Policy Options and Best Practices for End-of-Life Fishing and Aquaculture Gear

Task 2/3/4 Final Report

May 10th, 2023

Prepared For:
Canadian Council of Ministers of the Environment
Waste Reduction and Recovery Committee

Submitted By:

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1. Introduction

1.1 Background

The Canadian Council of Ministers of the Environment (CCME) is the primary minister-led intergovernmental forum for collective action on environmental issues of national and international concern. The 14 member governments work as partners on issues that are Canada-wide, international and intergovernmental in nature, and of interest to a significant portion of CCME member governments/regions. In support of the implementation of the Canada-wide Action Plan on Zero Plastic Waste, CCME's Waste Reduction and Recovery Committee (WRRC) is developing guidance to assist federal, provincial and territorial jurisdictions to increase the collection, end-of-life management and reuse, repair and recycling of fishing and aquaculture gear.

Canadian fisheries and aquaculture operations use large amounts of gear (e.g., rope, nets, line, lobster traps, crab pots, oyster baskets, etc.) to fish safely and successfully. When this gear is no longer safe and/or useful for fishing or containment, due to damage or wear and tear, it becomes what is known as "end-of-life fishing and aquaculture gear". Not all fish harvesters and aquaculture practitioners can easily dispose of or recycle their end-of-life gear, as there is no single, consistent, environmentally friendly system in place to recycle or repurpose different kinds of end-of-life fishing and aquaculture gear.[1] In part this leads to the proliferation of abandoned, lost or otherwise discarded (ALD) fishing and aquaculture gear. Other common terms for ALD fishing and aquaculture gear include ghost gear and derelict fishing gear.[2] In this report, the term ALD will be applied to fishing gear or to aquaculture gear.

In 2009, the UN Food and Agriculture Organization estimated that between 600,000 and 800,000 tonnes of ALD fishing gear enter the oceans on an annual basis.[3] ALD fishing gear has become recognized as one of the most harmful forms of plastic pollution to marine mammals and ecosystems. No global estimates of ALD aquaculture gear exist.[4]

[1] Accessed at the website of the Fishing Gear Coalition of Atlantic Canada (https://fgcac.org/end-of-life-fishing-gear-project/).
[2] Accessed at the website of the Department of Fisheries and Oceans (https://www.dfo-mpo.gc.ca/fisheries-peches/management-gestion/ghostgear-equipementfantome/what-quoi-eng.html).
[3] Macfadyen, G., Huntington, T., Cappell, R., 2009. Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies 185. FAO Fisheries and Aquaculture Technical Paper 523., Aquaculture.
[4] GESAMP, 2021. Sea-Based Sources of Marine Litter. Rep. Stud. GESAMP No. 108. (IMO/FAO/UNESCO-IOC/UNIDO/ WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.

1.2 Purpose

The purpose of this study is to assist the WRRC by evaluating and subsequently identifying the best policy options and work practices to increase the collection and end-of-life management of fishing and aquaculture gear in Canada.

1.3 Methodology

There were three main methodological components to this study, as follows:

- Research was conducted to identify the most relevant literature on policy options and work practices to manage end-of-life (EOL) fishing and aquaculture gear from the perspective of this study. Subsequently this literature was obtained, reviewed and relevant information extracted and incorporated into the Final Report. Existing literature on the types and quantities of fishing and aquaculture gear used/generated as EOL material in Canada annually as well as the value retention infrastructure in place in Canada to manage EOL fishing and aquaculture gear was also reviewed. Other miscellaneous literature sources were also reviewed.
- Interviews were conducted to address information gaps in the existing literature, to collect updated/current information such as information on where existing end-of-life fishing and aquaculture gear ends up and to gather unique Canadian perspectives on the management of EOL fishing and aquaculture gear. Organizations interviewed included companies currently providing value retention services for the management of EOL fishing and aquaculture gear, fishing industry associations, government organizations, non-governmental organizations, and municipal waste management organizations. A total of 15 interviews were conducted during the study.
- Two workshops were organized and held to collect viewpoints and perspectives on the best policy instruments and industry work practices to implement in Canada to address EOL fishing and aquaculture gear. The workshops also collected information on the barriers to the implementation of these policy options/work practices and opportunities to address barriers. The workshops were attended by approximately 60 people from more than 40 organizations.

1.4 Structure of the Final Report

There are six additional chapters in this report, as follows:

- Chapter 2 (Overview of the Commercial Fishing and Aquaculture Industry in Canada) – provides a summary of the value and quantity of landings/production within the commercial fishing and aquaculture industries in Canada as well as by region.
- Chapter 3 (Use and End-of-Life Fate of Fishing and Aquaculture Gear in Canada) –estimates the quantity of EOL fishing and aquaculture gear generated in Canada annually by type of gear and material. Estimates of the fate of this EOL gear is also provided and the extent that value retention infrastructure exists in Canada to manage this gear is outlined.
- Chapter 4 (Government Policies and Industry Best Practices to Manage End-of-Life Fishing Gear) – summarizes government policies and industry best practices to manage EOL fishing gear over the lifecycle of that gear.
- Chapter 5 (Government Policies and Industry Best Practices to Manage End-of-Life Aquaculture Gear) – summarizes government policies and industry best practices to manage EOL aquaculture gear over the lifecycle of that gear.
- Chapter 6 (Recommended Government Policies and Industry Best Practices) - applies criteria to identify the best policies and work practices to implement. Barriers/gaps to implementation and requirements to implement these options/practices are discussed.
- Chapter 7 (Bibliography) – identifies literature sources that are referenced in this report.

2. Overview of the Commercial Fishing and Aquaculture Industry in Canada

2.1 Introduction

This section provides an overview of fishing and aquaculture in Canada. Overall, the available information for 2020 shows: (i) marine landings of 719,000 tonnes; (ii) freshwater landings of 22,000 tonnes; and (iii) aquaculture production of 171,000 tonnes. Section 3.2 below covers commercial marine fishing, Section 3.3 commercial freshwater fishing, and Section 3.4 aquaculture.

2.2 Commercial Marine Fishing in Canada

2.2.1 A Regional View

In 2020, commercial marine fishing operations in Canada landed nearly 720,000 metric tonnes of fish as illustrated in the table on the following pages. Landings were highest (by mass) in Nova Scotia, accounting for almost one-third (31%) of the national catch. Significant landings also occurred in Newfoundland and Labrador and British Columbia, each with approximately one-quarter of Canada's catch (25% and 24% respectively). New Brunswick (10%), Québec (6%), and Prince Edward Island (4%) accounted for the remainder.

2.2.2 Landings by Type

Almost 50% of commercial landings in Canada are shellfish. Crab, shrimp, lobster, and clams together account for most of these shellfish landings. Fully two-thirds of Canada's shellfish are harvested in Nova Scotia and Newfoundland and Labrador.

Groundfish landings represent 30% of commercial fisheries landings. These primarily include hake, redfish, flatfishes (such as flounder, sole, and halibut), and haddock. Well over half (61%) of the Canadian take of groundfish is harvested in British Columbia.

Pelagic and other finfish account for the remaining 20% of landings. By weight these catches primarily include herring and capelin. Nearly 60% of the pelagic and other finfish are caught in Nova Scotia and Newfoundland and Labrador.

2.2.3 Landings by Value

The landed value of marine fisheries was nearly $2.5 billion in 2020. The value of shellfish landings dominated at $2.0 billion (80% of the national total).

Table 1: Marine Fisheries Landed Quantity, by Region (2020 Preliminary)

(Metric tonnes, live weight)

Species	Nova Scotia	New Brunswick	Prince Edward Island	Québec	Newfoundland and Labrador	British Columbia	Total Canada
Groundfish							
Hake	3,664	x	x	14	290	99,904	103,873
Redfish spp.	7,678	x	0	x	4,361	14,458	26,530
Flatfishes	717	5	0	400	14,639	5,836	21,597
Haddock	16,953	x	0	x	80	0	17,033
Cod	1,015	x	x	213	12,770	486	14,490
Greenland turbot	x	x	0	1,154	9,527	0	10,707
Pollock	3,082	x	0	x	88	7,080	10,250
Halibut	4,556	112	74	690	862	3,119	9,412
Skate	79	0	0	0	499	271	850
Cusk	146	x	0	0	x	0	146
Dogfish	x	x	0	0	x	118	119
Catfish	0	0	0	0	0	0	0
Other	651	x	0	x	34	3,315	4,025
Total groundfish	***38,569***	***122***	***78***	***2,527***	***43,151***	***134,586***	***219,032***
Pelagic & other finfish							
Herring	44,426	23,574	1,878	3,119	8,449	11,339	92,784
Capelin	0	x	0	x	23,986	0	26,391
Salmon	x	0	0	0	0	8,406	8,406
Mackerel	1,315	346	1,471	662	4,015	0	7,809
Alewife	789	2,311	50	0	0	0	3,150
Tuna	522	4	190	24	28	2,375	3,144
Swordfish	1,334	0	0	0	0	0	1,334
Silversides	0	0	167	0	0	0	167
Eel	x	19	46	x	17	0	89
Smelt	0	x	26	0	0	0	59
Shark	x	0	0	x	0	0	1
Other	11	x	0	x	18	0	31
Total pelagics	***48,404***	***26,779***	***3,829***	***5,721***	***36,513***	***22,120***	***143,365***

Species	Nova Scotia	New Brunswick	Prince Edward Island	Québec	Newfoundland and Labrador	British Columbia	Total Canada
Shellfish							
Crab, Queen	14,290	11,621	3,199	12,598	29,373	0	71,080
Shrimp	19,209	3,123	0	10,861	32,913	2,474	68,580
Lobster	20,151	16,403	16,755	10,310	4,451	0	68,070
Clams / quahaug	21,330	x	536	792	x	1,396	40,022
Sea cucumbers	x	x	0	1,031	6,733	1,582	12,036
Crab, Other	x	488	889	637	x	7,842	10,387
Squid	x	0	0	x	3,497	0	3,530
Sea urchin	x	715	0	x	337	1,022	2,497
Whelks	x	0	0	899	x	0	2,323
Mussel	0	0	0	0	0	0	0
Oyster	29	37	237	0	0	0	x
Scallop	57,780	3,942	269	448	975	x	x
Cockles	x	0	0	0	x	0	x
Other	0	0	0	0	0	106	106
Total shellfish	***136,550***	***37,138***	***21,883***	***37,990***	***96,570***	***14,422***	***344,552***
Others							
Marine plants	x	x	0	0	0	0	9,886
Lumpfish roe	x	x	0	x	79	0	80
Miscellaneous	x	x	0	x	2,333	0	2,335
Total others	***84***	***9,801***	***0***	***3***	***2,412***	***0***	***12,300***
Grand total	**223,607**	**73,839**	**25,790**	**46,240**	**178,646**	**171,128**	**719,249**

Source: Government of Canada, *Marine fisheries Landings*.
Note 1: "x" indicates data suppressed to meet confidentiality requirements.
Note 2: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

Table 2: Marine Fisheries Landed Value, by Region (2020 Preliminary)

(Thousands of Dollars)

Species	Nova Scotia	New Brunswick	Prince Edward Island	Québec	Newfoundland and Labrador	British Columbia	Total Canada
Groundfish							
Halibut	$45,723	$1,181	$797	$5,628	$7,065	$33,257	$93,652
Greenland turbot	x	x	$0	$4,927	$47,068	$0	$52,107
Redfish spp.	$15,942	x	$0	x	$6,604	$12,287	$34,859
Flatfishes	$1,831	$7	$0	$1,684	$21,248	$6,418	$31,188
Hake	$3,107	x	x	$10	$164	$22,025	$25,306
Cod	$4,087	x	x	$453	$18,765	$751	$24,067
Haddock	$20,109	x	$0	x	$152	$0	$20,261
Pollock	$2,170	x	$0	x	$35	$3,122	$5,327
Skate	$40	$0	$0	$0	$140	$349	$529
Cusk	$100	x	$0	$0	x	$0	$100
Dogfish	x	x	$0	$0	x	$16	$17
Catfish	$0	$0	$0	$0	$0	$0	$0
Other	$1,123	x	$0	x	$46	$21,660	$22,843
Total groundfish	***$94,345***	***$1,199***	***$801***	***$12,739***	***$101,288***	***$99,884***	***$310,255***
Pelagic & other finfish							
Herring	$28,152	$16,362	$1,948	$1,517	$2,943	$8,312	$59,235
Salmon	$0	$0	$0	$0	$0	$22,081	$22,081
Tuna	$6,773	$35	$1,449	$333	$219	$10,022	$18,831
Capelin	$0	x	$0	x	$14,753	$0	$15,737
Mackerel	$1,919	$687	$2,976	$781	$2,487	$0	$8,850
Alewife	$808	$1,921	$106	$0	$0	$0	$2,835
Swordfish	$2,254	$0	$0	$0	$0	$0	$2,254
Eel	x	$107	$226	x	$76	$0	$441
Silversides	$0	$0	$406	$0	$0	$0	$406
Smelt	x	x	$47	$0	$0	$0	$104
Shark	x	$0	$0	x	$0	$0	$2
Other	$15,223	x	$0	x	$45	$0	$15,304
Total pelagics	***$55,163***	***$19,263***	***$7,158***	***$3,555***	***$20,523***	***$40,415***	***$146,078***

Species	Nova Scotia	New Brunswick	Prince Edward Island	Québec	Newfoundland and Labrador	British Columbia	Total Canada
Shellfish							
Lobster	$280,798	$169,067	$153,074	$114,545	$43,665	$0	$761,148
Crab, Queen	$121,808	$88,788	$24,629	$104,612	$223,264	$0	$563,102
Shrimp	$61,868	$6,401	$0	$25,731	$143,028	$25,668	$262,697
Clams / quahaug	$44,859	x	$1,087	$1,054	x	$36,959	$121,109
Crab, Other	x	$661	$1,048	$1,197	x	$86,269	$89,791
Sea cucumbers	x	x	$0	$2,257	$8,164	$5,878	$20,442
Sea urchin	x	$2,824	$0	x	$719	$2,683	$8,592
Squid	x	$0	$0	x	$5,938	$0	$5,939
Whelks	x	$0	$0	$1,849	x	$0	$3,338
Mussel	$0	$0	$0	$0	$0	$0	$0
Oyster	$120	$174	$783	$0	$0	$0	x
Scallop	$157,909	$10,874	$713	$1,411	$1,863	x	x
Cockles	x	$0	$0	$0	x	$0	x
Other	$0	$0	$0	$0	$0	$368	$368
Total shellfish	***$671,534***	***$280,673***	***$181,334***	***$254,989***	***$468,191***	***$157,826***	***$2,014,547***
Others							
Lumpfish roe	x	x	$0	x	$563	$0	$568
Marine plants	x	x	$0	$0	$0	$0	$494
Miscellaneous	x	x	$0	x	$6,596	$0	$6,596
Total others	***$4***	***$490***	***$0***	***$5***	***$7,159***	***$0***	***$7,659***
Grand total	**$821,046**	**$301,625**	**$189,293**	**$271,288**	**$597,161**	**$298,125**	**$2,478,539**

Source: Government of Canada, *Seafisheries Landings* (https://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm).
Note1: “x” indicates data suppressed to meet confidentiality requirements.
Note 2: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

2.3 Commercial Freshwater Fishing in Canada

2.3.1 Freshwater Landings

The table below shows freshwater fish species by landed tonnage and region. At about 22,000 tonnes, landings of freshwater fish are in the range of 3% of the tonnages landed by marine fisheries. Most of the commercial freshwater fishing activity occurs in Ontario (representing 45% of the national total) and Manitoba (40% of the national total). Pickerel (yellow) is the most important fish by mass, representing over one-third (37%) of landed tonnages. Four species -- yellow pickerel, whitefish, smelt, and perch -- together account for nearly three-quarters of freshwater landings.

Table 3: Freshwater Fisheries Landed Quantity, by Region (2020 Preliminary)
(Metric tonnes, live weight)

Species	NB	QC	ON	MB	SK	NU	NT	Canada
Pickerel		4	4,023	3,531	554		8	8,120
Whitefish		0	684	2,195	640		231	3,750
Smelt		0	2,402					2,402
Perch			1,809	29				1,837
Sucker		6	2	1,062	317		2	1,390
Pike		2		1,026	262		10	1,300
White bass			645	1				647
Tullibee			138	374	60			571
Carp		60	3	482				545
Alewife	523							523
Lake trout			125		10		59	193
Catfish		145	23	2				169
Arctic Char						64	64	128
Sturgeon		115						115
Sauger		2		56				58
Eel	2	34						36
Sunfish		5	14					19
Shad	5	2	0					8
Rock bass			3					3
Tomcod		1						1
Burbot				0				0
Other fish		40	74	25	8		58	206
Total	**530**	**418**	**9,944**	**8,782**	**1,851**	**64**	**432**	**22,021**

Source: Government of Canada, *Freshwater Landings* (https://www.dfo-mpo.gc.ca/stats/commercial/fresh-yrlist-eng.htm).
Note 1: A minor issue exists with the data for the Northwest Territories in the cited publication (the total identified in the cited table is not the sum of its components).
Note 2: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

2.3.2 Value of Freshwater Landings

The value of freshwater landings in 2020 was $58 million, which is 2% of the value of marine fisheries landings. Over half of the value of freshwater catches (52%) was generated through landings in Ontario. Yellow pickerel, perch, and whitefish accounted for 85% of the value of the national freshwater catch.

Table 4: Freshwater Fisheries Landed Value, by Region (2020 Preliminary)

(Thousands of Dollars)

Species	NB	QC	ON	MB	SK	NU	NT	Canada
Pickerel		$29	$15,297	$13,983	$2,193		$22	$31,524
Perch			$8,835	$34				$8,869
Whitefish		$0	$2,432	$4,259	$1,241		$388	$8,320
White bass			$1,629	$1				$1,630
Pike		$2		$1,026	$262		$3	$1,293
Smelt		$1	$1,218					$1,219
Alewife	$750							$750
Sucker		$2	$0	$563	$168		$1	$735
Tullibee			$219	$445	$72			$735
Carp		$42	$3	$573				$618
Sturgeon		$394						$394
Eel	$7	$386						$393
Arctic Char						$159	$159	$318
Lake trout			$156		$12		$20	$187
Catfish		$131	$26	$2				$159
Sunfish		$29	$49					$78
Sauger		$9		$67				$76
Shad	$13	$2	$0					$15
Rock bass			$5					$5
Tomcod		$2						$2
Burbot				$0				$0
Salmon								-
Other fish		$41	$65	$30	$10		$116	$261
Total	**$769**	**$1,071**	**$29,933**	**$20,983**	**$3,957**	**$159**	**$709**	**$57,581**

Source: Government of Canada, *Freshwater Landings* (https://www.dfo-mpo.gc.ca/stats/commercial/fresh-yrlist-eng.htm).

Note 1: A minor issue exists with the data for the Northwest Territories in the cited publication (the total identified in the cited table is not the sum of its components).

Note 2: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

2.4 Aquaculture in Canada

2.4.1 Aquaculture Production

Total aquaculture production in Canada in 2020 was 171,000 tonnes. The vast majority of this production by mass was finfish (82% of the total), with shellfish accounting for the remaining 18%. Regionally, British Columbia is the most significant producer with 59% of national production. This is based largely on finfish production. New Brunswick (12% of the national total) and Prince Edward Island (11%) were the next most significant producers by mass. New Brunswick produces mostly finfish, while Prince Edward Island is Canada's leading producer of shellfish.

Table 5: Aquaculture Production in Canada, by Province (2020)
(Tonnes)

Province	Finfish	Shellfish	Total Aquaculture
Newfoundland and Labrador	7,802	2,818	10,620
Nova Scotia	11,710	1,009	12,719
Prince Edward Island	627	17,402	18,029
New Brunswick	18,900	1,844	20,744
Québec	689	291	980
Ontario	5,913	0	5,913
Manitoba	x	x	x
Saskatchewan	x	x	x
Alberta	x	x	x
British Columbia	93,613	6,666	100,279
Canada	**140,775**	**30,029**	**170,805**

Source: Government of Canada, Aquaculture, Production and Value, Table: 32-10-0107-01 (https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210010701).
Note 1: "x" indicates data suppressed to meet confidentiality requirements.
Note 2: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

The vast majority of finfish production is salmon, representing 85% of farmed production. British Columbia is the primary source of finfish production, accounting for two-thirds of Canada's output.

Table 6: Finfish Production in Canada, by Province (2020)
(Tonnes)

Province	Salmon	Trout	Steelhead	Other Finfish	Total Finfish
NL	..	..	..	..	7,802
PE	..	..	..	..	627
NS	9,719	1,991	0	0	11,710
NB	18,900	0	0	0	18,900
QC	0	359	0	330	689
ON	0	5,583	0	330	5,913
MB	x	x	x	x	x
SK	x	x	x	x	x
AB	x	x	x	x	x
BC	91,808	1,164	0	642	93,613
Canada	**120,427**	**10,511**	**0**	**1,409**	**140,775**

Source: Government of Canada, *Aquaculture, Production and Value*, Table: 32-10-0107-01 (https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210010701).
Note 1: .. not available for a specific reference period.
Note 2: x suppressed to meet the confidentiality requirements of the *Statistics Act*.
Note 3: There may be differences between this national data and provincial / territorial accounts, and production quantities and values vary by year.

The primary shellfish farmed in Canada are mussels and oysters which together account for over 90% of Canada's output. Prince Edward Island has the majority of shellfish farming (58% of the national total), including three-quarters of all mussel production.

Table 7: Shellfish Production in Canada, by Province (2020)
(Tonnes)

Province	Clams	Oysters	Mussels	Scallops	Other Shellfish	Total Shellfish
NL	0	0	2,818	0	0	2,818
PE	1,193	3,453	12,756	0	0	17,402
NS	33	74	732	4	166	1,009
NB	0	1,844	0	0	0	1,844
QC	0	123	130	1	38	291
ON	0	0	0	0	0	0
MB	x	x	x	x	x	x
SK	x	x	x	x	x	x
AB	x	x	x	x	x	x
BC	849	5,149	550	118	0	6,666
Canada	**2,076**	**10,643**	**16,985**	**123**	**204**	**30,029**

Source: Government of Canada, *Aquaculture, Production and Value*, Table: 32-10-0107-01 (https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210010701).
Note 1: x suppressed to meet the confidentiality requirements of the *Statistics Act*.
Note 2: There may be differences between this national data and provincial / territorial accounts.

The value of aquaculture production in Canada was over $1.0 billion in 2020. Finfish aquaculture accounted for over 90% of this value. Most of the produced value (64%) was from British Columbia owing in large part to the extent that salmon and oysters are farmed there.

Table 8: Value of Aquaculture Production, by Province (2020)
(Thousands of Dollars)

Province	Total finfish	Total shellfish	Total aquaculture
NL	$51,665	$5,940	$57,605
PE	$4,150	$34,269	$38,419
NS	$79,699	$10,459	$90,158
NB	$125,159	$14,243	$139,402
QC	$5,846	$3,497	$9,343
ON	$33,800	$0	$33,800
MB	x	x	x
SK	x	x	x
AB	x	x	x
BC	$645,707	$20,041	$665,748
Canada	**$954,675**	**$88,449**	**$1,043,123**

Source: Government of Canada, *Aquaculture, Production and Value*, Table: 32-10-0107-01 (https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3210010701).
Note 1: x suppressed to meet the confidentiality requirements of the *Statistics Act*.
Note 2: There may be differences between this national data and provincial / territorial accounts.

3. Use and End-of-Life Fate of Fishing and Aquaculture Gear in Canada

3.1 Introduction

This section estimates the types and amounts of fishing and aquaculture gear used and disposed of in Canada, provides information on the fate/management of EOL fishing and aquaculture gear in Canada, and describes the type of value retention infrastructure/operations in Canada for managing plastic EOL gear components and metal EOL gear components.

3.2 Types and Amounts of Fishing and Aquaculture Gear Used in Canada

3.2.1 Capture Fishing Gear

The estimated amount of fishing gear used annually in Canadian commercial fisheries is summarized below, where possible, by region. Summaries are provided on the major fisheries implemented in Canadian waters that produce the largest quantity of waste; a few small fisheries were not included primarily where available information was sparce. Information and data were compiled through literature and database reviews. The rates of replacement and the amount of EOL fishing gear entering the waste stream each year is estimated. Department of Fisheries and Oceans Canada (DFO) and other provincial resource management agencies were the primary sources of information augmented by available information from the commercial fishing industry and fishing gear manufacturers.

3.2.1.1 Canadian Pacific Marine Fisheries Fishing Gear Type and Quantities

Salmon

Pacific salmon are captured using gillnets purse seine, and troll gear in marine and river fisheries throughout British Columbia.

For gillnet fisheries, the marine waters of the Pacific Region (British Columbia) are split into three areas, the northern area (C), southern area (D), and the Fraser River area (E). In 2022, there were 623 gillnet licenses in Area C, 373 in area D, and 381 in Area E, for a total of 1,377 salmon gillnet licenses throughout the province that were allotted to 646

entities either representing individual vessels (n=490) or First Nation groups (n=156).[5] Based on license regulations, salmon gillnet lengths range from 183 to 550 m; however, the most common length is 375 m.[6] The maximum depth of a gillnet is measured by number of meshes, either 60 or 90 meshes, depending on fishing area and species targeted, and mesh sizes vary throughout the fishery depending on target species. While only one net is allowed to be deployed per fisher, due to these variations in gear specifications, it is necessary for fishers to have a collection of at least 2 or 3 nets to be used throughout the season if they are to maximize their fishing opportunities, and to provide redundancy if gear becomes damaged or lost. Based on these estimates, assuming most gillnets are 375 m long, and all vessels have 2 or 3 nets, we estimate there are 1,292-1,938 gillnets in British Columbia, equating to 484.5 - 726.8 km.

The salmon purse seine fishery in British Columbia is split into two areas; the northern area (A) and the southern area (B). In 2022, there were 106 purse seine licenses in Area A, and 168 in Area B. These 274 licenses were distributed among 137 commercial vessels, and 18 First Nation groups, for a total of 155 vessels. In most all fishing areas, the maximum size for purse seines is 400 m long and 52 m deep, which is the size of most purse seines in the fishery.[7] Purse seines cost significantly more money that do gillnets, and it is less likely for a fisher to keep a surplus of purse seine nets. Assuming each vessel owns and operates one purse seine net, based on the standard size of each purse seine, the estimated total amount of salmon purse seine net in British Columbia is 62 linear km, or 3.22 km^2.

Salmon are also caught in the Pacific by trolling. The region is split into three trolling areas, the northern area (F), West Coast Vancouver Island (G), and the Strait of Georgia (H). In 2022, there were 217, 89, and 68 licenses in each of these areas, respectively. These licenses were issued to a total of 226 commercial vessels and 21 First Nations groups, for a total of 247 salmon troll vessels in British Columbia. Vessels typically operate with six reels holding stainless fishing wire (~75 m), with a heavy lead weight attached to the bottom. Up to 11 monofilament leaders with flashers and lures are attached at different depths to the mainline.[8] With 247 vessels in the fishery, the total amount of gear in the fishery is estimated at 1,482 mainlines and lead weights, and 16,302 lures, flashers, and monofilament spreads.

[5] Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-eng.cfm?pg=LicReportSelect)
[6] Accessed at website of the Government of Canada Justice Laws Website. Pacific Fishery Regulations, 1993 (SOR/93-54) (https://laws-lois.justice.gc.ca/eng/regulations/SOR-93-54/page-3.html#docCont)
[7] Accessed at the website of Transportation Safety Board of Canada. Marine investigation Report M04W0225 (https://tsb.gc.ca/eng/rapports-reports/marine/2004/m04w0225/m04w0225.html?wbdisable=true)
[8] Accessed at the website of BC Salmon (https://www.bcsalmon.ca/faces-of-bc-salmon-fishing/salmon-trolling-on-the-north-coast-of-british-columbia)

Herring

The herring fishery in British Columbia targets Pacific herring with gillnets and purse seines. It occurs in a few specific locations where herring spawning takes place in six stock assessment areas along the British Columbia coast. The largest and most consistent fishing area is the Strait of Georgia. There are currently 1,267 active herring gillnet licenses in the herring fishery,[9] which is consistent with the number of active licenses since 2011.[10] Gillnets are made of monofilament; they are typically about 2 m in depth, with a maximum length of 135 m. Since 2015, herring gillnetters have been allowed to use more than one net per license to increase efficiency; however, we were unable to determine the number of fishers that use more than one net. With one gillnet per license, the minimum total amount of gillnet in the herring fishery is 171 linear km, and if each gillnetter used two nets, the total amount would be 342 linear km.

Purse seines used to catch herring in British Columbia are limited to a maximum of 411.48 m (225 fathoms), and most are about 400 m in length and between 20-40m deep.[11,12] The herring purse seine fleet includes 252 active licenses in 2022,[13] and this number has remained similar since 2011.[14] Assuming one net for each active license, this would equate to 100.8 linear km, and 508 - 1,016 km^2 of purse seine net from the herring fishery.

Dungeness Crab

The Dungeness crab trap fishery operates throughout the coastal waters of British Columbia, with 10 distinct license areas, each with maximum number of traps allowed in the fishery. Dungeness crab traps are made of a rubber wrapped mild steel round frame (d= 81 - 112cm, h = 30 - 35cm) wrapped with stainless steel web to form a cage, with 2 - 4 one-way gated tunnels. In the years 2020-2022 there were a total of 220 active licenses in the Dungeness crab fisheries, with a total of 81,473 crab traps in the fishery; equating to 87% of the maximum allowable traps in the fishery across all license areas (Table 3-2).[15] In addition to the traps themselves, 35-45m of sinking buoy line is attached to each trap

[9] Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-

[10] Fisheries and Oceans Canada, 2022. Pacific Region Integrated Management Plan, Pacific Herring, November 20, 2021 to November 6, 2022. 22-2124:223p.

[11] Accessed at the website of the Department of Fisheries and Oceans. Fisheries Fact Sheet – Purse Seining. (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40842599.pdf)

[12] Accessed at the website of Transportation Safety Board of Canada. Marine investigation Report M04W0225 (https://tsb.gc.ca/eng/rapports-reports/marine/2004/m04w0225/m04w0225.html?wbdisable=true)

[13] Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-

[14] Fisheries and Oceans Canada, 2022. Pacific Region Integrated Management Plan, Pacific Herring, November 20, 2021 to November 6, 2022. 22-2124:223p.

[15] Fisheries and Oceans Canada, 2022. Crab by Trap Fisheries Management Plan 2022/23. 21-2080: 325p.

and connected to 1-3 bullet shaped buoys >12 cm diameter and 2.5 litres. The sinking line is either 11/18" diameter braided nylon (Area A) or poly-blend ranging from 5/16" - 7/16" in diameter.[16] This equates to an estimated 3,264 km of nylon or poly-blend line.

Table 9: Number of active Dungeness crab trap licenses and associated crab trap in the fishery compared to maximum trap limits.

Dungeness Crab License Area	No. of Licenses	Active Trap Totals	Area Trap Limit
Crab Area A	36	28,800	35,000
Crab Area B	21	11,361	11,400
Crab Area Tofino - E	31	10,784	12,500
Crab Area Tofino - Outside E	2		700
Crab Area Sooke - E	7	3,290	2,800
Crab Area Quatsino - E	3	600	600
Crab Area G	19	5,586	5,600
Crab Area H	54	12,852	12,900
Crab Area I	23	4,600	8,400
Crab Area J	24	3,600	3,600
Total	220	81,473	93,500

Source: Fisheries and Oceans Canada, 2022. Crab by Trap Fisheries Management Plan 2022/23. 21-2080: 325p.

Shrimp by Trap

The shrimp by trap fishery in the Canadian Pacific targets spot prawns, with some incidental catch of humpback and coonstripe shrimp. There are 245 prawn by trap licenses, 39 of which have been transferred from one to another vessel already holding a license, equating to 206 active vessels in the fishery in the past several years.[17] Most traps are made of soft nylon mesh encompassing a truncated cone-shape steel frame, not to exceed volume of 170 litres. Traps are set on a weighted groundline (d=5/16") approximately 1,100 m long which is anchored at each end and marked with a polyform buoy (circum. ≥ 127 cm). The buoyed anchor lines are poly-blend weighted line approximately 120 - 150 m long. Each trap is attached to the groundline with a bridle made of about 2 m of hollow-braided 8 strand polypropylene line. Each license is limited to 300 traps and 6 groundlines; however, when a license is transferred, one-third of the allowable gear is relinquished. This means that a vessel fishing with two licenses is allowed 500 traps and 10 groundlines.[18]

[16] Accessed at the website of Pacific Net and Twine Ltd. (https://pacificnetandtwine.com/collections/ropes)
[17] Fisheries and Oceans Canada, 2022. Prawn and Shrimp by Trap Fisheries Management Plan 2022/23. 21-2081: 167p
[18] Ibid

In total, there are 68,000 traps and bridles, 1,496 km of groundline, 2,720 buoys and anchors, and 408 km of buoy line.

Shrimp by Trawl

Pink and sidestripe shrimp are the primary targets of the commercial shrimp trawl fishery off the British Columbia coast. In 2022 there were 207 vessels licensed to fish for shrimp by trawl in the commercial fishery, and 26 First Nation communal licenses, for a total of 233 licenses. Beam trawls are used on smaller vessels (< 15m overall lengthy (OAL)), which make up approximately 75% of the total fleet.[19, 20] There are currently 26 larger vessels, between 15-35 m OAL that use otter trawls. The fluctuations of shrimp biomass cause year-to-year changes in fishing opportunity and hence the number of active vessels vary from year-to-year. Since 2014, the number of active vessels per year using beam trawls have ranged from 21 to 36, and the number of active otter trawl vessels in any year has ranged from 8 to 24.[21] In total, the number of active vessels since 2016 has averaged around 42, with a high of 69 vessels in 2016, and a low of 26 active vessels in 2020 (DFO 2022a). Both otter and beam trawls in the British Columbia shrimp fisheries use only one net at a time while fishing.

Beam trawls in British Columbia have a beam length and headline length of about 14 m, with a footrope length of 15 – 16.5m. Bridles are 16.8 – 22 m long, and the overall length of the nets range from 26.5 – 30.5 m.[22] Otter trawls have headline length of 17.5 - 23.8m, footropes from 17.7 - 30.5m, 27.4m bridles, steel doors that weigh 303-318kg, and an overall net length of 36.8 - 38.2m.[23]

Based on the number of vessels and licenses that have been active since 2016, we assume there are 36 beam trawls, and 24 otter trawls within the shrimp trawl fishery.

Groundfish Trawl

The groundfish trawl fishery is one of seven sectors in the overall groundfish fishery in the Canadian Pacific. The other sectors include Halibut, Sablefish, Inside Rockfish, Outside Rockfish, Lingcod, and Dogfish fisheries.[24] There are 132 licensed vessels in the trawl

[19] Hillier, C.J., Gueret, D., Butterfield, S., and Pellegrin, N., 2007. Fish Harvesting Activities within the Proposed Gwaii Haanas National Marine Conservation Area. Fisheries and Oceans Canada. Report for Fisheries and Aquatic Sciences 2803: vi+65p.
[20] Fisheries and Oceans Canada, 2022. Shrimp Trawl Fisheries Management Plan 2022/23. 21-2709: 215p.
[21] Ibid
[22] Ong, S., Levings, C.D., Sutherland, T.F., Piercey, G.E., Keong, G.E., and Davis, R. 2002. Data Record on Trawling and Trapping Effects on Humpback Shrimp and Bycatch Organisms in Simoom Sound and Northumberland Channel, British Columbia. DFO Science Branch – Pacific Region.
[23] Ibid
[24] Fisheries and Oceans Canada, 2022. Groundfish Integrated Fisheries Management Plan 2022/23. 22-2125.353

fleet; 104 which can operate both bottom and midwater trawl gear (Option A), and 28 that can fish with only bottom trawls in Area 4B, covering all sectors, and of 132 vessels, in recent years the number of active trawl vessels has ranged from 48 to 43 since 2015.[25] Trawlers typically have at least one spare net either onboard their vessel during operations, or shoreside.

Based on the number of licensed vessels in the groundfish trawl sector, we estimate that there is at least 104 midwater trawls and 132 bottom trawls, and potentially 216 and 264, respectively. However, this includes latent gear that is not in use. Within the active fleet of up to 48 vessels, the number of trawl nets in the active fishery is likely around 96 (combined bottom and midwater trawls) and 192, including redundancy.

Groundfish Longline

The Halibut sector, using longlines, is the largest of the groundfish sectors, with over 400 licenses issued, and between 144 and 167 active vessels per year.[26] Halibut longlines are set in a series of 549 m long "skates", each with about 100 – 150 equally spaced monofilament gangions attached with baited hooks. Skates are snapped together to form a string of 4 to 12 skates each.[27] In total, the strings are 2.2 – 6.6 km long, and include up to 1,800 gangions with baited hooks. Each end of the longline has a steel anchor weighing 20 to 36 kg set in the bottom and connected to surface buoys and light/radar reflector poles.

Using the number of active vessels, and the high range of standard gear configurations, we estimate that there is as much as 1,102 km of groundline, and 300,600 gangions and hooks in the halibut longline fishery. Sablefish are often targeted in tandem with halibut, as the gear rigging is similar but with minor changes to hook size and spacing.[28] Similarly, rockfish and lingcod longline fisheries operate with essentially the same gear with minor adjustments, and since most of the vessels licensed for these sectors are also licensed for halibut, we assume that these estimates also cover the longline gear used to target those species.

Sablefish Traps

Sablefish are also captured by traps, which account for 50-70% of the catch.[29] There are about 33-40 active vessels in the fishing under a sablefish license each year, most of which

[25] Ibid
[26] Ibid
[27] International Pacific Halibut Commission, 2014. The Pacific Halibut: Biology, Fishery, and Management. Technical Report No. 59. (https://www.iphc.int/uploads/pdf/tech0059.pdf)
[28] Ibid
[29] Accessed at the website of British Columbia Marine Conservation Analysis – Commercial Fisheries Sablefish (https://bcmca.ca/datafiles/individualfiles/bcmca_hu_commercialfish_sablefish_trap_atlas.pdf)

also operate within other groundfish sectors (halibut, rockfish, lingcod),[30, 31] and there are 7 licensed vessels that carry only the sablefish license.

Sablefish trap strings consist of 60 to 80 traps attached to a 20 to 25 mm diameter groundline 3.5 to 5.6 km. Each trap is conical steel frame surrounded a single piece of nylon netting, 1.5 m in diameter and 0.5 m high.[32] Steel anchors are at each end of the trap string, and the trap line ends are connected to surface buoys with flags, lights, radar reflectors and sometimes radio direction beacons.[33] Based on the number of vessels with a sablefish license, and the overlap between other sectors that use longlines, we estimate the number of vessels using sablefish traps to be between 7 and 33. With each vessel operating up to 80 traps, this equates to 560 – 2,640 traps in the fishery.

Scallop Trawl

Pink and spiny scallop are harvested in an exploratory commercial trawl fishery using butterfly trawls, which are similar to beam trawls. In recent years there have been three active vessels in this fishery,[34] and the number of gears for this fishery is 3-6 butterfly trawls.

3.2.1.2 Canadian Atlantic and Québec Marine Fisheries Fishing Gear Type and Quantities

Lobster Fisheries

In the coastal waters of eastern Canada, American lobster are captured by lobster traps made of wood, vinyl coated wire, or a combination of both. Lobster traps are set with a single buoyed line or are attached to a groundline called a “trawl”; each trawl can consist of up to 30 traps, and the ends of the trawl are connected to a buoyed line.[35] Trawled traps are typically spaced about 10 fathoms (18 m) apart along the groundline.[36] Based on 2019 and 2020 data, the total number of licensed lobster traps throughout all five provinces is 2,395,365 (Table 3-3).

[30] Fisheries and Oceans Canada, 2022. Groundfish Integrated Fisheries Management Plan 2022/23. 22-2125.353
[31] Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-
[32] BCMCA, 2011 (https://bcmca.ca/datafiles/individualfiles/bcmca_hu_commercialfish_sablefish_trap_atlas.pdf)
[33] NRC, 2017. Internal document on fisheries and submarine cable interactions along Pacific Coast of North America.
[34] Fisheries and Oceans Canada, 2022. Scallop by Trawl Fisheries Management Plan 2022/23. 22-2133: 79p
[35] Goodman, A.J., Brillant, S., Walker, T.R., Bailey, M. and Callaghan, C., 2019. A Ghostly Issue: Managing abandoned, lost and discarded lobster fishing gear in the Bay of Fundy in Eastern Canada. *Ocean & Coastal Management*, *181*, p.104925.
[36] McCarron, P. and Tetreault, H., 2012. Lobster pot gear configurations in the Gulf of Maine. (https://www.bycatch.org/sites/default/files/Lobster_Gear_Report_0.pdf)

Table 10: Total Number of Commercial Lobster Fishing Licenses and Licensed Lobster Traps per Province

Province	Lobster Licenses	Traps Licensed	Year
Québec	582	154,131	2020
New Brunswick	1,462	420,390	2019
Nova Scotia	3,434	1,055,629	2019
Prince Edward Island	1,213	343,000	2019
Newfoundland and Labrador	2,326	422,215	2019
Total	9,017	2,395,365	

Source: Fishing Gear Coalition of Atlantic Canada, End of Life Fishing Gear Management Series (Kendall et al.), derived from DFO.

Snow Crab Fisheries

The Snow crab fisheries capture crab with traps made of 1.8 - 2.1m diameter conical steel ring frame covered with netting, and a cone shaped funnel on the topside through which crab enter the trap. The traps are connected to a groundline with bridle. The fishery occurs in the Gulf of St. Lawrence, where throughout the Crab Fishing Areas (CFAs) there are 309 total licenses for the snow crab fishery, with 29,616 total traps licensed in the fishery.[37] In the Newfoundland and Labrador snow crab fishery, there are currently 2,324 license holders within the suite of 27 different license categories, and a variety of trap limits depending on the license and if the license holder is a single user, or part of an enterprise.[38, 39] Based on the single user trap limits (low estimate), and the number of licenses per type, the estimated number of traps in the fishery is 608,600. Combined, there are an estimated 638,216 snow crab traps in the Canadian waters.

Northern Shrimp

The northern shrimp fishery occurs in all areas of the Canadian Atlantic. It is primarily a trawl fishery, yet some effort is applied to a small trap fishery. Several small vessels operate in the coastal areas, while large industrial factory freezer vessels operate in the offshore and well into the Arctic Region. Most of the smaller class vessels use small otter trawls or single beam trawls. The large vessels operate with larger trawl nets and stay at sea most of the year.

[37] Ibid
[38] Dawe, N., Kendall, R.A., Smith, S., and Davis, M., 2021. End-of-Life Fishing Gear Management in Newfoundland and Labrador. Fishing Gear Coalition of Atlantic Canada. March 31, 2021.
[39] Fisheries and Oceans Canada, 2021. Assessment of Newfoundland and Labrador Snow Crab. Canadian Science Advisory Report 2021-009.

In the Estuary and Gulf of St. Lawrence there are 109 active trawl licenses (as of 2019).[40] In the Maritimes Region, there are 28 licenses for vessels less than 20m length, and 14 midshore licenses for vessels 20-30m in length. In the smaller vessel license class there were 9 active vessels in 2018, and in the mid-shore class, 5 vessels were active in 2018.[41] In the Newfoundland Newfoundland Labrador Region the offshore fleet (> 30m length) consists of 17 licenses, and fish as far north as Greenland, while the locally based inshore (<30m length) consists of 250 licenses.[42]

Based on the number of licenses per vessel class, there are at least 390 active shrimp trawl nets in Canadian Atlantic waters, and could likely be double, considering the value in redundancy.

Additionally, in the Maritimes Region, there is a trap fishery with 14 licenses, of which, 7 have been active in recent years.[43] Each license has a trap allocation of 100 traps each.[44] These traps are rectangular shaped, vinyl-coated steel mesh with dimensions of approximately 1.2 m long, 0.6 m wide, 0.3 m high with steel or lead weights along the bottom edges.[45] The traps are set on a groundline and marked with a polyform buoy on each end. With 14 licenses, but only half of them active, there is likely 700 to 1,400 traps, and associated line and buoys in this fishery.

Groundfish Mixed-Gear

The groundfish fishery in the Canadian Atlantic is complicated suite of multiple species, multiple gear types, multiple vessel sizes, and multiple regions, with each combination of these having their own set of regulations. Groundfish licenses are distinguished by being fixed gear (gillnets and longlines), mobile gear (trawls), or both fixed and mobile gear. There several species covered by this fishery, including Atlantic cod, haddock, Atlantic halibut, Greenland halibut, redfish, flounder, and pollack. In 2020 there were a total of 8,066 total groundfish licenses across all areas.[46] In the Maritimes Region in 2017, there

[40] Department of Fisheries and Oceans Canada, 2020. Assessment of Northern Shrimp Stocks in the Estuary and Gulf of St. Lawrence in 2019. Québec Region Science Advisory Report 2020/010.
[41] Department of Fisheries and Oceans Canada, 2019. Assessment of Northern Shrimp Stocks on the Eastern Scotian Shelf (SFAs 13-15). Maritimes Region Science Advisory Report 2019/013.
[42] Department of Fisheries and Oceans Canada – Northern Shrimp (SFAs 0-7) and the Flemish Cap, Resource Management Operations (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/shrimp-crevette/shrimp-crevette-2007-eng.html)
[43] Ibid
[44] Department of Fisheries and Oceans Canada - Shrimp (*Pandalus borealis*) - Scotian Shelf - As of 2013 (https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/shrimp-crevette/shrimp-crevette-2013-eng.html)
[45] Chedabucto Bay Winter Shrimp Fishing (https://www.youtube.com/watch?v=ZViuyOYqxEI)
[46] Department of Fisheries and Oceans Canada - Licenses

were 563 active groundfish vessels; 547 fixed gears, and 16 mobile gear vessels.[47] In 2020, in the Newfoundland and Labrador Region, a total of 1,619 vessels were active; 1,409 of which were in the fixed gear fleet,[48] and 210 were likely trawlers. The breakdown between fixed gear types was found, but if we assume that fishers utilize both gear types as suitable, then this would equate to 1,956 gillnets, 1,956 longlines, and 226 trawl nets.

In the Gulf of St. Lawrence, the Greenland halibut fishery is executed primarily with demersal gillnets the allowable number of gillnets per vessel ranges from 90 to 120 gillnets. Gillnet height is about 3 m, and length is restricted to a maximum of 91.4m (50 fathoms).[49] If we apply these metrics to the estimated number of gillnets in the entire groundfish fleet, the length of gillnet in the groundfish fleet equates to 16,090 – 21,453 km.

Atlantic halibut bottom longlines sets include 1,000 hooks attached to the groundline via gangion,[50] and the maximum number of hooks allowed per vessel is 8,000.[51] Assuming a distance between hooks of about 5 m, similar to Pacific halibut fisheries, this would equate to a total of 40km of groundline per vessel, for an estimated 78,240 km of groundline, and 15.6 million hooks in the groundfish fishery.

Scallop Trawl

There are four inshore sea scallop trawl fisheries in the marine waters of eastern Canada; they occur in the coastal waters of Québec, in the southern Gulf of St. Lawrence, in the Bay of Fundy, and off Newfoundland and Labrador. The gear used is the Digby dredge, which includes chain bridles leading to 1-4 heavy steel frames, followed by a steel or iron ring bag and a nylon mesh apron. In general, these gears are mostly made of metal.

In the Québec fishery, there are about 72 vessels holding 179 licenses, which are split by fishing area.[52] In the southern Gulf of St. Lawrence there are 770 licenses, but only about 154 active vessels.[53] The Bay of Fundy fleet is the largest, with 206 licenses in the Mid Bay fleet, 16 licenses in the Upper Bay fleet, 180 licenses in the Inshore East of Baccaro

[47] Department of Fisheries and Oceans Canada – 4VWX5 groundfish – Maritimes Region. (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/groundfish-poisson-fond/groundfish-poisson-fond-4vwx5-eng.html#toc2)

[48] Department of Fisheries and Oceans Canada - Groundfish Newfoundland and Labrador Region NAFO Subarea 2 + Divisions 3KLMNO (https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/groundfish-poisson-fond/2021/groundfish-poisson-fond-2_3klmno-eng.htm#toc1)

[49] Treble, M.A. and Stewart, R.E.A., 2010. Impact and Risks associated with a Greenland Halibut (*Reinhardtius hippoglossoides*) gillnet fishery in inshore NAFO Subarea 0. DFO Canadian Science Advisory Secretariat Research Document 2010/032.

[50] Hurley, I., Wringe, B.F., den Heyer, C.E., Shackell, N.L. and Lotze, H.K., 2019. Spatiotemporal bycatch analysis of the Atlantic halibut (Hippoglossus hippoglossus) longline fishery survey indicates hotspot for species of conservation concern. *Conservation Science and Practice*, *1*(1), p.e3.

[51] Department of Fisheries and Oceans Canada - Notices to Fish Harvesters 4RST Atlantic Halibut and Greenland Halibut 4RST Gaspé fixed gears fleet of 13.71 m and over Gaspé Longliners group and others group_ 2022-2023 season Conservation Harvesting Plan Date of Notice 2022-05-20 (https://www.qc.dfo-mpo.gc.ca/en/4rst-atlantic-halibut-and-greenland-halibut-4rst-gaspe-fixed-gears-fleet-1371-m-and-overgaspe)

[52] Department of Fisheries and Oceans Canada, 2020. Scallop Stock Assessment in Québec Coastal Waters in 2019. Canadian Science Advisory Secretariat Science Advisory Report 2020/054.

[53] Department of Fisheries and Oceans Canada, 2019. Scallop Stock Assessment of the Sea Scallop from the Southern Gulf of St. Lawrence to 2016. Canadian Science Advisory Secretariat Science Advisory Report 2019/06.

fleet, and 15 Full Bay licenses held by First Nations groups, for an estimated total of 417,[54] which are fished on by about 200 vessels. In Newfoundland and Labrador, there are 759 inshore scallop licenses, with an estimated 265 of which are active. Therefore, based on the number of active vessels, there are roughly 743 dredges operating in the inshore scallop fisheries.

Herring

The Atlantic herring fishery in the Maritimes Region is a multi-gear fishery that includes capture by several types of gillnet, trap net, seine nets, trawl nets. Table 3-4 shows the breakdown of number of issued license and number of active licenses. It should be noted that the Vessel-based and the Bait gillnet licenses are similar in number issued and number active, because it is essentially the same fleet;[55] therefore, in estimating amounts of gear within the fisheries, only the largest (bait) value will be used. Along the Quebec North Shore, in the Atlantic herring Division 4S, there are a total of 254 licenses, most of which are for gillnets, although there are currently only 14 active licenses between all gear types (Table 11).[56] In the herring fishery off the west and southwest coast of Newfoundland (Area 4R3Pn), there are a total of 578 fixed gear licenses, and 19 purse seine licenses for herring (Table 11).[57] The herring fishery in waters off east Newfoundland and Labrador in Regions 2 and 3, there are a total of 1,409 fixed gear herring licenses, and 230 purse seine licenses (Table 11).[58]

Table 11: Licenses and active licenses in Atlantic herring fishery

		Maritime NS		Quebec North Shore		South NL	East NL
License type	**Gear type**	**Issued licenses**	**Active licenses**	**Issued licenses**	**Active licenses**	**Issued licenses**	**Issued licenses**
Fixed gear	Weir	180	30			578	1,409
	Shut-off (beach / drag / bar seine)	42	22				

[54] Department of Fisheries and Oceans Canada – Inshore Scallop – Maritimes Region. Accessed at: https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/scallop-petoncle/scallop-petoncle2015-sec1-eng.html
[55] Department of Fisheries and Oceans Canada – Atlantic Herring of the Maritimes Region (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/herring-hareng/2020/index-eng.html).
[56] Department of Fisheries and Oceans Canada – Atlantic herring Division 4S (Herring Fishing Area 15) (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/herring-hareng/2021/area-15-zone-eng.html)
[57] Department of Fisheries and Oceans Canada - Herring - Newfoundland and Labrador Region 4R3Pn (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/herring-hareng/herring-4r3pn-hareng-eng.html#app5)
[58] Department of Fisheries and Oceans Canada - Herring (Clupea harengus) Newfoundland and Labrador Region Divisions 2+3 (Herring Fishing Areas 1-11) (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/herring-hareng/2021/index-fra.html)

		Maritime NS		Quebec North Shore		South NL	East NL
License type	**Gear type**	**Issued licenses**	**Active licenses**	**Issued licenses**	**Active licenses**	**Issued licenses**	**Issued licenses**
	Trap net	18	4	25	19		
Vessel-based	Gillnet (set and fixed)	1,483	110	217	3		
	Gillnet (drift)	397	94				
Exempted vessel-based	Purse seine	32	9	12	6	19	230
	Mid water trawl	1	-				
Recreational	Gillnet	67	-				
Bait	Gillnet (set or fixed)	1,291	116				
Transport	-	81	7				
Total	-	3,592	392	254	28	597	1,639

Source: Department of Fisheries and Oceans Canada – Atlantic Herring IFMPs

Assuming similar size gillnet and seine net to those in the British Columbia, there is approximately 50.5 linear km of herring gillnet, and 105.6 linear km of purse seine.

Mackerel

The Atlantic mackerel fisheries in Atlantic provinces and Quebec are a multi-gear fishery using gillnets, trap nets and weirs, jigs, seine nets. Most enterprises licensed to fish for mackerel are also licensed to fish for other small pelagic species such as herring, and capelin, with similar gears. Therefore, potential exists for overcounting gears through duplication within these fisheries. There are over 7,800 total commercial licenses for mackerel, and in 2021, only 459 of those were active. Since the mid-2000's, most mackerel landing are made by purse seines primarily in Newfoundland and Labrador.[59] There are 320 licensed seiners in the mackerel fishery, 259 of which are in Newfoundland and Labrador (Table XX).

Table 12: Licenses in Atlantic mackerel fishery

DFO Region	Weir	Handline	Gillnet	Trap net	Purse seine	Total

[59] Department of Fisheries and Oceans Canada – Atlantic Mackerel (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/mackerel-atl-maquereau/mac-atl-maq-2022-eng.html#toc2.2)

Quebec	0	32	736 (gillnet & handline)	21	20	1,700
Newfoundland and Labrador	0	1 779 (includes gillnet, trap net, tuck seine)			259	4,459
Gulf	0	470	2,495	20	2	5,375
Maritimes	38	168 handline only	1,693 gillnet & handline; (575 of those gillnet only)	183	40	3,320

Source: Department of Fisheries and Oceans Canada – Atlantic Mackerel (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/mackerel-atl-maquereau/mac-atl-maq-2022-eng.html#toc2.2)

Capelin

Capelin is a small, schooling, pelagic species that is targeted in similar ways to herring and mackerel, with fixed gears using primarily trap nets and modified bar seines (tuck seines), and the mobile gear fleet using purse seines.[60, 61] In the Gulf of St. Lawrence, there are currently approximately 299 fixed gear licenses and 33 mobile gear licenses. In the Newfoundland and Labrador Region, there are 93 active mobile gear (purse seine) participants out of 230 total licenses issued, and 252 active fixed gear (trap nets and bar seines) participants out of 1,409 total fixed gear licenses issued.[62]

Rock Crab

The rock crab fishery in Atlantic Canada occurs in Newfoundland and Labrador, primarily in the nearshore waters around Newfoundland. There are a total of 31 rock crab licenses, each with a maximum allowable trap limit of 150 traps.[63] In Quebec, in 2022, there were 62 licenses with access to the rock crab fishery, with trap limits per license ranging from 75 to 200, depending on the fishing sub-areas.[64] The estimated number of rock crab traps

[60] Department of Fisheries and Oceans Canada – Capelin Northwest Atlantic Fisheries Organization Divisions 4RST (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/capelin-capelan/index-eng.html)
[61] Department of Fisheries and Oceans Canada – Capelin (Mallotus villosus) Newfoundland & Labrador Region Divisions 2+3 (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/capelin-capelan/2021/zone-area_1-11-eng.html#app7)
[62] Ibid
[63] Department of Fisheries and Oceans Canada – Rock crab (Cancer irroratus) Newfoundland and Labrador Region (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/rock-crab-commun/2022/index-eng.html)
[64] Department of Fisheries and Oceans Canada – Conservation Harvesting Plan Rock Crab, Quebec Region, Season 2022 (accessed at: https://www.qc.dfo-mpo.gc.ca/en/rock-crab-conservation-harvesting-plan-season-2022)

in Quebec, based on the number of permits per area, is 7,675 traps.[65] Rock crab traps are made of 0.5m (upper) and 1.2m (lower) diameter conical steel ring frame covered with netting, and a cone shaped funnel on the topside through which crab enter the trap. The traps deployed individually with a single buoyed line, or are connected to a groundline with bridle.

Whelk

The commercial whelk fishery in Atlantic waters of Canada are prosecuted using baited traps, typically longlined together in nearshore waters of Quebec[66] and off Newfoundland in water depths from 45 to 60 m.[67] Traps are either conical steel frames surrounded by nylon mesh, or made of plastic barrel type material with a braided poly line bridle, and a mesh topside with a whole in the center for the whelk through which the whelk enter the trap. In the whelk fishery along the inshore waters of Quebec, there were 240 licenses issued with 22,484 authorized traps in 2017, and of those, a total of 81 licenses and 8,825 traps were active.[68] There are 332 total whelk licenses in Newfoundland and Labrador, each with a maximum of 500 traps. Since 2012, the number of active whelk licenses in Newfoundland and Labrador dropped from 77 (in 2012), to 6 in 2019. The total number of allowable traps in the fishery is 166,000, yet in recent years the number of those that are active is around 3,000.

End of Life Marine Fishing Gear

The total amounts of fishing gear used in the marine capture fisheries of Canada were summarized by gear type by coast (Pacific-British Columbia, and Atlantic). Due to the nature of fisheries management and licencing schemes within the federally managed fisheries in the Atlantic waters of Canada, determining numbers and amount of gear per province was not feasible (Table 4.4). To estimate gear replacement rates and EOL gear that becomes part of the waste stream, NRC reviewed information available in public reports, and relied on commercial fishing industry and professional experience.[69]

[65] Ibid
[66] Brulotte, S., 2019. Assessment of the whelk fishery in Quebec's inshore waters – methodology and results. Canadian Science Advisory Secretariat, Research Document 2019/040. Quebec Region (accessed at https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40854711.pdf)
[67] Department of Fisheries and Oceans Canada – Whelk (Buccinum undatum) Northwest Atlantic Fisheries Organization (NAFO) Subdivision 3Ps Newfoundland and Labrador Region (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/whelk-buccin/2021/index-eng.html)
[68] Brulotte, S., 2019.
[69] NRC personnel have experience working closely with fishing vessel captains and crew on commercial longline, trawl, crab pot, and gillnet fishing vessels in the Pacific, as deckhands, scientists, and field party chiefs.

A monofilament drift gillnet will typically last 4-6 seasons before it needs to be replaced. The higher quality multi-filament can last much longer.[70] The breakdown between these materials within the fishing fleet is unknown, therefore, we estimate gillnet replacement every 4-6 years for the British Columbia salmon. No information was available for herring gillnets in Canada, so the estimates for salmon gillnets were also used for the herring gillnet fisheries in Pacific and Atlantic Canada. The rate of one net replacement per fisher every 4-6 years equates to 17-25% of a net being replaced each year, this was applied to the amount of gear in the fisheries to estimate annual EOL gillnet gear (Table 4.4).

Bottom longlines endure substantial wear and tear as they lay on the seafloor, often in rugged terrain. Longline gear in the groundfish fisheries in the Pacific require replacement every 1-3 years,[71] and the same rate was assumed for the longline fisheries in the Atlantic, as these fisheries are similar. Because the groundfish gillnet gear is subjected to the same stress as bottom longlines, the replacement rates for bottom longlines were also used for gillnets used in the groundfish fishery in the Atlantic because these gillnets are prone to more damage due to seafloor contact, deeper water, and harsh terrain which can cause added wear and tear on fishing gear.

In 2009, salmon purse seine vessels in British Columbia each spent $4,000 on average for fishing gear related costs.[72] The cost of full purse seine net can be as high as $100,000.[73] Complete purse seine gear replacement is unusual and very infrequent because repairs typically include mending and replacement of cut-out materials.[74] Based on the annual gear costs in comparison to the estimated total cost of a purse seine net, a 4% replacement rate was applied to the salmon purse seine gear in British Columbia. This same rate was applied to the herring seine fisheries in British Columbia and Atlantic Canada. Because salmon trolling gear is also a pelagic fishery, with no wear and tear from bottom contact, the same 4% replacement rate was applied to the salmon troll gear in the Pacific (Table 4.4).

Information from groundfish trawl captains in the North Pacific indicate that their primary trawl net is replaced every 5-10 years, with replacement frequency influenced by a variety of factors that cause gear to degrade.[75] Replacement every 5-10 years equates to 10-20% per year, which was applied to the total number of trawl nets within the fleets for both the

[70] Brandon Franulovic, pers. comm.
[71] Ibid
[72] GSGislason and Associates Ltd., 2011. British Columbia Salmon Fleet Financial Profile 2009. Prepared for Canada Department of Fisheries and Oceans. Vancouver, BC. April 15. Pacific Commercial Fishing Fleets Financial Profiles Series, 2011-2. v + 43 pp.
[73] Recycling Provides Net Benefit for Wildlife – Richmond News, accessed at https://www.richmond-news.com/weekly-feature-archive/recycling-provides-net-benefit-for-wildlife-3016213
[74] Hillier, A., Awais, M., Adams, N., Zvorufura, T., Hyndman, N., and James, L., 2022. Recycling Solutions for End-of-Life Fishing Rope in Newfoundland. The Leslie Harris Centre of Regional Policy and Development, Memorial University. 30 March 2022.
[75] Sean Serano. Pers. comm.

British Columbia fleet, and the Atlantic fleet to estimate the amount of EOL trawl nets or net material that are replaced each year (Table 4.4). Because no information was available for dredge gear, considering the similar fishing styles, primarily bottom tending, the 10-20% was applied to the dredge fisheries in Pacific and Atlantic Canada (Table 4.4).

A well-constructed Dungeness crab Trap can remain operable for 12-15 years before being replaced if taken care of properly; nevertheless, some fishers replace their gear with new gear every 3-4 years and sell their used gear to other fishers.[76] Based on these rates, the replacement for Dungeness crab traps was estimated as a range from 7.5 to 9.5 years. As a percentage of trap gear per year, this is equivalent to 10.5-13.3% replacement of crab traps annually. These rates were applied to the total number of Dungeness crab traps in the fishery to estimate the number of traps replaced each year (Table 4.4). Due to a lack of similar information about other trap fisheries, these same replacement rates were applied to the prawn traps and sablefish traps in British Columbia.

Research based on fisher surveys in Atlantic Canada reported that approximately 20% of lobster traps are replaced every year, and that very few (0.5-2%) of those traps needed to be replaced because they were lost during fishing.[77] Assuming these 20% of lobster traps are entering the waste stream and using the total number of traps used in the Atlantic lobster fisheries, this equates to 479,073 traps replaced per year. This metric was used as the high estimate of EOL lobster traps. Lower estimates equaling 375,267 lobster traps were reported in a series of reports summarizing EOL fishing gear by province.[78, 79, 80, 81, 82] Table 4.4 shows these estimated lobster trap replacements per province. Additionally, Dawe et al.[66] estimated that in Newfoundland and Labrador, a total of 65,319 snow crab traps are replaced annually, which equates to 10.7% of the total number of licenced snow crab traps in Newfoundland and Labrador. This loss rate was applied to the total number of snow crab traps throughout Atlantic Canada to estimate total EOL snow crab traps in Atlantic Canada (Table 4.4). To estimate shrimp trap, rock crab trap, and whelk trap replacement in the Atlantic Canada fishery, a low range of 10.7% (from the snow crab fishery), and a high range of 20% (from the lobster trap fishery)[83] was applied (Table 4.4).

[76] Ibid
[77] Goodman, A., 2020. State of Abandoned, Lost, and Discarded Fishing Gear in the Canadian Maritimes (East Coast). Fishing Gear Coalition of Atlantic Canada. Report accessed from https://fgcac.org/wp-content/uploads/2020/09/WWF_20200615_FGCAC_GhostGearReport_8-5x11_FP_HighRes.pdf
[78] Kendall et al., 2021. EOL Fishing Gear Management in New Brunswick
[79] Dawe et al., 2021. EOL Fishing Gear Management in Newfoundland and Labrador
[80] Kendall et al., 2021. EOL Fishing Gear Management in Nova Scotia
[81] Kendall et al., 2021. EOL Fishing Gear Management in Prince Edward Island
[82] Kendall et al., 2021. EOL Fishing Gear Management in Québec
[83] Goodman et al., 2020

Table 13: Estimated Annual EOL Fishing Gear from Commercial Marine Fisheries Quantities, by Region/Province

(number of gear, km of gear)

Province/Region	Gear Type	Fishery	EOL low estimate	EOL high estimate	Measurement
BC	Gillnet	Salmon	121.41	181.75	km of gillnet
BC	Purse seine	Salmon		2.48	km of purse seine
BC	Gillnet	Herring	57.11	85.50	km of gillnet
BC	Purse seine	Herring		4.04	km of purse seine
BC	Trap	Crab	8,550.89	10,831	traps and associated hardware
BC	Trap	Shrimp	7,140	9,044	traps and associated hardware
BC	Trawl	Shrimp	6	12.00	trawl nets
BC	Trawl	Groundfish	9.60	19.20	trawl nets
BC	longline	Groundfish	363.66	551.00	km of longline
BC	Trap	Sablefish	277.20	351.12	traps and associated hardware
BC	Trawl	Scallop	0.30	0.60	trawl nets
Atlantic	Trap	Lobster		479,073	traps and associated hardware
NB	Trap	Lobster	33,626		traps
NB	Trap	Lobster	164		tonnes rope
NL	Trap	Lobster	52,046		traps
NL	Trap	Lobster	202		tonnes rope
NS	Trap	Lobster	244,400		traps
NS	Trap	Lobster	1,130		tonnes rope
PEI	Trap	Lobster	37,600		traps
PEI	Trap	Lobster	87		tonnes rope
Québec	Trap	Lobster	7,595		traps
Québec	Trap	Lobster	20		tonnes rope
Atlantic	Trap	Snow crab		68,498	traps and associated hardware
Atlantic	Trawl	Shrimp	39	78.00	trawl nets
Atlantic	Trap	Shrimp	149.80	280	traps and associated hardware
Atlantic	Trawl	Groundfish	22.60	45.20	trawl nets
Atlantic	Gillnet	Groundfish	7,079.49	10,726.50	km of gillnet
Atlantic	longline	Groundfish	25,819.20	39,120	km of longline
Atlantic	Dredge	Scallop	74	149	dredges
Atlantic	Gillnet	Herring	8.43	12.63	km of gillnet

Province/Region	Gear Type	Fishery	EOL low estimate	EOL high estimate	Measurement
Atlantic	Purse seine	Herring		4.22	km of purse seine
Atlantic	Trap Net	Herring		80	trap nets
Atlantic	Gillnet	Mackerel	2.25	3.38	km of gillnet
Atlantic	Purse seine	Mackerel		5.14	km of purse seine
Atlantic	Trap Net	Mackerel		8.96	trap nets
Atlantic	Purse seine	Capelin		2.02	km of purse seine
Atlantic	Trap Net	Capelin		12	trap nets
Atlantic	Trap	Rock crab	1,319	2,465	pots and associated hardware
Atlantic	Trap	Whelk	1,265	2,365	pots and associated hardware

3.2.1.3 Commercial Freshwater Fisheries Fishing Gear Type and Quantities

Québec

The primary freshwater commercial fisheries in Québec include American eel, sturgeon, brown bullhead, and channel catfish. The commercial large eel fishery occurs primarily in the St. Lawrence Estuary; as of 2014 there were 52 tidal weir licenses.[84] A weir is a fish trap that is set in a riverbed or tidal zone that consists of a fence-like structure that guides the eel into the trap, and a terminal enclosure where eels congregate in a shallow pool as the tide lowers. Eels are then hauled from the pool with dip nets or spears.[85]

In Québec, weirs are made of nylon mesh netting, that extends between 70 and 360 m from the shoreline,[86] affixed to a series of wooden stakes. The nets are held upright between the stakes with either floats or rope running across the top of the stakes.

Other gear types used in the Québec freshwater fisheries include gillnets, seines, and fyke nets. There are about 74 freshwater commercial fishing license holders in Québec, which

[84] Hussey-Bondt, L., 2015. Management of the Amercian Eel Fisheries in Canada. Presentation. Fisheries and Oceans Canada – Maritimes Region. Accessed at: http://www.sargassoseacommission.org/storage/Hussey_Bondt_Canadian_Eel_Management_LHB_Oct_2015.pdf
[85] Accessed at the website of K. Turriff (https://heritagelsl.ca/weir-fishing/)
[86] Accessed at the website of MAPA (https://cdn-contenu.quebec.ca/cdn-contenu/peche/documents/PL_gestion_peche_MFFP.pdf?1669405554

is 12 less than the average between 2012 and 2016,[87] and most fishers operate within several different fisheries with multiple licenses. There are about 12 fishers that share 22 licenses to fish for American sturgeon with gillnets in the St. Lawrence Estuary. The gillnets are 3.66 m in height and 20-50m long, they are set in gangs of up to 10 nets, for a maximum of 914 m in length.[88] [89]

The 2022-2023 fisheries management plan for Québec lists every designated fishery in the province by region, gear type, target species, gear size and count restrictions, season, and maximum amount of gear per fishery.[90] Due to the spatial and temporal variability between the fisheries, it is clear that many fishers participate in multiple of these fisheries, and there is significant overlap between gear type and size restrictions. To simply add the maximum amount of allowable gear from each fishery by gear type would overestimate the amount of gear in the province; therefore, to estimate the amount of gear in the region we summarized gear type by size restrictions. The greatest maximum amount of gear per gear type was used to represent the minimum amount of gear per type and size that are in the freshwater commercial fisheries of Québec (Table 6). Weirs were summarized by the total amount of allowable weirs, and the sum of allowable leader lengths (Table 6).

[87] Accessed at the website of MAPA https://cdn-contenu.quebec.ca/cdn-contenu/peche/documents/PL_gestion_peche_MFFP.pdf?1669405554

[88] Accessed at the website of the Cultur et Communications from: https://www.patrimoine-culturel.gouv.qc.ca/rpcq/detail.do;jsessionid=957D88485CD849BDE99CA2D3A3EFFD06?methode=consulter&id=62&type=imma

[89] Accessed at the website of MAPA

[90] Accessed at the website of Ministre des Forets, de la Faune et des Parcs from https://cdn-contenu.quebec.ca/cdn-contenu/peche/documents/PL_gestion_peche_MFFP.pdf?1669405554

Table 14: Commercial fishing gear licenses and allowances in freshwater commercial fisheries of Québec

Target Species	Mesh size or range (cm)	Max. length of allowable gillnet (m)	Sum of allowable gillnet across fisheries (m)
rainbow smelt	3.2	46,854	53,052
brook trout	5.1-7.6	6,055	15,069
Carp	9-10	1,097	3,767
American shad	13-15	1,170	3,654
sturgeon, channel catfish, carp, walleye	19-20.3	10,058	24,875
channel catfish, carp	20.3-29.2	3,840	7,498
Carp	26.6-29.2	2,469	12,710
	Est. total gillnet	71,544	120,626
Target Species	**Mesh size or range (cm)**	**Max. length of allowable seine net (m)**	**Sum of allowable seine net across fisheries (m)**
brown bullhead, carp, others	3	366	366
rainbow smelt	3.2	768	1,628
American eel, brown bullhead, channel catfish, carp, others	5	240	560
banded killfish	-	1,829	1,829
	Est. total seine net	3,202	4,382
Target Species	**Mesh size or range (cm)**	**Number of allowable weir traps**	**Total leader length (m)**
American eel, rainbow smelt, lake whitefish, Atlantic tomcod	5.7	8	1,057
American eel, rainbow smelt, Atlantic tomcod	3.2-5.1	39	14,032
American eel	-	4	448
	Est. total weir traps	51	15,537
Target species	**Gear type**	**Max. number of allowable**	**Sum of allowable**
American eel, brown bullhead, catfish, carp, others	fyke net	877	2,531

Source: MAPAQ, 2022

New Brunswick

The freshwater commercial fisheries of New Brunswick consist mainly of alewife and American eel. The alewife fishery occurs in the nearshore coastal areas and riverways. Trap nets and gillnets are the primary gear types used in this fishery. DFO's Integrated Fisheries Management Plan 2007-2012 reported that, as of 2004 there were 129 commercial license holders sharing 337 trap nets and 700 fathoms (1 fathom = 1.83 m) of cumulative gillnet throughout the fishery.[91] The 2022 stock status report for alewife and blueback herring states that management measures reported in the alewife fishery have remained the same since 2001.[92] Therefore, while the number of active licenses may have shifted, the number of trap nets and total length of gillnet in the fishery remains at 616 and 1,280 m, respectively. The general dimensions of an alewife trap net includes the pen area that is 14m long x 4m wide x 2.5m tall, with the guide extending out approximately 10m.

Ontario and Great Lakes

The freshwater industrial fisheries in the Great Lakes are the largest in Canada. Fishers target yellow perch, white perch, walleye, and lake trout with gillnets and trap nets. Additionally, a fleet of midwater trawlers target rainbow smelt in Lake Erie. The bulk of the freshwater fisheries, over 45% in terms of volume landed, occurs in the Great Lakes, with Lake Erie accounting for the most.

In Ontario, the commercial fisheries primarily occur in Lake Superior, Lake Huron, and Lake Erie. The commercial fisheries in Lake Erie target yellow perch, walleye, white bass, and white perch; there has not been effort targeting lake whitefish since 2013. The gear used in these fisheries are bottom set gillnets, trap nets, and midwater trawls. There are approximately 190 commercial licenses that share the Ontario quotas in Canadian Lake Erie. Not all licenses are active, and some vessels may carry more than one license. In recent years about 60-70 vessels have been active in the gillnet fishery of Canadian Lake Erie.[93] [94] [95] The gillnets used in the western basin of Lake Erie typically range from 1.2 -

[91] DFO, 2007. Plan de Gestion Integree de la Peche du Gaspareau Secteur est du Nouveau-Brunswick Region du Golfe. Accessed at: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/349481.pdf
[92] Ibid

[93] SAI Global, 2021. Lake Erie Multi-species Commercial. Public Certification Report. Marine Stewardship Council fisheries assessment. 04 January 2021.
[94] Accessed from the website of Ontario's Sustainable Bait Management Strategy https://files.ontario.ca/ndmnrf-ontario-sustainable-bait-management-strategy-2020-en-2022-03-03.pdf
[95] Allen King, pers. comm

1.8 m high.[96] Each net is 32-40 m long and are strung together in "straps" up to 6.4 km in length.[97]

Mid-water trawls are used to capture rainbow smelt in Lake Erie. There are over 50 licenses for this fishery; however, from 2010-2019 the number of active vessels has ranged from 25 (in 2011) to 5 (in 2019). While trawlers often own spare nets in case gear becomes damaged, only one trawl net is used per vessel during fishing operations.

Trap nets are used in Canadian Lake Erie to target yellow perch. Since 2000, the maximum number of active trap net operations in Lake Erie was 8 (in 2004 and 2006), yet since 2012, the number of active trap net licenses has ranged between 2 and 5.[98]

In the early 2000's, there were 13 gillnet licenses and 11 trap net licenses operating in Lake Ontario.[99] Currently, there are 6 registered large fishing vessels on Lake Ontario. In the main basin of Lake Huron there are two large-mesh trap net operations, each operate 9 to 10 large-mesh trap nets used to target lake whitefish.[100,101]

Besides these trap net fisheries, Lake Superior, Lake Huron, and Lake Ontario fisheries employ gillnets from large and small-scale vessels[102]. There are currently 86 registered small fishing vessels throughout the Canadian Great Lakes, nearly all of which use gillnets to target multiple fish species[103]. Small scale gillnet operations use less gear than the larger gillnet tugs, and while specific information about net length was not available, based on regional projects, we assume strings of gillnet gear ranges from around 300-600 m.[104,105]

Gillnets used on inland lakes are typically made of monofilament webbing. The floatlines are braided poly cover with a foam core from 3/8" to ¾" in diameter. The plastic floats

[96] SAI Global, 2021

[97] NRC, 2021. Predictive model identifying locations of fishing gear loss or accumulation in Lake Erie, Canada. Prepared for: Ocean Conservancy

[98] OMNRF, 2020

[99] Ebener, M. P., R. E. Kinnunen, P. J. Schneeberger, L.C. Mohr, J. A. Hoyle, and P. Peters. 2008. Management of commercial fisheries for lake whitefish in the Laurentian Great Lakes of North America. Pages 99-144 in M. G. Schechter, N. J. Leonard, and W. W. Taylor, editors. International governance of fisheries ecosystems: learning from the past, finding solutions for the future. American Fisheries Society, Bethesda, Maryland.

[100] Ibid

[101] Brenden, T.O., Brown, R.W., Ebener, M.P., Reid, K., Newcomb, T., 2013. Great Lakes commercial fisheries: historical overview and prognoses for the future. In: Taylor, W.W., Lynch, A.J., J, L.N. (Eds.), Great Lakes Fisheries Policy and Management. Michigan State University Press, East Lansing MI, pp. 339–397.

[102] Ibid

[103] Transport Canada, 2022. Vessel Registration Query System.

[104] Accessed from Saugeen Ojibway Nation at: https://sonfishing.ca/

[105] Michaels, S., Brost, B., Mattes, W.P., 2013. Reducing the Incidental Catch of Lake Trout in Large-mesh Gillnet Fisheries for Lake Whitefish. Great Lakes Indian Fish & Wildlife Commission. Project Report 13-2. Accessed at: https://glifwc.org/Fisheries/GreatLakes/Modified%20Gill%20Net%20Study.pdf

attached to the floatline are made of polystyrene. Leadlines are either hollow braided poly line with small leads (approx. 5 oz) attached to the line equidistant from one another, or polyester, polypropylene braided fiber jacket over a crimped lead coreline.[106] Each gillnet is approximately 100 m long, and they are set in rows ("gangs") of 6-8 nets on average.[107]

Manitoba

Commercial fishing occurs in over 200 lakes in Manitoba. Gillnets are the primary gear type in these fisheries targeting whitefish, walleye, perch, mullet, and carp. Fishing typically occurs off small vessels (skiffs) or through the ice. The maximum gear length allowed per fishing license is 5,700 m on Waterhen Lake.[108] In Lake Winnipegosis there are 174 eligible licenses and 116 active licenses that include both open water and through the ice gillnet fishing operations. The maximum length of gillnets per license for the winter (ice) fishery is 11,100 m, and 4,600 m for the open water (summer) fishery.[109] On Lake Manitoba, there are 554 eligible commercial fishing licenses, with 250 to 300 active licenses per year in recent years.[110] On Cedar Lake there are 41 licensed fishers.[111] With around 500 active fishers per year in Manitoba, each of which likely operate with an amount of gillnet from 600 to 11,000 m, we estimate there is at least 300 km of gillnet in Manitoba.

Saskatchewan

Commercial fisheries in Saskatchewan occur in over 225 lakes across the province. Gillnet is the dominant gear type within these fisheries that primarily target lake whitefish, walleye, northern pike, lake trout, mullet, and cisco. There are approximately 500 commercial fishers in Saskatchewan that are issued between 900-1,200 licenses each year.[112] The commercial fisheries in Saskatchewan are generally considered small-scale, with operations conducted off small open-deck vessels or through the ice. Each gillnet is approximately 100 m in length and about 1-4m tall. Since there was not information available on the average number of nets per gang per license type, we assume the small-scale operations use 6-8 gillnets per gang, similar to fishing operations in Manitoba

[106] Accessed from the website of Lakefish Net & Twine, 2022: http://www.lakefish.net/about.htm

[107] Transportation Safety Board of Canada Marine Investigation Report M99C0048. Accessed at: http://tsb.gc.ca/eng/rapports-reports/marine/1999/m99c0048/m99c0048.html

[108] Klein, G. and Galbraith, W., 2017. Waterhen Lake Fisheries Management Plan. Wildlife & Fisheries Branch Report 2017-01 Province of Manitoba.

[109] Lake Winnipegosis Fishery on a Path to Stock Recovery. Accessed at: https://www.gov.mb.ca/nrnd/fish-wildlife/pubs/fish_wildlife/fish/lake_winnipegosis_fishery_summary.pdf

[110] Manitoba, 2022b. Lake Winnipegosis Fishery A Fishery on the Road to Sustainability. Accessed at: https://www.gov.mb.ca/nrnd/fish-wildlife/pubs/fish_wildlife/fish/lake_manitoba_fishery_summary.pdf

[111] Ibid

[112] Accessed at the website of CBC. Pandemic, low prices blamed for 95% decline in Sask. Commercial lake trout harvest. Reported by Kelly Provost: Accessed at: https://www.cbc.ca/news/canada/saskatchewan/commercial-lake-trout-harvest-1.6278613

described in TSB.[113] With 500 active fishers using at least 600 m of gillnet each, this equals 300 km of gillnet in the province.

Northwest Territories

The freshwater fishing industry in the Northwest Territories is largely based in Hay River on the south shore of Great Slave Lake, while other commercial fishers operate out of Yellowknife, and a very small fraction of the commercial fishers operate outside Great Slave Lake.[114] Lake whitefish are the primary species captured in the commercial fishery, followed by lake trout, pike, and walleye.[115] Similar to freshwater fisheries in other Provinces, gillnets are the prominent gear type, which are deployed both off vessels and through the ice. As of 2017, there were 71 commercial fishing licenses in the Northwest Territories.[116] Gillnets are made of monofilament with mesh sizes either 133 mm or 140 mm stretched mesh. Gear is deployed off large and small transport types; whitefish boats (avg. 13 m length) and bombardiers (large snow-machines), and skiffs and skidoos, respectively.[117] Currently there are 6 registered whitefish boats, and 18 registered skiffs.[118] The small transports set less nets per gang than those set from the larger transports.[119] Since there was not information available on the average number of nets per gang per license type, we assume the small scale operations use 6-8 gillnets per gang, similar to fishing operations in Manitoba described in,[120] and the larger operations likely operate with twice as many or more. Based on these values, we estimate the number of gillnet in Northwest Territory to be 58 km.

Nunavut

Arctic char are the primary target species for inland/freshwater fisheries in Nunavut, with set gillnets being the main gear type. The fisheries occur at the mouth of the rivers, and the main fishing areas are Cumberland Sound and Cambridge Bay.[121] The required mesh size for gillnets in the Arctic char fishery is 139 mm. In 2014 there were 18 active licenses in

[113] Transportation Safety Board of Canada Marine Investigation Report M99C0048. Accessed at: http://tsb.gc.ca/eng/rapports-reports/marine/1999/m99c0048/m99c0048.html

[114] GNT (Government of Northwest Territories), 2018. Economic Opportunities Strategy, Performance & Measures Report 2016-2017. Accessed at: https://www.iti.gov.nt.ca/sites/iti/files/12953_gnwt_iti_eos_report-final_web.pdf

[115] DFO Landings Data

[116] GNT, 2018

[117] Tallman & Frieson, 2007

[118] Accessed data from Transport Canada, 2022. Vessel Registration Query System at: https://wwwapps.tc.gc.ca/Saf-Sec-Sur/4/vrqs-srib/eng/vessel-registrations/advanced-search

[119] Tallman & Frieson, 2007

[120] TSB, 1999

[121] Hurtubise, J., 2016. Evolution of subsistence and commercial Inuit fisheries in the Territory of Nunavut, Canada: Research and summation of landings, quotas, gear type, significance, use and status of hunted marine species. (Marine Affairs Program Technical Report #14). Available at Marine Affairs Program: http://www.dal.ca/faculty/ science/marine-affairs-program/research/research-news/map-technical-series-reports.html

the Cambridge Bay fishery,[122] and in 2017 there were 15 active licenses in the Cumberland Sound area,[123] for an approximate total of 32 active fishers. No information was available regarding the length of these gillnets; therefore, we apply the size of river mouth gillnets used for salmon in British Columbia, which are limited to 135 and 183 m depending on the location (Canada SOR93-54). This would equate to an estimated 4,320 - 5,856 m of gillnet.

End of Life Freshwater Fishing Gear

There was no available information regarding freshwater gear replacement. Therefore, to estimate the amount of EOL fishing gear from the freshwater fisheries in Canada, the replacement rates used in the marine fisheries based on fishing gear types and materials were applied. The replacement rate range of 16.7-25% as estimated within the marine gillnet fisheries for salmon and herring was used for gillnets in the freshwater fisheries in all provinces. Replacement rates for trawl nets in Ontario (Lake Erie), were estimated to be same as trawl gear replacement in the Pacific groundfish fisheries (10-20%). Because weir and trap nets use similar materials as purse seine gear thicker and stronger than gillnet gear) and they are not mobile gears, their replacement was assumed to be relatively low in comparison to other gears. Therefore, the same gear replacement rate from the purse seine fisheries was used for trap nets and weirs (4%) (Table 4.6). Fyke nets, which are typically set like traps were applied the general replacement rate of lobster traps of 20%.[124]

[122] DFO, 2014. Integrated Fisheries Management Plan Cambridge Bay Arctic Char Commercial Fishery, Nunavut Settlement Area. Fisheries and Oceans Canada Central and Arctic Region. Accessed at: https://publications.gc.ca/collections/collection_2016/mpo-dfo/Fs134-22-2015-eng.pdf

[123]Galappaththi, E.K., Ford, J.D., and Bennett, E.M., 2019. Climate Change and Community Fisheries in the Arctic: A Case Study from Pangnirtung, Canada. Journal of Environmental Management, 250. Accessed at: https://eprints.whiterose.ac.uk/153433/3/Manuscript-Revised_Final_August%2005.pdf

[124] Goodman et al. 2020

Table 15: Estimated Annual EOL Fishing Gear from Commercial Freshwater Fisheries Quantities, by Province and Territory (number of gear, km of gear)

Province/Region	Gear Type	EOL low estimate	EOL high estimate	Measurement
Québec	Gillnet	20.1	30.2	km of gillnet
Québec	Purse seine		0.176	km of purse seine
Québec	Fyke net		470.2	fyke nets
Québec	Trap net		17.9	trap nets
New Brunswick	Trap net		24.6	trap nets
New Brunswick	Gillnet	0.2	0.3	km of gillnet
Ontario	Trawl	0.5	1.0	trawl nets
Ontario	Trap net		0.76	trap nets
Ontario	Gillnet	83.5	125.0	km of gillnet
Manitoba	Gillnet	50.1	75.0	km of gillnet
Saskatchewan	Gillnet	50.1	75.0	km of gillnet
Northwest Territories	Gillnet	9.7	14.5	km of gillnet
Nunavut	Gillnet	1.0	1.5	km of gillnet

3.2.2 Aquaculture Gear

3.2.2.1 Types and Common Materials

Canadian aquaculture systems use large nets, significant amount of line, chain, and buoys. Specific materials used in Canadian aquaculture operations differ between provinces and producers.

Canadian finfish aquaculture relies mainly on gravity-type cage systems (also referred to as net-pens) consisting of nylon, HDPE, or HDPE coated or sheathed steel nets hung from floating HDPE, rubber or steel collars, secured by upwards of eight mooring lines to submerged mooring grids, and with additional support provided by significant amounts of polypropylene line. Additional predator netting may be deployed around the perimeter of the mooring system or individual collars. Some nets may be treated using copper based antifoulants and add safety considerations for transport and disposal.

Shellfish growers in Canada use intertidal/beach culture, deepwater-suspended systems, bottom/subtidal culture, and various other off-bottom systems. Off-bottom systems consist of large floating, plastic, wooden or metal rafts or individual polypropylene long-lines from

which trays, cages, socks, or lines are suspended. Mussel culture is conducted in Prince Edward Island and Newfoundland using long-line culture techniques. In British Columbia, oysters, clams, and scallop growers employ a mix of rafts and long-line culture systems. Long-line systems are used in Atlantic Canada while a mixture of rafts and long-lines are used in British Columbia. Kelp cultivation also uses long-line systems.

In all systems, polyethylene, or polystyrene floats provide buoyancy, and delineate farm footprints. Smaller growers on the east coast of Canada may use common buckets and jugs to fashion homemade floatation. Large cement or helical anchors anchor the system to the substrate with a combination of chain and polypropeline rope securing infrastructure to the anchors.

Table 16: Aquaculture system plastic components

System	Plastic components	PMMA	EPS	FRP	HDPE	LLDPE	LDPE	Nylon	PE	PET	PP	PVC	UHMw-PE
Open-water cages and pens	Floating collars (inc. handrails)				x							x	
	Collar floatation		x										
	Buoys (in mooring systems)				x		x		x				
	Ropes (in mooring systems)							x			x		
	Net enclosures				x			x			x		x
	Predator and other nets				x			x	x				
	Feeding systems (pipes & hoppers			x	x							x	
Suspended ropes / longlines	Buoys (in mooring systems)				x		x		x				
	Ropes (in longlines & mooring systems)				x			x		x	x		
	Raft floatation		x		x								
	Stock containment (nets / meshes)				x			x			x		x
Land-based Coastal and inland ponds	Pond liners				x	x	x						
	Sampling / harvest nets				x			x			x		x

	Plastic green / poly housing						x						
	Aerators / pumps				x							x	
	Feeding systems (pipes, feeders & trays)			x	x							x	
Land-based Tanks (including recirculated aquaculture systems RAS)	Spawning, incubation & stock holding tanks			x	x								
	Pipework (including connectors, valves)			x	x							x	
	Office / laboratory fixtures & fittings	x	x				x	x				x	

Source: Huntington, T. 2019. Marine Litter and Aquaculture Gear – White Paper. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council. 20 pp plus appendices.

3.2.2.2 Literature and Publicly Available Data Review

A search for available publications regarding estimating total amount of aquaculture gear both in Canadian waters and globally returned no results. A similar search for EOL aquaculture gear waste volumes returned many results focused on assessing the contribution of marine aquaculture gear to microplastic pollution, but only four publications, all published within the last 4-years, specifically focused on estimating aquaculture waste stream volumes.[125] [126] A 2019 white paper published by the Aquaculture Stewardship Council notes the lack of systematic analyses regarding how plastic is used in aquaculture and subsequent waste stream volumes.[127] Tian et al. (2022) note that, to the best of the authors' knowledge, their efforts were among some of the first attempts to estimate the contribution of aquaculture to marine plastic waste.[128] Three of the four publications used material flow analysis (MFA) to attempt to develop estimates for sectors of the Norwegian finfish and Chinese shellfish industries respectively. The 2019 white paper estimates of micro-plastic waste (in terms of kg of plastic waste per tonne of finish biomass produced) relied on metrics developed in 2014 for the Norwegian Environment Agency (Miljødiredktoratet),[129] reported again in a 2016 study for the European Commission DG Environment.[130]

Publicly available data on current Canadian aquaculture lease holders, aquaculture lease area, and per lease production metrics are limited. Publicly available online lease holder information could only be obtained for British Columbia, Nova Scotia, and Newfoundland and Labrador.

Several global aquaculture companies with operations in Canadian waters did have publicly available annual reports, which included discussion of waste stream management

[125] Mengyu, B. Lihui, A. Guyu, P. & Daoji, L. 2018. Estimation and prediction of plastic waste annual input into the sea from China. Acta Oceanologica Sinica, 37(11): 26-39, doi: 10.1007/s13131-018-1279-0.
[126] Roy, P. & Yaakoubi, A. 2021. Using material flow analysis (MFA) to track the mass plastics in aquaculture gear in the Region of Møre and Romsdal. Master's thesis, Norwegian University of Science and Technology. 79 pp.
[127] Huntington, T. 2019. Marine Litter and Aquaculture Gear – White Paper. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council. 20 pp plus appendices.
[128] Tian, Y., Zongyao, Y., Xueying, Y, Zhen, J., Rosso, M., Dedman, S., Zhu, J., Xia, Y., Zhang, G., Yang, J. & Wang, J. 2022. Can we quantify the aquatic environmental plastic load from aquaculture? Water Research. 219(2022) 118551, doi: 10.1016/j.watres.2022.11851.
[129] Sundt, P., Schlze, P-E., & Syversen, F. 2014. Sources of microplastics-pollution to the marine environment. Presentation to the Nrowegian Environment Agency (Miljødiredktoratet). 108 pp.
[130] Sherrington, C., Darrah, C., Hamm, S., Cole, G. & Corbin, M. 2016. Study to support the development of measures to combat a range of marine litter sources. Prepared by EUNOMIA Ltd for the European Commission DG Environment. 429 pp.

and some limited information on volume of waste diverted from landfills, but this data was ultimately unhelpful in extrapolating to the provincial or national scale.

3.2.2.3 Stakeholder Interviews

Outreach and interview efforts initially focused on British Columbia and Nova Scotia, as well as regional DFO aquaculture managers before being expanded to other regions.

A total of 18 stakeholders were contacted for interviews (2 DFO regional aquaculture managers, 2 provincial authorities, 5 industry associations, and 6 producers). Of the 18 contacted, 9 responded (1 DFO manager, 1 provincial authority, 3 industry associations, and 4 producers).

No one interviewed for this report knew of any comprehensive data pertaining to estimates of total aquaculture gear in Canadian waters or annual waste stream volumes from the industry. During an interview with a representative from MOWI (one of Canada's largest finfish producers) it was explained that information on producer gear and waste volumes tend to be proprietary and that industry associations might be the best avenue for this data as they can aggregate proprietary information in such a way that protects the anonymity of individual producers. However, in interviews with provincial industry associations it was reported that they do not track gear or waste metrics and that producers or processors likely have this information. Difficulty in accessing waste volume information from producers was also noted by Roy and Yaakoubi (2021) during their attempts to use MFA to estimate waste volumes from a section of the Norwegian aquaculture sector.[131] Ultimately, the proprietary nature of this waste information made estimating waste volumes impossible for the Norwegian project.

Finally, while finfish aquaculture production in Canada is dominated by a small number of large producers who often operate on a global level, shellfish production is often carried out by individual producers. As a result, no interviews were conducted with shellfish producers. An interview with the British Columbia Shellfish Growers Association (BCSGA) was conducted. The BCSGA representative from the indicated that individual growers would likely be hesitant to participate in this exercise and that the association itself does not track waste metrics.

[131] Roy, P. & Yaakoubi, A. 2021. Using material flow analysis (MFA) to track the mass plastics in aquaculture gear in the Region of Møre and Romsdal. Master's thesis, Norwegian University of Science and Technology. 79 pp.

3.2.2.4 Canadian Aquaculture Waste Volume Estimates

Reliably estimating annual waste volumes from the Canadian aquaculture sector using Canada-specific data is not possible due to significant data gaps. In the absence of Canadian data, available data on microplastic waste production in Norway and infrastructure waste in China were used to extrapolate 2020 Canadian aquaculture production volume to develop estimates of plastic waste volume per tonne of biomass produced. The following estimates do not consider limited reports from individual producers regarding fate of waste and reflect the only available sector wide data on waste production for marine finfish and shellfish.

Significant differences in the data used to extrapolate annual waste production for the Canadian aquaculture sector make providing useful estimates difficult. Data from Lihui et al. (2018) includes household waste generation by marine finfish aquaculture sector employees while the 2014 Norwegian data pertains to microplastic production, as a result, the range of estimates is extreme (Table 16). Using data from Chinese oyster aquaculture rafts, provides estimates of 1254.31 tonnes of plastic waste per year, significantly greater than estimates by Sonnera (2020) of 460 tonnes per year using the 2014 Norwegian data (Sonnera 2020; Tian et al. 2022).

Table 17: Estimated Annual Waste Stream Volume for the Canadian Aquaculture Sector for 2020

Province	**Finfish Aquaculture Annual Waste (tonnes per year)**			**Shellfish Aquaculture (tonnes per year)**
	Infrastructure item	**2014 Norwegian data extrapolations for microplastic waste production by infrastructure type**	**Lihui et al. 2018 Extrapolations Chinese marine finfish data (including waste from industry personnel)**	**Tian et al. 2022 Chinese raft oyster aquaculture data extrapolations**
NL	Marine Cage Collars	45.17	x	x
	Feeding Pipes	5.16	x	x
	Cage Nets	16.13	x	x
	Ropes	19.36	x	x
	Total	**85.82**	**2896.80**	**117.7**
NS	Marine Cage Collars	67.79	x	x

Province	Finfish Aquaculture Annual Waste (tonnes per year)			Shellfish Aquaculture (tonnes per year)
	Infrastructure item	**2014 Norwegian data extrapolations for microplastic waste production by infrastructure type**	**Lihui et al. 2018 Extrapolations Chinese marine finfish data (including waste from industry personnel)**	**Tian et al. 2022 Chinese raft oyster aquaculture data extrapolations**
	Feeding Pipes	7.75	x	x
	Cage Nets	24.21	x	x
	Ropes	29.05	x	x
	Total	**128.81**	**4347.81**	**42.14**
PE	Marine Cage Collars	3.63	x	x
	Feeding Pipes	0.41	x	x
	Cage Nets	1.30	x	x
	Ropes	1.56	x	x
	Total	**6.90**	**232.80**	**726.88**
NB	Marine Cage Collars	109.42	x	x
	Feeding Pipes	12.51	x	x
	Cage Nets	39.08	x	x
	Ropes	46.89	x	x
	Total	**207.90**	**7017.38**	**77.023**
QC	Marine Cage Collars	3.99	x	x
	Feeding Pipes	0.46	x	x
	Cage Nets	1.42	x	x
	Ropes	1.71	x	x
	Total	**7.58**	**255.82**	**12.16**
ON	Marine Cage Collars	3.11	x	x
	Feeding Pipes	0.36	x	x
	Cage Nets	1.11	x	x
	Ropes	1.33	x	x
	Total	**5.91**	**2195.44**	**42.15**
MB	x	x	x	x
SK	x	x	x	x

Province	Finfish Aquaculture Annual Waste (tonnes per year)			Shellfish Aquaculture (tonnes per year)
	Infrastructure item	**2014 Norwegian data extrapolations for microplastic waste production by infrastructure type**	**Lihui et al. 2018 Extrapolations Chinese marine finfish data (including waste from industry personnel)**	**Tian et al. 2022 Chinese raft oyster aquaculture data extrapolations**
AB	x	x	x	x
BC	Marine Cage Collars	541.97	x	x
	Feeding Pipes	61.94	x	x
	Cage Nets	193.56	x	x
	Ropes	232.27	x	x
	Total	**1029.74**	**2195.44**	**278.44**
Canada	Marine Cage Collars	815.01	x	x
	Feeding Pipes	93.14	x	x
	Cage Nets	291.08	x	x
	Ropes	349.29	x	x
	Total	**1548.53**	**34757.57**	**1254.31**

Note 1: 2014 Norwegian data are reported in Huntington, T. 2019. Marine Litter and Aquaculture Gear – White Paper. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council. 20 pp plus appendices. The report estimates 11kg of microplastic waste per tonne of finfish produced.

Note 2: 2018 Chinese finfish data included per-capita estimates of household waste produced by aquaculture sector employees and may explain the large deviation from extrapolations from Norwegian data. Mengyu, B. Lihui, A. Guyu, P. & Daoji, L. 2018. Estimation and prediction of plastic waste annual input into the sea from China. Acta Oceanologica Sinica, 37(11): 26-39, doi: 10.1007/s13131-018-1279-0.

Note 3: 2022 Chinese shellfish data does break down waste volumes by infrastructure item but the rafts employed by Chinese shellfish growers are very different in material components than those described for the Canadian sector. Tian, Y., Zongyao, Y., Xueying, Y, Zhen, J., Rosso, M., Dedman, S., Zhu, J., Xia, Y., Zhang, G., Yang, J. & Wang, J. 2022. Can we quantify the aquatic environmental plastic load from aquaculture? Water Research. 219(2022) 118551, doi: 10.1016/j.watres.2022.11851.

3.2.2.5 Future Data Needs for End-of-Life Aquaculture Gear

While attempting to produce estimates of EOL aquaculture gear, it became clear that current reporting and monitoring efforts do not track aquaculture gear currently in use or EOL aquaculture gear. During interviews producers suggested looking to industry groups, and industry groups were explicit that they do not track waste or gear estimates.

Most aquaculture lease application processes require a description of the gear to be used as well as the development of a waste management plan for the site. While the integration of such data into permitting processes is an important first step, this data is not centralized on either a provincial or national level. Additionally, the amount of gear proposed on a lease application may far exceed the actual gear in the water at a given site at any time, representing, instead, potential maximum production and potentially leading to over-estimation of waste production. In the future, gear inventory reporting could be added as a license condition to better track and centralize information on gear types and amounts used in the Canadian aquaculture sector.

Producers interviewed during this project expressed solidarity with this effort and informed project staff that, in some cases, their own operations were currently engaged in the compilation of this data. Moving forward, it would help EOL aquaculture gear estimates if industry associations, working with producers, could begin to act as centralized data holders for EOL aquaculture gear data.

Finally, there is concern over an unknown and currently unknowable amount of ALD aquaculture gear already present on lease sites that have been in use for decades. Recent changes to the *Fisheries Act* for new lease applications in British Columbia, which require applicants to conduct surveys and ALD aquaculture gear removal before beginning new operations could address these issues. There is no method available to estimate the amount of potential ALD aquaculture gear currently in marine waters of Canada.

3.3 Fate of End-of-Life Fishing and Aquaculture Gear in Canada

3.3.1 Fishing Gear

Annual quantities of EOL fishing gear in Canada were placed into the following 8 gear-type categories:

1. Gillnet.
2. Purse seine.
3. Pots and associated hardware.
4. Trawl nets.
5. Longline.
6. Rope.
7. Fyke nets.
8. Trap nets.

The waste generation data for fishing gear did not include information on the volume of EOL gear that is reused, repurposed, repaired, or abandoned, lost or discarded and therefore these options were not considered in the analysis below. It must be assumed that if the EOL fishing gear has been classified as "waste" it is not suitable for reuse or repurposing and therefore must be disposed or recycled. Additionally, information on lost or discarded gear is unavailable as this information would not reasonably be publicly available or shared with policymakers due to the potential bad publicity resulting from these figures and/or potential legal ramifications. Interviews with the FGCAC indicated that – amongst some fishers in Atlantic Canada – the practice of illegally releasing gear to the environment remains standard practice.[132] It can be expected that Atlantic Canada is not unique in this regard, and that this information is known to the FGCAC because they have relationships with some of these individuals and are not in a position to prosecute or fine these individuals. Unfortunately, the scale of these practices cannot be reasonably estimated, and the project team is not in a position to try and investigate or quantify illegal behaviour. This should be considered a significant data gap.

In terms of managing waste EOL gear, several of the 8 above gear categories are generally managed in the same way due to material similarities and the capabilities of the waste management system. Nets (gillnet, purse seine, trawl nets, fyke nets, and trap nets) are most likely managed via long-term storage or disposal at a landfill. An interview of a recycler in B.C. (that is actively recycling fishing nets from Steveston Harbour) has indicated that these nets are often very large, very heavy (a single net "package" containing necessary rope and other associated materials can often weight in excess of ~7 – 9 tonnes) and very difficult to transport. Additionally, the nets can cause damage to earthmoving machines that are used at landfills and can therefore sometimes not accepted for landfilling – leaving few options for their management.[133] When nets are accepted for burial at some landfills, they require extra fees to be paid for their disposal due to the fact that the need to undergo "deep burial" – in order to avoid damaging the earthmoving vehicles (this means digging a deep hole, placing the netting down the hole, and covering it up with other waste – which can involve a substantial amount of labour).

Reports assembled by the Fishing Gear Coalition of Atlantic Canada on the management of end-of-life fishing gear in Québec and the Atlantic provinces did not mention or describe how fish nets are managed and focused only on lobster traps and rope, but regional experts have provided some context on the evolving situation, and an interview was carried out with the Island Waste Management Corporation landfill in PEI (the only landfill in PEI).

[132] Interview with the FGCAC, May 2nd, 2023.
[133] Interview with Pacific Carpet Recycling, October 18, 2022.

The Island Waste Management Corporation indicated that they accept netting, but that it is a "nightmare" to deal with at the landfill and damages the equipment.[134] The netting is accepted as commercial waste and is often mixed with other commercial waste (it arrives in front-end loader bins), and therefore no tracking is undertaken regarding the weight or volume of netting being landfilled each year. The netting is also sometimes sent to the Charlottetown incinerator and incinerated. The Island Waste Management Corporation is investigating ways of recycling or downcycling the fishing net, but no concrete plans are currently in place. No information was identified on the percentage of EOL nets that may be stored at private sites versus the percentage of EOL nets that might be landfilled/incinerated each year.[135]

In Newfoundland and Labrador, the Central Newfoundland Waste Management Authority accepts fisheries and aquaculture materials with the requirement that nets and rope are bagged. In practice, the Robinhood Bay landfill in Newfoundland sets these items aside when they are received and wait for the construction of a new cell to begin. When the construction of a new cell is started, they place stored netting at the bottom of the cell and cover it with other materials – similar to the "deep burial" option discussed above. This practice requires extra space to use for short-term storage, but is likely more efficient when it comes to labour (depending on how difficult it is to move the nets around the site – from receiving to storage and then back to the new landfill cell).[136] The Robinhood Bay Landfill site will charge a special commercial waste fee for this service, which may be a higher fee than what is charged for waste generally. No information was identified on the percentage of EOL fishing net that may be stored at private sites versus the percentage of EOL fishing nets that is responsibly disposed of at landfill.

There is little information about fishing net management on Canada's east coast, and the only information identified on EOL fishing net management from Canada's west coast has come from the one harbour in Canada that is working to get netting recycled (Steveston Harbour) and the single recycler that is working with them (Pacific Carpet Recycling). Even in that case, there is such a significant backlog of fish netting in storage at Steveston Harbour that the current recycling program does not impact the amount of fish nets that enter storage annually, there is simply too much netting in storage to work through first. Interviews with Ocean Legacy have indicated that some landfill sites in B.C. do accept netting for disposal, but as indicated above via the interview with Pacific Carpet Recycling, others do not. Given that there is no reliable data available with which to estimate netting disposal versus storage trends on either the west coast, central Canada, or Atlantic Canada, order of magnitude estimates has been applied. No better options were identified.

[134] Interview with the Island Waste Management Corporation, March 24, 2023.
[135] Interview with the Island Waste Management Corporation, March 24, 2023.
[136] Information accessed via conversations with the CCME, January 13th, 2023.

On the west coast, due to information received regarding some of the larger landfills not accepting netting, Steveston Harbour also stockpiling netting, and aquaculture operators stockpiling netting because it is less expensive than landfill disposal, it is estimated that 75% of netting is stored, and 25% of netting is disposed of in landfill annually. In central Canada, where no information of any kind was identified, it is estimated that 50% of netting is disposed, and 50% of netting is stored. In Atlantic Canada, due to the fact that many transfer stations/landfills accept netting, it is estimated that 75% of netting is disposed of in landfill, and 25% is stored long term.

Pots, lobster traps, and associated hardware are accepted at some Canadian waste management facilities, though due to transportation costs and tipping fees, these traps can often be set aside for long-term storage or simply burned. A company called AIM Recycling worked with the Fishing Gear Coalition of Atlantic Canada and the Fundy North Fisherman's Association in 2021 and 2022 on collection programs for lobster traps, and between the two programs collected over 350,000 traps that had been put into long term storage with no intention of final disposal. Those traps that are sent to waste management facilities can be either landfilled or forwarded to a metal recycler depending on the type of trap (wood traps are often not viable for recycling) and whether or not a metal recycler is locally available that will accept the traps or pots.[137] Additionally, some waste management facilities will only divert traps for recycling if the fishers have already separated out other materials (such as concrete) from the trap before bringing it in.[138] Given the complexity of these interrelated operations and the lack of any publicly available data on choices made by fishers regarding the storage/burning or disposal of their traps and pots, assumptions have been applied based on best available data.

The Fishing Gear Coalition of Atlantic Canada reports all have data on how far waste resource management facilities are from core commercial fishing harbours. For example: in Newfoundland and Labrador, "the linear distance to these facilities (from commercial fishing harbours) varies throughout the province, with 29% of core commercial fishing harbours within a 10 km range of a waste resource management facility, 71% within 25 km, and 97% within 50 km."[139] These figures have been extracted from the reports and placed in the table below.

[137] Interviews with metal recyclers have indicated that they often do not want these traps and pots because the metal content is low, and they contain concrete and rope that can damage their equipment or slow down their operations. They accept the pots and traps only if the waste management facility requires them to as part of a bid on metals that have been separated from other wastes. Generally, the traps and pots represent a cost and the remainder of the metal will need to be worth enough to cover the loss caused by the traps.
[138] Fishing Gear Coalition of Atlantic Canada, (2021), *End-Of-Life Fishing Gear Management in Newfoundland and Labrador*
[139] Ibid.

Table 18: Distance from Commercial Harbours to Waste Resource Management Facilities in Eastern Canada

Province	10 km	25 km	50 km
Newfoundland and Labrador	29%	71%	97%
New Brunswick	1%	13%	80%
Nova Scotia	12%	73%	100%
P.E.I.	20%	87%	100%
Eastern Québec	38%	40%	73%
Average	20%	57%	90%

Sources: Fishing Gear Coalition of Atlantic Canada reports on End-Of-Life Fishing Gear Management in the above provinces.

As much of the waste generation data on pots and traps was not available provincially, utilizing provincial percentages was not feasible. Therefore, the project team has opted to utilize the average percentages in the table above and apply it across Canada. Additionally, it has assumed that commercial fishers within 25 km of a waste management facility have opted to utilize that waste management facility. Finally, it is assumed that all waste resource management facilities within 25 km of commercial fishing harbours accept some fishing gear (including traps and pots). Therefore, it is assumed that 57% of the traps and pots and associated hardware reaching EOL annually in Canada have been brought to waste management facilities, and the other 43% have been sent to long term storage or burned.

Estimates regarding what happens to those traps and pots that arrive at waste management facilities vary depending on the region. According to an interview with the FGCAC, the only trap or pot recycler in Atlantic Canada is based in Nova Scotia, and has only been recycling pots and traps intermittently since 2018. The FGCAC indicated that traps and pots are usually either stored (the 43%) or landfilled.[140] The FGCAC recommended that a relatively low figure for annual recycling should be used, and therefore 25% of the traps that arrive at waste management facilities are considered recycled, and the remaining 75% of traps are landfilled. For other areas in Canada, it has been estimated that 50% of traps that get to waste management facilities are recycled, and 50% are landfilled.

The final types of EOL fishing gear generated in Canada annually are rope and longlines. Rope is often bound up in other equipment and difficult to separate, and will generally not be separated unless there is an intention to recycle the gear that it is attached to. For example, Steveston Harbour employs fishers to separate rope from nylon netting so that the nylon netting can be recycled. In Atlantic Canada, the FGCAC has been working with

[140] Interview with the FGCAC, May 2nd, 2023.

a select group of transfer stations and landfills (they are constantly negotiating with transfer stations and landfills to bring them on-board with their program) to have these locations require rope be brought in separated from other gear, and be stockpiled for recycling. Since approximately 2020, participating transfer stations and landfills have been stockpiling separated rope and lobster traps for the purposes of eventual recycling. Some facilities only collect rope, some only collect lobster traps, and some collect both. The FGCAC has kept details on the number of landfills/transfer stations that are participating in their program confidential, and therefore this data cannot be used to inform any estimates of waste being brought to transfer stations/landfills for either rope or lobster traps.[141]

Therefore, for the purposes of this study the same simplifying assumptions used for traps and pots have been applied to rope (57% are taken to waste management facilities, and 43% is placed into long-term storage or burned). Unlike traps and pots, ropes are rarely recycled in Canada outside of the FGCAC program, which was stockpiling rope at select landfills from ~2020-2023 and sent their first containers of rope to be recycled in Denmark in August of 2023.[142] While these recycling figures are public, and are presented later in this report, the fact that the rope was stockpiled for three years, and that it was collected without tipping fees as part of the FGCAC program[143] leaves this data unusable for the purposes of estimating annual recycling/landfilling rates.

Two main types of ropes are utilized by fishers in Canada – lead lines and basic thick nylon rope (aquaculture operations often use different rope made from multiple resins). In eastern Canada, the main types of rope used are polypropylene/polyethylene blended rope, and there may be polyester or other types of material in the blended ropes. The FGCAC indicated that 43% of rope sold in Atlantic Canada is polyethylene, 21% is polypropylene, and 36% is a blend of those materials and likely other materials. None of these ropes are easy to recycle. Lead line is heavy, and used in order to weight certain nets so that they fall through the water column, and no recyclers capable of recycling a mixture of lead and nylon have been identified. The thick basic nylon rope can damage a shredding machine if it is not cut into small lengths before it is sent to a shredder and prepared for recycling. This labour requirement has thus far rendered this rope too expensive and difficult to recycle.[144] Therefore, it has been assumed that 100% of the rope that is sent to waste management facilities is disposed of in landfill.

[141] Interview with the FGCAC, May 2nd, 2023.
[142] Interview with the FGCAC, May 2nd, 2023.
[143] Fishers will often opt to simply store rope and other waste instead of bringing it to a transfer station or a landfill, as storage has zero costs and tipping fees must be paid at landfills. The FGCAC program covers these tipping fees, and therefore fishers that have been stockpiling rope and traps for several years will use the program as an opportunity to get rid of their stockpiles for free. For this reason, trying to use the 2020-2023 FGCAC waste collection data to estimate annual waste generation is not feasible, as the figures represent some fishers getting rid of personal stockpiles that may have been building for many years.
[144] Interview with Pacific Carpet Recycling, December 23, 2022.

The table below shows the fate of EOL fishing gear in Canada based on the assumptions described above. As EOL fishing gear estimates were constructed with a high estimate and a low estimate, an average estimate of those figures was utilized when quantifying EOL gear fate.

Table 19: Fate of Fishing Gear Reaching EOL in Canada Annually

Province or Region	Gear Type	Fishery	Storage	Landfill	Recycling	Unit
BC	Gillnet	Salmon	152			km of gillnet
BC	Purse seine	Salmon	2			km of purse seine
BC	Gillnet	Herring	71			km of gillnet
BC	Purse seine	Herring	4			km of purse seine
BC	Pot	Crab	4,167	2,762	2,762	pots and associated hardware
BC	Pot	Shrimp	3,480	2,306	2,306	pots and associated hardware
BC	Trawl	Shrimp	9			trawl nets
BC	Trawl	Groundfish	14			trawl nets
BC	longline	Groundfish	457			km of longline
BC	Pot	Sablefish	135	90	90	pots and associated hardware
BC	Trawl	Scallop	<1			trawl nets
Atlantic	Pot	Lobster	206,001	204,804	68,268	pots and associated hardware
NB	Pot	Lobster	14,459	14,375	4,792	Pots
NB	Pot	Lobster	71	93		tonnes rope
NL	Pot	Lobster	22,380	22,250	7,417	Pots
NL	Pot	Lobster	87	115		tonnes rope
NS	Pot	Lobster	105,092	104,481	34,827	Pots
NS	Pot	Lobster	486	644		tonnes rope
PEI	Pot	Lobster	16,168	16,074	5,358	Pots
PEI	Pot	Lobster	37	50		tonnes rope
Québec	Pot	Lobster	3,266	2,165	2,165	pots
Québec	Pot	Lobster	9	11		tonnes rope
Atlantic	Pot	Snow crab	29,454	29,283	9,761	pots and associated hardware
Atlantic	Trawl	Shrimp	59			trawl nets
Atlantic	Pot	Shrimp	92	92	31	pots and associated hardware
Atlantic	Trawl	Groundfish	34			trawl nets
Atlantic	Gillnet	Groundfish	8,903			km of gillnet
Atlantic	longline	Groundfish	32,470			km of longline

Province or Region	Gear Type	Fishery	Storage	Landfill	Recycling	Unit
Atlantic	Dredge	Scallop	72			trawl nets
Atlantic	Gillnet	Herring	10			km of gillnet
Atlantic	Purse seine	Herring	<1			km of purse seine
Québec	Gillnet	Freshwater	25			km of gillnet
Québec	Purse seine	Freshwater	<1			km of purse seine
Québec	Fyke net	Freshwater	470			fyke nets
Québec	Trap net	Freshwater	18			trap nets
New Brunswick	Trap net	Freshwater	25			trap nets
New Brunswick	Gillnet	Freshwater	<1			km of gillnet
Ontario	Trawl	Freshwater	1			trawl nets
Ontario	Trap net	Freshwater	1			trap nets
Ontario	Gillnet	Freshwater	104			km of gillnet
Manitoba	Gillnet	Freshwater	63			km of gillnet
Saskatchewan	Gillnet	Freshwater	63			km of gillnet
Northwest Territories	Gillnet	Freshwater	12			km of gillnet
Nunavut	Gillnet	Freshwater	1			km of gillnet

Note: All figures rounded to the nearest whole number.
Source: NRC and Cheminfo Estimates

3.3.2 Aquaculture Gear

Estimates on the volume of EOL aquaculture gear entering the waste sector each year were generated for finfish operations and shellfish operations. As EOL gear-generation and value-retention operations for these two elements of the aquaculture sector are very different, they are described separately in sub-sections below. The waste generation data for these operations did not include information on the volume of EOL gear that is reused, repurposed, repaired, or abandoned, lost or discarded and therefore these options were not considered in the analysis below. It must be assumed that if the EOL aquaculture gear has been classified as “waste” it is not suitable for reuse or repurposing and therefore must be disposed or recycled. Additionally, information on lost or discarded gear is unavailable as this information would not reasonably be publicly available or shared with policymakers due to the potential bad publicity resulting from these figures and/or potential legal ramifications.

3.3.2.1 Waste from Shellfish Aquaculture Operations

Literature allowed for the generation of total waste estimates for shellfish aquaculture operations, and the composition of this waste stream was not specified (see section 4.2.2.4), and therefore estimates were made based on the types of shellfish farmed in Canada (described in section 3.4 - ~90% of Canada's output is mussels and oysters) and the types of aquaculture equipment typically used to farm mussels and oysters.

Oysters can be farmed using rafts or 'shelves' that have cages suspended in the water, or by simply allowing the oysters to grow on the bottom of a designated area – however these methods of oyster farming are unlikely to produce significant quantities of EOL gear waste due to the durable nature of metal cages. Some may need to be retired each year, but it is likely that metal cages may last for several seasons before they need to be retired.[145] In some instances, oysters within the cages are kept within mesh bags that can be made of a variety of materials (cotton, polyester, polyethylene and blends). Oysters can also be farmed using "socks", which are longer mesh bags made from similar materials to the bags that can be deployed in cages as described above. These socks are often hung from buoys and suspended in the water column.[146] These socks and other bags are likely of relatively low value, are likely difficult to clean, and are most likely disposed of at their end of each season. Therefore, for the purposes of this study it will be assumed that the waste produced from oyster farming is largely composed of socks and rope – both of which (given the state of Canada's value retention operations for EOL plastic aquaculture gear) are likely disposed of in landfill.[147]

Mussels are usually farmed in a similar fashion, using socks suspended from an anchored buoy in deep subtidal water. [148] It is expected that the majority of waste from mussel farms are also plastic or a mixture of plastic and cotton materials. It is likely that there are many other types of wastes associated with mussel and oyster farming including undersized specimens and packaging, but insufficient data was identified for estimating the composition of this waste in a detailed fashion.

Landfill was considered to be the most likely destination for these wastes because aquaculture operations have access to waste management services – given that they utilize terrestrial processing/packaging/shipping facilities. The other main potential route for the

[145] Interview with Mac's Oysters, December 23rd, 2022.
[146] Online Video: *Aquadocs – Oyster Farm in British Columbia: Mac's Oysters*, Accessed December 23rd, 2022.
[147] Three businesses participating in value-retention operations for plastic EOL aquaculture and fishing operations in Canada were identified. None of these operations were found to accept or process ropes or socks from oyster or mussel farms.
[148] Canadian Aquaculture Industry Alliance Website, *Shellfish – Canadian Farmed Mussels*.

disposal of these wastes would be illegal dumping, quantification of which is not included within the scope of this study Therefore – given the paucity of data and the resulting requirement to use simplifying assumptions – it must be assumed that all aquaculture waste generated by shellfish operations in Canada is disposed of via landfilling. These figures are shown in the table below.[149]

Table 20: Shellfish Aquaculture Waste Disposed Annually in Canada

(tonnes)

Province	Shellfish Aquaculture Waste Sent to Landfill
NL	117.70
NS	42.14
PE	726.88
NB	77.02
QC	12.16
ON	42.15
MB	-
SK	-
AB	-
BC	278.44
Canada	1,254.31

Source: NRC and Cheminfo Estimates

3.3.2.2 Waste from Finfish Aquaculture Operations

Estimates on the waste generated by finfish aquaculture operations (section 4.2.2.4) divided waste into four categories: (i) marine cage collars; (ii) feeding pipes; (iii) cage nets; and (iv) ropes. The materials commonly used in these different wastes are as follows:

- marine cage collars – PVC;
- feeding pipes – PVC;
- cage nets – HDPE, nylon, PET;
- ropes – nylon, polypropylene, polyethylene.

Marine cage collars are essentially made of PVC tubing, and there is therefore no reason they would not be accepted at a landfill along with other PVC wastes. The same can be said of PVC feeding pipes – which are most likely disposed of along with other general

[149] There is a new condition of licence for annual seafloor clean-ups of shellfish facilities in British Columbia and the expected annual disposal weights are expected to rise exponentially as a result. The full impacts of this new policy cannot yet be quantified.

municipal solid waste generated at onshore aquaculture processing facilities. Netting, however, is not always accepted for landfilling across the country. Some of these nets can weigh more than 2,500 kilograms, and cover a substantial area. While landfills can at times accept them, operators generally prefer not to. Some landfills have indicated that they only accept the nets on the condition that the generator pays extra so that the netting can undergo "deep burial" – in order to prevent the netting from getting caught up in the tracks of the landfill compactors.[150] Other landfills have indicated that they accept the netting, but consider it a "nightmare" to handle,[151] and also practice deep burial when they receive the netting in order to limit the damage that the netting can do to the vehicles at the landfill.

Common practice in Canada is to find unoccupied sites or storage space and to simply stockpile the nets. There is currently no long-term plan for their management or disposal. Aquaculture rope is generally stockpiled along with aquaculture netting, as there is a significant amount of labour involved in separating the rope from the netting and no reason or purpose to undertake this labour unless the netting is being targeted for recycling.

Each of the four quantified waste-types are plastics, and therefore metal fishing and aquaculture value retention operations are irrelevant. Plastic value retention operations in Canada include:

- Ocean Legacy;
- Pacific Carpet Recycling;
- The FGCAC; and
- Sustane Technologies.

Ocean Legacy has collected 1.5 million pounds of fishing gear and mixed marine debris between April 2021 and March 2023. Given that they recover gear through diving for lost gear, beach cleanups, their EOL gear depots, and other sources, Ocean Legacy's activities cannot be included in the quantification of how aquaculture waste is managed in Canada. Sustane Technologies has processed 1-2 tonnes of rope as part of the initiative "'Tackling Ghost Gear: Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia" which received $432,000 in funding from the federal government's Sustainable Fisheries Solutions and Retrieval Support Contribution Program (SFSRSCP). It can therefore be assumed that 1.5 tonnes of rope in Nova Scotia (out of 29.05 tonnes of waste rope generated) was successfully processed into diesel. The FGCAC has sent north of 2,000 tonnes of gear (lobster traps and ropes) to be recycled either in Canada or to a recycler in Denmark. However, the break-down of how much of this waste was traps, how much was rope, and whether or not the EOL gear was gathered from fishers

[150] Interview with Pacific Carpet Recycling, October 18, 2022.
[151] Interview with Robinhood Bay Landfill, March 29, 2023.

or aquaculture operators was not available. Therefore, this data can also not be used to quantify how aquaculture waste is managed in Canada. Finally, Pacific Carpet Recycling (PAC) is a larger volume recycler of EOL fishing and aquaculture gear in Canada (at 450 tonnes – combined aquaculture netting and fishing nets). All of PAC's netting is retrieved in B.C., however they largely collect aquaculture netting from sites where it has been stockpiled as opposed to continuously being involved in the EOL gear collection process. As a result, PAC can be considered to be working at reducing the volume of stockpiled EOL aquaculture netting instead of reducing the volume of EOL aquaculture netting exiting the water each year and are therefore not considered in this analysis (there is no information available on the amount of EOL aquaculture netting currently deposited at various sites around B.C.). Given the above assumptions, the table below shows the disposition of aquaculture gear in the waste sector in Canada.

It should be noted that buoys, feed bags, and foam flotation are also materials that take up a lot of volume and make up an element of the waste stream from aquaculture facilities in Canada. However, these wastes were not quantified for this report.

Table 21: Fate of EOL Finfish Aquaculture Gear in Canada Annually Based on 2020 Production Statistics

(tonnes)

	Infrastructure item	Stockpiled	Landfilled	Value-Retention
NL[1]	Marine Cage Collars		9.0	36.1
	Feeding Pipes		5.2	
	Cage Nets	8.1	8.1	
	Ropes	9.7	9.7	
	Total	**17.7**	**31.9**	**36.1**
NS	Marine Cage Collars		67.8	
	Feeding Pipes		7.8	
	Cage Nets	24.2		
	Ropes	27.6		1.5
	Total	**51.8**	**75.5**	**1.5**
PE	Marine Cage Collars		3.6	
	Feeding Pipes		0.4	
	Cage Nets	1.3		
	Ropes	1.6		
	Total	**2.9**	**4.0**	**0**
NB	Marine Cage Collars		109.4	
	Feeding Pipes		12.5	
	Cage Nets	39.1		
	Ropes	46.9		
	Total	**86.0**	**121.9**	**0**
QC	Marine Cage Collars		4.0	
	Feeding Pipes		0.5	
	Cage Nets	1.4		
	Ropes	1.7		
	Total	**3.1**	**4.5**	**0**

	Infrastructure item	Stockpiled	Landfilled	Value-Retention
ON	Marine Cage Collars		3.1	
	Feeding Pipes		0.4	
	Cage Nets	1.1		
	Ropes	1.3		
	Total	**2.4**	**3.5**	**0**
MB	x	x	x	x
SK	x	x	x	x
AB	x	x	x	x
BC	Marine Cage Collars		541.97	
	Feeding Pipes		61.94	
	Cage Nets	193.6		
	Ropes	232.3		
	Total	**425.8**	**603.9**	**0.0**
Canada	Marine Cage Collars		815.0	
	Feeding Pipes		93.1	
	Cage Nets	291.1		
	Ropes	347.8		
	Total	**638.9**	**908.2**	**1.5**

Source: NRC and Cheminfo Estimates

[1]: Jonathan Kawaja, Environmental Scientist at the Department of Fisheries, Forestry, and Agriculture in Newfoundland and Labrador, provided alternative means for estimating the division of aquaculture waste into the stockpiling, landfilling, and value retention categories. His figures have been used here in place of those used for the other jurisdictions.

3.4 Value Recovery Infrastructure in Canada for End-of-Life Fishing and Aquaculture Gear

3.4.1 Value Retention Operations for End-of-Life Metal Fishing and Aquaculture Gear

The primary EOL fishing and aquaculture gear made of metal are lobster traps and crab traps. Lobster and crab traps are typically constructed of steel which can either be stainless (where chromium is added to molten steel) or galvanized (where a zinc coating is applied to the steel), both of which are designed to reduce corrosion of the steel. In addition, a coating of polyvinyl chloride resin can be applied to provide further resistance to seawater corrosion.

There is a well-established metal recycling industry in all of the key provinces where lobsters/crabs are caught, specifically all of Atlantic Canada, Québec and British Columbia Metal recyclers do not specialize in specific types of scrap metal and therefore they will collect/accept a wide variety of metal scrap (including lobster and crab traps) and metals (i.e., both ferrous and non-ferrous metals). Lobster and crab traps will represent a very small percentage of the scrap metal that these facilities collect/process annually, with much larger scrap metal quantities being generated by EOL automobiles, EOL home appliances, construction, renovation and demolition debris, etc.

Scrap metal shredders are used to reduce the size of scrap metal into manageable, transportable pieces with the major commercial shredders in Canada being able to shred items like automobiles and home appliances. Shredded material is separated into ferrous and non-ferrous material using magnets before being carried along conveyor belts and eventually being separated into two separate piles for further sorting.[152]

Provided in the table below is an identification of the key metal shredders for lobster and crab traps in Canada. There may also be other shredders in Québec that accept lobster and crab traps. Several of these companies were contacted to obtain information on the quantity of lobster and crab traps that they receive/process annually. However, these facilities accept a wide range of scrap metal and typically do not document the different types of scrap metal that they receive annually.

[152] Morecambe Metals (undated), *How do Scrap Metal Shredders Work?*

Table 22: Key Metal Shredders Accepting Lobster/Crab Traps

Company	Location	Require Concrete Ballasts and Netting Removed	Notes on Annual Quantities
Richmond Steel Recycling	Richmond, BC	No	<10
AIM Recycling	Saint John, NB	No	
John Ross & Sons	Halifax, NS	No	
Dartmouth Metals	Dartmouth, NS	Yes	
A&S Scrap Metal	Charlottetown, PE	Yes	
Newco Metal	St. John's, NL	No	Do not track[1]

[1] They have no information on the number of metal traps collected. Metal traps are accepted at Newco locations, regional waste management sites, and municipalities throughout the province. At those locations, the metal traps are dropped off with other scrap metal at the numerous sites with no accounting for the different types of metal scrap collected. They accept metal traps as regular scrap metal. Lobster/crab traps are never separated into a distinct waste stream prior to being fed into the shredder.

Sources:

- Separate reports on "End-of-Life Fishing Gear Management" in each of the four Atlantic Canada provinces as developed by the Fishing Gear Coalition of Atlantic Canada.
- Consultations with the above metal recyclers.

It is important to note that work conducted by the Fishing Gear Coalition of Atlantic Canada[153] has indicated that there are metal recyclers in the Atlantic Canada provinces that have the capacity to accept and process all EOL metal lobster and crab traps generated in these provinces annually. This is also likely the reality in British Columbia and Québec. Therefore, the key issue with respect to lobster and crab traps is not capacity, but cost-effectively transporting these traps to locations where metal recyclers can collect them. This includes not only transportation costs but also tipping fees charged at waste resource management facilities, where ideally traps will be set aside for collection. Due to these tipping fees, lobster and crab traps are often stockpiled by owners instead of potentially entering the recycling system.

However, there are also inconsistencies with respect to waste resource management facilities in the Atlantic Canada provinces accepting metal traps with non-metal material (e.g., concrete ballasts and plastic netting) still attached. While some waste resource management facilities will set aside these traps for recycling, other waste resource management facilities will only set traps aside for recycling if the ballasts and other materials are removed. Traps not set aside are landfilled. There is also variability in whether metal recyclers in the Atlantic Canada provinces will accept lobster and crab traps with concrete ballasts and plastic netting.

[153] Separate reports on "End-of-Life Fishing Gear Management" in each of the four Atlantic Canada provinces.

AIM Recycling worked with the Fishing Gear Coalition of Atlantic Canada on a collection program for lobster traps. This partnership started in the spring of 2021 and ended in March 2022. This partnership resulted in the removal of 5,400 wire lobster traps from private and personal properties in Nova Scotia and 340,000 wire lobster traps from properties in Grand Manan New Brunswick. AIM also has a partnership with the Fundy North Fisherman's Association and removed ~7,000 wire traps between April 1, 2021 and March 31, 2022 for them from the Bay of Fundy side of New Brunswick.[154] Prior to these partnerships, AIM was not collecting many lobster traps in Nova Scotia and the majority of fishers in New Brunswick were stockpiling their traps on personal property (as many municipal landfills in the province do not accept wire traps).[155]

Ross and Sons did not record the volume of wire traps that they have accepted for recycling over the last few years. The company indicated that the landfills that they work with require them to accept wire traps for recycling as part of bids they submit to access metals stockpiled at landfills. Given the choice, wire traps reportedly offer little in the way of recoverable metal (and contain significant quantities of rope and concrete) and the company would prefer not to take them – the traps represent a cost that brings down the overall value of metal that they bid for from landfills. Fortunately, overall, it still makes economic sense for the company to bid on landfill steel due to the value of the remainder of the steel up for bid. Ross and Sons indicated that shredder mills can get jammed up with rope and concrete at times if they are not blended with other materials, which potentially adds to the cost of processing these traps for recycling via equipment damage. Ross and Sons also indicated that transporting the lobster traps from landfills to their shredding site is inefficient and therefore they bring a baler to the landfill site in order to "cube" the lobster traps before transport.[156]

3.4.2 Value Retention Operations for End-of-Life Plastic Fishing and Aquaculture Gear

There are very few companies in Canada accepting EOL plastic fishing and aquaculture gear into their value retention processes. Major EOL plastic fishing and aquaculture gear includes rope (typically made of polypropylene, polyethylene, polyethylene terephthalate or nylon and sometimes combinations of these plastics) and net (typically made of nylon). This rope and net have often been exposed to the ocean environment and are therefore contaminated (e.g., with salt water and marine life). In addition, plastic aquaculture gear

[154] Interview with the Fishing Gear Coalition of Atlantic Canada, October 17, 2022.
[155] Interview with AIM Recycling, October 17, 2022.
[156] Interview with Ross and Sons, October 31, 2022.

often has anti-fouling coatings (often containing copper of zinc compounds) applied which can pose additional problems within these value retention processes.

Outlined in the table below are the facilities in Canada that have some form of value retention process for EOL plastic fishing and aquaculture gear. As can be seen in the table, there are very few of these companies that exist in Canada at present and even within these companies, there have been multiple problems associated with the use of EOL rope and nets. Subsequent to the table, profiles of these companies have been provided. In addition, a final section outlines some other companies that have been actively analyzing value retention process for EOL plastic fishing and aquaculture gear or have recently ceased operations.

Table 23: Companies with Value Retention Processes for EOL Plastic Fishing and Aquaculture Gear

Company	Location	EOL Plastic Fishing Gear Accepted	Annual Quantities (tonnes)
Pacific Carpet Recycling	Vancouver, BC	Nylon net	~450
Sustane Technologies	Chester, NS	Rope	1-2 (testing)
Ocean Legacy	Richmond, BC	Oyster baskets, crab pots, foam floats, hard plastic buoys, netting, rope, tires with styrofoam, and hard plastic/fragments, tires, and styrofoam	No annual data, but has collected ~680 tonnes between April 2021 and March 2023.

Source: Cheminfo Services.

3.4.2.1 Pacific Carpet Recycling

Pacific Carpet Recycling (PAC) has been recycling nylon carpets for many years. The company began investigating the recycling of nylon netting over the last few years. PAC targeted EOL aquaculture netting due to large stockpiles of netting being available that represent an ongoing cost to the owners of the netting. This netting has no clear path to final disposal or recycling outside of PAC, and is often being stored indefinitely. PAC has partnered with an aquaculture netting supplier, Steveston Harbour, and a nylon recycler/pelletizer in the U.S. to recycle ~1 million pounds (453 tonnes) of netting in 2021 and ~500,000 pounds (227 tonnes) of netting in 2022.

Steveston Harbour Authority acquires nets from the commercial fishing operations that use the harbour by offering to manage the netting for free. The Authority pays fisherman to dismantle the netting and clean it – removing everything but the nylon-6 netting. PAC collects this from Steveston Harbour for recycling. At this time, Steveston Harbour Authority stores the netting in warehouses near the harbour and has no long-term disposal or recycling plans for the netting aside from PAC. They have had other recycling partners in the past, but these opportunities are not available at this time.

PAC also collects aquaculture netting from one of the three major aquaculture netting suppliers in British Columbia. This supplier typically cleans and repairs netting for aquaculture operators so that it can be reused. This involves stripping the netting of rope and other components, cleaning growth and copper-based antifouling compounds off of the netting, repairing any holes if possible, and re-coating the netting with an anti-fouling compound. If the netting has damage that cannot be repaired, the aquaculture netting will be retired. As with fishing nets, there is no long-term management solution for this netting. Currently, the same net manufacturers that sell and repair aquaculture netting are renting large tracts of low-value land in remote areas and stockpiling EOL aquaculture netting in these tracts – charging aquaculture businesses a storage fee.[157] EOL netting is accumulating in these relatively unmanaged dumps with no long-term plans for the proper management or recycling of the netting. PAC saw this practice as an opportunity.

PAC pays the aquaculture company to process the netting for them (cleaning the netting and removing rope and other contaminants), and shreds the netting and further cleans it before sending the shred to their U.S. recycling partner. The U.S. recycler uses the netting to manufacture auto-parts, blending pellets from EOL netting with virgin resin in order to make a product of acceptable quality.

[157] Interview with Pacific Carpet Recycling, October 18, 2022.

PAC has investigated trying to recycle the rope along with the nylon netting, but upon sending samples of the rope to laboratories, realized that there are four different kinds of plastics within a single length of rope and that they are tightly bound together – making recycling very difficult. As a result, PAC has limited their recycling efforts to the netting specifically and is not recycling any rope or any other EOL fishing or aquaculture gear. PAC indicated that a significant proportion of the overall EOL fishing and aquaculture gear generated each year in British Columbia is EOL nylon netting.

Throughout the process of finding ways to recycle aquaculture netting, PAC has served as an organizer central to the process. Steveston Harbour Authority and the aquaculture netting company that they work with collect and prepare netting, PAC works to shred and prepare it for recycling, and the pelletizing is done in the U.S. Everywhere along this supply chain adjustments have needed to be made. The anti-fouling coating on the netting and/or organics built up on the netting rendered pellets unusable (due to a high ash content). As a result, PAC worked with collectors in the process to ensure that the nets were as clean as possible. The U.S. recycler was still having trouble processing the netting, and PAC needed to adjust their shredding process until an ideal shred could be realized for the recycler to process into pellets of acceptable quality. The U.S. recycler PAC works with has been fine-tuning the process of making pellets of acceptable quality from this netting for three years, and PAC and the collection network have had to make adjustments along with the recycler to ensure useable pellets with a low ash content. This process of working with stakeholders throughout the reverse supply chain to manufacture a product of acceptable quality simply takes time and represents the major bottleneck in getting more EOL fishing and aquaculture gear recycled each year (there is plenty of available netting sitting in unmanaged storage sites). PAC has recently begun working with another recycler in order to expand capacity for net recycling, but given the three-year process PAC has undergone with their first recycling partner, it is expected that this new partner may not be recycling significant quantities of netting in the near future.

3.4.2.2 Sustane Technologies

Sustane Technologies (Chester, NS) operation has been built to transform 70,000 tonnes of municipal solid waste (MSW) (from the District of the Municipality of Chester, NS) per year into biomass pellets (for energy production), synthetic diesel fuel and recyclable metals.[158] Sustane's technology involves a series of low-temperature and low-pressure processes that separate MSW into purified streams. The first step in the process is a large industrial shredder to bring the material to size – roughly four-inch minus. That material is then conveyed to Sustane's proprietary system, which, through a unique process, conditions the material for separation. The de-bonded waste then goes through a series of 14 points of separation and screening to isolate material for the various product streams. A near-infrared scanner ensures the material has separated and forwards any off-grade material through a reprocessing centre. Roughly 20% of their MSW feedstock is plastic which is cleaned and taken through a pyrolysis system that converts it into a synthetic diesel.[159] Sustane's process generates two grades of diesel - Number 1 fuel, also known as kerosene or jet fuel, and Number 2 diesel. The Number 2 fuel is available for use by industrial customers as a low-sulphur light heating oil, and will eventually qualify for use as a marine and road transportation diesel.[160] In May 2020 Sustane took over the commissioning of the pyrolysis process from the supplier. The Chester facility had a target to be commercially operational in the late spring or early summer of 2021.[161]

Sustane Technologies was part of the initiative "'Tackling Ghost Gear: Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia" which received $432,000 in funding from the federal government's Sustainable Fisheries Solutions and Retrieval Support Contribution Program (SFSRSCP). The project, led by the conservation group Coastal Action, ran from July 2020 to March 2022. The project worked collaboratively with industry, academia, and government to prevent, reduce, and assess impacts of ALD fishing gear in Lobster Fishing Areas (LFAs) 33 and 34 on the South Shore and Southwestern Nova Scotia and in LFA 35 in the Bay of Fundy, Nova Scotia side. As part of this project, 10 small craft harbours in the three LFAs were equipped with rope collection bins. There were also 159 gear retrieval days in the three LFAs using grapples diverting approximately 2,000 lobster traps and 22 tonnes of rope from disposal. Sustane Technologies contribution to this project was to recycle the

[158] Accessed at the website of Sustane Technologies (https://sustanetech.com/).
[159] Church, M. (2020), Garbage Gold: Sustane Converts Curbside Waste into High-Value Biomass Products, published in Canadian Biomass.
[160] Accessed at the website of Sustane Technologies (https://sustanetech.com/).
[161] Morrison Hershfield (2020), *Sustane Technologies Chester Facility – Status Update*, prepared for Comox Strathcona Waste Management.

collected rope into diesel fuel.[162] An objective of 3-4 tonnes of rope being converted into diesel fuel had been established. [163]

To date, a nominal amount of EOL plastic fishing gear has been used as feedstock at the Sustane Technologies facility in Chester, NS – estimated at approximately 1-2 tonnes. The EOL fishing gear that has been used to date has been fishing rope – no fishing nets have been used so far. The EOL fishing rope has been blended into the raw material mix with other EOL plastics, typically from the MSW stream. The vast majority of the fishing rope that has been used by Sustane Technologies originated from the project led by Coastal Action which established fishing rope collection bins at 10 harbours in Nova Scotia. As part of this project, Sustane indicated that they would accept a maximum of 3-4 tonnes of EOL fishing rope, however ended up accepting in the vicinity of 1-2 tonnes. Sustane indicated that a small amount of fishing rope has also been accepted from another source.[164] The shredding of this EOL fishing rope actually occurred at Goodwood Plastic Products (see below) and not at the Sustane Technologies facilities, as Goodwood had an operating high-capacity shredder.[165]

There are a number of issues associated with the use of EOL fishing rope at the Sustane facility:[166]

- There is concern over the potential of chlorine/chloride emissions from the plant associated with the salt contained within the fishing rope. The Sustane facility has an operating permit that has established chlorine/chloride emission limits that cannot be exceeded. Therefore, there is a requirement to clean the rope prior to its use as feedstock at the facility. This cleaning includes the application of water via a high-pressure washer as well as leaving the rope exposed to the elements (i.e., sun/rainwater) which will have the effect of reducing the chloride content within the rope. Tests may also have to be undertaken on the rope prior to entering the system to ensure that the chloride content has been reduced to an acceptable level. Also, the rope would have to be blended with other plastics and not used as a pure waste stream as this would have a much higher potential of increasing emission beyond the established emission limits in the operating permit. There is also the potential of increased chlorine/chloride content in the actual diesel that is produced, however this is viewed as less of a concern versus exceeding operating permit emission limits. There also could be a lead core to the rope

[162] Johnson, K. (2020), Ghost Gear Fishing Project First of its Kind in Nova Scotia, published by Saltwire.
[163] Fishing Gear Coalition of Atlantic Canada (undated), Fate of ALDFG Knowledge in Canada.
[164] Interview with Sustane Technologies (October 20th, 2022).
[165] James, Dr. Lesley et. al. (2022), *Recycling Solutions for End-of-Life Fishing Rope in Newfoundland*, prepared for The Leslie Harris Centre of Regional Policy and Development, Memorial University.
[166] Interview with Sustane Technologies (October 20th, 2022).

in order to assist the rope sinking to the bottom of the ocean during its active life – this core could also pose a problem.

- The rope tends to tangle and risks clogging the shredder and other machinery within the facility. As a result, the rope needs to be processed prior to entering the system as raw material. This processing involves cutting the rope into smaller pieces/chunks that reduces the likelihood of the rope creating problems within the production process. In addition, after cutting into smaller pieces, the rope can only be fed into the shredder slowly. This poses problems for Sustane with the shredder that is currently operating at the facility. A new shredder that is purchased specifically to address fibrous material such as rope has the potential to reduce/eliminate this problem.
- Polypropylene and polyethylene are the best plastics to use as feedstock in order to produce diesel. However, EOL fishing rope is not necessarily made up of these two plastics as it often contains nylon and PET, in addition to polypropylene – and potentially no polyethylene. The quality of diesel produced using nylon (and potentially PET) is not as good as when polypropylene and/or polyethylene are used.

Sustane Technologies is considering purchasing equipment specifically to be able to address the issues associated with utilizing EOL fishing rope in their process. This new equipment would consist of the following:[167]

- A new shredder that would be better able to handle the fishing rope so that it does not become tangled within the shredder and other equipment. This could reduce or even eliminate the pre-processing of the fishing rope prior to entering the system. They are currently investigating the best shredder in Europe that could be employed at Sustane for EOL fishing rope. The current shredder at Sustane is not equipped to handle EOL fishing rope (or flexible plastics in general such as plastic wrap). A new shredder would not be needed for the current range of MSW plastics that are being used as raw material for their pyrolysis process – it would be needed for EOL fishing gear as well as other types of post-consumer plastics not currently used by Sustane.
- An agglomerater which would turn the shredded rope into balls of plastic. This is necessary as the experience to date is that shredded rope is much more difficult to move through the process than the MSW plastics that they are using otherwise. Plastics that are in a rigid form and much easier to move through the operating system at Sustane versus flexible plastics like EOL fishing rope and nets. The agglomerater would make it easier to move the shredded EOL fishing rope to storage bins and hoppers and other systems throughout the plant.

Fishing nets are likely even more problematic than EOL fishing rope for use within the Sustane Technologies facility. This is due to the fact that fishing nets will likely be even

[167] Interview with Sustane Technologies (October 20th, 2022).

more difficult in terms of gumming up the shredder and other equipment. In addition, fishing nets are typically made entirely of nylon, which Sustane has indicated is not a very good feedstock for producing diesel. The inherent properties of the nylon results in the diesel produced with this nylon having properties that are not nearly as favourable versus what is achieved when polyethylene and/or polypropylene are used as feedstock. The experience with nylon by Sustane Technologies has been through the testing of nylon waste generated by the food manufacturing industry. They have not actually tested EOL fishing nets. Sustane indicated that a small percentage of nylon nets could potentially be used at their facility.[168]

In order to use greater quantities of EOL fishing rope, they would need to run larger trials and conduct stringent testing of the chloride input and chlorine/chloride emissions to ensure that their emission limits will not be exceeded. This would need to be completed with favourable results prior to investing in the equipment outlined above which would be needed to facilitate the use of the EOL fishing rope. At present, Sustane has a capacity to run 10-11 tonnes of post-consumer plastic through their process daily, which is largely made up on MSW plastic which has proven to result in the production of diesel with favourable properties. As a result, their capacity is already largely taken up. Therefore, at present Sustane does not see the use of EOL fishing rope (or nets) as a core business of theirs. They would need to be comfortable with the feedstock prior to accepting much larger quantities. Also, the Chester facility would have to expand capacity for their plastic to diesel pyrolysis process in order for them to accept EOL fishing gear in much larger quantities. Sustane is considering expanding the capacity of the Chester plant to turn plastic into diesel. They are also close to putting another Sustane plant at an undisclosed location in British Columbia, as several communities in British Columbia are quite interested in the technology.[169]

Sustane is paid a tipping fee to accept MSW at present, which is $60/tonne, including by the Regional Municipality of Halifax. This is a less expensive option than landfilling the material, with the tipping fees for landfills in the area generally in the $80-90/tonne range. As a result, Sustane would require a tipping fee to receive large quantities of EOL plastic fishing gear to offset the tipping fee that they would not get by replacing the MSW for EOL fishing gear within their system.[170]

[168] Interview with Sustane Technologies (October 20th, 2022).
[169] Interview with Sustane Technologies (October 20th, 2022).
[170] Interview with Sustane Technologies (October 20th, 2022).

3.4.2.3 Ocean Legacy

The Ocean Legacy Foundation (OLF) is a Canadian based non-profit organization that was founded in 2013 with the goal to end ocean plastic waste.[171] They have established five British Columbia depots that accept end-of-life plastic fishing and aquaculture gear and equipment in Ucluelet, qathet, 7 Mile, Cumberland, and Powell River. They are working to establish another depot in Tofino later this year.

Aside from establishing depots to accept this equipment, Ocean Legacy has also established a recycling program via their subsidiary Legacy Plastic. Ocean Legacy also organises beach cleanups, works with aquaculture operations to recycle their netting, and recovers legacy plastics directly from the oceans. No publicly available information on the volume of plastic that has been processed into pellets by Legacy Plastics has as of yet been identified, but they offer three grades of plastic pellets that can be processed into new products: (i) marine gear; (ii) shoreline; and (iii) ocean recovered. The marine gear pellets are produced entirely from end-of-life aquaculture gear from aquaculture operations along the pacific coast, shoreline plastic is derived from plastics recovered during shore cleanup operations, and ocean recovered plastic is legacy equipment that has been recovered via recovery expeditions.

Ocean Legacy has recovered approximately 1.5 million pounds (~680 tonnes) of EOL fishing and aquaculture gear and mixed waste since April 2021 – though the amount that of that which has been successfully recycled is currently unknown. The following graphic shows the types of waste that Ocean Legacy accepts at their depots.

[171] Ocean Legacy Website, *About*.

Figure 1: Materials Accepted at Ocean Legacy Depots

Source: Ocean Legacy Website

3.4.2.4 Other Companies

A few other companies that may have been recycling or have investigated recycling marine plastics in Canada are listed below.[172]

- Goodwood Plastic Products (Stewiacke, NS) were utilizing fishing rope and net to produce recycled plastic lumber. They were using 50% virgin HDPE and 50% recycled material. They needed the 50% virgin HDPE in order to produce boards of an acceptable quality. However, they recently ceased operating their recycled plastic lumber business. They needed to invest in a wash line to make their business more viable via increasing the percentage of recycled material that could be used in their lumber, but ultimately decided to close this aspect of their business instead.[173]
- Reused Plastic, based in Nova Scotia, plans to convert industrial plastic waste into plastic sheets. Currently, they are not able to accept EOL rope, however they are interested in adding this in the future.
- PLAEX Building System Inc. (New Brunswick) is a recently founded company that is building construction materials from almost exclusively recycled waste materials (90%+). This company is developing a process to manufacture building material mostly from plastic material from the fishing and farming industry in Atlantic Canada. Their product dubbed "PLAEX Bricks" are a zero waste, mortarless, modular construction block system. The plastic materials that are possible to recycle for their product are PE (high and low density), PP, nylon, and PET. The key advantage of PLAEX is that they do not require the plastics to be thoroughly cleaned and the only pre-processing needed is shredding. After shredding, the plastic is combined with a dry mix in a mixer (just like a concrete mixer), the combination then moves to an extruding machine that can handle the mix. The material is melted together and extruded into a mold to cool. The company is currently setting up their supply chain under EPR programs, and have started planning a project in NL, partnering with a non-profit and schools. For the company to accept EOL fishing rope as a feedstock for their process, they require the rope to be shredded (8 mm or less) with no decontamination (heavy washing) required. The company does not have a shredder yet but are looking on the market for potential opportunities
- Drastic Plastic and Fundy Plastics have been noted in some news articles as being involved in recycling marine plastic, however very little information about these businesses is publicly available and it is unclear if they are currently still operating or if they are recycling significant quantities of plastic.[174]

[172] James, Dr. Lesley et. al. (2022), *Recycling Solutions for End-of-Life Fishing Rope in Newfoundland*, prepared for The Leslie Harris Centre of Regional Policy and Development, Memorial University
[173] Interview with Enviroculture, November 29, 2022.
[174] CBC News, (2018), *More Than 3 Tonnes of Rope Collected in Wharf Recycling Bins*.

4. Best Work Practices for the Management of EOL Fishing/Aquaculture Gear

4.1 Introduction

Outlined in this chapter are best work practices for the management of EOL fishing and aquaculture gear. There are three groups that the best work practices are focused on, specifically: (i) fishing and aquaculture gear manufacturers; (ii) aquaculture and fishing operations; and (iii) harbour and port operations. Tables 5.1-5.3 describe specific work practices that can be taken by each of the groups identified.

Chapter 6 - Policy Options for End-of-Life Fishing and Aquaculture Gear focuses on what measures and initiatives government agencies in Canada can implement to improve the management of EOL fishing and aquaculture gear.

It is important to note that the scope of the work practices outlined in this chapter are restricted to the generation, collection and management of EOL fishing and aquaculture gear. There are many additional work practices that can be applied to reduce and eliminate the loss of fishing and aquaculture gear into waterbodies as well as the subsequent collection of that gear. Those best practices may be mentioned within the work practices below but are largely outside the scope of this report. Instead, the focus of this report is on policies and work practices that impact how the gear that arrives at harbours or port reception facilities can be received, collected, sorted, deconstructed by material, and sent to recyclers or otherwise responsibly disposed of instead of released to the environment or stored indefinitely.

4.2 Best Work Practice Tables

Three tables are provided below that show best work practices focused on specifically: (i) fishing and aquaculture gear manufacturers; (ii) aquaculture and fishing operations; and (iii) harbour and port operations.

Table 24: Best Work Practices for Fishing and Aquaculture Gear Manufacturers

Best Work Practice	Description
Use Materials/Components in Production that are Easy to Reuse and/or Recycle	• Consider reuse and recycling early in the design stage for gear. For instance, avoid mixing of different materials in gear/equipment design that inhibits their recyclability. If at all possible, do not combine different polymers in the production of gear (e.g., rope). • Ensure components are easy to disassemble into different recycling streams. In particular, ensure components made of different plastic types are easily separable for disassembly and recycling. • Use recyclable plastics and other materials where possible. • Produce materials that have a high value at their EOL to increase demand for recycling. • Ensure materials resist fouling to reduce pre-recycling preparation.
Use Materials/Components that are Less Harmful to the Marine Environment/Wildlife	• Reduce the use of potentially damaging material (e.g., for aquaculture gear, reduce the use of expanded polystyrene (EPS) or other similar materials that break up and abrade when released into the environment). • If EPS or other friable materials are to be used, implement restrictions such as their being fully encased in a rigid, durable, non-toxic shell such as thick HDPE.
Use Biodegradable Materials	• Consider developing fishing gear and aquaculture equipment that have biodegradable components. Ensure any biodegradable components truly degrade in marine conditions rather than simply breaking down into harmful microplastics.
Ensure Traceability of Different Polymers in Gear	• Provide easily accessible information on the materials used in fishing and aquaculture gear so that when gear is brought in for management it can be identified and the materials used within the gear can be recycled (once cleaned and separated/sorted). • Utilize tagging or markings that include scannable codes or other methods to look up detailed information on the product (provided online by the manufacturer) so that those facilities that wish to deconstruct and material-sort incoming gear will have easy access to all of the information they need to ensure that the gear is appropriately recycled.
Establish Training Programs	• Increase/develop technical training for fishing and aquaculture operations to foster reuse, recycling or responsible disposal.
Incorporate Costs of EOL Management of Gear into the Price	• Build in the responsibility and costs for the recovery, recycling or otherwise responsible disposal of EOL fishing/aquaculture gear and equipment (e.g., reuse, buyback or recycling program).

Best Work Practice	Description
Contribute to the Establishment of Cleaning and Deconstruction Facilities at or Near Harbours and Ports and Help Establish New Reverse Supply Chains	• Successful recycling programs for EOL fishing and aquaculture gear have often included specialized facilities that have the equipment and the know-how to both clean and then disassemble various gear into their constituent components so that they can be sent for recycling. Fishing/aquaculture gear manufacturers could: o Seek partnerships with ports, harbours, or other stakeholders to provide equipment, training, and information on how to appropriately deconstruct and sort gear for recycling. o Seek relationships with recyclers that process the materials that are contained in their products and seek to connect EOL gear managers and potential deconstruction/cleaning facilities with recyclers that can manage their materials streams. o Work with these recyclers to determine the cleaning requirements and processing requirements that may be needed in order to appropriately recycle the materials contained in the gear so that new recycling solutions are established.

Sources:

- Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
- Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Fishing Gear*, prepared for the Global Ghost Gear Initiative.
- Aqua-Lit (2020), *Best Practice Factsheets*.
- Huntington, T (2019). *Marine Litter and Aquaculture Gear – White Paper*. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council.
- Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.
- East Coast Shellfish Growers Association (2010), *Best Management Practices for the East Coast Shellfish Aquaculture Industry*.
- North Carolina Coastal Federation et. al. (2019), *Prevention of Marine Debris from Shellfish Mariculture – Best Management Practices for North Carolina Producers*.
- Hipólito, C., et. al. (2020), *Policy Recommendations to Tackle Aquaculture Debris*.
- Devriese L., et. al. (2019), *Available Tools and Measures. Knowledge Wave on Marine Litter From the Aquaculture Sector*.

Table 25: Best Work Practices for Fishing and Aquaculture Operations

Best Work Practice	Description
Provide Safe and Secure Collection of EOL fishing and aquaculture Gear and Supporting Equipment	• Considerable plastic and other waste might be generated by aquaculture operations, including feeds sacks, plastic wrapped consumables, cover netting, disposable equipment (e.g., plastic gloves) and personal litter. These different waste streams need to be disposed of responsibly, requiring safe and secure waste collection (e.g., not vulnerable to informal waste pickers or being blown away by high winds). The easiest action for aquaculture operations to take is to bring a trash container to the site on each trip. Simply having somewhere to put trash will decrease the opportunities for items to fall in the water and ensure that they can be reused, recycled or disposed of on land. It is also prudent to ensure that the local landfill or waste facility is prepared to handle disposal of aquaculture gear. • There should be recurrent litter collection within and outside the aquaculture site to clear and responsibly dispose of any items lost during routine operations or when such materials are removed during maintenance or harvesting or become dislodged during storm events. For instance, ensure that any plastic or other waste materials generated by routine maintenance (e.g., net washing) are captured before they can reach the natural environment. • To the extent possible EOL fishing gear should be collected and stored on-board fishing vessels for collection/disposal/recycling at port reception facilities or linked waste management facilities. • Fishing operations should organize retrieval days to facilitate the retrieval of ALD fishing gear – planned outside active fishing seasons to avoid interfering with any active fisheries. ○ These days and any retrieval operations will need to follow DFO requirements that may vary by region. • Biofouling of fishing and aquaculture gear can cause very bad odours and contamination – depending upon the disposal situation at waste management facilities it could be important to clean this gear before disposal. • Connections with other fishing operations, local harvesters, and other related small businesses should be made in order to maximize the amount of cleaned fishing gear that might be repaired and reused by local businesses. • When collecting and storing ALD fishing gear or EOL fishing gear on a vessel so that it may be brought in for management at a port reception facility (PRF) try and keep the materials separated so that the waste can be managed by material upon return to the PRF.
Careful Selection of Fishing and Aquaculture Gear and Management	• Avoid the use of small, light plastic items that are prone to be lost in windy or other challenging environments. • Practice preventative maintenance where plastic and other components are replaced: (i) before the risk of failure starts to increase; and (ii) before the component is so damaged by environmental conditions (e.g., UV light, salt, etc.) that recycling is no longer technically or economically possible. • Use alternative products with a longer lifespan in order to reduce the generation of waste. For instance, maximize the reuse of plastics by purchasing high specification items rather than cheap single use alternatives. • Reduce packaging as much as possible and source it from sustainable sources (recycled steel, biodegradable plastics, sustainable forest products).

Best Work Practice	Description
	• Reuse or recycle feed packaging and other containers and packages by means of third parties that might be interested in these. For instance, reuse of the certain bags for non-food use that are made of resistant materials that can be reused for new purposes different of their original use. In addition, small feedbags can be used as waste bags reducing the need to buy them. • Avoid needless waste, such as excessive binding or ropes. • Establish limits for certain types of fishing gear – such as limiting lengths of gillnet fleets, trap strings, etc. to increase control of fishing gear and reduce damage or losses. • Good communication with other fishing operations to reduce gear loss from conflicts, sharing seabed and current mapping to reduce snagging and subsequent gear loss.
Tracking, Inventory and Planning of Fishing and Aquaculture Gear, Particularly for Plastics	• Obtain information on what plastics are used and in what components, to assist with sorting, recycling and disposal. Ideally this would include establishing an appropriate in/out inventory system for all key plastic components to track all plastics and their status on-site. Provide information on plastic types (polymers and products/components), approximate volumes/weights, installation date, expected lifetime and anticipated replacement date, location on farm and records of disposal. Connect this inventory system to an equipment labelling/tagging program. • Marking the position, nature and extent of fishing gear will help avoid conflicts with other fishing operations and aid in collection.
Establish Corporate Policies for the Management of EOL Fishing and Aquaculture Gear, in Particular Plastics	• Develop corporate policies/plans for: (i) the management of solid, nonbiological waste, with a particular focus on plastics and other persistent materials – focusing on reuse and recycling where possible; (ii) the minimization of the use of single use plastics in aquaculture farming operations; (iii) the monitoring of waste management effectiveness at farm/organizational levels; and (iv) decommissioning plans for farm sites that are closing down, to ensure that all plastic elements are disposed of responsibly (e.g., sold to other businesses, recycled, etc.). • Organize and fund local aquatic debris cleanup programs as part of a corporate social responsibility strategy. • Have larger companies consider working with aquaculture/fishing small-medium enterprises (SMEs) to collect recyclable and other waste and add that waste to their own managed waste streams. • Engage with equipment suppliers to maximize the use of recyclable plastics in aquaculture equipment. • Partner with recycling companies (e.g., Pacific Carpet Recycling in Vancouver, BC) and other aquaculture operators to dispose of gear that can be recycled in larger batches to have an economy of scale. • Repair nets and gear instead of throwing them away or find new uses for old nets and gear. • Engage in cleaning and materials separation practices for EOL gear – either through the establishment of cleaning and deconstruction facilities for this purpose or in cooperation with ports or harbours.
Provide Adequate Training to Staff	• There should be training and awareness building amongst management and staff to manage facilities and vessels so that plastic use is minimized, losses are reduced, and EOL plastics are recycled where possible. This would include developing management and staff awareness/training to: (i) promote better practices; (ii) the need to reuse equipment (rather than replacing from new) and fittings; and (iii) reduce and prevent marine litter from aquaculture/fishing operations.

Sources:

- Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
- Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Fishing Gear*, prepared for the Global Ghost Gear Initiative.
- Aqua-Lit (2020), *Best Practice Factsheets*.
- Huntington, T (2019). *Marine Litter and Aquaculture Gear – White Paper*. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council.
- Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.
- East Coast Shellfish Growers Association (2010), *Best Management Practices for the East Coast Shellfish Aquaculture Industry*.
- North Carolina Coastal Federation et. al. (2019), *Prevention of Marine Debris from Shellfish Mariculture – Best Management Practices for North Carolina Producers*.
- Hipólito, C., et. al. (2020), *Policy Recommendations to Tackle Aquaculture Debris*.
- Devriese L., et. al. (2019), *Available Tools and Measures. Knowledge Wave on Marine Litter From the Aquaculture Sector*.
- Fishing Gear Coalition of Atlantic Canada, (2022), *Best Management Practice Guide for Managing Abandoned, Lost, and Discarded Fishing and Aquaculture Gear*.

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Table 26: Best Work Practices for Harbour and Port Operations or Other Entities Collecting EOL Fishing and Aquaculture Gear

Best Work Practice	Description
Provide Facilities for the Landing, Temporary Storage, Sorting, Processing and Disposal of EOL Fishing and Aquaculture Gear. This may Require Public Funding to Ensure Affordability	• Provide facilities for the landing, temporary storage (including space for sorting and disassembly) and responsible disposal of EOL fishing and aquaculture gear and equipment. As required by IMO's MARPOL Annex V, signatory states must provide "adequate facilities at ports and terminals for the reception of garbage without causing undue delay to ships, and according to the needs of the ships using them". This could include collaborations with fishing and aquaculture operations, port authorities and gear producers. There is a need to define a system to receive and manage the waste on land, as well as to identify who should be responsible for the waste disposal and the associated costs. • Provide facilities for the waste sorting, cleaning and disposal of EOL and ALD fishing and aquaculture gear recovered by third parties. • Ensure that there are systems in place to facilitate the reuse of plastics and other materials. This could include a sorting system (e.g., to allow the sorting of different materials, including different types of plastics), waste collection points, wash plants, and storage and inventory systems. • Provide facilities for the transfer and possible temporary storage needs of large aquaculture infrastructure components, bulk feed and other supplies through port facilities.
Pursue Collaboration between Ports and Harbours and Other Entities	• Common ground can potentially be found between nearby ports and harbours regarding cost-sharing for EOL gear and other waste disposal issues. • Cooperate in handling waste with other industries in the vicinity.
Communicate Information on Available Facilities to Manage EOL Fishing and Aquaculture Gear	• Display and promote information (e.g., notice boards, Internet, other communications) at the port on the management and responsible disposal of EOL fishing and aquaculture gear and equipment, including available facilities.
Exchange Information with IMO's Port Reception Facility Database to Ensure Specialist Reception Facilities are Easily Located.	• Communicate to country focal points accurate and up-to-date information about fishing and aquaculture gear and other waste reception facilities available at port. This information can then be communicated to the fishing and aquaculture industry via the IMO's Port Reception Facility database, accessible through the IMO Global Integrated Ship Information System (GISIS) website (https://gisis.imo.org/Public/Default.aspx).

Best Work Practice	Description
Consider Working with Private Sector Actors or Other Stakeholders to Deconstruct Certain EOL Fishing and Aquaculture Gears in Order to Enhance Recycling	• Recyclers require a relatively pure and cleaned stream of a certain plastic in order to make a high-quality secondary material. Some fishing gear can contain several different kinds of plastics and some metals in addition. For example, a Norwegian company that collects discarded fishing gear operates two dismantling facilities in order to ensure that ALD fishing and aquaculture gear that they collect is disassembled and separated so that their downstream recyclers accept the material.

Sources:

- Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
- Aqua-Lit (2020), *Best Practice Factsheets*.
- Huntington, T (2019). *Marine Litter and Aquaculture Gear – White Paper*. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council.
- Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.
- East Coast Shellfish Growers Association (2010), *Best Management Practices for the East Coast Shellfish Aquaculture Industry*.
- North Carolina Coastal Federation et. al. (2019), *Prevention of Marine Debris from Shellfish Mariculture – Best Management Practices for North Carolina Producers*.
- Hipólito, C., et. al. (2020), *Policy Recommendations to Tackle Aquaculture Debris*.
- Devriese L., et. al. (2019), *Available Tools and Measures. Knowledge Wave on Marine Litter From the Aquaculture Sector*.
- Dr. Lesley James. (2022), *Recycling Solutions for End-of-Life Fishing Rope in Newfoundland*.

5. Policy Options for End-of-Life Fishing and Aquaculture Gear

5.1 Introduction

Provided in this chapter is an identification and brief description of policy options that could be implemented to improve the management of EOL fishing and aquaculture gear. The policy options that are outlined below include those that have already been established or are in development with respect to fishing and aquaculture gear as well as others that have been established for other EOL waste streams but have not been identified as being applied to fishing and aquaculture gear (in at least one jurisdiction internationally). While most of the policy options focus on EOL fishing and aquaculture gear, some of the policy instruments are targeted at the manufacturing stage. Outlined in the table below is an identification of the policy options that are briefly described in this chapter as well as whether they have been implemented (or are in development) for fishing and aquaculture gear.

Table 27: Potential Policy Instruments for Managing EOL Fishing and Aquaculture Gear

Policy Instrument	Previously/Currently Applied to Fishing and Aquaculture Gear
Extended Producer Responsibility	✓
Deposit-Refund Schemes	
Circular Design Standards	✓
Prohibition/Mandating Certain Types of Fishing Gear	✓
Government Funding	✓
Gear-Tagging Requirements	
Codes of Practice/Guidelines	✓
Green Procurement	
Voluntary Agreements	✓
Provision of Low-Cost Management Options for EOL Fishing Gear at Port Reception Facilities	✓
Exert Pressure on 'Green' or Environmental Fishing Standards to Include Responsible Gear Disposal	
Vessel Design Requirements	

The policy options represent different mechanisms in which a set of objectives can be accomplished. Subsequent to reviewing the available literature it has been noted that a few specific objectives are prioritized or are repeated across different policy options (implementation methods). These objectives are:

- the incentivization or legal requirement for fishing vessels to bring back their fishing gear whenever possible;
- the incentivization or requirement for fishing and aquaculture operations to bring any wastes or other gear that they have found or that is caught in their equipment into shore for appropriate waste management;
- the provision of low-cost and effective/integrated (with existing on-shore waste management operations) waste management options for fishing and aquaculture operations at port reception facilities that place a priority on recycling waste whenever possible and do not de-incentivize (charge extra for) bringing back more waste (such as litter found during fishing operations); and
- various methods of financing port reception facility waste management operations.

5.2 Extended Producer Responsibility

Extended producer responsibility (EPR) is a policy approach in which a producer's responsibility, physical and/or financial, for a product is extended to the post-consumer stage of a product's life cycle. EPR makes the producer accountable for EOL management costs, thereby providing incentives to producers to prevent waste at the source and to design products that are recyclable/reusable.[175] EPR is widely utilized in jurisdictions across Canada to address waste streams such as packaging and paper, electronics, paint and hazardous wastes. According to the CCME's Action Plan for Zero Plastic Waste, EPR programs are recognized as one of the most effective mechanisms to support the creation of a circular economy. To date, EPR has not been utilized to address fishing and aquaculture gear waste in any jurisdiction in Canada.

Under the European Union *Directive on the Reduction of the Impact of Certain Plastic Products on the Environment* (Single Use Plastics Directive 2019/904), Member States (i.e., individual EU countries) are to ensure that EPR schemes are established for fishing gear containing plastic placed on the market of the Member State by December 31, 2024. Member States are to set a national minimum annual collection rate of waste fishing gear containing plastic for recycling. As part of the Directive, Members States must monitor fishing gear containing plastic placed on their market as well as waste fishing gear

[175] Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.

containing plastic collected and must report to the European Commission with the view to establishing binding quantitative European Union collection targets.[176]

Member States are to ensure that the producers of fishing gear containing plastic cover the costs of: (i) the separate collection of waste fishing gear containing plastic that has been delivered to adequate port reception facilities (as outlined in the *Waste Framework Directive*) or to other equivalent collection systems (that fall outside of that Directive); (ii) its subsequent transport and treatment; and (iii) awareness raising measures regarding fishing gear containing plastic.[177]

The EPR program for fishing gear will also need to address fee modulation as outlined in the *Waste Framework Directive* to encourage better design by producers (e.g., durability, repairability, reusability, recyclability and presence of hazardous substances).[178]This means gear that is more challenging to recycle will cost producers more than gear that is made with less challenging materials or gear that is designed for recyclability.

Sweden is one of the first European Union countries to establish an EPR program for fishing gear. Sweden recently adopted Ordinance 2021: 1001 which will come into force on January 1, 2023. The Swedish ordinance only covers commercial fishing gear. The national collection target, which will be at least 20% of the weight of fishing gear released on the Swedish market during the same calendar year, will be applicable from 2027. To fulfil their obligations, producers of such equipment must contract with a producer responsibility organisation by the end of 2024. Within the EU, Austria and Estonia have also established EPR schemes for fishing gear, while outside of the European Union, Iceland has published a related law and both Norway and the United Kingdom are planning similar polices.[179]

5.3 Deposit-Refund Schemes

Deposit-return systems refer to a deposit paid when purchasing a product and a full or partial refund provided once the product is returned. Regulated government or industry-led deposit-refund systems are in place in multiple jurisdictions in Canada for the management of used beverage containers.

[176] Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.
[177] Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.
[178] Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.
[179] Landbell Group (2021), *Another Country Introduces EPR for Fishing Gear*.

Compared to other collection systems, deposit-refund schemes are perceived to have mainly three advantages:[180]

- the financial incentive to return the product or package can result in higher collection rates in some cases, which means that less of the specific product ends up disposed of;
- recycling is encouraged; and
- the closed loop recycling of single products ensures high-quality recycling.

Work conducted in Europe indicates a favorable view on the further promotion of deposit return systems especially for fishing gear. However to date, there is no known deposit-refund scheme established for fishing gear.[181] The Regional Plan for Marine Litter Management in the Mediterranean as well as the Helsinki Commission have both suggested the use of deposit systems to address marine litter, with specific gear mentioned in those reports as well as others being: (i) aquaculture items (like cages, passive aquaculture gear, tags, ropes, and gloves)[182]; and expandable polystyrene (EPS) boxes.[183] As part of deposit-refund schemes, a discount can be provided on subsequent purchases if the originally purchased item is returned depending on the weight/volume/quantity returned.[184]

5.4 Circular Design Standards

It has been estimated that 80% of a product's total environmental impact is determined in the design phase. Circular design considers all aspects of product development and product lifecycle right from the outset of the product creation process. Incorporating circular design considerations into the manufacturing of a product promotes keeping products in circulation in the economy (through reuse, repair and/or recycling) for as long as possible to help guide businesses in transitioning into renewable resources, regenerating natural capital and decoupling economic activity from consumption of finite resources.[185]

The European Commission has requested the European Standardisation Organisations to develop harmonized standards related to the circular design of fishing gear to encourage

[180] European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics – Working paper (2018), Deposit - Return Schemes - Data and figures from 16 member countries of the EPA Network.

[181] European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics – Working paper (2018), Deposit - Return Schemes - Data and figures from 16 member countries of the EPA Network.

[182] Hipólito, C., Vale, M., Devriese, L. and Paramio, L. (2020). *Policy Recommendations to Tackle Aquaculture Debris*. Deliverable 5.1., developed by FRCT under the AQUA-LIT Project.

[183] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.

[184] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.

[185] What is Circular Design (Accessed at www.foolproof.co.uk/journal/what-is-circular-design/).

preparing for re-use and facilitate recyclability at end-of-life.[186] In response the European Committee for Standardisation (CEN), has established a Technical Committee (CEN/TC 466 - Sustainable Fisheries, Aquaculture and Fishing Gear) to address different aspects of circular fishing gear. Various standards are in development across three CEN working groups.[187] Among the key standards that are being developed are the following (that are due for completion in the 2023-2024 time-period):[188]

- **Circular Design of Fishing Gear and Aquaculture Equipment - Part 4: Environmental and Circularity Requirements and Guidelines** - This document specifies the environmental and circularity requirements for the components of fishing gear and aquaculture equipment which contain plastics. It will establish sustainability principles that minimize the negative impact of the plastic components of fishing gear and aquaculture equipment on the environment, taking into account the impact on its performance (e.g., catchability or life span). The circular and environmental design of fishing gear and aquaculture equipment focuses on: (i) selection/sourcing of materials; (ii) manufacture/assembly; (iii) placement/installation/deployment of the gear/equipment; (iv) use and maintenance; and (v) end of life stage. Transport, storage and distribution are taken into account at the different stages, where applicable.
- **Circular Design of Fishing Gear and Aquaculture Equipment - Part 5: Circular Business Model** - This document lays out the requirements for organizations to establish, implement and maintain circular design of fishing gear and aquaculture equipment by integrating corresponding product requirements in their organizational procedures. The document will also incentivize new, innovative, circular business models. Opportunities for value retention and 'second life' of fishing gear and aquaculture equipment will be part of this document.

5.5 Prohibition/Mandating Certain Types of Gear

One of the actions that was included in a report to the European Commission to support the development of measures to combat a range of marine litter from sea-based sources was to reduce the use of plastic components of fishing gear that, by design, are lost or break apart during their use (e.g., plastic dolly rope[189], and polystyrene floats and buoys not sealed in a protective cover). This could be achieved with an outright ban on sale and use

[186] Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.
[187] Accessed at the following website (www.seafish.org/responsible-sourcing/managing-end-of-life-fishing-gear-and-aquaculture-equipment/#GovResponse).
[188] Accessed at the website of the European Committee for Standardisation (https://standards.cencenelec.eu/dyn/www/f?p=205:22:0::::FSP_ORG_ID,FSP_LANG_ID:2981666,25&cs=1B7DB366908D30D6DAF868D3D16CD49A1).
[189] Dolly ropes act as sacrificial plastic in order to prevent damage to fishing nets, which are more valuable. These dolly ropes not only pose an issue in entanglement, but also shed large amounts of plastic fibres, which end up in the marine ecosystem.

of such items, or an environmental tax that will make alternative products cost-competitive (and overcome the convenience factor).[190] The Government of Ireland also indicated that work should be undertaken towards banning the use of dolly ropes in favour of more sustainable materials/designs as they become available.[191] Other noted options/actions with respect to the potential prohibition of certain fishing gear, the requirement for gear that stops fishing after it has been in the water for a certain period of time (to prevent long-term ghost-fishing), or mandating that certain biodegradable materials be used for specific fishing gear include the following:

- Single-use plastic equipment, such as zip-ties, can often be replaced with a biodegradable alternative such as cotton twine or rope, without adding cost.[192]
- Canada's Department of Fisheries and Oceans has banned the use of un-encased Styrofoam in its aquaculture licenses,[193] and Oregon requires foam used in the water to be encapsulated;[194]
- In the Netherlands, the use of biodegradable socks for mussel suspension cultures and mussel larvae collector installations as an alternative for polypropylene socks is a significant improvement to reduce litter that is harmful to the environment if gear is lost or damaged at sea.[195]
- The NL mussel sector began using cotton socking over 20 years ago, when producers transitioned to continuous socking methods. Further to this NL mussel producers have made it standard practice to repurpose rope from the crab fishery, which can be used over and over. The rougher (fuzzier) the rope gets, the better for mussel seeding and grow-out, so this can be reused many times well beyond its useful life for crab harvest.[196]
- In France since 2013, the Ministry of Agriculture, Agrifood and Forests made it mandatory to use mussel larvae collector lines that are made of natural and degradable fibres such as hemp or coconut ropes for products labelled as Moules du Bouchot.[197/198]

[190] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.
[191] Recommendation for a national policy on the treatment of fishing gear as it relates to marine litter (Ireland).
[192] Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.
[193] Fisheries and Oceans Canada website, *Use of Foam Flotation*.
[194] Oregon.gov website, *Foam Encapsulation*.
[195] Aqua-Lit (2020), *Best Practice Factsheets*.
[196] Information provided by Jonathan Kawaja, Environmental Scientist at the Department of Fisheries, Forestry, and Agriculture in Newfoundland and Labrador.
[197] Aqua-Lit (2020), *Best Practice Factsheets*.
[198] Bouchot (French for "shellfish bed") is a traditional aquaculture technique for mussels. It means that the mussel was grown on ropes strung from wooden poles in the sea. This results in grit and barnacle-free mussels with full meats and a cleaner flavour.

- In Ireland, spat are increasingly being collected on reusable "hairy" rope and encased in biodegradable cotton mesh, replacing single use plastic mesh. Oyster growers can reuse bags for up to 10 years, often repairing tears.[199]

5.6 Government Funding

Government funding, whether it be federal, provincial, or municipal, can be targeted to specific activities related to EOL fishing and aquaculture gear. Provided below are two examples where governments have directly funded on-going collection activities for EOL fishing and aquaculture gear:

- In 2004, KIMO International started a Fishing for Litter project in Europe to tackle the problem of marine litter. Fishing boats are given big bags to collect the plastics, ALD gear and other debris that gathers in their nets during normal fishing activities. When the fishing boats come into port, they can unload the bags of litter. These bags are collected regularly and the rubbish is recycled or disposed of on land. OSPAR endorses Fishing for Litter and encourages its 15 member countries to adopt Fishing for Litter programmes as part of its Regional Action Plan against marine litter. The European Union's revised *Port Reception Facilities Directive* will make specific provision for Fishing for Litter waste in order to encourage more vessels and more harbours to take part. The funding for this program is often covered by the federal government in various European countries (e.g., Department of Environment, Food and Rural Affairs in England, Department of Agriculture, Food and the Marine in Ireland).[200]
- Another example could be funding the purchase and installation of receptacles for EOL fishing and aquaculture gear in various ports and harbours in Canada. The installation of different containers to facilitate the collection of various materials at collection points can improve and facilitate the recycling or disposal process.[201] As an example, some shellfish aquaculture communities in Florida (e.g., Cedar Key) have conveniently placed dumpsters for proper disposal of aquaculture gear.[202]
- Funding clean-ups for legacy gear that is already in place. This would need to reflect the fixed location nature of the farms and the reality that years of various management regimes and eras of gear types encouraged (by government in many cases) for the aquaculture sectors has contributed to farms having large amounts (layers) of debris underneath them. Contribution funding has been suggested, where the government pays for a portion of the cleanup fee and farmers must pay the remainder. Once more funding to assist clean-ups is provided, then follow up funding is provided to ensure best

[199] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
[200] Accessed at the website of Fishing for Litter (https://fishingforlitter.org/).
[201] Aqua-Lit (2020), *Best Practice Factsheets*.
[202] Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.

practices and innovative/greener gear is sourced and used. With clear rules about the farmer now having to maintain their facility clean of lost gear. Going forward, they pay into a polluter pay fund based on their farming footprint. That fund helps fund future remediation and retrieval projects, so it's self funded going forward.[203]

5.7 Gear Tagging Requirements

Gear-tagging requirements are often used to establish ownership of lost gear, containment compliance and inspection, and biosecurity. In Canada, the ropes must have identifiers of the region, species being fished and individual fishing area. The requirement is also intended to maintain access to the U.S. seafood market by demonstrating Canada has rules comparable to those in place for fishermen in the U.S.[204] What is not often discussed is how knowing what specific materials are used in fishing or aquaculture gear is critical to being able to recycle it. Once fishing or aquaculture gear is in the water, it can be difficult to tell which specific product it is, or who manufactured the product. In 2016, the Department of Parks and Wildlife – Nature Protection Branch – in Western Australia tried to trace the origin of abandoned fishing gear that caused the death of humpback whales. They identified some 7,450 different suppliers of similar ropes on Alibaba.com, and were unable to track down the specific manufacturer of the rope that was involved in the deaths.[205]

In that particular case, the rope was clearly made from polypropylene, but in other instances the specific materials used in rope or in other gear is not always known with perfect certainty, and some recyclers have had to resort to sending material samples to labs (which is very expensive) in order to identify the specific plastics used.[206] This can be especially challenging when multiple plastics are used within a single product. It may be sensible to consider tagging gear so that the specific product type, manufacturer, and materials within the gear can be easily identified[207]. Manufacturers could make publicly accessible data sheets indicating the specific materials contained in the product, how to deconstruct the product, and potentially even locations where the plastics within the product can be recycled. These sheets could be accessed by scanning QR codes or similar identifiers placed on the gear so that waste managers can easily assess various types of gear when they arrive at waste management facilities and know how to recycle them as best as possible. These measures would have a much greater impact if they were backed by 'design

[203] Comment from Marie, Chistopher, January 10th, 2023.
[204] Aqua-Lit (2020), *Best Practice Factsheets*.
[205] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear, prepared for the Global Ghost Gear Initiative*.
[206] Interview with Pacific Carpet Recycling (October 18, 2022)
[207] He, P., & Suuronen, P. (2018). Technologies for the marking of fishing gear to identify gear components entangled on marine animals and to reduce abandoned, lost or otherwise discarded fishing gear. *Marine Pollution Bulletin*, *129*(1), 253–261. https://doi.org/10.1016/j.marpolbul.2018.02.033

for deconstruction' or 'design for recycling' requirements for gear manufacturers to maximize the utility of information on the materials used within the gear.

5.8 Codes of Practice/Guidelines

Codes of practice/guidelines can be voluntary or mandatory instruments that recommend procedures and practices or environmental controls relating to works, undertakings, and activities. They aim to encourage the sustainable use of the environment and to reduce pollution.[208]

Different levels of government in Canada can work in collaboration with the relevant fishing and aquaculture industry associations to establish a Code of Practice/Guideline, specifically for the management of EOL fishing and aquaculture gear. HELCOM in their report "Regional Actions Addressing Sea-based Sources of Marine Litter" advocated the promotion and dissemination of best practices in relation to all relevant aspects of waste management within the fishing sector (e.g., waste management on board, waste management at harbours and operational losses/net cuttings).[209] It was also advocated that governments work with the aquaculture industry and other stakeholders to develop and promote best practices in relation to ALD aquaculture gear and its removal.[210]

It has also been suggested that governments develop a formal plastic use policy for the fishing and aquaculture sector that reduces and where possible eliminates: (i) the use of single-use plastics, (ii) plastics with low levels of recyclability, (iii) equipment that mixes different types of plastic, thus complicating/increasing the cost of recycling; and (iv) methods that hinder recyclability (e.g., coating of nets with substances that impede recycling).[211] This plastic use policy could be incorporated into a Code of Practice/Guideline.

5.9 Green Procurement

Governments often utilize their own procurement strategies to encourage the private sector to adopt more environmentally friendly management practices. Examples of where green procurement could be beneficial for fishing and aquaculture gear include the following:

[208] Environment and Climate Change Canada (2021*), Environmental Codes of Practice: Fact Sheet*.
[209] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.
[210] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.
[211] Huntington, T (2019). *Marine Litter and Aquaculture Gear – White Paper*. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council.

- specifying alternatives to plastics where possible and/or specifying plastics designed to allow for greater durability, reuse, and high-quality recycling;[212]
- specifying the use of biodegradable materials instead of single-use plastics in certain aquaculture applications, such as cable ties, shellfish bag fasteners and feed sacking – there are challenges associated with this, especially if such items are expected to last a long time (e.g., cable ties fixing shellfish bags to trestles);[213] and
- supporting the development of local or regional recycling/reuse schemes (through procuring services from local or regional operations that recycle) to incentivize other producers to use less mixed-plastic material – this may help facilitate the recycling process and help with the upgrading of waste handling facilities by stimulating demand.[214]

5.10 Voluntary Agreements

Voluntary agreements are established between a government authority and one or more private parties to achieve environmental objectives or to improve environmental performance beyond compliance to regulated obligations. In terms of EOL fishing and aquaculture gear, voluntary agreements could be established to manage the entire range of gear that is used or simply focus on specific types of gear.[215]

For example, in Belgium, "blue deals" have been signed with different sectors. Through these "blue deals", companies will be specifically encouraged per sector to make voluntary efforts to combat marine litter. Eligible sectors include fishing and aquaculture. In the Adriatic Sea, mussel farmers have established voluntary agreements to bring to shore the no longer usable polypropylene socks and to try to cover the costs of the waste disposal.

Voluntary agreements could be established with industry on a wide range of issues. Policymakers could consider identifying those areas where voluntary agreements may make more sense that regulations or specific requirements and engage with industry.

5.11 Provision of Low-Cost Management Options for EOL Fishing Gear at Port Reception Facilities (PRFs)

[212] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.
[213] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
[214] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
[215] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.

There is a lack of easy and low-cost management options available for EOL fishing and aquaculture gear at some Canadian ports and harbours. This issue is not specific to Canada, and has been identified as a consistent problem in many jurisdictions within much of the literature that has been reviewed for this study. The ability of the waste management sector to efficiently dispose of or recycle fishing and aquaculture gear after it has been collected only becomes a relevant challenge to address if the EOL gear is collected in the first place.

Another factor to consider in collecting EOL fishing and aquaculture gear for disposal that is linked to management at PRFs is the pre-processing that is often required before either disposal or recycling. The Vancouver Landfill and Recycling Depot, for example, has experienced serious issues with netting getting caught in the tracks of their vehicles, and will only accept netting for "deep burial" which is significantly more expensive than regular disposal. Shredding this netting before sending it to landfill could severely reduce this cost. Similar issues exist for potential recycling, where rope must be separated, and any buildup of organic materials from time in the water must be removed before the net is sent to a recycler (shredding must generally also occur).[216] Therefore, in order to be integrated with the larger waste management sector PRFs must not only accept waste for storage and eventual management but must also pre-process the waste so that other waste management stakeholders can accept it.

The International Convention for the Prevention of Pollution from Ships 1973 as Modified by its 1978 Protocol (MARPOL) is an international instrument that governs ship wastes. Under MARPOL, port reception facilities are required to be "adequate", though what that might entail is not well defined.[217] The remainder of this section describes policy options being considered or implemented in Canada or other international jurisdictions that could help to relieve some of the issues with inadequate waste management/processing options at PRFs and harbours.

In the EU, the Single Use Plastics Directive (SUP Directive) and Port Reception Facilities Directive (PRF Directive) were developed and implemented in 2021. The SUP Directive establishes EPR requirements that help finance some of the requirements of the PRF Directive.[218] The PRF Directive (2019/883) was promulgated partially in order to better enforce/clarify PRF waste management requirements under MARPOL, as well as establish additional binding obligations for member states and requirements for ships engaged in port services. The most important elements of the PRF Directive regarding this study are: (i) requirements for waste reception and handling plans to be developed by PRFs that account for the waste they expect to receive; (ii) requirements regarding the delivery of waste from ships; and (iii) the indirect fee requirement for cost recovery that specifically provides no incentive for ships to discharge their waste at sea. In addition to the PRF Directive, EC Council Regulation 1224/2009 clarifies some aspects of the community

[216] Interview with Pacific Carpet Recycling (October 18, 2022)
[217] Arguello, (2020), *Environmentally Sound Management of Ship Wastes: Challenges and Opportunities for European Ports*
[218] More information on EPR programs is provided earlier in this chapter.

control system for common fisheries but also offers member states with the ability to incentivize the return of ALD fishing gear that they find while at sea.

The first of these requirements specifies that the port work with stakeholders to identify any likely wastes – including EOL fishing gear – that may be incoming and prepare a plan (in cooperation with other ports if necessary) to effectively manage the reception of the wastes. There are significant documentation requirements, stakeholder consultation requirements, and tracking requirements associated with the development and implementation of these plans – but for the purposes of this study it is most important to note that the plans must be comprehensive, be updated every five years, and include distinct procedures for the delivery of every type of waste described by stakeholders as requiring disposal.

Requirements of ships are many, and include[219]: (i) providing at least 24 hours advance notice of all wastes contained in the ship that require disposal to the PRF; (ii) a requirement to deliver all waste to the PRF before departing unless the PRF is unable to handle certain wastes (this occurs when two PRFs share responsibilities as described in their waste management plans); and (iii) participating in a tracking system via forwarding data on waste management requirements and receiving a receipt from the PRF for the management of the waste. All of these requirements are generally designed to make it easier for PRFs to handle the waste that they will be required to process, and tracking the receipt and movement of the waste in order to establish a more robust informational basis for future policy work.

Finally, the PRF Directive requires EU nations to establish an indirect fee for waste management that does not provide an incentive for vessels to dump their waste at sea to avoid waste management costs (i.e., the cost remains regardless of whether or not they actually drop off any waste). Due to how EPR programs promulgated via other directives are partially responsible for how waste management systems at PRFs are funded, it is not useful to go into much detail regarding the fees that ships pay for waste management or how PRFs manage the costs of waste management in the EU. However, the fact that ships will be charged an indirect waste management fee regardless of whether or not they deposit waste (and will not be charged additionally if they do deposit waste) is important to note as this measure has been undertaken specifically to prevent the practice of dumping excess waste such as EOL fishing gear at sea.

The other relevant EU policy relevant for this section is EC 1224/2009 – which encourages "fishing for litter". While this in and of itself is not directly relevant to PRFs, Italy has chosen to implement "fishing for litter" requirements in such a way that PRFs are impacted in a manner directly relevant to this work:

[219] Some of these requirements have detailed exemptions in place that are not discussed in detail. Different countries across the EU will have implementing national laws that vary from overarching EU requirements.

"In the beginning of April 2019, a first green light from the Italian government was given to the "SalvaMare" draft law, that was unanimously approved by the Italian Council of Ministers, and that should be approved by the Chamber in June. The draft law, which the Italian Ministry of Environment Sergio Costa renamed #SalvAmare, requires that:

- *Fishermen will be allowed to bring plastic they find caught in their nets and will be able to deposit it in specific recycling areas placed in ports;*
- *They will be provided with an environmental certificate attesting their commitment to the sea and sustainable fishing;*
- *Their catch chain will be recognizable and recognized;*
- *They will not be subject to a fine or penalty for illicit traffic of waste;*
- *Recycling collection points will be installed in ports for the disposal of waste taken from the sea;*
- *Fishermen will be subject to awards and incentives for their "fishing for litter" activities."*[220]

The requirement for PRFs to include recycling points for any plastics that they catch in their fishing nets would implicitly indicate that these PRF facilities have links to the larger waste management chain for plastics to be sent for recycling.

In Canada, vessels are required to handle their own wastes and while PRFs can offer some assistance in this regard there is no requirement for these facilities to have established chains for sending certain specific materials into the waste sector for recycling or other types of management. Overall, while there are many policy options for funding or otherwise requiring PRFs to take a more active and integrated role in waste management systems and the plastics reverse-supply chain (to recyclers as opposed to landfills), it is the lack of any requirements or incentives of this type in Canada that may have led to the current status quo. Policymakers interested in diverting EOL fishing and aquaculture gear from current management options (often long-term storage in private warehouses or rural areas) to more final or circular management options should consider various ways to manage the EOL-cycle of these materials, from collection through to processing and recycling. The first step of this – of course – is collection, and this is where PRFs are a sensible intervention-point.

5.12 Exert Pressure on 'Green' or Environmental Fishing Standards to Include Responsible Gear Disposal

There are a number of "green" or "environmentally friendly" certification standards that exist for certain seafood products that are used to secure consumer brand loyalty and indicate that fishing or aquaculture operations behave in an environmentally sensible

[220] Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.

manner. Relatively few certification standards focused on aquatic litter (including lost gear and other litter directly attributable to fishing activities) issues, with only 3 of the 16 sustainability programs assessed for WWF International in 2009 including waste in their standards: (i) the UK's Responsible Fishing Vessel Scheme considers lost fishing gear recovery, vessel discharges and aquatic litter recovery; (ii) the Clean Green of the Southern Rock Lobster fishery supports removing environmentally unfriendly practices, such as the use of plastic bait box straps, and managing responsible disposal and recycling of aquatic wastes—oil, plastics and cardboard; and (iii) Carrefour's Pêche Responsible promotes "responsible production methods and reducing waste."[221]

If more of these standards were to include environmentally responsible waste disposal or recycling requirements then it could pressure some of the larger businesses that seek these standards as a means of differentiating themselves from other products on the market to invest in or otherwise work with governments to achieve higher rates of recycling or responsible waste management practices for EOL fishing and aquaculture gear.

5.13 Vessel Design Requirements

Policies that are being increasingly implemented in the EU under EC Council Regulation 1224/2009 encourage "fishing for litter" and can provide financial incentives to those vessels that bring back ALD fishing gear they find in the water or that gets caught up in their equipment. One barrier to this is the availability of storage on vessels. Some fishing vessels prioritize storage for catch and working space over storage for EOL fishing gear and other garbage. For example, routine discard of up to 30 km of gillnets per vessel per trip was documented in a 50-vessel a deep-water gillnet fishery off the UK continental shelf in the 1990s, with vessels bringing back only reusable headline and foot ropes.[222] While this may be an extreme example, it highlights the impact that something as simple as storage space on a vessel can have on the ability of said vessel to either bring in their own gear or retrieve other gear via 'fishing for litter'. Vessel design should include adequate waste storage solutions, especially for items like lightweight plastic baitbox packaging and waste, that are easily blown overboard. [223]

[221] Global Ghost Gear Initiative (2021) *Best Practice Framework for the Management of Aquaculture Gear*. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. for GGGI. 81 pp. plus appendices.
[222] Global Ghost Gear Initiative (2021) Best Practice Framework for the Management of Fishing Gear: June 2021 Update. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. 94 pp plus appendices.
[223] Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Fishing Gear, prepared for the Global Ghost Gear Initiative*.

6. Recommended Government Policies and Industry Best Practices

6.1 Introduction

This chapter initially presents criteria to apply to the work practices (Chapter 5) and policy options (Chapter 6) for the purposes of identifying the most appropriate work practices/policy options for discussion during workshops to be held in February, 2023. These criteria were developed in conjunction with the Policy Options for Fishing and Aquaculture Gear Project Team at CCME. The criteria are subsequently applied to the work practices/policy options (that were outlined in Chapters 5 and 6), with a short-list of work practices/policy options identified based on the application of those criteria.

6.2 Criteria for Short-listing Identified Government Policies and Industry Best Practices

The criteria outlined in this section have been developed to qualitatively assess the policies and work practices identified earlier in this report. These criteria will be used to establish a short-list of work practices/policy options that will be discussed during workshops in February, 2023. The criteria that have been developed are as follows:

1. Effectiveness: How well does this policy or work practice address the specific shortcomings of the current EOL fishing/aquaculture gear collection, cleaning/deconstruction, and recycling or disposal framework?
2. Magnitude: Could this policy or work practice directly or indirectly contribute to the recycling of significant volumes (hundreds of tonnes per year minimum) of EOL fishing/aquaculture gear materials now or within the next 10 years either alone or in combination with supporting policies/work practices?
3. Applicability: Is this policy or work practice scale-able and applicable to a type of fishing or aquaculture gear that is widely used across Canada?
4. Prevalence: Has this policy or work practice been widely implemented (or is in the process of being widely implemented) by other jurisdictions that are addressing the same EOL fishing/aquaculture gear challenges that Canada is?
5. Barriers/Costs: What is the level of investment (in new infrastructure) or the level of disruption to standard business practices that would be required in order to implement this policy or work practice?

6.3 Application of Criteria to Identified Government Policies and Industry Best Practices

A 5-point rating system has been applied, wherein each policy/work practice has been measured against each criterion and qualitatively rated on a scale of 1-5 for alignment (5 is a "good" score, and 1 is a "poor" score). Each policy or work practice is therefore rated on a total scale of 5-25. The following tables provide scoring for: (i) policy options; (ii) work practices for fishing and aquaculture gear manufacturers; (iii) work practices for fishing and aquaculture operations; and (iv) work practices for harbour and port operations or other entities collecting EOL fishing and aquaculture gear. Accompanying this report is an excel spreadsheet that provides a rationale for each of the scores assigned to each of the policies/practices across each of the criteria.

Table 28: Scoring Table – Policy Options

Policy Option	**Effectiveness**	**Magnitude**	**Applicability**	**Prevalence**	**Barriers/Costs**	**Total Score /25**
Extended Producer Responsibility	5	5	5	5	1	21
Deposit-Refund Schemes	2	4	5	1	2.5	14.5
Circular Design Standards	5	3.5	3.5	5	3.5	20.5
Prohibition/Mandating Certain Fishing Gear Types	1	1	2.5	5	4	13.5
Gear-Tagging Requirements	3.5	3.5	3.5	1	5	16.5
Codes of Practice/Guidelines	3	4	5	4	3.5	19.5
Green Procurement	2	2	3	4	4	15
Voluntary Agreements	2	3	5	5	3.5	18.5
Provision of Low-Cost Management Options for EOL Fishing Gear at Port Reception Facilities	5	5	5	4	2	21
Exert Pressure on 'Green' or Environmental Fishing Standards to Include Responsible Gear Disposal	1	2.5	5	3	4	15.5
Vessel Design Requirements	1	1	3	1	1	7

Table 29: Scoring Table – Work Practices for Fishing and Aquaculture Gear Manufacturers

Work Practices	Effectiveness	Magnitude	Applicability	Prevalence	Barriers/Costs	Total Score /25
Use Materials/Components in Production that are Easy to Reuse and/or Recycle	5	4	3.5	1	4	17.5
Use Materials/Components that are Less Harmful to the Marine Environment/Wildlife	1	2	3	2.5	4	12.5
Use Biodegradable Materials	3	1	2.5	3	4	13.5
Ensure Traceability of Different Polymers in Gear	4	3.5	5	1	4	17.5
Establish Training Programs	4	4	4	1	2	15
Incorporate Costs of EOL Management of Gear into the Price	3	3.5	5	1	3	15.5
Contribute to the Establishment of Cleaning and Deconstruction Facilities at or Near Harbours and Ports and Help Establish New Reverse Supply Chains	5	4	4	2.5	2	17.5

Table 30: Scoring Table – Work Practices for Fishing and Aquaculture Operations

Work Practices	Effectiveness	Magnitude	Applicability	Prevalence	Barriers/Costs	Total Score /25
Provide Safe and Secure Collection of EOL fishing and aquaculture Gear and Supporting Equipment	5	4	4	2.5	2	17.5
Careful Selection of Fishing and Aquaculture Gear and Management	3	2	2.5	4	5	16.5
Tracking, Inventory and Planning of Fishing and Aquaculture Gear, Particularly for Plastics	3.5	2	2.5	1	2	11
Establish Policies for the Management of EOL Fishing and Aquaculture Gear, in Particular Plastics	5	5	5	1	1	17
Provide Adequate Training to Staff	1	1	5	4	1	12

Table 31: Scoring Table – Work Practices for Harbour and Port Operations or Other Entities Collecting EOL Fishing and Aquaculture Gear

Work Practices	Effectiveness	Magnitude	Applicability	Prevalence	Barriers/Costs	Total Score /25
Provide Facilities for the Landing, Temporary Storage, Sorting, Processing and Disposal of EOL Fishing and Aquaculture Gear. This may Require Public Funding to Ensure Affordability	5	4	4	2.5	2	17.5
Pursue Collaboration between Ports and Harbours and Other Entities	4	4	4	2	4	18
Communicate Information on Available Facilities to Manage EOL Fishing and Aquaculture Gear	3	2	5	1	4	15
Exchange Information with IMO's Port Reception Facility Database to Ensure Specialist Reception Facilities are Easily Located.	3	2	5	1	4	15
Consider Working with Private Sector Actors or Other Stakeholders to Deconstruct Certain EOL Fishing and Aquaculture Gears in Order to Enhance Recycling	5	4	4	2.5	2	17.5

6.4 Identification of Short-listed Government Policies and Industry Best Practices

Amongst the scoring tables above there were many policies and work practices that scored equally, and there were some overlap as similar work practices could be utilized by different stakeholder groups (manufacturers, operations, and port/harbour facilities). In order to simplify and focus this element of the analysis, the highest scoring ten practices from the tables above have been assembled in the table below. These ten practices were then analysed qualitatively to determine which of these practices had elements that overlapped other practices. Those practices that were found to overlap sufficiently with other practices were combined and described once.

Additionally, some of the practices shown in the tables above are best considered to be "supporting" practices. For example, providing deconstruction instructions and indicating what types of materials are used in various types of gear will help recyclers and help those facilities that are deconstructing EOL gear for recycling – on the condition that there are facilities available to carry out said deconstruction, and recyclers available to conduct the recycling. Those policies that have been deemed to be "supporting" policies have been noted but de-emphasized, as they require other steps to be taken first.

Table 32: Ten Highest-Scoring Policies and Work Practices

Policy Option	Effectiveness	Magnitude	Applicability	Prevalence	Barriers/Costs	Total Score /25
Extended Producer Responsibility	5	5	5	5	1	21
Provision of Low-Cost Management Options for EOL Fishing Gear at Port Reception Facilities	5	5	5	4	2	21
Circular Design Standards	5	3.5	3.5	5	3.5	20.5
Codes of Practice/Guidelines	3	4	5	4	3.5	19.5
Pursue Collaboration between Ports and Harbours and Other Entities	4	4	4	2	4	18
Voluntary Agreements	2	2	5	5	3.5	17.5
Use Materials/Components in Production that are Easy to Reuse and/or Recycle	5	4	3.5	1	4	17.5
Ensure Traceability of Different Polymers in Gear	4	3.5	5	1	4	17.5
Consider Working with Private Sector Actors or Other Stakeholders to Deconstruct Certain EOL Fishing and Aquaculture Gears in Order to Enhance Recycling	5	4	4	2.5	2	17.5
Contribute to the Establishment of Cleaning and Deconstruction Facilities at or Near Harbours and Ports and Help Establish New Reverse Supply Chains	5	4	4	2.5	2	17.5

The following policies or work practices were considered to overlap to a significant enough degree that they have been combined into one work practice/policy:

- provision of low-cost management options for EOL fishing gear at port reception facilities;
- consider working with private sector actors or other stakeholders to deconstruct certain EOL fishing and aquaculture gears in order to enhance recycling; and
- contribute to the establishment of cleaning and deconstruction facilities at or near[224] harbours and ports and help establish new reverse supply chains.

The bottom line with these three policies/work practices is the establishment or identification of public or private facilities that can collect/clean/deconstruct EOL fishing and aquaculture gear into constituent materials so that these relatively pure material streams can be forwarded to recyclers. This could be done through establishing public facilities at harbours and port reception facilities similar to material recovery facilities (MRFs) used in the terrestrial waste management systems across Canada, getting harbours (such as Steveston Harbour) to undertake deconstruction activities for certain products, or through identifying private partners that are willing or able to take on certain tasks within the vicinity of harbours and port reception facilities. These facilities are currently the major gap preventing the responsible management/recycling of EOL fishing gear in Canada. The new policy/work practice (shortlisted) is as follows:

- find methods (either public, public/private partnerships, or private) to establish facilities at or near harbours and port reception facilities that can accept, clean, and deconstruct EOL gear into its constituent components so that these pure materials streams can be forwarded to recyclers.

Similarly, the following three policies or work practices were found to overlap as well:

- circular design standards;
- use materials/components in production that are easy to reuse and/or recycle; and
- ensure traceability of different polymers in gear.

[224] What "near" may mean is going to change dramatically from location to location based on many factors, including how many other facilities are nearby (using one deconstruction facility to serve a number of harbours or ports or aquaculture facilities could be efficient in some cases), how much waste any specific facility may generate, the type of waste generated (it may make sense for some deconstruction facilities to more efficiently handle specific wastes generated at nearby aquaculture sites – for example), and even real-estate prices and general population density. The presence of existing waste management facilities could also contribute to decision-making regarding what might constitute "near" in any specific case. There could also be collection sites/depots set up that are "near" relevant facilities that have no deconstruction capacity that are designed to "feed" more centrally located deconstruction facilities. Given the number of variables involved, no specific number can be attached to "near" for the purpose of this report. Instead, it is to be understood that each situation may be unique and that each specific area will have to determine what solution may be effective or efficient.

All three of these options center around considering the full lifecycle of the product during the design and production stages, and making information on how to successfully deconstruct and recycle EOL gear available to those stakeholders that will be tasked with deconstruction/recycling. These three policies have been combined as follows:

- encourage fishing and aquaculture gear manufacturers to consider the full lifecycle of their product during the design stage, including prioritizing the use of recyclable materials and ensuring that information on how to deconstruct their products (and what materials their products are made of) are easily available through instruments such as voluntary agreements, codes of practice, or circular design standards.

The remaining policies and work practices (6) have been shortlisted and are briefly described in sub-sections below, including the rationale behind their scoring.

1. Extended Producer Responsibility.

Criteria Scoring Rationale:

1) An EPR program would provide the funding needed to put infrastructure in place and likely cause gear manufacturers (who would be funding the program) to consider design for recycling requirements for their gear in order to lower their recycling costs.
2) EPR programs have been effectively applied to a number of different waste streams - and when properly structured achieve high rates of diversion.
3) An EPR program could be designed to include all types of gears used across Canada and is not specific to any type of gear.
4) EPR will be applied to EOL fishing gear across the European Union as described under the Waste Framework Directive and is already applied in Sweden.
5) An EPR program would be meant to help establish infrastructure to capture and recycle EOL fishing gear, and there is little to no infrastructure currently in place. 1 Point was awarded as industry would fund infrastructure development under EPR.

2. Find methods (either public, public/private partnerships, or private) to establish facilities at or near harbours and port reception facilities that can accept, clean, and deconstruct EOL gear into its constituent components so that these pure materials streams can be forwarded to recyclers.

Criteria Scoring Rationale:

1) If fishers had low-cost options for their EOL gear at port reception facilities, they would likely use these options and the lack of low-cost management options is the primary shortcoming of the current management system.
2) The development of this infrastructure would lead to significant recycling opportunities given that long-term storage (the main alternative) would become less affordable than proper management.
3) Port reception facilities would be a sensible location to capture a significant proportion of EOL fishing gear generated in Canada.
4) The EU is requiring the provision of these facilities as a part of their evolving EPR program.

5) The development of new infrastructure at port reception facilities across Canada would likely be expensive.

3. Encourage fishing and aquaculture gear manufacturers to consider the full lifecycle of their product during the design stage, including prioritizing the use of recyclable materials and ensuring that information on how to deconstruct their products (and what materials their products are made of) are easily available through instruments such as voluntary agreements, codes of practice, or circular design standards.

Criteria Scoring Rationale:

1) This policy in and of itself would not create the infrastructure required for recycling, but this policy would make the actual recycling of gear far easier and potentially reduce the need for new infrastructure (it addresses shortcomings in the system via reducing the need to develop other more complex/costly solutions). It could therefore be considered a foundational element of any larger program (such as an EPR program).
2) It is unclear if all types of gear could be designed in a way that makes them easier to recycle - but there is a strong possibility that if time/money/research is invested in this specific problem solutions could be found for many gear types.
3) Please see rationale for criteria 2.
4) Circular design standards for fishing gear are being developed in Europe. Design for recycling requirements are being considered or implemented in other sectors.
5) Costs would be borne largely by manufacturers, but these costs are difficult to quantify due to the number of unknowns regarding design/productions costs and potential changes to manufacturing facilities.

4. Codes of Practice/Guidelines.

Criteria Scoring Rationale:

1) This would depend on the specific content of the code of practice and whether or not it was voluntary or mandatory - regardless a code of practice may not include specific legal/financial implications if the code was to be ignored and this could lower the effectiveness.
2) The code of practice could be tuned to impact many different areas, but different codes of practice would have to be developed for different elements of fisheries/aquaculture sector and the possibility of missing stakeholders or overlap must be considered.
3) Codes of practice could potentially be designed and applied to any sectors.
4) Codes of practice and codes of practice involving managing wastes are prevalent and widely utilized in a variety of industries, fewer examples have been identified specific to managing EOL fishing and aquaculture waste.
5) The costs should be considered highly uncertain and dependent upon the content of the codes - but would be borne largely by private sector operations targeted by the codes as opposed to government.

5. Voluntary Agreements.

Criteria Scoring Rationale:

1) This would depend on the specific voluntary agreement, but it is unlikely to significantly impact any of the main weaknesses in the current EOL management system and as the agreement is voluntary it is less likely to be adhered to.
2) If voluntary agreements were part of a larger overall package that included the provision of collection/dismantling stations (i.e., compliance with voluntary standard would become low-cost) then a voluntary standard could help move some businesses towards recycling.
3) Voluntary standards could be developed for any stakeholder group.
4) Voluntary standards have been applied in practice.
5) Costs would be difficult to quantify, but would largely be borne by the private sector as opposed to government.

6. Pursue Collaboration between Ports and Harbours and Other Entities.

Criteria Scoring Rationale:

1) Different port reception facilities working together to establish networks (with certain facilities specializing in certain types of gear or certain operations) could substantially reduce infrastructure development costs involved in implementing a recycling system - with costs being a significant barrier to increasing recycling rates.
2) Reducing costs and pursuing specialization could lead to higher recycling rates and contribute to significant quantities of EOL gear being properly managed and recycled.
3) There are uncertainties regarding whether or not there are always going to be enough port reception facilities available for specialization to be worthwhile, but there is a strong possibility that effective cooperation could be achieved with sufficient research and communication.
4) We have not identified many examples of this type of activity, however Steveston Harbour is trying to organize with other facilities to accept their netting for processing.
5) While establishing infrastructure is expensive, it cannot be realistically avoided, and this practice will reduce those costs.

6.5 Challenges/Barriers and Gaps to the Implementation of the Short-Listed Policy Options/Work Practices

6.5.1 Extended Producer Responsibility

- EPR programs can be challenging to implement due to their complexity, the number of stakeholders that are often involved, and uncertainties regarding how the costs of managing a waste-type (such as EOL aquaculture and fishing gear) may compare with the resources that producers may be able to shoulder.
- Existing EPR programs in Canada are often “piggybacking” off of infrastructure investments made by the public over a number of decades, whereas collection/cleaning/deconstruction infrastructure for EOL fishing and aquaculture gear are much less prevalent in Canada – making required capital investment in infrastructure potentially very high.
- Ensuring that the EPR system is organized appropriately will be a significant challenge given the variations in volumes, management costs, and available collection/cleaning/deconstruction and recycling infrastructure currently present in

different areas of Canada (costs will vary both regionally and by equipment type). The EPR landscape is different across Canada, led individual provinces, and a cross-Canada implementation of an EPR program would be different from current EPR programs already operating in Canada.

6.5.2 Find methods (either public, public/private partnerships, or private) to establish facilities at or near harbours and port reception facilities that can accept, clean, and deconstruct EOL gear into its constituent components so that these pure materials streams can be forwarded to recyclers

- There will be no "one-size-fits-all" solution to establishing facilities that will collect/clean/deconstruct EOL fishing and aquaculture gear in Canada – variables include: (i) location and type of gear used; (ii) local labour costs/availability; (iii) downstream recyclers/processors available; (iv) volume of various types of gear to be managed; (v) available space/real estate costs; (vi) distance from downstream recyclers/processors to markets; etc.
- The main examples of facilities that currently collect/clean/deconstruct EOL fishing gear for the purposes of materials separation and transmission to downstream recyclers are located in countries that have lower value currencies and very low labour costs – potentially indicating that the process may be expensive and time consuming.
- While terrestrial MRFs can utilize automated processes (such as scanners and air-jets that separate out various plastics resins) it is less likely for automation opportunities to be present for EOL fishing and aquaculture gear given the diversity of equipment and the potentially complex process of deconstructing this gear.

6.5.3 Encourage fishing and aquaculture gear manufacturers to consider the full lifecycle of their product during the design stage, including prioritizing the use of recyclable materials and ensuring that information on how to deconstruct their products (and what materials their products are made of) are easily available through instruments such as voluntary agreements, codes of practice, or circular design standards

- This will have no impact on legacy gear that is already either in storage or has not yet been retrieved from the water.
- The private sector will not act without some type of financial incentive or penalty, and codes of practice can be ignored.
- Circular design standards are not yet global for EOL fishing and aquaculture gear (they are under development in the EU), and if standards are implemented in Canada some private sector stakeholders may simply choose to stop selling gear into Canada – which could have unforeseen consequences.

6.5.4 Codes of Practice/Guidelines

- Codes of practice/guidelines are most often voluntary, and therefore levels of adoption and levels of compliance amongst those private sector stakeholders that choose to participate will both be uncertain.
- Different codes of practice or sets of guidelines would likely need to be developed for different elements of the fishing and aquaculture sectors given the variety of equipment, management methods, and practices that each individual type of

6.5.5 Voluntary Agreements

- As voluntary agreements are non-binding, there is a higher probability of non-compliance amongst those who have signed the agreements.
- It is unlikely that any voluntary agreements would address any of the main shortcomings of the current EOL fishing and aquaculture gear management systems (most notably lack of infrastructure) – though voluntary agreements could be utilized for supporting actions such as circular design standards.

6.5.6 Pursue Collaboration between Ports and Harbours and Other Entities

- It would require significant study and a very high degree of participation amongst fishers, aquaculture operations, port reception facilities/harbours in Canada, private stakeholders engaged in cleaning/deconstruction of EOL gear, and downstream recyclers in order to appropriately identify synergistic opportunities for the EOL fishing/aquaculture gear management facilities.
- The variety of gear-types in Canada, Canada's dispersed geography, and a potential lack of downstream recycling opportunities for separated/cleaned material may cause there to be relatively few opportunities for synergies and cooperation.
- If cooperation opportunities are identified, shipment will still need to be arranged for certain gear to get shipped to the facilities that are best-suited to handle it, and some EOL fishing gear is large, heavy, and difficult to transport and manage.

7. Bibliography

1. Accessed at the following website (www.seafish.org/responsible-sourcing/managing-end-of-life-fishing-gear-and-aquaculture-equipment/#GovResponse).
2. Accessed at the website of BC Salmon (https://www.bcsalmon.ca/faces-of-bc-salmon-fishing/salmon-trolling-on-the-north-coast-of-british-columbia)
3. Accessed at the website of CBC. Pandemic, low prices blamed for 95% decline in Sask. Commercial lake trout harvest. Reported by Kelly Provost: Accessed at: https://www.cbc.ca/news/canada/saskatchewan/commercial-lake-trout-harvest-1.6278613
4. Accessed at the website of Fishing for Litter (https://fishingforlitter.org/).
5. Accessed at the website of K. Turriff (https://heritagelsl.ca/weir-fishing/)
6. Accessed at the website of MFFP (https://cdn-contenu.quebec.ca/cdn-contenu/peche/documents/PL_gestion_peche_MFFP.pdf?1669405554
7. Accessed at the website of Ministre des Forets, de la Faune et des Parcs from https://cdn-contenu.quebec.ca/cdn-contenu/peche/documents/PL_gestion_peche_MFFP.pdf?1669405554
8. Accessed at the website of Pacific Net and Twine Ltd. (https://pacificnetandtwine.com/collections/ropes)
9. Accessed at the website of Sustane Technologies (https://sustanetech.com/).
10. Accessed at the website of the Cultur et Communications from: https://www.patrimoine-culturel.gouv.qc.ca/rpcq/detail.do;jsessionid=957D88485CD849BDE99CA2D3A3EFFD06?methode=consulter&id=62&type=imma
11. Accessed at the website of the Department of Fisheries and Oceans (https://www.dfo-mpo.gc.ca/fisheries-peches/management-gestion/ghostgear-equipementfantome/what-quoi-eng.html).
12. Accessed at the website of the Department of Fisheries and Oceans (www.dfo-mpo.gc.ca/fisheries-peches/management-gestion/ghostgear-equipementfantome/program-programme/projects-projets-eng.html).
13. Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-eng.cfm?pg=LicReportSelect)
14. Accessed at the website of the Department of Fisheries and Oceans. Fisheries Fact Sheet – Purse Seining. (https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/40842599.pdf)
15. Accessed at the website of the Department of Fisheries and Oceans. Fishing License Statistics – Pacific Region. Commercial License Reports by Fishery (https://www-ops2.pac.dfo-mpo.gc.ca/vrnd-rneb/index-
16. Accessed at the website of the European Committee for Standardisation (https://standards.cencenelec.eu/dyn/www/f?p=205:22:0::::FSP_ORG_ID,FSP_LANG_ID:2981666,25&cs=1B7DB366908D30D6DAF868D3D16CD49A1).
17. Accessed at the website of the Fishing Gear Coalition of Atlantic Canada (https://fgcac.org/end-of-life-fishing-gear-project/).
18. Accessed at the website of Transportation Safety Board of Canada. Marine investigation Report M04W0225 (https://tsb.gc.ca/eng/rapports-reports/marine/2004/m04w0225/m04w0225.html?wbdisable=true)
19. Accessed at the website of Transportation Safety Board of Canada. Marine investigation Report M04W0225 (https://tsb.gc.ca/eng/rapports-reports/marine/2004/m04w0225/m04w0225.html?wbdisable=true)
20. Accessed at website of the Government of Canada Justice Laws Website. Pacific Fishery Regulations, 1993 (SOR/93-54) (https://laws-lois.justice.gc.ca/eng/regulations/SOR-93-54/page-3.html#docCont)
21. Accessed data from Transport Canada, 2022. Vessel Registration Query System at: https://wwwapps.tc.gc.ca/Saf-Sec-Sur/4/vrqs-srib/eng/vessel-registrations/advanced-search
22. Accessed from Saugeen Ojibway Nation at: https://sonfishing.ca/
23. Accessed from the website of Lakefish Net & Twine, 2022: http://www.lakefish.net/about.htm

24. Accessed from the website of Ontario's Sustainable Bait Management Strategy https://files.ontario.ca/ndmnrf-ontario-sustainable-bait-management-strategy-2020-en-2022-03-03.pdf
25. Allen King, pers. comm
26. Aqua-Lit (2020), *Best Practice Factsheets*.
27. Arguello, (2020), *Environmentally Sound Management of Ship Wastes: Challenges and Opportunities for European Ports*
28. BCMCA, 2011 (https://bcmca.ca/datafiles/individualfiles/bcmca_hu_commercialfish_sablefish_trap_atlas.pdf)
29. Brenden, T.O., Brown, R.W., Ebener, M.P., Reid, K., Newcomb, T., 2013. Great Lakes commercial fisheries: historical overview and prognoses for the future. In: Taylor, W.W., Lynch, A.J., J, L.N. (Eds.), Great Lakes Fisheries Policy and Management. Michigan State University Press, East Lansing MI, pp. 339–397.
30. Canadian Aquaculture Industry Alliance Website, *Shellfish – Canadian Farmed Mussels*.
31. CBC News, (2018), *More Than 3 Tonnes of Rope Collected in Wharf Recycling Bins*.
32. Accessed at the website of British Columbia Marine Conservation Analysis – Commercial Fisheries Sablefish (https://bcmca.ca/datafiles/individualfiles/bcmca_hu_commercialfish_sablefish_trap_atlas.pdf)
33. Chedabucto Bay Winter Shrimp Fishing (https://www.youtube.com/watch?v=ZViuyOYqxEI)
34. Church, M. (2020), Garbage Gold: Sustane Converts Curbside Waste into High-Value Biomass Products, published in Canadian Biomass.
35. Dawe, N., Kendall, R.A., Smith, S., and Davis, M., 2021. End of Life Fishing Gear Management in Newfoundland and Labrador. Fishing Gear Coalition of Atlantic Canada. March 31, 2021.
36. Department of Fisheries and Oceans Canada – 4VWX5 groundfish – Maritimes Region. (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/groundfish-poisson-fond/groundfish-poisson-fond-4vwx5-eng.html#toc2)
37. Department of Fisheries and Oceans Canada – Atlantic Herring of the Maritimes Region (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/herring-hareng/2020/index-eng.html).
38. Department of Fisheries and Oceans Canada - Groundfish Newfoundland and Labrador Region NAFO Subarea 2 + Divisions 3KLMNO (https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/groundfish-poisson-fond/2021/groundfish-poisson-fond-2_3klmno-eng.htm#toc1)
39. Department of Fisheries and Oceans Canada – Inshore Scallop – Maritimes Region. Accessed at: https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/scallop-petoncle/scallop-petoncle2015-sec1-eng.html
40. Department of Fisheries and Oceans Canada - Licenses
41. Department of Fisheries and Oceans Canada – Northern Shrimp (SFAs 0-7) and the Flemish Cap, Resource Management Operations (accessed at https://www.dfo-mpo.gc.ca/fisheries-peches/ifmp-gmp/shrimp-crevette/shrimp-crevette-2007-eng.html)
42. Department of Fisheries and Oceans Canada - Notices to Fish Harvesters 4RST Atlantic Halibut and Greenland Halibut 4RST Gaspé fixed gears fleet of 13.71 m and over Gaspé Longliners group and others group_ 2022-2023 season Conservation Harvesting Plan Date of Notice 2022-05-20 (https://www.qc.dfo-mpo.gc.ca/en/4rst-atlantic-halibut-and-greenland-halibut-4rst-gaspe-fixed-gears-fleet-1371-m-and-overgaspe)
43. Department of Fisheries and Oceans Canada - Shrimp (*Pandalus borealis*) - Scotian Shelf - As of 2013
44. Department of Fisheries and Oceans Canada, 2019. Assessment of Northern Shrimp Stocks on the Eastern Scotian Shelf (SFAs 13-15). Maritimes Region Science Advisory Report 2019/013.
45. Department of Fisheries and Oceans Canada, 2019. Scallop Stock Assessment of the Sea Scallop from the Southern Gulf of St. Lawrence to 2016. Canadian Science Advisory Secretariat Science Advisory Report 2019/06.
46. Department of Fisheries and Oceans Canada, 2020. Assessment of Northern Shrimp Stocks in the Estuary and Gulf of St. Lawrence in 2019. Québec Region Science Advisory Report 2020/010.
47. Department of Fisheries and Oceans Canada, 2020. Scallop Stock Assessment in Québec Coastal Waters in 2019. Canadian Science Advisory Secretariat Science Advisory Report 2020/054.

48. Devriese L., et. al. (2019). *Available Tools and Measures. Knowledge Wave on Marine Litter from the Aquaculture Sector*. D2.3. AQUA-LIT Project.
49. DFO, 2007. Plan de Gestion Integree de la Peche du Gaspareau Secteur est du Nouveu-Brunswick Region du Golfe. Accessed at: https://waves-vagues.dfo-mpo.gc.ca/library-bibliotheque/349481.pdf
50. DFO, 2014. Integrated Fisheries Management Plan Cambridge Bay Arctic Char Commercial Fishery, Nunavut Settlement Area. Fisheries and Oceans Canada Central and Arctic Region. Accessed at: https://publications.gc.ca/collections/collection_2016/mpo-dfo/Fs134-22-2015-eng.pdf
51. Ebener, M. P., R. E. Kinnunen, P. J. Schneeberger, L.C. Mohr, J. A. Hoyle, and P. Peeters. 2008. Management of commercial fisheries for lake whitefish in the Laurentian Great Lakes of North America. Pages 99-144 in M. G. Schechter, N. J. Leonard, and W. W. Taylor, editors. International governance of fisheries ecosystems: learning from the past, finding solutions for the future. American Fisheries Society, Bethesda, Maryland.
52. Environment and Climate Change Canada (2021*), Environmental Codes of Practice: Fact Sheet*.
53. European Network of the Heads of Environment Protection Agencies (EPA Network) - Interest group on Plastics – Working paper (2018), Deposit - Return Schemes - Data and figures from 16 member countries of the EPA Network.
54. Fisheries and Oceans Canada, 2021. Assessment of Newfoundland and Labrador Snow Crab. Canadian Science Advisory Report 2021-009.
55. Fisheries and Oceans Canada, 2022. Crab by Trap Fisheries Management Plan 2022/23. 21-2080: 325p.
56. Fisheries and Oceans Canada, 2022. Groundfish Integrated Fisheries Management Plan 2022/23. 22-2125.353
57. Fisheries and Oceans Canada, 2022. Groundfish Integrated Fisheries Management Plan 2022/23. 22-2125.353
58. Fisheries and Oceans Canada, 2022. Pacific Region Integrated Management Plan, Pacific Herring, November 20, 2021 to November 6, 2022. 22-2124:223p.
59. Fisheries and Oceans Canada, 2022. Prawn and Shrimp by Trap Fisheries Management Plan 2022/23. 21-2081: 167p
60. Fisheries and Oceans Canada, 2022. Scallop by Trawl Fisheries Management Plan 2022/23. 22-2133: 79p
61. Fisheries and Oceans Canada, 2022. Shrimp Trawl Fisheries Management Plan 2022/23. 21-2709: 215p.
62. Fishing Gear Coalition of Atlantic Canada (undated), Fate of ALDFG Knowledge in Canada.
63. Florida Department of Agriculture and Consumer Services (2021), *Shellfish Aquaculture Gear Management*.
64. Galappaththi, E.K., Ford, J.D., and Bennett, E.M., 2019. Climate Change and Community Fisheries in the Arctic: A Case Study from Pangnirtung, Canada. Journal of Environmental Management, 250. Accessed at: https://eprints.whiterose.ac.uk/153433/3/Manuscript-Revised_Final_August%2005.pdf
65. GESAMP, 2021. Sea-Based Sources of Marine Litter. Rep. Stud. GESAMP No. 108. (IMO/FAO/UNESCO-IOC/UNIDO/ WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection.
66. Global Ghost Gear Initiative (2021) *Best Practice Framework for the Management of Aquaculture Gear*. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. for GGGI. 81 pp. plus appendices.
67. Global Ghost Gear Initiative (2021) *Best Practice Framework for the Management of Fishing Gear*: June 2021 Update. Prepared by Huntington, T. of Poseidon Aquatic Resources Management Ltd. 94 pp plus appendices.
68. GNT (Government of Northwest Territories), 2018. Economic Opportunities Strategy, Performance & Measures Report 2016-2017. Accessed at: https://www.iti.gov.nt.ca/sites/iti/files/12953_gnwt_iti_eos_report-final_web.pdf
69. Goodman, A.J., Brillant, S., Walker, T.R., Bailey, M. and Callaghan, C., 2019. A Ghostly Issue: Managing abandoned, lost and discarded lobster fishing gear in the Bay of Fundy in Eastern Canada. *Ocean & Coastal Management*, *181*, p.104925.

70. He, P., & Suuronen, P. (2018). Technologies for the marking of fishing gear to identify gear components entangled on marine animals and to reduce abandoned, lost or otherwise discarded fishing gear. *Marine Pollution Bulletin*, *129*(1), 253–261. https://doi.org/10.1016/j.marpolbul.2018.02.033
71. Hillier, C.J., Gueret, D., Butterfield, S., and Pellegrin, N., 2007. Fish Harvesting Activities within the Proposed Gwaii Haanas National Marine Conservation Area. Fisheries and Oceans Canada. Report for Fisheries and Aquatic Sciences 2803: vi+65p.
72. Hipólito, C., Vale, M., Devriese, L. and Paramio, L. (2020). *Policy Recommendations to Tackle Aquaculture Debris*. Deliverable 5.1., developed by FRCT under the AQUA-LIT Project.
73. Huntington, T (2019). *Marine Litter and Aquaculture Gear – White Paper*. Report produced by Poseidon Aquatic Resources Management Ltd for the Aquaculture Stewardship Council.
74. Hurley, I., Wringe, B.F., den Heyer, C.E., Shackell, N.L. and Lotze, H.K., 2019. Spatiotemporal bycatch analysis of the Atlantic halibut (Hippoglossus hippoglossus) longline fishery survey indicates hotspots for species of conservation concern. *Conservation Science and Practice*, *1*(1), p.e3.
75. Hurtubise, J., 2016. Evolution of subsistence and commercial Inuit fisheries in the Territory of Nunavut, Canada: Research and summation of landings, quotas, gear type, significance, use and status of hunted marine species. (Marine Affairs Program Technical Report #14). Available at Marine Affairs Program: http://www.dal.ca/faculty/ science/marine-affairs-program/research/research-news/map-technical-series-reports.html
76. Hussey-Bondt, L., 2015. Management of the Amercian Eel Fisheries in Canada. Presentation. Fisheries and Oceans Canada – Maritimes Region. Accessed at: http://www.sargassoseacommission.org/storage/Hussey_Bondt_Canadian_Eel_Management_LHB_Oct_2015.pdf
77. International Pacific Halibut Commission, 2014. The Pacific Halibut: Biology, Fishery, and Management. Technical Report No. 59. (https://www.iphc.int/uploads/pdf/tech0059.pdf)
78. Interview with AIM Recycling, October 17, 2022.
79. Interview with Enviroculture, November 29, 2022.
80. Interview with Mac's Oysters, December 23rd, 2022.
81. Interview with Pacific Carpet Recycling (October 18, 2022)
82. Interview with Ross and Sons, October 31, 2022.
83. Interview with Sustane Technologies (October 20th, 2022).
84. Interview with the Fishing Gear Coalition of Atlantic Canada, October 17, 2022.
85. James, Dr. Lesley et. al. (2022), *Recycling Solutions for End-of-Life Fishing Rope in Newfoundland*, prepared for The Leslie Harris Centre of Regional Policy and Development, Memorial University.
86. James, Dr. Lesley et. al. (2022), *Recycling Solutions for End-of-Life Fishing Rope in Newfoundland*, prepared for The Leslie Harris Centre of Regional Policy and Development, Memorial University
87. Johnson, K. (2020), Ghost Gear Fishing Project First of its Kind in Nova Scotia, published by Saltwire.
88. Klein, G. and Galbraith, W., 2017. Waterhen Lake Fisheries Management Plan. Wildlife & Fisheries Branch Report 2017-01 Province of Manitoba.
89. Lake Winnipegosis Fishery on a Path to Stock Recovery. Accessed at: https://www.gov.mb.ca/nrnd/fish-wildlife/pubs/fish_wildlife/fish/lake_winnipegosis_fishery_summary.pdf
90. Landbell Group (2020), *Extended Producer Responsibility Schemes – What Role for Fishing Gear Producers*.
91. Landbell Group (2021), *Another Country Introduces EPR for Fishing Gear*.
92. Macfadyen, G., Huntington, T., Cappell, R., 2009. Abandoned, lost or otherwise discarded fishing gear. UNEP Regional Seas Reports and Studies 185. FAO Fisheries and Aquaculture Technical Paper 523., Aquaculture.
93. Manitoba, 2022b. Lake Winnipegosis Fishery A Fishery on the Road to Sustainability. Accessed at: https://www.gov.mb.ca/nrnd/fish-wildlife/pubs/fish_wildlife/fish/lake_manitoba_fishery_summary.pdf
94. McCarron, P. and Tetreault, H., 2012. Lobster pot gear configurations in the Gulf of Maine. (https://www.bycatch.org/sites/default/files/Lobster_Gear_Report_0.pdf)
95. Mengyu, B. Lihui, A. Guyu, P. & Daoji, L. 2018. Estimation and prediction of plastic waste annual input into the sea from China. Acta Oceanologica Sinica, 37(11): 26-39, doi: 10.1007/s13131-018-1279-0.

96. Michaels, S., Brost, B., Mattes, W.P., 2013. Reducing the Incidental Catch of Lake Trout in Large-mesh Gillnet Fisheries for Lake Whitefish. Great Lakes Indian Fish & Wildlife Commission. Project Report 13-2. Accessed at: https://glifwc.org/Fisheries/GreatLakes/Modified%20Gill%20Net%20Study.pdf
97. More information on EPR programs is provided earlier in this chapter.
98. Morecambe Metals (undated), *How do Scrap Metal Shredders Work?*
99. Morrison Hershfield (2020), *Sustane Technologies Chester Facility – Status Update*, prepared for Comox Strathcona Waste Management.
100. NRC, 2017. Internal document on fisheries and submarine cable interactions along Pacific Coast of North America.
101. NRC, 2021. Predictive model identifying locations of fishing gear loss or accumulation in Lake Erie, Canada. Prepared for: Ocean Conservancy
102. Ocean Legacy Website, *About*.
103. OMNRF, 2020
104. Ong, S., Levings, C.D., Sutherland, T.F., Piercey, G.E., Keong, G.E., and Davis, R. 2002. Data Record on Trawling and Trapping Effects on Humpback Shrimp and Bycatch Organisms in Simoom Sound and Northhumberland Channel, British Columbia. DFO Science Branch – Pacific Region.
105. Online Video: *Aquadocs – Oyster Farm in British Columbia: Mac's Oysters*, Accessed December 23rd, 2022.
106. Poseidon Aquatic Resource Management (2021), *Best Practice Framework for the Management of Aquaculture Gear*, prepared for the Global Ghost Gear Initiative.
107. Roy, P. & Yaakoubi, A. 2021. Using material flow analysis (MFA) to track the mass plastics in aquaculture gear in the Region of Møre and Romsdal. Master's thesis, Norwegian University of Science and Technology. 79 pp.
108. SAI Global, 2021. Lake Erie Multi-species Commercial. Public Certification Report. Marine Stewardship Council fisheries assessment. 04 January 2021.
109. Sherrington, C., Darrah, C., Hamm, S., Cole, G. & Corbin, M. 2016. Study to support the development of measures to combat a range of marine litter sources. Prepared by EUNOMIA Ltd for the European Commission DG Environment. 429 pp.
110. Sundt, P., Schlze, P-E., & Syversen, F. 2014. Sources of microplastics-pollution to the marine environment. Presentation to the Nrowegian Environment Agency (Miljødiredktoratet). 108 pp.
111. Tallman & Frieson, 2007
112. Tian, Y., Zongyao, Y., Xueying, Y, Zhen, J., Rosso, M., Dedman, S., Zhu, J., Xia, Y., Zhang, G., Yang, J. & Wang, J. 2022. Can we quantify the aquatic environmental plastic load from aquaculture? Water Research. 219(2022) 118551, doi: 10.1016/j.watres.2022.11851.
113. Transport Canada, 2022. Vessel Registration Query System.
114. Transportation Safety Board of Canada Marine Investigation Report M99C0048. Accessed at: http://tsb.gc.ca/eng/rapports-reports/marine/1999/m99c0048/m99c0048.html
115. Treble, M.A. and Stewart, R.E.A., 2010. Impact and Risks associated with a Greenland Halibut (*Reinhardtius hippoglossoides*) gillnet fishery in inshore NAFO Subarea 0. DFO Canadian Science Advisory Secretariat Research Document 2010/032.
116. What is Circular Design (Accessed at www.foolproof.co.uk/journal/what-is-circular-design/).