietary routine and dry pellet formulations. The first fish feed pellets were introduced to hatchery trout at the Red River Hatchery near Taos. The pellets resulted in improved conversion rates of food intake to fish production, and lead in turn to the wider adoption of fish pellets in hatcheries.

As nutritional research was carried out and farmers switched to pelleted feeds, the efficiency of the feeds increased – less feed was required to grow more fish. Technical developments in feed extrusion and coating technology supported these improvements until, by the mid-2000s, diets could be produced with high protein (40 to 50%) and high oil (up to 40%). Such diets represent the maximum capability of technology to hold together a balance of nutrients. From this point on, nutritional work focused on how to make the same dietary specifications more economical. The limited future supply of raw materials has also been a driver for their development. Once the feed performance stabilized, farmers found that they had to manage this feed more effectively to be more efficient. Farms established management systems for greater efficiencies, as measured by the amount of feed fed converted into fish harvest.

The efficiency with which fish convert their feed into body weight, as this is the resource farmers should be most interested in producing, can be affected by a wide variety of factors, which fall into the following broad categories:

- feed manufacture;
- logistics and storage;
- on-farm handling; and
- feeding methods, timing, and quantity.

The nutritional requirements of a fish vary mainly depending on the species, its size/life stage, and the environment. There can also be some requirements relating to the flesh quality of the product. For example, Atlantic salmon requires dietary pigments to make the flesh red. For white-fleshed fish, such as striped catfish, raw materials containing pigment, such as corn, should be avoided in the grow-out phases to reduce the risk of making the flesh an undesirable yellow color.

Having determined the dietary specifications to be used, the feed formulator will then choose the mix of raw materials and their qualities. Large feed companies may be able to source globally, while smaller companies may have to focus on local purchases or buy through traders. Obviously, different raw materials have different nutritional properties, but even within one raw material type there can be seasonal variation, resulting in different qualities that will affect the precise nutritional value.

After determining the composition of the feed, feed manufacturers to make it of a technical quality that allows that feed to be consumed by the fish. Factors to consider for this are:

- form of diet (unprocessed materials, mash, mince, formed pellets or extruded pellets);
- density and hardness;
- moisture content;
- pellet size; and
- dust and fines.

The diet type determines not just whether the feed is easily consumed by the fish, but also whether it can be stored and the methods available for feeding it to the fish. Some of the variety of feed types used in different farm situations are shown in Figure 1: Fish Feed Types Used in Aquaculture:

- top left: low-value shellfish fed whole;
- top right: frozen low-value fish blocks left to float in a cage;
- middle left: fish trimmings fed chopped into a cage;
- middle right: cage-side mince preparation;
- bottom left: on-farm wet-pellet mill;
- bottom right: extruded salmon pellets



Figure 1: Fish Feed Types Used in Aquaculture

Trash fish/low-value fish and wastes. Low-value fish (so-called ‘trash fish’), trimmings of fish from processors, dead fish, and animal and plant wastes may be fed directly to fish. This practice is often used in developing aquaculture countries, and there are concerns related to the variation in quality of the different sources in terms of their nutritional value, as well as the potential to spread disease. To help the fish eat the material, it may be chopped up before feeding, which takes considerable time. Each piece may then have considerably different nutrient content, so fish eating this feed will vary greatly in nutritional

intake. Farmers often recognize the nutritional limitations of these feeds and may use additives, either injected into the fish pieces or sprayed on top prior to feeding.

Mashes. Mashes are frequently used by farmers in developing countries who often prepare their own feeds. Raw materials can be mixed. However, there is a great concern that the mash will disperse and leach nutrients quickly, reducing the benefits to the fish and potentially fouling the waters through enrichment.

Minces. Minces are prepared on-farm. Generally low-value fish, or fish or meat trimming wastes, are minced up with plant raw materials as a binder to create a nutritional or economic balance. The resulting paste, which can be quite coarse, is then either fed directly to the fish or formed into ‘spaghetti-like pellets’ by pressing through a die and cutting. These pellets may then be dried in the sun on-farm before being fed. Sun-drying makes the pellets hold their form a bit longer in the water, which increases the chance of fish eating them before they dissolve. Also, the texture of the mince may reduce the losses by leaching as compared to the mashes. However, sun-drying will also encourage oxidation of oils and the ultra-violet light will also lead to degradation of vitamins (especially vitamin C) at the surface, reducing the nutritional properties of the mince.

Pellets. In contrast to mashes and minces, pellets (both steamed, pressed, and extruded) tend to stay whole in water for an extended period, allowing more to be eaten by the fish. They can also be stored for a period at the place of manufacture or on-farm. This increases flexibility for farmers. Such pellets are also dry, so they provide more nutrients for the same weight as mashes and minces. This increases their weight for weight efficiency and reduces the need for farmers to carry large volumes of wet feed to the fish. If the raw materials are mixed efficiently before pelleting, each pellet should have roughly the same composition, so each fish fed pellets should receive similar nutrition.

While wet feeds must be fed to fish almost immediately, dry feeds (in practice about 10–12% moisture) can be stored for several months under the proper conditions. Care must be taken by the feed manufacturer to control the maximum amount of moisture in feeds that may be stored, or moulds may develop during the storage period. Feeds with high moisture content are heavier per unit of nutrients offered. In practical terms, this means that farmers have to move a much greater weight and volume of feed when using wet feeds in order to provide the same nutrient input to the fish. This can result in a high cost of logistics, depending on the location of the farm.

The logistics of getting the feed to the farm have an obvious impact on the finances of the farm – distance and method of transport. Trucks are more expensive than boat, being less fuel efficient, but can be more flexible for small deliveries and of course for delivering to inland facilities. Bulk transportation of feed offers a potential to reduce costs.

Traditionally, feed has mainly been sold in small bags (10 to 40 kg) that can be carried easily around the farm. However, the cost of packaging is significant over a large volume of feed. Transporting the feed loose in a lorry, or even better in a boat, removes this cost, but then requires on-site storage of loose feed, typically in silo. An intermediate step towards this has been the use of 500 kg or 1-ton bulk bags, which reduce the packaging costs without the need for large silos at the farm site. However, both solutions to reducing packaging require short-term investment in feeding equipment – which opens further opportunities for cost savings in the long term, but which may be prohibitive to small-scale farmers.



Figure 2: Fish Feed Packages Stored on Farm Sites

THERE ARE SEVERAL CONCERNS RELATED TO THE QUALITY OF FEED PACKAGING AND STORING. Constant high temperatures can cause oil to leak out of medium- to high-fat diets, reducing their

nutritional qualities. Oxidation of the oil can also occur, causing problems and resulting in rancidity that may be repellent to the fish. Fluctuations in temperature can cause accumulation of moisture, which could encourage the growth of moulds and soften the feed. So, feeds should always be kept dry, during transporting and storing. It is essential to ensure that logistics are set up to protect the feed as much as possible. Storage Feed can be stored on-farm or nearby for some period before it is fed to the fish. Normally a farmer would try to minimize the storage time, as this ties up working capital. However, typically part of a feed batch will be stored for at least a week before being fed. During this time, if it is not safely stored, the feed can get wet and become soft and mouldy. Too often the quality of storage facilities available on-farm does not protect against these issues.



Once the farmer decides to feed the fish, it is far from certain that the best use of what quality is left will be made. Figure 3: Examples of Fish Feeding Methods shows different feed management techniques applied on fish farms.

Top left: tipping feed from a platform into the water;

Top right: casting the feed by hand from a platform;

2nd row left casting the feed by hand from a boat in a pond;

2nd row right: a fixed feed spreader over a cage, using a spinning disc to flick the feed out;

3rd row left: a feed cannon;

3rd row right: feeding over the area where the feed is falling from the blower;

4th row: sub feeder;

5th row: feed barge.

The next step is to get the feed into the water. There are many solutions in use, depending on the feed type, pond or cage size, density of fish and, of course, investment required.

The simplest solution is just to hand feed, throwing the feed into the water from one place. If there is a lot of feed, farmers may just tip the bags into the water, using floating pellets to disperse slightly. Alternatively, they may use a scoop to flick feed out across the water, covering some 4 or 5 m range. This works best with dry feeds, as wet feeds are too heavy to do this for long. The problem with this method is that the feed enters the unit at only one point and often is given rather slowly. This means that not all the fish will get the opportunity to eat at every meal.

Figure 3: Examples of Fish Feeding Methods

An alternative for wet feeds is to put the feed or mash into bags with large holes in them. These are then arranged in the water (normally this is done in ponds) where the fish can pull the feed out of the bags. This has been adapted somewhat for species such as sturgeon, where sinking pellets are spread on a flat net like tray that is suspended in the water. As these fish are relatively slow eaters that prefer to take food from the bottom, they can swim over the tray and take the pellets at their own rate. If the integrity of the pellets is not sufficient, they will dissolve before they are eaten, and their nutrients will be wasted. Fish will hit a target (normally a lever in the water) that causes a release of feed in the immediate area. Similar to this concept is the sub feeder designed for feeding fish below the lice belt. With this approach, you can feed every day without being dependent on weather conditions (wind/current). It can be directly

connected to the feeding tube and the feed will be brought down to the desired depth. THIS TECHNIQUE CAN BE OF PARTICULAR INTEREST TO THE CLIENT AS FEED BAG IMMERSION CREATES GREAT OPPORTUNITIES FOR BIODEGRADABLE PACKAGES.

This is an attempt to allow the population of fish to eat as continuously as they require – perhaps also at times that are not convenient for the farmers to feed, such as at night. It is also an attempt to allow the smaller fish to eat, as the bigger, dominant fish cannot defend the food source all the time. However, there are often not enough of the feeders in each unit to allow all fish to eat optimally. Instead, farmers with larger units spread the feed further across the units, either by using small boats to move around the unit or by using a machine, such as feed cannon or spinning machines, to cast the feed out. Using boats to move around large units allows a degree of dispersion, but often farmers still just tip the feed into the water from the boat, creating a line of feed. The use of machines to spread the feed started to allow better feeding, dispersing the feed so that all fish have a chance to eat and also providing a large volume of feed quickly so that the larger fish cannot defend the feed easily.

Aquaculture feeding barges takes the concept of feeding fish several steps further. The barge is designed around the central feeding system – not the other way around. Its main function is to store and transport feed undamaged to the fish.

THE CONSULTANT BELIEVES THAT CONSIDERATION SHOULD BE GIVEN TO THE QUALITY OF PACKAGING MATERIAL FROM THE POINT OF ITS COST AND ALSO ENSURING FEED PRESERVATION (BEING MOLD AND MOISTURE RESISTANT). IN ADDITION, GIVEN THE LIKELY PREFERENCE TO LARGER BAGS FOR COST CUTTING ECONOMICS, PACKAGING SHOULD BE DURABLE AND CAPABLE OF BEARING HEAVY WEIGHT. ALL THESE CONCERNS SHOULD BE TAKEN INTO CONSIDERATION BY THE CLIENT WHEN DEVELOPING THE MATERIAL FOR FEED PACKAGING AND ALSO DEVELOPING MARKET DIFFERENTIATION MESSAGES. THE TARGET MARKET IS LIKELY TO CONSTITUTE FARMS RAISING BOTTOM FEEDERS. MARKET MESSAGE SHOULD ALSO EMPHASIZE THE FACT THAT THE USAGE OF BIODEGRADABLE FEED BAGS CAN HELP WITH THE REDUCTION OF RECYCLING AND / OR UTILIZATION COST REQUIRED FOR STANDARD FEED BAGS.

AS DISCUSSED IN SECTION COMMERCIAL AQUACULTURE, BRITISH COLUMBIA LEADS IN THE VOLUME AND VALUE OF AQUACULTURE IN CANADA; FISH FARMS PRESENT A NATURAL AND ATTRACTIVE TARGET FOR FISH FEED PACKAGING SOLUTIONS, SUCH AS THE CLIENT'S PRODUCT.

9. FISH TAGS AND GEAR TAGS: ANALYSIS OF TYPES AND USES AS APPLICABLE TO THE CLIENT

Fish tags and gear tags serve different purposes but share similar features: they are usually made either completely or partially with plastic marked with carrying information about the origin of the item/fish it is attached to. Gear tags are attached to fishing gear so that in the event it is lost in the ocean it can be traced back to its owner, or fishery. This helps to identify the owners of lost gear and is used as evidence in cases of entangled whales or other aquatic mammals.

Fish tags are attached to fish. Fish tagging is typically an initial step (data collection) of scientific research, conservation efforts, and campaigns aimed at assessing and improving fish population. Such studies usually have the goal of examining movement patterns, seasonal variations, harvest levels, abundance, growth rates, age, migrations, strain identification, and stocking success.

THIS SECTION DISCUSSES TYPES OF FISH TAGS AND GEAR TAGS AND THEIR APPLICATIONS. THIS INFORMATION CAN BE USEFUL FOR THE CLIENT IN IDENTIFYING POTENTIAL APPLICATIONS FOR ITS PRODUCTS AND ALSO ENTITIES RUNNING TAGGING CAMPAIGNS.

Fish Tags and Fish Tagging Programs

Fish tags are typically applied at a hatchery prior to being planted in water or on location by scientific organizations, resource managers and volunteers during "catch and release" projects.

There are two common methods used to monitor fish populations:

1. Movement mapping, or tracking, a process in which marine biologists and resource managers use radio technology to tag fish and map their movements;
2. Mark and recapture, a process where a small group of a particular fish species is captured, marked, or tagged, and then released so they can be recognized during a later recapture. Fish tags are later collected by those who harvest fish, typically by anglers (residential fishermen) and commercial fisheries.

Types and Features of Fish Tags: From Spaghetti to Transmitters

The industry has come a long way since the days of tying ribbons onto fish. The main types out there are spaghetti tags, archival tags, PSATs, and SPOTs. Below is the summary of these tags.²

“Conventional” spaghetti tag is a piece of tough plastic with an ID code attached to the fish. Once someone catches it, they report the tag, and you find out where the fish ended up. These tags are cheap and easy to attach. The problem with these tags is that they rely on an angler or commercial fishermen reporting the tag. You also have no idea what happened between point A and point B. Because of this, they are mainly used for inshore or freshwater species. They also work well when used in large quantities.



Figure 4: spaghetti tag (Wikimedia, Des Colhoun / CC BY-SA 2.0)

Pop-up Archival Tags are a high-tech version of the standard spaghetti tag. As their name suggests, they archive (or store) data. These small devices are deployed on a fish where they log a variety of information. If the fish is recaptured and the tag recovered, the logged data can be downloaded. They tell where a fish ended up, but they also gather info along the way. Archival tags can record location, water temperature, and depth as the fish travels. They are not too expensive, and they are just as easy to attach. The downside is that like conventional tags, you need someone to hand it in to get the data.



Figure 5: A Bull Shark receiving an archival tag (Flickr, Doug Adams / CC BY-ND 2.0)

“Pop-up Satellite Archival Tags” (PSAT) are specially designed for billfish, sharks, tuna, and other large fish tagging. They record everything a standard archival tag does and more. After a specific amount of time, they break off from the fish and transmit the data to a satellite. You do not need anyone to hand it in. This significantly simplifies the process and ensures much more accurate data collection. PSATs are expensive with costs reaching thousands of dollars.



Figure 6: A Ray gets tagged with a PSAT (Virginia Sea Grant / CC BY-ND 2.0)

“Smart Positioning or Temperature” (SPOT) tags capture a range of data every few minutes and transmit it whenever the fish comes to the surface. This is the cutting edge of tagging technology. SPOT tags are not a complete bust if they get destroyed. They are also more accurate than pop-up tags, and expensive. They are ideal for air-breathing marine animals (seals, whales, and sea turtles) and animals that often swim close to the surface (salmon sharks, blue sharks and makos). When the antenna breaks the surface, it sends data to a satellite.



Figure 7: Shark has been given a SPOT tag (Flickr, OCEARCH / CC BY 2.0)

WHILE THE MOST MODERN AND ADVANCED TAGS ARE MANUFACTURED MAINLY OF DURABLE AND NON-DESTRUCTIVE MATERIALS, THE MAJORITY OF TAGGING ACTIVITIES IS STILL BASED ON CONVENTIONAL PRINCIPALS (SPAGHETTI TAGS), WHICH ARE PLASTIC-BASED. THESE CONVENTIONAL TAGS, DUE TO THEIR LOW COST, ARE THE MOST COMMON IN CASES OF MASS TAGGING.

Global Fish Tagging Programs. Dominance of Advanced Tags

There is a multitude of fish tagging programs. Some of them are specialized and executed by researchers and scientists targeting specific species or service specific events usually promoting conservation. Some are global in nature. The majority of these programs are run on federal, state (provincial), and regional levels by designated authorities and funded by the state. Each one of them has different objectives, rules, types of tags and reporting procedures. This section summarized some of these programs.

The International Game Fishing Association is a strong supporter of tag-and-release fishing. Their most successful initiative is the Great Marlin Race. This is an ongoing event where Marlin released at fishing tournaments “race” around the world. Whichever one gets the farthest wins. They use PSATs for accurate data and invite people to sponsor these expensive tags.

The Billfish Foundation is probably the most important organization when it comes to big game tagging. They work with tournaments and charter operators, tagging Marlin, Sailfish, Swordfish, and Spearfish. They are responsible for almost a quarter of a million tagged Billfish. Anyone is invited to donate by sponsoring tagging your next Marlin.

Gray FishTag Research. Focusing on “bridging the gap between professional fishermen and science,” Gray FishTag Research works with 10,000 charter captains around the US and beyond. They provide the charters with free tagging kits to encourage tag and release.



Figure 8: A crew tagging fish in collaboration with Gray FishTag Research

American Littoral Society. This society have been in existence since the ‘60s. During that time, their members have tagged 640,000 fish. These days, American Littoral Society focuses on Striped Bass, Bluefish, and Summer Flounder.

The Dolphinfinh Research Program. Originally founded as a state funded program in 2002 by the South Carolina Department of Natural Resources, the DRP has grown into the world’s largest dolphinfinh mark and recapture program driven by the collaboration of fisheries, scientists, and volunteer recreational, charter, and commercial fishermen. From 2002-2016, 21,458 dolphinfinhes were marked and released, and of those, 551 were recaptured throughout the Atlantic and Pacific Oceans, which provided fundamental scientific data on the movements and life history of this species.

Cooperative Marine Turtle Tagging Program. The Archie Carr Center for Sea Turtle Research (ACCSTR), with funding from the National Marine Fisheries Service Southeast Fisheries Science Center, coordinates a centralized program to distribute sea turtle tags, manage tagging data, and facilitate exchange of tag information. CMTTP tags are only available for projects conducted in the Atlantic Region. Sea turtle research programs initiated over the last six decades have generated critical information for the conservation and management of sea turtle populations.

GLOBAL FISH TAGGING PROGRAMS, WHICH DRAW THE MOST ATTENTION AND FUNDING FROM THE NATIONS, TYPICALLY UTILIZE THE MOST ADVANCED RADIO-EQUIPPED TAGS.

Fish Tagging Programs in Canada: Plastic Tags Still Hold Grounds Among Rising Numbers of Wire Tags and Genotyping

In Canada, fish tagging programs are typically run by governmental bodies and are focused on monitoring endangered and threatened species, especially those that are critical for Canada’s economy. Some programs are summarized below.

2020 - Snow Crab tagging study³ run in **Moncton and Quebec** requires snow crab fish harvesters fishing in the southern Gulf of St. Lawrence to record the tag number, the date and position of catch (minimum information required for the study) and then return the tagged crab (without cutting off the tag) to the water as soon as possible. Returning the tagged snow crab at sea allows multiple recaptures of the same animal during its lifespan. This is a study currently being conducted by DFO Science to better understand the movements of snow crab.

Fisheries Science Collaborative Program (FSCP)⁴. The findings of previous Atlantic Cod tagging, which are used for stock assessments, indicate that there are complex seasonal movements of cod within each management area. Two different types of tags are being used to track the migration behavior,



temperature preferences, stock mixing, and harvest rates of Atlantic Cod in NAFO Divisions 3Pn and 4RS. Data gathered by the traditional tagging program has enabled researchers to calculate the fishing mortality (harvest) rate and study migration patterns and stock mixing. The goal of the data storage tagging program is to study the migration behavior of cod and their depth and temperature preferences over time. The findings of this research may have important implications for the assessment and management of cod stocks.

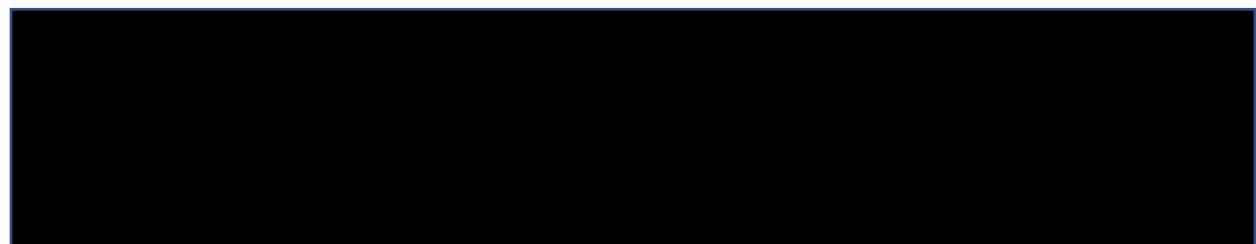
Figure 9: Tagging of Atlantic Cod in NAFO Divisions 3Pn and 4RS. Credit: Philippe Schwab, DFO

Cod Tagging pilot project (northwestern Gulf – 4S)⁵. Under the pilot project, cod from the northern Gulf of St. Lawrence stock (NAFO 3Pn, 4RS) are tagged in Northwest Atlantic Fisheries Organization (NAFO) area 4R, but not 4S or 3Pn. The NAFO area 4S cod abundance appears to be approaching the level of that in 4R (although at a lower density), so DFO and the industry are tagging 4S cod. This data will support decision-making on exploitation and conservation of cod stocks in the northern Gulf of St. Lawrence. The Maurice Lamontagne Institute in Mont-Joli, Quebec, will apply 800 external “spaghetti tags” annually to cod in the western part of NAFO area 4S. The pilot project will provide cod migration data, fish mortality rate (or exploitation rate) and will confirm the mortality rate among fish handled during tagging. The industry and DFO are performing the work at sea and DFO is monitoring tag returns and analyzing the exploitation rate data. The results will be integrated into the next stock assessment and will be published by DFO’s Canadian Science Advisory Secretariat.

BC Salmon Tagging Program⁶. There is an ongoing tagging programs in BC to study the migration and growth of salmon. This involves attaching numbered tags to fish, usually located near the dorsal fin. If anyone discovers an external tag on the catch or find a PIT tag, it should be reported to the nearest DFO office. The two kinds of external tags are:

- Floy tags: brightly coloured, look like a piece of string about five inches long.
- Peterson tags: Small round plastic disks.

The Coded Wire Tag (CWT) Program⁷ guides the Chinook and Coho salmon fisheries along the west coast and is one aspect of Canada’s obligations under the Pacific Salmon Treaty with the United States. The program’s activities aim to rebuild vulnerable salmon stocks and provide harvest opportunities. It includes tagging juvenile fish, collecting heads from fisheries and escapement, dissecting heads to recover



CWTs, and providing CWT information for stock assessment and management decisions. The program is one of the largest animal tagging programs in history, and it has been running every year since the 1970s.

Coded wire tags are tiny lengths of metal wire inscribed with a numeric code that are inserted in the snout of some juvenile salmon before they make their way to the ocean. Every year, approximately 50 million juvenile salmon are tagged in Canada and the US. Tags can be recovered when returning fish are caught. This provides important information about their origin, age, growth, run timing, and other characteristics. Data from these tags are used to make science-based stock assessment and fishery management decisions, as well as negotiating catch allocation between the two countries. All data recorded is shared between Canada and the US.

CWTs are recovered from heads of adipose fin-clipped fish that are voluntarily submitted by fishers through head collection programs. This means the program relies on participation from all fishers.

Parentage-based tagging of Chinook Salmon in British Columbia⁸. Currently, hatcheries rely heavily on CWT methods to track individuals released into the wild. These tags can only be applied to a portion of juvenile fish upon their release. Though it can be an effective way of quantifying certain metrics, CWTs cannot be used to determine parentage, family survival, or reproductive success. Developing an alternative to CWTs that can increase fidelity, cost-effectiveness, and potential applications is a critical innovation to hatchery management. This project consists of genotyping Chinook Salmon hatchery broodstock to establish parentage-based tagging (PBT) as a stock management method. This is a genetic-based fish tagging method that involves genotyping hatchery broodstock. PBT is a passive non-invasive approach to stock identification because the parents, not the offspring, are genetically sampled at spawning, thereby "tagging" the offspring. This method provides the same information as traditional physical tags but also allows for collection of more detailed information that previously was impossible or impractical to gather using traditional tagging methods. Genotyping all broodstock will enable the identification of all juveniles, instead of the ~10% typically tagged using CWTs. Complete tagging of juveniles allows researchers to accurately track their activity and the effectiveness of introducing hatchery reared juveniles into struggling fish stocks.

PBT methods has been used by the USA researchers in Columbia and Snake river basins and has already been tried in 2014 on Coho Salmon in BC. If this method proves to be successful, as in a more accurate and cost-efficient alternative to traditional CWT method, PBT method will replace CWT in Canada on other fish species.

FISH TAGGING HAS MULTIPLE APPLICATIONS IN THE CANADIAN FISH INDUSTRY. WHILE THE NEW TREND IS REPLACING THE MASS WIRE-BASED TAGGING WITH GENETIC-BASED METHODS, PLASTIC TAGS STILL REMAIN IN THE GAME FOR SALMON, COD AND OTHER SPECIES.

IT SHOULD BE RECOGNIZED THAT THE MAIN CONSUMERS OF FISH TAGS ARE FISH FARMS (AS THE POINT OF SERVICE DELIVERY), WHICH DOMINATE BRITISH COLUMBIA (THIS IS DISCUSSED IN DETAIL IN SECTION COMMERCIAL AQUACULTURE) FROM THE POINT OF VOLUME AND VALUE. ACCORDINGLY, BRITISH COLUMBIA PRESENTS A SOUND TARGET FOR FISH TAGS. THE CLIENT SHOULD NOTE THAT THE KEY PROVIDER OF PLASTIC TAGS FOR CANADIAN TAGGING CAMPAIGNS IS FLOY TAG COMPANY LOCATED IN SEATTLE, WA (<http://www.floytag.com/>).

THE CLIENT SHOULD CONSIDER THAT THE MAJORITY OF RESEARCH AND CONSERVATION CAMPAIGNS SPAN SEVERAL YEARS, WHICH EFFECTIVELY ELIMINATES THE CLIENT'S PRODUCT AS A VIABLE OR DESIRED OPTION. MEANWHILE, IN CASES OF SHORT-LIVED PROGRAMS, BIODEGRADABLE FISH TAGS WILL BE THE MOST VALUABLE; IT SHOULD CONSTITUTE THE TARGET MARKET FOR THE CLIENT'S FISH TAGS.

Fishing Gear Tagging in Canada: Atlantic Fisheries Held Responsible

GEAR TAGGING IS RISING IN PROMINENCE WITH MORE ATTENTION DRAWN TO THE DANGER FROM GHOST FISHING AND GROWING NUMBER OF MAMMALS ENTANGLED AND KILLED BY LOST GEAR. IN THE USA, GEAR TAGGING IS MANDATORY FOR FISHERIES AND CANADA IS CATCHING UP WITH ITS COUNTERPART.

In Canada, gear tags and tabs are required for some commercial fisheries in the Gulf of St. Lawrence. The primary objective of this program is to increase the level of responsibility for any lost gear that might result in entangling whales and other marine mammals, as well as creating ghost gear.

Gear Tagging in Atlantic Commercial Fisheries

As of April 1, 2013, the fishing industry began assuming the responsibility of obtaining and paying for any gear tags used in the commercial fisheries where gear tagging is required. Prior to that, DFO was supplying these tags to fisheries. This new requirement is enforced through license conditions. License holders must tag their gear with a valid tag that has been obtained by a DFO-approved gear tag supplier.⁹

To guide the process, DFO developed the Protocol for Gear Tagging in Atlantic Commercial Fisheries (The Protocol) with repeating 3-year cycle for tags distribution. The first cycle of the Protocol was implemented from 2014-2017. The second cycle started on April 1, 2018, which is currently under enforcement and is expiring in 2020¹⁰.

The Protocol sets out application procedures, tag specifications, the process for issuing tags to license holders, and audit processes in place to ensure the reliability of the tagging process. The Protocol has strict requirements for the tags with each tag requiring the following information:

- fishing area;
- tag supplier identification number assigned by DFO to the approved tag supplier;
- a unique sequential number; and
- identification of the tag manufacturer.

Tags are issued on an annual or multi-year basis. Each fishery is assigned a predefined number of tags with some allowance for replacement tags that are lost or damaged during the fishing season or the term of a multi-year tagging plan. The approved tag supplier provides replacement tags to those license holders who obtained their initial tag allotment from that approved tag supplier.

Multi-year tags agreed upon between DFO and industry may be metal or traditional polyurethane type tags. Tag colors vary on the basis of service length, region, and fish type. Polyurethane type tags used for multi-year tags may only be natural or white (Pantone 001) in color. Single year tags are to differ in color to provide visual confirmation that valid current year tags are attached to fishing gear. Appendix A: Fish Tag Colors **lists the required color scheme for different types of gear.**

Every three years, DFO considers applications from potential new suppliers.

A list of all DFO “approved tag suppliers” is maintained on DFO’s website ([/fm-gp/sdc-cps/nir-nei/tags-supplier-region-eng.htm](https://fm-gp/sdc-cps/nir-nei/tags-supplier-region-eng.htm)). Below is the list of the currently approved suppliers sorted by the gear type and region. Each one contains the link to the applicable supplier contact information.



Gulf Region
Eel (NB & PEI)
Herring-Mackerel Bait
Herring Gillnet 16B
Herring Gillnet 16C/E
Herring Gillnet 16F
Herring Gillnet 16G
Lobster LFA 23
Lobster LFA 24
Lobster LFA 25
Lobster LFA 26A
Lobster LFA 26B
Lobster LFA 27
Rock Crab LFA 23
Rock Crab LFA 24
Rock Crab LFA 25
Rock Crab LFA 26A
Rock Crab LFA 26B
Snow Crab 12, 18, 25, 26
Snow Crab 12E
Snow Crab 12F
Snow Crab 19
Smelt (NB & PEI)
Toad Crab, 24
Toad Crab, 26A
Maritimes Region
MAR Crab Jonah
MAR Rock Crab
MAR Whelk
Lobster LFA 27
Lobster LFA 28
Lobster LFA 29
Lobster LFA 30

Lobster LFA 31A
Lobster LFA 31B
Lobster LFA 32
Lobster LFA 33
Lobster LFA 34
Lobster LFA 35
Lobster LFA 36
Lobster LFA 38
AREA 38B
MAR Shrimp Trap
Snow Crab 20-22
Snow Crab 23
Snow Crab 24
Snow Crab 4X
Newfoundland and Labrador
Region
Lobster LFA 3
Lobster LFA 4A
Lobster LFA 4B
Lobster LFA 5
Lobster LFA 6
Lobster LFA 7
Lobster LFA 8
Lobster LFA 9A
Lobster LFA 9B
Lobster LFA 10
Lobster LFA 11
Lobster LFA 11W
Lobster LFA 12
Lobster LFA 13A
Lobster LFA 13B
Lobster LFA 14A
Lobster LFA 14B

Lobster LFA 14C
Snow Crab, Area 13
Quebec Region
Bait
Exploratory Toad Crab CN
Herring 15
Herring 16A
Herring 16B
Herring 16D
Lobster LFA 15-16-17-18
Lobster LFA 19-20-21
Lobster LFA 22
Rock Crab 12
Rock Crab 16
Rock Crab 12D to 12Z
Rock Crab 12Z
Rock Crab 17
Snow Crab 12, 18, 25, 26
Snow Crab 12A
Snow Crab 12B
Snow Crab 12C
Snow Crab 12E
Snow Crab 12F
Snow Crab 13/16A
Snow Crab 14
Snow Crab 15
Snow Crab 16
Snow Crab 17
Tod Crab 12
Whelk 1 à 9
Whelk 11 à 14
Whelk 15
Winter Flounder - Fixed Gear

NOTE THAT A CALL FOR INTEREST FOR POTENTIAL NEW TAG SUPPLIERS IS SCHEDULED TO BE ISSUED BY DFO IN NOVEMBER 2020 VIA PUBLIC WORKS AND GOVERNMENT SERVICES CANADA'S BUYANDSELL.GC.CA WEBSITE. AN INTERESTED PROPONENT MAY SUBMIT A NEW TAGGING PLAN APPLICATION FOR THE NEXT THREE-YEAR CYCLE. THE CLIENT SHOULD RECOGNIZE THOUGH THAT THE POTENTIAL CUSTOMERS ARE LOCATED ON THE CANADIAN EAST COAST WHERE THE MAJORITY OF COMMERCIAL FISHERIES ARE AFFECTED BY THE REQUIREMENTS FOR MARKED FISHING GEAR. THE CLIENT'S FISHING GEAR TAGS CAN BE OF AN INTEREST TO THE COMMERCIAL FISHERIES WHEN THEY ARE USED TOGETHER WITH BIODEGRADABLE NETS.

10. FISHING LINES: EXAMINATION OF DIFFERENT TYPES FOR POSITIONING A BIODEGRADABLE ALTERNATIVE

Fishing lines represent a long, thin string, and vary in material. There are many features to a fishing line, and that makes it important in successful fishing. It should be noted that a fishing line is used as a key element for angler fishing; it also is a material used for net fishing. Net fishing is described in section Fishing Net. Both, line and net fishing, are used by residential as well as commercial fishermen.

When selecting a fishing line, one has to consider angling technique and the fishing conditions. One can then match these factors to different types, sizes, and colors of fishing line. A fishing line is arguably the single most important piece of equipment used by all fishermen.

THIS SECTION COVERS, IN DETAIL, DIFFERENT FISHING TECHNIQUES, UTILIZED FISHING LINES, AND THEIR FEATURES. THE CONSULTANT BELIEVES THAT THIS INFORMATION CAN BE USEFUL FOR DEVELOPING A COMPARATIVE ANALYSIS OF THE CLIENT'S PRODUCTS WITH CONVENTIONAL LINES, PREPARING MARKET MESSAGE, MARKET POSITIONING AND TARGETING POTENTIAL CUSTOMERS.

Techniques of Line Fishing

There are various techniques involving fishing lines that are used to catch different types of fish. The target fish, different types of water environment, time of day and other environmental factors define the selection of lures, rods, lines, reels, and other paraphernalia for fishing setup. Some of the most common fishing settings are summarized below.

- Fishing with a hook and line is called **angling**. This is the most common and frequently the only legal option for fishing by residential fishermen. Fish are caught with a fishing line by encouraging them to bite on a fishhook with a lure or bait, live or artificial. A fishhook will pierce the mouthparts of a fish and is normally barbed to make escape less likely. A fishhook is usually attached to a mainline via leader, a short line typically of a smaller diameter (lighter) than the mainline. A leader can be heavier than a mainline and can even be made of wire in cases of strong fish with sharp teeth. Mainline is spun on a reel, which is usually attached to a rod. It is what is cast from the rod, flies, that ultimately lands down into the depths of the water. A fisherman holds or watches the rod and the line for bites. When the fish bite, the mainline is reeled back to bring the fish to the boat or to shore. This is the most common technique used for the majority of fish in fresh and salt waters worldwide. Fly fishing is an angling technique that targets fish, such as trout, that feed from the surface of the water.

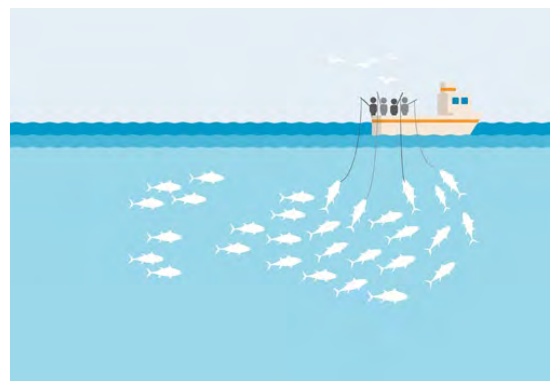


Figure 10: Pole and Line Fishing. Courtesy Marine Stewardship Council (MSC)

- **Fishing with gorge** is a type of passive fishing. Gorge is buried in the bait so that it will be swallowed by the fish. The tightening of the line fixes it cross-wise in the quarry's stomach or gullet and so the capture would be assured. This technique is typically used for bottom feeders, such as carp,

catfish, and sturgeon. The line is attached to some fixed structure and typically left overnight. In the morning, fisherman reel in the line to collect whatever has been caught.

- **Trolling** is a technique in which a fishing lure on a line is drawn through the water. Trolling from a moving boat is a technique of big-game fishing and is used to catch large open-water marine species such as tuna and marlin. Trolling is also a freshwater technique often used to catch salmon, pike, muskellunge, and walleye. This technique allows anglers to cover a large body of water in a short time. It is used for commercial and residential / sport fishing.
- **Longline fishing**, also known as a trot line, is a commercial fishing technique that uses many baited hooks hanging from a single line. Longlines are long fishing lines that have a hook every few feet. They can be many miles long. Bycatch in longline fisheries is highly variable depending on the fishery. Issues in longlining are more common in fisheries close to the surface where seabirds, sharks, and turtles get caught eating baited hooks. Longlines are used extensively, both on the surface (usually targeting large pelagic species) and on the bottom, targeting high value demersal species. Longlines are used in a wide variety of locations. Their use in temperate waters tends to focus on demersal fish such as cod but can also be used in the water column for species such as halibut. In tropical waters hand lines and longlines are commonly used to catch tuna, and bottom species like snappers and groupers.



Figure 11: Fishing with Longlines

THE EXTENSIVE USE OF FISHING LINES, THEIR OFTEN EXTREMELY LONG-SET CONFIGURATION AND RELATIVELY LOW COST MEANS THAT THE OVERALL QUANTITY LOST IS LIKELY TO BE HIGH. THERE IS ALSO LIKELY TO BE SOME DELIBERATE GEAR DISCARDING WHEN TANGLED OR DAMAGED. THE MORTALITY RATE FROM LOST DEMERSAL LONGLINES IS TYPICALLY LOW. BUT IF IT IS CONSTRUCTED OF MONOFILAMENT IT CAN REMAIN IN THE ENVIRONMENT. GHOST MORTALITY IS A FUNCTION OF THE GEAR TYPE, THE OPERATION AND THE LOCATION REGARDING ACTIVE OCEAN FEATURES AND ELEMENTS. LOST GEAR MAY CONTINUE TO CATCH FISH IF BAIT EXISTS ON THE HOOKS. FISH CAUGHT ON THE HOOKS MAY THEMSELVES BECOME A FORM OF BAIT FOR SUBSEQUENT FISH, BOTH TARGET AND NON-TARGET. LINES WILL NOT STOP FISHING UNTIL ALL THE HOOKS ARE BARE. BAITED HOOKS MAY ALSO POSE AN INVESTMENT RISK TO MARINE MAMMALS, BIRDS, TURTLES, AND OTHER ANIMALS WHILE THE LINES THEMSELVES POSE AN ENTANGLEMENT RISK.

History of a Fishing Line

The modern fishing line has a long history. As written in 1667 by Samuel Pepys, the fishing lines in his time were made from catgut. Silk fishing lines came into use around 1724.

Modern fishing lines are almost entirely made from artificial substances including nylon, polyvinylidene fluoride (PVDF, also called fluorocarbon), polyethylene, Dacron and UHMWPE (Spectra or Dyneema).¹¹

In 1938, DuPont announced the discovery of nylon, a “group of new synthetic super polymers” that could be made into textile fibers stronger and more elastic than cotton, silk, wool, or rayon. The following year, DuPont began commercial production of **nylon monofilament** fishing line.¹²

Dacron was also created by DuPont in the late 1950s, just 20 years after nylon was invented. It is a long-chain polyester that is a slight improvement over nylon in terms of its strength, flexibility, and low stretch.

Spectra and Dyneema are modern brand names for ultra-strong polyethylene fiber used for high-tech fishing lines. Spectra and Dyneema are stronger than steel and more durable than polyester but come with a higher price tag. These materials can be worth the extra price as they reduce the weight of tackle while increasing the amount of line that fits onto the spool. They offer more sensitivity, abrasion resistance and knot strength, with low stretch and almost no line memory.

In 1958, DuPont introduced Stren, a thinner line of more uniform quality that could be used for different types of reels, including newly introduced spinning and spin casting tackle. This line was quickly embraced by fishermen and led to a boom in sportfishing popularity because it helped make fishing much easier.

Like monofilament, **fluorocarbon** fishing line is also extruded in a single strand similar, but fluorocarbon molecules are more tightly packed, so the line is denser and noticeably heavier by size than nylon. Like mono, fluorocarbon is a compound that can be made of varying materials. Organics like carbon and chlorine are popular materials, as are hydrocarbon synthetics and polymer intermediates. Fluorocarbon refers to a broad family of compounds, including organics comprised of fluorine, chlorine, and carbon, along with synthetics made from hydrocarbons. In the fishing world, though, fluorocarbon is all about the polymer PVDF, which is extruded in a similar way to mono but differs a fair bit in terms of stretch and durability. PVDF is a denser material, and therefore, is not nearly as buoyant as monofilament.

There are also **braided** fishing lines. Braided fishing lines are made of **synthetic plastic fibers such as nylon or more specialty materials like Dacron**. Braided lines entered the market in the early 1900s to replace horsehair lines. In earlier days, natural fibers such as cotton, linen, and silk were used for braided lines. These materials have now been largely replaced with synthetic plastic fibers. Dacron possessed poor knot strength, low abrasion resistance and little stretch. So, it was used much less after the superior nylon monofilaments were introduced. Today braided line maintains only a very small-market interest, but it does have its usages.

In the early 1990s, gel-spun and aramid fibers such as Spectra, Kevlar and Dyneema entered the fishing line market, creating a new category of braided lines often called “**superlines**” or “**microfilaments**.” These synthetic fibers are thin and incredibly tough (more than 10 times stronger than steel). Individual fiber strands are joined through an intricate, time-consuming braiding process to produce ultrathin, super strong, sensitive, yet expensive lines. Anglers who experimented with early superlines were frustrated by low knot strength, backlashes, poor coloration, and damaged equipment. To many, these disadvantages outweighed the benefits of strength, micro diameter, and ultra-sensitivity. Makers of superlines have made continual advances and improvements to the raw material fibers and the process that converts them into fishing line. Coloration, castability, and strength have all been improved.

Fly lines consist of a tough braided or monofilament core, wrapped in a thick waterproof plastic sheath, often of polyvinyl chloride (PVC). In the case of floating fly lines, the PVC sheath is usually embedded with many 'micro balloons' or air bubbles and may also be impregnated with silicone or other lubricants to give buoyancy and reduce wear. To fill up the reel spool and ensure an adequate reserve in case of a run by a powerful fish, fly lines are usually attached to a secondary line at the butt section, called backing. Fly line backing is usually composed of braided Dacron or gelspun monofilaments. All fly lines are equipped with a leader of monofilament or fluorocarbon fishing line, usually (but not always) tapered in diameter.

Tenkara lines are special lines used for the fixed-line fishing method of Tenkara. Traditionally these are furlled lines the same length as the Tenkara rod. Although original to Japan, these lines are similar to the British tradition of furlled leader. They consist of several strands being twisted together in decreasing numbers toward the tip of the line, thus creating a taper that allows the line to cast the fly. It serves the

same purpose as the fly-line, to propel a fly forward. They may be tied of various materials, but most commonly are made of monofilament.

Wire lines are frequently used as leaders to prevent the fishing line from being severed by toothy fish. Usually braided from several metal strands, wire lines may be made of stainless steel, titanium, or a combination of metal alloys coated with plastic. Wire, either single strand or braided, can also be used as fishing line. Wire fishing lines can be especially helpful in catching fish when used as a leader material for fishing toothy fish like mackerel and tuna. Wire is also used during trolling when reaching deeper depths is important. When fishing with wire, you will require specialized, hardened spools for your reels.

Stainless steel line leaders provide bite protection and abrasion resistance: it is extremely hard for fish to cut the steel wire, regardless of jaw and tooth strength and sharpness, or for them to be damaged by sharp rocks and objects. Single wire (single strand) leaders are not as flexible as multi strand steel wire but are extremely strong and tough. Multi strand steel wire leaders are very flexible but are somewhat more abrasive and more damage prone than single strand wires.

Titanium fishing leaders are made of titanium-nickel alloys that make leaders very flexible, regardless of if they are single or multi strand lines/wires, stretchable up to 10% without permanent damage to the line itself. They are knottable, just as nylon monofilament lines, and abrasion and corrosion resistant.

Copper, monel, and lead core fishing lines are used as heavy trolling main lines, usually followed with fluorocarbon line near the lure or bait with fishing swivel between the lines. Due to their high density, these fishing lines sink rapidly in water and they require less line for achieving desired trolling depth. On the other hand, these lines are relatively thick for desired strength, especially when compared with braided fishing lines and they often require reels with larger spools.

Fishing Line Types and Their Features: Critical Values for Biodegradable Alternatives

UNDERSTANDING FISHING LINE PERFORMANCE IS OF A HIGH IMPORTANCE FOR THE CLIENT. GIVEN THAT THERE IS A MULTITUDE OF FISHING LINES SERVING DIFFERENT PURPOSES IN A VARIETY OF ENVIRONMENTS, IT SHOULD BE CLEAR WHERE IN THIS RANKING THE CLIENT'S PRODUCTS CAN BE POSITIONED. A VARIETY OF FEATURES THAT DIFFERENTIATE FISHING LINES AND THEIR PREFERENCE BY THE FISHERMEN CAN CONSTITUTE BASE POINTS WHEN DEVELOPING THE PRODUCT AND DEVELOPING POSITIONING MESSAGE.

When looking for a line, fishermen typically look for several attributes such as those listed below.

- **Material** (see description in the section Fishing Line Types and Their Features: Critical Values for Biodegradable Alternatives).
- **Pound Test.** Often thought of as the most important factor in selecting a line, a “pound test” simply refers to the line’s overall strength. Varying from 2 pounds up to 400 pounds, a line should be chosen by the type of fish (and expected weight) that one plans on fishing for. Actual strength is determined by how much force it takes to break a wet line rather than the “dry” one advertised. Line strength is divided into two categories: “test” and “class.” Class lines will break at or under the labeled strength in wet conditions, whereas test lines do not offer any such guarantees. The IGLA (International Game Fish Association) is a regulating board that checks this when applications are made by companies to sell lines.
- **Knots.** As one ties a lure and a hook on the line, thus increasing its resistance, it is important to use strong knots to keep them secured. The lighter the pound test, the more secure the knots.

- **Diameter.** The diameter of a line is the relative degree of its thickness or thinness. Each degree has its own advantages and disadvantages. Too thick and its visible to the fish, but too thin and it is liable to snap, snag, and tangle. Modern lines get around the problem of diameter thanks to both technology and materials. “Double strength” lines are strong yet narrow enough to not be too obvious. Other line types employ different materials and weave them together (like the braided types) to compromise. Usually, diameter is advertised next to strength or pound test when it comes to a line’s packaging. Monofilaments, for example, have a wide range in terms of diameter and can run anywhere between 0.06 mm and 0.26 mm alongside strengths ranging from 12 oz to 11lb 16 oz. The relationship between diameter and strength is the gold test when it comes to selecting a line. The stronger a line is for its diameter, the better it will be to use.
- **Stretch.** Stretch is a measure of elasticity All lines have breaking points at a maximal stretch capacity, but it’s almost impossible to know what this will be on the line despite the packaging telling you it’s “low stretch,” “pre-stretch,” “high stretch.” The value of stretch varies for different purposes. Long stretch line is more likely to be pulled by a fish on a cast and lead to them either breaking away or failing to be hooked. Short stretch line generally makes it easier to handle and hook a fish. In some cases, it is just easier to manage certain lure types, especially crankbait lures, which require tugging and pulling the line to mimic the action of live bait. A little bit of stretch helps to “smooth” out the action and make it less jerky. Good line stretch also has further advantages in reducing the force that occurs when the hook is set in a strong fish, like salmon, thus preventing the line breaking.
- **Color / transparency.** Many line manufacturers try to get the edge by touting the efficacy of one line color above another. As for what the best is, it all comes down to conditions and water clarity. Clear is a good choice for ice-fishing because it blends in well with the water’s icy surface. It also works well in clear water. Blue fluorescent is a good choice if you fish in sunny conditions. You can see the sun reflect off the line from above the surface, but fish do not detect the reflection. Gold (yellow) helps see your line in low-light conditions. Moss green masks your line well if you fish in waters with a lot of vegetation. Pink fluorocarbon line, for example, is argued to be one of the most effective colors as “pink loses its color at various depths” and thus blends in with water more easily. Then there are the popular monofilament choices of red (said to be invisible underwater at depth). Braided line, due to its thickness, is the most visible line to spot so there is not much in the way of a special color when it comes to this type of line.

FISHING LINES CAN BE BROKEN DOWN LOGICALLY ACCORDING TO ITS USES OR APPLICATIONS. EACH LINE TYPE HAS SPECIFIC PROPERTIES THAT ENABLE ANGLERS TO ACHIEVE VARYING GOALS. IDENTIFYING THE TARGET SPECIES, FISHING STYLE, HABITAT, LURES, BAITS, AND THE SKILL OF THE ANGLER - ALL HAVE BEARING IN CHOOSING THE BEST LINE FOR THE JOB. EACH FEATURE CAN CARRY A POSITIVE OR NEGATIVE OUTCOME, DEPENDING ON THE ACTIVITY OBJECTIVE. FISHERMEN TYPICALLY DECIDE WHAT CAN BE VIEWED AS A TRADE-OFF TO ACHIEVE BEST RESULTS. THE CLIENT SHOULD KEEP THIS IN MIND FOR THE PRODUCT DESIGN AND MARKETING. ALSO, THE CLIENT SHOULD THINK WHETHER SOME OF ITS PRODUCT’S FEATURES CAN MITIGATE THE APPARENT DRAWBACKS OF THE CONVENTIONAL “STANDARD” FISHING LINES CURRENTLY ON THE MARKET.

Essentially, there are three major types of fishing lines employed: monofilament, braid, and fluorocarbon. There are pluses and minuses for each line type, which are detailed below.^{13 14} In **green font** there are properties that are considered positive by the fishermen, in **red font** – negative.



Monofilament

Description / Composition.	 Monofilament, “High Stretch” line, has been the standard line for millions of anglers for over half a century. Monofilament line, also referred to as “mono,” is possibly the most rudimentary of fishing line types, made from only a single plastic fiber. Made from mixing and melting polymers to form strands of lines, monofilament is finished by being spun onto spools of different shapes and thickness. This process is relatively inexpensive, producing a less costly product. Monofilament products to this day, remain the most popular.
Water absorption / Stretch	Monofilament can absorb water easily (due to its reduced diameter), providing an extra 5 to 7% elasticity. Knots tied to secure lures or live bait can come undone very quickly at depth while overall sensitivity also decreases. This is due to the line swelling as it absorbs water, creating additional pressure on the knot. It makes it poorly suited for deep water fishing. Monofilament line has significant "stretch." The line stretch under pressure has advantages, such as dampening the force when setting the hook and when fighting strong fish. This can be an asset for some fishing and fishermen, but it makes for loss of lure "feel," and some anglers have a difficult time detecting light strikes. Mono stretch also requires anglers to make a solid effort when setting hooks to drive barbs deeply for taking fish; on extremely far distances the dampening may become a disadvantage.
Price	Cheap to produce and inexpensive to purchase. Less expensive than other lines. Cost is the number-one factor why monofilament line is so widely popular. Even so, it is important to remember that cheaper brands of monofilament usually do not receive the quality-control attention and attention in the finishing process that premium-grade lines receive. As a result, they may not offer the tensile strength, limpness, abrasion resistance, and knot strength characteristic of more expensive monofilament fishing lines.
Diameter / test strength	
Color / transparency	
Hardness, resistance to abrasion	
Knots	
Casting	
Environmental factors	
Lures and reels	
Applications	

	trout and salmon, as well as flathead, small tuna, kingfish, and snapper. Generally, when fishing on a lake, lighter and more sensitive line is ideal, as casting is a more active style of fishing and the targeted species are smaller. Light tests are good for stream trout fishing with small lures and for pan fishing. In deep jigging, it provides better hookups. It is good when using bottom-bumping lures like jigs and plastic worms for bass. Mono does not sink like fluorocarbon or offer a darker silhouette like braid, so it is ideal for any surface lure fishing. For bigger game like salmon, trout, and steelhead, use monofilament line with fluorocarbon leaders. The extra "stretch" in the line compensates for the mistakes that inexperienced anglers make when playing bigger fish. Use monofilament leaders when using live baits—especially with fish-finder rigs and when float fishing with slip-bobber rigs.
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Braided

Description / Composition.	 "No Stretch" line, braided was originally made from natural materials like linen and cotton or even vines or plant fibers, modern braided line uses modern man-made materials like polymers as its main components. These tend to offer less resistance to abrasion, though, compared to other line types. The oldest of line types in terms of history, braided line still enjoys a fair amount of popularity in fishing circles today.
Stretch	No stretch. Perhaps braid's biggest asset is that it has virtually no stretch, thus it is extremely sensitive making it a top choice for deep water fishing and for "feeling" the slightest bite from fish. However, no stretch can be detrimental if anglers overplay fish, which can pull out or straighten hooks, resulting in a loss.
Price	It is more expensive than monofilament.
Diameter / strength	
Color / transparency	
Resistance to abrasion	
Twisting	
Knots	

Lures / reels	
Casting	
Applications	

Fluorocarbon

Description / Composition.	 Fluorocarbon is a relatively new product that has been improved dramatically over the years. Fluorocarbon fishing line is made of the fluoropolymer PVDF and it is valued for its refractive index, which is similar to that of water, making it less visible to fish. Fluorocarbon is also a denser material, and therefore, is not nearly as buoyant as monofilament. Similar in design to monofilament in that it is extruded in a single strand, it is virtually invisible in even ultra-clear water because light passes through it. The new-era fluorocarbon is quickly gaining lots of endorsements from plenty of top anglers.
Water absorption / Stretch	While fluorocarbon does stretch, in practical fishing it has less stretch than mono—though it is more elastic than braided line. Unlike mono, fluorocarbon does not absorb water. Because fluorocarbon does not absorb water, it will not weaken or increase in stretch like a monofilament fishing line.
Price	More expensive than other types of lines.
Color / transparency	Like the mono, it offers low visibility, not distorting light passing through the line at depth (same refractive value as water) and being nearly invisible in most settings. Fluorocarbon certainly offers advantages in clear-water situations where fish are heavily pressured or slow to bite.

Hardness, resistance to abrasion	
Knots	
Lures / reels	
Casting	
Applications	

11. FISHING NETS: ANALYSIS OF MAJOR CULPRITS IN GHOST FISHING

Nets are made from fibers woven in a grid-like structure. Early nets were woven from grasses, flaxes, and other fibrous plant material. Later cotton was used. **MODERN NETS ARE USUALLY MADE OF ARTIFICIAL POLYAMIDES LIKE NYLON**, although nets of organic polyamides such as wool or silk thread are still used. Fishing nets are usually manufactured on industrial weaving machines, though traditional methods are still used where the nets are manually woven and assembled in home or cottage industries.

FISHING NETS ARE THE KEY CULPRITS IN GHOST FISHING. LOST NETS ARE THE CAUSE OF THE MOST DEVASTATING MASS KILLINGS OF FISH AND MAMMALS. DIFFERENT TYPES OF NETS THOUGH, WHEN LOST, CAUSE A VARYING LEVEL OF DAMAGE TO MARINE LIFE. THIS SECTION DISCUSSES DIFFERENT TYPES OF NETS, THEIR APPLICATIONS AND CONTRIBUTIONS TO GHOST FISHING. THIS INFORMATION CAN BE USEFUL WHEN DECIDING ON A TARGET MARKET, SPECIFIC NETS AND DEVELOPING A MARKET MESSAGE.

Net Fishing Global Distribution by Types

Fishnets are one of the oldest tools for fishing. The oldest known modern-style fishing net is the net of Antrea found within the alternative fishing instrumentality in the Karelian city of Antrea. The net was made of willow and dates to 8300 B.C. Recently, fishing net sinkers from twenty-seven, 000 B.C. were discovered in Korea, placing them as the oldest fishing implements discovered, to date, in the world. The remnants of another fishing net date back to the late Mesolithic and was found beside sinkers at the bottom of a former ocean. Several of the oldest rock carvings at Alta (4200–500 BC) have mysterious images, together with tangled patterns of horizontal and vertical lines sometimes explained as fishing nets. American Native Indians on the river wove seine nets from spruce root fibers or wild grass, again using stones as weights. With the help of enormous canoes, pre-European Maori deployed seine nets that might have been over one thousand meters long. The nets were plain-woven from green flax, with stone weights and light wood or gourd floats, they required many men to haul them.

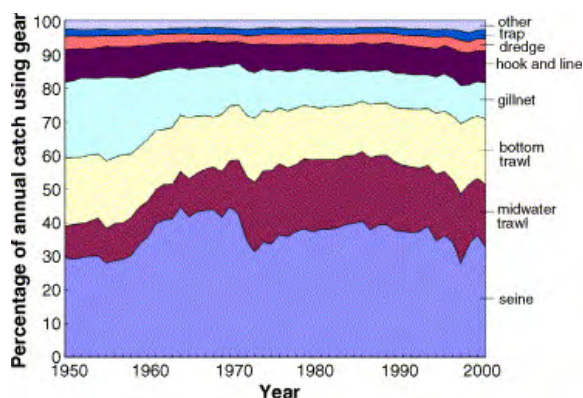


Figure 12: Share of Annual Catch Using Different Gear, %¹⁵

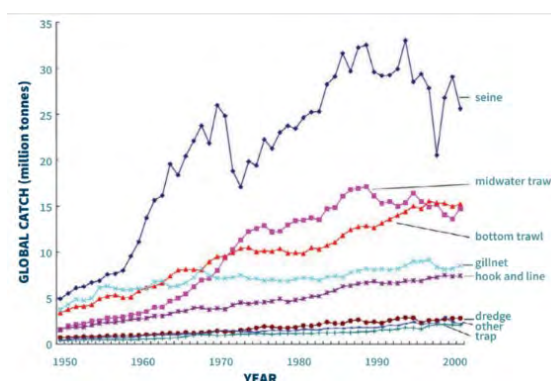


Figure 13: Total Global Catch Using Different Gear, Million Tons¹⁶

Commercial fishermen prefer to use nets as they will yield more catch than a rod, although netting is also used by residential fishermen. **IN MODERN COMMERCIAL FISHING, OVER 80% OF FISH ARE CAUGHT WITH NETS.** This is clearly demonstrated in Figure 12: Share of Annual Catch Using Different Gear and Figure 13: Total Global Catch Using Different Gear, Million Tons.

According to the graphs, seine nets account for around 35% of the global catch. Mid-water and bottom trawls both account for around 15% each. Gillnets and hook and line both account for about 10% each; with dredges, traps and other unidentified ‘other gear’ representing the remainder. Trends show that the proportion of catch by each gear has remained surprisingly consistent between the 1950s and 2000s. The exception is a period over the 1960s when seine net use expanded to nearly 45% (mainly at the expense of midwater trawls). By the 1970s, the catch by mid-water trawl gear increased and remained at that level into the 1990s. Seine gear (especially purse seine) continued to dominate the industry throughout.

IN 2012, AROUND 78% OF FISHERS WERE IN ASIA. THE REMAINDER WERE IN AFRICA (14%); LATIN AMERICA AND THE CARIBBEAN (5%); EUROPE (1.2%); NORTH AMERICA (0.8%) AND OCEANIA (0.3%). IT WOULD BE FAIR TO ASSUME THAT THE USAGE OF NETS IS ALSO PROPORTIONAL TO THIS DISTRIBUTION.

Commercial fishing has risen steeply since the 1970s, though the trend appears to be reaching a plateau. This has occurred due to a considerable reduction in commercial fishing in Europe, North America, and Africa. The fishing capacity of developed nations had decreased by 37% in 2012 from peak levels in 1991. Conversely, the fishing capacity of developing nations dramatically increased over the last 30 years and drives the global trend.

Net Fishing Techniques, Contribution to Ghost Fishing by Type

There are numerous forms of techniques for net fishing out there, the most common are described below.^{17 18 19}

Cast Net

Target fish: schooling and other small fish.

Cast-net fishing is one of the additional property ways of **recreational or sports fishing**. A solid net is sometimes sufficiently small enough to be operated by one person. It is round or oval, and might be thrown, or cast, over an outsized space. Weights on the facet of the net facilitate that it sinks, catching any ocean creatures within. Fish are caught as the net is hauled back in. Sizes vary up to about four metres in diameter. These nets are some of the oldest and most effective ways to catch small- to medium-sized fish sourcing from the traditional Polynesian technique.



Figure 14: Cast Net

Coracle Nets

A boat net is employed with small fishing boats. Whereas fishing with a small boat net is an ancient fishing technique it is uncommon these days, although they are still utilized in some locations of the planet. Coracles are usually used to catch trout or salmon. Traditionally, these nets were additionally adapted to catch eels. Coracle fishing can be performed by two people, each seated in a coracle, plying their paddle with one hand, and holding a shared net with the other. When a fish is caught, each hauls up their end of the net until the two coracles are brought to touch and the fish is secured. Whereas these styles of nets are best when operated by two fishermen, there are ways for using a net with only one person.



Figure 15: Coracle Nets

Trawling

A trawl is a large net, conical in shape, designed to be towed along the sea bottom. The trawl is pulled through the water by one or more boat, called trawlers or draggers. The activity of pulling the trawl through the water is called trawling or dragging. It is a **typical commercial fishing technique**. There are two different kinds: bottom trawls and midwater trawls.

Bottom Trawls

Target fish: demersal fish such as groundfish, cod, squid, halibut, and rockfish.

Bottom trawls involve weighing a net down to the seafloor then dragging it across the bottom to scoop up fish. Bottom trawling catches each bottom-living fish. The trawl doors disturb the bed. They produce a cloud of muddy water that hides the oncoming fishing net. It additionally makes a noise that attracts fish, and the fish begin to swim before the net mouth. Because the trawl travels along the bed, fish begin to tire and slip into the net. Finally, the fish become exhausted, move into the net, and are caught. The speed that the trawl is towed at depends on the swimming speed of the species that is being targeted. It additionally depends on the gear that is being used. Trawling is a simple approach to catching giant amounts of fish.

Bycatch is not overly concerning with bottom trawls, but habitat damage is. It has been compared to “fishing with bulldozers”. Sort of a bulldozer, it scrapes up everything. Sandy bottoms and rocky environments regenerate quickly after a bottom trawl net comes through, but bottom trawls can significantly impact sensitive habitat like deep water coral or sponge gardens. Good fishery management should ensure that bottom trawling is done in sustainable areas and not in places with irreplaceable habitat.

They are widely used by commercial whitefish, shrimp and nephrops fisheries in temperate waters. Due to the need for powerful vessels, it is generally used by commercial fisheries operating on the continental shelf. Mainly the eastern seaboard of North America, shallow coastal waters of north-east Europe, the north-east and south-east coasts of South America, West Africa, and most coastal waters of South East Asia.

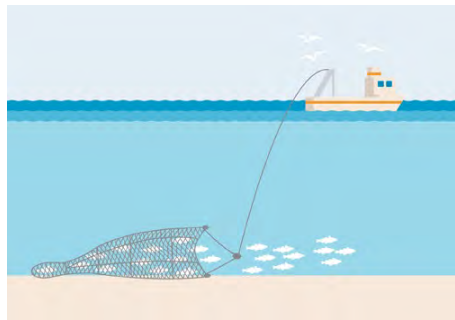


Figure 16: Bottom Trawling. Courtesy Marine Stewardship Council (MSC)

Apart from the Norwegian, and some Irish and United Kingdom surveys, there is little other reference in European literature to the lost levels of trawl nets and other mobile gear. Anecdotal information suggests that considerable effort is put into the immediate recovery of lost gears. This is due to their high value and improvements in navigation and gear marking technologies. However, it is apparent that some trawl nets are lost, possibly even in considerable volume –three-quarters of fishing debris in Cape Arnhem in Australia consists of trawl nets. It is also likely that trawl warps are sometimes discarded at sea.

THE LARGER DIAMETER SYNTHETIC MULTIFILAMENT TWINE COMMON TO TRAWL NETS IS THE KEY FACTOR THAT REDUCES GHOST FISHING MORTALITY IN LOST TRAWL GEAR. IT TENDS TO WEIGH THE NET DOWN, SPEEDING THE SUBSTRATE AGGREGATION PROCESS. HOWEVER, THIS CAN INCREASE THE LIKELIHOOD OF ENTANGLEMENT WITH MARINE MAMMALS, REPTILES, OR BIRDS. IN DYNAMIC AREAS, SUCH AS TIDAL STREAMS OR EVEN OCEANIC CURRENT GYRES, TRAWL NETS MAY NOT ACCRETE TO THE SEABED AND MAY CAUSE MORE DAMAGE AS THEY MOVE AROUND. IN THIS CASE THEY MAY REPRESENT A POTENTIAL NAVIGATION HAZARD OR CAUSE PHYSICAL ABRASION TO THE BENTHIC SUBSTRATE.

Midwater Trawls

These trawls are much larger than bottom trawls, and midwater trawling could need the use of 2 boats (known as combine trawling). Midwater trawls pull a net through the water off the bottom. Mid-water trawling is referred to as water trawling. This can be wherever a net is towed higher within the water column. A midwater trawl may be a massive, cone-like fishing net with one open and closed finish. Once midwater trawling, anglers will catch massive quantities of oceanic species, because the net is supposed to herd bodies of water fish into the giant mesh net.

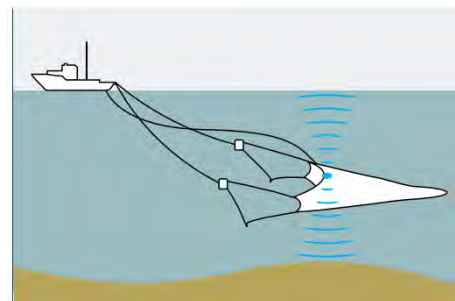


Figure 17: Midwater Trawling

Midwater trawls are usually used to target large schools of small pelagic species such as anchovy, herring, mackerel, and capelin. Like bottom trawls, they usually require powerful vessels, and their large-catch volumes require considerable on-board handling and storage space. As such, they are mainly restricted to **larger commercial operations**. Mainly used in north-east European waters. Used less frequently in tropical waters, although used to target Indian mackerel in the Bay of Bengal.

AS THEY ARE FISHED MID-WATER, THEY SELDOM HAVE CONTACT WITH THE BOTTOM AND SO GEAR LOSS IS RELATIVELY INFREQUENT. BECAUSE THEY ARE GENERALLY LARGE AND EXPENSIVE SETS OF EQUIPMENT, ATTEMPTS WILL BE MADE TO RECOVER THIS GEAR. THE SIZE OF THE GEAR, AND THE SOPHISTICATION OF THE VESSELS INVOLVED, MEANS RECOVERY IS USUALLY SUCCESSFUL.

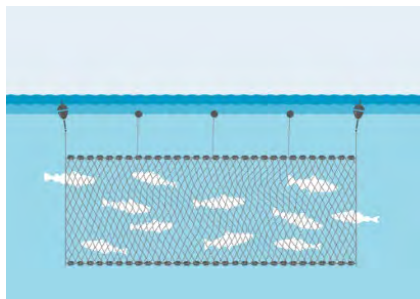
WITH A SMALLER MESH SIZE THAN BOTTOM TRAWLS, THESE SMALL PELAGIC FISH TARGETING NETS MAY CAPTURE FISH. HOWEVER, BECAUSE THEY ARE LARGE AND HEAVY, THEY ARE MORE LIKELY TO QUICKLY ACCRETE TO THE SEABED. THEIR SMALL MESH MEANS THEY ARE LESS LIKELY TO ENTANGLE MARINE ANIMALS, BUT OTHER ELEMENTS OF THE GEAR SUCH AS THE WARPS AND HEAD / FOOT ROPES MAY BE PROBLEMATIC. THEY MAY CAUSE DAMAGE TO SENSITIVE HABITATS IF MOVED BY CURRENTS, BUT TEND TO BE LOST IN DEEPER, POSSIBLY LESS BIODIVERSE SEABED AREAS.

Drive-in Net

A drive-in net is a mounted net used by **small-scale fishermen** in some fisheries in Japan and South Asia, particularly within the Philippines. It is used to catch schooling forage fish like fusiliers and different reef fish. It is a dustpan-shaped net, resembling a trawl with long wings. The front part of the net is set on the ocean bottom. The fishermen either wait till a school swims into the net, or they drive fish into it by making some form of commotion. Then the net is closed by lifting the front end that the fish cannot escape.

Gillnet and Tangle Nets

Gillnet fishing also nicknamed gillnetting is a common technique that **small-size commercial, as well as residential fishermen in some locations**, use in oceans, fresh bodies of water, and estuary spots. Gillnets are totally different from other nets because they are vertical, instead of horizontal, and set in a very specific line. Gillnets are set up to be a wall with holes in it. Fish unknowingly swim into it and get stuck. The gillnet catches fish which try to pass through it by snagging on the gill covers. Thus trapped, the fish can neither advance through the net nor retreat. Gillnet uses a system of nets with floats and weights. It is



anchored to the sea floor and allowed to float at the surface. They are an effective fishing method, suited to a wide range of waters, cheap and easy to buy and repair. Gillnets mainly target demersal and epipelagic finfish but are also used for small pelagic species and tuna. They can be set on the surface, mid-water or on the bottom. Gillnets are widely used in both temperate and tropical waters. They are particularly popular in north-east European waters, much of Africa and the Middle East, and South East Asia. They are also a common gear for use in estuarine, river or lake fisheries worldwide.

Figure 18: Gillnets. Courtesy Marine Stewardship Council (MSC)

Fixed gillnets (on stakes) are nets for catching fish in shallow intertidal zones. It consists of a sheet of network stretched on stakes fixed into the ground, generally in rivers or where the sea ebbs and flows, for entangling and catching the fish.



Figure 19: Fixed Gillnet

Gill nets that are not set at a particular location and drift with the current are called drift nets. In driftnet fishing, a fishing net could be gillnet allowed to drift in open water for the aim of catching a target species of fish. Drift nets catch giant amounts of fish quickly. However, the drifts netting technique is somewhat polemic and is prohibited in some areas. Several controversies stem from their tendency to catch uncaused fish and marine life. Its use on the high seas is prohibited, but still occurs.



Figure 20: Drifting Gillnet

Gillnets have the most bycatch of any kind of fishing net, but their use has been declining. Gillnets can be sustainable in some cases, for example salmon congregate at choke points that can be walled off without affecting other species.

Tangle nets, also known as tooth nets, are similar to gillnets except they have a smaller mesh size designed to catch fish by the teeth or upper jawbone instead of by the gills. Modern tangle nets are generally created using strong materials, like nylon. Sturdy materials cut back wear and prices related to

net replacement. However, the tangle net fishing methodology is an environmental hazard if lost. They are infamous for entrapping marine life and endangering boat crews.

GILLNETS CAN HAVE HIGH RATES OF LOSS, ESPECIALLY IN MIXED FISHERY AREAS WHERE GEAR CONFLICTS (ESPECIALLY WITH MOBILE GEAR) ARE MORE LIKELY. MANY GILLNETS ARE SET IN AREAS WITH STRONG TIDAL OR OTHER CURRENTS AND ARE SUSCEPTIBLE TO ACCIDENTAL LOSS. AS GILLNET PANELS ARE RELATIVELY CHEAP, THERE IS LESS INCENTIVE TO RECOVER LOST OR ABANDONED GEAR. CONSEQUENTLY, THEIR DELIBERATE DISCARDING AT SEA – EITHER DUE TO LACK OF STORAGE SPACE OR HEAVY DAMAGE – IS COMMON.

AS THEY ARE OFTEN MADE OF LIGHT MATERIAL, E.G. MONOFILAMENT NETTING, GILLNETS ARE NOT EASILY SEEN BY FISH AND OTHER MARINE ANIMALS. THEY WILL OFTEN RESUSPEND IN DIFFERENT CURRENT CONDITIONS. WITH A WIDE RANGE OF MESH SIZES AND STRUCTURES, THE RISK OF ENTANGLEMENT WITH MARINE ANIMALS AND SEABIRDS IS HIGH.

Haaf Net

The haaf net is set in a rectangular wooden frame usually about four or five metres long and two metres wide supported by three legs. A central pole extends from one of the longer edges at a right angle. The fisherman wades into deep water and submerges the net, holding it upright with the central pole. When a fish swims into the net the fisherman tilts the pole backwards to scoop the net upwards, thereby trapping the fish. This is typically used by **artisan fishermen in limited locations**.



Figure 21: Haaf Net

Hand Net and Push Net

A hand net (or a scoop/dip net) is a net featuring an oversized mesh basket that hangs from a hoop. The net may or may not feature a handle. If your net contains handles, they are usually stated as dip nets. They have been known since antiquity and can be used for sweeping up fish near the water surface like muskellunge and northern pike. When such a net is used by an angler to help land a fish, it is a landing net. In England, hand netting is the only legal way to catch eels.



Figure 23: Push Net

A version of a hand net is a push net, a small triangular fishnet with a rigid frame that is pushed on the lowest in shallow waters and is used in elements of the southwestern Pacific for catching shrimp and tiny bottom-dwelling fishes.



Figure 22: Hand Net

Landing Nets

A landing net is a small, manual net used to transfer hooked fish from a cord to a ship or bucket. Once using fishing landing nets, anglers will simply move their catch into their boat or put unwanted fish back in the water. Moreover, the correct fishing net definition refers to a bag-shaped netting connected to a handle. Techniques for using this net vary depending on the fish species anglers would like to catch, moreover because of the fishing method. While heavier nets are ideal for catching larger fish, a nylon fishing net is best for catching smaller fish.



Figure 24: Landing Net

Lave Nets

A lave net is a fishnet used throughout the follow of lave net fishing, a centuries-old sport fishing technique. While these nets are not used in the U.S., they are used as shallow-water fishnets in Europe. Lave net fishermen have used these manual fishing nets for thousands of years. The lave net is set in the water and the fisherman waits till he feels a fish hit against the mesh and the net is then lifted. Fish as large as sturgeon are caught in lave nets.

While the best lave net instrumentality is used to catch salmon, these nets have traditionally been used to catch ganoids fish.



Figure 25: Lave Net

Lift Nets

A lift net is a static or movable net used to target and trap little fish. These are held horizontally by a large, fixed structure and periodically lowered into the water. Huge mechanical contrivances hold out horizontal nets with diameters of twenty meters or more. The nets are dipped into the water and raised again, but otherwise cannot be moved. The nets may hold bait or be fitted with lights to attract more fish. Once lift net fishing, fish become cornered within the net and therefore the angler simply lifts the net from the water in a very vertical motion. A lift net has an opening which faces upwards. It can be lifted either manually (hand lift net) or mechanically (shore-operated lift net) and can be operated on a boat (boat-operated lift net.) The most famous examples are found in Kochi, India, where they are known as Chinese fishing nets (Cheena vala). Despite this name, this technique is used all over the world. They are also widely used on the Atlantic coast of France, where they are operated from small huts built over the water on stilts, known as carrelets, and on the Adriatic coast of Italy as trabucco by **small commercial fisheries**.

Though these nets are designed to require smaller fish, several larger nets are available.



Figure 26: Lift Net

Plankton Nets

A plankton net is a specially designed net used to gather samples of plankton for observation and analysis functions. Research vessels collect plankton from the ocean using fine mesh plankton nets. The vessels either tow the nets through the sea or pump sea water onboard and then pass it through the net. These nets are tow nets made of fine-mesh materials. Generally, most plankton net usage is to gather and observe live plankton from oceanic bodies of water. However, the simplest plankton net can vary depending on a particular situation.



Figure 27: Plankton Net

Seine Net

A seine is a massive net that can be organized in various ways and used by **commercial and residential fishermen**. In seine fishing, the net hangs vertically in the water by attaching weights on the bottom edge and floats on the highest. A steel cable that runs through rings at the bottom of the seine is pulled up to shut the net.

A simple and commonly used fishing technique is with dragnet (beach seine), where the seine net is operated from the shore. For fishing with a dragnet, the net is usually meant to encircle and lure a faculty of baitfish. It may also be operated from shallow waters at changing intervals. Laws for dragnet fishing vary by state; dragnets will usually solely be used to catch baitfish like shrimp or mullet.



Figure 28: Beach Seine Net

In purse seine fishing, the net hangs vertically in the water by attaching weights along the bottom edge and floats along the top. A boat locates a school of fish, then, using either a crane or small boat, takes one end of a net around the school and back to the fishing vessel. The ends of the net are synched together like a drawstring bag and pulled aboard with the fish inside.

Because purse seining targets a particular school of fish after it has been located, bycatch is extremely low. Sometimes fishing boats will deploy floating objects like big rafts or floating barrels to attract fish (fish love structure); these fish aggregating devices (FADs) make seining much easier by reducing fuel use and time spent looking for schools of fish, however FADs also attract other marine life and bycatch is



Figure 29: Purse Seine Using FAD

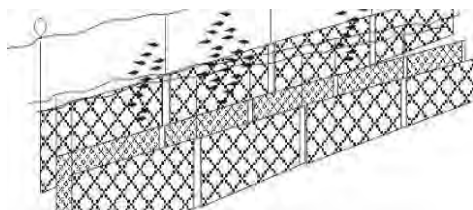
higher. Purse seines are used to capture both large and small pelagic fish. They are an important gear for fishing tuna – around 67% of tuna is caught this way – especially in association with FADs. Purse seines are commonly used by tuna fisheries in the Atlantic, Indian and Pacific Ocean waters. They are also an important gear for pelagic fisheries in the south-east Pacific Ocean. Seine nets are commonly used in coastal and archipelagic tropical waters, especially for neritic tunas and small pelagic species.

BECAUSE THEY ARE FISHED ON THE SURFACE, SEINE NETS SELDOM HAVE IMPACT WITH THE BOTTOM AND SO COMPLETE GEAR LOSS IS HIGHLY UNUSUAL. AS THEY ARE GENERALLY LARGE AND EXPENSIVE SETS OF EQUIPMENT, ATTEMPTS WILL BE MADE TO RECOVER THEM IF LOST. GIVEN THE

SIZE OF THE GEAR, THE FACT THAT IT FLOATS, AND THE SOPHISTICATION OF THE VESSELS INVOLVED, THIS IS USUALLY SUCCESSFUL. THERE IS POTENTIAL FOR THE LOSS OF FLOATS FROM PURSE SEINES, BUT THESE ARE NORMALLY RETRIEVED OR WASHED UP AND DO NOT THREATEN MARINE LIFE. WITH A SMALLER MESH SIZE THAN BOTTOM TRAWLS, THOSE PURSE SEINES TARGETING SMALL PELAGIC FISH MAY CAPTURE FISH. HOWEVER, BECAUSE THEY ARE LARGE AND HEAVY, THEY ARE MORE LIKELY TO QUICKLY ACCRETE TO THE SEABED. WITH A SMALL MESH THEY ARE LESS LIKELY TO ENTANGLE MARINE ANIMALS. THEY MAY CAUSE DAMAGE TO SENSITIVE HABITATS IF MOVED BY CURRENTS, ALTHOUGH THEY WILL TEND TO BE LOST IN DEEPER, POSSIBLY LESS BIODIVERSE SEABED AREAS.

Trammel Nets

Trammel nets are one of the foremost complicated, yet economical gill nets. Primarily, a trammel is three layers of netting tied together on a typical floating and common lead line. The two outer layers of netting (known as walls or brails) are created out of huge mesh netting (12" to 18" square) with a twine size of #



multifilament nylon or 0.81mm to 0.90mm monofilament. The light-weight or fine netting sandwiched between the two walls is usually little mesh multifilament or monofilament gill netting. Trammel nets have a large amount of light-weight gill netting hung within the nets, and fish will be caught by gilling or by tangling in the excess netting. These efficient nets are fished floating or sinking, and stationary or drifting.

Figure 30: Trammel Net

Harvesting Shellfish with Different Nets

Dredge

Dredging is like bottom trawling, but instead of a net, a metal rake is dragged across the bottom to collect shellfish and bivalves buried in the substrate, e.g., scallops, clams, or mussels. Bycatch is low but the same considerations apply for bottom trawling: good fishery management ensures that dredging is done in sustainable sandy areas and not in places with irreplaceable habitat.

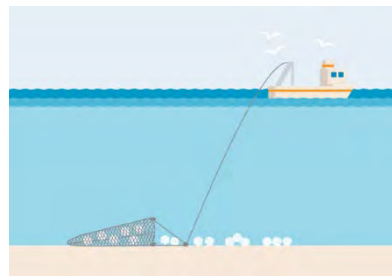


Figure 31: Dredging. Courtesy Marine Stewardship Council (MSC)

Traps and Pots

Traps and pots are mainly used to catch invertebrates like crab and lobster. Traps or pots are dropped to the bottom with bait to attract crab and lobster. Once they crawl inside, they cannot escape and are pulled back to the surface when the fishers return.

Traps and pots are used in a wide variety of crustacean and finfish fisheries. For crustacean fisheries, traps or parlour type pots are particularly popular to catch lobster, crab and nephrops. Traps can also be used to catch finfish e.g., the Seychelles cordonnier (rabbitfish) fishery. Traps and pots are usually used in shallow coastal waters, and in the margins of rivers and lakes. The use of pots in temperate waters is

mainly targeted at crustacean fisheries, while warmer waters tend to have a more mixed crustacean (e.g., spiny lobster / swimming crab) / finfish use.

Bycatch is not a problem, but sometimes gear gets swept away or fishers forget where they set their traps. THE LOSS OF TRAPS AND POTS IS OFTEN LINKED TO CONFLICT WITH TOWED GEARS, WITH OTHER INSHORE WATER VESSELS AND EVEN LARGE MARINE MAMMALS. THEY ARE ALSO PARTICULARLY SUSCEPTIBLE TO THEFT AND ACCIDENTAL LOSS THROUGH STORMS AND OTHER EVENTS. LONGER POT STRINGS MAY BE EASIER TO RECOVER, BUT INDIVIDUAL POTS MAY BE LESS SO.

The traps are usually baited when they are set; if the pot is lost, over time the bait or lost catch attracts scavengers. These scavengers may then become entrapped and subsequently die, forming new bait for other scavengers. Entrapped animals may escape over time. Animals captured in traps die from starvation, cannibalism, infection, disease, or prolonged exposure to poor water quality (i.e., low dissolved oxygen). A SECOND KEY RISK OF THIS GEAR IS ENTANGLEMENT OF LARGE MARINE MAMMALS WITH CONNECTING ROPES AND LINES. THIS CAN OCCUR WHEN THE GEAR IS ABANDONED, LOST, OR DISCARDED.

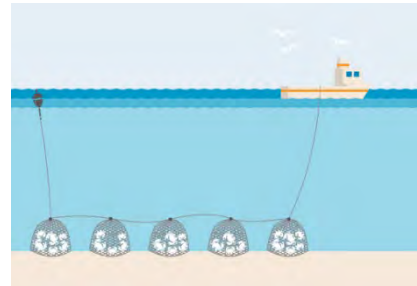


Figure 32: Traps Courtesy Marine Stewardship Council (MSC)

Fyke net

A fyke net may be a style of the fish trap. It consists of a long cylindrical netting bag sometimes with many netting cones fitted within the netting cylinder to create an easy entry and a troublesome exit. This net is then mounted on rigid rings or a different rigid framework and stuck on the ocean bed by anchors, ballast, or stakes. It also has wings or leaders to assist guiding the fish towards the doorway of the bag. They are usually used in estuaries or inshore shallow water. These can be linked together in long chains and are used to catch eels in rivers. If fyke nets are equipped with wings and leaders, they can also be used in sheltered places in lakes where there is plenty of plant life. Hundreds of these nets can be connected into systems where it is not practical to build large traps. It is like putcher fishing.

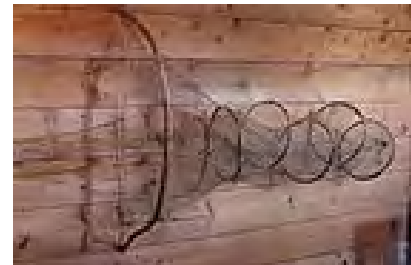


Figure 33: Fyke Net. Source: Wikipedia

CATCHING FISH AND OTHER AQUATIC ORGANISMS FROM THE WILD HAS BEEN PRACTICED FOR MILLENNIA. DESPITE THE RELATIVELY RECENT RISE OF AQUACULTURE, COMMERCIAL FISHERIES ARE STILL AN IMPORTANT SECTOR OF FISHING INDUSTRY. BECAUSE OF THIS, THE PROBLEM OF GHOST FISHING IS NOT GOING TO GO AWAY. THE MAJORITY OF THE COMMERCIAL FISHERIES, WHO ARE THE MAIN CULPRITS IN LOSING FISHING NETS, ARE LOCATED ON THE CANADIAN EAST COAST; THEY ARE POTENTIAL CUSTOMERS FOR THE CLIENT'S PRODUCT.

12. DANGERS OF GHOST FISHING. MOST DAMAGING TYPES OF FISHING GEAR

All fishing nets, lines and traps that get lost or abandoned at sea continue to operate long after fisheries lose track of them. The main resulting threat for the marine environment is so-called ghost fishing: abandoned floating entangled lines and nets keep catching fish and other marine animals for decades, unattended. Ghost fishing can affect commercially important fish stocks, resulting in high wastage (up to 30 per cent of the fish that are brought ashore) that can compromise the viability of both the fishing industry and fish populations.^{20 21}

Fishing lines also represent a danger to the creatures living near the shoreline and other marine megafauna (for example, turtles, seabirds, or marine mammals). It often wraps around legs, tails, and wings, where it can cause starvation, cut off circulation and kill the affected appendage, and, in those that need to return to the surface to breathe, suffocation.

Some animals may ingest it inadvertently while feeding. This can include grass carp munching on submerged vegetation, turtles patrolling for wiggling creatures near the shoreline and wading birds, who attempt to eat frogs, fish, and other small creatures who themselves may be trapped in loops of the nearly invisible line. In almost all such cases, the line will fatally damage the animal's internal organs, and cause plenty of suffering in the meantime. In addition, discarded nets contribute to pollution and accumulation of debris in our oceans, adding to high levels of microplastics and releasing toxic compounds (lead, for example) that accumulate in the food web. Floating gear also offers a means for invasive species to travel over large distances and occupy non-native habitats. And when it sinks, it can affect the biological communities living on the seafloor.



The Pacific Whale Foundation states that 100,000 metric tons of mono-filament lines and fishing gear are dumped into the ocean each year. Whales, dolphins, turtles, and seabirds die from ingesting or getting tangled in plastic products such as fishing lines. 90% of surveyed albatrosses had plastics in their intestines. Entanglement in fishing gear is responsible for the death of an estimated 300,000 whales and dolphins each year.²²

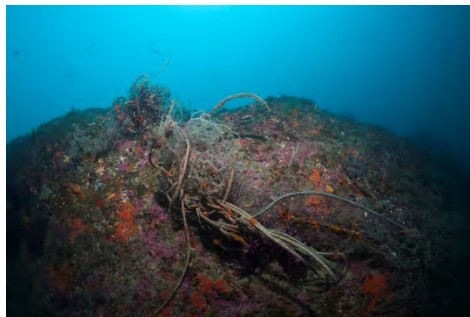
Figure 34: Sunfish trapped in lost fishing net in Cap de Creus, Costa Brava, Spain © Reinhard Dirscherl/ullstein bild via Getty Images

According to a study run by the Virginia Institute of Marine Science, only in the Virginia portion of the Chesapeake Bay, over four consecutive winters, there were almost 32,000 crab traps which contained almost 32,000 animals. Abandoned traps is a global problem in almost all trap fisheries. Fishermen lose anywhere from 10 – 70% of their traps annually. In 2008, the team reported that a single lost pot might snag around 50 crabs each year through this deadly cycle. Multiplied over tens and thousands of pots, such hidden fishing likely claims millions of crabs each year.

It is estimated that between 81,000 and 121,000 drifting FADs are being deployed each year, a big share of which get lost.²³ An estimated 179,000 Dungeness crab are killed in derelict traps each year in Washington waters of the Salish Sea.²⁴

Ghost gear is the single deadliest form of marine debris to sea life, continuing to catch and kill organisms long after it has been lost or discarded in the ocean. It is also one of the most prevalent: recent studies indicate that ghost fishing gear makes up 46-70% of all floating microplastics in the ocean by weight. Globally, an estimated 90% of species caught in lost gear are of commercial value.²⁵

The problem of derelict gear and ghost fishing has become more pressing with the advancement of technology, which has led to the geographical expansion of fishing efforts and the use of synthetic, more durable, and buoyant fishing materials. Their impact on the oceans is long term and large scale. This is particularly problematic for gillnets, which trap fish by their gills. Gillnets and other passive gear that captures organisms swimming into them are generally made of nylon and therefore maintain high fishing efficiency for many years.



Nylon monofilaments remain for 600 years, fluorocarbon lasts longer, and Spectra and Dyneema even longer in the environment before they decompose. That means all the monofilament line ever discarded in any lake, river or ocean is still there, representing a menace to all who come too close.

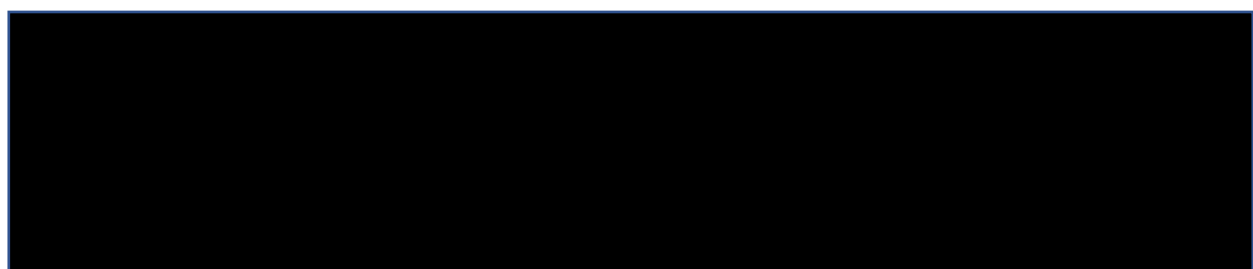
Divers may become trapped in fishing nets; monofilament is almost invisible underwater. Divers often carry a net cutter to extricate themselves if trapped by a fishing net or fishing line. It has a small sharp blade such as a replaceable scalpel blade inside the small notch.

Figure 35: Lost fishing net over a reef in Cap de Creus, Costa Brava, Spain © Reinhard Dirscherl/ullstein bild via Getty Images

THE REVIEW OF GLOBAL FISHING GEAR USE BY THE GLOBAL GHOST GEAR INITIATIVE INDICATES THAT SEINE NETS, MID-WATER AND BOTTOM TRAWLS ACCOUNT FOR MOST FISH CATCHES BY VOLUME ALTHOUGH THEY ARE NOT SO DAMAGING TO THE ENVIRONMENT. FADs, TRAPS AND POTS, AND GILLNETS ARE USED LESS FREQUENTLY BUT POSE THE MOST RISK FOR TURNING INTO GHOST FISHING GEAR.²⁶

GEAR CLASS	LIKELIHOOD	IMPACT	TOTAL RISK
Gillnets	5	5	25
Traps and pots	4	4	16
Fish Aggregating Devices	4	3	12
Hooks and lines	3	3	9
Bottom trawls	2	3	6
Mid-water trawls	1	2	2
Seine nets	1	2	2

Although seine nets and trawls have the lowest risk of ghost fishing, the fact that they account for the highest volume of global catches means they need to be considered. This is especially as losses can be concentrated in relatively small areas. Conversely, while traps and pots and FADs account for lower volumes of fish capture, they have a relatively higher risk of ghost fishing, and so must also be considered.



13. GOVERNMENT INITIATIVES ON GHOST GEAR REDUCTION

Nowadays, government support is the most effective force behind any new technology that provides solution(s) to existing environmental challenges. Plastics pollution is one of these challenges. Any solution and product that influences reduction and elimination of plastics pollution has a chance of getting some sort of government support, which might be in a form of grants, subsidies, tax reductions, etc. Biodegradable plastics are at the core of the solutions for plastic pollution.

LOST FISHING GEAR HAS BEEN RECOGNIZED AS A SERIOUS THREAT TO AQUATIC LIFE. THE ABOVE SECTION DESCRIBES THAT NET FISHING, AT A LARGER DEGREE, AND LINE FISHING, IN THE SMALLER DEGREE, BOTH CONTRIBUTE TO GHOST GEAR VOLUME. WHILE THERE IS NO GOVERNMENT REGULATION MANDATING THE USAGE OF BIODEGRADABLE PLASTICS FOR FISHING GEAR, THERE ARE SOME INITIATIVES THAT OFFER AN ENCOURAGEMENT TO ITS MANUFACTURERS. This section discusses these initiatives and regulations.

UNDERSTANDING THESE POLICIES AND INITIATIVES IS VERY IMPORTANT. DEPENDING ON THE ANGLE AND FOCUS OF THE POLICY, THE CLIENT CAN LEARN WHERE AND HOW TO SOURCE GOVERNMENTAL SUPPORT, AND HOW TO FORMULATE AND ADJUST THE MARKETING MESSAGE TO TARGET EACH AUDIENCE. ALSO, STAYING ABEAST OF THE CHANGES TO THE REGULATIONS AND MOVEMENTS WILL HELP THE CLIENT STAY AHEAD OF THE COMPETITION.

The Global Ghost Gear Initiative Looks for Options for Derelict Gear Reduction via Biodegradable Technology

The Global Ghost Gear Initiative (GGGI) (<https://www.ghostgear.org/>) is an international cross-stakeholder alliance of the fishing industry, private sector, corporates, NGOs, academia, and governments focused on solving the problem of lost and abandoned fishing gear worldwide.

The GGGI includes members of the fishing industry, the private sector, academia, governments, intergovernmental and non-governmental organisations. Every participant has a critical role to play to mitigate ghost gear locally, regionally, and globally.

Its current membership count includes private sector (48 companies), NGOs (60 entities), academia (6 institutions, IGOS (2) and governments (17 agencies including Canada and the USA).

THE GGGI IS THE FIRST INITIATIVE DEDICATED TO TACKLING THE PROBLEM OF GHOST FISHING GEAR ON A GLOBAL SCALE.

The GGGI's study identified²⁷ a multitude of measures already in place targeting the reduction and elimination of ghost fishing. They are tentatively divided into a) preventative, b) mitigation and c) cure. **Preventative measures are the most numerous**; they are the preferred approach because they prevent gear from getting into the marine environment in the first place and include:

- Spatial and / or temporal measures;

- Gear design to reduce whole or partial loss of fishing gear;
- Vessel design to reduce gear and other marine litter discards;
- Better marking and identification of fishing gear;
- Improved redundant fishing gear disposal facilities;
- Education and awareness;
- Improved fisheries management regime;
- Good practice for avoidance, mitigation, and response; and
- Gear design to reduce the incidence and duration of ghost.

Curative measures are those taken to report and assist the recovery of gear. It is recognised that gear recovery can often be an expensive exercise, and so it is less of a focus than prevention but may be appropriate in some circumstances. These recoveries are frequent and have been exercised around the globe; they frequency and scale has been growing. Some of them, conducted in Canada, are addressed in the next section.

Mitigation measures are those that are in place when fishing gear is presumed irretrievably lost and unrecoverable.

These measures include gear design to reduce the incidence and duration of ghost fishing. [THE CONSULTANT BELIEVES THIS IS THE AREA WHERE THE CLIENT’S PRODUCT FITS.](#)

In all examples brought up by the GGGI, the focus is on biodegradable parts of pots and traps allowing for the safe escape:

- One Florida’s spiny lobster fishery has had a requirement for escape mechanisms since 1982. And the fisheries management plan for king and tanner crab in the Bering Sea states that “an escape mechanism is required on all pots; this mechanism will terminate a pot catching and holding ability in case the pot is lost”.
- Biodegradable escape cords (‘rot cords’) are used for disabling derelict traps.
- The blue crab trap fishery has a fully biodegradable panel with a cull or escape ring designed for placement on the sides of a crab pot. It completely degrades into environmentally neutral constituents after approximately one year.
- French and Spanish purse seine fleets are attempting to develop ‘ecological FADs,’ which are biodegradable and therefore are not conducive to ghost fishing.

[THE GGGI FOUND THAT NEWER BIODEGRADABLE POLYMERS \(POLYHYDROXYALKANOATES, A FAMILY OF NATURALLY OCCURRING BIOPOLYESTERS PRODUCED BY BACTERIA ARE COMPLETELY BIODEGRADABLE BY MICROBES TYPICALLY FOUND IN THE MARINE ENVIRONMENT\) ARE FAR MORE EFFECTIVE THAN OTHER TYPES OF BIODEGRADABLE PLASTICS PRODUCED IN THE PAST.](#)

[ANOTHER OBSERVATION, WHICH SOUNDS MORE LIKE A WISH FROM THE GGGI IS THAT THE USAGE OF BIODEGRADABLE MATERIALS SHOULD NOT BE RESTRICTED TO TRAP FISHERIES ONLY. THEY CAN ALSO BE USED FOR MUSSEL SOCKS AND THE MULTITUDE OF OTHER PLASTICS USED ON BOARD BOATS, SUCH AS BAIT BOX PACKAGING MATERIALS, ETC.](#)

Canadian Ghost Gear Initiatives: Objectives and Impact on Fisheries

With the longest coastline in the world and one-quarter of the world's freshwater, Canada has a unique responsibility to actively reduce plastic pollution. In Canada, threats related to fishing interactions that can impact marine species at risk include entrapment or entanglement in active or lost fishing gear, as well as being caught as bycatch. **ENTRAPMENT AND ENTANGLEMENT ARE THE PRIMARY CONCERNS FOR MARINE MAMMALS**, Leatherback Sea Turtles, and large marine fishes, while smaller marine fishes, mollusks and Loggerhead Sea Turtles are at the greatest risk for being caught as bycatch.

Canadian Marine Life Conservation Programs Focused on Atlantic Coast Trappers

Over the past few years, there have been the disastrous consequences ghost gear can have on the marine environment, specifically on large mammals like the endangered North Atlantic right whale. **IN FACT, WHALE PROTECTION HAS BEEN AT THE CORE OF CANADIAN EFFORTS TO BATTLE GHOST GEAR.**

Canada has adopted several measures since 2017, when 12 whales were found dead in Canadian waters. Under North Atlantic Right Whales Program,²⁸ the government of Canada is taking measures that manage fisheries via

- 1) establishing season-long closure protocol in the Gulf of St. Lawrence, and Temporary closures in Atlantic Canada and Quebec when whales are present;
- 2) provisions for waters shallower than 20 fathoms;
- 3) increased surveillance; and
- 4) several provisions for fishing gear. Thus, gear marking is required for all fixed gear fisheries in Atlantic Canada and Quebec. The gear marking requirements identify region, fishery, and, for lobster and crab fisheries only, the specific fishing area. License holders in all fixed-gear fisheries are required to report lost gear. Any accidental contact between marine mammals and a vessel or fishing gear must be reported. The program also explores new fishing technologies and methods. Those are industry trials of "whale safe" gear technologies that minimize or eliminate the risk of entanglement to whales, and authorized ropeless gear trials in closed areas. It plans to implement weak rope or weak breaking points by the end of 2021.

Alongside North Atlantic Right Whales Program, Fisheries and Oceans Canada's Canada Nature Fund for Aquatic Species at Risk (CNFASAR) is supporting several projects that aim to reduce the threat of fishing interactions on marine species at risk., some of which address the lost gear issues. Some of these projects are summarized below.²⁹

- A project in Newfoundland and Labrador led by the Quebec-Labrador Foundation is promoting the protection of marine species at risk. Through dialogues with over 300 commercial harvesters in 100



ports, this project is generating support for recovery activities that will reduce threats to species at risk

Zero Plastic Waste

Zero Plastic Waste Program includes the following steps to reduce plastic pollution Canada-wide:

- Ban single-use plastics– such as shopping bags, straws, cutlery, plates, and stir sticks - **as early as 2021 under the** Canadian Environmental Protection Act;
- Reduce plastic waste from federal operations by diverting at least 75% of plastic waste by 2030;
- **Ensure that manufacturers and sellers of plastic products are responsible for collection and recycling of their plastic waste via** Extended Producer Responsibility programs;
- Reduce plastic microbeads in freshwater marine ecosystems. (Canada prohibited the manufacture and import of all toiletries that contain plastic microbeads as of July 1, 2019);
- Help keep our shorelines, bodies of water, parks, and other natural places free of plastic pollution, by providing \$1.5 million in 2019 to start new plastics projects that mobilize and engage citizens;
- \$100 million to help developing countries prevent plastic waste from entering the oceans, address plastic waste on shorelines, and better manage existing plastic resources;
- Canada’s Plastics Science Agenda to accelerate research along the lifecycle of plastics and the impacts of plastics pollution on humans, wildlife, and the environment;
- Sustainable Fisheries Solutions and Retrieval Support Contribution Program to eliminate ghost gear.

caused by fisheries interactions. Additionally, this project is minimizing the threat of plastic debris ingestion and fishing gear entanglement by installing collection boxes for bait box liners at fishing stations.

- Several CNFASAR funded projects are developing and testing new fishing equipment that is less hazardous to aquatic species. For instance, Homarus Inc. is conducting a project in the Gulf of St. Lawrence to implement technological innovations in the snow crab fishery to prevent entanglement of marine mammals and turtles in vertical ropes. Other project elements include establishing an alliance of snow crab fishers to promote best practices, conducting educational activities for youth in coastal communities, as well as mapping and retrieving lost gear.

- The Canadian Wildlife Federation is working with fishers operating in Atlantic Canadian waters to develop standard methods for evaluating ropeless fishing gear and testing ropeless technologies.

- World Wildlife Fund (WWF) Canada, in collaboration with NunatuKavut Community Council and the Marine Institute of Memorial University of Newfoundland, initiated a project to reduce the threat of ghost gear on species in the Gilbert Bay Marine Protected Area. This project involves removing ghost gear from the area, collecting Indigenous Knowledge on practices concerning ghost gear and identifying more sustainable gear practices.

- Project led by Merinov is to use innovative technology, such as sonar detection and underwater vehicles, to detect and retrieve ghost traps in the Gulf of St. Lawrence. This project is also sharing knowledge with fishers and developing a best practice guide to minimize trap losses in the fishing industry.

At the 2018 G7 meeting of the Environment, Energy and Oceans Ministers, Canada became a signatory to the Global Ghost Gear Initiative and committed to combatting ghost fishing gear at home and internationally. [IN SUPPORT OF THE G7 PLASTICS CHARTER, FISHERIES AND OCEANS CANADA HAS COMMITTED \\$2.6 MILLION DOLLARS TOWARDS INITIATIVES THAT INVITE CANADIAN SMALL BUSINESSES TO DEVELOP INNOVATIVE TECHNOLOGIES TO REDUCE DOMESTIC MARINE PLASTIC WASTE.](#)

Canadian regional government bodies have been running their own gear retrieval campaigns:

- In July 2019, Fisheries and Oceans Canada and the Canadian Coast Guard, alongside industry partners and local communities conducted a three-day ghost fishing gear retrieval program in the Gulf

of St. Lawrence. Over 100 snow crab traps and nine kilometers of rope were removed during the operation.

- On August 27, 2019, Halifax announced a new gear retrieval contribution program that will provide up to \$8.3 million to assist fish harvesters, environmental groups, Indigenous communities, the aquaculture industry, and coastal communities to find and retrieve harmful ghost gear from the ocean and dispose of it responsibly.³⁰

New Canadian Ghost Gear Fund Supports Mainly Gear Removal

In 2019, the federal government announced that reduction of ghost gear pollution will be falling within the framework of the Canadian initiative on reducing plastic pollution, **the Government of Canada's Strategy on Zero Plastic Waste announced on June 10, 2019.**³¹ The Strategy mentions prevention and retrieval of abandoned, lost, or discarded ghost fishing gear through a **Sustainable Fisheries Solutions and Retrieval Support Contribution Program or Ghost Gear Fund**³² that will support fish harvesters to acquire new gear technologies to reduce gear loss and take concrete actions to support ghost gear retrieval and responsible disposal.³³

THIS PROGRAM IS DESIGNED TO ADDRESS THE ENTIRE SPECTRUM OF ISSUES SURROUNDING GHOST GEAR, INCLUDING PREVENTION, MITIGATION, AND DISPOSAL OF DERELICT EQUIPMENT.

Activities of Ghost Gear Fund include projects by third parties to retrieve ghost gear during closed fishing times, solutions for the disposal of fishing related plastic waste and ghost gear, acquiring and piloting of innovative gear technology for use in Canadian fisheries, and supporting international work in high-risk areas to reduce ghost gear.

The Ghost Gear Fund will finance 26 projects over two years (2020-2022). All projects fall under at least one of four themes, or pillars of activity: 1) Ghost gear retrieval; 2) Responsible disposal; 3) Acquisition and piloting of currently available innovative gear technology; 4) International leadership.

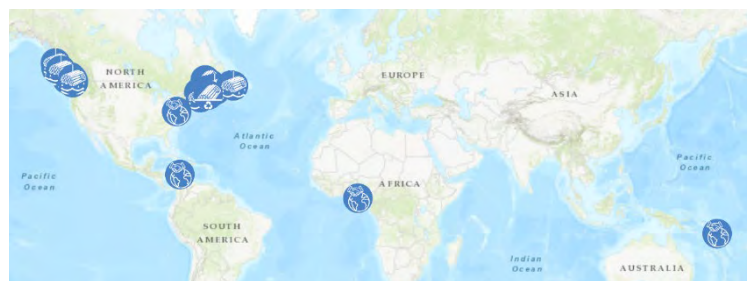


Figure 36: Location of Ghost Fund International Focus

MEANWHILE, THE MAJORITY OF EFFORTS BY THE CANADIAN GOVERNMENT ARE FOCUSED ON CURATIVE MEASURES, SUCH AS THE RETRIEVAL OF GHOST GEAR. APPENDIX B: RECIPIENTS OF CANADIAN GHOST GEAR FUND LISTS THESE PROJECTS.

The Ghost Fund program involves working with a recognized international body or organization to help developing or small island states establish their own sustainable fisheries practices and programs to mitigate the impact of ghost gear. These projects must also fall into at least one of the other three Ghost Gear Fund pillars of activity (retrieval, disposal, or technology), and help work towards long-term

solutions in the regions where the work will be completed. International hotspots for ghost gear include the Caribbean, South Pacific, and West African coast.

Gear Innovation Summit – the First Ghost Gear Event in Canada to Feature New Technologies

In February 2020, Fisheries and Oceans Canada hosted a Gear Innovation Summit in Halifax, Nova Scotia, which included discussions on technological solutions to prevent ghost fishing gear from entering the oceans in the first place.³⁴ **THE GEAR INNOVATION SUMMIT WAS THE FIRST OF ITS KIND IN CANADA. ITS PURPOSE WAS TO EXPLORE CURRENT AND EMERGING WHALE SAFE TECHNOLOGIES AND STRATEGIES AS WELL AS CURRENT AND EMERGENT TECHNOLOGIES, STRATEGIES AND PROGRAMMATIC INTERVENTIONS DESIGNED TO REDUCE AND/OR MITIGATE THE RISK OF ABANDONED, LOST, DISCARDED FISHING GEAR.**

Hosted by Fisheries and Oceans Canada, it brought together approximately 250 harvesters, industry representatives, fishing gear developers and manufacturers, scientists, NGOs, marine mammal responders and government officials, from Canada, the United States, and Europe. **THE SUMMIT DID NOT ATTEMPT TO FOCUS ON SOLUTIONS OR RECOMMENDATIONS. RATHER, IT WAS ABOUT RAISING AWARENESS, AND EXPLORING THE ART OF THE POSSIBLE AT THE INTERSECTION OF ROBUST FISHERIES, WHALE SAFETY, AND THE ENVIRONMENT.**

The summit incorporated Trade Show, providing an **IN-DEPTH OPPORTUNITY FOR PARTICIPANTS TO SEE GEAR DEMONSTRATIONS, TALK TO DEVELOPERS AND MANUFACTURERS, AND EXPAND THEIR CONVERSATIONS AND NETWORK BUILDING.** One of the key outputs was a report that was meant to serve as a reference for attendees and those whose interests intersect. As stated in the report, the focus of the summit was on in-trial, whale-safe technologies, and the emergent technology of rope-less gear, specifically developing, adapting, and trialling **weak ropes, sleeves and the time tension line cutter, as well as lost gear.**

Efforts to reduce, retrieve and recycle lost gear, and the technology solutions and programs cover a range of Electronic Monitoring systems and Visualization tools exist, and are being used to enable gear monitoring, loss prevention and retrieval initiatives worldwide. Notable examples were showcased from the West Coast/Pacific Region as well as Europe, including Iceland and Norway, and the collaborative efforts being led by the KIMO International collaboration.

Concerns were raised on gear tracking and reporting. Electronic monitoring of gear, side scan radar to map and identify lost gear, and visualisation tools were among the technology innovations discussed. Effective use of these tools can increase awareness, location, and recovery of lost gear, as well as reduce vandalization and theft of gear. The durability of current gear, e.g., rope strength was also noted as a dimension of the lost gear issue, leading to the longer-term question of how future gear design and modification options might be developed for more sustainable ocean use and health.

RETRIEVAL WAS ACCEPTED AS ONLY ONE COMPONENT OF AN EFFECTIVE APPROACH. ULTIMATELY, A COMPREHENSIVE APPROACH THAT REFLECTS BOTH WILL BE NEEDED TO ACHIEVE A FULL SOLUTION. IN THE MEANTIME, EXISTING WORLDWIDE REDUCTION AND PREVENTION STRATEGIES PROVIDE EXCELLENT INSIGHTS AND PROVEN MODELS UPON WHICH TO BUILD. THE CLIENT'S PRODUCTS PRESENT EXACTLY THIS TYPE OF SOLUTION. THE CLIENT SHOULD CONSIDER ATTENDING THIS SUMMIT NEXT TIME AS AN EXHIBITOR AND PRESENTER.

14. GLOBAL FISHING INDUSTRY: PRODUCTION AND TRADE

Fishing is an important activity and industry throughout the world. It produces more than █ million tons of fish and fishery products each year. More than a billion people, particularly in poorer countries of the world, are dependent on fishery products.

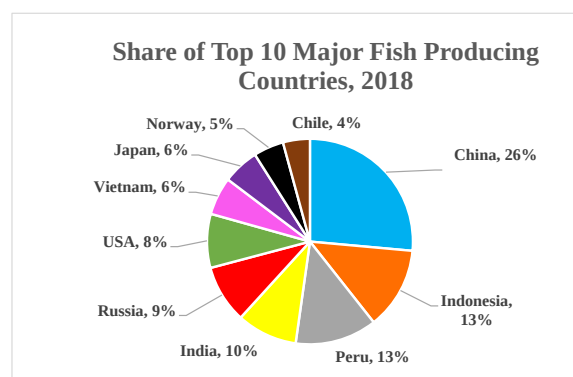
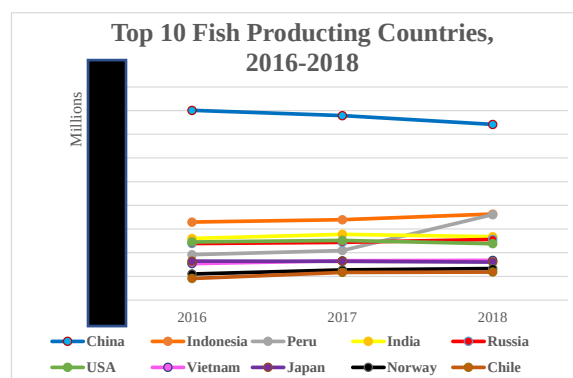
Fishing also contributes to human welfare by fulfilling cultural needs and social benefits, such as recreation.

Globally, the fishing industry is a highly adaptive, market-driven, and dynamic internationalized sector within the world economy. Its pressure on resources is still rising, owing to a persistent worldwide upward trend in fish consumption, in concert with continuing human population growth (especially in coastal zones). Many fishing fleets are highly mobile, and rapid technological innovation has increased their efficiency and limited the capacity of individual governments to exercise control overfishing pressure.

According to the data reported by Fisheries and Oceans Canada (DFO)³⁵, Canada held the █ position among all countries by the volume of caught fish. China, whose share constitutes █ of the top 10 world producers, almost doubles the volume of the next in line, Indonesia. Meanwhile, Chinese production, similar to that of Canada and USA, deceased its production volume between 2016 and 2018. During the same period, Chile doubled its production rate.

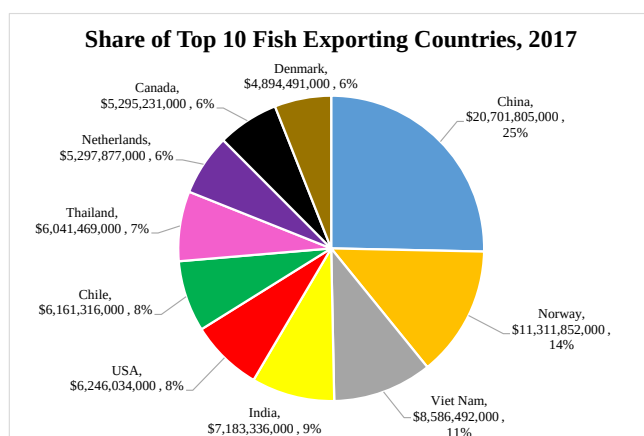
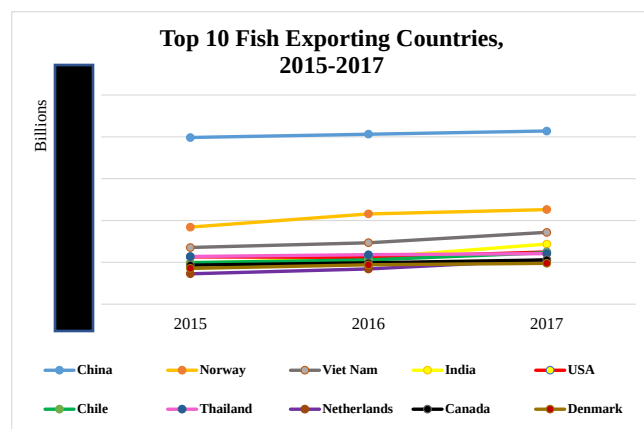
	Country	2016	2017	2018
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

Figure 37: Nominal Fish Catches by Major Producing Countries, 2016-2018, Metric Tons, Live Weight



	Country	2015	2016	2017
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
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25				

Table 1 : Exports by Principal Trading Countries, 2015-2017³⁶



International trade in seafood has evolved considerably. The United States and Canada were the 1st and 2nd major exporters of seafood in terms of value prior to 1990. Beginning in 1991, the gradual decrease in groundfish catches coupled with increased aquaculture production in Asian countries caused Canada to slip from [REDACTED] place in total export value in 1993. Since 1993, Canada has not been among the top ten major seafood exporters, although it is slowly sliding down the scale. In 2017, similar to production volumes, value of exports was dominated by China, which held a [REDACTED] share among the top 10 exporters. Canada held the [REDACTED] position, which is significantly above its [REDACTED] position in production volume. **IT IS INDICATIVE OF CANADA DIRECTING THE MAJORITY OF ITS CATCH TO TRADE. IT MEANS THAT INTERNATIONAL RELATIONS, TRADE AGREEMENTS, AND FOREIGN DEMAND ARE THE KEY DRIVERS OF THE CANADIAN FISHING INDUSTRY.**

15. CANADIAN FISHING INDUSTRY'S SEGMENTS: HISTORICAL ANALYSIS, TRENDS, POTENTIAL POSITIONING OF BIODEGRADABLE PRODUCTS

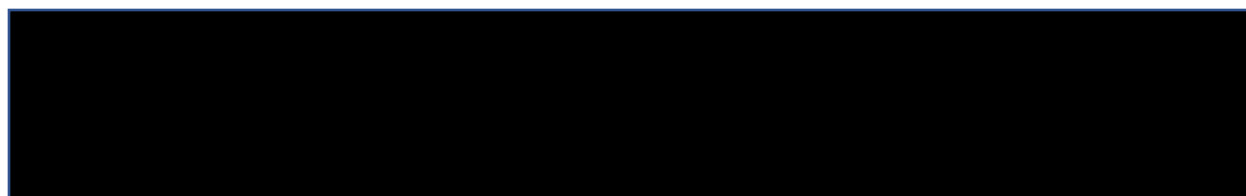
General Overview. Contribution to the Canadian Economy, Trade

Canada, the second largest country in the world in area (after Russia), occupies roughly two-fifths of the continent of North America. Despite Canada's great size, it is one of the world's most sparsely populated countries with an extremely low population density.

Canada has the longest coastline in the world of over 265k km and is surrounded by three oceans, Atlantic, Pacific, and Arctic; it also has the Great Lakes that contain abundant and valuable sources of fish and seafood. The variety of products that Canadian fishermen harvest from these sources are sold within Canada and exported around the world. The Department of Fisheries and Oceans oversees the management of Canada's aquatic resources and works with fishermen across the country to ensure the sustainability of Canada's oceans and in-land fisheries³⁷.

The Canadian economy is a highly developed market economy dominated by the private sector. It is the 10th largest GDP in the world³⁸ constituting around \$1.8 billion.

Canada's fishing industry is a noticeable contributor to the Canadian economy. In 2019, the fishing, hunting, and trapping industry (collectively referred to as "fishing") contributed ██████████ to the nation's GDP. It should be noted, though, that between 2015 and 2019, the fishing industry has been on a declining scale dropping from ██████████ in 2015, in reverse trend from the ascending total nation's GDP³⁹. This trend is also in sync with employment, which continuously dropped in fishing between 2000 and 2016 with a slight increase in the last three years⁴⁰. At the same time, the total labor force on the country level has also been gradually increasing. Another observation that can be drawn from this graph is that **THE ECONOMIC DOWNTURN CAUSED BY THE COVID-19 EPIDEMY HAS HAD A VERY LIMITED (IF ANY) IMPACT ON THE FISHING SECTOR WHEN COMPARED TO THE REST OF THE NATION: FISHING SUSTAINED AT THE SAME LEVEL WHILE THE TOTAL ECONOMY HAS BEEN SLIDING SINCE THE BEGINNING OF THE COVID-19 LOCKDOWN.**



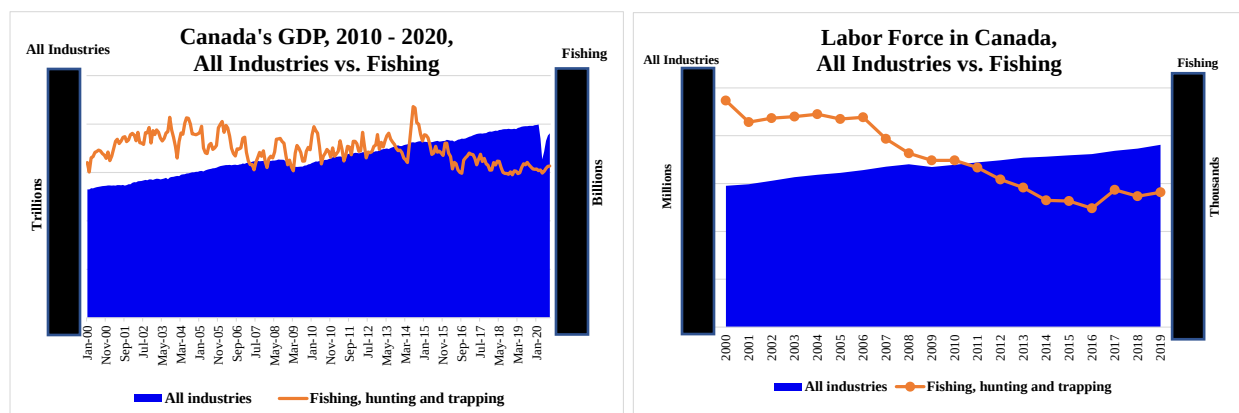


Figure 38: Canada GDP and Employment in 2000 - 2020, All Industries vs. Fishing

According to the data reported by Food and Agriculture Organization of the United Nations, in Canada, the majority of fish production originates from wild capture (█████ vs. █████ coming from aquaculture).

Canada's fish production is dominated by finfish (█████ in 2017) with Atlantic salmon and Atlantic herring being the top contributors.⁴¹

Canada is also characterized by fish consumption, of over █████ kg/capita per year. On average, Canadians consistently spend approximately █████ of household home food expenditures on fish and seafood annually. In 2016, average annual household expenditure on all fish and seafood products was \$████. In contrast, households spent █████ on meat products (both processed and unprocessed). Most Canadian households' expenditures on seafood go towards salmon and shrimp, products that are largely sourced from aquaculture.

Canada is both an importer and exporter of products within every species group. Shrimp consumption exceeds production, but imports are substantial. In 2017, █████ of exports were cold water shrimp

(*Pandalus borealis*), while about █████ of imports were warm water shrimp from Thailand, Vietnam, India, and China where much of the production is cultured.

Tuna consumption in Canada is fulfilled almost exclusively by imports, as production is small.

Salmon consumed in Canada is of both domestic and imported origin. Canada exports the majority of its salmon to the U.S., while the U.S. remains Canada's primary source of salmon imports (\$█████ in 2016), with smaller amounts coming from Chile (\$████) and Norway (\$████).⁴²

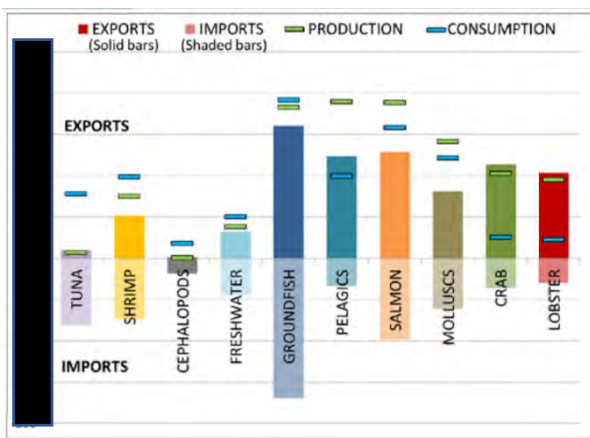


Figure 39: Canada's Fish and Seafood Production, Exports, Imports, and Consumption in 2017 (Thousand tons Live Weight)

Lobster and crab production far exceed consumption, and most is exported due in part to seasonal harvest and high prices abroad. For American lobster, Canada and the U.S. are the largest trade partner for each other. The landing patterns of the two countries are complementary. Each country ships fresh lobster to the other during peak landings, when the other country's harvest is low.

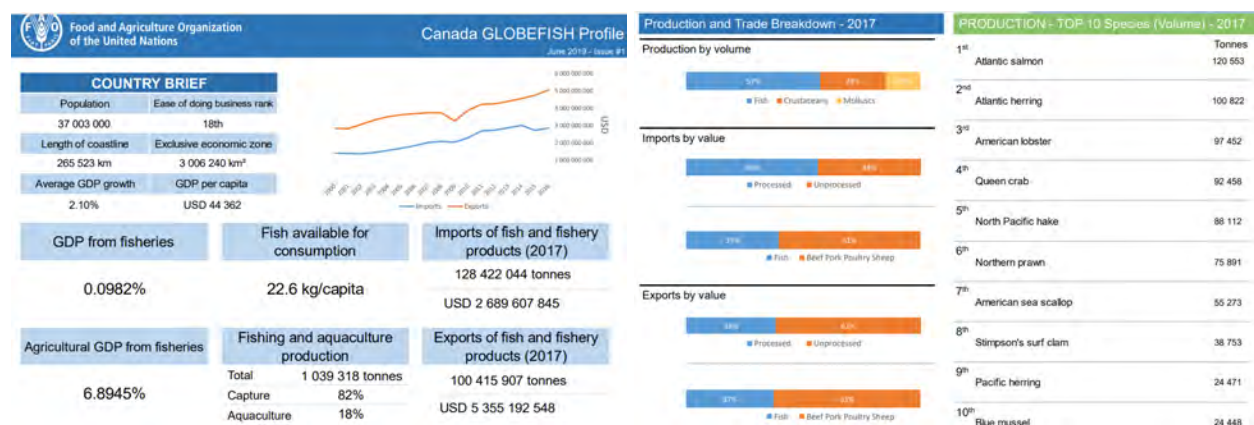


Figure 40: Canada's Profile, Fish Production in 2017

In total, the Canadian fishing industry exports █% of the products harvested and processed in Canada. Canadian exports from the fishing industry have been growing at a much higher rate than exports from other industries. A significant increase was recorded in 2014, which extended until January 2020.

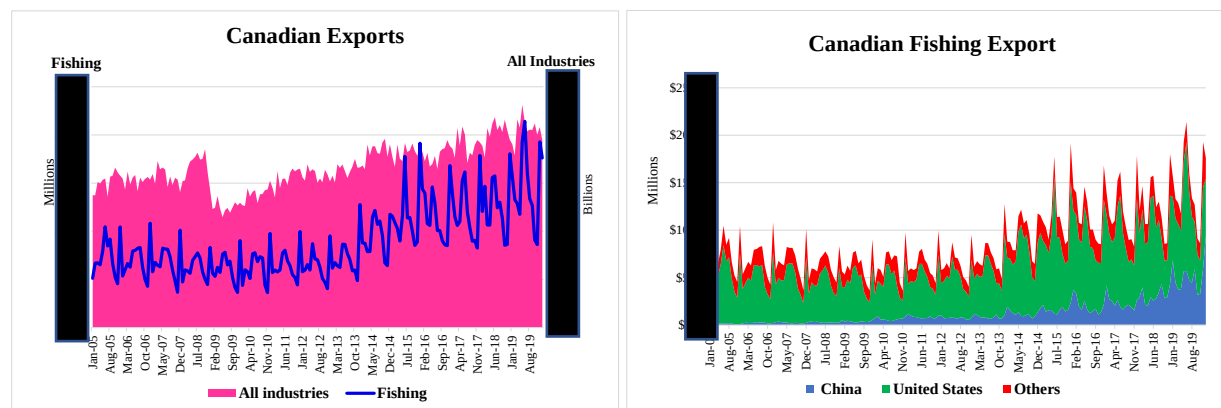


Figure 41: Canadian Monthly Fishing Exports, January 2005 – January 2020⁴³

The United States has been the most important market for Canadian seafood exports: in January 2005, the US share in Canadian exports constituted around █%; in January 2020, this share dropped to █%. Chinese exports, however, have grown from █% in January 2005 to █% in January 2020.

THE SEAFOOD TRADE IS A SECTOR OF THE CANADIAN ECONOMY WITH A TRADE SURPLUS, MEANING THAT THE VALUE OF CANADIAN SEAFOOD EXPORTS IS GREATER THAN THE COST OF SEAFOOD IMPORTS COMING FROM FOREIGN MARKETS. In 2019, Canada's export doubled the volume of import (\$█ vs. \$█) creating almost \$█ of the trade surplus.

Lobster dominates the export volume (█ tons) and value (\$█) comprising about █% of the total in 2019. It is followed by crab (\$█) and salmon (\$█), as shown in Figure 40: Canada's Profile, Fish Production in 2017.

	Volume (metric tonnes)		Value (\$'000)	
	2018	2019	2018	2019
Top Product Exports, by Species				
Lobster				
Snow/Queen Crab				
Atlantic Salmon				
Crab, other				
Shrimp				
Total Exports				
Top Product Imports, by Species				
Salmon, all species				
Shrimp				
Lobster				
Skipjack/Bonito Tuna				
Crab, all species				
Total Imports				

Figure 42: Canada's Fish Export and Import, 2017-2019⁴⁴

While salmon production dominates the Canadian market, on the global market Canada is not leading. According to the FAO data⁴⁵, Canada holds the 8th place preceded by Norway, Chile, Sweden, Denmark, Poland, UK, and USA. The USA is the largest recipient of Canadian salmon (█% of the total American salmon imports or \$█ in 2017), as shown in graphs below.

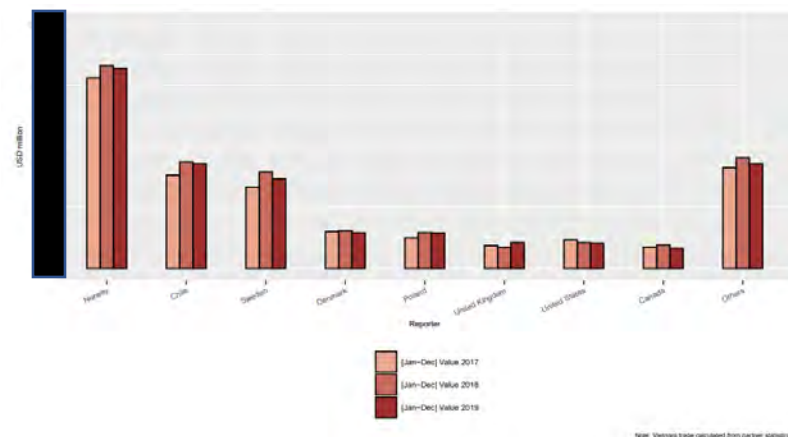


Figure 43: World Salmon Export Partners (\$Value, 2017- 2019)

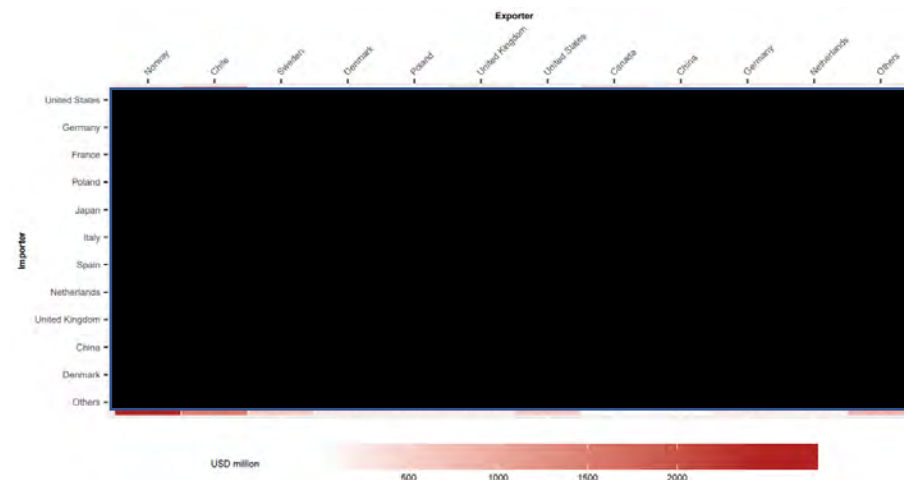


Figure 44: World Salmon Exporter-Importer Trade Flows (\$Million, Jan-Dec 2019)

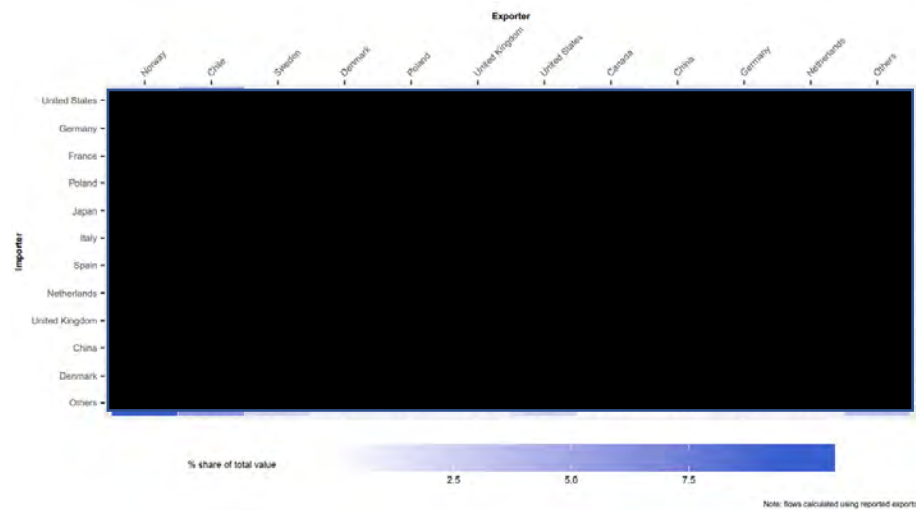


Figure 45: World Salmon Exporter-Importer Trade % Share of Total \$Value (Jan-Dec 2019)

Canadian fishing industry consists of the four different sectors:

- Recreational fishing,
- Commercial fisheries,
- Aquaculture, and
- Aboriginal fisheries.

Each sector is characterized by different rules and regulations, impact on the nation's economy and cultural significance. Also, each of them presents different targets for the Client in relation to the Product.

Aboriginal Fisheries: Potential Support in Conservation and Preservation Efforts

Aboriginal fisheries are the least significant sector from the point of its contribution to the national economy; its regulatory focus is on protecting the fishing rights for Indigenous peoples.^{46 47} In 1990, the Supreme Court of Canada issued a landmark ruling in the Sparrow decision. This decision found that the Musqueam First Nation has an Aboriginal right to fish for food for social and ceremonial purposes. The Supreme Court found that where an Aboriginal group has a right to fish for food for social and ceremonial purposes, it takes priority, after conservation, over other uses of the resource. The Supreme Court also indicated the importance of consulting with Aboriginal groups when their fishing rights might be affected.

In response to this decision, and to provide stable fishery management, Fisheries and Oceans Canada launched the Aboriginal Fisheries Strategy (AFS) in 1992. The AFS is applicable where DFO manages the fishery and where land claims settlements have not already put a fisheries management regime in place.

DFO issues a Communal Commercial License (issued annually) to most First Nations. As such, there is a distinction between regular commercial licenses (issued to individuals or companies) and communal commercial licenses. This license lists the species of fish and amounts each First Nation is entitled to harvest for food for social, and ceremonial purposes. It also states where the fish can be harvested.

DFO supports First Nations involvement in fisheries resource management, while also enhancing catch monitoring and reporting across fleets. It also provides grant and contribution funding for investment in vessels and fishing gear. The current annual funding of the AFS is \$35 million, with about 125 AFS agreements signed each year. Approximately two thirds of these agreements are reached with Aboriginal groups in DFO's Pacific Region, with the balance in Atlantic Canada and Quebec.

WHILE INDIGENOUS GROUPS DO NOT NOTICEABLY INFLUENCE CANADIAN FISH PRODUCTION, THEY ARE VERY ACTIVELY INVOLVED IN CONSERVATION EFFORTS. THEY ALSO INFLUENCE MANY DECISIONS AND REGULATIONS REGARDING GHOST GEAR AND OTHER PRESERVATION EFFORTS. THE CLIENT SHOULD CONSIDER FINDING COMMON GROUNDS AND COOPERATING WITH ABORIGINAL FISHERIES IN THESE EFFORTS.

Commercial Aquaculture: Growing Sector with British Columbia in the Leadership Position



Figure 46: Commercial Aquaculture Farm in Canada

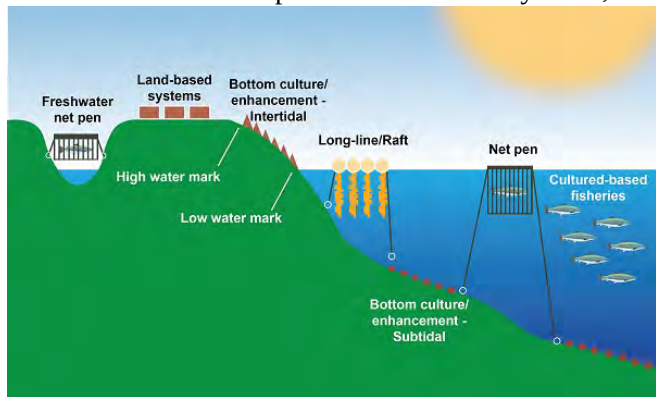
AQUACULTURE, FARMING OF FISH, SHELLFISH, AND AQUATIC PLANTS IN FRESH OR SALT WATER IS THE FASTEST GROWING FOOD PRODUCTION ACTIVITY IN THE WORLD AND A GROWING SECTOR IN CANADA. Many finfish producers are fully integrated, conducting both grow-out and processing activities. Many shellfish growers process their own output and process on behalf of other growers.

Commercial aquaculture in Canada traces its history to the 1950s, with trout farming in Ontario, British Columbia and Québec, and oyster culture in New Brunswick, British Columbia, and Prince Edward Island. The industry took off with the successful development of salmon farming. The first attempts to culture salmon commercially in Canada began in the early 1970s in British Columbia, with development work in the mid-1970s in New Brunswick and Nova Scotia. A mussel industry emerged on the east coast during the 1970s, expanded rapidly in Prince Edward Island during the 1990s, and today is the nation's leading shellfish species by weight and value.⁴⁸

Aquaculture is practiced in every province and in the Yukon and takes place in marine environments, freshwater lakes and rivers, land-based ponds, or tanks.

Production varies across the country depending upon the species being farmed, the environment within which it is farmed (marine or freshwater), the conditions on the ocean, lake, or river floor (e.g.: sand or rock), and the culture technologies used.

Figure 47: Types of Aquaculture in Canada shows how the scope of aquaculture operations vary across the country depending upon the species being farmed, the environment (marine or freshwater) and the culture technologies being used (land based, ocean, or lake based). The main types of growing operations include freshwater net pen and land-based systems; bottom culture shellfish operations in intertidal zones;



long-lines, net pens and restocking operations in open water; and bottom culture shellfish grow-out areas in sub-tidal zones.

There are 26 different species of finfish cultivated in all regions of Canada. Finfish represents the largest component of the aquaculture sector. Salmon (Atlantic, Chinook and Coho) is the most significant finfish in terms of volumes produced and sold, although several species of trout and Arctic char are also produced.

Figure 47: Types of Aquaculture in Canada

Shellfish is an important part of the aquaculture sector on Canada's East and West coasts with 16 different species cultured. Mussels and oysters are the most significant in terms of volumes produced and sold, but clams, scallops, and other species are also growing sectors.

Marine algae farming is a small, yet growing sector in Canada, with many species of kelp, moss and seaweed cultivated in the Atlantic provinces.

The diversity of species in all sectors is expected to increase in the coming years.⁴⁹

Canada's production of cultured fish and seafood other than salmon and molluscs has shown little growth since 2000; in 2017 Canada produced ██████% of the world's aquaculture output.

Molluscs contribute about ███% of Canadian aquaculture production by quantity and about ███% of value while freshwater species are ███% of quantity and less than ███% of value. The remainder of Canada's aquaculture is salmonid species (█████% of quantity, █████% of value).⁵⁰

Aquaculture production in Canada increased more than two-fold between 2000 and 2018 with farm gate value increased from \$██████████ to just over \$██████████ (Figure 48: Canadian Aquaculture Production Growth) mainly to sharply increased salmon prices as output in Chile dropped.

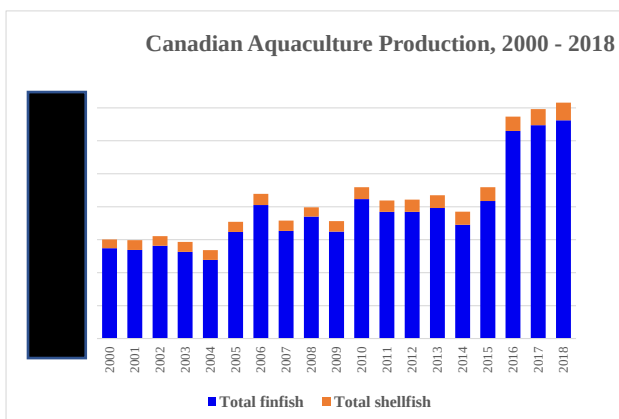


Figure 48: Canadian Aquaculture Production Growth⁵¹

According to the 2018 statistics, reported by DFO⁵², there are ■ aquaculture establishments in Canada with most of them located in the Atlantic region (■%). Despite the overwhelming number of farms, Atlantic fish farms produce a smaller volume of fish (■%), which also results in less money collection (■%), as shown in Figure 49: Number of Aquaculture Establishments in Canada, 2018 and Figure 50: Canadian Aquaculture Volume and Value of Fish Production, 2018.

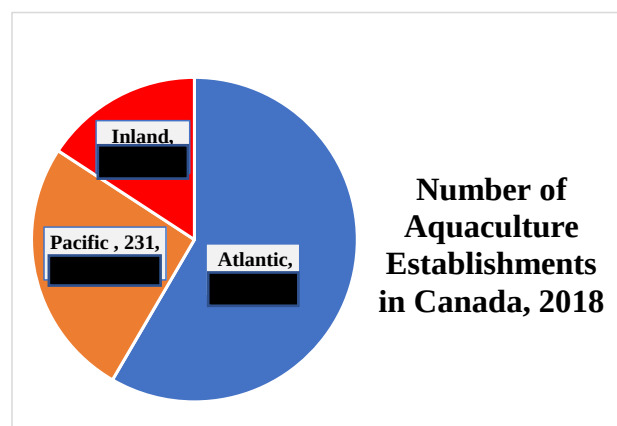


Figure 49: Number of Aquaculture Establishments in Canada, 2018

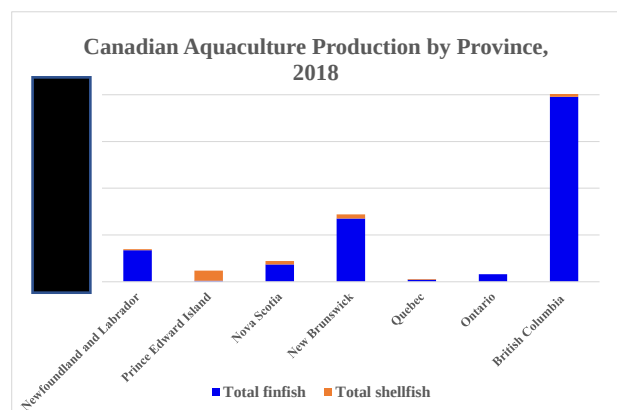
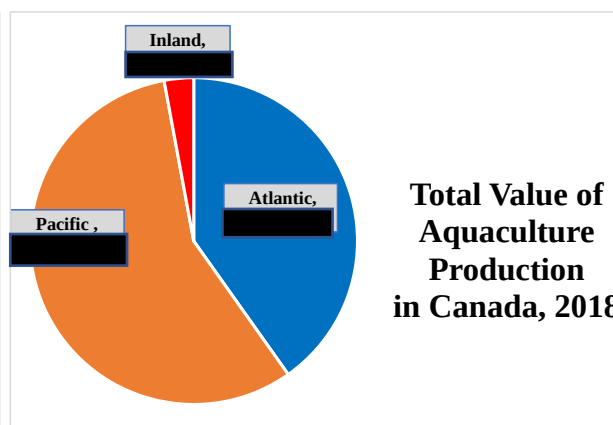
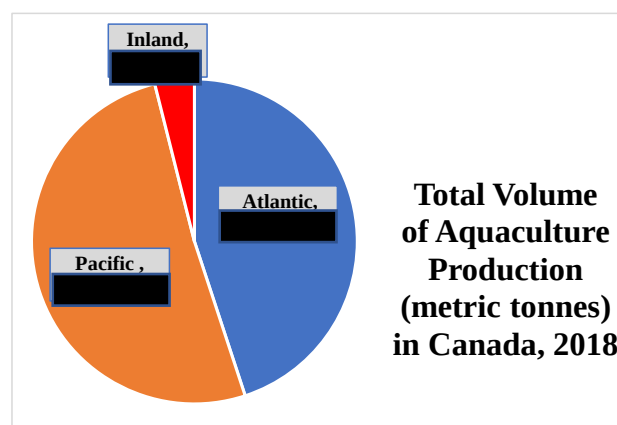


Figure 50: Canadian Aquaculture Volume and Value of Fish Production, 2018

In Canada, about ■% of salmon production is from aquaculture. Salmon aquaculture occurs on both coasts, although most of the production occurs off the west coast. Canada primarily farms Atlantic salmon, although small volumes of Pacific salmon are farmed in British Columbia. While Atlantic salmon is the dominated species farmed in Norway and Chile, there has been rapid growth in Chilean farmed Pacific salmon that does not appear to be matched in Canada.

While globally more than ■% of molluscs are produced by aquaculture, in Canada only about ■% of production is from culture. Shellfish aquaculture in Canada is dominated by mussels and oysters, species with limited wild capture production. Oyster production is split almost equally between the east and west

coasts, while PEI produces most cultured mussels. Most of the bivalve production does not enter international trade, but some species travel long distances to reach their customers.⁵³

	Volume (Metric tonnes)	Value (\$'000)	Main Producing Province
Salmon			
Trout			
Steelhead			
Other finfish			
Clams			
Oysters			
Mussels			
Scallops			
Other shellfish			
Total Aquaculture			

Figure 51: Aquaculture Production by Species in Canada, 2018⁵⁴

BC leads in Canadian aquaculture. There are four types of aquaculture in B.C.:

- Marine finfish (almost exclusively Atlantic salmon) – approximately █ sites primarily in the Campbell River, Port Hardy and Tofino areas;
- Shellfish (e.g., clams, oysters, mussels, scallops, and geoducks) – approximately █ sites;
- Freshwater finfish (pond culture of rainbow trout; private hatcheries for sturgeon, Coho salmon, and sockeye salmon) – approximately █ sites;
- Enhancement facilities where Pacific salmon are raised and released to rebuild wild fish stocks and provide fishing opportunities.

The Campbell River and Comox (Comox-Strathcona) region leads in salmon production. Most of the spending that drives economic impact occurs here. This includes [THE MAJOR SALMON COMPANIES THAT ARE HEADQUARTERED IN CAMPBELL RIVER, AS WELL AS MANY OF THE COMPANIES SUPPLYING GOODS AND SERVICES INCLUDING FISH PROCESSING, NETS AND MAINTENANCE, TRANSPORTATION, PACKAGING, CONTAINERS, DIVING SERVICES, AND MACHINERY AND EQUIPMENT](#). As well, most of the employees working the salmon sites are based there. With the decline in forestry and the commercial fisheries, salmon and shellfish aquaculture occupy an increasingly important place in the economy of Vancouver Island.^{55 56}

New Brunswick, the second contributor after BC, is specialized in the shellfish aquaculture industry. Shellfish aquaculture operations are carried out on leases allocated by the provincial government. Most of these leases are located on New Brunswick's east coast. Although *Crassostrea virginica* (eastern oyster) is the main shellfish species that is commercially farmed, there is potential for other species, such as bay scallops and clams. In the province in 2016, there were more than █ leases covering approximately █ issued for shellfish aquaculture. Other spaces suitable for shellfish aquaculture that have been identified along New Brunswick's coasts could be put into production. In New Brunswick, eastern oysters are farmed on the seabed or in suspension in the water column where conditions are the most suitable for growth. Because they filter their food from the sea, shellfish assist in improving the quality of the coastal marine ecosystem. Shellfish aquaculture is recognized as being environmentally friendly. New Brunswick farmed oysters are a premium product characterized by their shape, meat yield, and taste. The oysters are

marketed fresh year-round in North American, Asian, and more recently, European markets. Food safety is assured through the Canadian Shellfish Sanitation Program (CSSP), which meets some of the highest standards in the world and is intended to protect consumers in domestic and international markets. Given this assurance of food safety and traceability through the value chain, Canadian products have an international reputation for quality.⁵⁷

WITH THE DECLINE IN COMMERCIAL FISHERIES, SALMON AQUACULTURE OCCUPIES AN INCREASINGLY IMPORTANT PLACE IN CANADA AND BRITISH COLUMBIA IN PARTICULAR. IT SHOULD BE NOTED THAT AQUACULTURE PRESENTS A TARGET MARKET FOR THE CLIENT'S FISH FEED BAGS AND FISH TAGS; HENCE UNDERSTANDING ITS DYNAMICS, DRIVERS AND DEVELOPMENTS IS IMPORTANT FOR PROPER ASSESSMENT OF POTENTIAL OPPORTUNITIES FOR THE PRODUCT.

Commercial Fisheries: Atlantic Dominance in Production and Fishnet Usage



Figure 52: Canadian Commercial Fishing Vessel

History of Commercial Fisheries in Canada

The Canadian fishing industry traces its origins back to the first European Settlers who arrived in Canada and harvested seafood products for survival and transportation back to Europe. French, English, Spanish, and Portuguese settlers first began fishing off the Grand Banks of Newfoundland in the 16th century.

The American Revolution and Napoleonic Wars increased British dependence on the North American fisheries located on the East Coast to sustain their troops, caused the Atlantic economy to grow, and intensified the establishment of permanent communities based on harvesting seafood.

Following Confederation in 1867, Canada's federal government established the Department of Marine and Fisheries to oversee Canada's fisheries and aquacultural resources. The relationship between Canada and the United States during these years following confederation was rocky and uncertain as disputes arose over control and access to the fisheries located in the North Atlantic.

The Second World War saw the widespread adaption of modern technology and communication devices such as radios, sonar, nylon nets, and hydraulic power equipment to haul in larger catches of seafood products. The fleet of boats and harvesting vessels became more sophisticated with the construction of larger vessels and developing more powerful engines. During this period, the federal government supported independent fishermen by funding the construction of new vessels through a series of subsidies,

creating the Fisheries Price Support Board in 1947 to help with fluctuating prices, and extended unemployment insurance to self-employed fishermen.

Due to over-expansion and unstable markets, the fishing industry in Canada was constantly cycling between boom-and-bust periods that created widespread uncertainty and instability in the affected fishing communities. The government responded by introducing limits on the size and overall number of vessels that could operate in any given fishery, establishing industry-government advisory committees to foster communication between industry stakeholders and government policy makers, encouraging fishermen to form collective organizations (an example of such an organization is the Canadian Council of Professional Fish Harvesters), and introduced fishing quotas and operational zones. Although these solutions were effective to some degree, the Canadian fishing industry continued to experience widespread instability and significant crises throughout the following decades.

The Department of Fisheries and Oceans was established in 1979 and has since been responsible for overseeing fisheries management and research, oceanography.

Industry Monitoring

DFO has established guidelines and procedures to support healthy and productive ecosystems and maintain the fisheries' sustainability. All seafood products that come from Canada's fisheries are required to be inspected and comply with product and processing standards for domestic and international consumption. For a fish or seafood product harvested or produced in Canada to be eligible for export, it has to meet defined standards and originate from a registered fish processing establishment.

An important part of establishing sustainable fisheries in Canada is certifying and monitoring where fish and seafood products originate from, where they are processed, and how they are sold to consumers. Certification of fish and seafood products means that producers must show evidence that their products have been harvested and grown in a sustainable manner. Certification and traceability ensure that fish and seafood products harvested from Canada's fisheries comply with chain of custody requirements established by an independent third-party to avoid conflicts of interest between regulators and industry members.

Thus, in response to the European Unions' Illegal, Unreported, and Unregulated (IUU) fishing regulations implemented on January 1, 2010, DFO established Canada's Catch Certification Program to oversee the distribution of catch certificates to Canadian fish harvesters and producers who export seafood products to the European Union. The goal of the European Union's IUU regulations was to identify and prevent illegitimate seafood products from entering European markets. For example, if a fish was caught by an unlicensed fisherman and then sold as a different type of fish, or a fisherman was unable to demonstrate the legitimacy of their product through supply chain traceability, then this product would not be able to be sold in Europe.

The Catch Certification Program provides government certified catch certificates to exporters of fish and seafood products harvested and processed in Canada. The benefit of this program is that Canadian producers and exporters can sell their seafood products in countries that have an established IUU frameworks such as countries in the European Union, Japan, Chile, and Ukraine. Essentially, this program tells importers that Canadian fish and seafood products have been harvested and processed in sustainable fisheries, have documentation that shows where exactly the product was during each stage of its processing, and guarantees that the product is genuine and authentic.

Aside from the fisheries keeping track of their catch in electronic and paper logbooks, there are several programs that provide an external monitoring.

- The At-Sea Observer Program provides independent third-party verification of fish harvesting activities. Observers are assigned to fishing vessels operating in the offshore, inshore, and near-shore

areas. The program provides accurate and timely information on fish harvests. It also provides scientific catch and sampling data for fisheries management and scientific research purposes. Commercial fishers make agreements with service providers qualified by the Canadian General Standards Board and designated by Fisheries and Oceans Canada.

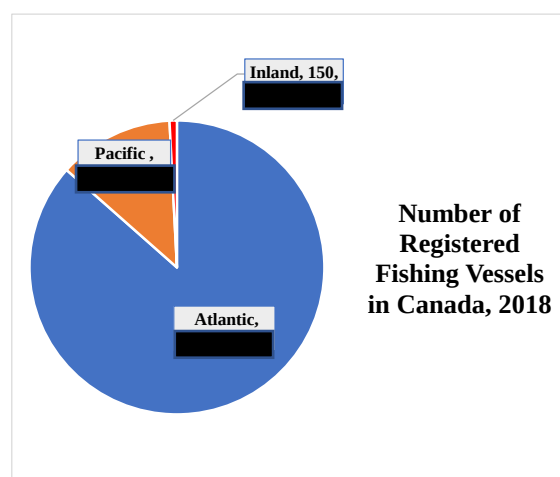
- The Dockside Monitoring Program provides independent third-party verification of fish landings. Commercial fishing licenses require participation in the program for most species (for all or a portion of fleets and landings). The program supports fisheries management by providing accurate and timely harvest data, including the weight and species landed. The program is paid for by the fishing industry. Commercial fishers make agreements with service providers qualified by the Canadian General Standards Board and designated by Fisheries and Oceans Canada.
- The Vessel Monitoring System is a program for tracking the positions and movements of vessels. License conditions for certain Canadian and foreign fishing vessels require them to participate in the Vessel Monitoring System. Participating vessels must buy, carry, and register an approved vessel monitoring unit.

Production Levels on Canadian Commercial Fisheries

After the decline of Atlantic cod stocks, the commercial fishing industry on Canada's East Coast underwent a period of significant change. In the early 1990s, groundfish played a major role in the fish harvesting and processing sectors in Atlantic Canada, representing almost one-half of all landings in terms of quantity. Over time the predominance of groundfish was reduced.

On the Pacific coast, the quantity of landings of salmon and, to a lesser extent, herring have consistently declined since the early 1990s. Salmon and herring landings have declined from almost one-half of the total catch in 1990 to about one-fifth in 2011. Landings of Pacific salmon and herring - based on dock price – have also dropped.

In recent years, shellfish on both coasts have replaced other species as the main species harvested. The most important crustaceans harvested in Canada are lobster, snow crab and shrimp. Typically, these species account for over a half of the total value of landings of marine species in Canada.⁵⁸



Due to the relatively high value, the value of fish landings has remained stable despite declining quantities of overall landings.

FISHERIES IN THE ATLANTIC COAST ARE THE LARGEST CONTRIBUTORS TO CANADA'S FISH PRODUCTION, employing over [REDACTED] fishing vessels ([REDACTED]%) and accounting for [REDACTED] of the total Canadian catch in 2018 valued at \$ [REDACTED] ([REDACTED]%) of the total.⁵⁹ Pacific Coast hosts [REDACTED] fishing vessels ([REDACTED]%), which contribute about the same share of fish landing size to the national economy valued at \$ [REDACTED] million.

Figure 53: Number of Fishing Vessels in Canada, 2018

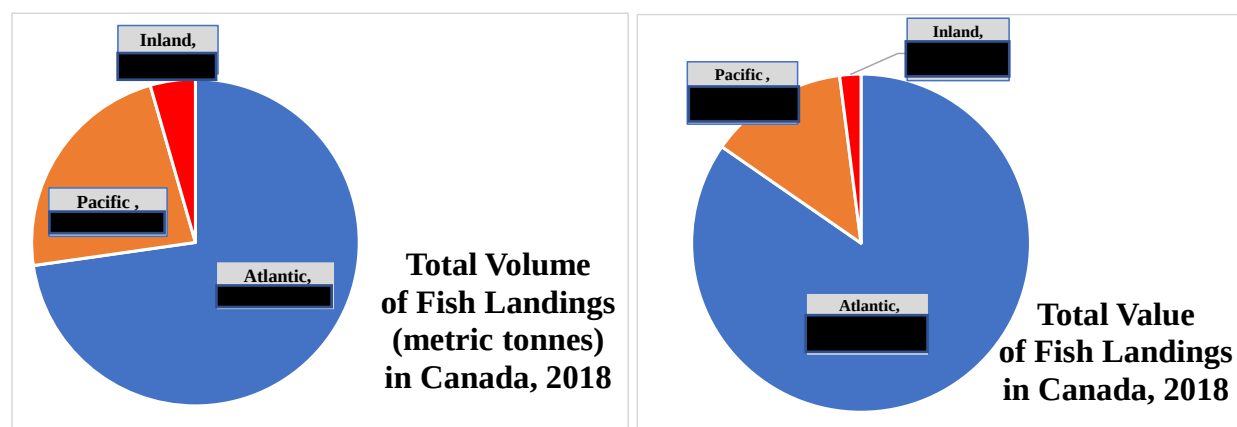


Figure 54: Commercial Fisheries Landings in Canada, 2018

Marine commercial fishing occurs in six of ten Canadian provinces and one territory - Nunavut. **NOVA SCOTIA, NEWFOUNDLAND AND LABRADOR AND BRITISH COLUMBIA ARE THE TOP THREE PROVINCES WHERE FISHING HAS THE GREATEST VALUE. BRITISH COLUMBIA ALSO BENEFITS FROM MAJOR AQUACULTURE PRODUCTION.**

As shown in Figure 55: Commercial Sea Fisheries Landings by Species Groups and Region, 2018, shellfish is the core content of landing in Canada sourced primarily from Atlantic region.

	Atlantic	Pacific	Canada
Total Volume of Landings (metric tonnes)			
Groundfish			
Pelagics			
Shellfish			
Other			
Total Value of Landings (\$'000)			
Groundfish			
Pelagics			
Shellfish			
Other			

Figure 55: Commercial Sea Fisheries Landings by Species Groups and Region, 2018⁶⁰

More detailed data on species fished in different provinces is summarized in Appendix C: Statistics of Canadian Commercial Fish Landings. Thus, in 2018, over [REDACTED] of the commercial marine catch was landed in Nova Scotia, valued at \$[REDACTED]. The main species caught in this province were lobster contributing \$[REDACTED] followed by scallops [REDACTED] and crabs (\$[REDACTED]), as well as haddock, halibut, and herring (Table 10: 2018 Value of Atlantic & Pacific Coast Commercial Landings, by Province (thousand dollars)).

Newfoundland and Labrador recorded the second largest commercial landings in 2018 ([REDACTED]% of the total), with catches valued at \$[REDACTED] million. Crab contributed almost \$[REDACTED] million followed by shrimp valued at \$[REDACTED] million.

British Columbia ranked third, contributing nearly \$[REDACTED] to the total commercial landings in Canada with salmon remaining the key contributor of \$[REDACTED].

In Canada, freshwater or inland commercial fishing takes place primarily in Lake Erie, Lake Huron, Lake Ontario, and Lake Superior in Ontario, in lakes Winnipeg, Cedar, Manitoba and Winnipegosis in the province of Manitoba, and in Great Slave Lake in the Northwest Territories. In 2018, total freshwater harvest was valued at \$[REDACTED], or about [REDACTED]% of the total commercial catch in terms of value (

Table 11: Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2018 (Nominal catches (Q) in tons, live weight. Values (V) in thousand dollars).

The top species fished commercially in Canada are yellow pickerel, whitefish, and perch. Landings of these three species represented close to [REDACTED]% of the total quantity of freshwater species caught in Canada in 2018.

Fishing Gear in Canada

In 2011, almost two-thirds of the landings from commercial fisheries on the Atlantic coast were captured with pots and traps. Pots and traps were also the primary fishing gear in the Pacific coast. Species caught using trawling gear, was the second largest contributor to landings in 2011, accounting for [REDACTED]% and [REDACTED]% of total value of catches in the Atlantic and Pacific regions, respectively.⁶¹

	Pacific	Atlantic
Seine Nets	[REDACTED]	[REDACTED]
Trawls		
Dredge (Boat)		
Gillnets		
Longline		
Hooks and Other Lines		
Pots and Traps		
Miscellaneous Gear		
Total		

Table 2: Commercial landings by gear type, marine fisheries, Canada, 2011, “000\$

AS DISCUSSED IN SECTION DANGERS OF GHOST FISHING, THE BIGGEST DANGER FROM GHOST FISHING COMES FROM GILLNETS AND TRAPS AND POTS. TRAPS AND POTS REPRESENT THE MAJOR SHARE OF GEAR ((VALUE-WISE) ON BOTH COASTS IN CANADA: [REDACTED] IN THE ATLANTIC AND [REDACTED] IN THE PACIFIC REGION). FISHERIES WHICH USE THIS GEAR (LOBSTER AND CRAB CATCHERS) ARE THE MOST LIKELY CUSTOMERS OF THE CLIENT’S PRODUCT.

COMMERCIAL FISHERIES IS THE KEY TARGET MARKET FOR FISHING NETS. THE LARGEST OPERATORS OF TRAPS AND POTS AND ACCORDINGLY THE LIKELIEST CONTRIBUTORS TO GHOST FISHING ALSO OPERATING UNDER STRICT REGULATORY OVERSIGHT- ATLANTIC LOBSTER AND CRAB TRAPPERS SHOULD BE THE FOCUS OF THE CLIENT’S EDUCATIONAL EFFORTS.

⁶¹ Fisheries and Oceans Canada: Commercial Fisheries and Aquaculture. <<https://www.dfo-mpo.gc.ca/stats/commercial/cfs/2012/section2>

Residential Fishing: Inland Fishermen Lead in Investments in Industry



Figure 56: Recreational Fisherman

With over two million lakes and rivers that flow into five major ocean drainage basins, Canada is well known for its recreational fisheries. Fishing has historically been one of the country's popular leisure activities for both Canadians and visitors alike.

Every year, anglers from all around the world come to visit and participate in recreational fishing activities across Canada. The important socio-economic contributions of recreational fishing are felt in all of Canada's provinces and territories, particularly in some of the more remote areas of the country.⁶²

The governance structure for managing Canada's recreational fisheries is a complex combination of federal, provincial, and territorial legislative and management responsibilities. The table below provides a summary of the different management responsibilities for recreational fisheries in Canada.

Table 3: Summary of Federal, Provincial and Territorial Responsibilities, Management of Recreational Fisheries, Canada⁶³

Province/Territory	Federal (DFO)	Provincial / Territorial	Co-Management Boards
Newfoundland and Labrador	marine species		
Prince Edward Island, New Brunswick, Nova Scotia	freshwater species anadromous, catadromous, other marine species	freshwater species (licensing) anadromous species fished in inland waters (licensing)	
Quebec	all other marine species	freshwater, anadromous, and catadromous species	
Ontario, Manitoba	marine species	freshwater species	
Saskatchewan	Aboriginal fisheries and fish habitat protection	day-to-day legislative fishery amendments	
Alberta		freshwater species	
British Columbia	salmon in marine and freshwater salmon – tidal waters (licensing) other tidal water species	freshwater species inland salmon sport fishing (licensing)	
Northwest Territories, Nunavut		sport fish licensing (Order- in-Council)	fishery allocations; provide advice on conservation, fishery management and science activities
Yukon	marine species	freshwater species	

According to the data reported by DFO for the year 2018⁶⁴, the majority of anglers can be found in Inland regions (■■■■■, ■■■% of the total). The Atlantic area houses ■■■% of all anglers and the Pacific ■■■% or ■■■■.

The population of active adult anglers is older relative to the general population. Almost half of Canadian anglers (■■■■%), for example, were in the 45-64 age group whereas only ■■■% of the general Canadian population fell within the same age range.

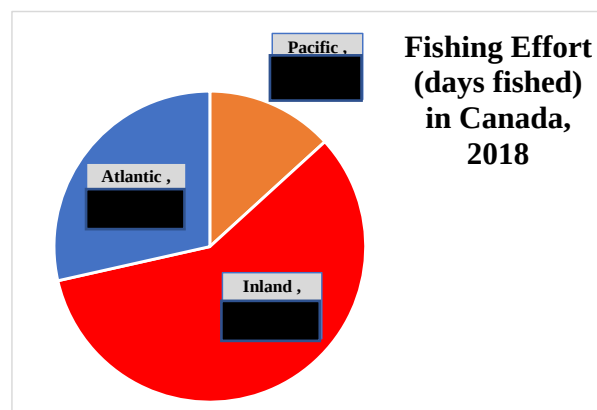


Figure 58: Number of Total Days in 2018 Fished by Anglers

According to the most recent survey on recreational fishing in Canada, conducted every 5 years⁶⁵, in 2015, residential anglers continued to make up the majority of the active angler population in Canada, particularly in Ontario and Quebec, which accounted for ■■■% of all active resident anglers. Most Canadian non-resident and foreign anglers travelled to fish in either Ontario or British Columbia (Tidal Waters) for their recreational fishing activities. These trips accounted for almost ■■■% of all fishing trips taken by non-resident anglers in Canada.

Canadian non-resident and foreign anglers made over ■■■ trips within Canada in 2015. Almost half of these trips (■■%) were made specifically to fish for recreation in the jurisdiction they visited.

Overall, walleye was the most predominant species caught nationally, representing a quarter of the total catch, followed by trout, northern pike, perch and bass. Trout is the most predominant species harvested by resident anglers, while walleye is the predominant species among all non-resident anglers.

Anglers contributed a total of \$■■■■ to various local economies in Canadian provinces and territories in 2018. Of this amount, \$■■■■ was in the form of investments and major purchases of durable goods related to recreational fishing activities. The remaining \$■■■■ covered direct recreational fishing expenditures during fishing trips, such as package deals, transportation, food, lodging, fishing services, and fishing supplies. The largest contribution came from Inland anglers (■■■■%) of the national total.

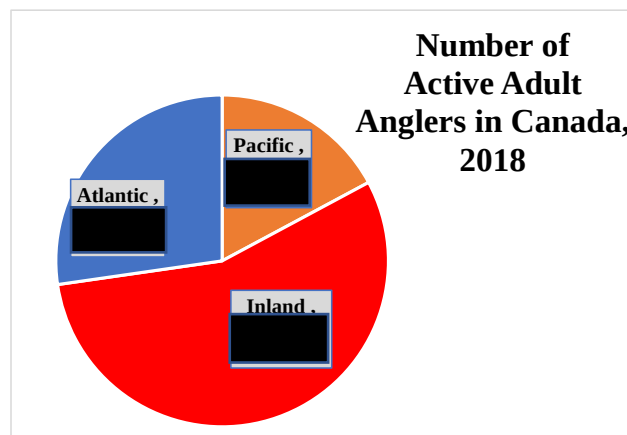


Figure 57: Number of Active Adult Anglers in Canada, 2018

The average number of days fished per angler was ■■■ days in 2015 compared with ■■■ days in 2010. In 2018, this number remained close to that in 2015. As demonstrated in Figure 58: Number of Total Days in 2018 Fished by Anglers, Inland fishermen spend the most days a year fishing (■■■■). Atlantic fishermen dedicate over ■■■ days to their hobby (■■%) of the total national level and those in the Pacific region spend ■■■ days on rivers, lakes, and oceans.

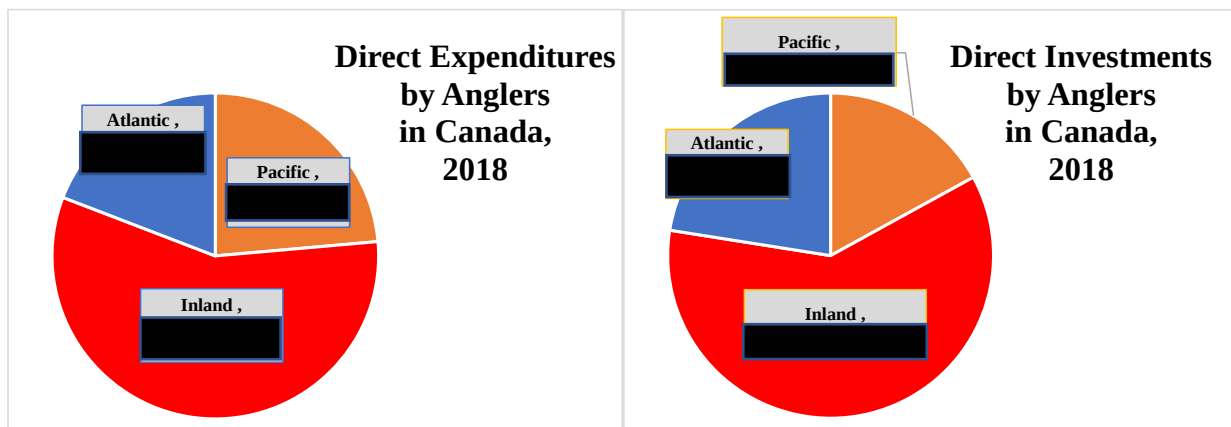


Figure 59: Canadian Anglers' Direct Investments and Expenditures in 2018

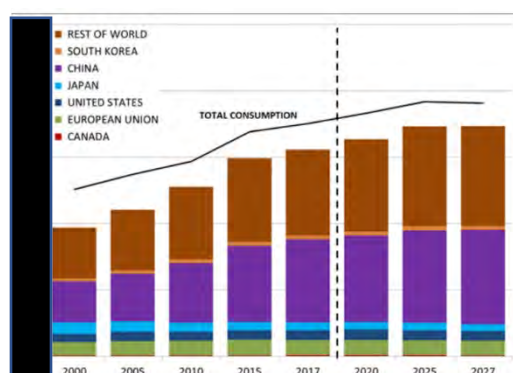
ANGLERS (RESIDENTIAL FISHERMEN) ARE LARGE IN NUMBER BUT LOW IN IMPACT ON THE FISHING INDUSTRY ECONOMY WHEN COMPARED TO AQUACULTURE AND COMMERCIAL FISHERIES. MEANWHILE, THE MAJORITY OF THEM ARE MAINLY ACTIVE IN INLAND, WHICH INDICATES THAT FRESHWATER FISHING IS DOMINATING THE RESIDENTIAL SECTOR. WHILE THE DAMAGE FROM ANGLERS' ENTANGLED FISHING LINES IS INSIGNIFICANT WHEN COMPARED TO THE DAMAGE FROM COMMERCIAL FISHING, ON THE LOCAL LEVEL, IT CAN CREATE SERIOUS CONCERNS FOR THE AQUACULTURE (E.G. CHILLIWACK / VEDDER RIVER IS HEAVILY POLLUTED WITH FISHING GEAR, WHICH THEN GETS SWEEPED DOWN TO THE FRASER RIVER AND ULTIMATELY ENDS UP IN THE PACIFIC OCEAN). THESE CONCERNS CAN BE ADDRESSED BY THE CLIENT'S PRODUCT.

16. OUTLOOK ON CANADIAN FISHING INDUSTRY: AQUACULTURE TO GROW, FISHERIES DRIVEN BY GLOBAL DEMAND

The Outlook to 2027 for Canadian Fish and Seafood was developed at Fisheries and Oceans Canada in 2018.⁶⁶

The world population will increase by more than 770 million, exceeding 8 billion by 2027. In absolute terms population will increase the most in China (28 million). In percentage terms, growth to 2027 is expected to be higher for the ROW aggregate (14%), Canada (9%) and the U.S. (7%), and significantly lower in South Korea (3%), China (2%) and the EU (1%). Japan's population is expected to decline by 3%.

Demand for fish and seafood is comprised of a) demand for direct consumption as food by humans (approximately 90% of total consumption), and b) demand for indirect consumption through other uses such as feed for aquaculture and animal production, or to a lesser extent as bait, an input to fisheries.



Total global consumption of fish and seafood will increase by about 9%, as direct consumption of food grows by over 11% to almost 174 million tons while other uses, such as fish meal and fish oil, decline by almost 13% to around 17 million tons. By 2027, over 40% of fish and seafood will be consumed in China, but only 17% of the world's population will live there. Fish and seafood consumption as food will remain stable in the EU, Canada, South Korea, and U.S.A., decline is expected in Japan (-13%), fueled by a combination of population decline, limited economic growth, and changing tastes.

Figure 60: Total Global Consumption of Fish and Seafood and Consumption as Food by Country (Million tons)

The use of fish for feed (fish meal and oil) will decline, with a number of factors contributing to this trend:

- High prices for fish-based products are encouraging food producers to substitute lower- priced vegetable proteins and oils into feed mixtures;
- Technological changes allow recovery of more fish processing waste;
- Aquaculture's ability to shift toward species with lower feed intensity requirements.

PRODUCTION IN THE WILD (CAPTURE) FISHERY WILL EXHIBIT LITTLE CHANGE IN TOTAL PRODUCTION OVER THE PROJECTION PERIOD, AS CAPACITY FOR GROWTH IS LIMITED BY NATURAL FACTORS. HARVESTS FROM MANY WILD STOCKS HAVE REACHED OR EXCEEDED THEIR SUSTAINABLE LIMITS AND SUSTAINED RECOVERY OF DEPLETED STOCKS WILL TAKE TIME.

In the U.S., legislated management measures have been underway since 2006 to reduce overfishing and rebuild overfished stocks. These goals have been achieved for a number of stocks, often with significant

harvest reductions. While new allowable harvest levels have increased for some stocks, these sustainable harvest levels may be lower than past unsustainable levels.

Similar measures to increase sustainability are being undertaken in several jurisdictions, including the EU, Canada, and through Regional Fisheries Management Organizations.

Planned harvest reductions in China are anticipated to reduce China's share of global capture fisheries from 19% to 16%. Nevertheless, China's harvest will continue to account for substantial shares of the global wild harvest of crab (47%), shrimp (38%), cephalopods and molluscs (24% each), other crustaceans (41%), and groundfish (20%).

The United Nations 2030 Agenda for Sustainable Development highlights the role the fisheries and aquaculture sector need to play in the fight to end world hunger, achieve food security, improve nutrition, and promote sustainable agriculture. In response to continued growth in demand for seafood, aquaculture will expand, but at a slower pace.

TOTAL AQUACULTURE PRODUCTION IS PROJECTED TO EXPAND BY ALMOST 100% FROM THE BASE PERIOD TO 2027. While aquaculture production already exceeds wild harvest destined for human consumption, cultured volume will surpass total capture fisheries harvest before 2027, reaching almost 100 million tons. **PRODUCTION IN DEVELOPING COUNTRIES (INCLUDING CHINA) WILL ACCOUNT FOR 60% OF GLOBAL AQUACULTURE PRODUCTION AND WILL CONTINUE TO BE CONCENTRATED IN ASIA (40%) WITH MARKED INCREASES IN LATIN AMERICA AND AFRICA.**

SHRIMP, SALMON, MOLLUSCS (NONCEPHALOPOD), AND FRESHWATER SPECIES WILL CONTINUE TO DOMINATE AQUACULTURE, AND ONLY MODEST EXPANSION WILL OCCUR AMONG OTHER SPECIES GROUPS. By 2027, the proportion of global production from aquaculture will increase:

- 10% for molluscs,
- 10% for salmon,
- 10% for freshwater species,
- 10% for shrimp, and
- 10% for crab.

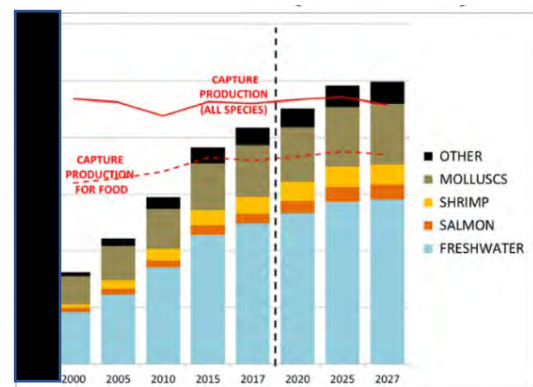


Figure 61: Global Supply from Aquaculture will Exceed Total Wild Harvest (Million tons)

Strong growth projections for global prices of key Canadian seafood exports support substantial gains in export value in the medium term, exceeding \$8 billion in 2027. After stabilizing near \$4 billion from 2000 to 2014, export value increased to over \$6 billion in 2016 and 2017. This was mainly a result of high prices for lobster and crab, but higher harvest volumes for both species also played a role.

LOBSTER WILL CONTINUE TO DOMINATE THE CANADIAN FISHERY EXPORT VALUE THROUGH 2027. VALUES FOR BOTH LOBSTER AND CRAB ARE EXPECTED TO REMAIN HIGH GIVEN STRONG DEMAND AND FEW SUBSTITUTES, ALTHOUGH RECENT DECLINES IN HARVEST OF CRAB TO MORE HISTORICAL LEVELS WILL LIMIT GAINS.

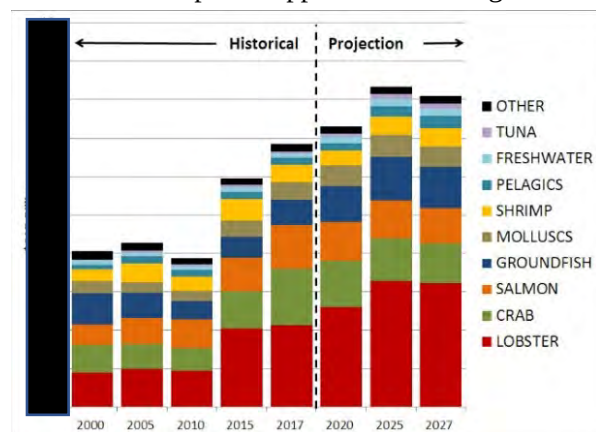


Figure 62: Canadian Exports by Species Group (Billions CAD)

Canada's fishery value is concentrated in capture fisheries, where output volumes change little and prices, rather than volume, drive major changes in the value of exports. Furthermore, Canada's species mix has a high proportion of the highest-valued species in global trade. The trade-weighted prices for Canadian seafood exports are expected to grow more rapidly than the corresponding world price, reflecting the faster price growth in key export products, lobster, and crab.

THE QUANTITY OF SEAFOOD EXPORTS FROM CANADA IS EXPECTED TO GROW ONLY SLIGHTLY (0.1%) BY 2027, MAINLY FROM AQUACULTURE. MEANWHILE, CANADA WILL REMAIN A MINOR PLAYER IN GLOBAL AQUACULTURE PRODUCTION. The market environment will support an expansion of Canadian aquaculture production from about 200 thousand tons in 2017 to almost 300 thousand tons annually for all cultured species combined.



Figure 64: Canada and World Fish Export Price (CADD per ton) and Quantity (Million Tons)

AMERICAN LOBSTER (HOMARUS SPECIES) FROM CANADA WILL CONTINUE TO INCREASE ITS SHARE IN MARKETS NOW DOMINATED BY OTHER LOBSTER SPECIES. While the price of lobster from Canada in

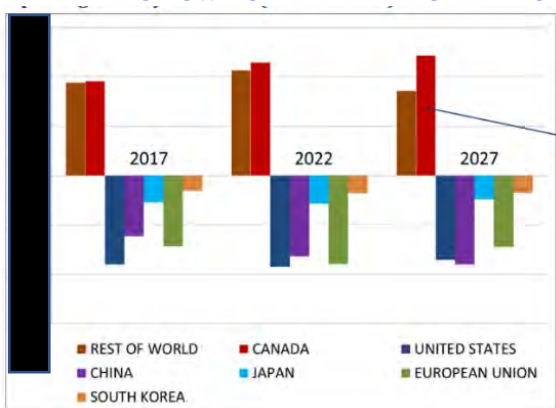


Figure 65: Canada Will Remain the Largest Exporter of Lobster (\$, Billions)

GROWTH IN CRAB CONSUMPTION WILL ALSO CONTINUE TO BE A RESULT OF INCREASED CONSUMPTION IN CHINA (UP 12% BY 2027). Crab consumption is expected to remain relatively constant in Canada, Korea, and the EU with expected decreases in the U.S. and Japan. Changing demographics,

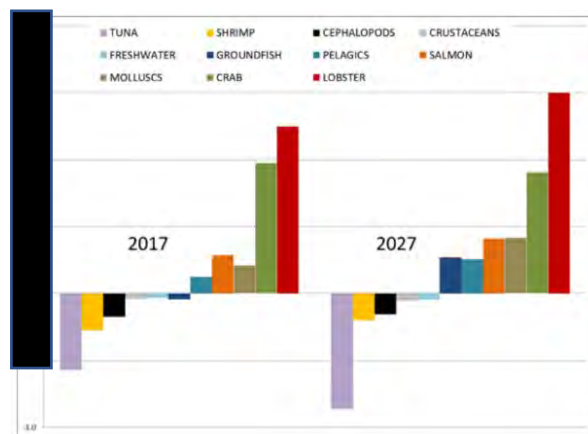


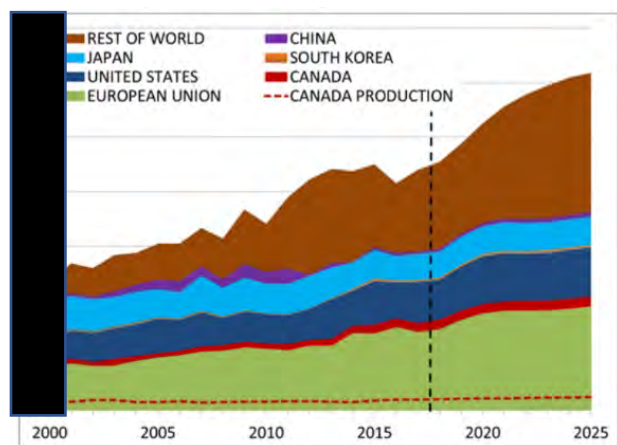
Figure 63: Canada's Net Trade by Species (CAD, Billions)

Canada is projected to maintain a strong export balance for most product groups in the medium term. OVERALL NET EXPORT VALUE IS PROJECTED TO INCREASE BY MORE THAN 12% BETWEEN 2017 AND 2027. LOBSTER AND CRAB CONTRIBUTE THE MOST TO CANADA'S POSITIVE TRADE BALANCE. Net exports of a number of products will increase between 2017 and 2027.

environmental, and health concerns may hinder continued growth in China's crab aquaculture production. Increased disposable income in China has increased demand for premium imported products.

tonnes)

Growth in Canadian salmon aquaculture will continue in response to strong world demand. Increased production efficiency for salmon culture has lowered costs and allowed prices to fall fueling growing consumption. World consumption of salmon is projected to increase by 40%, or almost 2 million tons, by 2027.



WHILE CANADA WILL REMAIN A SMALL PRODUCER OF FARMED SALMON ON THE WORLD STAGE, THE SECTOR GROWTH WILL CONTINUE TO BE SUPPORTED BY STRONG GLOBAL DEMAND.

Canada's production of cultured salmon is expected to remain at about 4% of global production. Positioning to take advantage of production efficiencies and potential opportunities in global markets could modify this forecast. The world's two largest producers, Norway and Chile, are currently facing constraints on expansion of production (space constraints, mortality resulting from high density production, environmental concerns), slowing their output growth.

Figure 66: World Demand for Salmon and Canadian Total Production (Million Tons)

While aquaculture is increasingly important to the world's food supply, Canada's aquaculture industry continues to face several challenges. Although Canada may seem well-suited for aquaculture production in terms of natural resources, a number of barriers have been identified as impediments to the growth of the sector including access to space for new production sites, negative public perception of the finfish industry, complexity of the federal regulatory framework, and the need for changes in the delivery of the Canadian Shellfish Sanitation Program. Many efforts are underway to resolve the sector's struggles, but the evolution of any major "breakthrough" is not currently clear.

High feed costs make bivalve culture attractive. Fish-based feed prices have been pushed higher in the past decade, due to biological constraints on harvest levels for species used for fish meal and fish oil, and the rapid expansion of feed-intensive aquaculture of species such as salmon and shrimp. Prices are expected to stay at these higher levels.

ACCORDING TO THE FORECAST, CANADA WILL RETAIN ITS CURRENT STATUS OF THE DOMINATING EXPORTER OF LOBSTER FOLLOWED BY CRABS WHILE MAINTAINING ITS SOMEWHAT MODEST POSITION OF SALMON TRADING. WITH THIS IN VIEW, IT IS LIKELY THAT THE POTENTIAL DEMAND IN POTS AND TRAPS FOR CAPTURING CRUSTACEANS WILL CONTINUE OFFERING MORE OPPORTUNITIES FOR THE CLIENT'S PRODUCT (BIODEGRADABLE NETTING). EXPECTED TO CONTINUE SALMON FARMING WILL SUSTAIN DEMAND IN OTHER TYPES OF PRODUCTS, SUCH AS FISH TAGS AND FISH FOOD BAGS.

17. COVID-19 IMPACT ON CANADIAN ECONOMY AND FISHING INDUSTRY

THE PANDEMIC LOCKDOWN THAT STARTED IN EARLY 2020 HAS HAD A DRAMATIC IMPACT ON ECONOMIES WORLDWIDE. WITHIN EACH INDIVIDUAL INDUSTRY AND SECTOR, THIS IMPACT HAS NOT BEEN UNIFORM; SOME OF THEM WILL FACE IRREPARABLE DAMAGE AND/OR TRANSFORMATION WHILE OTHERS HAVE PROSPERED. THIS SECTION EXAMINES THE IMPACT FROM COVID-19 LOCKDOWN(S) ON THE FISHING INDUSTRY AND WHETHER THIS IMPACT WILL ALTER THE PROJECTIONS ON INDUSTRY DEVELOPMENTS DISCUSSED IN SECTION OUTLOOK ON CANADIAN FISHING INDUSTRY.

Canadian Economy During COVID-19 Shows Varying Outputs

The outbreak of COVID-19 followed by the economy shut down impacted economic activity in Canada. The lockdown that started in March pummelled Canada's economy; yet by May, the nation witnessed the signs of slow recovery. According to Statistics Canada, real GDP contracted 8.2% annualized in Q1 as domestic demand collapsed amid declines in business investment, residential investment, and consumption. In May, it had a 4.5% growth, 6.5% in June and receded to 1.2% in August.

According to the economic news update released on November 6th, 2020⁶⁷, the economy has ceased its decline.

- Canada's unemployment rate edged down to 8.9% in October, after peaking at 13.7% in May. After peaking at 5.5 million in April, the total number of Canadian workers directly affected by the COVID-19 economic shutdown stood at 1.1 million in October. This includes net employment losses of 636,000 along with an increase of 433,000 in the number of Canadians who were employed but working less than half their usual hours.
- International merchandise trade has been recovering. After edging lower in August as trade flows stabilized, merchandise trade picked up in September as both exports and imports advanced. At \$94.3 billion, merchandise trade in September was 4% below pre-COVID levels. Much of the decline in the total value of trade since February reflected decreases in energy products and aircraft and other transportation equipment.
- Headline exports rose 1.5% in September, supported by a 23% increase in lumber exports which advanced for the fifth consecutive month. Rising lumber prices, bolstered by strong demand and lower supplies, brought lumber exports to their highest level in 14 years. Higher shipments of aircraft and passenger cars and light trucks also contributed to the increase in headline exports. Despite these gains, overall exports in September were 5.8% below pre-COVID levels, reflecting a sharp decrease in energy exports and lower shipments to the United States. Exports to countries other than the U.S. were 1% above pre-pandemic levels.
- Merchandise imports also rose 1.5% in September, led by a notable increase in crude oil shipments and higher imports of industrial machinery and equipment. Total merchandise imports in September were 2.3% below pre-pandemic levels, reflecting lower shipments from the United States.
- While merchandise trade flows have largely rebounded to near pre-pandemic levels, Canada's international trade in services remained well below levels observed in February, due to severe

contractions in travel-related services. Receipts from travel services in September were 70% below pre-COVID levels, while payments for travel services were 90% below.

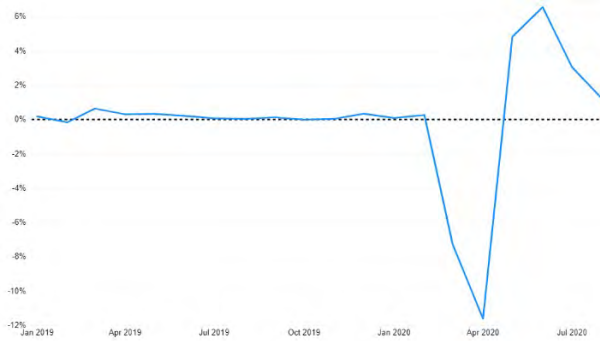


Figure 67: Canadian GDP, Jan 2019 – Nov 2020



Figure 68: Canadian Employment, Jan 2019 – Nov 2020



Figure 69: Canadian Exports, Jan 2019 – Nov 2020



Figure 70: Canadian Import, Jan 2019 – Nov 2020

According to the National Bank of Canada, while a rebound is likely in the second half of 2020 as more of the economy reopens and firms rebuild inventories, that will not make up for the first half collapse in economic activity, leaving Canada with the worst annual GDP contraction on record- despite unprecedented fiscal and monetary policy stimulus.

With the second wave of Covid-19 well under way in the country, an episode of labour market weakness cannot be excluded in the near term. Though the curve of new cases in Canada is much more encouraging than in other developed countries, Canada is not safe from a possible flare-up. Many provinces are closing bars, restaurants, theatres, concert venues, and physical fitness salons in many affected regions. Despite a probable downshift, the growth scenario is upwardly revised for 2020 (-5.5% vs. 5.7% previously). Next year has also been revised up (4.3% vs. 4.1% previously) given that there is now a light at the end of the tunnel (i.e., a vaccine) which could support business and consumer confidence.

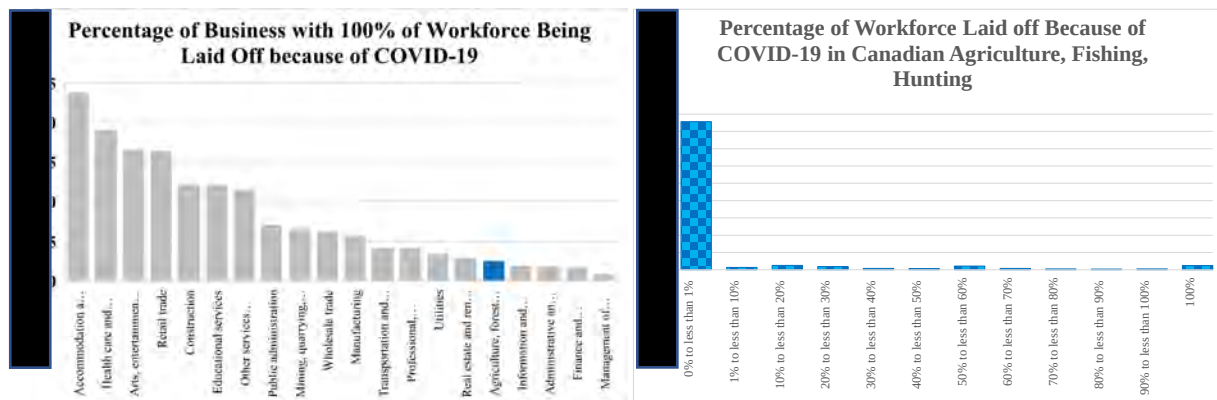
Canadian key economic indicators, as projected by National Bank of Canada, are summarized in the figure below.⁶⁸

Canada Economic Forecast							
(Annual % change)*	2017	2018	2019	2020	2021	Q4/Q4 2020	2021
Gross domestic product (2012 \$)	3.2	2.0	1.7	(5.5)	4.3	1.5	(3.6)
Consumption	3.7	2.2	1.6	(7.3)	4.8	1.7	(5.7)
Residential construction	2.2	(1.6)	(0.6)	(2.4)	3.3	4.3	(1.8)
Business investment	3.9	1.4	0.4	(9.7)	3.2	2.4	(6.7)
Government expenditures	2.9	3.4	1.7	(0.2)	3.0	1.8	0.5
Exports	1.4	3.1	1.3	(8.3)	6.6	0.2	(4.5)
Imports	4.2	2.6	0.6	(10.7)	7.3	0.5	(6.0)
Change in inventories (millions \$)	17,951	13,025	15,077	(2,885)	9,250	9,362	11,000
Domestic demand	3.3	2.1	1.3	(5.3)	4.1	1.8	(3.8)
Real disposable income	4.0	2.0	2.8	7.5	0.2	3.1	4.1
Employment	1.9	1.3	2.1	(5.2)	3.9	1.8	(2.9)
Unemployment rate	6.3	5.8	5.7	9.6	8.6	5.7	8.9
Inflation	1.6	2.3	1.9	0.6	1.8	2.1	0.5
Before-tax profits	19.9	2.5	(0.1)	(19.2)	12.7	5.5	(14.3)
Current account (bil. \$)	(60.2)	(55.5)	(47.0)	(53.8)	(55.0)		

Figure 71: Canada Economic Indicators Forecast for 2020 – 2021

COVID-19 Impact on Canadian Fishing Industry is Mild

Statistics Canada examined how COVID-19 impacted different industries. The results demonstrating the amount of laid off workforce is shown in Figure 72: %age of Canadian Businesses Laid off 100% of the Workforce in Q1 2020 vs. Q1 2019 because of COVID-19 . [ACCORDING TO THE REPORTED DATA, FISHING, AS PART OF AGRICULTURE, REMAINS THE LEAST AFFECTED COMPARED TO OTHER SECTORS WITH ABOUT 1% OF BUSINESSES LOSING 100% OF THE WORKFORCE.](#)


Figure 72: %age of Canadian Businesses Laid off 100% of the Workforce in Q1 2020 vs. Q1 2019 because of COVID-19⁶⁹

Fishing also was at the lower end among all other industries with about 1% of businesses losing over 50% of revenue. At the same time, about 95% of businesses either retained the same financials or have even improved their financial position, as shown in Figure 73: %age of Canadian Businesses Losing over 50% of Revenue in Q1 2020 vs. Q1 2019 because of COVID-19 .

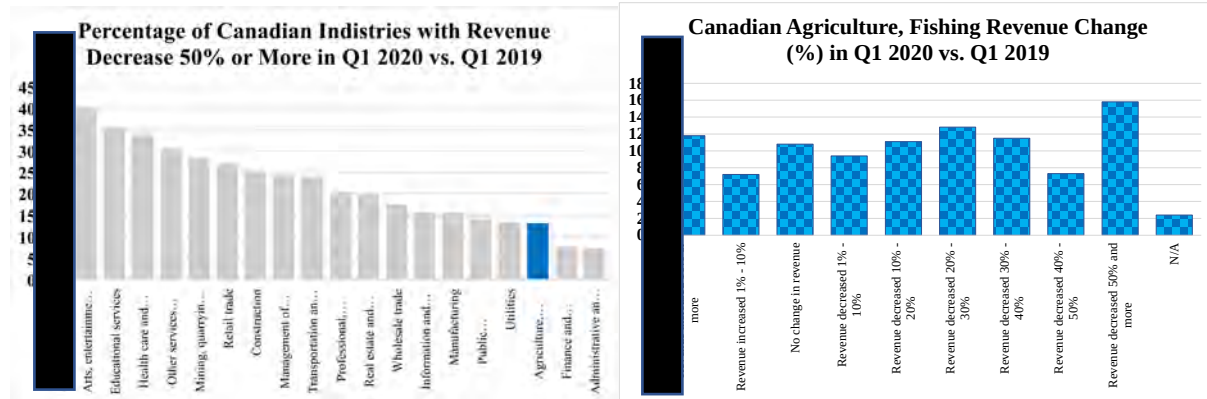


Figure 73: %age of Canadian Businesses Losing over 50% of Revenue in Q1 2020 vs. Q1 2019 because of COVID-19 70

Examination of the degree of the impact from COVID-19 to the decrease in demand in products and services showed that **FISHING EXPERIENCED SOME OF THE LOWEST IMPACTS FROM COVID-19 COMPARED TO ALL OTHER CANADIAN INDUSTRIES** (■% of businesses), as shown in Figure 74: Decrease in Demand for Products or Services in Canadian Businesses due to COVID-19 preceded by Public and Financial sectors only (■% and ■% respectively).

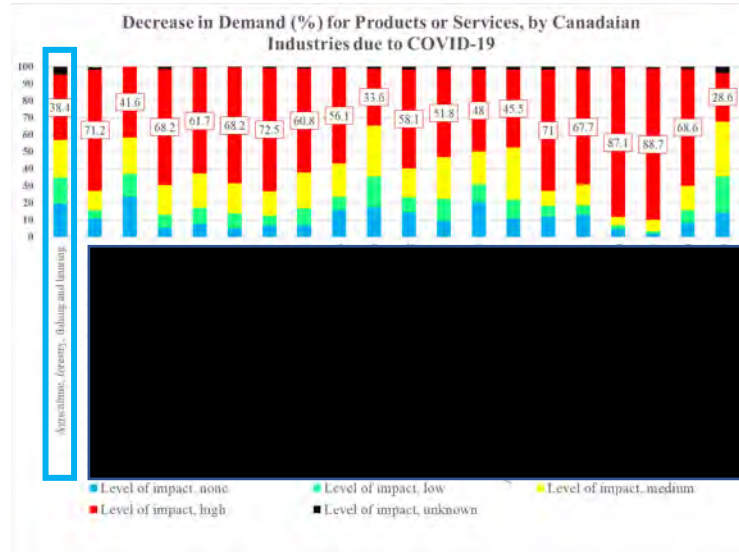


Figure 74: Decrease in Demand for Products or Services in Canadian Businesses due to COVID-19

Similar to the decrease in demand, Fishing was the second among all other industries which suffered the lowest degree of cancellation of services (only ■% of firms had their services cancelled completely), as shown in Figure 75: Cancellation of Services by Canadian Businesses due to COVID-19. Only financial services did better (15.8%).



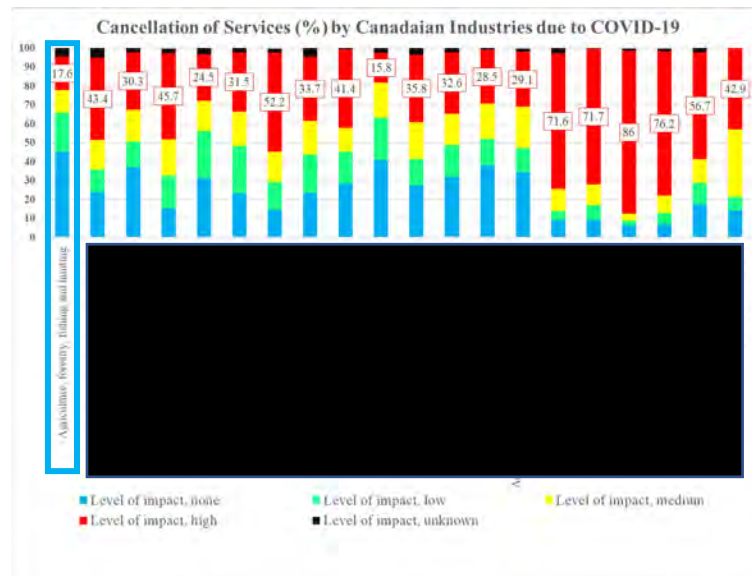


Figure 75: Cancellation of Services by Canadian Businesses due to COVID-19

AGRICULTURE (FISHING) HAS PROVED TO BE BETTER PROTECTED FROM THE LOCKDOWN CONSEQUENCES DEMONSTRATING THE LOWEST DECREASES WHEN COMPARED TO ALL OTHER INDUSTRIES IN THE CANADIAN ECONOMY.

Specifics of Fishing Sector Response to COVID-19

BECAUSE THE FISHING INDUSTRY IN CANADA HAS A DISCRETE STRUCTURE WITH DIFFERENT SECTORS FOLLOWING DIFFERENT OPERATIONAL PROCESSES AND PROCEDURES, THE PANDEMIC LOCKDOWN HAS HAD VARYING IMPACTS ON THESE SECTORS. DUE TO A LIMITED AMOUNT OF INFORMATION PUBLISHED ABOUT AQUACULTURE DURING COVID-19, THIS SECTION IS FOCUSED MAINLY ON COMMERCIAL FISHERIES AND RESIDENTIAL AND DISCUSSES IMPACT ON ANGLERS AND ALSO THE KEY EXPORT PRODUCTS THAT DRIVE THE CANADIAN FISHING INDUSTRY – CRAB AND LOBSTER.

Crab Production and Export Declined but Retail Picks up the Slack

CRAB PRODUCTION WAS AFFECTED FROM THE SUPPLY AND DEMAND SIDES. ⁷¹

Poor weather in spring in the Gulf of St. Lawrence and the Newfoundland and Labrador Canadian meant crab fisheries got off to a late start in the 2020 season; this reduced supplies in the early season.

Foreign buyers were not active. Global imports of crab (all types) fell by █%. China was hardest hit, with imports falling by over 40% to █ tons. US imports fell to █ tons.

Domestic demand suffered too. Since foodservice and restaurants have been closed, sales through these channels were cut off, and this represented a large segment of the crab market. As a solution, home deliveries increased. Established online and retail sales nearly quadrupled during the COVID-19

pandemic. Good demand through the retail sector and reduced supply pushed prices up to record levels. For the larger size, crabs' prices were above the five-year averages, and they still seem to be going up.

It may well be that the growth of home delivery will be a permanent result of the pandemic.

Lobster and Other Luxury Items Market is Seriously Affected

The 2020 lobster season in eastern Canada turned out to be noticeably short because the start of the season was delayed in Newfoundland and Labrador, Prince Edward Island, and Quebec.

Canada's lobster exports to China, which enjoyed a surge at the end of 2019 and in January 2020, dropped off dramatically in February with the advent of the COVID-19 pandemic.

Canadian exports began climbing again in March and April, although far from the volumes shipped at the start of 2020. In January, Canada shipped █████ tons of lobsters to China, █% more than in January 2019. Yet in February 2020, shipments dropped to just █████ (█% less than in February 2019), and █████ in March 2020 (█% less than in March 2019). In late May, Canadian exporters joined forces with some Chinese supermarket chains to promote lobster to rebuild the trade. Canada's Trade Commissioner Service network in China partnered with local retailers as well as e-commerce firms, targeting the "home cooking" market. As a result, trade picked up a little, but this is probably just as much due to the gradual return to "normal".⁷²



Demand on the domestic markets in both Canada and the United States of America was weak during the lobster season, and prices were "terrible", according to lobstermen.

Lobster is a typical restaurant item, and with restaurants closed due to the COVID-19 pandemic, there was little demand for this delicacy. A similar situation pertains to halibut, another luxury item, with sales having been curtailed by restaurants since the restaurant closure.⁷³

AS A RESULT, PRICES HAVE DECLINED AND WILL LIKELY STAY LOW WHILE THE PANDEMIC LASTS AND BEYOND.

THE DROP IN SALES THROUGH THE RESTAURANT SECTOR HAS BEEN COUNTERED BY LOBSTERMEN WHO HAVE TRIED DIRECT SALES TO THE CONSUMER. Direct sales are also being promoted through

Facebook. These efforts seemed to obtain particularly good results. Prices, however, remained below what they were before the COVID-19 outbreak.

In response to the low prices, harvesters in the Canadian province of Newfoundland and Labrador have set the minimum price at [REDACTED] per lb. This is the lowest since 2014. In 2019, harvesters were getting an average of [REDACTED] per lb.

THE LOBSTER OUTLOOK IS VERY UNCERTAIN. WHILE DEMAND SEEMS TO PICK UP SOMEWHAT IN SOME MARKETS (NOTABLY IN CHINA), MUCH WILL DEPEND ON THE DEVELOPMENT OF THE COVID-19 SITUATION.

In addition, worries remain about the future of luxury items. A weakening of the economy quickly translates into weaker sales of luxury items, including lobster. Furthermore, most countries have strict rules about reducing restaurant seating capacity, and this naturally limits sales through restaurants.

At any rate, PRICES WILL BE UNDER PRESSURE FOR AS LONG AS THE PANDEMIC LASTS. A CERTAIN SHORTAGE IN SUPPLIES MAY COUNTERACT THIS, BUT TIGHTER SUPPLIES WILL JUST OFFSET PRICE REDUCTIONS IN A NORMAL FUNCTIONING MARKET. THE PRESENT DEMAND AND PRICE SITUATION MUST BE EXPECTED TO LAST WELL INTO 2021.

Domestic Anglers are Getting Good Results

The COVID-19 pandemic has had a serious impact on travel tourism. In Canada, a large component of the economy is the outdoor tourism sector. This business relies primarily on anglers and hunters, most of whom travel north from the United States.⁷⁴

WITH THE PANDEMIC RAMPING UP AND STRICT MEASURES IN PLACE AT THE CANADIAN BORDERS TO KEEP NON-ESSENTIAL TRAVELERS OUT, NEXT YEAR'S OUTDOOR TOURISM SEASON IS STILL IN JEOPARDY. THE WINTER TOURISM AND ICE FISHING SEASON HAS ALREADY BEEN CANCELLED.

ONE OF THE OPTIONS IS TO FOCUS MORE ON THE DOMESTIC ANGLER AND IT HAS DRAWN SOME POSITIVE RESULTS. The restrictions placed on Canadians have not made it easy for them though with distancing required by local and provincial authorities. Keep Canada Fishing has created a Code of Conduct list of 10 guidelines for anglers fishing during the pandemic. Their report states that most anglers are following the guidelines.⁷⁵

INCREASE IN DOMESTIC ANGLER NUMBERS HAS BEEN VERY PROMISING AND IS LIKELY TO SUSTAIN IN THE FUTURE AS PEOPLE DEVELOP THE FOLLOWING HEALTHY HABITS OF THIS HOBBY, WHICH ALSO HELPS WITH LOWERING FOOD BILLS.

Canadians see fishing as a healthy and easy way to practice social distancing. Many anglers fish in secluded areas where they rarely see another boat on the water. In this respect, angling easily meets health directives pertaining to COVID-19. It is one of the few ways for Canadians to practice social distancing while still enjoying an engaging and productive activity.

There are other reasons to be optimistic. Fishing is an ecologically sound method of putting healthy food on the table. It is also a crucial part of the Canadian economy. During the COVID-19 pandemic, fishing offers an escape from the constant barrage of ever-changing information and worries.

This is small consolation for those in the fishing industry who rely on tourism. Many fishing lodges and charter companies are having to cancel bookings. Small retailers and "mom and pop" shops are also particularly hard-hit. Meanwhile, the number of purchased fishing licenses keeps growing.



FISHERMEN WHO USUALLY SELL THEIR CATCH TO RESTAURANTS OR RESTAURANT SUPPLIERS HAVE HAD THE INDUSTRY DROP OUT FROM UNDER THEM WITH COUNTRY-WIDE RESTAURANT CLOSURES. THOSE WHO SELL TO COMPANIES EXPORTING OVERSEAS HAVE ALSO FOUND AN ALARMINGLY REDUCED MARKET FOR THEIR PRODUCT, WITH MANY BORDERS AND PROCESSING PLANTS CLOSED, AND LITTLE TO NO DEMAND. SUPPLY CHAINS ACROSS THE GLOBE ARE STRUGGLING TO HAVE WORKERS TO MOVE FISH ALONG. THE FACT THAT THE FISHING INDUSTRY CAN'T SELL TO RESTAURANTS MEANS A LOT OF THAT PREMIUM-GRADE FISH IS ENDING UP IN GROCERY STORES. ON THE OTHER HAND, A LOT OF PEOPLE HAVE LOST THEIR JOBS AND ARE ON A TIGHT BUDGET. SOMETIMES SOME OF THESE OPTIONS ARE NOT AFFORDABLE.

SOME PARTS OF THE INDUSTRY ARE PIVOTING TO KEEP THEIR PRODUCT MOVING. MANY HAVE SWITCHED TO A DIRECT-TO-CONSUMER MODEL, WHICH MIGHT JUST BECOME THE FUTURE OF THE INDUSTRY.

IT IS LIKELY THAT THE LUXURY ITEMS' MARKETS WILL RECOVER IN PARALLEL WITH THE OVERALL ECONOMY.

18. PLASTIC PELLETS MARKET

Plastic (resin) pellets materials refer to a large class of polymers which consist of a range of synthetic or semi-synthetic compounds that are malleable and can be molded into solid objects of diverse shape about the size of a lentil. Plastic pellets are produced by petrochemical chemical companies and transported to plastic manufacturing facilities where they are melted down and shaped into a final product.

Plastic pellets are the building blocks for nearly every product made of plastic.

Plastic pellets market includes plastic materials, resins, and non-vulcanizable thermoplastic elastomers, and mix and blend resins on a custom basis and/or manufacture non-customized synthetic resins.

Plastic Pellets Market Segmentation

Plastic pellets market can be segmented by product and application.

There is a multitude of products that are manufactured within this sector:

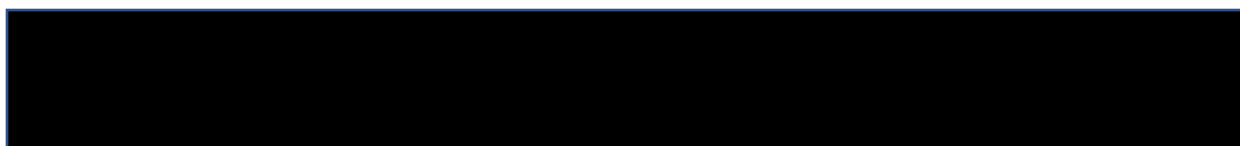
- High-Density Polyethylene (HDPE)
- Polypropylene (PP)
- Low-Density Polyethylene (LDPE)
- Polystyrene (PS)
- Poly-Vinyl Chloride (PVC)
- Polyethylene Terephthalate (PET)
- Polyurethane (PUR)
- Others

“Others” segment was the largest segment in the global plastic pellets materials market in 2018, accounting for █% of the market or \$█ billion⁷⁶. Acrylic polymers, polyether, polyamide, epoxide resins, amino resins, polycarbonates, elastomeric resins, vinyl acetate copolymers are the major plastic resin pellets materials within the “Others” segment constituting around █% of the “Others” segment.⁷⁷

The polyurethane segment is expected to be the fastest-growing segment going forward at a compound annual growth rate (CAGR) of █%.

The plastic resin pellets materials market is segmented by application:

- Packaging
- Automotive
- Construction
- Electrical and Electronics
- Logistics
- Consumer Goods
- Textile & Clothing



- Furniture & Bedding
- Agriculture
- Medical Devices
- Others

According to GrandView Research, the biggest application segment is Packaging, then Construction and Consumer Goods as shown in Figure 76: Global Plastic Resin Pellets Materials Market by Application.

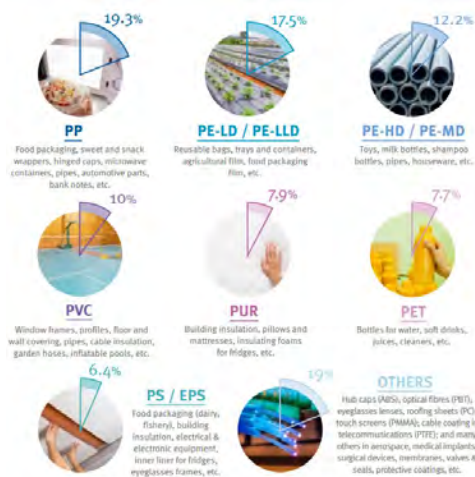


Figure 77: Plastics demand distribution by resin types 2018⁷⁹

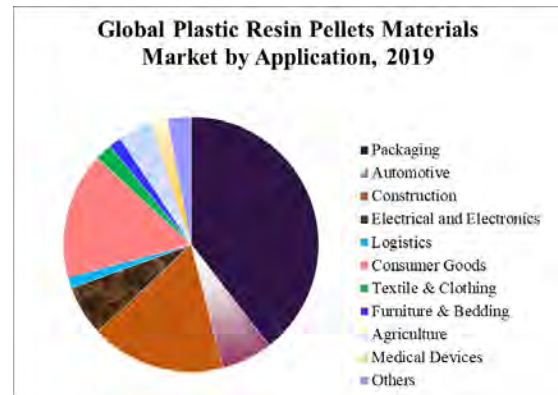


Figure 76: Global Plastic Resin Pellets Materials Market by Application⁷⁸

According to the data reported by PlasticsEurope Market Research Group and Conversio Market & Strategy GmbH, the highest demand for PP is coming from such sectors as food packaging, sweet and snack wrappers, hinged caps, microwave containers, pipes, automotive parts, bank notes, etc.

Opinions of different researchers on the regional distribution of plastics production differ. Maximize Market Research believes that North America and Asia are equal producers (■% each) while, Plastics Europe recons Asia to dominate with market holdings of over ■% of the market.

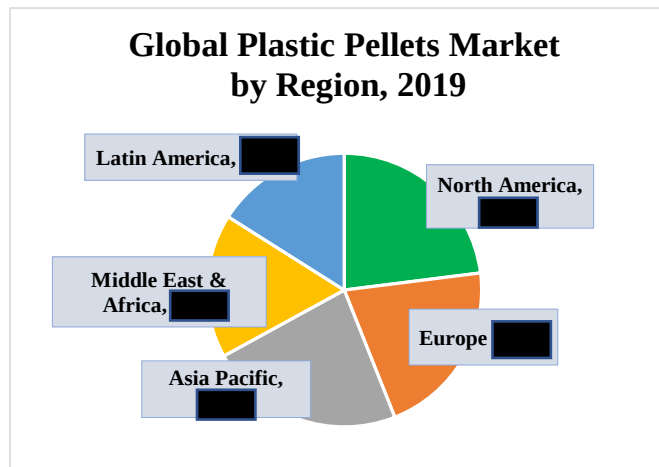


Figure 78: Distribution of Global Plastics Production⁸⁰

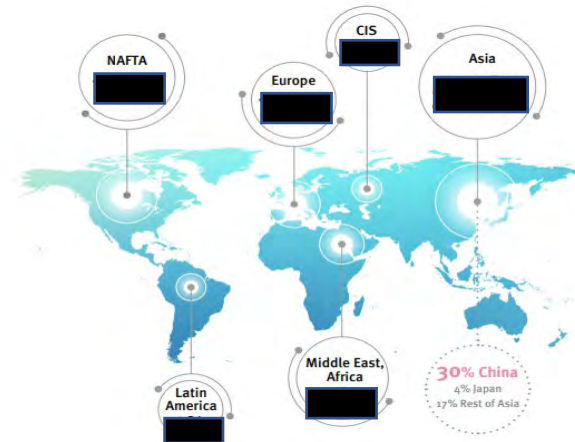


Figure 79: Global Plastics Production Distribution⁸¹

Plastic Pellets Materials Market Size

According to Business Wire, a Berkshire Hathaway company, the global plastic pellets materials market reached a value of nearly \$[REDACTED] billion in 2018, following a decline of CAGR of more than - [REDACTED]% since 2014⁸².

According to the report published by Allied Market Research, the global plastic resin pellets materials industry generated \$[REDACTED] billion in 2019.

The difference can be explained by profiling more companies by Berkshire Hathaway company in comparison with Allied Market Research accompanied by a consistent market size decline.

THE CONSULTANT BELIEVES THAT THE GLOBAL PLASTIC RESIN PELLETS MATERIALS MARKET SIZE EXCEEDS \$[REDACTED] BILLION.

Plastic Resin Pellets Market Drivers

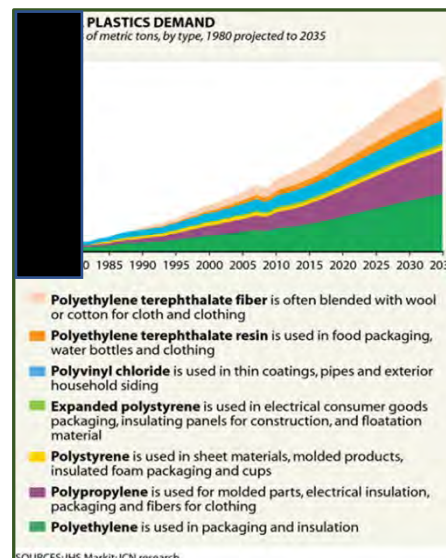
The plastic resins market is driven by various drivers that push it in opposing directions.

The key growth driver is increased demand for industrial packaging products⁸³. It has increased recently, particularly in emerging economies such as China and India. As the size of the middle-class is growing in these countries, the consumption of processed packaged foods, poultry, meat, and agricultural products increases. According to the World Bank, China's GDP per capita increased from \$[REDACTED] in 2014 to \$[REDACTED] in 2015 and India's GDP per capita increased from \$[REDACTED] in 2014 to \$[REDACTED] in 2015.

Analysts at HIS Markit forecast global plastic demand to grow on average ██████% per year in coming years as shown in Figure 80: Global Plastic Demand

The key restraints on the plastic materials and resins market are environmental regulations. Many of the products in the plastic materials and resins industry are potentially hazardous during the manufacturing stages because the manufacturing processes involve reactions that can be dangerous unless controlled carefully. In addition, some of the manufactured plastic products can have an adverse impact on both living organisms and the environment. Plastic material and resin manufacturers are to be compliant with complex regulations that govern labeling, handling, manufacturing, and shipping and storage of the product, leading to an increase in compliance costs for the manufacturers.

Figure 80: Global Plastic Demand ⁸⁴



The importance in reducing plastic pollution leading to contamination of soil and oceans, ghost fishing being just one part of it, has been growing in prominence. Governments worldwide are putting bans on disposable plastic items, demanding an overall decrease in plastic consumption. This factor has suppressing results on plastics market growth. It has also led to a rapid increase in demand for eco-friendly plastics, bioplastics, manufactured from polymer resins derived from plants and plastics that can be decomposed with the help of bacteria. For instance, global bio plastics production capacity was estimated to be around ██████ tons in 2017⁸⁵, the global market for bio plastics and biopolymers is expected to increase dramatically indicating high demand for eco-friendly plastic products.

Plastic material and resin manufacturers use recycled plastic products as raw materials to reduce raw material costs, lower carbon footprint, and reduce dependence on other materials such as oil and gas. Recycled plastic has properties nearly identical to those of virgin plastic (plastic material which is produced without using any recycled plastic products) and contains only a fraction of impurities. Additionally, the recycled plastic has a carbon footprint ██████% lower than new plastic. Recycled plastic costs ██████% less than the plastic made from virgin raw materials.

Virgin Resin Production in Canada

With a production value of approximately ██████ in 2017, virgin resin production accounts for the vast majority of the resins used by plastic producers and manufacturers. The industry is concentrated, mostly in Ontario and Alberta, with ██████ companies producing ██████ kt of plastics resins and employing 4,000 people.

Domestic production is specialized in high-volume thermoplastic resins, which represented ██████ kt in 2017, with a value of ██████. Polyethylene accounts for the majority of this production, with approximately ██████ produced in 2017. Other major thermoplastics include polyvinyl chloride (PVC, ██████), polyethylene terephthalate (PET, ██████) polyamide (PA, ██████), polystyrene (PS, ██████)

Virgin plastic resin production is dependent primarily on oil or natural gas for its source of chemical raw materials.

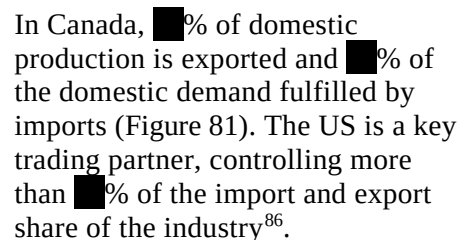


Figure 81: Virgin Plastic Resin Production Demand and International Trade in Canada, 2016, kt⁸⁷

According to IBISWorld⁸⁸:

- Average industry growth between 2015 and 2019 was ████%.
- Revenue in the plastic and resin manufacturing industry is forecast to decrease ████% in 2020, compared to the ████% growth projected before the pandemic hit. The ongoing COVID-19 outbreak has slowed global productivity, weakening demand for industry products.

- Market Size is approximated to decline to \$ [REDACTED] in 2020.

According to GrandView Research agency, US plastic raw materials market size is slightly lower than that forecast by ISISWorld. US plastic raw materials market size is shown in Figure 82: US Plastic Pellets Market Size.

There are estimated to be over [REDACTED] plastics manufacturing businesses in the USA with the largest players Dow Inc., Hexion Inc., Wacker Chemie AG.

Figure 82: US Plastic Pellets Market Size⁸⁹

Current prices for plastics are shown in Table 4: Plastic Pellets Prices.

www.ThePlasticsExchange.com, a company based in Chicago operates an online spot market and provides market intelligence on commodity plastic resin pellets. Snapshot of a trading window is shown in Figure 83: Plastics Exchange.

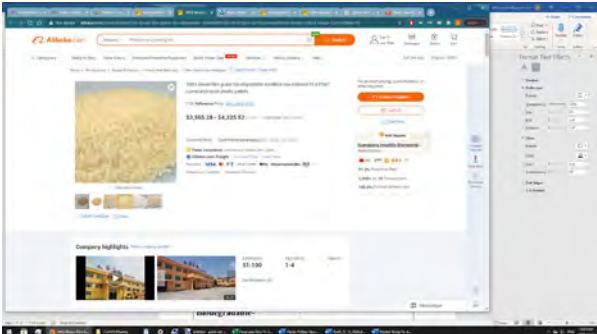
Traditional	
 Resin Granule Pa66 Pellets Pa66 G30 Price Nylon 6 Nylon 66 3 buyers FOB Reference Price: Get Latest Price \$1.85 - \$3.44 / Kilogram 1000 Kilogram/Kilograms (Min. Order) Samples: \$2.32 / Kilogram 1 Kilogram (Min. Order) Buy Sample Shipping: Support Express Sea freight Land freight Air freight Lead Time: Quantity(Kilograms) 1-100 >100 Est. Time(days) 7 Negotiable Customization: Customized logo (Min. Order: 1000 Kilograms) Customized packaging (Min. Order: 1000 Kilograms) More View larger image	 Wear Resistant High Gloss Self-Lubricating Nylon Pa6 Granules Pellet 1 buyer FOB Reference Price: Get Latest Price \$1.59 - \$3.97 / Kilogram 500 Kilogram/Kilograms (Min. Order) Samples: \$0.0133 / Kilogram 1 Kilogram (Min. Order) Buy Sample Customization: Customized logo (Min. Order: 500 Kilograms) Customized packaging (Min. Order: 500 Kilograms) More Trade Assurance protects your Alibaba.com orders Alibaba.com Freight Compare Rates Learn more Payments: VISA T/T Online Transfer Pay WesternUnion WU Alibaba.com Logistics Inspection Solutions View larger image
 General Nylon Pellets Plastic Raw Material For Injection Molding FOB Reference Price: Get Latest Price \$2.38 - \$2.51 / Kilogram 25 Kilogram/Kilograms (Min. Order) Shipping: Support Sea freight Lead Time: Quantity(Kilograms) 1-20000 >20000 Est. Time(days) 7 Negotiable Trade Assurance protects your Alibaba.com orders Alibaba.com Freight Compare Rates Learn more Payments: VISA T/T Online Transfer Pay WesternUnion WU Alibaba.com Logistics Inspection Solutions View larger image	 Pa6 resin pa66 plastic raw material price gf35 fr v0 virgin polyamide 6 30gt/gf40/gf50 granule nylon 6 pellet Pa6 gf25 ★★★★★ 5.0 1 Reviews \$2.91 / Kilogram 25 Kilograms (25 lot) (Min. Order) 1 batch = 1 Kilograms Quantity: 25 + Kilograms Samples: \$2.91 / Kilogram, 1 Kilogram (Min. Order) Buy Sample Customization: Customized Color (Min. Order: 1 Kilograms) Trade Assurance protects your Alibaba.com orders View larger image
Biodegradable	
 Compostable 100% Biodegradable PLA Plastic Granule/PLA resin pellets for making biodegradable dinnerware FOB Reference Price: Get Latest Price \$3.93 - \$6.61 / Kilogram 1000 Kilogram/Kilograms (Min. Order) Lead Time: Quantity(Kilograms) 1-5000 >5000 Est. Time(days) 15 Negotiable Customization: Customized logo (Min. Order: 1000 Kilograms) Customized packaging (Min. Order: 1000 Kilograms) More Trade Assurance protects your Alibaba.com orders Alibaba.com Freight Compare Rates Learn more View larger image	 Screenshot of Alibaba.com product page for PLA granules, showing product details, price range (\$3.93 - \$6.61), and company information.

Table 4: Plastic Pellets Prices



THE BIODEGRADABLE AND BIO-PLASTIC PELLET MARKETS ARE GROWING GLOBALLY DUE TO THE SHIFT IN CONSUMER PREFERENCE AND INCREASING REGULATIONS SUPPORTING ECO-FRIENDLY PLASTIC PRODUCTS FOR FOOD PACKAGING AND COMPOSTABLE BAGS.

AT THE SAME TIME, LOW CRUDE OIL PRICES, RESULTING IN LOWER TRADITIONAL POLYMER PRICES, HAVE MADE BIODEGRADABLE PLASTICS LESS ATTRACTIVE COST-WISE. MOREOVER, THE PANDEMIC HAS HAD A DRAMATIC AND NEGATIVE IMPACT ON THE RESIN MARKET. THE LATEST FORECAST BY IBISWORLD PROJECTS A $\text{ }^{\circ}90$ DECLINE IN THE US PLASTIC AND RESIN-RELATED REVENUE IN 2020.

Figure 83: Plastics Exchange

19. BIODEGRADABLE PLASTICS AND FISHING PRODUCTS: PRODUCTION DRIVEN BY ENVIRONMENTAL CONCERNS

Bioplastics Market Overview^{91 92 93}

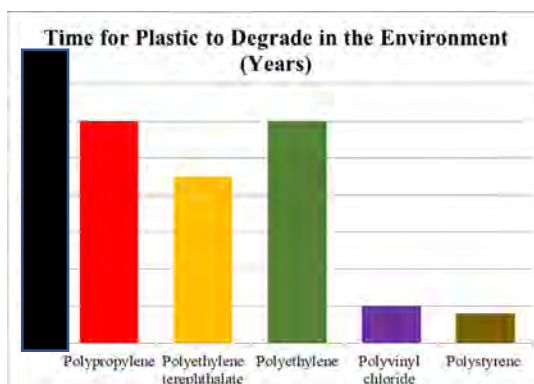


Figure 84: Years for Plastics to Degradate⁹⁴

Approximately 99% of all **plastics** are currently produced or derived from energy sources, including natural gas, naphtha, crude oil, and coal, which are used as both feedstock material and an energy source in plastics manufacturing.

A confluence of factors, volatility of oil prices, worldwide interest in renewable resources, growing concern regarding greenhouse gas emissions and a new emphasis on waste management (elimination of plastic pollution) have grown an interest in biopolymers and bioplastics and the efficiency with which they can be produced.

As shown in Figure 84: Years for Plastics to Degradate, the time for plastic to degrade in the environment is very long; up to 600 years. However, this can be reduced to a mere year for biodegradable products.

A plastic is considered a **bioplastic (bio-based plastics)** if it was produced partly or wholly with biologically sourced polymers. Biopolymers or are derived from renewable biomass sources such as vegetable oil, starch, proteins etc. Biopolymers provide the dual advantages of conservation of fossil resources and reduction in CO₂ emissions. Not all bioplastics are biodegradable as many of them are made up of polylactic acid (PLA). They are chemically identical to their fossil-fuel counterpart but are made from renewable resources. PLA has properties similar to polypropylene, polyethylene, and biobased nylons and looks just like ordinary plastic. However, as they are chemically identical to their fossil-based counterparts, it also means that their properties are similar. PLA-based bioplastics should be taken to a commercial composting facility where it can be broken down in a controlled environment by microbes. Currently, bioplastics represent about 1% of plastic produced annually. But as demand is rising, and with more sophisticated biopolymers, applications, and products emerging, the market for bioplastics is continuously growing and diversifying.⁹⁵

Biodegradable plastics are defined as materials whose physical and chemical properties undergo deterioration and completely degrade when exposed to microorganisms, carbon dioxide (aerobic) processes, methane (anaerobic processes), and water (aerobic and anaerobic processes). Biodegradable

plastics are commonly produced with renewable raw materials, micro-organisms, petrochemicals, or combinations of all three.

To help better define the difference between biodegradable plastics and bioplastics, some states, and countries (such as state of California) have passed labeling laws to keep the two terms separated.

In recent years, more and more biopolymers have been studied by researchers revealing a large range of possible sources from which they can be obtained, and an increasing range of applications that bio-plastic produced from them can fulfill. The possible sources range from different types of biomass including proteins (from animal and vegetal sources which are gaining interest due to their high functionality and excellent properties) lipids and polysaccharides (e.g., starch and cellulose based biopolymers). Others include bio-based polymers obtained from bio-derived monomers, e.g., from corn, which are then polymerized through standard routes. This is the case for biopolyesters such as PLA, until recently the most widely available biopolymer on the market and set to be out ranked by bio-based polyethylene terephthalate (PET) or polyethylene (PE), among others, also obtained via similar synthesis.

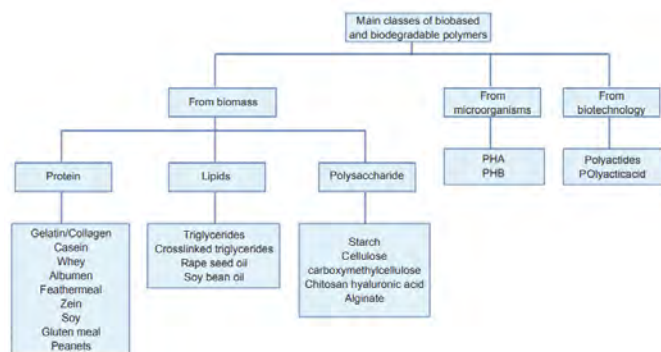


Figure 85: Different Classes of Polymers which are Bio-based and Biodegradable⁹⁶

In contrast, polyhydroxyalkanoates (PHAs) are biogenic polyesters that can be naturally accumulated in microbial cultures. Algae has numerous advantages such as high yield and the ability to grow in a range of environments. The use of algae opens up the possibility of utilizing carbon, neutralizing greenhouse gas emissions. Algae-based plastics have been a recent trend compared to traditional methods of utilizing feedstock, such as starch from corn and potatoes, in polymers production. These polyesters are 100% bio-based and biodegradable. Although they still occupy a limited market share, PHAs are gaining attention due to their high biodegradability in different environments and versatility.

Bio-based, non-biodegradable plastics altogether, also including the drop-in solutions bio-based PE (polyethylene) and bio-based PET (polyethylene terephthalate), as well as bio-based PA (polyamides), currently make up for over 14% (almost 1 million tons) of the global bioplastics production capacities as shown in Figure 86: Bioplastics Global Production Capacities, 2019, by Material.



Figure 86: Bioplastics Global Production Capacities, 2019, by Material⁹⁷

The production of bio-based PE is predicted to continue to grow with new capacities planned to come online in Europe. Intentions to increase production capacities for bio-based PET, however, have not been nearly realised at the rate predicted in previous years as it actually declined instead. Instead, the focus has shifted to the development of PEF (polyethylene furanoate), a new polymer that is expected to enter the market in 2023. PEF is comparable to PET but 100% bio-based and is said to feature superior barrier and thermal properties, making it an ideal material for packaging.

Biodegradable plastics altogether, including PLA, PHA, starch blends and others, account for over 55.5 % (over 1 million tons) of the global bioplastics production capacities.

According to the latest market data compiled by European Bioplastics in cooperation with the research institute nova-Institute, global bioplastics production capacity is set to increase from around 2.11 million tons in 2019 to approximately 2.43 million tons in 2024.

The production of biodegradable plastics is expected to increase to 1.33 million in 2024, especially due to PHA's significant growth rates as shown in Figure 87.

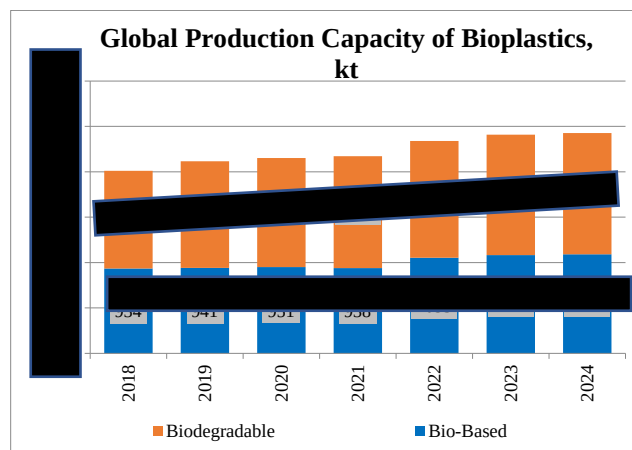


Figure 87: Global Production Capacities of Bioplastic, kt⁹⁸

PHAs' production capacities are estimated to more than triple in the next five years.

Bio-based PP (polypropylene) show the highest relative growth rates. In 2019, bio-based PP entered the market on a commercial scale with a strong growth potential due to the widespread application of PP in a wide range of sectors. Their production capacities are predicted to almost sextuple by 2024.

The practical side of the use of biopolymers is related to the economic advantage for industries and municipalities. Packaging is the biggest polymer processing industry with the food sector being its principal customer. In the wake of future laws in relation to reducing the weight and volume of these products, cheap and biodegradable polymeric products are receiving growing attention in this market. Other applications include household, catering products, medical disposable devices, consumer electronics, automotive,

agriculture/horticulture, toys, textiles, and a number of other segments as shown in Figure 88: 2019 Global Production of Bioplastics by Market Segment, kt.

Packaging remains the largest field of application for bioplastics with more than 53% (1.14 million tons) of the total bioplastics market in 2019. However, the portfolio of application continues to diversify. Segments, such as automotive & transport or building & construction, significantly increased their share.

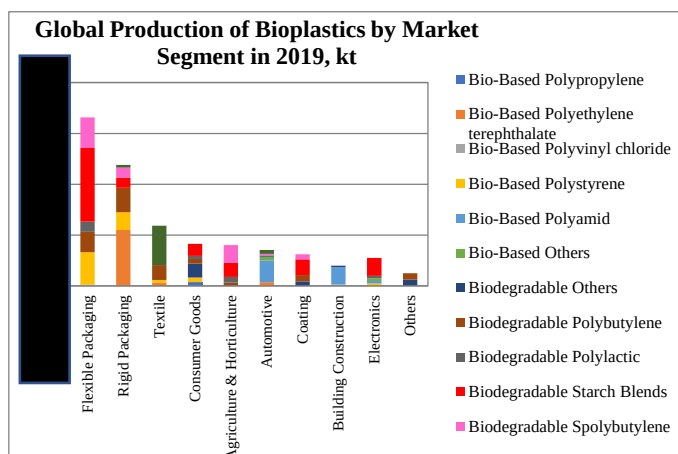


Figure 88: 2019 Global Production of Bioplastics by

Market Segment, kt

Europe strengthened its position as a major hub for the entire bioplastics industry once again; it ranks highest in the field of research and development and is the industry's largest market worldwide. As shown in Figure 89: Global Production Capacities of Bioplastic by Region, 2019, by now, one fourth of the global bioplastics production capacity is in Europe.

However, with a view to the actual production of bioplastics and regional capacity development, Asia continues to be the major production hub. In 2019, 45% of bioplastics were produced in Asia. At the same time, production in the Americas has also increased.

The land used to grow the renewable feedstock for the production of bioplastics amounted to approximately 0.79 million hectares in 2019, which accounted for less than 0.02% of the global

Global production capacities of bioplastics in 2019 (by region)



agricultural area of 4.8 billion hectares, 94% of which were used for pasture, feed, and food. Despite the market growth predicted in the next five years, the land use share for bioplastics will remain around 0.02%. This clearly shows that there is no competition between the renewable feedstock for food, feed, and the production of bioplastics.

Figure 89: Global Production Capacities of Bioplastic by Region, 2019⁹⁹

Polyhydroxyalkanoates (PHAs) Use as a Biodegradable Plastic in Fisheries

PHAs are gaining increasing attention in the biodegradable polymer market due to their promising properties such as high biodegradability in different environments and processing versatility. Among biopolymers, these biogenic polyesters represent a potential sustainable replacement for fossil fuel-based thermoplastics.

Most commercially available PHAs are obtained with pure microbial cultures grown on renewable feedstocks (i.e., glucose) under sterile conditions; the most recent research is focusing on the use of wastes as growth media. It has physical characteristics similar to non-degradable plastics and can be extracted from the bacteria cell and then formulated and processed by extrusion for production of rigid and flexible plastic suitable, not just for the most assessed medical applications, but is also being considered for applications including packaging, moulded goods, paper coatings, non-woven fabrics, adhesives, films, and performance additives¹⁰⁰. **THE MOST RECENT RESEARCH IS ALSO FOCUSED ON PHA APPLICATIONS FOR FISHING NETS, TRAPS AND POTS.**

PHAs are completely biodegradable by microbes typically found in the marine environment. PHA meets the American Society of Testing and Materials certification and European Standards for biodegradation in the marine environment. The rate of biodegradation can be controlled by adjusting the thickness of the polymer.

EXPERTS CAUTION THAT PHA IS NOT THE PANACEA FOR TACKLING GHOST FISHING. BIODEGRADABLE NETS MIGHT BREAK OR GET LOST MORE EASILY THAN STANDARD NETS. THEY ARE

ALSO LIKELY TO COST MORE AND, AS A RESULT, FISHERMEN MAY BE LESS INCLINED TO ADOPT THEM. HOWEVER, IF INTEGRATED INTO A WIDER MANAGEMENT FRAMEWORK THAT INCLUDES STRATEGIES TO MARK NETS, REDUCE LOSS AND IMPROVE RECOVERY, BIODEGRADABLE MATERIALS COULD PLAY AN IMPORTANT ROLE IN SHORTENING THE IMPACT OF DISCARDED FISHING GEAR, THUS REDUCING ITS SOCIOECONOMIC AND CONSERVATION COSTS.

Commercial name	Producer	Country	Product
Biomer	Biomer	Germany	Biomer P209 Biomer P226 Biomer P240
Minerv-PHA	Bio-on	Italy	MINERV-PHA™
Biogreen	Mitsubishi Gas	Japan	Biogreen
Biocycle	PHB Industrial	Brazil	BIOCYCLE 1000 BIOCYCLE 189C-1 BIOCYCLE 189C-1 BIOCYCLE 189D-1
Ecogen	Tianan Biological Material Poly-one	China	ENMAT Y1000 ENMAT Y1000P ENMAT Y3000 ENMAT Y3000P
Mirel	Metabolix	USA	Mirel P4001 Mirel P4010 Mirel P5001 Mirel P5004 Mirel M2100 Mirel M2200 Mirel M4100
Nodax	P&G Chemicals	USA/Japan	Nodax™
Metabolix	Tellex LLC	USA	Mvera™ B5011 Mvera™ B5010
Jiangsu Nantian	Jiangsu Nantian Group	China	P3HB
Goodfellow	Goodfellow Cambridge Ltd	UK	Polyhydroxyvalcanoate – Biopolymer (PHA) Polyhydroxybutyrate/Polyhydroxyvalerate 12% – Biopolymer (PHB88/PHV12)
Tepha [86]	Tepha Inc	USA	P(4HB)

Figure 90: Commercial PHAs

Figure 90: Commercial PHAs lists the most known commercially available polyhydroxyalkanoates. The thermal and mechanical properties of materials described in the previous table, obtained from their respective technical datasheets, are summarized in Figure 91: Thermal and Mechanical Properties of Commercial PHAs.

In the 1980s, Imperial Chemical Industries developed poly (3-hydroxybutyrate-co-3-hydroxyvalerate) obtained via fermentation that was named ‘Biopol’. It was sold under the name ‘Biopol’ and distributed in the U.S. by Monsanto and later Metabolix. Commercial ventures scaling up PHA production using fermentation processes include Telles, USA; Biomer Biotechnology Co., Germany; PHB Industrial, Brazil; Mitsubishi Gas Chemical, Japan; Kaneka, Japan; Biomatera, Italy; Jiangsu Nantian Group, China; Tianan Biologic Material, China; and Lianyi Biotech, China.

Product	Thermal properties			Mechanical Properties		
	T _m [°C]	N _{cr} [%]	T _g [°C]	E [GPa]	σ [MPa]	ε [%]
Biomer P209	–	30–40	–	0.84–1.20	15–20	600–1200
Biomer P226	–	60–70	–	1.14–1.90	24–27	6–9
Biomer P240	–	60–70	–	≈1.85	28	≈11
BIOCYCLE 1000	170–175	–	117	2.2 (Flex)	32	4.0
BIOCYCLE 189C-1	165–170	–	117	2.4 (Flex)	25	2.2
BIOCYCLE 189C-1	165–170	–	121	2.6 (Flex)	30	2.2
BIOCYCLE 189D-1	165–170	–	125	3.8 (Flex)	36	2.0
ENMAT Y1000	170–176	–	–	2.8–3.5	39	2
Mirel P4001	–	–	110	1.90 (Flex)	20	5
Mirel P4010	–	–	–	1.45 (Flex)	10	10
Mirel P5001	170	–	–	0.30–0.32	20	404–463
Mirel P5004	170	–	–	0.3–0.4	25–30	400–500
Mirel M2100	165–170	30–60	–	–	–	–
Mirel M2200	160–170	40–60	–	–	–	–
Mirel M4100	164–166	27–45	–	–	–	–

Figure 91: Thermal and Mechanical Properties of Commercial PHAs

Examples of Biodegradable Fishing Gear

Fishing Nets and Crab Traps are the First in Line for Required Degradation

WHILE THERE IS NO COMMERCIALIZED SOLUTION ON THE MARKET AT THIS TIME, THERE HAVE BEEN SEVERAL PUBLISHED PAPERS / ANNOUNCEMENTS DESCRIBING BIODEGRADABLE FISHING NETS BEING ON DIFFERENT STAGES OF DEVELOPMENT.

A study published in the journal Animal Conservation¹⁰¹ describes tests done by researchers from the National Institute of Fisheries Science in Korea, in collaboration with FAO, who presented an alternative biodegradable material for **drifting gillnets**. The researchers developed a net made of a blend of █% polybutylene succinate (PBS) and █% polybutylene adipate-co-terephthalate (PBAT), which was announced to be comparable in its fishing efficiency with conventional nets.

This new polymer gets degraded by microbes after only two years in seawater, substantially reducing the potential duration of ghost fishing. At the same time, the nets would remain economically viable, since the material ensures catch rates similar to conventional nylon nets.

During lab testing, run off the coast of China, the biodegradable nets had inferior theoretical performance to the regular nets (they had lower breaking strength and were stiffer), but during actual fishing they performed similarly to regular nylon monofilament nets and started to biodegrade after 24 months in seawater. This was only a first step. More testing needs to be done, and the biodegradable materials could no doubt be improved to better match the performance of conventional nets, but these tests were promising enough to show that this solution should be pursued further.

Another concept of a biodegradable net incorporates the radio frequency identification chips.



Alejandro Plasencia, a Barcelona, Spain-based product engineer who grew up in the Canary Islands, called his fishing net project Remora, inspired by the symbiotic relationship of the remora fish that attaches itself to sharks.

The net was treated with the biodegradable additive d2w, which the manufacturer claimed would cause the polymer to begin to break down after four years. The net is studded with ultrathin RFID transmitters to pinpoint its location so it can be quickly repaired rather than abandoned.

Figure 92: Biodegradable Purse Seine with Radio Chip

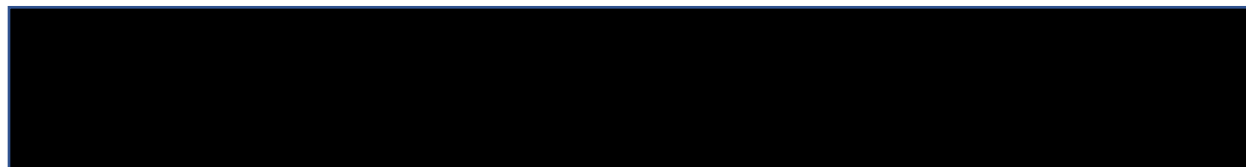
A smartphone app would let fishing boat captains keep track of their nets. Plasencia's main target was the commercial tuna operators who use the **purse seining** method of fishing, some measuring more than a mile wide and 700 feet deep—around entire schools of fish. Plasencia estimated his production cost to be 15% - 20% higher than nets currently in use, but fishers would save money by being able to easily locate the nets for repair.¹⁰² There is not much follow up information on progress in moving the net concept to the next stage.

A project called Innovative Fishing Gear for Oceans (INdIGO) was launched recently with the aim of developing a completely biodegradable **fishing net** with a controlled lifespan. The nets will biodegrade into natural materials within two years.

The project will run for almost 4 years to finish in June 2023, when it is hoped a commercially viable product will be produced. It has a budget of €4.3m, of which €2.9m is funded by the European Regional Development Fund via the Interreg France Channel England Program. It has 10 partners in the UK and France: it involves the Universities of Portsmouth and Plymouth in the UK and the University of Brittany in France, plus three research centers and five private organizations from the UK and France.

As part of the project, partners will undertake a study of the impact and degradation of biodegradable nets on the marine environment and develop two prototypes of biodegradable fishing nets. INdIGO will also create an app to locate discarded or lost fishing equipment on beaches and promote the use of biodegradable nets among fishing communities and political networks in order to influence future regulations. It is believed that the presence of the industry in INdIGO project is an essential factor in achieving the marketing of the new fishing gears and their adoption by fishing and aquaculture professionals in the France Channel England area.^{103 104}

Researchers at the Center for Coastal Resources Management, Virginia Institute of Marine Science (VIMS), College of William & Mary, have tested two types of environmentally friendly marine degradable plastics polymers PCL (Polycaprolactone) and PHA. The team selected PHA as the material



of choice for use in escape panels called "cull rings," for **crab traps**. This PHA is comprised of plant-based and petroleum-based polymers that meet American Society for Testing and Materials standards for degradation in the marine environment.

The panel should last for only one season. The panel incorporates the circular cull ring, mandated by state regulations to allow undersized crabs to escape the trap. Two panels should be required for each trap to be



Figure 93: Biodegradable Panels in Crab Traps

placed on opposite walls which allows for escape even if the trap rolls on its side. If the trap is lost, the degradable cull panel would minimize the by-catch while still allowing the trap to become habitat for bivalves, juvenile crabs, and small fish.

The panel decomposes into carbon dioxide, methane, water, inorganic compounds, or biomass via microbial assimilation (the enzymatic action of microorganism).

Lost traps remain on the bottom, out of UV light exposure, and populations of bacteria can proliferate and more quickly consume the PHA. When pots that include the new panels are left out in the water, those escape hatches, which measure six inches wide, dissolve entirely, leaving a much wider gap in the pot. Anything that gets into the trap could then get out. PHA biopanel panels have an added benefit of lasting longer if regularly fished. This is because microbes feeding on the PHA have inhibited or delayed growth when exposed to UV light during trap retrieval requiring constant regrowth of bacteria on biopanel panels of active traps.¹⁰⁵

With funding support from NOAA's Marine Debris Program and the National Fish and Wildlife Foundation, VIMS employed commercial watermen to fish pots with cull panels alongside standard pots in Chesapeake Bay, USA to assess potential effects on blue crab (*Callinectes sapidus*) catch and test the biodegradation time of panels. There was no evidence that biodegradable cull panels adversely affected crab catch. In all locations and time periods, legal catches were similar (or greater) in abundance, biomass, and size between modified and standard pots. Panel biodegradation rates suggest a functional time frame of one year.¹⁰⁶

In addition to blue crab traps, VIMS researchers developed prototype biopanel panels for a number of fisheries including lobster, Dungeness crab, black sea bass, and stone crab as well as a universal biopanel to fit most trap fisheries worldwide.

The escape panels are licensed to Mobjack Binnacle Products; they should cost around \$1 a piece, which is more expensive than traditional cull rings, which cost about 15 to 20 cents each.¹⁰⁷

Other researchers have explored attaching biodegradable latches to crab traps, allowing small doors on those traps to swing open. Earlier methods of providing escape vents for animals captured in lost traps were prone to failure either by degrading too quickly or not at all. Other escape panels use degradable or biodegradable attachment points. In fact, it just takes a little bit of encrustation from a single barnacle to prevent that from working. Hence all those designed proved to be ineffective.

Biodegradable Fishing Lines: Historical Failures

THERE IS NO CREDIBLE VENDOR IN THE NORTH AMERICAN MARKET AT THIS POINT WHO MANUFACTURES BIODEGRADABLE FISHING LINES. THERE ARE SOME MANUFACTURERS IN CHINA WITH THEIR SOLUTIONS SOLD ON ALIBABA'S ONLINE TRADING PLATFORM; HOWEVER, THERE IS NO INFORMATION AVAILABLE IN ENGLISH DESCRIBING THEIR PRODUCTS AND PROVIDING MANUFACTURERS' DETAILS. MEANWHILE, IN THE PAST THERE HAVE BEEN A HANDFUL OF COMPANIES THAT HAVE OFFERED LINES.



American Portland, Oregon-based company **Bioline®Fishing** applied the technology of absorbable medical sutures (dissolvable stitches) to produce the world's first commercially available, biodegradable line, leaders, and tippets. ^{108 109 110}

Bioline was a biofilament fishing line designed out of 100% biodegradable polymers. Unlike standard monofilament lines, Bioline would breakdown significantly faster with the combination of carbon dioxide, water, and biomass. The process of degradation begins at the surface of the line itself as microorganism's breakdown and digest Bioline with the aid of sunlight and moisture. Bioline breaks down whether it is under the water's surface or above.

Figure 94: Biodegradable Bioline

BIOLINE WAS ADVERTISED TO LOOK AND FEEL LIKE ANY LO-VIS, CLEAR, TRADITIONAL MONOFILAMENT LINE, WITH EXCEPTIONAL KNOT STRENGTH, ALONG WITH OUTSTANDING UV AND ABRASION RESISTANCE. BIOLINE WOULD NOT ABSORB WATER LIKE TRADITIONAL MONOFILAMENTS AND ITS CHARACTERISTICS DO NOT CHANGE AS IT IS FISHED.

Stored in its original package, Bioline has a five-year shelf life. ONCE SPOOLED ON A REEL, THE LINE WOULD RETAIN 100% OF ITS STRENGTH FOR A PERIOD OF 10 TO 12 MONTHS.

The difference between Bioline and nylon monofilaments, fluorocarbon, Spectra® and Dyneema® fiber lines is found in what happens once it comes off the reel, whether lost due to breakage or discarded as garbage.

IN ROUGHLY FIVE YEARS, BIOLINE WOULD DEGRADE IN THE ENVIRONMENT TO A MINIMAL QUANTITY OF CARBON DIOXIDE AND WATER. Market offering were stated as follows:

- Spool Weight: 3 oz / 85 grams
- Capacity: 210 yards
- Available in 4,6,8,10, and 12 lb. test.
- P.S. - Even the Spool is biodegradable.

The Australian National Sportfishing Association (ANSA) tested Bioline in 2009. Follow-up tests after 12 months of exposure to the elements showed little loss of breaking strain. For the Bioline to lose as little as 3.7% of its original breaking strain after constant 12 month's exposure to sun, wind and rain is a surprising result and a testament to the technology used in developing these lines.

Dr Ben Diggles, Australian and New Zealand distributor of Bioline conducted further tests, which also supported the manufacturer's claims of biodegradability. "The 4-pound Bioline disintegrates after six months in compost, with the thicker lines lasting a bit longer due to their larger diameter." said Diggles. "Even the spools the line comes on become completely soft and brittle after 12 months in compost, showing they are properly biodegradable too"¹¹¹

UNFORTUNATELY, MOST ANGLERS WHO TRIED BIOLINE FOUND THAT IT CAME UP A BIT SHORT IN SEVERAL RESPECTS.

- Most reported that it felt stiffer than high-quality monofilament lines, and it was not quite as clear as monofilament or fluorocarbon lines, which presented problems for those trying to catch line-shy fish.
- It was also more expensive than traditional monofilament lines, although probably not enough to dissuade environmentally friendly anglers from giving it a try. Its cost was equivalent to fluorocarbon or 3 X that of monofilament.
- The line also retained its strength for a maximum of one year, thus it had to be replaced every season or on nine-month intervals in year-round fisheries: for less regular anglers who typically change their line every five years on average, to change annually would be a big extra expense.

Bioline was sold to tackle company Eagle Claw. In 2017, Eagle Claw stopped manufacturing and withdrew from retailing the line after concerns surfaced online about durability, strength, and cost resulted in declining sales.

Another biodegradable line, **FieldMate**, marketed by Japanese manufacturer Toray International has also been withdrawn from the market. Toray made a biodegradable fishing line and lure - a worm, called the Trebiomer. FieldMate fishing line was made of biodegradable polymer and after about 3 months in salt or fresh water, it decomposes under hydrolytic action through the enzymatic reactions of naturally occurring microorganisms before eventually being reduced to water and carbon dioxide.



It did not deteriorate when kept clean and dry but does when exposed to the biological activity of bacteria underwater or underground. Performance would not be affected by biodegradation if the FieldMate fishing line was stored in a dry place or rinsed with tap water immediately after it was used.

The lines were available in three grades: 8-LB, 10-LB, and 12-LB lines, all wound on 100m spools. The FieldMate line came in various weights and was about ¥1,451 or \$14\$per 100m.

Figure 95: FieldMate Fishing Line

The company succeeded in upgrading strength, durability, and other properties of polymer by employing Toray's unique yarn-making technology.

Meanwhile, its advertised feature was its undoing, especially so if they could not control the decomposition rate – even when dry or in a package. After hitting the market back in 1996, with similar concerns of durability and line maintenance Field Mate went the same way as Bioline and is no longer in production despite meeting fishing line standards with a remarkable 4-month bio-degradation time.^{112 113}

114

Another company currently involved in manufacturing and marketing of biodegradable fishing line is also a Japanese manufacturer **Globeride Inc.**, a fishing-gear company based in Higashi-Kurume, Tokyo.

At first glance, it just looks like a plain old fishing line. The time it takes to degrade depends on water temperature and other conditions, but it usually dissolves completely in five years. Making a stout fishing line from a fragile, naturally dissoluble material was challenging. Ichikawa solved the problem by using a stretchable material that was about 80% as strong as a regular nylon fishing line.

As it was only 10% more expensive, the product sold out quickly and they had to scramble to produce enough to meet the demand. The company is developing a fishing line using natural materials such as rice and corn.

"Products won't sell just because they're 'environmentally friendly.' We have to sell things without lowering their quality. If we can do that, an awareness of biodegradable material will spread," Ichikawa, Head of Product Development said.¹¹⁵ While the product is said to sell, it is available only in Japan and its website with all information is in Japanese only. Hence no additional information is available.

ANY FUTURE MAINSTREAMING OF BIODEGRADABLE LINES WILL REQUIRE CUSTOMER CONFIDENCE ON QUALITY AND PERFORMANCE, AS WELL AS BEING COST COMPETITIVE COMPARED WITH SYNTHETIC VARIETIES. RETAIL COST AND RELIABILITY WOULD HAVE TO BE MAJOR FACTORS TO CONSIDER. THE FIELD-TESTING OF NEW PRODUCTS WITH SUSTAINABILITY FEATURES – FOR EXAMPLE, GIVING AWAY FREE TEST SAMPLES TO ANGLING CLUB MEMBERS (PERHAPS WITH A VOUCHER REDEEMABLE AGAINST FUTURE PURCHASES) – COULD PROVE INVALUABLE IN BUILDING ANGLER CONFIDENCE.

20. MANUFACTURERS OF PELLETS, NYLON AND BIOPLASTICS

Plastic Pellets Manufacturers

The table below lists top plastic raw materials producers. The information includes the embedded link to the company's website, headquarter location and manufactured polymer types¹¹⁶.

Company		Country	Polymer														
			PL	PO	PS	EP	FP	PM	PA	PU	PVC	TRE	SR	PC	FR	CD	
1	Alpek	Mexico															
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
11																	
12																	
13																	
14																	
15																	
16																	
17																	
18																	
19																	
20																	
21																	
22																	
23																	
24																	
25																	

	Company	Country	Polymer													
			PL	PO	PS	EP	FP	PM	PA	PU	PVC	TRE	SR	PC	FR	CD
26																
27																
28																
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47																
48																

where

CD - Cellulose Derivatives
 EP - Engineering Polymers
 FP - Fluorinated Polymers
 FR - Functional Resins
 PA – Polyamides
 PC – Polycarbonates
 PL – Polyesters

PM – Polymethacrylate
 PO – Polyolefins
 PS – Polystyrene
 PU – Polyurethanes
 PVC – Polyvinylchloride
 SR - Synthetic Rubbers
 TPE - Thermoplastic Elastomers

Table 5: Top Resin and Plastics Producers

Nylon Manufacturers are Stepping into Biodegradable Sector

The table below summarizes the information about the top companies that produce nylon (monofilament and multifilament). The information includes the link to the website, location, annual revenue, description of product(s). There is also information on corporate positions on environmental issues, as well as a description of development of new bio-base or biodegradable products.

Some observations from the collected information are summarized below.

- The majority of the examined chemicals and advanced materials including nylon producers are located in North America followed by Europe. The general breakdown by geography is:
 - North America, US (35%)
 - Europe (30% Germany, France, Italy, Spain, Netherlands, and Belgium)
 - Asia (30% China, Taiwan, Japan)
 - Middle East (5% Israel)
- Nylon is not the only product manufactured by these companies but is part of a wide set of offerings.
- Annual revenue ranges between \$0.27 million (Ashley Polymers Inc. Engineered) and \$429.2 billion (China Petrochemical Corporation (Sinopec Group)).
- Almost all big companies producing nylon emphasize their focus on reduction of environmental impact and position their bio-based or biodegradable products as a means to achieve these goals.
- Many of these companies have already started production of bio-based or biodegradable products.

THE GENERAL MARKET TREND IS TO PURSUE THE BIODEGRADABLE OR BIO- PRODUCTS TO REMAIN IN LINE WITH THE ENVIRONMENTAL AGENDA AND TO BE RECOGNIZED AS A PROGRESSIVE SUSTAINABLE COMPANY. IT IS MOST LIKELY THAT IT IS A MATTER OF TIME THAT ALL LARGE MANUFACTURERS JOIN THE SUITE TO START PRODUCTION OF BIODEGRADABLE OR BIO-PLASTICS.

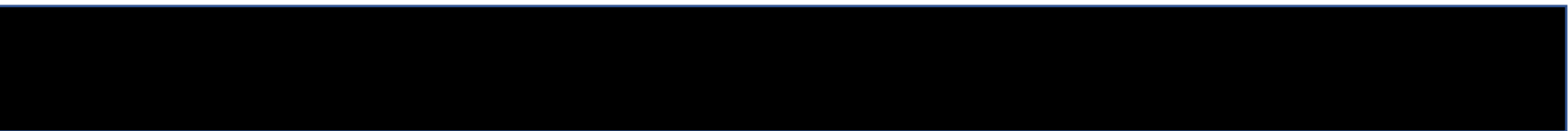
#	Company	Location	Annual Revenue	Main Products	Strategy on Environmental Issues	Biodegradable or bio-based products
1						
2						
3						
4						
5						
6						
7						
8						



#	Company	Location	Annual Revenue	Main Products	Strategy on Environmental Issues	Biodegradable or bio-based products
9	Ube Industries Ltd.	Japan	\$6.3 billion ¹²⁴	UBE Nylon	Ube Industries Ltd. takes a stake in Nagasuna mayu Inc., which possesses technology for extracting and processing silk proteins from silkworm cocoons. Silk protein is a bio-based material that decomposes through the action of microbes found in nature.	Bio-based product: processing silk proteins from silkworm cocoons.
10	Li Peng Enterprise Co. Ltd.	Taiwan	\$477.77 million ¹²⁵	Nylon chip, nylon filament yarn and synthetic fabric	Company has a strong eco message: Reduce, Reuse, Recycle and Recovery	Eco-product: Ecoya (recycle polyester)
11						
12						
13						
14						
15						

#	Company	Location	Annual Revenue	Main Products	Strategy on Environmental Issues	Biodegradable or bio-based products
16						
17						
18						
19						
20						

Table 6: Big Nylon Market Players



Manufacturers of Nylon Fishing Gear

The table below summarizes the information about top manufacturers of nylon monofilament and multifilament fishing gear. The information on each manufacturer includes the company website (if available) embedded into the company name, location, annual revenue, main product(s) including products that can be considered a direct competition to the Client's Product, main markets, export information (if available), and web link to the pricing information.

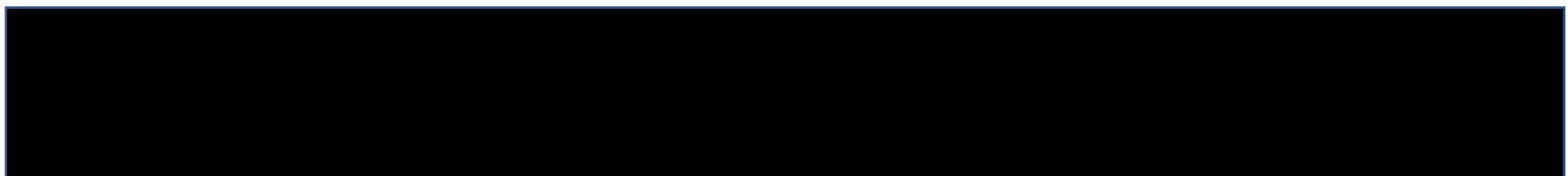
Big market players which produce Nylon monofilament and multifilament fishing gears have following characteristics:

- Majority of them are in Asia (71%)
- Over 100% of analyzed companies have fishing lines as their main product. At least 100% of companies produce fishing lines and nets. The remaining listed companies have fishing nets as the main product.
- Annual revenue ranges between \$1 million and \$11 billion (Mylon).
- According to Reports and Data agency,¹³⁵ over half of the total Nylon filament market takes place via offline distribution channels.
- Most of them are involved in voluminous exporting activities:
 - 100% of evaluated manufacturers export ~ 90% of production;
 - more than 100% of these manufacturers export more than 90% of production; and
 - ~100% of evaluated manufacturers export ~50% of production.
- Almost all manufacturers specialize in technologies targeting Nylon mono & multifilament fishing lines & nets.

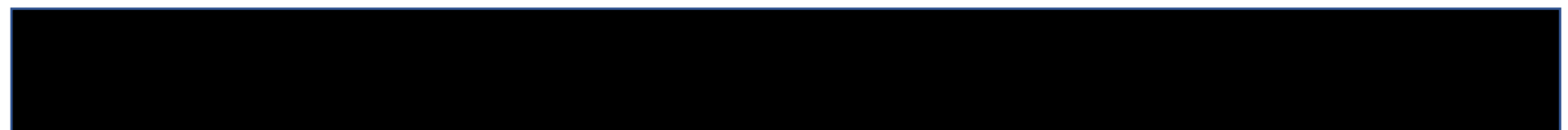
THE MAJORITY OF NYLON MANUFACTURERS ARE LOCATED IN ASIA, MAINLY CHINA. FISHING GEAR DOES NOT CONSTITUTE A MAJOR PART OF THEIR PRODUCTION. SINCE THE EXPORT VOLUMES ARE NOT VERY LARGE OVERALL, IT IS INDICATIVE OF THEM TO PREDOMINANTLY SERVE THEIR LOCAL MARKETS, AND THAT ASIAN MARKETS EXPERIENCE HIGH DEMAND.

Company		Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
1.	Barry Cordage Ltd.	Canada, QC	\$1 million ¹³⁶	Fishing nets, including nylon lines and nets	North America, Rest of World		https://pacificnetandtwine.com/collections/twisted-tarred-nylon
2.	Bullbuster	United States, FL	Confidential	Fishing lines including nylon lines	North America		https://bullbuster.net/community/articles/3.7mm-nylon-fishing-line/
3.	Filmar	Canada, QC	\$1.81 million ¹³⁷	Fishing nets including nylon nets	North America, Rest of World		http://www.filmar.qc.ca/index.php?filet=contact&lang=en
4.							
5.							
6.							
7.							
8.							
9.							

	Company	Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
10.							
11.							
12.							
13.							
14.							
15.							
16.							
17.							



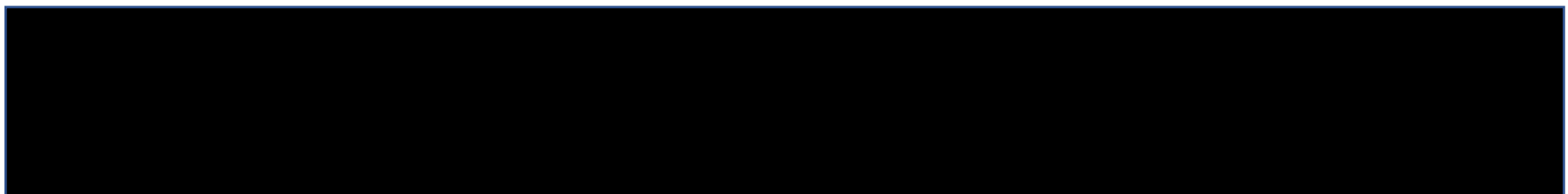
	Company	Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
18.							
19.							
20.							
21.							
22.							
23.							
24.							



	Company	Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
25.							
26.							
27.							
28.							
29.							
30.							
31.							
32.							



	Company	Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
33.							
34.							
35.							
36.							
37.							
38.							
39.							
40.							
41.							
42.							



	Company	Location	Annual Revenue	Main Products	Main Markets	Export Share, %	Price
43.							
44.							
45.							
46.							
47.							

Table 7: Top Nylon Fishing Gear Companies

21. ESTIMATION OF THE NYLON-BASED FISHING GEAR MARKET SIZE

Market Size Forecast Approach

The market size for nylon fishing gear is estimated based on the data available in the public domain. For calculations, the Consultant used the data reported by government agencies and forecasts developed by credible researchers.

Estimation of the market size for the Client's Product follows the algorithm described below.

1. Evaluate the global nylon market composition by product, type, and application.
2. Estimate the total nylon global market size.
3. Establish the share of fishing application in the total market.
4. Establish the market composition by geography and user type.
5. Establish the market growth rate and adjust it to the COVID 19 epidemic.
6. Calculate the total market size for Low Case and High Case and the Client's potential market share.

Global Nylon Market Composition by Product, Type, and Application

By Product

There are many products of Nylon available (e.g., Nylon 6 Nylon 66, Nylon 6/6-6, Nylon 6/9, Nylon 6/10, Nylon 6/12, Nylon 11, Nylon 12). The material is available as a homopolymer, co-polymer or reinforced. Nylons may also be blended with other engineering plastics to improve certain aspects of performance.

The most common products of Nylon are:

- Cast Nylon (Type 6)
- Extruded Nylon (Type 66)

BOTH MAJOR PRODUCTS (NYLON 6 AND NYLON 66) ARE USED FOR MANUFACTURING FISHING GEAR, HENCE THEIR DATA IS UTILIZED AS THE BASIS FOR FURTHER MARKET ANALYSIS AND BUILDING FORECAST.

FURTHER ANALYSIS OF CAST NYLON AND EXTRUDED NYLON SHOWS THESE NYLON PRODUCTS ARE DISTRIBUTED UNEVENLY ACROSS DIFFERENT GEOGRAPHIES. According to BEROE Advance Procurement, globally, Nylon 6 presents an overwhelmingly large share (■■■■%)¹⁶⁶ while on the USA market, shares of these two products are almost even. According to Grand View Research¹⁶⁷, US Nylon 6 market share was ■■■% and Nylon 66 market share was ■■■% in 2016.

166

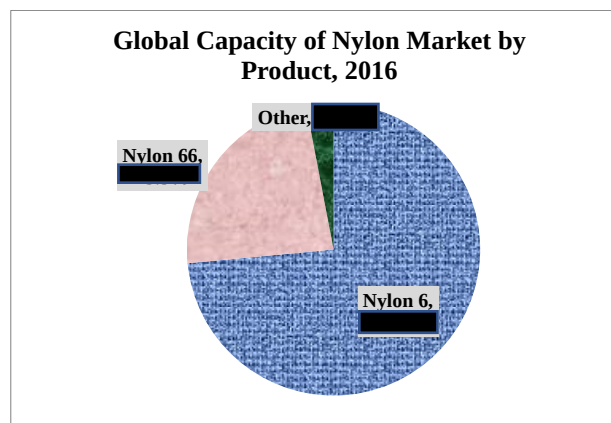


Figure 96: Global Capacity of Nylon Market by Product, 2016

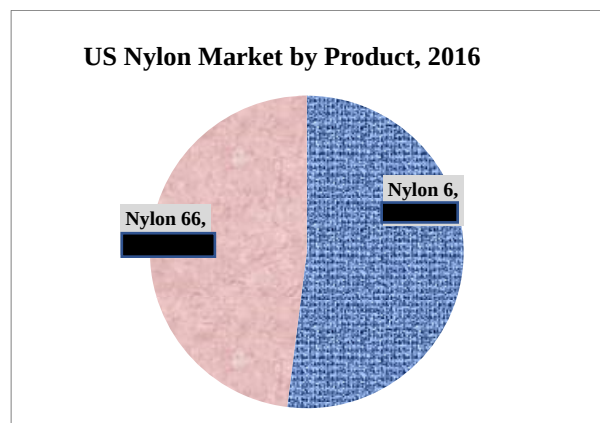


Figure 97: US Nylon Market Share by Product, 2016

By Type

Further, Nylon products can be transformed into monofilament, multifilament, or microfilament yarns.

- Monofilaments (monofilament yarn) are single filaments of synthetic fibers that are strong enough to be useful without being twisted with other filaments into a yarn.
- A multifilament yarn is composed of a bundle of very thin, infinitely long threads. The threads are generally referred to as filaments. Multifilament yarns contain a multitude of fine, continuous filaments (often 5 to 100 individual filaments) usually with some twist in the yarn to facilitate handling.
- Microfilament yarn (microfiber) is characterized by advantageous properties such as softness, good draping qualities, luster, etc. Major applications for microfibers are clothing and technical textile concepts.

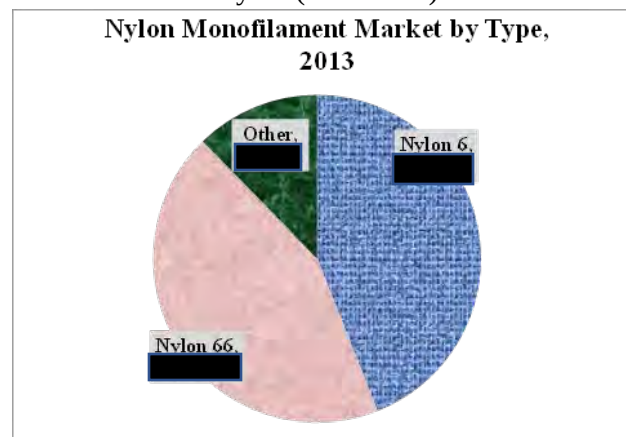


Figure 98: Nylon Monofilament Market by Type, 2013

MONOFILAMENT YARN AND MULTIFILAMENT YARN ARE THE MOST FREQUENTLY USED FOR FISHING GEAR.

Nylon 6 and Nylon 66 are presented almost equally in monofilament yarns. In 2013, Nylon 6 comprised █% of the market, followed by Nylon 66 and others with █% and █% respectively.

By Application

Because there is only limited information about Nylon 66, the Consultant used data on Nylon 6 and applied it as proxy to estimate the total market size.

Nylon 6 is used in the fishing industry as well as in fabric sport apparel, equipment production, and travel accessories. According to Grandview Research,¹⁶⁸ █% of Nylon 6 Filament is used for fishing gear production, as shown in

Figure 99: Global and US Nylon 6 Filament Yarn Market by Application, 2016.

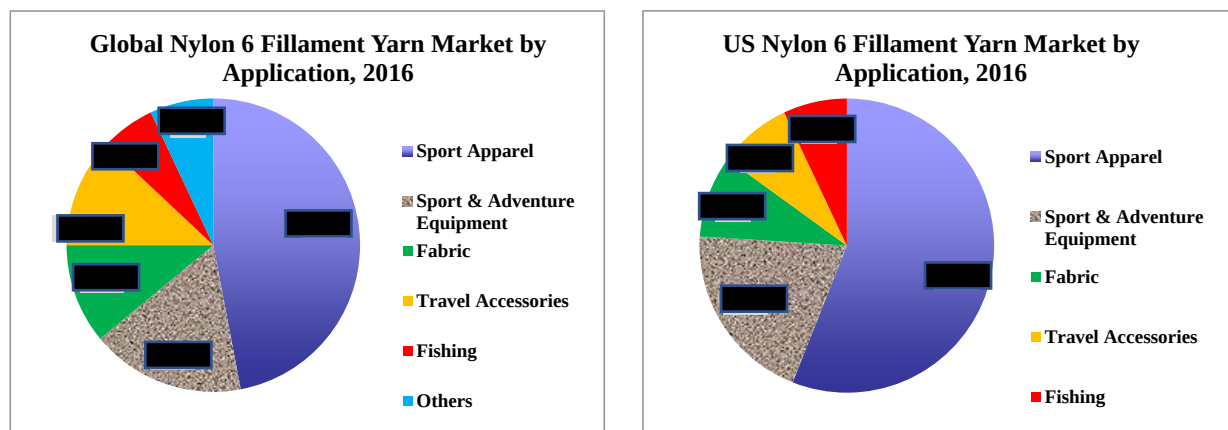
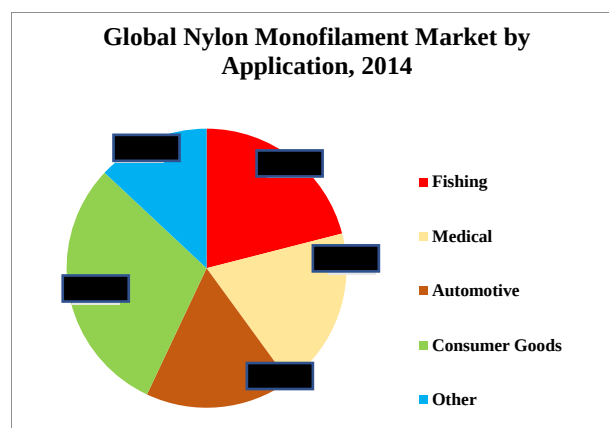


Figure 99: Global and US Nylon 6 Filament Yarn Market by Application, 2016



Nylon monofilament is used in the fishing industry as well as in medical, automotive, consumer good and other.

According to Grand View Research,¹⁶⁹ █% of global Nylon monofilament is used in fishing industry, as shown in Figure 100: Nylon Monofilament Market by Application, 2014.

Figure 100: Nylon Monofilament Market by Application, 2014

The Total Nylon Market Size

To estimate the Nylon market size, the Consultant collected a multitude of available Nylon market forecasts developed by various research companies and extracted the most common trends, adjusted to the input parameters specific to each estimate. The Consultant identified 20 such forecasts developed in recent years that provide estimates of the current and future size of the global Nylon Filament Market, Nylon 6 Filament Market, Nylon 66 Market, Nylon Monofilament market. Table 8: Nylon Market Future Size Estimates summarizes data from these forecasts arranged in the order of their release.

Data sets include information on Nylon market product, market size, market demand, geography, market segments, and applications, as well as CAGR and other forecasting parameters. The data from this table is used to develop assumptions and input parameters into future projections, as summarized in section Assumptions and Input Data for Nylon Fishing Gear Market Size Forecast.

¹⁶⁸ GrandView Research: Nylon 6 Filament Yarn Market < <https://www.grandviewresearch.com/industry-analysis/nylon-6-filament-yarn>

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Market Demand	CARG	Market Segments	Region's Market Share	Application	Big Market Players	Link
1	Grand View Research	Nylon Monofilament	Mar-15	2014	2020		324.0 kilo tons in 2012		Nylon 6 dominated the regional Nylon monofilament market in 2013 with a 44.0% market share, followed by Nylon 66 and others with 43.7% and 12.2% respectively	Asia Pacific dominated the global Nylon 66 monofilaments market, followed by Europe. Asia Pacific demand was 95.1 kilo tons in 2013 to reach 136.1 kilo tons in 2020. North America Nylon 66 monofilaments demand was 15.1 kilo tons in 2013 to grow at a CAGR of 5.1% and reach market demand of 21.2 kilo tons in 2020.	Fishing ~7%	Ashley Polymers Inc., Hinafil India Ltd., Engineered Monofilaments Corporation, Toray Monofilament Co. Ltd., Superfil Products Ltd., Ningbo Judin Special Monofilament Co. Ltd., Perlon Monofil GmbH, Luftking Enterprise Co. Ltd and Wenzhou Ruichang Special Monofilament Factory.	https://www.grandviewresearch.com/industry-analysis/nylon-monofilament-market
2													
3													
4													
5													
6													

Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Market Demand	CARG	Market Segments	Region's Market Share	Application	Big Market Players	Link
7												
8												
9												
10												

	Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Market Demand	CARG	Market Segments	Region's Market Share	Application	Big Market Players	Link
11													
12													
13													
14													
15													
16													
17													

Report Provider	Market	Published	Base Year	End of Forecast Period	Market Size	Market Demand	CARG	Market Segments	Region's Market Share	Application	Big Market Players	Link
18												
19												
20												

Table 8:Nylon Market Future Size Estimates

The Share of Fishing Gear in the Total Nylon Market

To calculate the share of fishing gear in the total nylon market size, the Consultant used the following input data, which is derived from the sources discussed above:

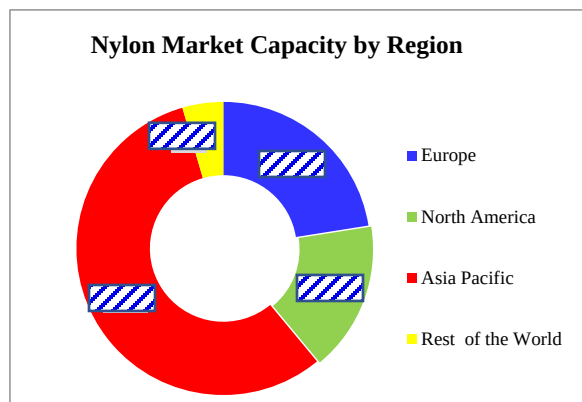
- According to GrandView Research¹⁷⁰ fishing gear accounts approximately █% in total Nylon 6 market and in the US Nylon 6 market;
- According to the same agency, the share of fishing application Nylon monofilament market is █%;
- According to BEROE Advance Procurement, the capacity of Nylon 6 is █% of total Nylon capacity and capacity of Nylon 66 is █% of total Nylon capacity;¹⁷¹
- Based on Nylon 6 data, Nylon Filament market size estimates provided by different agencies and summarized in Table 8, Nylon multifilament market is approximately █ times greater than Nylon monofilament market.

The resulting estimate for the fishing gear share in the total Nylon market is █%.

Market Distribution by Geography and Consumer Type

TO ARRIVE AT THE MARKET OF THE NYLON FISHING GEAR DISTRIBUTED BY GEOGRAPHY AND CONSUMER TYPE THAT MEET THE REQUIREMENTS FOR THE CLIENT'S PRODUCT, THE CONSULTANT APPROXIMATES THE RELEVANT DATA AS A WEIGHTED AVERAGE OF FORECASTS PROVIDED BY DIFFERENT AGENCIES AND SUMMARIZED IN TABLE 8. EACH FORECAST IS ASSIGNED WEIGHT ACCORDING TO THE DATE OF FORECAST AND RELEVANCE TO THE CLIENT.

Regional Market Shares



Breakdown by geography is relatively consistent across all estimates by the market researchers and as summarized in Table 9: Nylon Market Share and Growth by Region. Many report forecasts for Europe, North America, and Asia – Pacific. Some reports also include South America and Middle Eastern & African regions. The Consultant assigns relative shares according to these market forecasts.

Based on the estimate, the approximate shares of the intended market are likely to constitute the breakdown shown in Figure 101: Nylon Market Capacity by Region.

Figure 101: Nylon Market Capacity by Region

ASIA PACIFIC LEADS AMONG ALL REGIONS COMPRISING MORE THAN HALF OF THE MARKET. IT IS FOLLOWED BY EUROPE (█% OF THE WORLD). THE GROWTH RATE SLIGHTLY DIFFERS AMONG REGIONS.

Region	Share	Growth Rate
Europe		
North America		
Asia Pacific		
Rest of the World		

Table 9: Nylon Market Share and Growth by Region

Residential vs. Commercial Users

The American Sportfishing Association (ASA) reports¹⁷² commercial fishing accounting for █% of all finfish landings while recreational fishing - only █%.

According to Sustainable Fisheries,¹⁷³ recreational fishers outnumber commercial fishers █ yet commercial fishing brings in █ number of fish.

According to the same agency analysis, around █% of people in developed nations fish for pleasure, amounting to over █million people worldwide, as shown in Figure 102: Recreational Fishers.

BASED ON THESE NUMBERS, THE CONSULTANT ASSUMES THAT FISHING GEAR UTILIZATION CONSTITUTES █% FOR RESIDENTIAL AND █% FOR COMMERCIAL FISHERMEN.

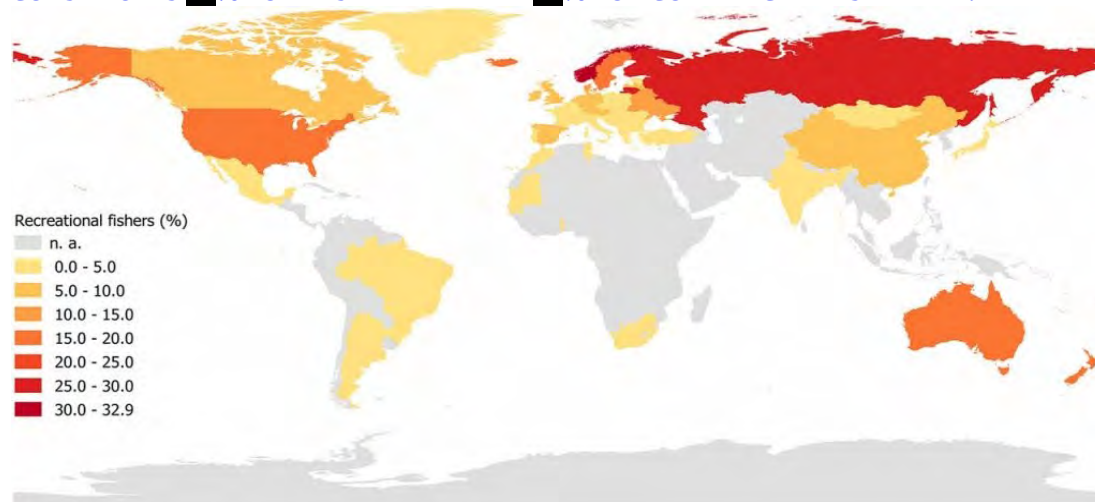


Figure 102: Recreational Fishers

Assumptions and Input Data for Nylon Fishing Gear Market Size Forecast

To develop estimates of the future market that is the potential target for the Client, the Consultant uses the assumption and input parameters described below.

The total Nylon market size for fishing application is estimated based on 20 synopses of forecasts provided by credible agencies and reports from the largest engine manufacturers.



- According to the data on the share Nylon usage in fishing applications discussed in section The Share of Fishing Gear in the Total Nylon Market, the Consultant expects that Nylon used for fishing applications constitutes approximately █% of the total market size.
- As discussed in section about COVID-19 impact on industry, it is likely that mainly luxury species (lobster) will be impacted by epidemic to some noticeable degree. Since traps and pots used to catch lobster constitute only a small fraction of nylon-based fishing gear, this lobster decline is unlikely to cause any significant impact on demand for fishing industry-related nylon products. Besides, growing demand in fishing lines from residential anglers is likely to provide some balance to the overall demand. Accordingly, the Consultant assumes that the market will not grow in 2020, being mildly suppressed by COVID-19 consequences.
- According to the forecast data summarized in Table 8: Nylon Market Future Size Estimates, the total market size ranged from around █ in 2019. Adjusted to the current decrease in production due to COVID-19 pandemic, the Consultant assigns the same amounts to the year 2020: █ for the LOW CASE and █ the HIGH CASE of the market forecast. At █% Nylon use for fishing application, it results in █ kt to the LOW CASE and █ kt to the HIGH CASE of the market size forecast (Fishing Application).
- The average market growth is expected to range between █% (North America) and █% (Asia-Pacific), which is applied to the future market estimates.
- The Consultant assumes that the Client's market share will constitute █% of the market at the end of the forecast period in the LOW CASE scenario and █% in the HIGH CASE scenario:
 - The limited number of similar products in the fishing market provide the opportunity for the Client. The Consultant assumes that the Client's market share will constitute █% of the market at the end of the forecast period. This is the HIGH CASE.
 - The Client enters a mature Nylon market with the established market players. Currently, large Nylon producers create bio-based and biodegradable products. However, these products have not been applied to the fishing industry. The Consultant assumes that the Client's market share will constitute █% of the market at the end of the forecast period. This is the LOW CASE.
 - The Client's market share is assumed to grow gradually, from the minimum in 2021 to the fully assumed shares in 2030.

Resulting Market Size Estimates

Future Nylon Market (Fishing Application) Size

The future market size is estimated to remain within the [REDACTED] range in 2030, valued between \$[REDACTED] and \$[REDACTED], as shown in Figure 103: Nylon Market (Fishing Application) in 2021-2030.

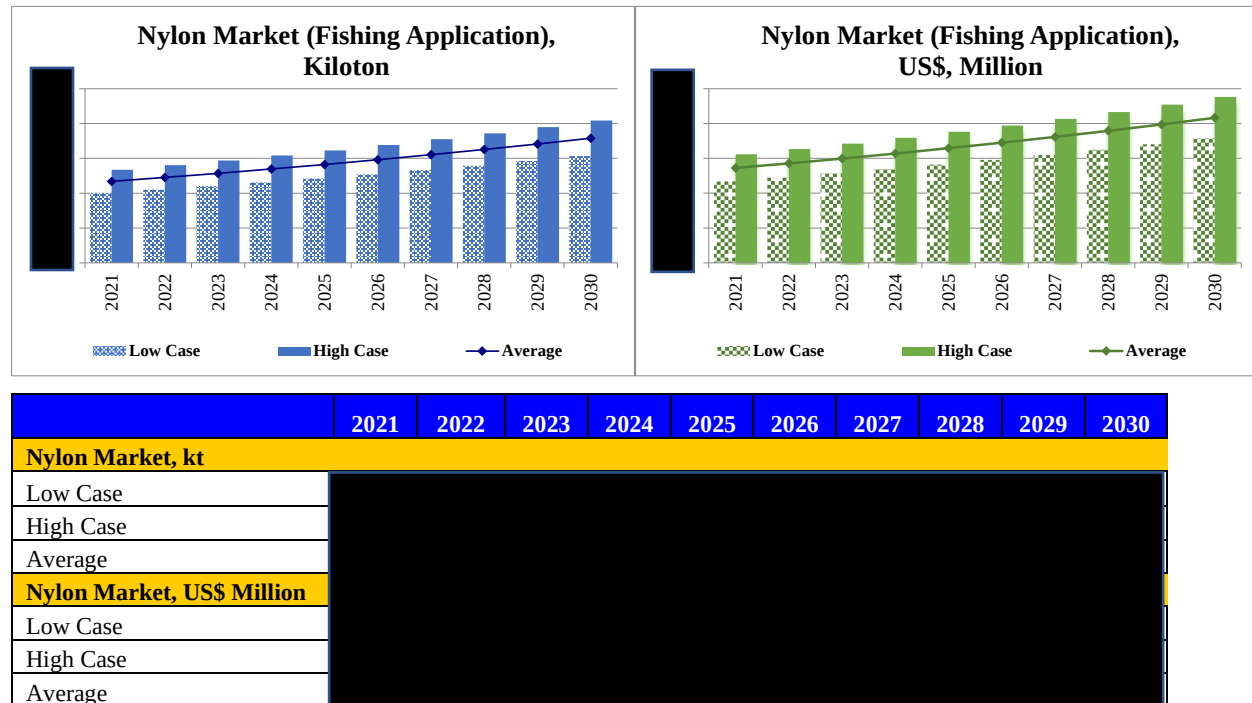


Figure 103: Nylon Market (Fishing Application) in 2021-2030

Future Nylon (Fishing Application) Market Size by Region

The future Nylon (Fishing Applications) market share by region is shown in Figure 104: Nylon Market Size (Fishing Application) by Region, 2021-2030. Asia Pacific is the largest market to reach [REDACTED]% or the highest of [REDACTED] in 2030. It is followed by Europe to constitute [REDACTED]% in 2030.

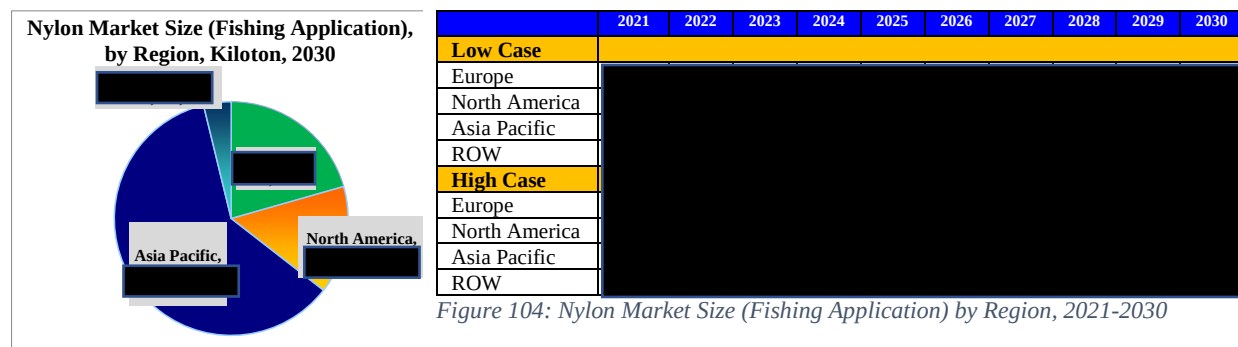
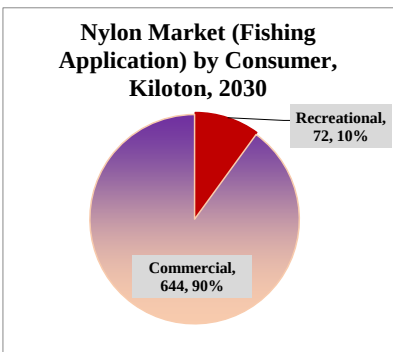


Figure 104: Nylon Market Size (Fishing Application) by Region, 2021-2030

Future Nylon (Fishing Application) Market Size by Consumer

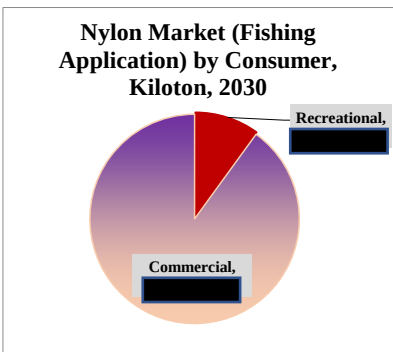
Nylon (Fishing Application) market size by consumer is shown in Figure 105: Nylon Market Size (Fishing Application) by Consumer, 2021-2030.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Recreational										
Low Case	40	42	44	46	48	51	53	56	58	61
High Case	53	56	59	62	65	68	71	74	78	82
Commercial										
Low Case	361	379	397	416	436	457	479	502	526	552
High Case	481	505	529	555	581	609	639	670	702	736

Figure 105: Nylon Market Size (Fishing Application) by Consumer, 2021-2030

. Commercial consumers share will be [REDACTED], [REDACTED]% of the market in 2030.



	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Recreational										
Low Case										
High Case										
Commercial										
Low Case										
High Case										

Figure 105: Nylon Market Size (Fishing Application) by Consumer, 2021-2030

Client's Market Share Forecast

The resulting forecast for the Client's share is demonstrated in Figure 106.

The market to be potentially captured by the client can achieve between [REDACTED] valued at between [REDACTED] and \$[REDACTED] million in 2030.

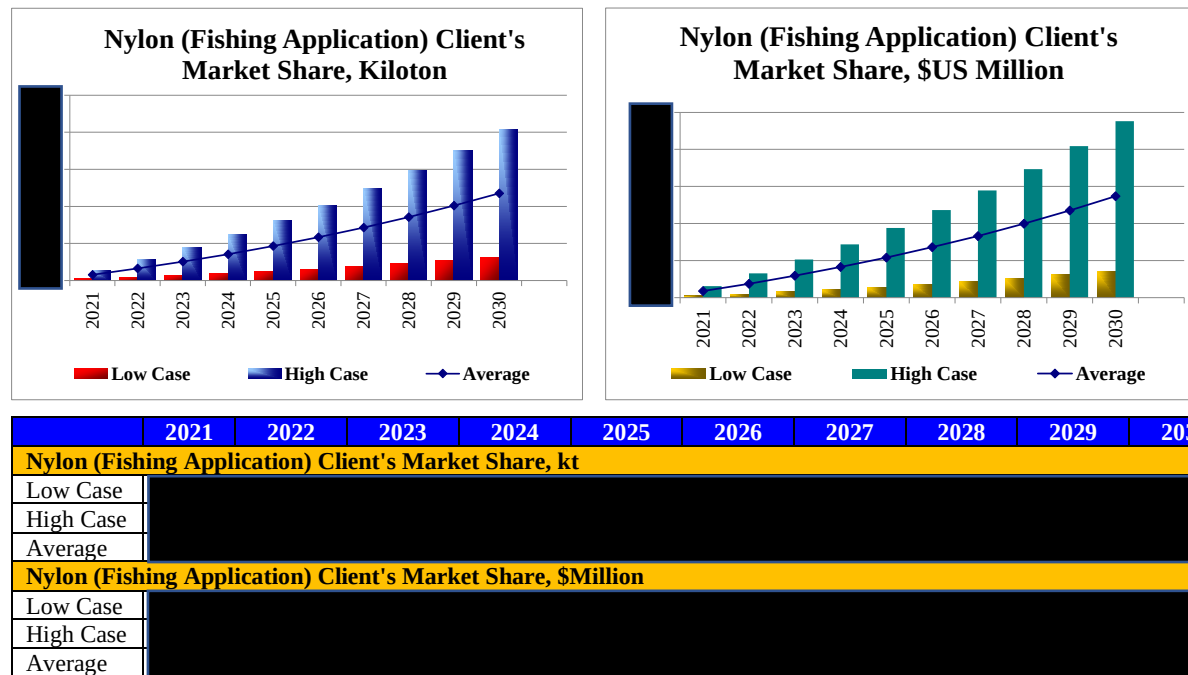


Figure 106: Nylon (Fishing Application) Market Share, \$Million

22. MARKETING STRATEGY

Marketing strategy is shaped by business objectives, market, and companies' available resources. Analysis of the Client's Strengths and Weaknesses, as well as market Opportunities and Threats (SWOT), provides the baseline for identifying the differentiators that separate the Client's Solution and delivering it to the marketplace.

This information is then used to develop the proper marketing mix. The marketing mix is a crucial tool to help understand what the Product and the Company can offer to potential customers and how to plan for a successful product offering. The marketing mix is most executed through the 4 Ps of Marketing: Price, Product, Promotion, and Place. The 4 Ps of the marketing mix establish the Product's position within its target markets. It is designed to meet the company's marketing objectives by providing its customers with the value.

Unique Value Proposition is built based on SWOT and 4 Ps. UVP, in its turn, helps to draft the marketing message. The main marketing message must be simple and straightforward, to be easily absorbed by the target market. It also should be generic enough to be easily transferred to all market segments.

Once the marketing strategy is finalized, the Client should draw up a detailed marketing plan that sets out the specific actions to put that strategy into practice. A marketing plan should set out the goals, actions, dates, costs, resources and selling programmes. The plan should be constantly reviewed so it can respond quickly to changes in customer needs and attitudes in market, and in the broader economic climate. Note that marketing message and marketing plan are not part of this engagement.

This section outlines the process of developing the marketing strategy and tactics and some recommendations for positioning in the market. The Client might consider some of the ideas outlined by the Consultant below and build on them to refine the vision for the Company.

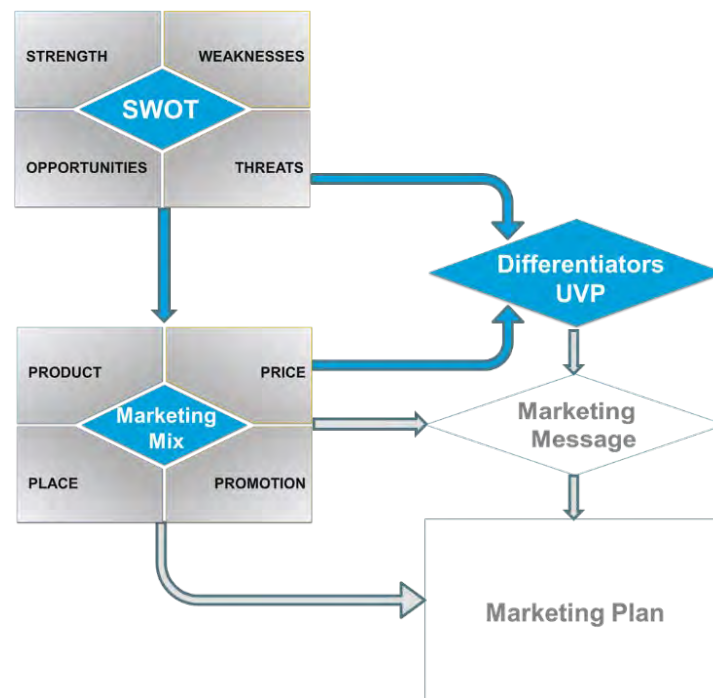


Figure 107: Schematics of Marketing Strategy and Tactics

THE CLIENT ENTERS THE NICHE OF A MATURE MARKET WITH THE ESTABLISHED MARKET PLAYERS, AS A DISRUPTOR. According to the Business Dictionary, entering the niche market means “concentrating all marketing efforts on a small but specific and well-defined segment of the population.”¹⁷⁴ In short, a niche market has several advantages:

- **LESS COMPETITION.**

[REDACTED]

- **FOCUSED EFFORTS.**

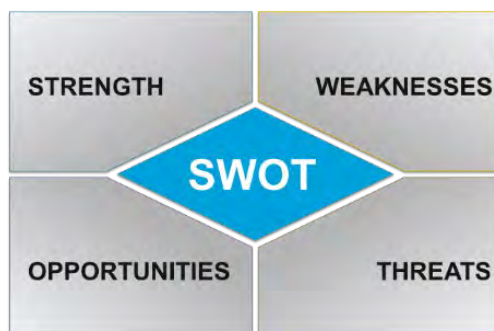
[REDACTED]

- **ESTABLISHING BRAND LOYALTY.**

[REDACTED]

SWOT Analysis

With the understanding of a business' internal strengths and weaknesses and the external opportunities and threats, the Client can develop a strategy that plays to strengths and matches them to the emerging opportunities. The Client should also identify weaknesses and try to minimise them. It is recommended that the Client play “a devil’s advocate” by preparing questions and situations that point at company vulnerabilities in its product/services and come up with the ways on how to address them. Tables below are an example of how it can be executed. In addition, they contain some information that can be applied by the Client for diving deep into the issues.



Understanding Strengths

Strengths	Resulting Benefits to the Client
Competence in the sector supported by an experience in a lateral sector (chemical engineering and	[REDACTED]

¹⁷⁴ Business Dictionary: Niche marketing, <<http://www.businessdictionary.com/definition/niche-marketing.html>>

Strengths	Resulting Benefits to the Client
biological engineering).	
Limited number of similar products in the market.	
Unique technology features	
Small business.	

Mitigating Weaknesses

Weaknesses	Actions to Mitigate Weaknesses
Dependence on one product makes you vulnerable to the market changes or failures.	
Lack of the established reputation in the market segment.	
Limited financial and manufacturing capacity.	

Market Opportunities

Opportunities	Resulting Benefits to the Client
Well established target markets with stable structure and market players.	[REDACTED]
Lower cost of production.	[REDACTED]
Regulatory requirements favoring the Client's technology.	[REDACTED]
Generic features of the product.	[REDACTED]

Mitigating Business Risks / Threats

Threats	Client's Mitigation Actions
Established long-term procurement contracts due to the maturity of the market.	[REDACTED]
Small profit margins in the target markets would prevent potential buyers from venturing into new technology that might be more expensive.	[REDACTED]
Fragmented market means smaller segments = limited growth	[REDACTED]
New technology, untested by the market.	[REDACTED]
Limited capacity in achieving the intended market reach.	[REDACTED]

Threats	Client's Mitigation Actions

Marketing Mix

The marketing mix can be divided into four groups of variables commonly known as the four Ps:

Product: the products and/or services offered to customers;

Price: the amount of money paid by customers to purchase the product/service;

Place: activities that make the product available to consumers, distribution channels'

Promotion: activities that communicate the Solution's benefits and persuade customers to purchase it.



All four marketing mix's variables are interrelated and affect each other. For example, increasing the price might negatively affect demand and, as a result, less distribution efforts (place) might be needed. On the other hand, the UVP can be so high that maximum concentration should be on creating brand awareness, thus increasing the need of higher pricing and more promotions. The Client should remember that the combination of marketing mix variables is not set and should be analyzed and adjusted with the clientele response to the marketing mix and as the market and company conditions and objectives change (SWOT). The initial setting for the Client's efforts is discussed below. Because the Client intends to introduce several Products into the market, each subsection below includes the information on how to approach each individual segment.

EACH PRODUCT SEGMENT UNDER CONSIDERATION TARGETS DIFFERENT MARKETS. EACH OF THESE TARGET MARKETS HAS DIFFERENT STRUCTURE, REGULATIONS, MARKET PLAYERS, DISTRIBUTION NETWORKS, MARKET DRIVERS, ETC. THIS NECESSITATES VARYING APPROACHES WHEN DEVELOPING MARKETING STRATEGY ON ENTERING THE MARKET AND DEVELOPING SPECIFICS TACTICS.

Each subsection contains a table with questions and possible answers to the basic arguments that need to be cleared before preparing a comprehensive marketing strategy and marketing plan. There is a speculation by the Consultant added to each item in each section related to the expectation of how this position can contribute to the overall success of the Product with the target market. **In bold red written are observations and conclusions that suggest a likely negative market perception or high cost to the Client. In green – the likely positive perception or lower cost to the Client.**

Note that these tables and questions are just suggestions and are intended to provide a baseline consideration for the Client. The Client is to expand the tables with the questions / answers, which would

help to see how different Product segments can be addressed and approached within the company resource pool and financial capacity. A side-by-side comparison can be especially useful to examine the scale of coverage and resources required in order to develop a clear vision of the likelihood of success and all required elements to achieve it. The Client should review it and adjust/expand, as needed, when additional information becomes available or the company's position on different issues changes.

Product



Product decisions are the first ones to make when preparing a marketing plan. This information will then affect other variables of the mix.

The Products are introduced into a mature market, as disruptors. Hence, the main objective at the current stage is to [REDACTED]

The main objective here is to [REDACTED]

. In order to be successful, the Client has to understand the [REDACTED]

PRODUCT					
Product	Target market	How the buyers will use the Client's Product	What the buyers want from the Product	Differentiation from competing offerings / when the Product provides value	Potential market interest and the level of success
Plastic Pellets	Pellet manufacturers (see examples in section Plastic Pellets Manufacturers)	The most fitting approach in this option is to license the technology to vendor(s) who will then control the rest of the product cycle. Client's technology will be utilized whenever it suites the license holder.	Buyers have established contracts with products manufacturers, or they also manufacture these products themselves. The main expectation from the Clients is to ensure that the licensed technology is tested, certified, and all legal aspects of IP transfer are negotiated and documented properly.	Pellet manufacturers and plastic products manufacturers are entering difficult times. Demand for standard plastics is being slowly replaced by bioplastics and biodegradable products, which forces them to look for alternative solutions and increase their R&D investing. Client's technology can become an extremely attractive option for these buyers as the number of companies specialized in plastic that is biodegradable in water is limited. In fact, the Client might not have any competition in this sector.	This target market has potentially the highest success rate. Limited market offerings due to extremely high entry barriers supported by growing demand create the best combination for the Client's success. With the Client's proven technology, the buyer receives the access to the innovative unique solution while saving millions of dollars and years of R&D efforts. The value to the market is very high.
	Plastic products manufacturers (see examples in section Nylon Manufacturers are Stepping into Biodegradable Sector)	Pellets are to be sold in bulk to the manufacturers specialized in producing bioplastic and biodegradable products. The Client will operate as a raw material vendor.	Buyers expect to receive from the Client pallets (raw material) that meet the required criteria. Production of plastic pellets by the Client must be reliable, in volumes and quality, consistent with contractual obligations.		There is a large market potential for such raw materials, especially due to the limited number of those specialized in water-based degradation. The level of success can be high provided the Client can ensure the reliable production capacity.
Fish Tags					
Gear Tags					

PRODUCT					
Product	Target market	How the buyers will use the Client's Product	What the buyers want from the Product	Differentiation from competing offerings / when the Product provides value	Potential market interest and the level of success
Fish Feed Bags	Aquaculture (fish farms), Fish feed producers, Fish feed packaging manufacturers				
Fishing line	Residential anglers, commercial fisheries, manufacturers of fishing lines (see examples in section Manufacturers of Nylon Fishing Gear in case of licensing the technology and fish tackle stores in case of self-manufacturing)				
Fishing nets	Commercial fisheries, manufacturers of fishing nets (see examples in section Manufacturers of Nylon Fishing Gear)				

Price, Packaging



Pricing reflects every other aspect of a go-to-market strategy, from customer to the market to how one uses strategies like PR, marketing, and sales, thus, it needs to be a purposeful and deliberate choice. Price depends on different variables and hence it is updated periodically. Major factors (each one can change independently), which affect pricing, are:

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Pricing affects positioning (unique features at high prices), and vice versa. There are different pricing strategies, which are influenced by the factors listed below.

Note that Table 7: Top Nylon Fishing Gear Companies contains links to the pricing information of the top manufacturers of nylon-based fishing gear. This information can be used by the Client when developing pricing policy for its Products.

PRICE, PACKAGING			
Product	Are there established prices points	Options for selling the Product	Expected price differential from the current market prices, its acceptance by the target market.
Plastic Pellets			
Fish Tags			
Fish Feed Bags			
Fishing line			
Fishing nets	This is a specialized market with the established market players and prices. Some information can be found in section Manufacturers of Nylon Fishing Gear.	This is predominantly the B2B selling approach.	Fishing nets are coming under scrutiny by regulators with traps and pots already required to have degradable elements. Some extra price tolerance can be anticipated. Aside from the potential and pending regulatory pressure, clear messages supported by quantifiable data should communicate the value of this technology over conventional fishing nets.

Place



Place refers to distribution channels of the product. Distribution can have a big impact on profitability especially when the product must be shipped long distances.

PLACE			
Product	Where buyers look for the product	The best approach to target each channel	How important is it to hold high levels of inventory?
Plastic Pellets			
Fish Tags			
Fish Feed Bags			
Fishing Lines	Retail stores, large department stores (Canadian Tire, as well as small, specialized retailers (My Fly Shop, Fred's Custom Tackle). The likely distribution is via distributors or directly (in cases of small shops).	Sales can be executed via specialized dealerships, which will serve as intermediaries between the Client and buyers. As part of the deal, the Client might consider offering the in-kind marketing support and co-promotional activities. This approach removes some costs such as administrative, inventory, and significantly reduces marketing and sales efforts. The Client can also target businesses directly. Some businesses purchase products directly from the manufacturers and look for them online, via referrals or use the established contacts. These are usually cost-concerned owners of the smaller businesses. Potentially, the Client can sell online, on Amazon, eBay.	Retailing requires holding a working stock of the items that are in high demand ready for shipping. Considerable consideration should be given to the inventory holding costs. Additional expenses for this channel are to be allocated to building strong online presence. Overall, this is a more cash intensive market.
Fishing Nets			

Promotion



Promotions in the marketing mix are comprised of sales promotions and integrated marketing communications, which include advertising and educating the market base of the product. Promotions are dependent on the product, place, and pricing decisions. In their turn, promotions affect all the other three variables – the product, price, and place. If the promotions are effective, you might have

Generally, any other marketing activity should be directed at meeting three main objectives:

Brand awareness is an important aspect, especially on the initial market entry stage

An educational stream of materials should be

Selling online directly to the businesses is

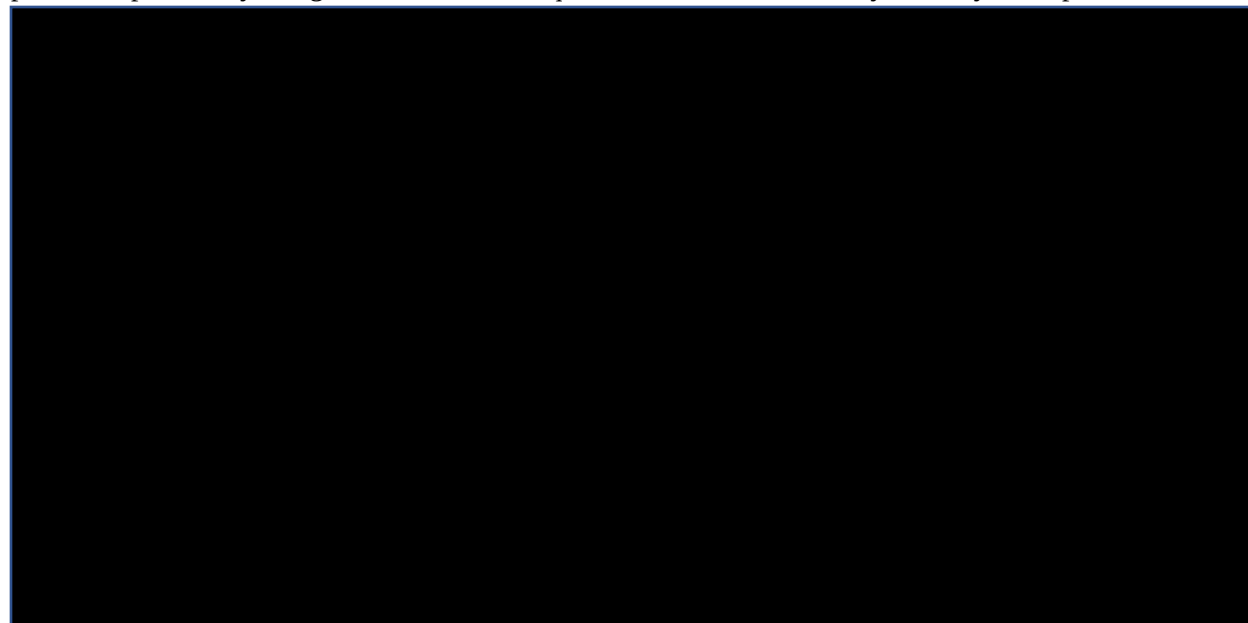
PROMOTION			
Product	Where can the marketing messages get across to the target market?	Best approach for promotional activities	Best approach for selling
Plastic Pellets			
Fish Tags			
Fish Feed Bags			
Fishing Nets			

PROMOTION			
Product	Where can the marketing messages get across to the target market?	Best approach for promotional activities	Best approach for selling
Fishing Lines			

AS THINGS STAND NOW AND WITH THE INFORMATION AVAILABLE, THE CONSULTANT EXPECTS THAT PLASTIC PELLETS AND FISHING NETS HAVE THE HIGHEST LEVEL OF MARKET ACCEPTANCE ALTHOUGH AT VARYING MARKETING AND SALES COSTS. THE LEAST LIKELY SUCCESS RATE CAN BE ATTRIBUTED TO FISH TAGS AND FISH FEED BAGS EVEN THOUGH THEY ENTAIL LESS MARKETING AND SALES EXPENSES. THE MOST EXPENSIVE MARKET IS FISHING LINES.

23. CONCLUSIONS AND RECOMMENDATIONS

Biodegradability of plastics is in high demand globally with a growing focus on the elimination of widespread plastics pollution. Plastics which degrade in water is a niche technology intended to replace products specifically designed for use in the aquatic environment. The key industry that operates in this

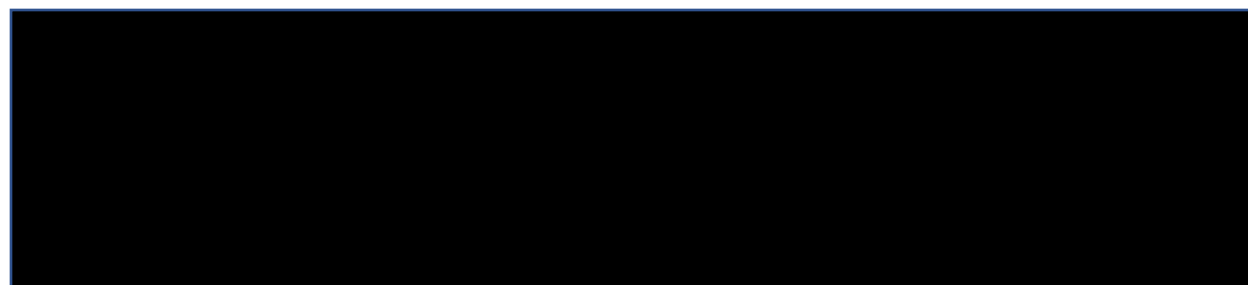


Without facing practically any competition, the Client has a multitude of options of entering the market; however, each option should be assessed properly with decisions supported by a financial modeling exercise.

Multiple Product Lines Need Multiple Touchpoints

The Client intends to enter the market via several product lines. What makes it challenging is that the fishing industry is not homogeneous: it consists of different segments that rarely overlap. Each one of these segments has its own cycle, market players, different infrastructure, vendors, distribution channels, and regulations. Because each of the Client's Products target different fishing segments, market entry approach should differ for each one of them. This means different marketing scopes, different targets, different messages, and different budgets. While this does complicate efforts and increases required funding, at the same time it dilutes business risk: if one product fails or faces delays due to obstacles, the organization will be able to switch the focus to another target. Some topics that can arise during analysis of market entry for each Product and observations / recommendations are discussed below.

- **Plastics pellets.**



thus reducing the cost of carrying an inventory. The marketing message should focus on the value of biodegradability in plastic.

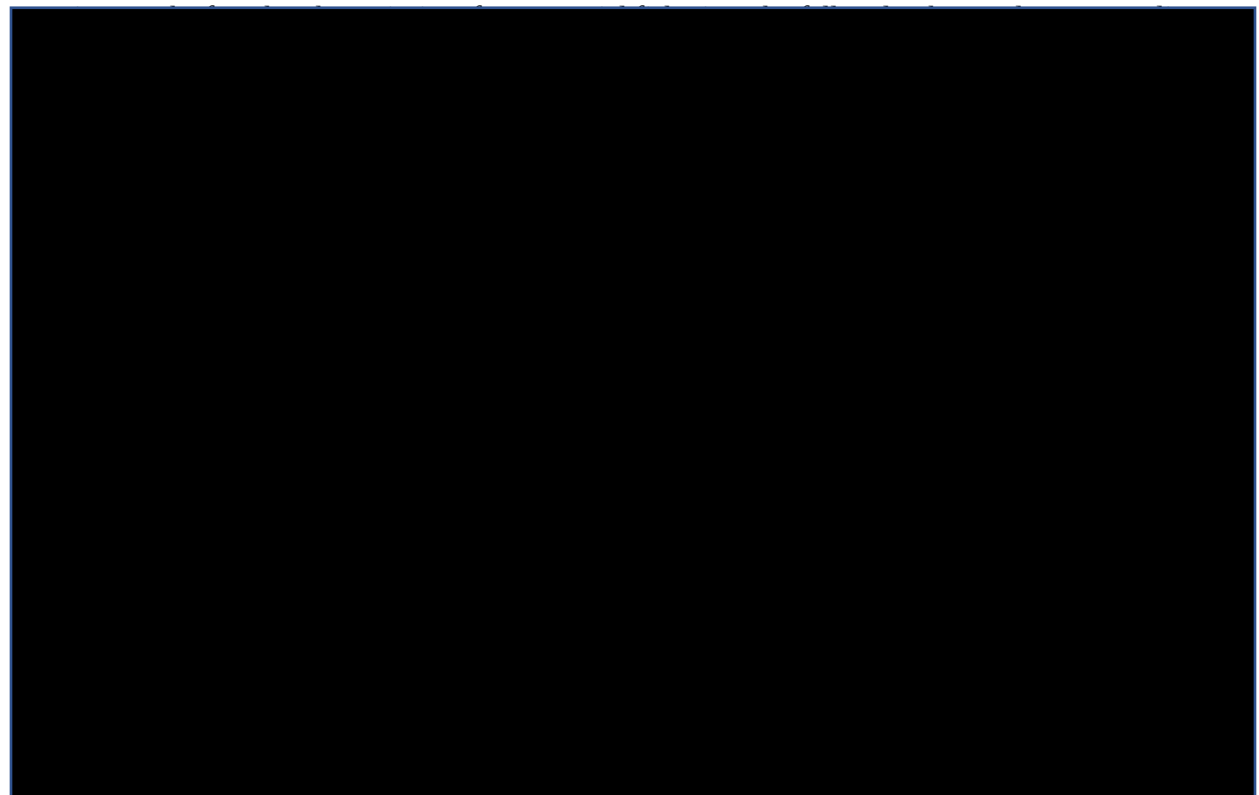
- **Fish tags.** The majority of tagging programs in Canada are executed in cooperation with fish farms (aquaculture) but are actually run by governmental agencies. The target market - these governmental agencies - usually enters into long-term contracts with suppliers as a result of a publicly run tender process. Manufacturing process should be less involved, but the quality of the Product should comply



- **Fish feed bags** are designed for aquaculture. Similar to fish tags, British Columbia's dominance in this segment makes it logistically easier to target the market when establishing relationships with fish



- **Fishing nets** is arguably the most attractive segment since regulatory pressure has been put on commercial fisheries in connection with their contribution to ghost fishing. Consideration should be



Get a Grip on Your Future with Analysis and Planning

It is recommended that prior to entering the market and starting any marketing activities, the Client conduct validation surveys for each Product. Information from these surveys should be entered into a financial model to analyse feasibility of each Product.

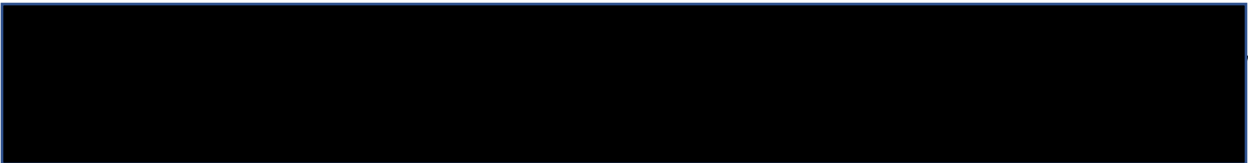
Validation studies to confirm availability and readiness of each target market for the Client's Products. Validation studies can be conducted in the form of a survey or a discussion that would extract the same



Financial marketing model simulating all associated costs will help with determining the sufficiency of the internal fiscal and operational capacity to determine what Product will be feasible for development and commercialization by calculating multiple outputs, including but not limited to the following:



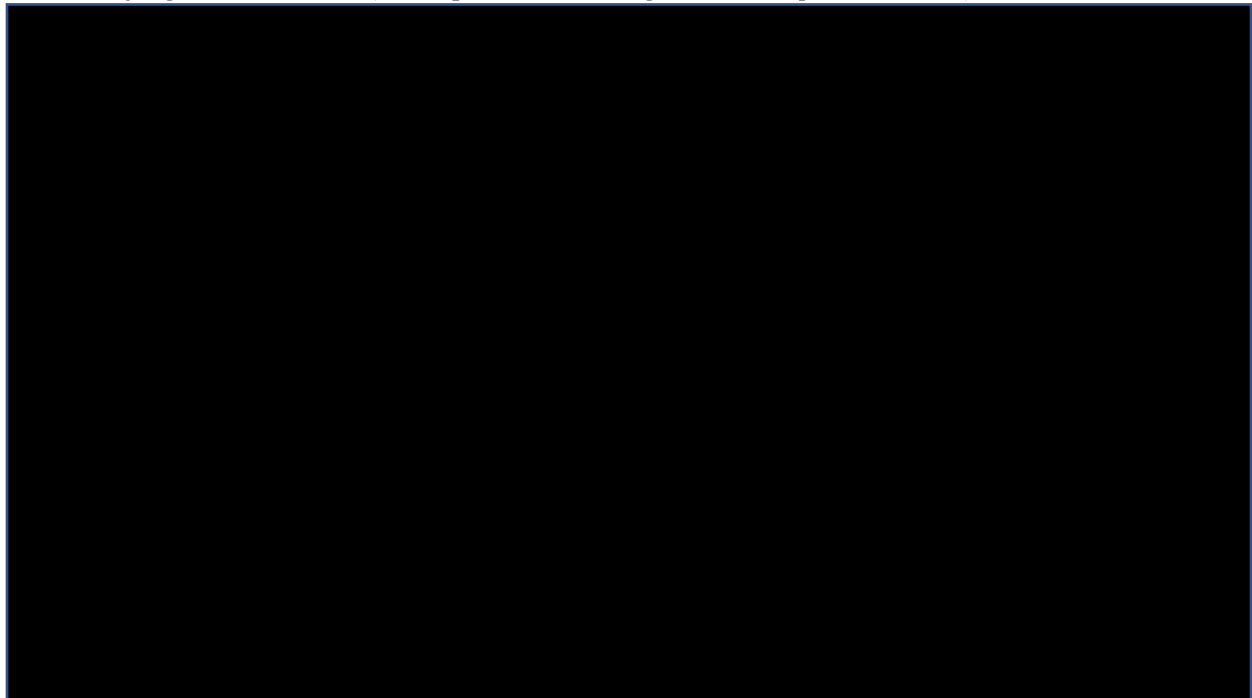
Building Awareness is the Key to the Marketing Strategy for Market Disruptors



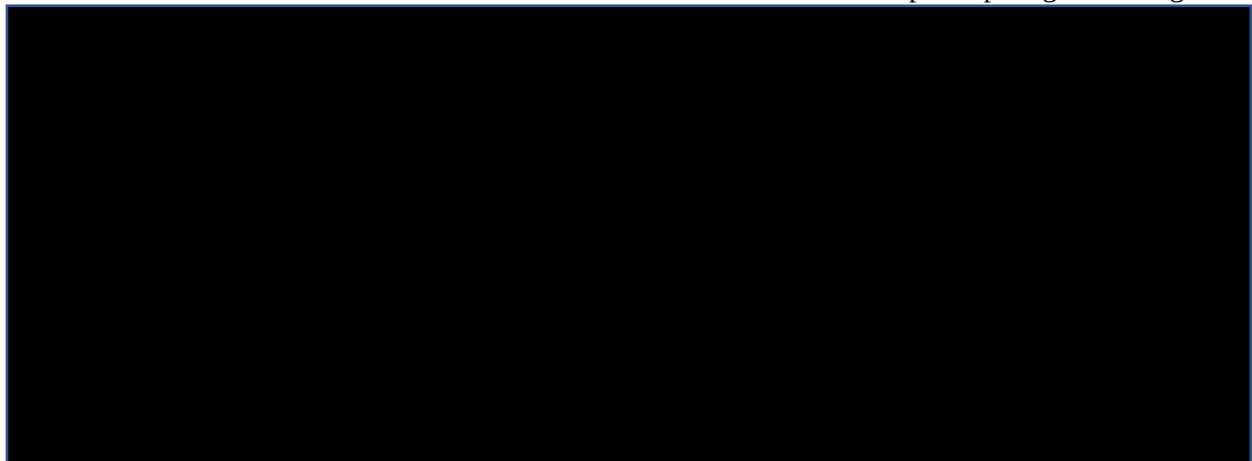


Brand awareness is one of the most expensive marketing ventures especially in the case of new, disruptive technology.

Because the main distribution approach is Business-to-Business and key differentiators are inherited in the Product itself and its features, the focus of marketing efforts should be on educating the market about the underlying issues it solves (ocean pollution, endangerment of aquatic life, etc.) and differentiation



Since the Products intended for development target different market segments serviced by different distribution channels and influenced by different factors, marketing strategies and efforts should be clearly separated by each Product. All marketing costs should be allocated properly to a specific Product to ensure that calculations of viability and profitability are executed correctly. It might help the Client in the planning stage when making decisions on the required funding, and later – to track the success rate of each Product. Few examples of such cost allocation are described below.

- Costs of participating in the next Gear Innovation Summit, discussed in section Gear Innovation Summit – the First Ghost Gear Event in Canada should include a fee for participating, travelling and
- 

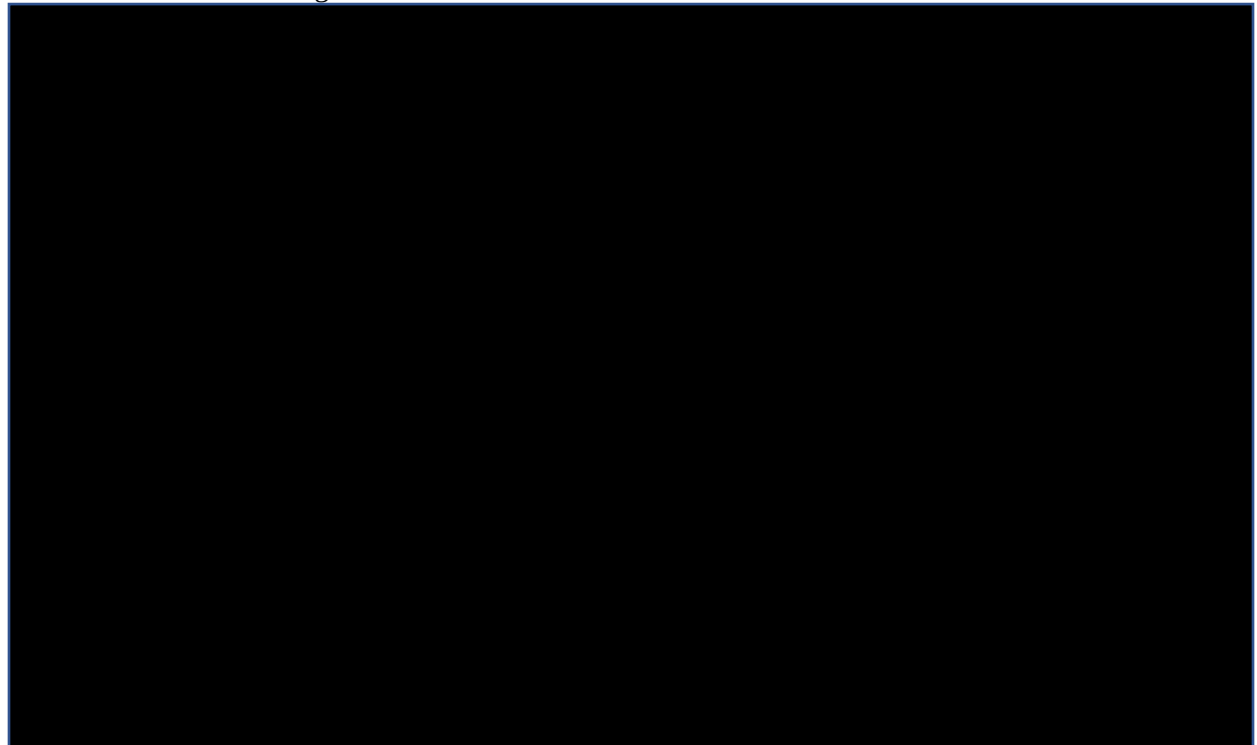
Succeed Through Joining the Environmental Movement: Help the World, Help Yourself

The importance of environmental regulations and initiatives for the Client's success cannot be overstated. In fact, the severity of their limitations, and expansion to a wider set of applications will be the key to the Client's success, at least for Fishing Nets.

Ideally, the more types of fishing gear that fall under regulatory control, the bigger the Client's potential target base. The Client should remain vigilant of these environmental regulations, pending changes and



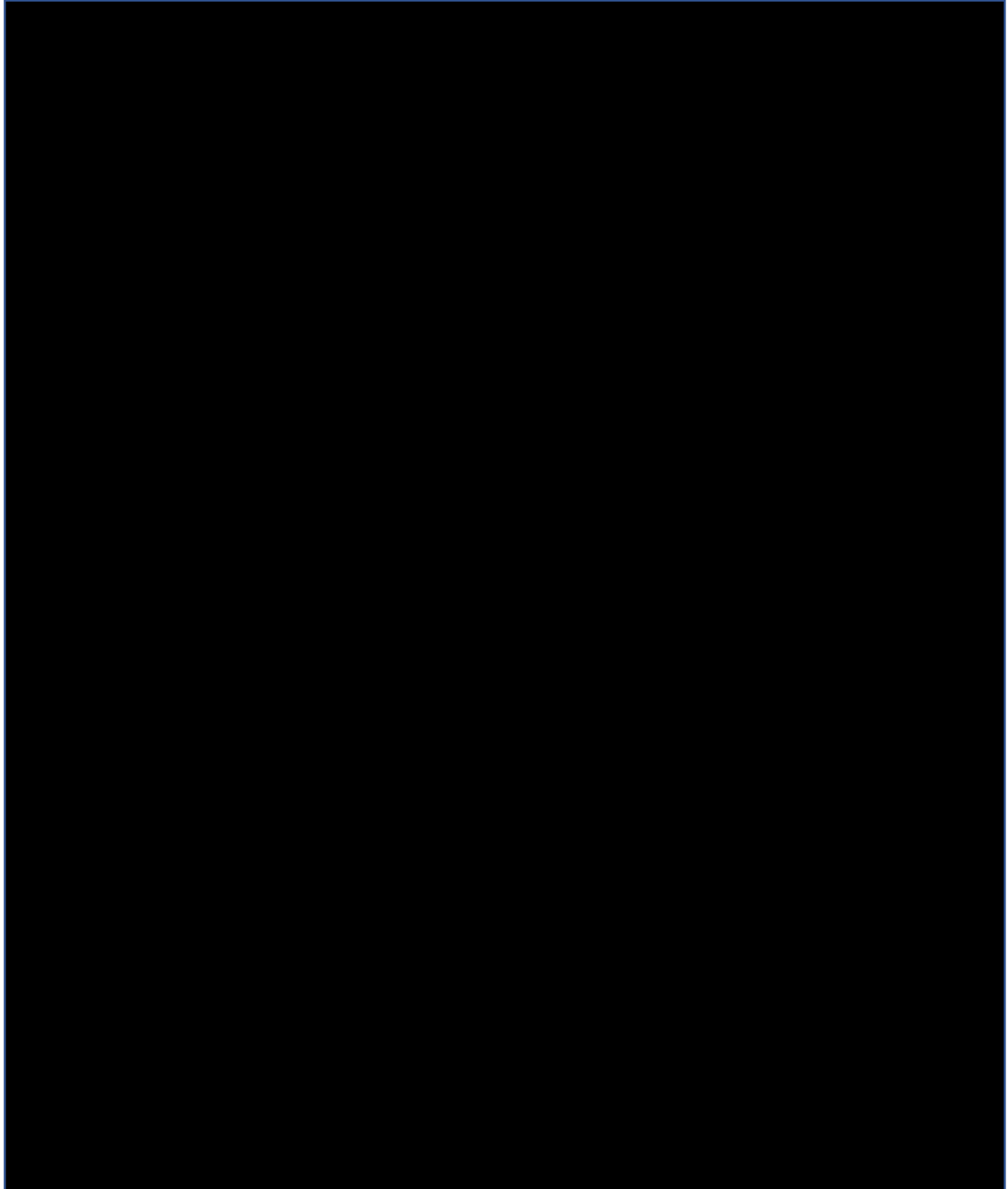
The Client should also consider joining organizations that influence, or at least attempt to influence, governmental policies that promote biodegradable gear, directly or indirectly. There are multiple environmental organizations that the Client can engage to promote its technology and Products as one of these solutions. Also, in the case of governmental and legal organizations, lobbying efforts can be put forward. Some of these organizations are listed below:

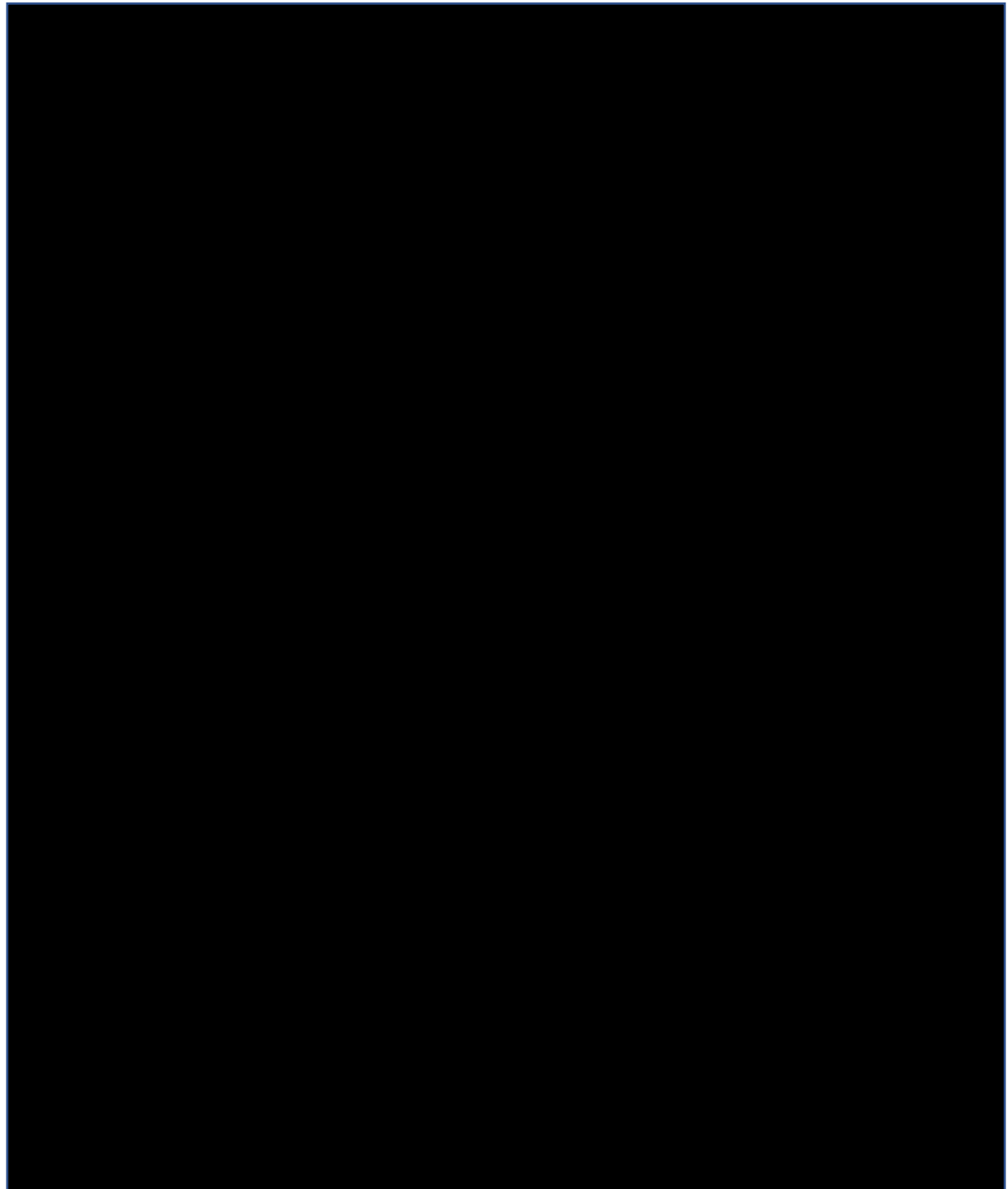




24. APPENDIX A: FISH TAG COLORS

Tag colors to be used in the Atlantic Regions for the fishing seasons covered by the 2018-2020 Protocol cycle:





25. APPENDIX B: RECIPIENTS OF CANADIAN GHOST GEAR FUND¹⁷⁵

Name	Area of work	Description	Pillars of activity
The Ocean Legacy Foundation	Powell River, BC Tofino, BC	The Ocean Legacy Foundation is partnering with the Regional District and the Alberni-Clayoquot Regional District to build two pilot collection programs in Tofino and Powell River, BC to manage select ghost gear resources in Pacific Canada. This support will provide much needed critical infrastructure to capture plastic wastes, divert them from landfill and responsibly recycle items to not only support innovative technologies but further implement pragmatic solutions to grow the Canadian plastic circular economy.	Gear disposal



Name	Area of work	Description	Pillars of activity

Name	Area of work	Description	Pillars of activity

Name	Area of work	Description	Pillars of activity

26. APPENDIX C: STATISTICS OF CANADIAN COMMERCIAL FISH LANDINGS

Table 10: 2018 Value of Atlantic & Pacific Coast Commercial Landings, by Province (thousand dollars)¹⁷⁶

Species	Nova Scotia	New Brunswick	PEI	Quebec	NFLD	Atlantic Total	British Columbia	Total Canada
Groundfish								
Cod	2,719	15	11	891	23,218	26,854	490	27,344
Haddock								
Redfish spp.								
Halibut								
Flatfishes								
Greenland turbot								
Pollock								
Hake								
Cusk								
Catfish								
Skate								
Dogfish								
Other								
Total Groundfish								
Pelagic & other finfish								
Herring	23,717	19,776	1,358	2,232	4,788	51,871	12,936	64,807
Mackerel								
Swordfish								
Tuna								
Alewife								
Eel								
Salmon								
Smelt								
Silversides								
Shark								
Capelin								
Other								
Total Pelagics								
Shellfish								
Clams / quahaugs								
Oyster								
Scallop								
Squid								
Mussel								

Source: Statistics Canada, 2019, *Commercial Fisheries of Canada*, Table 26-101, <https://www150.statcan.gc.ca/n1/pub/26-101-x/2019001/article/00001-eng.htm>

Species	Nova Scotia	New Brunswick	PEI	Quebec	NFLD	Atlantic Total	British Columbia	Total Canada
Lobster	771,107	290,653	194,407	116,616	46,869	1,419,651	0	1,419,651
Shrimp								
Crab, Queen								
Crab, Other								
Whelks								
Cockles								
Sea cucumber								
Sea urchin								
Other								
Total Shellfish								
Subtotal								
Other								
Marine plants								
Lumpfish roe								
Miscellaneous								
Total								
Grand Total								

Table 11: Freshwater Fisheries - Catches and Landed Values by Species, By Province/Territory, 2018 (Nominal catches (Q) in tons, live weight. Values (V) in thousand dollars)

	N.B.		Quebec		Ontario		Manitoba		SK		Nunavut		N.W.T.		Canada	
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
Alewife																
Arctic Char																
Burbot																
Carp																
Catfish																
Eel																
Lake trout																
Perch																
Pike																
Rock bass																
Salmon																
Sauger																
Shad																
Smelt																
Sturgeon																
Sucker																
Sunfish																
Tomcod																
Tullibee					331	258	643	1,513	25	6					999	1,777
White bass																
Whitefish																
Yellow Pickerel																
Other																
Total																