

A Ghostly Issue: Managing abandoned, lost, and discarded lobster
fishing gear in the Bay of Fundy

By

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Abstract

Abandoned, lost, and discarded (ALD) fishing gear contributes to economic losses across fisheries and can be a significant hazard to marine mammal conservation and safety at-sea. Lobster fishers (n = 32) and management agencies (n = 5) were interviewed from the Bay of Fundy in the Scotia-Fundy Region to determine how to estimate and mitigate ALD fishing gear. Results show that fishers across all lobster fishing areas (LFAs) regularly lost gear and that it was not always retrieved, although fishers informally notify each other of gear that was lost and often returned gear that was found. Fishers will, however, avoid retrieving old gear that is unidentifiable, because possession of this gear is prohibited by their licenses. New regulations to manage ALD are expected in the coming years, but through these interviews, regulatory and community-based solutions were identified that can potentially help estimate and mitigate ALD fishing gear.

Keywords: lobster; Bay of Fundy; fishing gear; ghost gear; marine debris; fisher; community-based management; decision-making; fisheries management.

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List of Abbreviations

ALD	Abandoned, lost, and discarded
DFG	Derelict Fishing Gear
DFO	Department of Fisheries and Oceans
HES	Human-Environment System
LFA	Lobster fishing area
NOAA	National Oceanic and Atmospheric Administration
PVC	Polyvinyl chloride

CHAPTER 1 – Introduction

The commercial fishing industry uses large quantities of gear during each fishing season to support their practices, where gear may often end up abandoned, lost, or discarded at-sea for various reasons (Macfadyen, Huntington, & Cappell, 2009; National Oceanic and Atmospheric Association Marine Debris Program, 2015). Fishing gear is comprised of a combination of materials that are designed for longevity, such as plastic monofilament for longlining and vinyl coated-steel lobster traps, where the exact materials and gear quantities vary among fisheries (NOAA Marine Debris Program, 2015; Macfadyen et al., 2009). Depending on how the gear was lost, it can leave little to no trace at-sea but may last for over 100 years in the environment (NOAA Marine Debris Program, 2015; Gilman, Chopin, Suuronen & Kuemlanguan, 2016). Shoreline cleanups have provided information on the types of debris that frequently wash up along beaches, but estimating the amount abandoned, lost, and discarded (ALD) fishing gear that remains in the water is difficult because of low visibility, challenging underwater terrain, and lack of recorded information (David, 2016). This makes quantifying lost gear problematic and creates difficulties in estimating the impacts (Stevenston Harbor Authority, 2016; Ackman, 2016). Marine debris, namely plastics, is a growing issue worldwide and is the largest pollutant to our oceans (Walker, 2018). Although the majority of marine debris originates from land-based sources, fishing gear is contributing to the problem, making up 46 to 70% of all macro debris (Galgani, Hanke & Maes, 2015; GGGI, 2018). This project will solely focus on estimating and mitigating abandoned, lost and discarded lobster fishing gear in the Bay of Fundy.

CHAPTER 2 – Abandoned, Lost, and Discarded Fishing Gear At-Sea

2.1 – Ghost Gear vs. Derelict Fishing Gear

Fishing gear that is abandoned, lost, or discarded, either intentionally or unintentionally, can be classified in two ways once it enters the environment: ghost gear and derelict gear. Gear that continues to catch both target and non-target fish species indiscriminately is referred to as ghost gear because the gear is no longer being controlled by the fisher although it continues to catch species (Macfadyen et al., 2009). Ghost fishing can continue from days to years depending on the durability and construction of the gear, and large numbers of fish can be caught by the gear over long periods of time including species that are commercially valuable or threatened

(Macfadyen et al., 2009; NOAA Marine Debris Program, 2015). Alternatively, the gear may not continue to function as a harvesting mechanism and is referred to as derelict fishing gear (DFG). Derelict fishing gear can still be a threat to wildlife because of the potential to damage habitat and entangle other species such as marine mammals. The distinction between ghost gear and DFG is relevant because they imply different effects, and both are cause for concern among different users of the marine environment. For example, a fisher may be more concerned with gear that is ghost fishing as it could potentially contribute to future decreased catches, where a cargo ship captain may be more concerned with derelict rope as it may cause a navigational hazard.

2.2 – Vectors of Generation

Knowing the exact cause of gear loss in a given situation is challenging because losses often occur unseen or are unrecorded. The identified conditions that result in gear remaining at-sea include unfavorable environmental conditions, gear conflicts, poor gear condition, and inappropriate disposal at-sea (NOAA Marine Debris Program, 2015). These factors rarely stand alone, and may work together, in that combined effects are more powerful and are more likely to occur.

Environmental Conditions

Unfavorable environmental conditions include storms, high intensity wave action, currents, and various oceanographic features, such as tides, currents, bathymetry, and sea-floor characteristics (NOAA Marine Debris Program, 2015). Storms and wave action create rough conditions at-sea, which can damage or sever the gear, which can lead to loss (NOAA Marine Debris Program, 2015). Once gear is lost, tides can push it back and forth, where surface and deep-sea currents can transport it large distances (Macfadyen et al., 2009). It should be noted that tides and currents may not be the direct cause of gear loss but may add an additional pressure. For example, flood and ebb tides can create large, complex tangles of rope and gear (often referred to as snarls), and one lost trap can snag another, creating a snowball effect of lost gear (Recchia, M., pers. comm., February 1st, 2018). Depending on a location's bathymetry and sea-floor characteristics, gear could become snagged along seafloor terrain, where friction or chaffing can damage the gear, causing losses. Large marine mammals may also contribute to gear loss, because if the animal cannot see or sense gear in the water it may become entangled, which could displace the gear (Johnson et al., 2005).

Gear Conflicts

Gear conflicts include entanglement with gear from other fish harvesters or with vessels (NOAA Marine Debris Program, 2015). If a boat passes over gear that has been set with a surface buoyline, the gear may become severed by the propeller (Figure 1). In some cases, intentionally cutting (vandalism) can cause gear loss (Beswick, 2018). In areas of high competition among fishers, congestion of gear is likely, which can lead to losses if gear is set too close or on top of each other. For example, when lobster trawls are set on top of each other there is risk of losing gear because when one trawl is brought up to the surface (hauled up) it could sever another trawl.

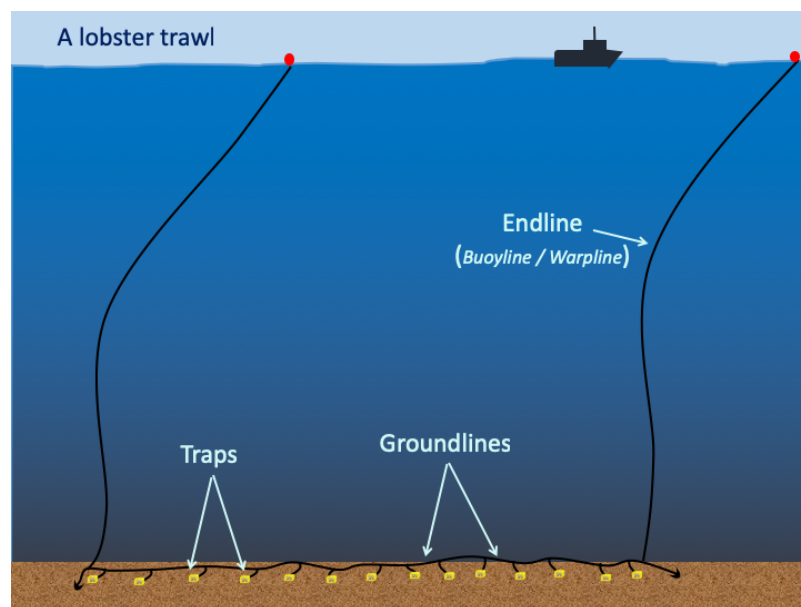


Figure 1. Lobster trawl configuration. The number of traps per trawl can range from 3-30 (Sean Brilliant, 2018).

Poor Gear Condition

If fishing gear is in poor condition, it could break loose or get cut easily, either accidentally or deliberately (NOAA Marine Debris Program, 2015).

Inappropriate Disposal At-Sea

Inappropriate disposal of fishing gear at-sea refers to the abandonment of old or unwanted gear into the oceans (NOAA Marine Debris Program, 2015; Ackman, 2016). This is done with intent by the fisher, as disposal at sea is seen as a ‘convenient’ method in comparison to land-based disposal, where some fishers believe that partly dismantling the gear reduces the environmental impact and creates habitat for some species (Ackman, 2016). This is misinformed as at-sea

disposal is considered to have negative impacts on wildlife and habitats (Ackman, 2016; NOAA Marine Debris Program).

2.3 – Harmful Effects

Abandoned, lost, and discarded fishing gear can affect marine wildlife and habitat, contribute to monetary losses, and create vessel navigational hazards (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015). Impacts to both humans and the environment, in the short and long term, vary among fisheries and gear type, but negative effects can be expected nonetheless.

Ecosystem Health

Ghost fishing and DFG affect ecosystem health negatively by impacting marine life and habitat (NOAA Marine Debris Program, 2015). For example, gear that covers a large area may smother marine species, such as corals, and the seafloor. Physical damage to the ocean floor habitat is also likely, as gear can be dragged by currents and storms, destroying the benthos in its path (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015). When gear remains uncontrolled in the marine environment for long periods of time, it increases the risk of entanglement or ingestion by seabirds, turtles, seals, marine mammals, and both target and non-target fish species, some of which are species at risk (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015). Ghost fishing impacts can persist for long periods due to a process known as ‘self-baiting’; species entrapped within the gear die and form new bait, which then attracts scavengers, who then become entrapped and die themselves. Ghost fishing may also persist for long periods of time as once the gear has lost all captured animals, it can regain its functional shape and continue ghost fishing in an endless negative cycle (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015).

DFG also degrades the environment, contributing to marine litter. As larger pieces of plastic debris get broken down over time into smaller fragments, called microplastics, they can leach toxic particles into the food chain (NOAA, n.d.). These particles can be lethal to marine life as they are indigestible, which can compromise internal organs, or can lead to other serious implications. For example, in crustaceans like lobsters, alkylphenols, such as bisphenol A (BPA) present in the PVC coating on lobster traps, interferes with natural hormone production and disrupts endocrine function which can cause shell disease (Laufer, Baclaski & Koehn, 2012). Shell disease caused by alkylphenols interferes with molting patterns by slowing natural cycles, which

can reduce growth, cause lobsters to molt while carrying eggs, a process that kills potential offspring and is toxic to lobsters at low concentration levels (Laufer, Baclaski & Koehn, 2012). Since the 1980's, lobster traps are made of wire mesh coated in polyvinyl chloride (PVC), which contains alkylphenols (The Lobster Trap Company, n.d.; Alonso-Magdalena et al., 2018). This is problematic because traps left at-sea will break down, leaching these toxic chemicals into the food chain, contaminating the environment and subsequently lobsters too, which could lead to future decreased catches.

Monetary Losses

Ghost fishing often occurs in and near commercial fishing areas. This means that commercially valuable species are likely to be impacted and caught by ghost gear, reducing potential profit from fishers through decreased catch rates (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015). Replacing lost gear can be quite expensive, furthering the financial burden of losing gear (NOAA Marine Debris Program, 2015). Exact monetary losses are hard to estimate, because they vary among fisheries and gear type, but can be expected nonetheless (Macfadyen et al., 2009; NOAA Marine Debris Program, 2015).

Navigational Hazard

Abandoned, lost, and discarded fishing gear also pose hazards to navigation, as gear can get tangled in propellers, propeller shafts, rudders, jet drives or water intakes, and can snarl anchors (Macfadyen et al., 2009; California State Parks, 2017). This leads to safety-at-sea concerns from reduced vessel stability or maneuverability (Macfadyen et al., 2009). Each year, vessel damage from DFG costs thousands of dollars in repair and replacement fees and decreases time spent fishing as the boat must remain on land during repairs (Macfadyen et al., 2009; California State Parks, 2017) Therefore, it furthers monetary losses from direct damages as well as from as reduced fishing time from being dry-docked.

CHAPTER 3 – Context Within the Maritimes

3.1 – Lobster Fisheries

The lobster industry in Atlantic Canada has become the most commercially valuable fishery in Canada, as it contributes to roughly one-third of all fishery exports by value, where inshore fishing operations are now almost entirely exclusive to lobster (Government of Canada,

2017; Macnab, 2002). Lobster fisheries are very competitive, and fishers are likely to operate out of self-interest for short term economic gain, where fishers seek to maximize their profit margins (Davis, Whalen & Neis, 2006). The industry is managed by Fisheries and Oceans Canada (DFO) and has around 10,000 licenced holders over 45 management areas referred to as lobster fishing areas (LFAs; DFO, 2008; DFO, 2018). Each LFA has varying numbers of licence holders that operate under licence conditions specific to each LFA (DFO, 2015; Davis, Whalen & Neis, 2006). Although fishers are permitted to fish anywhere within their licensed LFA, social agreements usually determine their specific fishing grounds within the fishing area.

3.2 – Political Landscape & Legal Backing

When traps are lost, DFO requires that fishers record the lost trap tags in their “Record of Fishing Gear Tags” form kept on board the vessel. This information is used to prove which traps are validly tagged if boarded by a conservation and protection officer. Other information regarding lost gear is expected to be reported to tag suppliers according to the respective LFA license conditions and tag replacement policies. Tag suppliers act as intermediaries between the DFO and fishers, recording lost tags and tag replacements for effort monitoring. Only some of this information, such as license and tag number(s), gets passed along to DFO through a data entry spreadsheet. This has excluded any information regarding gear loses and retrievals, because, until recently, it has been outside of their mandate. As of 2019, all LFA licence conditions will require that lost gear be reported to DFO, and not just recorded onboard the vessel (Quigley, S., pers. comm., November 13st, 2018). Prior to this change in Conditions of Licence, DFO only collected tag replacement information to monitor fishing effort.

From a legal perspective, the Canadian Code of Conduct for Responsible Fishing Operations has guidelines that all lost gear should be reported, and its removal should be attempted if possible, but this may not always happen in practice (Government of Canada, 1998). The Fisheries Act (1985) outlines measures for the conservation and protection of fish and habitat, where section 35(1) states: “No person shall carry on any work, undertaking or activity that results in serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery”. In terms of removing gear, section 25(2) states: “Subject to the regulations and subsection (3), any person who places or sets any fishing gear or apparatus in any water, along any beach or within any fishery shall remove it when the gear or apparatus is not being tended and prior to the commencement of a close time.” Thus, furthering the claim that gear

loss remaining at-sea must be reported, in order to gain more information on the environmental impacts and to coordinate future removal efforts. The *Vessel Pollution and Dangerous Chemicals Regulations* under Canada's Shipping Act (2001) state that "accidental loss" of waste or dumping as a result from "damage to a vessel" is permitted (Section 5), but intentional dumping of fishing gear is prohibited at-sea, which is reinforced under the Canadian Environmental Protection Act (1999) (Permits for disposal – sections 122 to 136).

3.3 – Bay of Fundy Site Overview

The Bay of Fundy is a unique estuarine embayment located between Nova Scotia and New Brunswick and is an extension of the Gulf of Maine. The geomorphology was shaped during the quaternary deglaciation period, which created moraines and drumlins both in and out of the water (Parrott et al., 2008). The Bay of Fundy is known globally for its diverse marine life and for having the world's highest tides, which has a maximum tidal range of roughly 16 meters at the Basin Heads (Parrott et al., 2008). These high tides are caused by the funnelling effect, where the rapid change in seafloor depth towards the Basin Heads compresses the water laterally, which creates dramatic tidal ranges (Parrott et al., 2008). The Bay of Fundy has a resonant period of approximately 13 hours, where 160 billion tonnes of seawater get displaced with each tide (Parrott et al., 2008). The volume of water displaced twice daily is greater than "the combined flow of the world's freshwater rivers" and the tidal flow is powerful enough to generate electricity (Todd & Shaw, 2009).

There are several important fisheries in the Bay of Fundy such as lobster, scallops, groundfish, mackerel, and herring (DFO, 2018), and many other ocean-industries (e.g. aquaculture, eco-tourism, energy generation, shipping). There are five LFAs in the Bay of Fundy (LFAs, 34-38). As a result of the various intense conditions of the Bay of Fundy (oceanographic, hydrodynamic, human activities), loss of fishing gear is not uncommon (DFO, 2015).

3.4 – Knowledge Gap & Uncertainty

Limited data and information exists regarding the amount and effect of ALD lobster fishing gear in the Bay of Fundy, and Maritimes more generally. This is attributed to a lack of recorded information on where and how gear is lost at-sea, and because it has not been widely studied. As a result, the effects of ALD lobster gear, negative or positive, are mostly unknown.

3.5 – Project Context

The purpose of this project was to determine what management methods can be used in the Bay of Fundy’s lobster fishery to accurately estimate and mitigate the amount of abandoned, lost, and discarded lobster gear that remains at-sea. This project focused specifically on areas 34, 35, 36 & 37 (Figure 2).

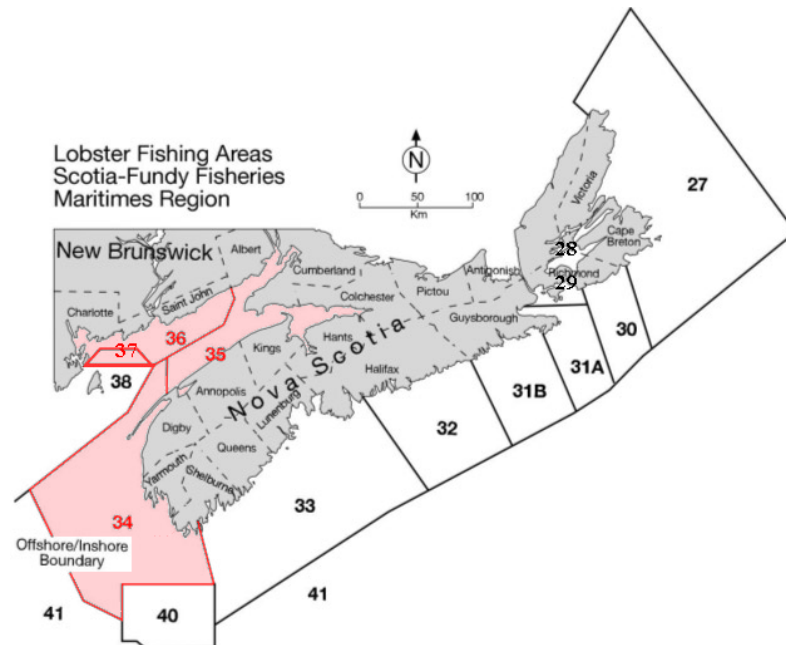


Figure 2. A map of the lobster fishing areas included in this project: areas 34, 35, 36 and 37 (Map produced by Gary Pardy).

CHAPTER 4 – Methodology

In-person interviews were conducted with 32 fishers and 5 management agencies from lobster fishing communities on each side of the Bay of Fundy in LFAs 34, 35, 36 and 37, where participants were selected by referral (Appendix A). Interviewees were provided with information about the study prior to the interview. The interviews ranged from 30 minutes to 1 hour in duration and were recorded and transcribed afterwards. The interview questions were a mix of closed and open-ended questions related to the research questions and were targeted to each stakeholder group being interviewed (Appendix B1 and B2). The participants signed a consent form to ensure that the research conditions and their participation were clearly understood and that privacy would be maintained. The answers were coded to assist with interpreting the results. Answers to each question were categorized and each category was then quantified according to LFA and by stakeholder group. These categorical responses were compiled and presented by percentage.

Quotes recorded from the interviews were included to supplement the answers to ensure that the qualitative information was retained.

CHAPTER 5 – Results

5.1 General Background Information & Monitoring and Reporting Questions

Of the fishers interviewed for this study, 29 were active licence holders and three were retired (Appendix A). Fishers are able to hold licences in multiple LFAs and can hold multiple licences within the same LFA (i.e. stacked). Fisher with stacked licenses have a reduction in allowable traps. As a result, although 32 individual fishers were interviewed, the number of representatives examined among different LFAs was 39, because seven individuals fished in more than one LFA. For these representatives, each individual was asked to respond separately for each of the LFA in which he fished. As a result, some tables show more than 39 responses (where individuals could provide multiple responses).

The average experience of the fishermen that were interviewed was substantial, averaging 36.34 years (Appendix A). For management agencies, average experience was determined by the number of years working for the stakeholder group; 17.33 years for DFO participants and 12 years for fishing association participants.

There is no clear estimation as to how much gear is lost and remains at-sea, but it is low in proportion to the total number of traps per licence holder. Fishermen stated that similar amounts of gear are lost within the same LFA but could not estimate an average loss. This is because gear is sometimes only lost temporarily, as it may be found later in the season or is returned by other fishermen. When fishers were asked about their average gear loss, they stated that gear loss varied by: fishing experience, specific fishing locations, gear configurations, rope length, and temporality (seasonally).

All interviewed fishers reported that they have lost gear. Although fishers reported losing many parts of their gear (trap, rope, buoy, ect.), this varied by LFA. The trap was the most common part of gear that was reported lost (Appendix A). The causes for these losses varied widely (Table 1). Although conflicts with other industries and congestion with other fishing operations were the most common identified cause of lost gear, this varied across LFAs.

Table 1. Reported causes for gear loss among LFAs. Conflicts with other industries include: shipping, energy, aquaculture, mobile fishing fleets, and ferries. Reports included in the category Miscellaneous included water movement (includes tides and currents), weather, human error and trees.

LFA	Conflicts with other industries	Chafing/Burnt off & Congestion	Bottom Conditions	Gear Condition	Miscellaneous	Total
34	2	6	2	0	6	18
35	3	1	1	2	0	11
36	7	7	4	3	0	24
37	2	4	3	2	0	12
Sum	14	18	10	7	6	65
Percentage	22	28	15	10	9	101

A large number of interviewed fishermen (n = 36) reported that they had lost gear returned (often or sometimes), but very few (n = three) reported that they never have gear returned (Appendix A). Common explanations provided by fishermen for why lost gear is never returned include not knowing where the gear went (e.g. if it had been towed and moved to a different location), and because the unlikely ability to find single traps without rope attached to it. Thirteen percent of fishers reported that they often get their gear returned back to them by other lobster fishers or from scallop fishers. When lost gear was recovered, the most common means of doing this was by the fisher grappling for the lost gear. Other answers included dragging the gear up with an anchor, by resetting gear in the location gear was lost and getting the two sets entangled (i.e. self-snarled), and by being returned by others (Appendix A).

Across all LFAs, 62% of fishermen stated that they record the location where they lost gear and have been unable to retrieve it, but 95% of fishers said they do not report their losses to management bodies (Appendix A). Almost all fishers (n = 38) interviewed reported finding gear that was not their own while fishing (Appendix A). Many fishers (n = 12) indicated that when discovering lost gear, the condition of the gear is indicative of how long it was in the water (i.e. the ‘age’), and nine of the fishers indicated that lost gear is found very often (i.e. daily basis, regularly, all the time). The majority of fishers (75%) indicated that they discover lost gear because it gets entangled in their own gear or anchor (Appendix A). Lobster gear was the type of lost gear that was most commonly discovered (65%), although other types of gear have also been discovered, such as gillnet, cable, and portions of groundfish and scallop trawls (Appendix A).

It was most commonly reported that extremely large (i.e. jumbo) lobsters were mostly commonly found in ALD lobster traps (Table 2), but many interviewed fishers indicated that most fish caught within these traps will not be seen as by-catch when lost gear is found, because they create bait for lobsters either already trapped within or attract new lobsters who then become entrapped themselves. This ‘self-baiting’ cycle was indicated by five fishers. Other comments included that the escape hatch is too small for larger lobsters to escape (n = seven), and that lost lobster traps create habitat (n = three).

*Table 2. Types of marine life found as by-catch or present on lost gear found by fishers in each LFA. Note that multiple responses for each fisher were possible. *The category for human harm caused by lost gear was only reported by 2 fishers from LFA 35 and made up 3% of all responses and was therefore excluded from the table.*

LFA	Nothing caught - Escape hatch works	Lobsters (jumbo)	Barnacles/ov ergrown/ ‘grassed up’	Fish (Redfish, Sculpin & groundfish)	Echinoderms (urchins, starfish, ect.), crabs and bivalves (mussels, scallops, and oysters)	Total
34	9	6	3	2	1	21
35	2	2	0	0	1	7
36	2	11	5	2	3	23
37	1	6	3	2	2	14
Sum	14	25	11	6	7	65
Percentage	22	38	17	9	11	100*

Most fishers indicated that there are ‘hotspots’ of areas where gear is lost and found more often than others (76%; Appendix A). Some fishers identified areas specific within their LFAs:

- In ferry traffic lanes (Saint John to Digby, Deer Island and Grand Manan)
- Near harbours, especially Saint John
- Along LFA boundaries (‘lobster lines’)
- Debris zones in areas of river input (LFA 35)
- Spruce Island Point (LFA 36)
- Fairway buoy off Bliss Point (LFA 36)
- Wolves Banks (LFA 36 and 37)
- Cod Hole (LFA 36)
- Cape Spencer off Cossem Cove (LFA 36)
- “Lurchers” (German Bank; LFA 34)
- Seal Island (LFA 34)
- Grand Passage, Cape Saint Mary’s, “The Dump” (LFA 34)

The reasons for more frequent gear loss in the areas varied widely, but many fishers indicated that these reasons acted in combination (Table 3). Traffic, bottom conditions, and water depth were the most common reasons for loss.

*Table 3. Causes for areas having frequent gear loss. Multiple reasons could be expressed by each fisher, including that causes can act in combination. * Note that only one fisher from LFA 34 expressed human error (accidental) as a reason representing 2% of all responses and was therefore excluded from the table.*

LFA	High traffic between industries	Congestion	Storms	Bottom conditions	Water depth	Tides	River input	Trees	Combination	Total
34	7	5	6	7	5	5	0	0	7	43
35	3	1	0	0	1	1	0	1	0	8
36	8	4	0	5	9	9	1	2	5	43
37	5	2	0	4	4	4	4	1	4	28
Sum	23	12	6	16	19	19	5	4	16	122
Percentage	19	10	5	13	16	16	4	3	13	101*

While most fishers (54%) would consider meeting with others to map out additional lost gear hotspots, 41% said no, and 5% said maybe (Appendix A). Comments related to this included:

- No point because gear loss is everywhere
- Fishermen already know where gear is lost, no point in meeting to talk about it
- Might not be useful information if everyone says the same areas
- Fishermen might not want to meet
- Would be useful and give interesting information
- Could happen at board meetings
- Use technology to map lost gear: digital maps have finer levels of detail, use of side scan sonar

There were nearly equal proportions of fishers in each LFA that either always or did not always retrieve lost gear at-sea (Table 4). Fishers who leave gear they encountered at-sea stated they do so for several reasons: it is illegal according to their licence conditions; the traps are old and not good for anything; or because the gear is in good enough condition that it may not be abandoned, and the owner may be returning for it. This latter reason was a commonly reported situation for LFA 37, because this LFA is a highly congested area, shared between SWNB and Grand Manan, which may explain why cooperation to return gear is not always a given.

Table 4. Number and percentage of fishers who stated whether or not they always retrieve lost gear in each LFA.

LFA	Always retrieve old gear		Don't always retrieve old gear		Total number of fishers per LFA
	Sum	Percentage	Sum	Percentage across individual LFA	
34	3	20	12	80	15
35	3	60	2	40	5
36	7	54	6	46	13
37	5	83	1	17	6
Total sum and percentage across all LFAs	18	46	21	54	39

According to DFO's regulations under Schedule 1 of license conditions, it is illegal to have invalid gear on board a vessel that is either not your own or that is not validly tagged during lobster season. Additionally, under Atlantic Fishery Regulations, having lobster gear on board a boat outside of lobster season is illegal (Minister of Justice, 2018). With respect to both regulations, fishers stated:

- The DFO should change their policy because "some people leave gear [at-sea] because of it" (F13)
- "There needs to be a better and easier way to bring gear in. People don't want to deal with DFO for retrieval, it's too complicated" (F17)

Many fishers reported that they do not retrieve old gear because it creates habitat when it is left partially dismantled without heads (netting) and doors: "you're creating, on a very small scale, an artificial reef" (F05). On the contrary, some fishermen expressed they always retrieve lost gear because of the implications to the fishery: "I tend to not leave it there for obvious reasons, like the expense of the gear and replacing it...and one good part about retrieving lost gear is that you can release the jumbos" (F19). If the gear is identifiable some fishers will try to return it to the owner by talking to others (over VHF, cell phone or at wharf) to arrange for the gear to either be reset at-sea, dropped off at wharf, or another method specified by the owner on a per-case basis.

Most fishers (97%) stated that they do not report losing gear unless it is for a tag replacement or to identify the owner of the lost gear (Table 5). Other comments included: reporting is "just a bunch of paperwork... it's foolishness and not worth the hassle" (F18), and that the information that is recorded on gear loss does not get relayed from tag suppliers to the DFO. Although, most fishers (90%) stated that they communicate where they have lost gear to other

fishers in their area, either over VHF radio, cell phone or in-person (i.e. at the wharf) (Appendix A).

Table 5. Percentage of fishers who stated whether or not they report gear losses and finds to management bodies in each LFA.

LFA	Always reporting losses		Don't report losses and finds beyond replacement tags and identification		Total number of fishers per LFA
	Sum	Percentage across individual LFA	Sum	Percentage across individual LFA	
34	0	0	15	100	15
35	0	0	5	100	5
36	1	8	12	92	13
37	0	0	6	100	6
Total sum and percentage across all LFAs	1	3	38	97	39

Fishers also stated that:

- There is good communication and cooperation about losses among fishermen even in disputed areas
- Fishermen work together to return each other's lost gear - "We help each other out" (F11)

Most fishers (56%) stated that they would report losses to DFO by email, 26% percent said they would not, 5% said maybe, and 13% did not specify their preference (Appendix A). Across the five management agency participants, three (60%) said email would work for reporting losses, while one (20%) said maybe, and one (20%) did not specify (Appendix A). Other comments expressed included:

- Emails will have generational and educational problems:
 - "Email?!?!!" (F22)
 - "No way! I'm 71 years old, I have never used it and never will" (F21)
 - "I won't be able to do it. I don't own a phone or email" (F27)
 - "I'm computer illiterate" (F15)
- The DFO needs to clearly explain the 'why' behind reporting and 'what is the benefit' to fishers. If that does not happen then fishers are less likely to report as they will fear for the repercussions and believe that reporting will disadvantage them.

- "It's only worthwhile to report if the traps will be retrieved. If it's a single trap that can't be retrieved, then it's a futile effort" (F06)
- "Why would you [report to DFO]?... They put lost traps in the compound and crush them... Everyone takes care of their traps themselves. We don't need DFO to interfere with these things" (F20)
- "Reporting it to DFO is silly... what are they going to do with it? They won't tackle anything that's of use to anybody... I don't understand what possibly is the point?" (F21)
- When reporting "to DFO you don't know where [the information] goes" (F25), and fear what they will do with it.
- "I'm nervous of reporting to DFO" because of the possible repercussions (F26)
- Quality of information and compliance will be low because there's no incentive for fishers.
 - "[Reporting via email is] not going to work, it just won't... The things that sound good and are easy up front don't always turn out to be that way... So we, big 'WE' in quotes, do something that might be good [on paper] but maybe not in practice" (M03).
 - "I can't see fishermen reporting losses" (F28)
 - "Why are we reporting?... It's more paperwork for us... What's the benefit of reporting it?... [it's] just more work for the honest guys" (F31)

In order of reporting method preference, most fishers stated logbook (33%), then email (20%) with calling or texting losses as the third preference (17%) (Appendix A). Across management agency responses, reporting losses through tag suppliers was the most common answer (Appendix A). Other comments that arose included:

- Trust is important if you want honest and accurate answers:
 - "[Tag suppliers] have a good repertoire with all the fishermen... they're trusted" (F28)
 - "What's important is trust, [fishing associations are] trying to help them and not punish them... people assume they'll be punished for reporting" (M05)
- Education is key
 - "It's not a matter of the method we use, but how do we program the guys to do it" (M04)

- Need for consultation and discussion
- Technology is the way forward, it's easy and quick but needs to be a gradual transition:
 - "Paper route needs to be open because one avenue might not cover all of the bases. Over time you can narrow that down with the younger generation" (F05)

According to all participants, the information collected for reporting lost gear must be and should include:

- Anonymous
- Losses and finds across all fisheries
- Must be updated frequently for accuracy
- Date
- Location
- How gear was lost (if known)
- What was done to retrieve personal loss
- What was done with gear found? (Returned, brought to wharf)

Only 36% of fishers felt it was possible to prevent gear loss. The remainder felt it was not possible (46%) or were unsure (18%; Appendix A). Similarly, only two of the five managers interviewed believed preventing gear loss is possible (40%) and 3 (60%) said it is not preventable (Appendix A). Participants who responded 'no' had expressed that loss is inevitable and that there is no way to prevent it 100%. When respondents that answered 'yes' to gear loss prevention were asked how gear loss could be prevented several ideas were put forward between fishers and management agencies (Appendix A).

When participants were asked if they could comment on illegal dumping of old and unfishable traps at-sea after being partly dismantled at the end of fishing season, 38% of fishers had heard of others doing it, but there was no clear idea as to whether or not it is a problem (Appendix A). In comparison, two management agencies participants (40%) stated that illegal dumping of old gear is a problem as people still dump (Appendix A). Other comments expressed in relation to illegal dumping of old gear at-sea, in order of descending frequency, included:

- Need for convenient and cheap waste management system
 - "What do you do with them?" (F20)
 - "No way to dispose of that stuff on shore" (F17)
 - "We need a system to get rid of old traps, and make it easy" (F20)

- Ways that fishermen currently handle their own gear
 - Fishers sell their old traps
 - Bring old traps to landfills
 - Give old traps away for retaining walls and other building materials
 - Rope is burnt or send to a landfill
 - Rope is given away to people in need
- It's an easy way to get rid of traps
 - "Oh, if you got junk gear that you're not going to use anymore, cut out the heads and let er go" (F08)
 - "You don't have to handle it again" (F12)
- Becomes habitat
- Education is key
- Concern over materials of traps

The final question was opened ended and allowed for participants to bring up anything they wanted to say. Comments related to project and worth noting across fishers and management agencies included that:

- Old traps create "lobster habitat" - to what extent is this true?
- Benefits of owner-operator compared to companies with respect to gear loss - increased stewardship and ownership of losses, mostly comes down to money
- Education plays a key role in preventing and reducing ghost gear
- Illegal poaching (IUU) and ghost trawls are an issue
 - Need for increased patrol and enforcement
 - Fishermen would collaborate with DFO Officers
- Need for revision of DFO regulation on having untagged gear on board so that ghost gear can be brought ashore
- Marine debris is an issue - specifically bait wrappers and lobster bands generated from the fishery
 - Need to find solutions to reduce waste
 - Are there ways to eliminate packaging? Some fishers suggested unwrapped bait

5.2 Issue Comprehension & Factual Information (Management Agency Interviews)

All management agency participants (100%) stated that they do not know how big the issue of lost gear at-sea is and how much gear remains at-sea. Other comments included:

- DFO employees are on the "outside looking in" (M01)
- No way to quantify gear loss
- Gear loss happens every season but don't know how much is recovered
- Fishers try to recover their gear

Management agencies gave varying answers on how often gear is lost; two (33%) said they do not know, one (17%) said gear loss happens all of the time, two (33%) said it happens mainly around storm events, while one (17%) said it varies according to which industries are present, how much congestion is in the area, and illegal poaching activity (Appendix A). Two management agency participants (40%) said they do not know where gear is lost, one (20%) said it's everywhere, one (20%) said it varies, while one (20%) was able to identify areas of loss (Appendix A). Specific areas that had been mentioned by the DFO stakeholder included: Digby ferry tract, Saint John Harbour and the Grey Zone (38B). Other comments included:

- Gear loss happens everywhere because it's "just the nature of the Bay of Fundy" (M04)
- Loss is dependent on other industries present and "so many other reasons" (M05)

All management agencies stated that no information is recorded on gear loss, with the exception of a DFO participant who stated that LFA 38B has a slip in their logbook for gear lost in the grey zone due to conflict with Americans, but this information is not digitized.

When asked what information is recorded on tag replacements, two (40%) specifically referenced the tag replacement sheet or tag replacement policies, one (20%) said they did not know, and two (40%) could not specify (Table 30). Other comments on tag replacement information and why more is not recorded included:

- "What's the point in asking for more?" (M01)
- Tags are used for effort monitoring, so DFO has no need to do more for anything outside of that: "tags are an effort to control effort, it doesn't matter to DFO why they lost it" (M03)

Most management agencies across both stakeholder groups (80%) stated that fishers are required to report when replacement tags have been used, while one DFO participant responded 'no'. Other comments made with respect to the tag replacement system included:

- Replacement tags are not a great system: it's not enforceable or traceable; it's hard to track replacement tags, fishermen don't know which tags they lost for certain most of the times, so recorded tag numbers are a guess for them
- Replacement tags are only recorded and not 'reported', that information stays within tag suppliers and fishers must have record kept on board.

All (100%) of management agency participants stated that issuing replacement tags does not mean the trap was lost at-sea said, and 100% also said they do not know why replacement tags are needed. Other comments on the subject included:

- New tags can be needed for many reasons, such as new gear configuration or getting new traps
- There's no place to record information for why replacement tags are needed
- Fishers can report to the tag supplier why they need the tag, but that info doesn't get sent to the DFO.

Most (80%) of management agencies said they do not know when a tag simply falls off, while one (20%) said they are aware sometimes, and no one responded 'yes' (Appendix A). Similarly, when asked how often a tag simply falls off a trap, four (80%) said they do not know, and one (20%) said it happens sometimes (Appendix A). No management agency participant stated that they know when a trap is lost at-sea, three (60%) said no while two (40%) said sometimes, for example if it is reported or discussed among industries (Appendix A). Other comments included that not everyone who loses a trap reports it and that there is more reporting of losses in 36 compared to other LFAs because of the ghost gear retrieval project undertaken by Fundy North Fishermen's Association.

When management agencies were asked who is responsible for lost gear at sea, respondents said fishermen or owner of the gear but legally hard to identify for a few reasons; classification of marine debris versus derelict fishing gear and because it is not always fishers who causes losses. When management agencies were asked who is responsible for lost gear on land, there was no clear answer as it depends on where it ends up and if it is identifiable. It was stated that everyone is responsible to a certain degree.

CHAPTER 6 – Discussion

The Bay of Fundy lobster fishery currently does not have an estimation of how much ALD fishing gear remains at-sea, and the impacts have not been studied. However, this study provides some qualitative data for estimating and mitigating the issue.

6.1 How much fishing gear remains at-sea and where?

The Bay of Fundy has many unique seascapes that vary in biotic (living) and abiotic (non-living) conditions (Berdin, Garriets & Van Gulpen, 2002). Oceanographic features such as bottom substrate, depth, and hydrodynamics, combined with the activities of many industries, adds further challenges to both active and ALD gear and helps explain why loss will vary among location in the Bay. The combination of biotic and abiotic factors also creates areas of gear accumulation, called hotspots, which are of critical importance when prioritizing removal efforts because some hotspots overlap with habitat for species listed on the Species at Risk Act (SARA) and / or Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Depending on LFA, some fishers have identified hotspots, while others denied their existence, either because gear loss is considered to be everywhere or spread out, or because they are unaware of the impacts of ALD and disregard it as an issue. Thus, it is recommended that future collaborative research map hotspots through the use of digital mapping systems used on board vessels that can engage fishers in identifying areas of concern and help improve their understanding of the issue. This should be funded by the government and delivered by fishing associations.

With varying biotic and abiotic conditions in mind, implementing solutions to mitigate ALD broadly across large scales, like an entire LFA, at the early onset will not work because blanket solutions tend to overlook the unique challenges that each localized community may face. Mitigation measures must, therefore, be investigated at multiple spatial scales in order account for these differences. To do so, spatial analysis in identifying mitigative measures should start at individual wharfs, then move to regional scales, ending with each LFA. Different levels of organization, either formal or informal, are also critical to recognize at each scale because they create groups of individuals with shared concerns and problems which may differ from other groups, act as a point of centralization, and can serve as a means to systematically manage ALD related issues at community-based levels (Davis, Whalen & Neis, 2006). Therefore, by starting at the smallest spatial scale, localized issues and concerns that are prioritized by fishers can be addressed in developing mitigative solutions, which could have larger scale benefits impacting

other wharfs, regions or LFAs under the sustainability lens of “act locally, benefit globally” (Chua et al., 2006). This means that effective solutions at smaller scales can also serve to exemplify solutions that can be used elsewhere on larger scales by upscaling them. Although, it should be noted that regional areas within LFAs are not clearly defined or static in nature because they are informal arrangements of multiple wharfs based on their geographic location and proximity to each other. While regional areas were not explicitly discussed or identified during the interviews, observations inferred the rationale for regional connectivity, and fishers did identify why they lose gear and what parts in particular.

6.2 Why does gear remain at-sea and what particular parts?

Fishers seldom lose gear from a single cause, although additional factors, or pressures, like oceanographic conditions, contribute to why gear is irretrievable. Unexpectedly, fishers in the upper Bay of Fundy Region (LFA 35) reported that deadfall trees commonly become entangled in their gear, as strong water movement can tangle trees and branches into rope. They identified ‘debris zones’ where natural material, like trees and branches, accumulate by freshwater outputs (i.e. rivers) when runoff is high, like in the spring or following a major rainfall event. Trees and branches create large and heavy snarls that weigh the gear down, sinking it to the bottom, which then furthers the snarl as it moves back and forth on the seafloor with the tides creating a ball of lost gear which is mostly irretrievable. This was unexpected as trees were not identified explicitly in the literature as a factor generating losses, although it could be classified as an environmental condition. Although, trees can also enter the marine environment from coastal erosion (i.e. falling off a cliff) and from intentional disposal by coastal property owners. Preventing trees from entering the marine environment naturally is not feasible as it is part of biological and physical processes, although a tree removal program for coastal homeowners may be beneficial in reducing cliffside disposal.

Conflicts between lobster fishing and other ocean industries highlights that fishers are not always at fault for lost gear. Although fishers are often implicated for derelict fishing gear, other marine industries bear some responsibility for generating derelict fishing gear, and therefore should be considered in efforts to identify solutions. Increased communication between industries could help mitigate losing gear due to conflicting uses, perhaps with increased zoning in areas of conflicting uses.

Current methods of retrieval in the Bay of Fundy use grapnels, a modified anchor like hook,

to snag or hook the rope of ALD fishing gear (Figure 3) (Fundy North Fishermen’s Association, 2015). Without rope, retrieving a single trap is next to impossible. Therefore, new technology or methods should be investigated in collaboration with fishers to enable retrieving single traps, perhaps by modifying grapnels with different configurations. Considering that the amount of rope lost with each trap will vary in each scenario and was reported to be relatively minimal compared to the total amount of rope used while fishing, losing a just the trap may not create entanglement hazards if the rope is relatively short and loose on one end. Future research on the entanglement hazards of ALD lobster traps with varying amounts of rope attached may shed light on the risks associated with ALD gear to large marine mammals.



Figure 3. Grapnel designed and used to retrieve gear near Saint John Harbour (Photo courtesy of Jeff McGuire, 2018).

Unexpectedly, 38% of fishers and 40% of management agencies stated that illegal dumping or discarding of old gear at-sea is a problem that still happens, contributing to the amount of gear remaining at-sea. The response from fishers was unexpected because it did not seem likely for fishers to either admit they have done something illegal or know someone who has or does something illegal. With that in mind, the problem is likely to be much larger as most fishers will not admit dumping. Therefore, it is probable that greater than 38% of fishers know that dumping still occurs. When probing into why dumping still occurs, most fishers simply do not have a convenient and cheap way to dispose of their gear, where some have grown up with the mentality that partly dismantling the gear creates habitat or the gear just ‘goes away’. Waste management strategies for old gear should be explored, and fisher’s environmental education and awareness should be addressed in order to reframe the issues of ALD fishing gear. This question yielded similar results to those found by Ackman (2016), where he also pointed out the need for effective recycling of old fishing gear. While recycling fishing gear is a great idea it is not feasible for modern lobster traps as they are made of mixed materials, although rope can be recycled in certain areas in the Maritimes. Instead, lobster traps can be repurposed for retaining walls and other construction materials (Figure 4). Fundy North Fishermen’s Association, located in Southwest



Figure 4. Retaining wall made from repurposed lobster traps in Southwest New Brunswick (Fundy North Fishermen's Association, 2018).

New Brunswick and represents all fishers from LFA 36, have successfully created a waste management system that connects fishers with landscapers to settle old traps for free. Fishers are happy to get rid of their old gear, especially when landscapers are keen to collaborate in making the process as easy as possible for both parties. While this project worked in LFA 36, waste management systems for old lobster traps will vary from LFA to LFA. Future research should be funded by the government to investigate effective waste management programs for old fishing gear, not just lobster gear, across LFAs to provide sustainable alternatives to dumping at-sea, mitigating the amount that ends up at-sea.

6.3 What happens to ALD lobster traps at-sea and how do they impact marine life?

When ALD gear is found, the gear's condition indicates its age because the more overgrown, filled with crustacean shells, and less structurally sound a lobster trap is, the older it is. Within a few weeks, traps will have algal growth, where over time traps can continue to accumulate sessile and benthic organisms (Figure 5), giving rise to the argument that ALD lobster traps create



Figure 5. Fishermen retrieving a derelict lobster trap covered in sessile and benthic organisms in Southwest New Brunswick as part of Fundy North's Ghost Gear Retrieval Project (Fundy North Fishermen's Association, 2012).

artificial habitat, where lobsters may, possibly, move freely in and out of the trap. In some cases, this may be true, but fishers have also reported that ALD traps can catch jumbo lobsters unintentionally, thus these traps may not always create habitat. Despite that ALD traps can provide beneficial artificial habitat to some organisms like echinoderms, algae, and bivalves (Bilkovic et al., 2014), there is a difference between good and bad artificial habitat for lobsters (Battin, 2004; Hale & Swearer, 2016). First, some marine species, like lobster and groundfish, can become entrapped within the gear and die, where fish caught are not likely to be seen because of the 'self-baiting' cycle. For lobsters, old traps can appear to be habitat, but this would be considered low-quality in comparison to natural habitat (i.e. boulder, rocky, gravel, silt/sand substrate), because it is composed of plastic, which can cause shell disease and may trap them in some cases (Bitten, 2004; Chang et al., 2010; Laufer, Baclaski & Koehn, 2012). Overtime, as more ALD traps remain at-sea, lobsters may shift to low-quality habitat preferences, which may fool them in some cases

because traps may not allow them to escape if the trap is active, not partly dismantled, or the lobster is too large for the escape mechanism. Therefore, ALD lobster traps are not good habitat for all species and will keep fishing on commercially valuable ones. This is expected to cause economic losses based on the findings of previous studies. For example, in the Chesapeake Bay blue crab fishery it has been estimated derelict traps catch up to 900,000 animals and contributes to \$300,000 USD in economic losses annually (Bilkovic et al., 2014). Thus, drawing inferences that derelict lobster traps have potential to contribute to considerable economic losses, especially if lobsters have become attracted to low-quality habitat.

Second, in terms of the structural integrity, the traps are coated in PVC vinyl, where overtime this breaks down into microplastics, which negatively affects marine species and humans when it is leached into the food chain (Laufer, Baclaski & Koehn, 2012). Additionally, within a few months the biodegradable hog rings on the escape panel should rust out, assuming it is attached correctly and not compromised, creating a hole for lobsters to escape when a trap is lost at-sea (DFO, 2008). Considering that large ‘jumbo’ lobsters are commonly found in ALD traps even if the escape panel had rusted away suggests that the escape panel may not be large enough for mature lobsters to escape, and that the trap is not actually creating lobster habitat, contrary to what some fishers believe. Not to mention that the rust away escape panel is usually made of plastic, increasing the amount of marine plastics generated from the fishery sector. While the rate of modern lobster trap decomposition is unknown, studies have shown the negative impacts of plastics on marine food chains (Laufer, Baclaski & Koehn, 2012). Future research is needed to reduce the impacts of ALD traps in terms of by-catch and to determine whether or not ALD lobster traps create good or bad artificial habitat using a cost-benefit analysis.

Future research should address estimating income lost from ghost fishing, and the ideal escape panel size to reduce by-catch of lobster and other fish species. As a fisher suggested, perhaps the whole trap or a side panel could be attached with hog rings that rust away. Studies should also address the decomposition of modern traps to determine how long it takes to break down, and how they break down to determine if the plastic coating is as problematic as the literature suggests. The information put forward by future research should also be disseminated to fishers in appropriate manners to educate them on the matter, in a collaboration with fishing associations.

6.4 Is ALD gear retrieved and returned when found at-sea?

In terms of personal gear recovery, not all fishermen record the positions of where they set their gear digitally through the use of technology; some still rely on triangulation. This highlights the divide in fisher demographics, as portions of the older generation are less technologically experienced and therefore do not use digital systems, like AIS – Automatic Identification System, to mark gear positioning and hard copy necessary information on paper. In comparison, the younger demographic of fishers relies heavily on digital technology to plan where they set their gear, where some use a colour coding plotting system to mark areas where gear has been set and where gear was lost and not retrieved. Demographics are essential to consider when implementing methods to estimate and mitigate ALD gear because they determine if a solution will be appropriate for all impacted users. Solutions should not and cannot exclude any portion of fisher demographics, as it would not be a uniform solution and would therefore be biased and ineffective.

In terms of returning gear, fishers expressed that they work together to return one another's gear, because it is expensive, and a lost trap means less catch and less income. Cooperation seemed stronger in some areas than others, particularly so in LFA 36 where fishers who reported to work together believe that if they were good to their neighbours, others would do the same, exemplified in a statement from fisher 26: "if one guy returns gear, then others will want to do the same". Strong levels of cooperation help build trust and improves communication, which therefore increases organization among fishers, and can contribute to better fishing practices and overall fishery stewardship. Interestingly, while 90% of fishers are communicating information on losses and retrievals among themselves, these conversations exclude management agencies. This occurs unintentionally due to implications of the current management structure, and intentionally because of distrust between fishers, management, and science which has been ongoing for years (Pauley, 2017).

The legalities behind DFO's licence conditions and Atlantic Fishery Regulations, suggests issues within the management regimen and distrust, highlighting the entrenched tension between fishermen and government. As it stands, retrieving ALD gear without the proper permission is illegal, and fishers know and fear the legal repercussions of breaking the law in doing so. Fishers also know that dumping at-sea is prohibited, but some fishers do not want to leave ALD gear out at-sea because it degrades the environment which their livelihoods are dependent on. Many fishers feel that retrieving ALD gear is a double-edged sword, where no matter what they do they are

breaking the law. Thus, suggesting that DFO's regulations must be modified to allow for retrieving ALD gear when it is found at-sea. While this seems like a simple solution, it does create the potential for individuals partake in illegal activities like poaching, which must be considered to reduce facilitating illegal, unregulated, and unrecorded (IUU) fishing. Including a trap retrieval tagging system for gear found at-sea could be a solution to minimize the potential for IUU fishing.

These legalities combined with deep-rooted distrust provide a strong backing as to why fishers exclude management agencies in retrieving and reporting ALD gear. When fishers do encounter ALD gear and cannot return it to the owner themselves, the last thing they would do is call DFO because, to them, reporting is more work with little reward, exemplified by fisher 31: "It's more paperwork for us... What's the benefit of reporting it?... [it's] just more work for the honest guys". Paperwork is often seen as a hassle, where in the past, addressing ALD gear with DFO has resulted in nothing but frustration as fishers lose valuable time from government process. Fishers also expressed frustration when nothing happens at all after including DFO, where they instruct fishers to leave the gear there for future removal by DFO, which rarely occurs, or the gear gets impounded rather than tracking down the rightful owner. DFO should work with fishers to remove gear from identified hotspots. Fishers do not want more work and want tangible results; if they can handle ALD gear themselves they will because it is less work for them and appears to be effective in reducing the amount of ALD gear remaining at-sea. Despite all of this, DFO is changing licence conditions to require reporting of gear losses, which could either help relations if done right, or could add more tension between both stakeholders.

6.5 Dealing with ALD from a regulatory perspective: Changing the reporting structure

In light of the recent increase in entanglement issues of large marine mammals in the North Atlantic Ocean, the DFO is changing licence conditions to require reporting of losses via email in order to gain an accurate estimation of how much ALD gear remains at-sea. As pointed out by M03, this change was in order to continue fishery exports to United States by showing that Canada is addressing the issue and working towards reducing threats to marine mammals. The method of reporting was initiated by government and was not selected with input from fishers in all LFAs. Fishers had mixed opinions on the method of reporting and on reporting overall. Demographics and education levels influenced each fisher's preferred method of reporting, where the older generation of fishers seemed to prefer the paper route for reporting losses. This suggests that

having choice in reporting methods may be beneficial in catering to all fishers, as one method will not work for all, where technology can be integrated overtime to help digitize reporting processes.

While there was some general speculation that fishers would be opposed to new regulations supporting reporting gear losses, it was unanticipated that fishers demanded to know what was in it for them. Fishers want to know how reporting will impact them. Fishers believe reporting losses will disadvantage them in some capacity, exemplified by fisher 25: When reporting “to DFO you don't know where [the information] goes”, and fears what will be done with it. Without transparency, fishers stated that compliance will be low, because trust between fishers and management agencies is not uniformly strong. Implementing a new regulation without consulting fishers omits their concerns and feedback, and therefore limits the overall effectiveness because fishers feel like they have not been considered, despite that these regulations are directly impacting them. While current fishery management is iterative and adaptive by making changes to regulations over time as needed, the process is very slow and therefore if these concerns and comments are not accounted for early on, it could reduce compliance and further distrust (Jentoft, 2000). Without strong baseline trust and transparency between stakeholders, the data collected on estimating the amount of ALD gear remaining at-sea may be skewed. For example, some fishers may not report their losses if it is not in their preferred method and the data could be falsified if the reporting purpose is not explained, and because the structure has omitted a key detail: retrievals must also be included in reporting.

This study found that fishers do sometimes retrieve and return gear that has been lost at-sea. If fishers are only told to report their losses and not retrievals, then estimations will inaccurately tell how much gear remains at-sea. This suggests that reporting both losses and retrievals is necessary in order to accurately estimate of how much gear remains at-sea and how much gets recovered and returned. Without meaningful consultation and discussion between stakeholders prior to implementing the regulation change, key concerns and considerations, such as including retrievals in the reporting structure, are therefore excluded (Chuenpagdee & Jentoft, 2007). This furthers the distrust between stakeholder groups and acts as a further disincentive to fishers because neither party has found common ground on the matter, and because fishers feel that they are not included in management decisions. Therefore, the lack of communication between regulators and fishers does not create trust, and a lack of trust can reduce the willingness to comply with new rules.

6.6 How should ALD lobster gear in the Bay of Fundy be managed?

The interviews with management agencies provided additional background knowledge not available in the literature on how ALD gear is managed from a regulatory perspective. Management admit they do not know the extent or intricacies behind the issue of ALD gear in the Bay of Fundy's Lobster Fishery, highlighted by M01: "We are on the outside looking in". Therefore, management knows that fishers are the experts when it comes to knowing how much and where gear is commonly lost and why. This point suggests a need for collaboration with fishers, in addition to other agencies and organizations, in order to estimate and mitigate the amount of ALD lobster gear in the Bay of Fundy. Collaboration is important because it allows all affected stakeholders to participate in data collection or scientific approaches, allows for concerns to be heard early on, and builds capacity for change, which helps increase the legitimacy of management regimes (Davis, Whalen & Neis, 2006; Jentoft, 2000). Building capacity for change refers to increasing trust among stakeholders, which then facilitates increased compliance and cooperation, and thus can help effectively make sustainable changes (Chuenpagdee & Jentoft, 2007). Therefore, it is recommended that the DFO builds trust with fishers, using consultation to work towards this goal.

Collaboration is not synonymous with consultation. Consultation is when one stakeholder group speaks to another on a given project or regulation to hear their concerns, feedback, and questions. Consultation should be meaningful and just not a box checking activity to gain token information. In this case, fishers could have been consulted beyond conversations with advisory committees prior to implementing new licence conditions on reporting in order to incorporate their feedback, questions and concerns into the regulation. In doing so, this would have been a good step towards building trust between stakeholder groups and increase reporting compliance because fishers want to be considered, heard, and involved in managing the resources that their livelihoods depend on. Collaboration with fishers is necessary to identify preventative solutions and ghost gear hotspots and investigate appropriate waste management systems. This can be accomplished by using participatory approaches, where fishers would work alongside scientists and other stakeholder groups to collect data and provide local knowledge. Trying to manage ALD gear without including fishers in the process may not be as effective because they have valuable local knowledge (Recchia, M., pers. comm., February 1st, 2018). Therefore, without consulting and

collaborating with fishers, estimating and mitigating ALD gear in the Bay of Fundy may not be effective.

6.7 Study Limitations

While this study has provided new information on ALD gear in the Bay of Fundy, limitations and weaknesses may have influenced the project's findings. Due to the limited time frame for data collection, LFA 38 was unable to be included in the project as a trip to Grand Manan was not feasible. In addition, trying to schedule interviews with fishers and management agencies from LFA 38 was challenging as they did not respond to an outsider. The unequal number of fishers interviewed from each LFA limits the ability to interpret different attitudes among LFAs. Although, due to the sampling techniques, the sample size was as representative as time allowed for it to be. Another weakness would be that no female fishers were included in the study as I had not met one willing to participate, therefore fishers were entirely male and did not incorporate the female perspective. Not having resources to access coding software was a limitation because analysis had to be done manually, which required more time and leaves room for bias as the analysis could be subjective to the researcher who coded it. If another individual were to have coded the data, perhaps the analysis would vary slightly, although the results would largely be the same, and is therefore only a slight weakness. Lastly, some issues brought up during the interviews had to be excluded from the discussion as they fell outside of the study's scope. Although, these issues are valid in representing fishers concerns and further management issues and should therefore be addressed by management agencies and academia.

CHAPTER 7 – Recommendations & Conclusion

In order to estimate and mitigate the amount of ALD lobster fishing gear in the Bay of Fundy, modifications to new and existing regulations are necessary, and additional research is needed to prevent and respond to the issue. The following recommendation have been synthesized based on this project's findings to clearly address the research question:

1. *Estimating* the amount of ALD gear remaining at-sea should require reporting of both losses and retrievals across all fisheries for accurate estimations of how much gear remains at-sea and how much gets recovered and returned. DFO must change the reporting requirements to include losses and retrievals, and they must consider

age demographics and varying levels of education and should therefore allow choice in reporting methods. Demographics are essential to consider when implementing methods to estimate and mitigate ALD gear because they determine if a solution will be appropriate for all impacted users. The purpose of reporting must be clear and transparent to fishers if compliance is expected, and therefore requires that DFO provides a transparent explanation to fishers. In order for DFO to build trust with fishers, DFO needs to consult fishers more frequently and meaningfully. Fishers must also be held accountable for reporting their losses and retrievals, where fishing association should act as an intermediary between fishers and DFO to facilitate the process and disseminate the estimation information.

Mitigating the amount ALD gear needs to both prevent and respond to the issue:

2. *Preventing* ALD gear requires the identification of specific issues causing or contributing to ALD at varying spatial scales in order to determine the appropriate solution, where several solutions were identified in this project's interviews (Appendix A). Implementing solutions to mitigate ALD broadly across large scales, like an entire LFA, at the early onset will not work because blanket solutions tend to overlook the unique challenges that each localized community may face. Mitigation measures must, therefore, be investigated at multiple spatial scales (wharf, region, and LFA) in order account for these differences. For example, as previously mentioned, if an area is experiencing gear loss due to conflicting uses with other industries, increasing zoning and communication among the industries could be a potential solution. Conflicts between and among industries should be mediated by DFO in partnership with fishing associations. Gear modifications, like mandatory colour codes on north and south markers, could be used to reduce loss by enabling all gear to be set in the same direction to avoid gear overlap, and thus avoid traps being burnt off. It should be noted that identifying underlying generating causes of ALD, hotspots, and solutions should be developed in consultation with fishers using participatory and collaborative ways in order to build trust between stakeholders and to incorporate fisher's local knowledge into management solutions.

3. *Preventing* discarding of old gear at-sea will require the implementation of waste management systems. This cannot be a blanket approach, suiting an entire province or LFA, but must be researched at varying scales to determine the appropriate system for a given area. Research and solutions should be led by fishermen and fishing associations, and funded by the government. Waste management systems can include both recycling and repurposing old gear. Although, some gear types may not be best suited for recycling, like lobster traps. Therefore, innovative and collaborative ways to repurpose old lobster traps are needed. Following the work of Fundy North Fishermen's Association for example, traps were repurposed into retaining walls through collaborating with local landscapers. Preventing gear from being abandoned or discarded at-sea must also address educating fishers to improve their overall awareness on the issue of ALD gear and the potential impacts. To do so, public education strategies can be used to facilitate behavioural change in fishers and their surrounding communities. An example of a preliminary education design strategy is shown Appendix B. This should be funded by the government but delivered by fishing associations as they are more trusted, where they would be required to report back to the government on their progress.
4. *Responding* to part of the issue requires that DFO modifies licence conditions to legalize retrieving ALD gear that is found at-sea. While this does raise concerns for illegal activity, if retrievals are a reporting requirement, then this could legitimize the retrieval process. DFO should implement a retrieval tag system for ALD traps found at-sea as an additional measure to increase the legitimacy of retrieving gear and reduce avenues for illegal activity.

Overall, this study emphasized that fishers are practitioners with valuable experience and knowledge in the handling and retrieving of fishing gear. Fishers are clearly important partners for identifying and implementing successful solutions to reduce ALD gear and should therefore be included in managing it. While management agencies are integral in maintaining fishery organization and functioning, it is important that they are transparent and inclusive when managing ocean resources that belong to all Canadian citizens. Ultimately fishers do not want to degrade the resources that their livelihoods depend on and want to conserve it for future generations, and management seeks to be effective in their duties. Moving forward, collaboration through

participatory approaches should be used in determining what methods are appropriate to estimate and mitigate the amount of ALD fishing gear in the Bay of Fundy's lobster fishery, while helping reduce deep-rooted distrust between stakeholders and improve overall management within the fishery.

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Appendices

A – Results Tables

Table 6. Summary of interview participants and their involvement within the Bay of Fundy's lobster fishery.

Fishermen		Management Agencies		Total Participation
Active	29	Department of Fisheries	3	
Retired	3	Fishing Associations	2	
Total	32	Total	5	37

Table 7. Breakdown of fishermen per LFA and their average time involved in the industry as a measure of experience.

LFA	Number of Fishermen	Average Years Involved
34	15	34.93
35	5	36
36	13	38.54
37	6	39.67
Total	39	36.34

Table 8. Reported and relative proportion of portions of gear lost among LFAs 34-37.

LFA	Just the trap (and some attached rope)	Loose everything (trap, rope, anchors, buoys, etc.)	Just buoys or with some line attached	Total
34	9	5	1	15
35	2	3	0	5
36	4	3	6	13
37	2	1	3	6
Sum	17	12	10	39
Percentage	44	30	26	100

Table 4. Recovery of lost gear among LFAs.

LFA	Yes (90% or more)	No	Sometimes / Most of the time	Total
34	5	2	8	15
35	1	1	3	5
36	6	0	7	13
37	2	0	4	6
Sum	14	3	22	39
Percentage	36	8	56	100

Table 5. How gear is recovered in each LFA. Note that multiple responses for each fisher were possible in each LFA.

LFA	Grapple	Drag with anchor	Self-snarl	Returned by others	Total
34	8	5	3	5	21
35	5	0	0	1	6
36	11	0	3	0	14
37	5	0	1	0	6
Sum	29	5	7	6	47
Percentage	62	11	15	13	101

Table 6. Do fishers record the location of their gear loss?

LFA	Yes	No	Sometimes	Total
34	8	5	2	15
35	2	2	1	5
36	10	3	0	13
37	4	2	0	6
Sum	24	12	3	39
Percentage	62	31	8	101

Table 7. Do fishers report their gear losses to management bodies, such as the DFO fishing associations, tag suppliers or dockside monitors?

LFA	Yes	No	Sometimes	Total
34	1	13	1	15
35	0	5	0	5
36	0	13	0	13
37	0	6	0	6
Sum	1	37	1	39
Percentage	3	95	3	101

Table 8. Do fishers find gear while fishing that was not their own in each LFA?

LFA	Yes	No	Total
34	14	1	15
35	5	0	5
36	13	0	13
37	6	0	6
Sum	38	1	39
Percentage	97	3	100

Table 9. Ways that lost gear is encountered by fishers in each LFA. Note that multiple responses for each fisher were possible.

LFA	Tangled/caught/snarled in active lobster gear (trap or anchor)	Can see it floating	Found in other fishing gear (scallop or longline)	Total
34	13	3	0	16
35	5	1	0	6
36	11	1	3	15
37	4	0	3	7
Sum	33	5	6	44
Percentage	75	11	14	100

Table 10. Types of lost gear and debris that fishers reported to find in each LFA. Note that multiple responses for each fisher were possible.

LFA	Always lobster gear (trap, rope or buoy)	Old gillnet	Cable	Plastic or garbage	Pieces of scallop drag or groundfish trawl	Total
34	14	3	4	1	3	25
35	5	0	0	0	0	5
36	13	3	2	1	1	20
37	6	1	0	1	0	8
Sum	38	7	6	3	4	58
Percentage	66	12	10	5	7	100

Table 11. Responses to whether or not there are known hotspots for lost gear to be found or generated in each LFA.

LFA	No	Yes	Total
34	6	9	15
35	2	3	5
36	1	12	13
37	0	6	6
Sum	9	29	39
Percentage	24	76	100

Table 12. Would fishers be willing to meet to map lost gear hotspots in each LFA.

LFA	Yes	No	Maybe	Total
34	5	9	1	15
35	3	2	0	5
36	9	4	0	13
37	4	1	1	6

Sum	21	16	2	39
Percentage	54	41	5	100

Table 13. Whether or not fishers communicate where they have lost gear with others in each LFA.

LFA	No	Yes (Nearby, over VHF, cell phone or at wharf/in-person)	Total
34	2	13	15
35	1	4	5
36	1	12	13
37	0	6	6
Sum	4	35	39
Percentage	10	90	100

Table 14. Whether fishers would report gear losses by email to the DFO in each LFA.

LFA	Yes	No	Maybe	Not Specified	Total
34	7	5	0	3	15
35	4	0	0	1	5
36	7	4	1	1	13
37	4	1	1	0	6
Sum	22	10	2	5	39
Percentage	56	26	5	13	100

Table 15. Responses for whether or not email will be an effective way to report gear to the DFO from each stakeholder group within management agencies.

Stakeholder Group	Yes	No	Maybe	Not Specified	Total
DFO	3	0	0	0	3
Fishing Associations	0	0	1	1	2
Sum	3	0	1	1	5
Percentage	60	0	20	20	100

Table 16. Preferred methods for fishers to report losses in each LFA.

LFA	Email	Logbook	Call or Text	Tag Suppliers	Combination or choice of options	Not Specified	Total
34	3	13	1	1	6	1	25
35	3	1	3	0	0	0	7
36	5	5	4	4	2	2	22
37	2	2	3	2	1	0	10
Sum	13	21	11	7	9	3	64
Percentage	20	33	17	11	14	5	100

Table 17. Preferred methods for management agencies receiving reports of lost gear.

Stakeholder Group	Email	Logbook	Tag Suppliers	Combination or choice of options	Not Specified	Other	Total
DFO	0	1	0	0	1	1	3
Fishing Associations	0	0	2	1	0	0	3
Sum	0	1	2	1	1	1	6
Percentage	0	17	33	17	17	17	101

Table 18. Fishers responses in each LFA to whether or not gear loss is preventable.

LFA	Yes	No	Maybe/Don't know	Total
34	7	5	3	15
35	2	3	0	5
36	4	7	2	13
37	1	3	2	6
Sum	14	18	7	39
Percentage	36	46	18	100

Table 19. Management agency responses across both stakeholder groups to whether or not gear loss is preventable.

Stakeholder Group	Yes	No	Total
DFO	1	2	3
Fishing Association	1	1	2
Sum	2	3	5
Percentage	40	60	100

Table 20. Ideas put forward by fishers and management agencies with respect to preventing gear loss. Frequency denotes the number of times the idea was stated.

Idea	Frequency
Gear modifications:	8
Mandatory colour code on north and south markers	
Steel/cable gangions	
Timed release marker to find single traps	
Thicker rope 1/16 rather than 3/8 diameter	
Shorten lines	
Led rope	
Anchor to ground line attachment	
Better communication between and across industries:	5
Man on skiff	
Cages on propellers	
Marked cage movements in season	
Use good and strong rope	5
Avoid areas of known conflict, traffic, and congestion	5
More and restricted shipping lanes	2
Use caution around storms	2
Don't set on top of others	2
Consult with aquaculture	2
Reduce trap limit	1
Mark buoys well	1
Record locations of gear	1
Encourage owner operator	1
Slow hauling	1

Table 21. Fisher's responses across LFAs to the mention of dumping old and unfishable traps at-sea after being partly dismantled.

LFA	Never heard of it	Admit to doing it in the past	Heard of others doing it	It's still a problem, people still dump	It's much of an issue/doesn't happen much anymore	Don't know if it's a problem	Total
34	1	4	8	5	2	1	21
35	1	0	2	0	0	0	3
36	0	2	8	3	4	4	21
37	0	1	3	1	3	2	10
Sum	2	7	21	9	9	7	55
Percentage	4	13	38	16	16	13	100

Table 22. Management agencies' responses across both stakeholder groups to the mention of dumping old and unfishable traps at-sea after being partly dismantled.

Stakeholder Group	Heard of people doing it	It's still a problem, people still dump	It's much of an issue/doesn't happen much anymore	Don't know if it's a problem	Total
DFO	0	1	1	1	3
Fishing Association	1	1	0	0	2
Sum	1	2	1	1	5
Percentage	20	40	20	20	100

Table 23. Management agencies' responses to how often gear is lost across both stakeholder groups.

Stakeholder Group	Don't know	All of the time	Around major storm events	It varies with other industries present, congestion and poaching	Total
DFO	2	0	1	0	3
Fishing Association	0	1	1	1	3
Sum	2	1	2	1	6
Percentage	33	17	33	17	100

Table 24. Management agencies' responses to where gear is commonly lost across both stakeholder groups.

Stakeholder Group	Don't know	Everywhere	It varies	Specific areas mentioned	Total
DFO	2	0	0	1	3
Fishing Association	0	1	1	0	2
Sum	2	1	1	1	5
Percentage	40	20	20	20	100

Table 25. Management agencies responses to what information is recorded with respect to tag replacement information across both stakeholder groups.

Stakeholder Group	Reference to tag sheet & policies	Don't know	Not Specified	Total
DFO	1	0	2	3
Fishing Association	1	1	0	2
Sum	2	1	2	5
Percentage	40	20	40	100

Table 26. Management agencies' responses to whether or not they know when a trap sag simply falls off across both stakeholder groups.

Stakeholder Group	Yes	No	Sometimes	Total
DFO	0	3	0	3
Fishing Association	0	1	1	2
Sum	0	4	1	5
Percentage	0	80	20	100

Table 27. Management agencies' responses to how often a trap sag simply falls off across both stakeholder groups.

Stakeholder Group	Don't know	Sometimes	Total
DFO	3	0	3
Fishing Association	1	1	2
Sum	4	1	5
Percentage	80	20	100

Table 28. Management agencies' responses to whether or not they know when a trap is lost at-sea across both stakeholder groups.

Stakeholder Group	Yes	No	Sometimes, if it's reported or discussed among industries	Total
DFO	0	3	0	3
Fishing Association	0	0	2	2
Sum	0	3	2	5
Percentage	0	60	40	100

B1 – Interview Questions: Fishers

General Factual Background Questions

- 1) How are you involved in the Bay of Fundy's lobster fishery?
- 2) How many years have/had you been a licensed lobster fisher(wo)men? In which LFAs?
- 3) On average, how many traps per season do you lose?

What about rope and other gear?

What about the other fishermen in your LFA, do they lose the same amount?

Monitoring & Reporting Questions

- 1) Have you ever lost some of your own gear?

Were you ever able to recover it?

How?

If you can't, do you record the location?

Do you report it?

- 2) Have you ever come across lost gear while fishing that was not your own?

How?

What kinds? (Probe: What was it?)

Was any harm – to humans or the environment – observed?

- 3) Are there areas where you see it more often?

Why does it happen in those areas? (Probe: What type of bottom is in the area? What about the surrounding area? Was this an area with high water movement? Other conflicts?)

- 4) How do you react to lost gear?

Do you retrieve it?

Report it to the DFO or Dockside Monitors? Tell other fishers?

- 5) Is it worth developing a way to report losses easier than by email?

Which method would you prefer: log book sheet, an app, online form, or email?

- 6) Would you consider meeting with other fishermen to map out where everyone has lost gear?

- 7) Are there ways to prevent gear loss from happening? How?

- 8) I have heard that some people at the end of fishing seasons will remove the netting and doors from old and unfishable traps and dump them at-sea. Can you comment on that?

- 9) Is there anything else you would like to say?

B2 – Interview Questions: Management Agencies

General Factual Background Questions

- 1) How are you involved in the Bay of Fundy's lobster fishery?
- 2) How many years have/had you been involved?
In which LFAs?
- 3) On average, how many traps per season do you think a fisherman in you LFA loses?
What about rope and other gear?

Understanding of the Issue & Factual Information

- 1) How big is the problem of lost gear at-sea?
How much gear remains at-sea?
How often is gear lost?
How is it lost?
Where is it lost?
Is this information recorded?
- 2) When replacement tags are issued, what information is recorded? (Why isn't more information recorded?)
When issuing replacement tags up front, are fishers supposed to report when they are used?
Does issuing a replacement tag(s) mean a trap was lost at-sea?
Do you know why replacement tags are needed?
Do you know when a tag simply falls off a trap? How often does that happen?
Do you know when a trap is lost at-sea?
- 3) Who is responsible for abandoned, lost, and discarded lobster fishing gear?
At-sea?
On land? (when it washes up)

Monitoring & Reporting Questions

- 1) Is it worth developing a way to report losses easier than by email?
Which method would you prefer: log book sheet, an app, online form, or email?
- 2) Are there ways to prevent gear loss from happening? How?
- 3) I have heard that some people at the end of fishing seasons will remove the netting and doors from old and unfishable traps and dump them at-sea. Can you comment on that?
- 4) Is there anything else you would like to say?

C – Education Design Strategy

Demographic & Age Group

Fishers ranging in age from teenagers to older folks, roughly 16 - 75 years old.

Goals & Objectives

- Short-term objective: facilitate behavioral change by reducing the number of fishers discarding old lobster traps at sea.
- Long-term objective: facilitate environmental transformation change, where fishers' views and environmental beliefs change to match and fully embody guarding and improving the fishery's resources.

The goal is to allow fishers to see how they fit into the greater issue of marine debris and no longer discredit the negative impacts of old lobster traps on the environment. Fishers should be able to think of the issue holistically and know how to act appropriately and serve as environmental stewards for fishers across Atlantic Canada.

Format & Approach

The program will begin by priming the selected group of fishers with the necessary background information on abandoned, lost, and discarded (ALD) fishing gear. This will help set the stage for the program. A multi-pronged approach is necessary to achieve the programs' short and long-term goals. Addressing the short term will focus on the lack of proper waste management systems of old fishing gear because it can act as a situational trigger. Without effective strategies to manage old fishing gear, fishers are likely to revert to old habits, which contributes an additional barrier in changing behaviour (Steg & Vlek, 2009). To address this barrier, proper waste management strategies need to be implemented at varying scales within the lobster industry. Initiatives should start at the wharf level, then move to the regional, and lobster fishing area (LFA) level. Although, regional areas within LFAs are not clearly defined or static in nature because they are informal arrangements of multiple wharfs based on their geographic location and proximity to each other. It should also be noted that strategies for waste management will likely vary laterally (across scales) and hierarchically (between scales). Addressing the long-term goal will require multiple activities overtime that are participatory and collaborative in addressing the barriers underlying transformation. This should happen in installments and cannot be decided on until consultation with fishers has occurs in designing the program.

Facilitators

Fishing associations will be the initiating institutions. This program was designed with Fundy North Fishermen's Association in mind because they have been primed for the issue through their decade long ghost gear retrieval project (Fundy North Fishermen's Association, 2018). They have the context needed to support this program and make it a success, but the program could be used by other associations as well. Association board members and key fishers would be the program leaders. Key fishers are individuals who are highly motivated and involved within their communities where they, combined with board members, are respected and trusted among other fishers and are therefore appropriate agents of change in getting others on board with the program. The program will also need support from academia and science to: aid in program design, provide scientific information, and provide resources needed where applicable and possible.

Evaluation Methods

The success of the program's short-term objective can be evaluated by determining the number of individuals that have engaged in the activity of properly disposing of old gear set up through the program. It can therefore be inferred that individuals partaking in proper waste management are no longer disposing of old gear inappropriately, although this could be a false assumption. This assumption could therefore be validated by doing pre and post interviews with fishers, asking questions regarding their values, environmental beliefs, and knowledge before and after the program.

Shortcomings & Potential Pitfalls

Using participatory approaches could be a pitfall as it allows fishers to bring forward their issues at the easy onset, which may or may not be outside of the scope of this program. To design with this in mind, the program could have multiple chapters to address different concerns and issues, the first being discarding old gear at-sea. Age and education demographics are also a potential shortcoming because they will determine the appropriate methods of program design, implementation, and evaluation. To design with this in mind all material should be written at the 8th grade level using plain and clear language and must be available both in print and digitally.

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