# Ghost Gear Hurricane Relief in Atlantic Canada; Retrieval Results Summary (2023 - 2024)

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Ghost Gear Hurricane Relief in Atlantic Canada: Retrieval Results Summary (2023 - 2024)

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# Table of Contents

# List of Tables and Figures

**Tables**

## Executive Summary

Abandoned, lost, and discarded fishing gear (ALDFG), also known as *ghost gear*, is commonly found in our oceans and negatively impacts marine environments and industries. Managing ALDFG in Atlantic Canada has been challenging due to knowledge gaps in loss rates, ghost gear impacts, and regulatory retrieval barriers. To address these problems over the last three years, Coastal Action undertook the *Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia* project funded by the Department of Fisheries and Oceans Canada (DFO)'s Ghost Gear Fund (GGF). This year, Coastal Action expanded the project to include PEI and Newfoundland to align with DFO's requirement of targeting areas impacted by Hurricane Fiona. The primary objective of this project was to collectively address the issues of ALDFG across Nova Scotia in Lobster Fishing Areas (LFAs) 27, 33, 34, PEI (LFA 24), and Newfoundland (LFAs 11 and 12), while fostering collaboration among stakeholders from the fishing industry, governmental bodies, non-profit organizations, local communities, and academia. The aim was to implement prevention, reduction, and assessment measures to mitigate the impacts of ALDFG in these regions.

This report provides an overview of project retrieval methods and results. It presents the results of retrieved gear and released bycatch, with key findings summarized below. Additionally, future project activities and recommendations are provided.

Key findings from at-sea ALDFG retrieval are summarized below:

- Captains from 11 vessels towed grapples searching the seafloor for ghost gear and completed **1,265 tows** over **85 trips**.
- An additional vessel completed **5 island cleanups** contributing to a total of 90 sea trips.
- A total of **18,928.6 kg** of ALDFG was retrieved at-sea: 16,651 kg from the ocean surrounding NS, 218 kg from the ocean surrounding northern PEI, and 2,058 kg from the ocean surrounding southern Newfoundland.
    - Of the total debris retrieved, **45.6% were lobster traps** and **15.2% was dragger cable** by weight.
- A total of **16,220.6 kg** of ALDFG was retrieved from shorelines throughout the project: 7,168.9 kg from ten shoreline and five island cleanups in western NS; 7,432.3 kg from four shoreline cleanups in Cape Breton, NS; 1,584.4 kg from four shoreline cleanups in PEI; and 35 kg from one shoreline cleanup in NL.
    - Of this debris, **58.5% were lobster traps by weight**.
- **35,149.24 kgs** of ALDFG in total were removed during this project.
- Traps with tags ranged in age from **0** to **37 years old**, with a median age of **19.5 years** for at-sea traps and **12 years** for shoreline traps.

- A total of **17 different species of bycatch** were found in ALDFG, which included **398 lobsters, 79 fishes, and 1 bird.**
- Carapace length measurements of lobster bycatch showed that **73.2 % of lobsters released were market-sized in NS/NL and 71.8% were market-sized in PEI**.

# 1.0 Introduction

Abandoned, lost, and discarded fishing gear (ALDFG), commonly referred to as ghost gear, comprises a large portion of all marine debris. Research has shown that it can cause significant negative environmental, economic, and social impacts including habitat degradation, indiscriminate fishing (also known as *ghost fishing*), entanglements, decreased catches, at-sea safety hazards, and vessel damage (Macfadyen et al. 2009; National Oceanic and Atmospheric Administration (NOAA) 2015). ALDFG can be generated by harsh environmental conditions, like storms and unfavourable bottom types, gear conflicts among fishers and other industries, poor gear condition, mismanagement, accidents, ship strikes, and inappropriate disposal at sea. Accidental losses can occur, and fishers may not always be responsible, given that the marine environment is utilized by multiple industries (Goodman et al. 2019). As an example, gear buoy lines can be unintentionally cut by passing commercial vessels and even pleasure crafts. Further, Michael Larkin, President of Brazil Rock 33/34 Lobster Association, explained that "fishing gear is very expensive to purchase, if it's lost, fishers have to replace that [on their own] so that's a double expense. Also, no fishers want their lost gear killing species that get caught or tangled" (personal communication with author; 2024, unreferenced).

The management of fishing gear loss and recovery in marine environments is governed by three key legislations: The Fisheries Act (Government of Canada 1985), the Environmental Protection Act (Government of Canada 1999), and the Vessel Pollution and Dangerous Chemicals Regulations (Government of Canada 2001). These legal frameworks strictly prohibit the disposal of ALDFG at sea, safeguarding the protection of marine life and habitats, and mitigating environmental impacts. Department of Fisheries and Oceans Canada (DFO) considers ALDFG a "wreck" under the Wrecked, Abandoned or Hazardous Vessels Act (WAHVA). Under this designation, the Minister, upon reasonable grounds, can identify ALDFG as posing a hazard as defined by WAHVA (Government of Canada 2019).

While most fishers try to retrieve lost gear, some gear inevitably remains at sea due to several challenges (Goodman et al. 2019). Gear can be hard to relocate once it is lost, and existing license conditions prescribed by DFO limit retrieval of ALDFG. Heather Mulock, Executive Director of Coldwater Lobster Association, explained that "[…] existing licencing conditions present challenges for harvesters to bring ghost gear to shore, so projects like this are a great start to easing retrieval efforts" (personal communication with Coastal Action, 2020; unreferenced). In Atlantic Canada's trap fisheries, such as American lobster (*Homarus* *americanus*) and snow crab (*Chionoecetes opilio*), it is estimated that roughly 0.5 to 2% of traps are lost annually (Goodman 2020; Goodman et al. 2021). Additionally, insight from prior research and project efforts has forecasted ALDFG "hotspots," regions where traps are commonly lost and discovered, highlighting the importance of local fishing knowledge (Goodman et al. 2019).

Historically, the disjointed waste management of end-of-life-gear restricted the availability of low-impact disposal methods (Goodman 2020; Dawe et al. 2021). Gear disposal options were not always consistent between regions in the province. Cost and convenience are known barriers that hinder effective disposal which perpetuates high-impact disposal methods, such as illegal dumping and burning. New disposal options over the last four years have brought major improvements to end-of-life-gear disposal. The options in Nova Scotia particularly expanded during the 2023-2024 season led by the Fishing Gear Coalition of Atlantic Canada (FGCAC), the Ocean Legacy Foundation (in partnership with Coastal Action), and Sustane Technologies. However, the uncertainty of future funding threatens the viability of these valuable programs and fishers may yet again be faced with limited options across Atlantic Canada.

For three years (2020-2023), Coastal Action undertook the *Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia*, a project funded through DFO's Ghost Gear Fund. The goals of this project were to reduce, repurpose, and recycle ALDFG in SWNS by removing ghost gear from at-sea and shoreline locations in LFAs 33 through 35. The project also aimed to promote and explore responsible gear disposal and recycling options and to develop and deliver educational outreach regarding ghost gear and ocean conservation to fishing communities and the public.

September 2022 brought a special set of circumstances with the arrival of Hurricane Fiona. The worst of the storm's impacts were felt in Cape Breton and the Antigonish region of Nova Scotia, the entirety of Prince Edward Island, and southwestern Newfoundland, impacting a wide range of LFAs (Figure 1Figure 1. Lobster Fishing Areas in Atlantic Canada and associated fishing seasons (CBFHA 2024).). Storm surge, high winds, and heavy wave action were felt throughout the entire maritime region. In areas where fishers didn't have active lobster gear in the water, many traps were lost from wharves and shorelines. Many vessels that were geared for fishing herring and groundfish also sustained damage. When DFO responded to the disaster with additional funding through a Supplementary Approved Project Fund, Coastal Action pivoted to Cape Breton to help clean up shorelines in Neil's Harbour and communities around Sydney, laying the foundations for future efforts.

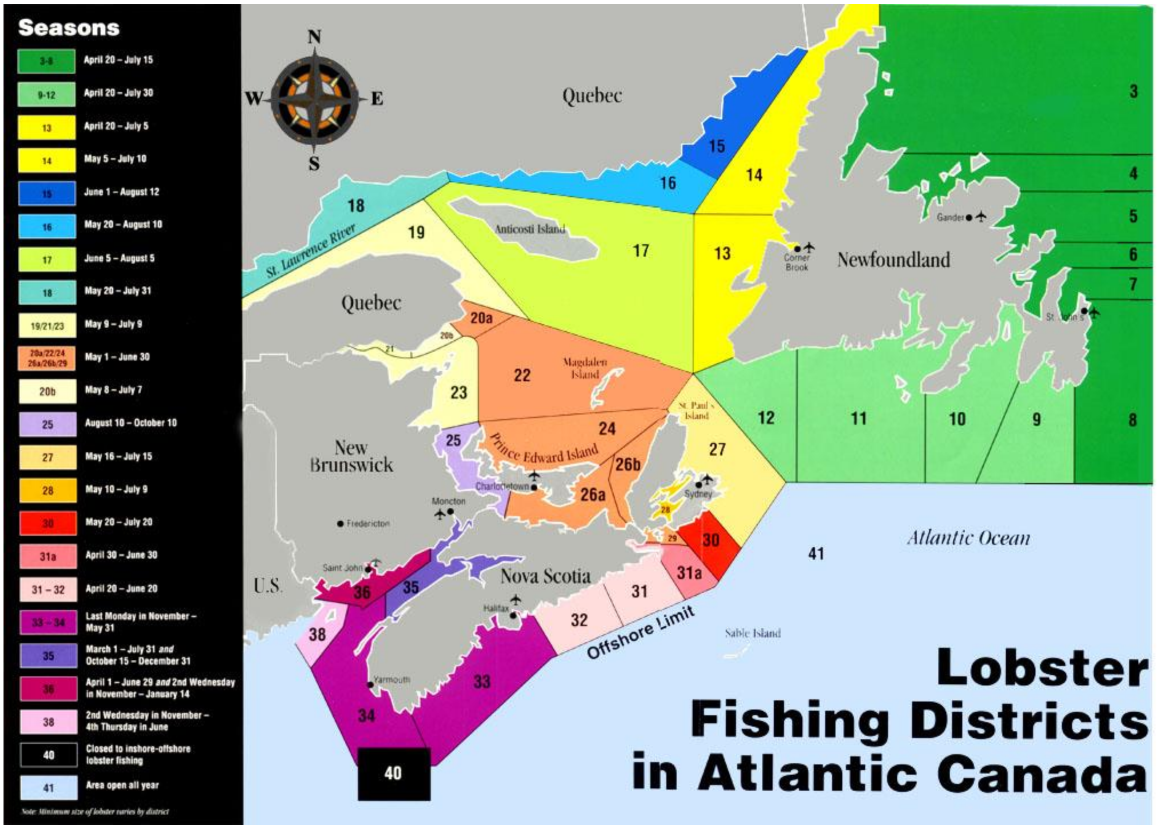


Figure 1. Lobster Fishing Areas in Atlantic Canada and associated fishing seasons (CBFHA 2024).

During 2023-2024, efforts to retrieve ALDFG continued in regions affected by Hurricane Fiona across Nova Scotia, alongside expansions into areas of concern in PEI and Newfoundland. Retrieval operations were conducted both at sea and along shorelines in all three provinces. In addition, we prioritized the end-of-life management of ALDFG, to establish and maintain partnerships with local organizations capable of recycling the bulk of the retrieved gear.

# 2.0 Materials and Methods

## 2.1 Lost Gear Identification and Area Selection

To identify retrieval areas, we explored several techniques throughout this project. Conversations with former retrieval captains focused on areas of previous retrieval success and locations of frequent gear loss. Under DFO licencing conditions, fishing license holders are required to report any lost gear within 24 hours, contributing to a national database. These data, along with input from fishers via an anonymous online survey, were instrumental in selecting our retrieval areas (Figure 2). Additionally, we consulted other ghost gear retrieval groups for recommendations and to coordinate efforts occurring in close proximity or in overlapping areas to maximize retrieval efficiency.

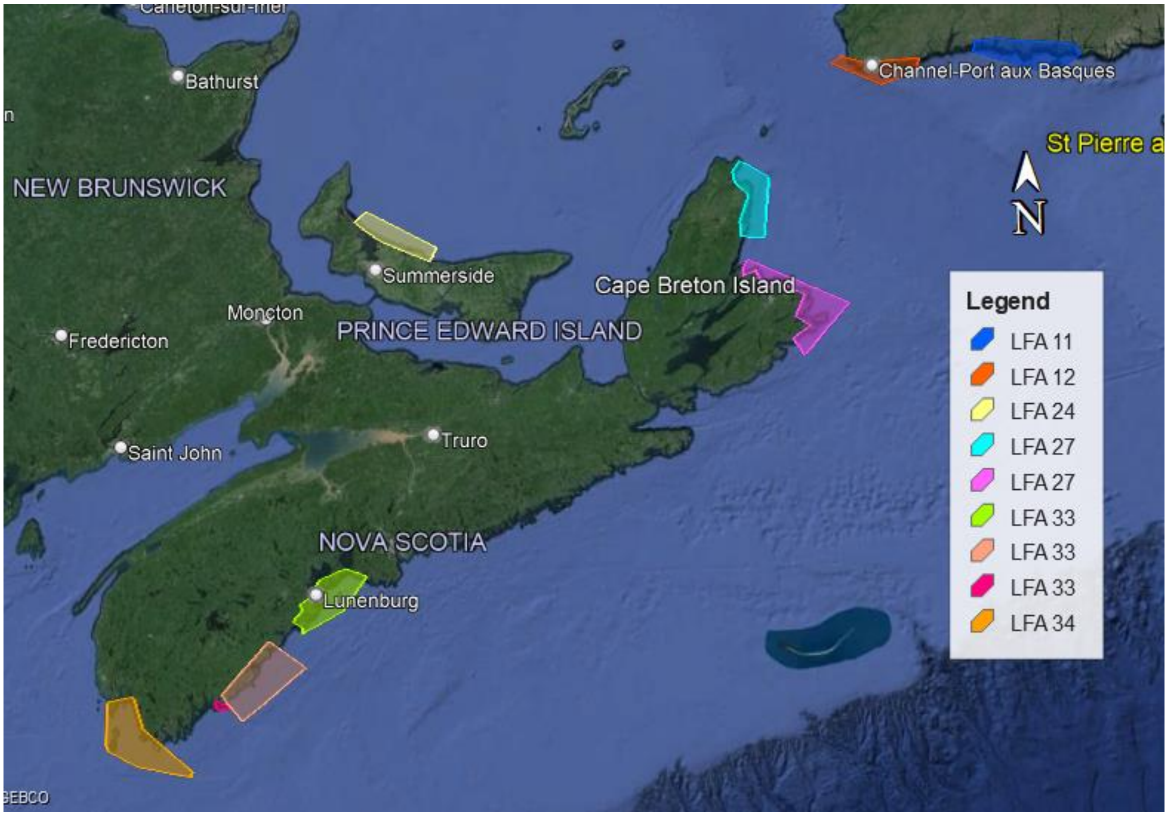


Figure 2. Polygons of Coastal Action's at-sea retrieval areas.

Once retrieval areas were selected, they were approved by DFO under the Fishery (General) Regulation Section 52 Scientific Permit (Permits #361 225, #SG-RHQ-23-211, and #NL-7730-23). Throughout the retrieval season, amendments to our retrieval strategy and permits were made accordingly, based on areas of captain availability and insight gained from ongoing operations.

## 2.2 At-sea Retrieval and Data Collection

At-sea retrievals rely on favourable environmental conditions to safely operate retrieval gear. Generally, retrievals were conducted when winds were low (< 15 knots) and with calm sea states (Beaufort scale < 5). The captains utilized span drags and grapples that were designed and constructed in previous project years, tailored to their specific boat design, and informed by the success of the previous seasons (Figure 3). This equipment was towed from their respective commercial vessels using hydraulic haulers and winches. The preferred towing speed for retrievals ranged between 0.5 to 3 knots.


Figure 3 . Examples of grapples used in the 2023 season for gear retrieval: A. Span drag; B. Cylinder block grapple; C. Span drag with cylinder grapples.

All at-sea retrieval trips were carried out by commercial captains and deckhands. Retrieval captains were selected based on their area of interest, capacity, and commitment to ocean stewardship. Between July 12th and November 1st , 2023, 85 at-sea retrieval trips were completed in the areas pictured in Figure 2. Of these trips, 5 were conducted in LFA 11, 10 in LFA 12, 15 in LFA 24, 30 in LFA 27, 6 in LFA 33, and 19 in LFA 34. Additionally, 5 extra trips were undertaken in LFA 33, specifically targeting offshore islands, bringing the total at-sea retrieval days to 90. For these island retrievals, a Carolina skiff was used to access the islands in Lunenburg Bay and Mahone Bay, facilitating the removal of gear from the shorelines and its safe transportation to the mainland for disposal. Since some island shorelines are rarely accessed by people, gear accumulation can be significant. Islands were previously surveyed by that captain, chosen based on accessibility and the abundance of debris accumulation.

Technicians from Coastal Action, ACAP Humber Arm (ACAP HA), and Bedeque Bay Environmental Management Association (BBEMA) staffed 100% of the retrieval trips to collect standardized data on gear and bycatch. All data were recorded on Coastal Action's ghost gear retrieval data form (Appendix A – Figure 24). Coastal Action's data form merges required fields from DFO's Data Collection for Retrieval of Lost Fishing Gear (Appendix A – Figure 23) with additional data columns assisting with the collection of other scientific information, as will be further described.

Standardized data on gear and bycatch was recorded during all retrieval trips. All relevant retrieval data recorded for DFO reporting was entered into the Fishing Gear Reporting System (FGRS) within 48 hours. Trap age was determined either by the colour of trap tags (2013 to 2022) – DFO possesses the capability to date these tags using colour and tag numbers, which we lack – or by year (2012 and older, and from 2023 onward under the newest tagging system). However, this latter method relies on DFO's tag management system and is an approximation. Therefore, in cases of uncertainty, no age was recorded.

Tagged gear from 2018 or later, considered reusable, was transported to a designated Small Craft Harbour secure compound, with the intent of it being returned to owners by DFO. Older tagged, untagged, or degraded gear was either recycled in collaboration with local partners, disposed of at nearby landfills, or repurposed by fishers.

To assess the ecological impacts of ghost gear additional metrics were recorded including the number of sessile biofouling species present on the gear (e.g., algae, tunicates, barnacles), and the degradation level of gear. If organisms were caught, the length, weight, and evidence of predation (i.e., partial organisms or shells) or injury (i.e., missing limb, evidence of disease, or if they were deceased) were recorded. If American lobsters were caught, sex, clutch size, and egg stage (if applicable) were also recorded. Methods were adapted from DFO's standardized lobster survey trawl methods from Denton (2020).

## 2.3 Mapping and Spatial Analysis

To gain geographical insight into retrieval results, mapping and spatial analyses were conducted on retrieval efforts using Esri ArcGIS Pro (Version 3.0.3). Outliers from human error during data recording and entry were proofed for irregularities, and coordinates and tows that could not be confidently corrected were omitted.

## 2.4 Shoreline Cleanups

Across southwest Nova Scotia, Digby, Cape Breton, PEI, and southwest Newfoundland a total of 19 shoreline cleanups were undertaken. Whenever feasible, these cleanups involved volunteers from the community and industry. In certain instances, cleanups were solely managed by the Coastal Action team and project partners; BBEMA and ACAP HA.

### 2.4.1 Southwest Nova Scotia

Ten shoreline cleanups were completed in western Nova Scotia covering areas in Pubnico, Clark's Harbour, Shelburne, and Digby. Sites were selected based on community insight regarding locations with significant debris accumulation. When possible, these efforts engaged community volunteers. Cleanup participants traversed the shoreline while collecting debris along the way. In some instances, we utilized all-terrain vehicles to aid in retrieval efforts. All retrieved debris was transported to a centralized collection point, where Coastal Action staff sorted and catalogued each piece.

The cataloguing process utilized the Coastal Action ghost gear retrieval data form for shoreline retrievals (Appendix A –Figure 25Figure 25), capturing essential information such as gear weight, length, and tag details. Gear length was measured in feet, and weight was recorded in kilograms using luggage scales. Additionally, observations regarding biofouling organisms and gear conditions were documented to provide comprehensive insight for subsequent analysis.

The data collected from shoreline retrievals assisted in determining recycling priorities and educational material requirements for community engagement and volunteer initiatives. All retrieved shoreline debris was recycled and/or appropriately disposed of following cleanup efforts.

### 2.4.2 Cape Breton

Retrieval operations in Cape Breton focused on sites in the Sydney area, the New Haven-Neil's Harbour area, and Grande Greve. Site selection relied on input from local environmental groups and on-foot shoreline scouting conducted by Coastal Action team members during both this and the previous year's seasons. The New Haven site was identified last season as an area severely impacted by Hurricane Fiona. Several fishing gear storage sheds were demolished by the high storm surge. A tangled concentration of various gear types, along with construction debris and general waste, promoted a two-day collaborative effort involving the Harbour Authority, FGCAC, and the local community. The methodology was the same as that of the NS shoreline retrieval efforts.

### 2.4.3 Prince Edward Island

Shoreline retrieval operations targeted four priority areas identified by our partner technicians at BBEMA. Coastal Action and BBEMA collaborated for the Stanley Bridge cleanup to address an extensive accumulation of debris resulting from Hurricane Fiona's damage. The methodology was the same as that of the NS shoreline retrieval efforts.

#### 2.4.4 Newfoundland

Our partner technicians at ACAP HA organized a shoreline cleanup during an Ocean's Week event in collaboration with the Hurricane Fiona affected community of Isle aux Morts. The methodology was the same as that of the NS shoreline retrieval efforts.

### 2.5 Data Analysis and Assessment

Ghost gear and bycatch data were analyzed in Microsoft Office applications and mapped using ArcGIS software systems.

## 3.0 Results and Discussion

### 3.0.1 Industry and Community Knowledge

Retrieval captains shared their expertise regarding areas prone to ghost gear accumulation as well as gathered valuable insight on locations of gear loss from other local fishers throughout the project. This collective knowledge was essential for the success of our retrieval efforts. While DFO's database of reported gear losses provided useful information on broad-scale patterns and areas warranting exploration, community insight proved to be more effective in identifying specific gear locations.

### 3.1 Retrieval

The length of tows varied based on local conditions, search areas, and the preferences of the captain conducting retrievals. Some captains opted for shorter, straight-line tows that were 30 minutes or less, while others opted for longer tows spanning multiple hours, with the grapple submerged and continuously towed. In cases where gear was snagged, the grapple was raised and gear was brought aboard, if safe to do so. If retrieval was deemed unsafe the location of the loss was recorded and reported. Additionally, any surface debris, such as buoys, spotted during retrieval efforts was also recovered.

Most captains were successful in retrieving debris from their designated search areas with five captains experiencing "nil days" during which no gear was collected (Table 1). While the method of towing and grappling for gear from the seafloor proved relatively successful, it is important to acknowledge that towing over large areas, with limited knowledge of gear loss locations, proved to have mixed outcomes. Therefore, prior knowledge of ALDFG hotspots is critical for successful gear retrievals.

"Nil days" were primarily observed in LFAs new to the Coastal Action team, with captains who were new to the project, which may account for some of the challenges faced. LFA 24 presented difficulties with a notably higher proportion of "nil tows" and "nil trips". This highlights the need for further exploration to determine whether more effective retrieval techniques should be used in this area.

Table 1. Summary of the total at-sea area searched and ghost gear retrieval tows, trips, and "nil" metrics per captain.

| **Fisher ID** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LFA | 34 | 34 | 34 | 34 | 33 | 27 | 27 | 27 | 24 | 24 | 24 | 11, 12 |
| **Total Tows** | 163 | 118 | 68 | 20 | 144 | 197 | 146 | 106 | 45 | 13 | 6 | 239 |
| Nil Tows | 64 | 64 | 60 | 11 | 110 | 106 | 120 | 36 | 42 | 12 | 6 | 105 |
| Nil Tows (%) | 39% | 54% | 88% | 55% | 76% | 54% | 82% | 34% | 93% | 92% | 100% | 44% |
| Total Retrieval Trips | 8 | 6 | 4 | 1 | 6 | 10 | 10 | 10 | 5 | 5 | 5 | 15 |
| Nil Trips | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 4 | 5 | 0 |
| Nil Trips (%) | 0% | 0% | 0% | 0% | 0% | 10% | 10% | 0% | 40% | 80% | 100% | 0% |

In addition, Fisher ID 13 in LFA 33 (not included in Table 1) did not tow a grapple but instead assisted with retrieval efforts off island shorelines (Figure 4). This was an effective strategy as the captain had good knowledge of where debris accumulated on islands, and we were able to build off of scoping and methods from the previous season. This resulted in the removal of 1,183 kg of gear (Table 1Table 2). Although ALDFG on shorelines is not actively fishing, it is essential to remove this gear to prevent it from being washed back into the ocean, endangering other wildlife, and island users, or harming critical shoreline habitats (Blettler and Mitchell 2021).

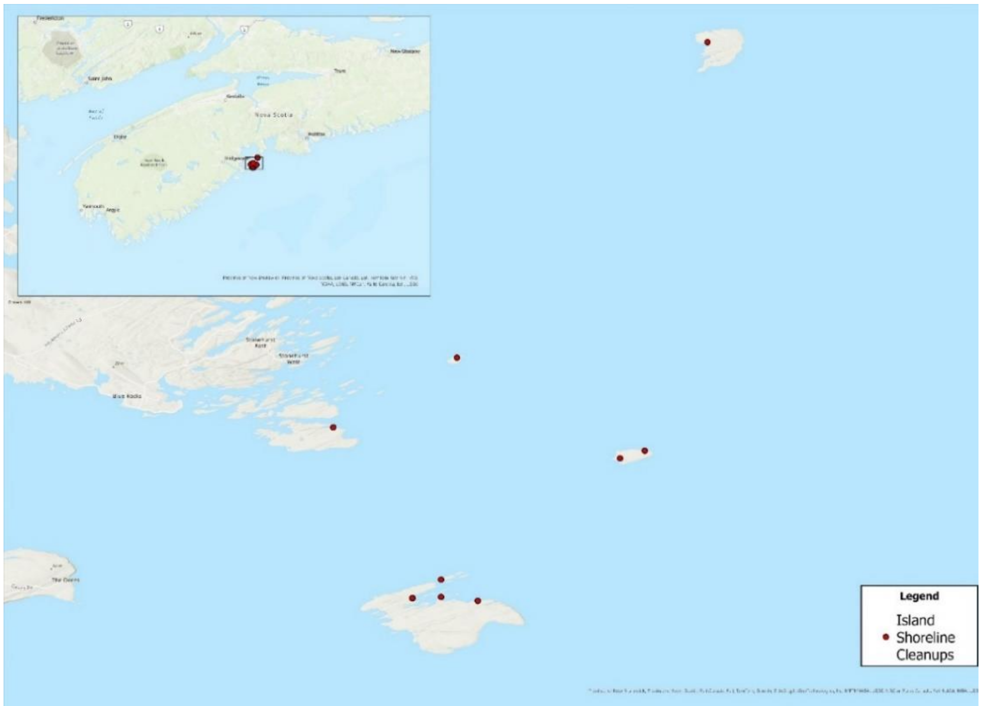


Figure 4. Island retrieval efforts in LFA 33. These trips differed from other at-sea days as island shorelines were targeted instead of underwater retrieval. On some of the islands, multiple sites were visited by our team as gear was dispersed and not all areas could be accessed from the same landing site.

Table 2. Shoreline cleanup summary for western Nova Scotia.

| Gear | Anderson Cove | Black Point Apple Island | Black Point South | Hawk Beach | Johnstons Beach | Stephen's Cove West | Stephen's Cove East | LFA 33 Islands | West Head Pond Cove | West Head Sunset Lookout | West Pubnico Point Trail | Grand Total | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Buoy Count | 3 | 1 | 5 | 1 | 4 | | 4 | 23 | 2 | 4 | 39 | **86** | **count** |
| Trap Count | 2 | 9 | 35 | 5 | 9 | 26 | 20 | 22 | 17 | 39 | 19 | **203** | **count** |
| | | | | | | | | | | | | | |
| **Fishing Gear** | | | | | | | | | | | | | |
| Bouy Weight | 0.3 | 0.1 | 1.9 | 0 | 0.6 | | 1.7 | 13.9 | 4.3 | 0.4 | 48.3 | **71.3** | **kg** |
| Netting Weight | 2 | 6 | 0 | 0.1 | 0.1 | | 50.5 | 15.1 | 0.2 | 0.1 | 0.1 | **74.2** | **kg** |
| Partial Trap Weight | 19.6 | 37.5 | 28.1 | 28.5 | 118.9 | 75.8 | 107.3 | 222.2 | 135.5 | 250 | 225.8 | **1249** | **kg** |
| Rope Weight | 105 | 35.2 | 25 | 1.5 | 30 | 1.1 | 29 | 84.6 | 68 | 41.6 | 110 | **531** | **kg** |
| Trap Weight | 31.5 | 168 | 538 | 79.5 | 176 | 576 | 385.5 | 450 | 348 | 775 | 437.5 | **3965** | **kg** |
| Commerical Fishing Equipment Weight | 15.5 | 9.1 | 3.2 | 0.1 | 10 | | 166.4 | 111.1 | 3.5 | 2.6 | 36.5 | **357.9** | **kg** |
| Hand Fishing Gear Weight | 0.2 | | | 1 | | | | 0 | 0 | | | **1.2** | **kg** |
| **Total** | **174.1** | **255.9** | **596.1** | **110.7** | **335.6** | **652.9** | **740.3** | **896.8** | **559.5** | **1069.7** | **858.1** | **6249.6** | **kg** |
| | | | | | | | | | | | | | |
| **Trash** | | | | | | | | | | | | | |
| Rubber Weight | 1 | | | | | | 1 | 0.3 | 3 | 0.8 | 3.9 | **9.9** | **kg** |
| Domestic Trash Weight | 2.3 | | 1.2 | 0 | 9.6 | | 3.9 | 4.9 | 7.6 | 6 | 120.1 | **155.6** | **kg** |
| Recyclable Weight | 2 | | 1.1 | | 2.1 | | 6 | 5.9 | 2.6 | 2.5 | 8 | **30.2** | **kg** |
| Hard Plastic Weight | 85.3 | | 4 | 2 | 6 | | 10.4 | 3.1 | 9.5 | 5 | 42.9 | **168.2** | **kg** |
| Metal Weight | 13.6 | | 19 | 1.3 | | | | 260 | | 3.9 | 37 | **334.7** | **kg** |
| Tires/Rim Weight | | | 34 | | | | | 0 | | 41 | 31.5 | **106.5** | **kg** |
| Textile/Clothing Weight | 0.1 | | 1.3 | 0.3 | 19 | | 13 | 3 | 10 | 4 | 5.8 | **56.4** | **kg** |
| Foam Weight | 0.2 | | 0 | | 2 | | 1.5 | 8.7 | 1.3 | 2 | 21.3 | **36.9** | **kg** |
| Film Weight | 0.2 | | 4.5 | | 0.3 | | 4.3 | 0.7 | 0.8 | 1.3 | 9 | **21** | **kg** |
| **Total** | **104.7** | **0** | **65.1** | **3.5** | **39** | **0** | **40** | **286.7** | **34.7** | **66.4** | **279.3** | **919.3** | **kg** |
| | | | | | | | | | | | | | |
| **Grand Total** | **278.8** | **255.9** | **661.2** | **114.2** | **374.6** | **652.9** | **780.3** | **1183.4** | **594.2** | **1136.1** | **1137.4** | **7168.9** | **kg** |

### 3.1.1 At-sea Retrieval

Nearly 19 metric tonnes of debris, predominantly ALDFG, were removed from the Atlantic Ocean over 85 gear retrieval days across the Atlantic provinces (Table 3). Additionally, 5 at-sea days of island shoreline cleanups are documented later in Table 4. Gear retrieved at sea and across island shorelines varied in type, age, condition, and weight. The spatial distribution of ALDFG retrieved was influenced by the locations chosen by the captains. Their decisions were guided by known locations of lost gear, local fishing effort, bottom type, and “retrievability” factors such as safety considerations, and boat access. A significant portion of the total gear retrieved was from Lobster Bay (Figure 5), an area with historically high fishing activity. This area should be prioritized for future retrieval efforts. Additionally, large volumes of debris were retrieved near Ingonish and Neil’s Harbour, two areas heavily impacted by Hurricane Fiona. A disproportionately low amount of gear was retrieved from LFA 24. If further work is planned in this area, alternative retrieval methods should be considered (Figure 6).

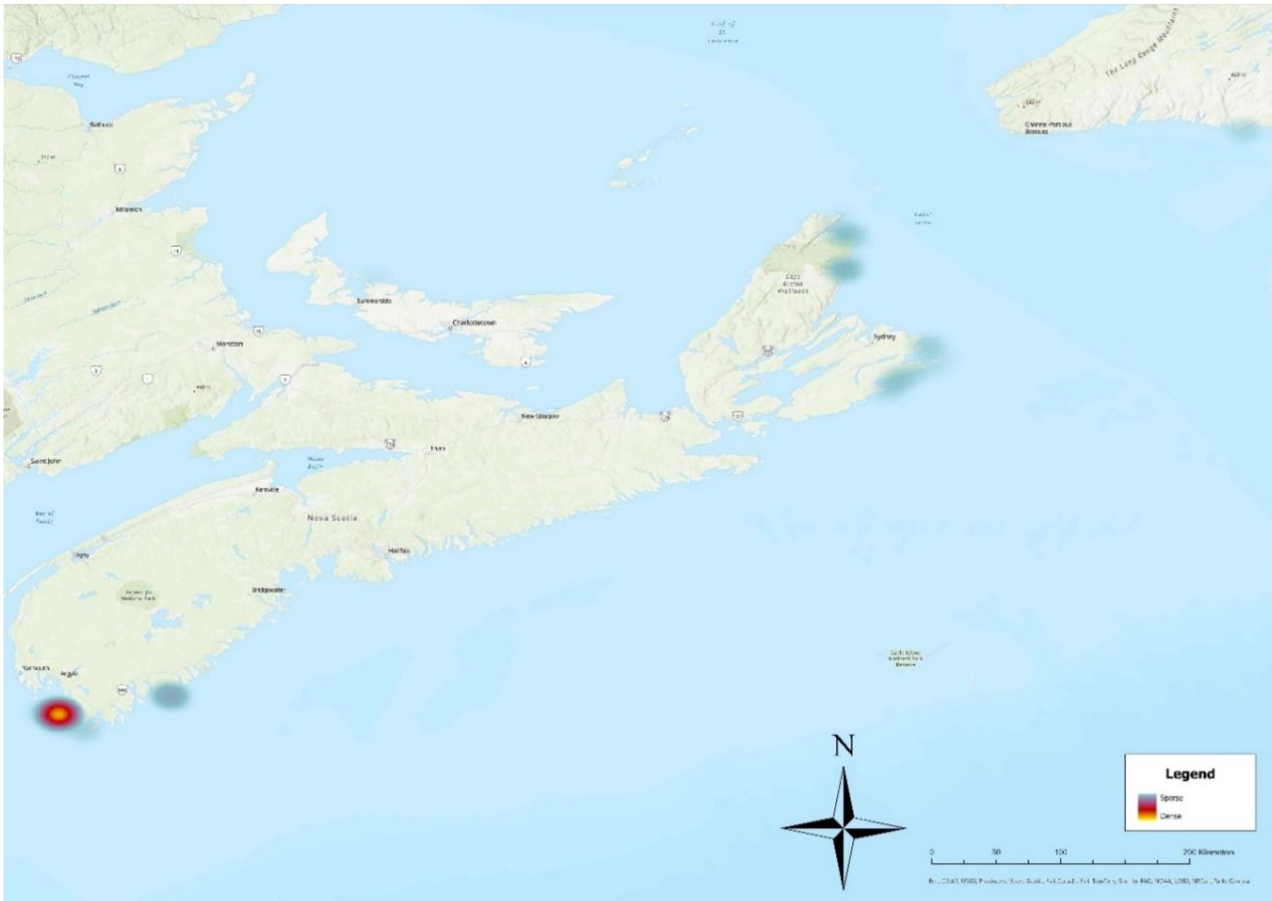


Figure 5. Heat map of lobster trap retrieval frequency in all targeted LFAs.

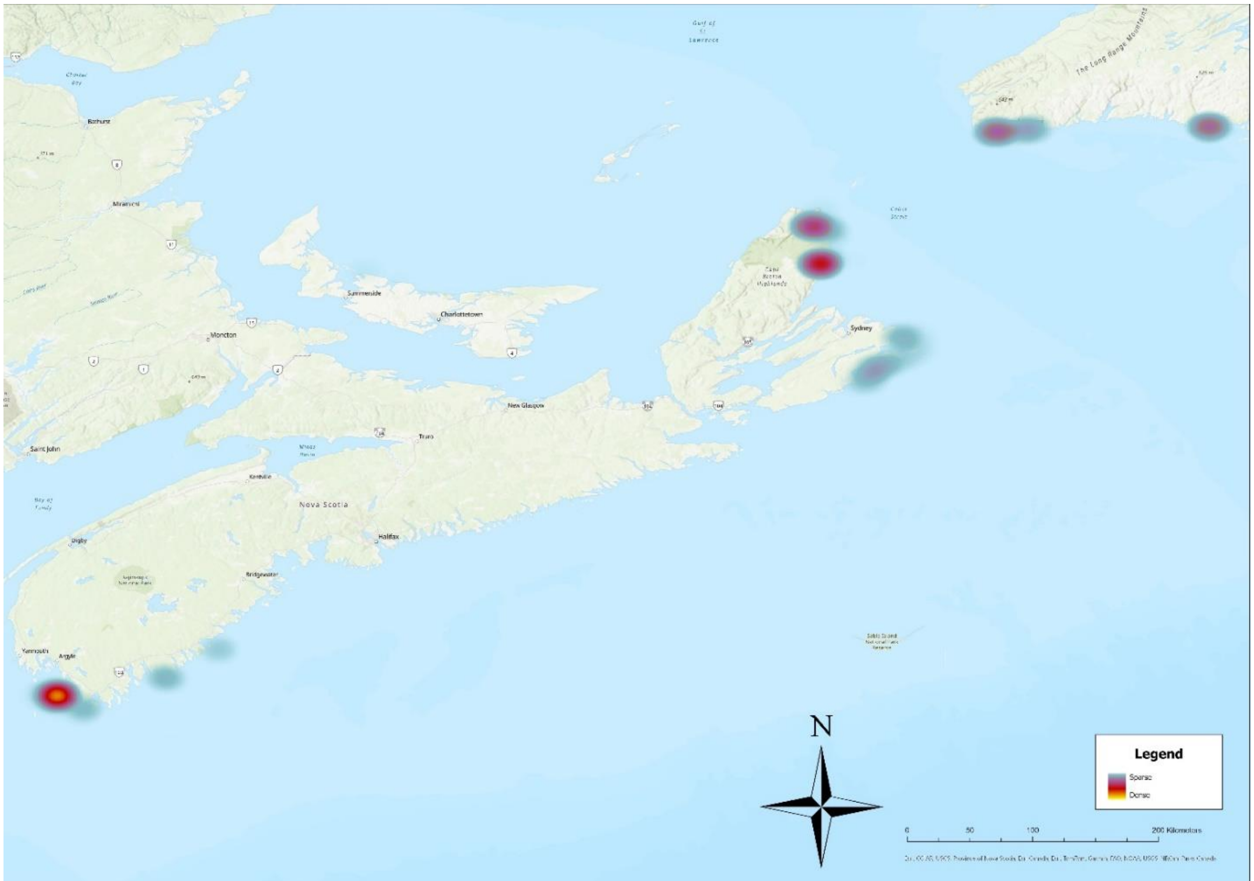


Figure 6. Heat map of the weight of all gear collected at sea during the 2023 season.

Table 3. Summary of the total at-sea retrieval effort from LFAs 11, 12, 24, 27, 33, and 34.

| Fisher ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LFA | 34 | 34 | 34 | 34 | 33 | 27 | 27 | 27 | 24 | 24 | 24 | 11, 12 | |
| **Total Lobster Traps** | 131 | 50 | 9 | 2 | 20 | 7 | 10 | 52 | 0 | 4 | 0 | 11 | 296 |
| Escape Panel Functioned | 99 | 43 | 2 | 1 | 19 | 3 | 7 | 4 | 0 | 4 | 0 | 5 | 187 |
| Escape Panel Did Not Function | 6 | 2 | 5 | 1 | 1 | 1 | 3 | 47 | 0 | 0 | 0 | 2 | 68 |
| Illegal Escape Panel | 22 | 5 | 2 | 0 | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 33 |
| Unknown | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 8 |
| Compounded Traps | 2 | 0 | 1 | 0 | 1 | 2 | 2 | 48 | 0 | 4 | 0 | 0 | 60 |
| Average Trap Age (yr) | 22.04 | 20.07 | 24.5 | NA | 11.75 | 31.5 | 16 | 0.34 | NA | 0 | NA | 15 | 15.69 |
| Min Trap Age (yr) | 10 | 11 | 22 | NA | 6 | 30 | 16 | 0 | NA | 0 | NA | 15 | 0 |
| Max Trap Age (yr) | 35 | 34 | 27 | NA | 15 | 33 | 16 | 16 | NA | 0 | NA | 15 | 35 |
| **Total Weight (kg)** | 3893.55 | 1853.82 | 361.9 | 2580.85 | 1088.5 | 1795.68 | 2398.57 | 2678.47 | 2.5 | 216 | 0 | 2058.75 | 18928.59 |
| Lobster Trap (kg) | 3250.25 | 1698 | 288 | 72 | 460.2 | 173 | 321 | 1999.6 | 0 | 200 | 0 | 163.95 | 8626 |
| Partial Trap (kg) | 193.5 | 29 | 13 | 0 | 39 | 25 | 65 | 0 | 0 | 0 | 0 | 0 | 364.5 |
| Rope (kg) | 134.45 | 11.8 | 13.7 | 2.35 | 15.6 | 106.23 | 34.35 | 197.95 | 0.5 | 16 | 0 | 121.1 | 654.03 |
| Trap Pieces (kg) | 42.95 | 15 | 0 | 0.1 | 37.6 | 27.2 | 4.85 | 0.8 | 0 | 0 | 0 | 2.2 | 130.7 |
| Gill Net (kg) | 0 | 0 | 0 | 0 | 453.6 | 0.27 | 0 | 0 | 0 | 0 | 0 | 79.5 | 533.37 |
| Seine/Lead Line (kg) | 0 | 0 | 0 | 0 | 0 | 25.5 | 1158.8 | 323.4 | 0 | 0 | 0 | 0 | 1507.7 |
| Dragger Cable (kg) | 13.2 | 23.5 | 0 | 2465.7 | 0 | 9 | 0 | 86.5 | 0 | 0 | 0 | 282.65 | 2880.55 |
| Net (kg) | 0.3 | 0 | 0 | 0 | 0 | 0.40 | 0 | 0 | 0 | 0 | 0 | 275.36 | 276.06 |
| Bait Bag (kg) | 1 | 0.45 | 0 | 0.1 | 0 | 1.29 | 0 | 0 | 0 | 0 | 0 | 0.1 | 2.94 |
| Buoy (kg) | 0 | 0 | 2.2 | 0.1 | 42 | 19.35 | 2.1 | 42.72 | 2 | 0 | 0 | 10.4 | 120.87 |
| Snarl (kg) | 73.85 | 41.8 | 0 | 3 | 5 | 245.25 | 281.85 | 27.3 | 0 | 0 | 0 | 259.75 | 937.802 |
| Anchor (kg) | 71 | 20 | 45 | 0 | 35.5 | 716.5 | 455 | 0 | 0 | 0 | 0 | 8.25 | 1351.25 |
| Crab Pot (kg) | 0 | 0 | 0 | 0 | 0 | 0 | 75 | 0 | 0 | 0 | 0 | 0 | 75 |
| **Total Length (ft)** | 20052 | 1339 | 345 | 9278 | 1413 | 8924 | 13938 | 8756 | 2 | 385 | 0 | 8824.5 | 73256.5 |
| Rope (ft) | 3407 | 345 | 345 | 78 | 677 | 1574 | 1156 | 6360 | 2 | 385 | 0 | 2959 | 17288 |
| Gill Net (ft) | 0 | 0 | 0 | 0 | 716 | 15 | 0 | 0 | 0 | 0 | 0 | 300 | 1031 |
| Snarl lengths (ft) | 635 | 817 | 0 | 50 | 20 | 5281 | 2954 | 106 | 0 | 0 | 0 | 2499 | 12362 |
| Seine/Lead Line (ft) | 0 | 0 | 0 | 0 | 0 | 168 | 9802 | 1866 | 0 | 0 | 0 | 0 | 11836 |
| Dragger Cable (ft) | 60 | 145 | 0 | 9147 | 0 | 23 | 0 | 419 | 0 | 0 | 0 | 873 | 10667 |
| Net (ft) | 5 | 0 | 0 | 0 | 0 | 22 | 0 | 0 | 0 | 0 | 0 | 291 | 318 |
| Monofilament (ft) | 15929 | 28 | 0 | 0 | 0 | 518 | 0 | 0 | 0 | 0 | 0 | 190 | 16665 |
| Trap Piece - Netting (ft) | 16 | 4 | 0 | 3 | 0 | 59 | 21 | 5 | 0 | 0 | 0 | 0 | 108 |
| **Total Bycatch** | 128 | 57 | 41 | 10 | 118 | 50 | 246 | 289 | 0 | 64 | 0 | 41 | 1044 |
| Lobster | 14 | 0 | 34 | 6 | 9 | 1 | 14 | 238 | 0 | 64 | 0 | 18 | 398 |
| Crabs | 108 | 55 | 4 | 1 | 72 | 38 | 230 | 23 | 0 | 0 | 0 | 14 | 545 |
| Groundfish | 0 | 0 | 0 | 0 | 7 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 12 |
| Other Fish | 2 | 0 | 3 | 3 | 27 | 10 | 0 | 16 | 0 | 0 | 0 | 6 | 67 |
| Mollusk | 4 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |

Lobster traps (including partial traps and trap pieces) comprised 48.19% of the total retrieved weight (Figure 7), ranging from 4 to 45 kg along the south shore of Nova Scotia. The average trap weight is approximately 25 kg, with the most common weight being 32 kg. The heaviest trap retrieved, weighing 59 kg, was found near Louisbourg. Traps retrieved ranged in age from zero years (fresh for the 2023 season, roughly 1 to 10 months old) to thirty-five years old (Table 3). However, not all traps were tagged, making it challenging to determine the true age distribution of the retrieved gear. Traps were predominantly retrieved in Lobster Bay, with similar but fewer recoveries near Liverpool, Louisbourg, Ingonish and Neil's Harbour. In Newfoundland, more traps were recovered in the Burgeo area compared to the Port aux Basques area (Figure 8).

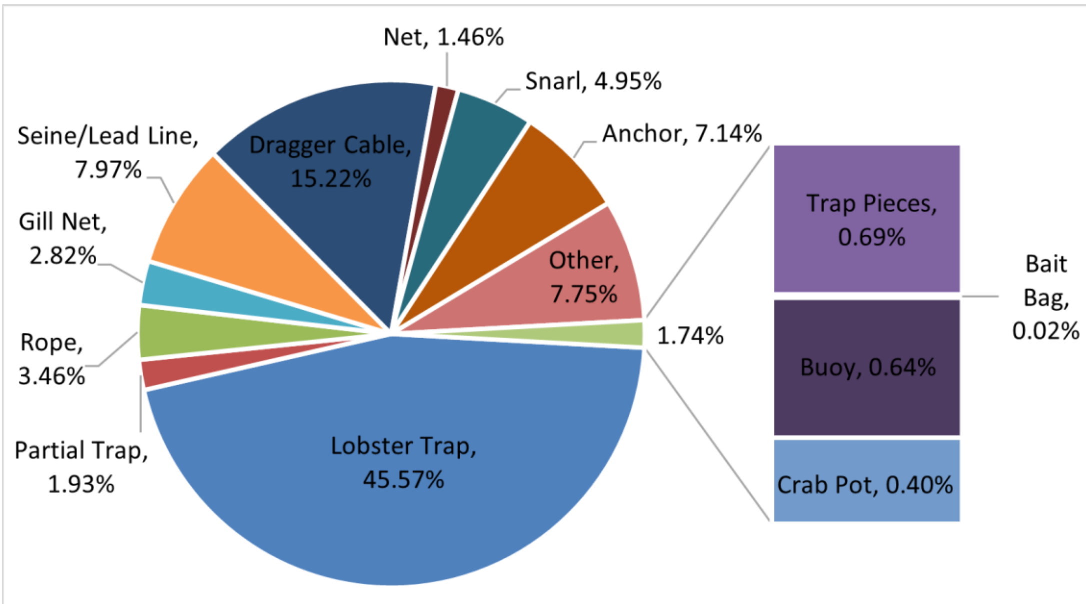


Figure 7. Proportions of item types retrieved at sea in all targeted LFAs by weight.

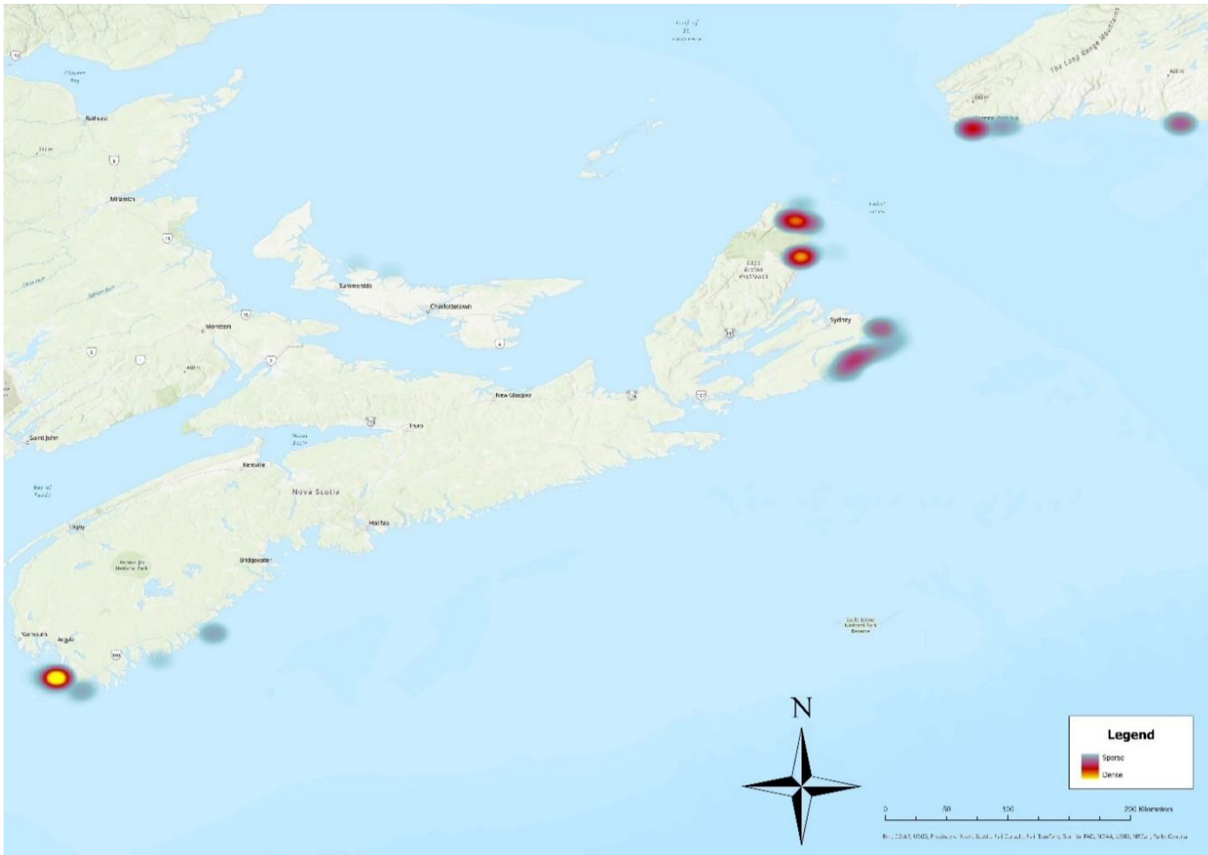


Figure 8. Heat map of rope retrieval frequency in all targeted LFAs.

Rope retrieval frequency was not solely linked to trap retrieval frequency. Quite a lot of unassociated rope was retrieved, with rope hotspots occurring in Lobster Bay, Cape Breton, and Port aux Basques. This is unsurprising as rope is used in multiple fisheries and industries and resists degradation well. Rope made up 3.46% of all gear retrieved at sea by weight (Figure 8) and totalled 17,288 ft (5.27 km). An additional 11,836 ft (3.61 km) of lead line (rope with a lead core, including seine rope) was also retrieved, bringing the grand total of all types of rope to 29,124 ft (8.88 km).

Dragger cable made up a significant portion by weight, accounting for 15% of at-sea retrievals (Figure 9). Consistent with the previous season, captains safely retrieved 2,880 kg of cable. However, additional cable was initially grappled but ultimately remained unrecovered due to safety concerns, including issues of heavy cable destabilizing vessels, cable stuck on the seabed, cables fracturing easily, and sharp frayed edges becoming hazardous to handle. Local knowledge suggests that historically commercial trawl vessels (draggers) would discard dragger cables at sea rather than hauling them ashore. A significant amount of dragger cable was retrieved at the mouths of harbours notably in Clark's Harbour, Lobster Bay, Louisburg, and Port aux Basques.

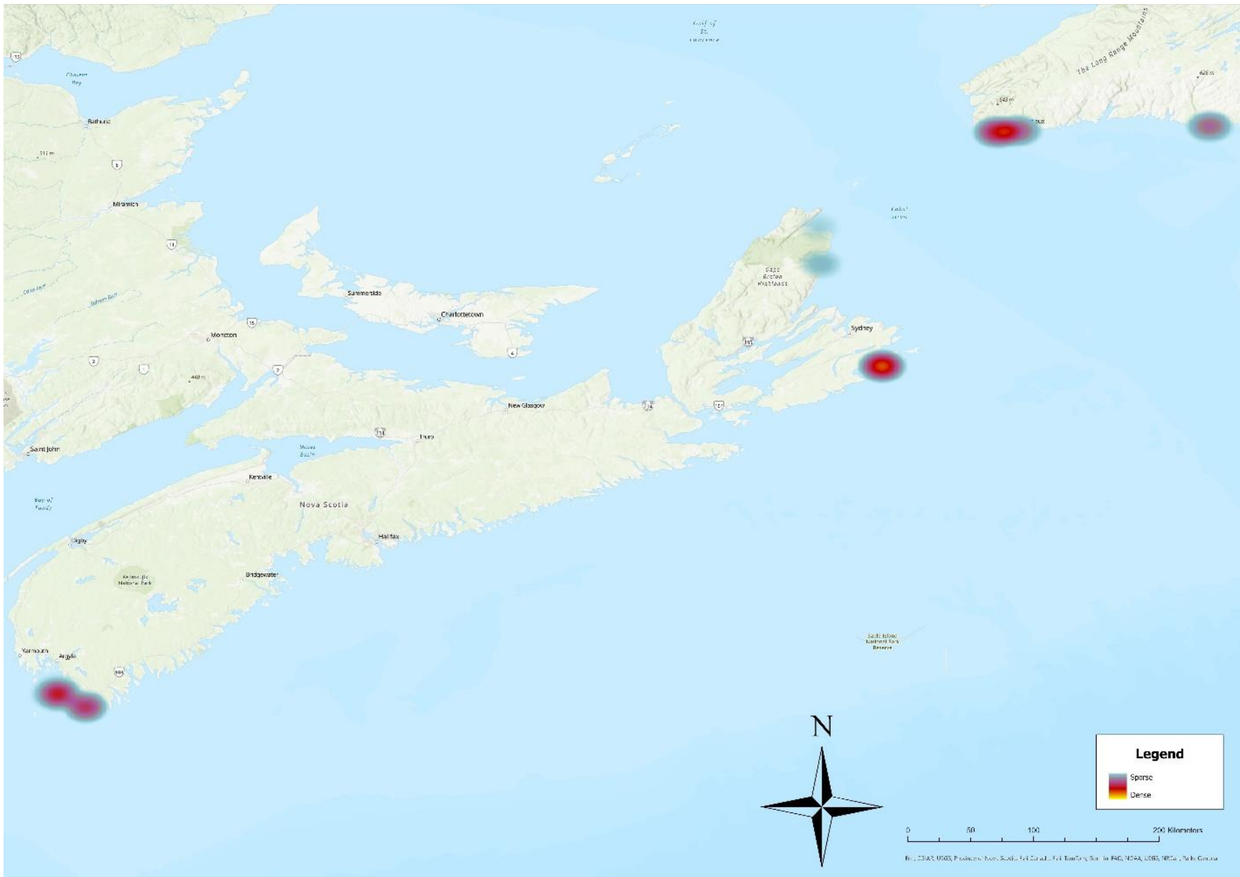


Figure 9. Heat map of dragger retrieval frequency in all targeted LFAs.

For the first time throughout this project, we encountered Danish seine line (also known as seine rope or seine warp) in Cape Breton. Danish seine line consists of a thick steel cable, often with a lead core, encased in synthetic rope. It is notably heavy and prone to tangling with other gear types as well as natural debris. However, the rope casing does make it considerably easier and safer to handle, as it does not fracture or create burrs. Additionally, it typically runs smoothly through hauler winches. On several occasions, we hooked seine line and had to release it either because it was tethered to the seabed or because it had formed such a mass that it exceeded the maximum capacity of the vessel's boom winch. Hotspots for seine line were primarily in Cape Breton, although some additional pieces were retrieved in Newfoundland as well (Figure 10).

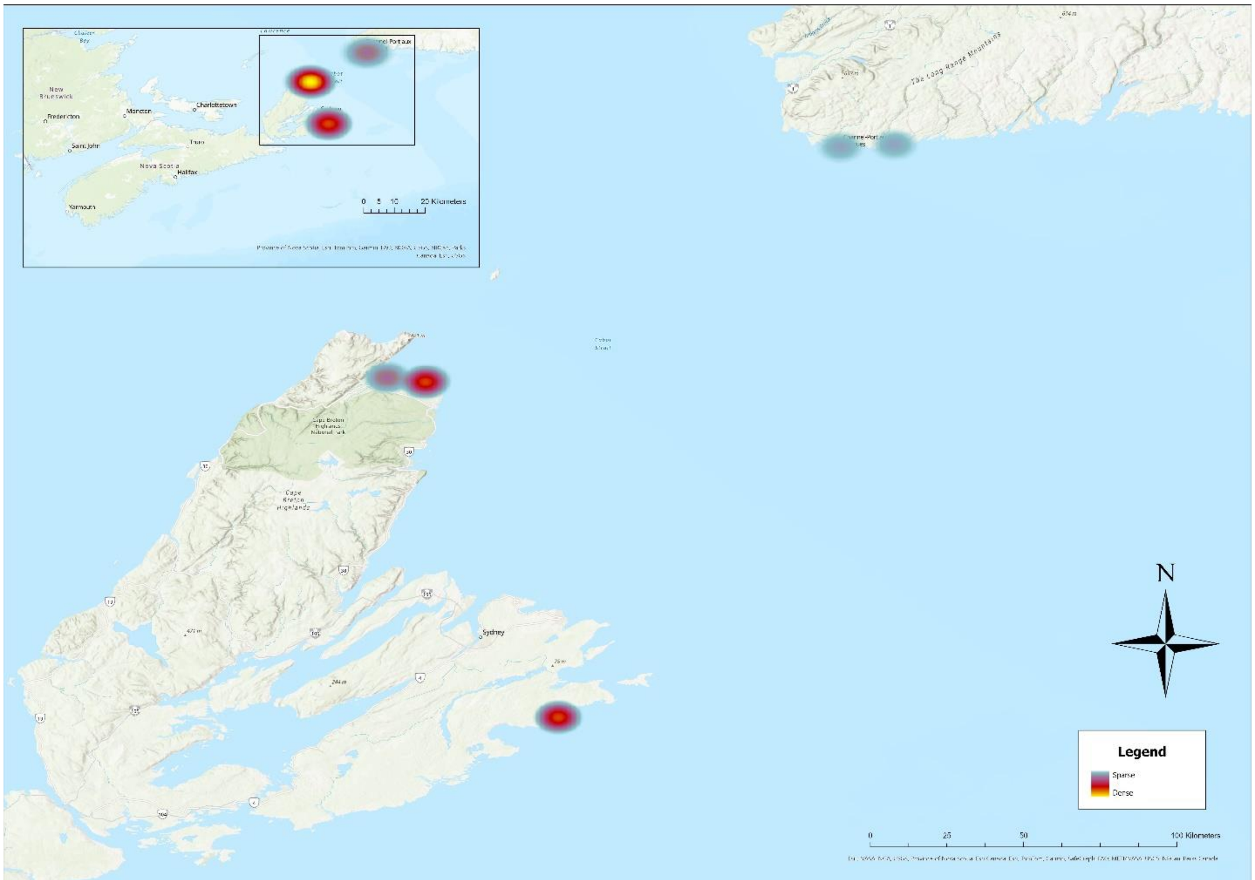


Figure 10. Heat map of Danish seine line retrieval frequency in all targeted LFAs.

In Nova Scotia, the highest number of retrieval trips occurred in LFA 27 (30 trips) and LFA 34 (19 trips). Despite completing fewer trips than LFA 27, captains in LFA 34 retrieved the greatest amount of gear by weight, as indicated in Table 3. This observation highlights the need for further retrieval days in Lobster Bay. In addition, the quantity of rope retrieved in feet between LFA 34 and 27 was nearly equivalent.

### 3.1.2 Shoreline Retrieval

Shoreline retrievals were conducted in western Nova Scotia as illustrated in Figure 11. A total of 7,168.9 kgs of debris were removed from these areas, including 531 kgs of rope (including rope snarled with other material) measuring 18,041 ft and 203 lobster traps weighing 3,965 kgs (Table 2). Notably, West Pubnico and West Head had some of the largest amounts of ALDFG removed. These areas are identified as hotspots and warrant additional efforts in future seasons. The success of these retrievals can be partly attributed to the accessibility to the shorelines, volunteer support, and the availability of supporting equipment.

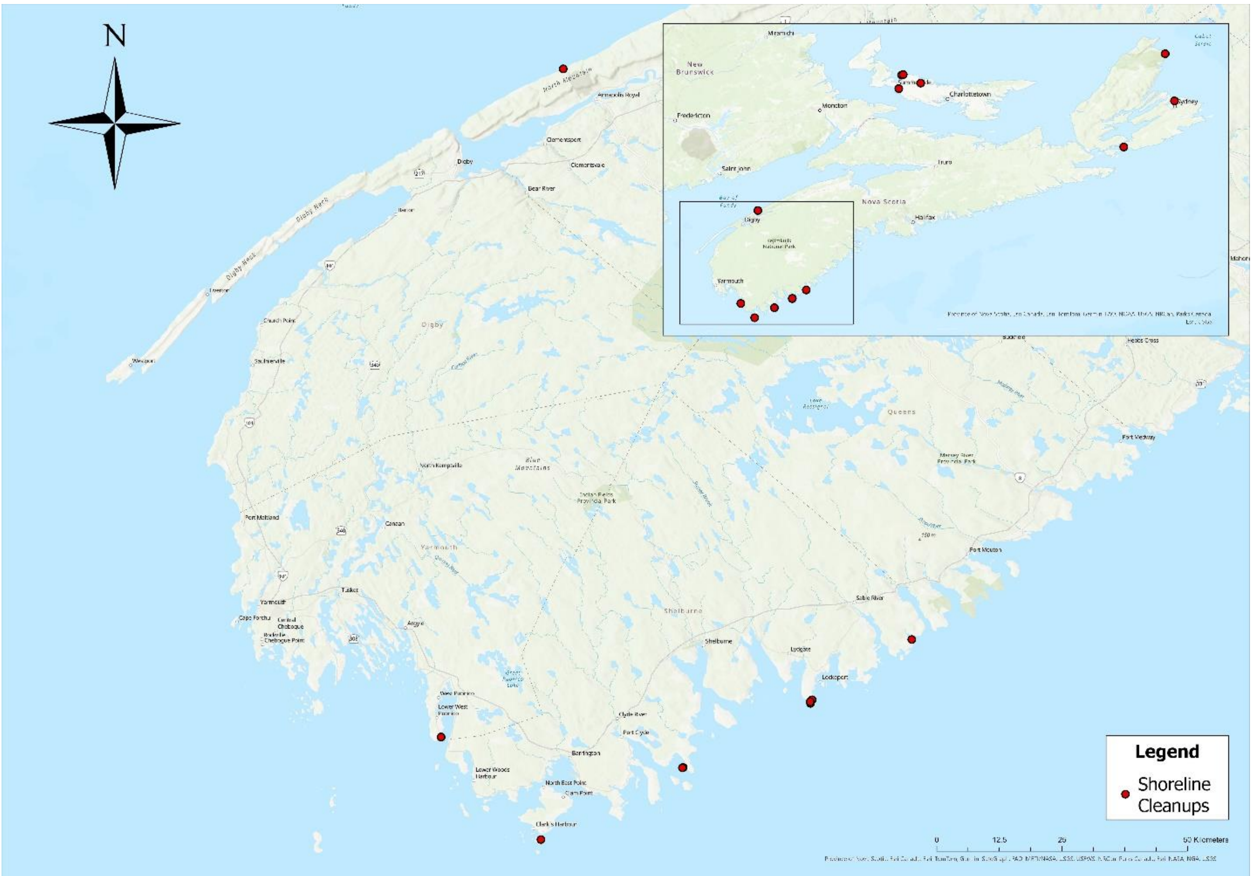


Figure 11. Locations of shoreline cleanups in western Nova Scotia.

Additional shoreline retrievals were carried out in Cape Breton NS, PEI, and southwestern NL (Figure 12). These areas were particularly impacted by Hurricane Fiona. A total of 9,051 kgs of debris were removed from the shorelines in these regions, including 351.6 kg of rope (including rope snarled with other material), totalling 15,226 ft and 5,523 kgs of lobster traps (198 traps) (Table 4). Due to the significant accumulation of gear and debris, two days of retrieval efforts were required in New Haven. This location yielded the highest amount of gear retrieved by weight in a single location, approximately 6,583.3 kg.

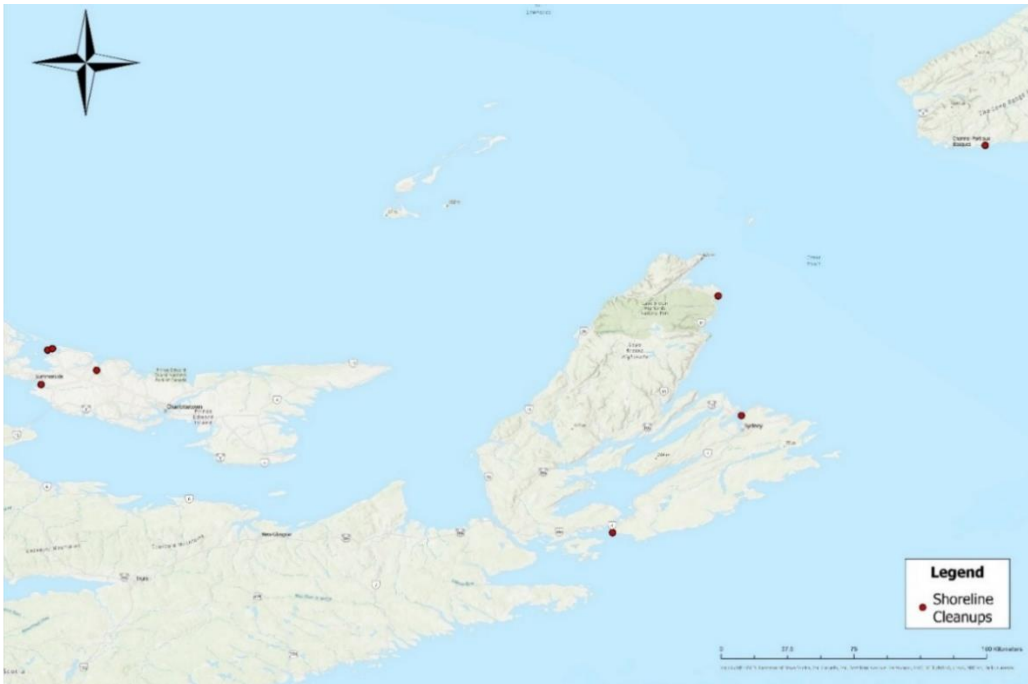


Figure 12. Locations of Prince Edward Island, Newfoundland, and Cape Breton Nova Scotia shoreline retrieval efforts.

Table 4. Shoreline cleanup summary for Cape Breton NS, PEI, and NL.

| Gear | Grand Greve, NS | New Haven North, NS | New Haven South, NS | South Bar, NS | Harvey Trail, NL | Baker Shore, PEI | Montgomery, PEI | Stanley Bridge, PEI | Taylor Road, PEI | Grand Total | Units |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Buoy | 1 | 1 | 13 | 4 | 14 | 6 | 1 | 9 | 0 | **49** | **count** |
| Trap | | 82 | 98 | 17 | | | | 1 | 0 | **198** | **count** |
| | | | | | | | | | | | |
| **Fishing Gear NS,NL,PEI** | | | | | | | | | | | |
| Buoy Weight | 0.1 | 0.1 | 6.7 | 2.0 | 5.8 | 4.3 | 2.0 | 4.1 | | **25.1** | **kg** |
| Netting Weight | 0.1 | 200.1 | 385.0 | 1.0 | 0.1 | 2.5 | | 6.0 | | **594.8** | **kg** |
| Partial Trap Weight | 180.6 | 130.8 | 19.0 | 200.0 | 0.7 | 0.5 | 9.5 | 1.0 | 0.5 | **542.5** | **kg** |
| Rope Weight | 2.5 | 19.6 | 25.8 | 106.2 | 2.3 | 18.8 | 4.0 | 99.5 | 73.0 | **351.6** | **kg** |
| Trap Weight | | 1477.0 | 3836.5 | 196.5 | | | | 13.0 | | **5523.0** | **kg** |
| Commercial Fishing Equipment Weight | 1.8 | 0.8 | 25.4 | 6.9 | 1.1 | 1.3 | 4.1 | 2.4 | 4.0 | **47.7** | **kg** |
| Hand Fishing Gear Weight | | | | 0.1 | | | | 0.1 | 26 | **26.2** | **kg** |
| **Total** | **185.1** | **1828.4** | **4298.3** | **512.7** | **10.0** | **27.4** | **19.6** | **126.1** | **103.5** | **7110.9** | **kg** |
| | | | | | | | | | | | |
| **Trash NS,Nl,PEI** | | | | | | | | | | | |
| Rubber Weight | 0.1 | 11 | | 3.5 | 0.2 | | | 6.2 | | **21.0** | **kg** |
| Domestic Trash Weight | 1.5 | 6.6 | 4.5 | 21.6 | 3.2 | 1.5 | 4 | 41.8 | 463.8 | **548.5** | **kg** |
| Recyclable Weight | 0.5 | | 0.1 | 11 | 1.1 | 8.6 | | 2 | | **23.3** | **kg** |
| Hard Plastic Weight | 1.3 | 9 | 0.5 | 24.3 | 3.5 | 1 | 3 | 576.7 | | **619.2** | **kg** |
| Metal Weight | | 21.5 | 1.0 | 11.5 | 1.4 | | 3 | 63.5 | | **101.9** | **kg** |
| Tire/Rim Weight | | | | 45 | | | | 20 | 28 | **93.0** | **kg** |
| Textiles/Clothing Weight | 0.1 | 12 | 1 | 6 | 0.8 | | | 4 | | **23.9** | **kg** |
| Foam Weight | 0.3 | | | 3.1 | 14.5 | 2.8 | | 60 | | **80.7** | **kg** |
| Film Weight | 0.1 | 0.1 | 0.1 | 21.5 | 0.3 | | | 18 | | **40.1** | **kg** |
| C&D Waste | | | 389.2 | | | | | | | **389.2** | **kg** |
| **Total** | **3.8** | **60.2** | **396.4** | **147.5** | **25.0** | **13.9** | **10.0** | **792.2** | **491.8** | **1940.8** | **kg** |
| | | | | | | | | | | | |
| **Grand Total** | **188.9** | **1888.6** | **4694.8** | **660.1** | **35.0** | **41.2** | **29.6** | **918.3** | **595.3** | **9051.7** | **kg** |

Construction and domestic debris items were found at all our cleanup sites (i.e., food wrappers, shotgun shells, lighters, housing insulation) however, fishing-related debris accounted for most of the debris by weight (i.e., rope, nets, longline, lobster trap escape panels, etc.) (Table 2, Table 4).

Overall, a total of 50 volunteers actively participated in shoreline cleanup events, dedicating 368 hours to removing shoreline debris. These cleanup efforts provide strong evidence of community support for shoreline conservation initiatives. Given that the majority of debris retrieved was associated with the fishing industry, we strongly encourage fishers and fishing associations to actively engage and potentially lead shoreline retrievals. This not only fosters industry stewardship but also parallels the success of ALDFG at-sea retrievals.

### 3.1.3 Bycatch Released

A total of 398 lobsters were released from retrieved gear, along with 79 fishes, and 545 crabs (Table 3). Overall, observations included 17 different species, all of which were released (Figure 13). Fish species released included sculpins (*Myoxocephalus* or *Hemitripterus* sp.), rock gunnel (*Pholis gunnellus*), and cunner (*Tautogolabrus adspersus*) which were found as bycatch in both lobster traps and fishing nets.

Toad crabs *(Hyas* sp.*)* accounted for over a third of all released bycatch (Figure 13). It's important to note that these individuals were very small and could easily move in and out of the traps; none were market-sized. Jonah crab (*Cancer borealis*) and rock crab (*Cancer irroratus*) were commonly found in traps, with some being smaller, free-moving crabs while others were likely stuck in the traps.

Other species released, encompassing both bycatch and colonizing species, included hermit crabs (*Paguroidea*), starfish (*Asterias* sp.), brittle stars (*Ophiuroidea*), whelks (*Buccinidae*), sea urchins (*Euechinoidea*), scallops (*Pacopecteni magellanicus*), and polychaete worms (*Nereidae* sp.).

Jonah crabs, rock crabs, and sculpin are among the common bycatch species in active lobster fishing gear (Pezzack et al. 2014), which aligns with the bycatch released from our retrieved ALDFG during this project (Figure 13).

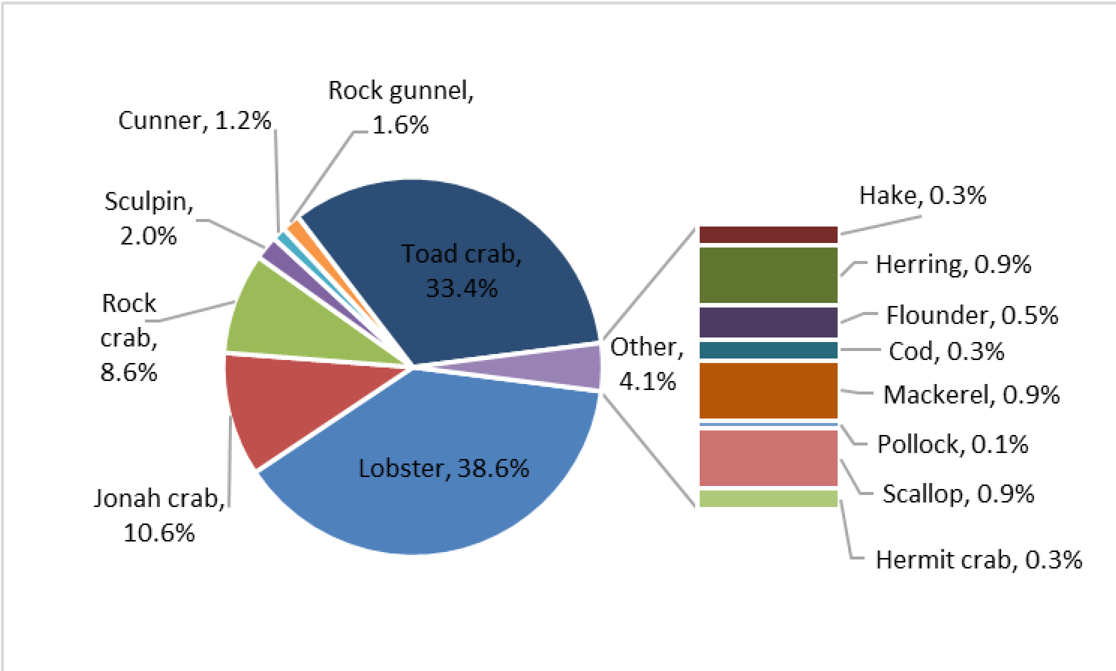


Figure 13. Proportion of bycatch in at-sea ALDFG retrievals.

Traps retrieved from the 2023 fishing season had the highest incidences of ghost fishing, catching 180 individuals. This outcome is unsurprising considering that many of these traps still had their escape panels attached, making it challenging for captured organisms to escape. Notably older traps continue to trap and retain bycatch, including larger species such as lobsters and crabs as depicted in Figure 14.

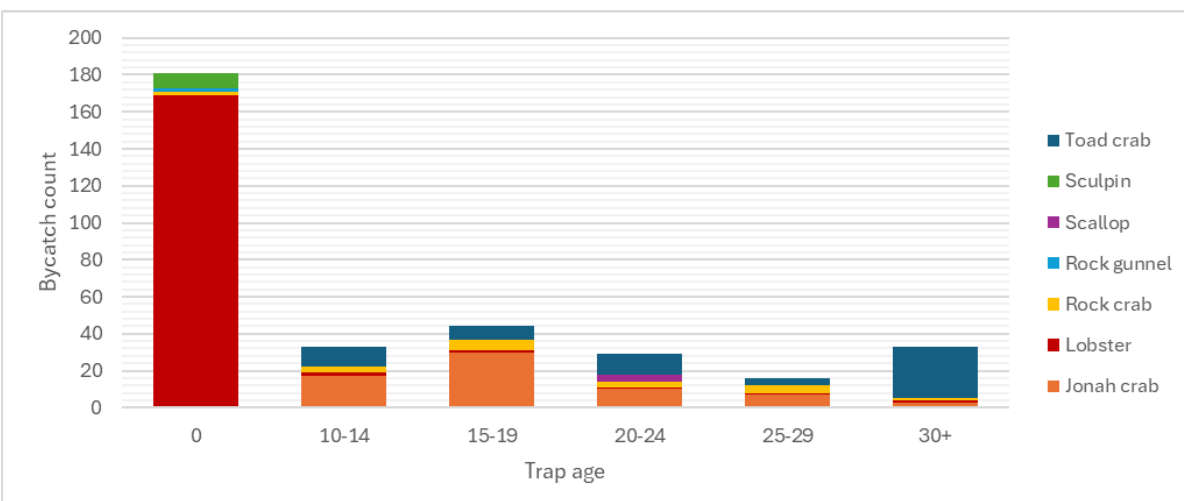


Figure 14. Frequency of bycatch species in relation to trap age.

### 3.1.4 Lobster Bycatch

On all trips, lobsters were assessed by weight, sex, and size. Approximately 73.2% of bycatch lobsters were market-sized or over the NS and NL minimum legal carapace size (MLCS) of 82.5 mm (

Table 5, Appendix B-Figure 26) (Fisheries and Oceans Canada, n.d. a; Fisheries and Oceans Canada, n.d. b; Fisheries and Oceans Canada, n.d. c). Lobsters reach the MLCS of 82.5 mm at approximately 8 to 10 years of age and weigh roughly 0.45 kg (Tremblay et al. 2013). However, we observed lobsters of market size weighing below this threshold. Many of these lobsters had sustained injuries or been preyed upon in the traps, resulting in missing appendages, contributing to below-average weights. Six lobsters (1.8%) were categorised as unknown sex due to either missing tails or state of decomposition and thus were excluded from the analysis. Regardless of size, male lobsters were more frequently found as bycatch and, on average, measured and weighed more than females (

Table 5, Appendix B-Figure 28). Among the 116 female lobsters released, 17 were found to have eggs, ranging from newly laid to fully hatched. All 17 of these egg-bearing females were captured in LFA 27.

Table 5. Carapace length (mm) and total weight (kg) summary statistics of lobster bycatch and market-sized bycatch from Nova Scotia and Newfoundland. True minimum weights for 6 lobsters in the "all lobster" statistics were lighter than 0.01 kg, their inclusion made no appreciable difference to the summary.

| | | | Carapace length (mm) | | | | Weight (kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Sex** | **n** | **Mean** | **Median** | **Min** | **Max** | **Mean** | **Median** | **Min** | **Max** |
| **All** | F | 116 | 85.1 | 83.5 | 48 | 126 | 0.40 | 0.40 | 0.01 | 1.3 |
| | M | 212 | 94.9 | 92 | 21 | 147 | 0.77 | 0.7 | 0.01 | 2.75 |
| | Total | 328 | 91.4 | 89 | 21 | 147 | 0.64 | 0.5 | 0.01 | 2.75 |
| **Mark-et sized** | F | 65 | 92.5 | 91 | 83 | 126 | 0.57 | 0.5 | 0.2 | 1.35 |
| | M | 175 | 99.8 | 96 | 82.5 | 147 | 1.15 | 0.67 | 0.15 | 6.75 |
| | Total | 240 | 97.8 | 93 | 82.5 | 147 | 0.78 | 0.7 | 0.1 | 2.75 |

Catch rate differences between male and female lobsters may be attributed to several factors. Male lobsters are generally more aggressive than females and exhibit higher predation rates during the self-baiting cycle (Huber and Kravitz 1995; Figler et al. 1998). Differences in catchability rates between sexes, as well as variations in thermal preferences, could also contribute to these discrepancies (Tremblay et al. 2011; Clark et al. 2015a, Jury and Watson 2013).

The MLCS for LFA 27 in PEI is 75 mm. Additionally, LFA 27 has a release rule for females between 115 mm and 129 mm (DFO 2023). Eighteen of the females caught fell within this range and were therefore excluded from the market size statistics. 71.8% of lobsters met the market-sized criteria based on these parameters (Table 6; Appendix B-Figure 27. Carapace length (mm) of all lobster bycatch released in PEI in LFA 24 by sex. The black line indicates MLCS (75 mm) used in this fishing area. The two red lines indicate the release window for females (115 mm to 129mm) in this fishing area. The middle line of each boxplot indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, the points are outliers, and the X is the mean.). Among the 31 female lobsters released, 1 was found to have freshly laid eggs. All 64 lobsters from LFA 27 were caught in one string of traps. An error occurred during data collection for these lobsters, as total length (TL) was recorded instead of instead of carapace length (CL). Due to limited literature correlating TL to CL in American lobsters, we approximated CL using a formula from Kristiansen et al. (2004) for the European lobster (*Homarus gammarus*), a closely related species. In their study CL and TL were highly correlated, suggesting that this approximation may be suitable for estimating CLs of PEI lobsters. Male lobsters and females were caught in roughly equal proportion in PEI. On average, males measured and weighed more than females (Table 6, Appendix B-Figure 29).

Table 6. Carapace length (mm) and total weight (kg) summary statistics of lobster bycatch and market-sized bycatch from Prince Edward Island.

| | | | Carapace length (mm) | | | | Weight (kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Sex** | **n** | **Mean** | **Median** | **Min** | **Max** | **Mean** | **Median** | **Min** | **Max** |
| **All** | F | 31 | 119.9 | 117.7 | 105.3 | 189.6 | 0.41 | 0.2 | 0.2 | 1.4 |
| | M | 33 | 133.8 | 133.5 | 103.6 | 173.8 | 0.6 | 0.5 | 0.2 | 1.4 |
| | Total | 64 | 127.0 | 121.2 | 103.6 | 189.6 | 0.5 | 0.5 | 0.2 | 1.4 |
| **Mark-et sized** | F | 13 | 119.9 | 112.4 | 105.4 | 189.6 | 0.42 | 0.2 | 0.2 | 1.4 |
| | M | 33 | 133.8 | 133.5 | 103.6 | 173.8 | 0.6 | 0.5 | 0.2 | 1.4 |
| | Total | 46 | 129.9 | 129.9 | 103.6 | 189.6 | 0.55 | 0.5 | 0.2 | 1.4 |

When the carapace length falls between 90 and 105 mm for females, it is estimated that 50% of them are sexually mature (Tremblay et al. 2013). 46.3% of all females caught during this project were within or exceeded these lengths, indicating their potential capability to contribute to population stocks. Among these potentially mature females, all but one were still alive upon release. This highlights the significance of ghost gear retrieval efforts, as surviving females will have the chance to contribute to the overall population of the stock.

### 3.1.5 Escape Panels

As per fishery licence conditions, escape panels must be attached to the outer walls of all metal lobster traps as a conservation mechanism. These panels allow undersized lobsters to escape during the season while also reducing bycatch if traps are lost. The attachments securing the panel (typically cotton twine or iron hog rings; Figure 15), degrade over time (Minister of Justice 2018; DFO 2020). When the metal rings or cotton twine degrades sufficiently, the panel swings open or falls off and larger bycatch can escape (Richard and Clayton 1998).

Figure 15. Yellow escape panel on white lobster trap attached with iron hog rings.

The functionality of escape panels was assessed for each retrieved trap to determine if panels were attached (had not functioned) or had fallen off (had functioned as intended). It was observed that 63% of escape panels had functioned properly, while 23% had not, with the remaining 14% categorized as illegal escape panels (Figure 16).

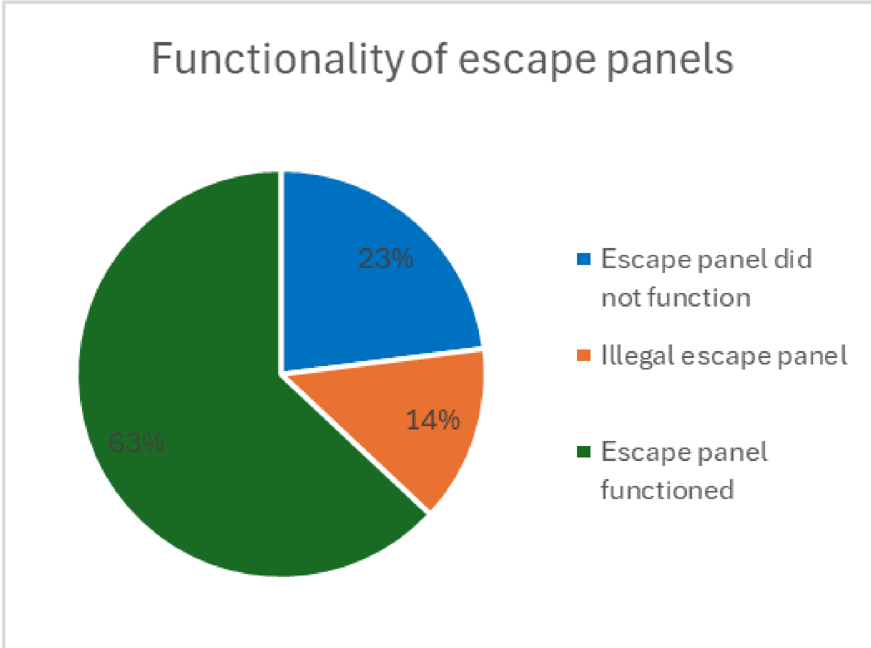


Figure 16. Functionality of escape panels from retrieved lobster traps. Illegal panels include any panels that were attached with something other than iron hog rings or cotton twine, or the trap did not have an escape panel at all.

More lobsters were caught in traps where escape panels remained intact, consistent with findings from previous years. However, many smaller bycatch species such as toad crabs were discovered in traps where the escape panel had functioned (Figure 17). This may be a result of animals utilizing ALDFG as artificial habitats, which is discussed more extensively in Section 3.3.4. This observation warrants further investigation, as the timeline for traps to be colonized by both encrusting organisms and smaller species taking shelter has not yet been thoroughly studied.

It is particularly important to target newly lost gear during retrievals, to best minimize the effects of ghost fishing. However, our observations suggest that despite escape panels functioning, lost lobster traps can still catch lobsters and other species (Figure 17). Additional research on escape panel functionality is required to assess the efficiency of the conservation mechanisms over time. Nonetheless, the results presented here show that functional escape panels decrease bycatch compared to traps where panels are still attached, this is consistent with other fisheries that use the same mechanism (Richard and Clayton 1998; Macfadyen et al. 2009; Bilkovic et al. 2012; Drinkwin 2018).

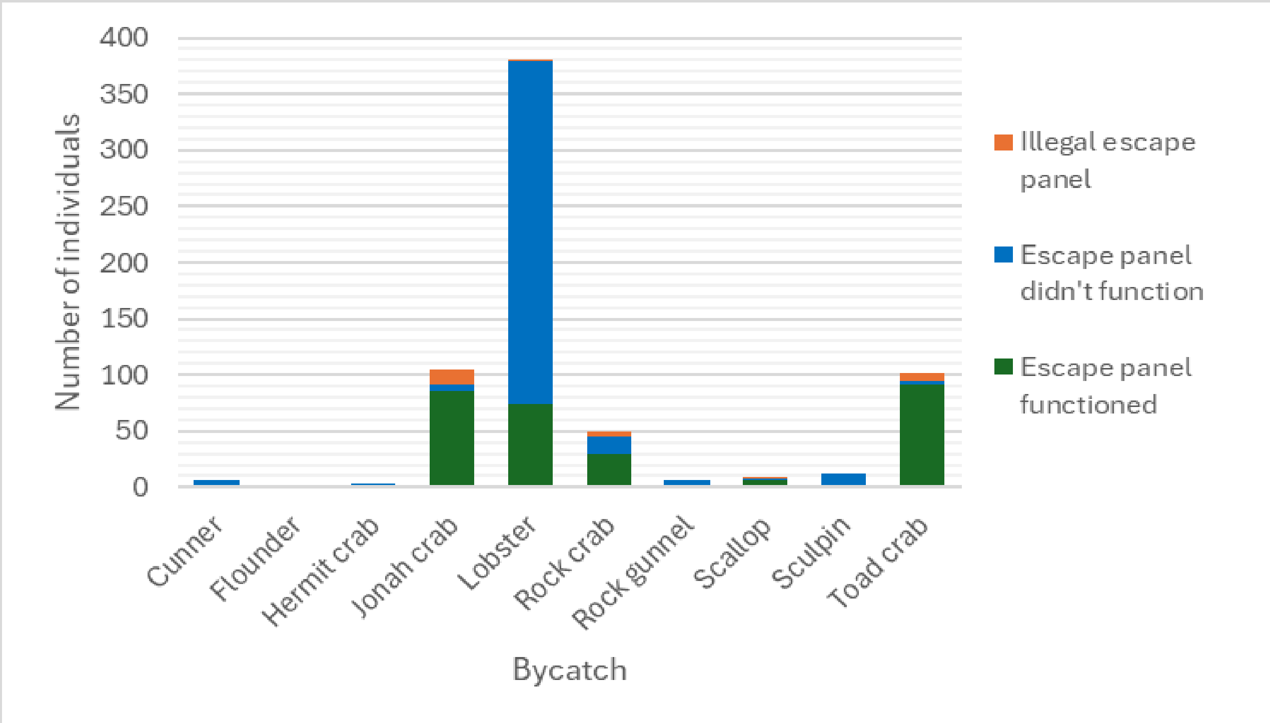


Figure 17. The number and type of bycatch organisms in relation to whether a lobster trap escape panel functioned or not. Illegal escape panels include those that were permanently affixed so they could not detach as designed and traps that had no escape panels at all.

While escape panel attachments are expected to degrade within a timeframe ranging from six months to a year (Larissa Goshulak, DFO correspondence; unreferenced), reports from retrieval captains and fishers indicated a need for replacing escape panel attachments throughout the fishing seasons, which can be six months in duration. The majority of traps dating from before 2023 had already lost their escape panels. However, certain panels remained attached well beyond this anticipated degradation period (Figure 18).

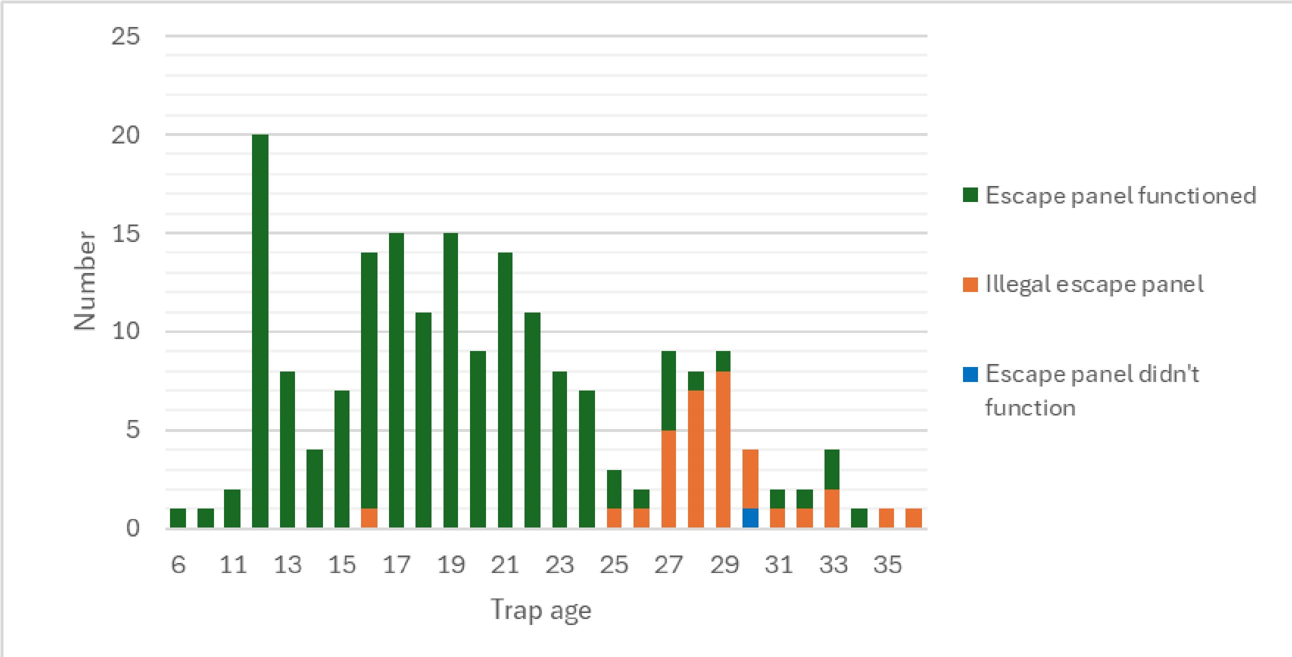


Figure 18. The functionality of escape panels in relation to retrieved lobster trap age. Only traps with a year on their tag are represented. New traps (from the 2023 fishing season) are also excluded from this graph as they skewed the data and made the older traps hard to visualize.

### 3.1.6 Predation and Injury

To comprehensively assess the additional impacts of ghost gear, we recorded instances of bycatch predation and injuries sustained by each organism, categorising each scenario using a scoring system. Out of the 675 bycatch organisms examined, 50.4% were found to be injured, scoring above zero on the injury scale (Figure 19). Of all bycatch species, lobsters were the most frequently injured organisms across all injury scores, sustaining a variety of injuries including missing and partially severed claws, antennas, and legs, tail damage, crush injuries, and total mutilation (Figure 19). Jonah crabs and rock crabs were the next most injured species, respectively.

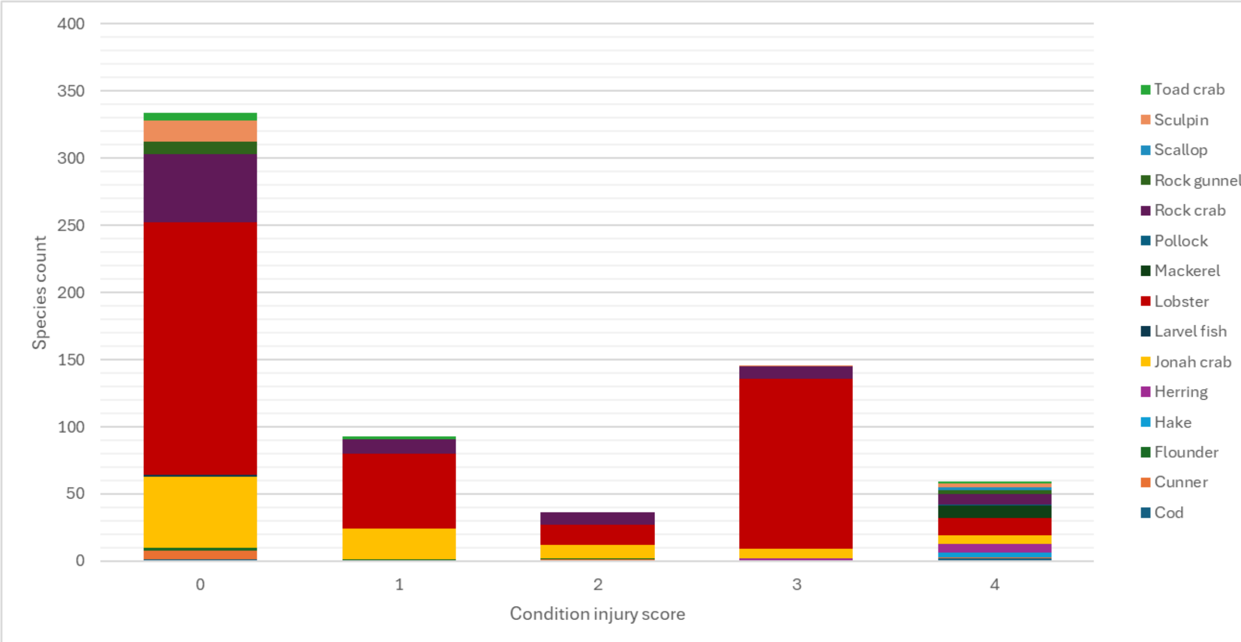


Figure 19. Injuries sustained by bycatch in retrieved gear. A score of 0 represents no injuries; 1 is a minor injury; 2 is multiple minor injuries; 3 is major injuries; and 4 is dead or dying.

A portion of observed injuries likely resulted from the self-baiting cycle within traps or from organism predation while confined. Determining the exact cause of injuries or how remains became trapped posed challenges. In some cases, instances of predation were evident due to the presence of observed injuries, indicating potential predation events within the traps. Organisms may have also received injuries from the gear itself (i.e., chaffing, and pinned and torn appendages), natural causes, or from events that occurred before the organisms were caught (i.e. many lobsters in Cape Breton potentially have shell damage from being tumbled during Hurricane Fiona).

Approximately 25.1% of the assessed bycatch exhibited evidence of predation. Predation was identified through an observed injury such as missing claws or legs, cracked carapace and/or tail, or mutilation, occurring within traps containing multiple individuals or indications that other organisms had been present. Predation incidences were primarily observed with lobsters, Jonah crabs, and rock crabs. Observations indicate that there were six instances where only lobster parts, such as claws, were found within the trap. While it is possible remains could have drifted into traps or were moults, aggressive behaviour among lobsters and other species is common, therefore suggesting that some instances were likely the result of predation within the traps (Jury et al. 2001).

Partial organisms were rarely found, as expected, they were likely consumed by other bycatch or drifted out. Additionally, many traps contained multiple organisms, potentially indicating the occurrence of self-baiting cycles. However, fully assessing the extent of self-baiting and predation in lost traps required alternative methods of analysis (i.e., diet analysis of bycatch or long-term video surveillance), as it is challenging to obtain evidence of organisms that were ghost-fished and/or consumed by others.

### 3.1.7 Degradation and Biofoul

To evaluate the environmental impact of ALDFG, we assess all retrieved gear based on its degradation status. Approximately 10% of recovered gear was found to be in good condition, with an estimated loss of <25% of the gear's original integrity, corresponding to a gear degradation score of 1. The vast majority of gear recovered (90%) was more than 25% degraded. This highlights the importance of ghost gear retrieval efforts, as degraded gear has the potential to release microplastics, entangling components, and hazardous sharp fragments into the environment (Figure 20).

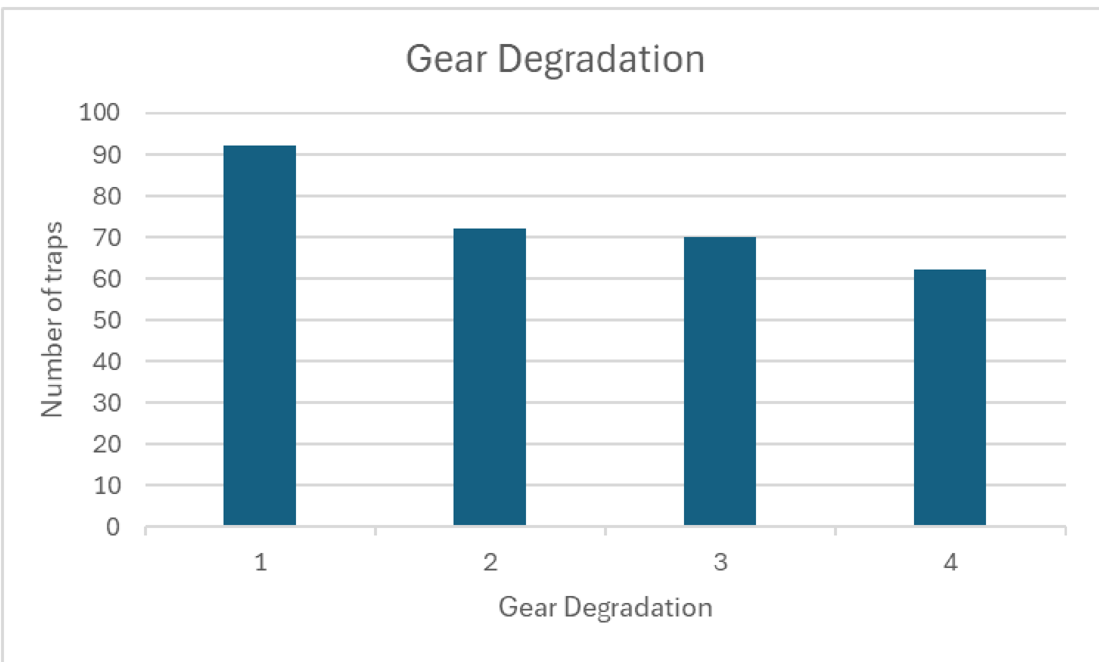


Figure 20. Gear degradation levels of traps collected during at-sea retrievals. Gear degradation 1: <25% degraded, 2: 25-50%, 3: 50-75%, and 4: >75% degraded.

Some suggest that ALDFG could function similarly to an artificial reef, potentially creating a habitat in the marine environment (Goodman et al. 2019). Artificial reefs are submerged human-made structures that aid in restoring degraded ecosystems worldwide. Over time these structures become colonized by sessile biofouling organisms (i.e., barnacles, algae, tunicates) which modify the structure and attract a variety of species including fish, crustaceans, and larger wildlife (Seaman 2007). Generally, the number of biofouling species increases with the duration of submersion (Svane and Petersen 2001; Brown 2005). Unlike ghost gear, artificial reefs are designed as permanent structures with minimal unintended impacts on the surrounding benthic environment.

Surprisingly, we observed no relation between the number of biofouling species and the age of ghost gear. Gear from the 2023 season had up to 12 species, while gear over 20 years old could have as few as 6 species. Although lobsters often seek shelter in crevasses on hard substrates to evade predators (Ennis 1984), traps may not provide suitable habitat conditions (Goodman et al. 2019). Lost traps are unlikely to offer coverage from predators unless incorporated into a softer substrate like mud or sand. While ALDFG may provide some reef-like conditions, the mobility of gear may consequently damage habitats and harm organisms (see Roy 2020 for examples of artificial reefs designed for lobsters).

Additionally, using synthetic plastic materials as a refuge can pose hazards to marine life compared to natural habitats. The industry predominantly relies on polypropylene rope, and PVC-coated lobster traps, filled with synthetic head netting and outfitted with plastic escape panels. All of which can have negative impacts if left in the environment. Both PVC and polypropylene release microplastics as they degrade over time, posing potential toxicity risks to aquatic and marine organisms throughout the environment (Walker et al. 2006; Coastal Action 2018; Xue et al. 2020; Karbalaei et al. 2021). Specifically, research has shown that PVC coating on lobster traps can interfere with natural hormone production and disrupt endocrine function, causing shell disease when ingested by crustaceans (Laufer et al. 2012). Microplastics have been observed to decrease the oxygen consumption of larval lobsters, potentially causing broader population and ecosystem-level effects (Woods et al. 2020). Furthermore, studies from other commercially fished species in Atlantic Canada suggest that target species ingest plastics from gear, likely ALDGF, further emphasizing environmental risks (Saturno et al. 2020).

Ghost gear can also serve as a substrate for sessile organisms such as algae, bryozoans, barnacles, tunicates, and mussels, creating habitat-like conditions and attracting mobile organisms including sea stars, polychaete worms, toad crabs, and free-moving molluscs. Additionally, we observed several instances of ghost traps being used as an anchor point for squid egg masses. However, it is important to note that gear can also act as a vector for invasive species. We documented 30 occurrences of invasive species, including algae, bryozoans, tunicates, and skeleton shrimp on ghost gear. As ghost gear is transported by currents and storm events, these invasive species can be introduced into new areas.

Most gear retrieved at sea had at least one species of biofouling. Of the 1,427 discrete units retrieved, 1,158 of them were biofouled (81.1%). The maximum number of observable biofouling species on a single piece of gear was 25. More severely degraded gear was more likely to be biofouled, although the degradation state was not correlated with age in this analysis (Figure 21).

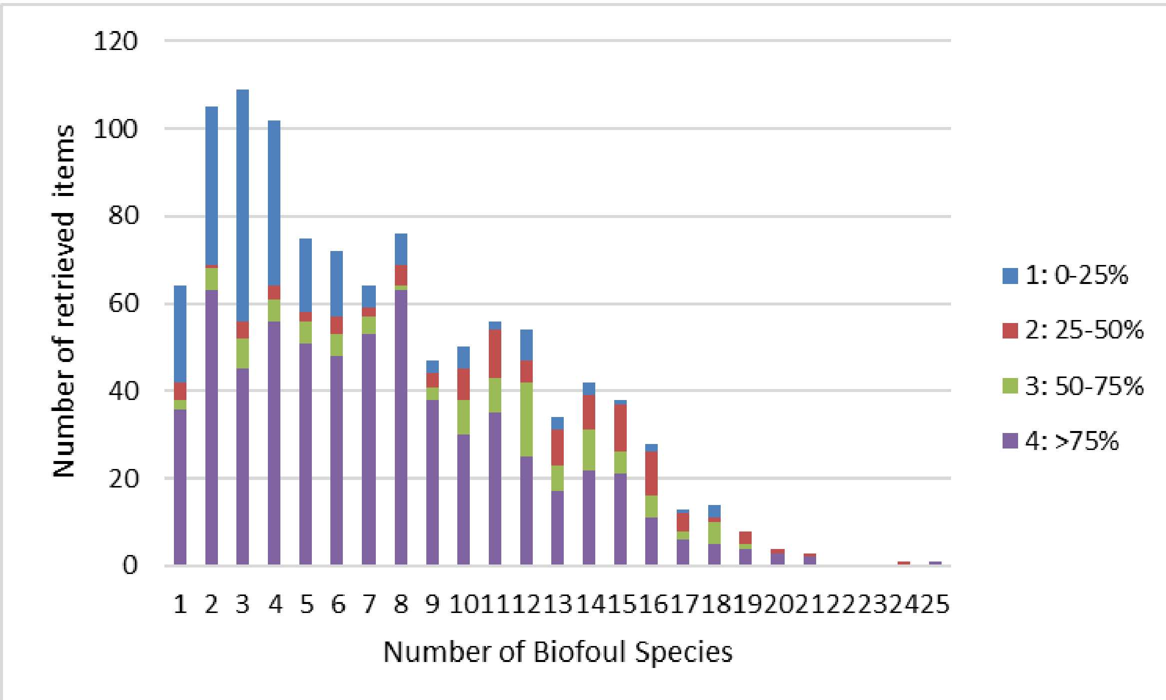


Figure 21. The number of biofouling species found on retrieved fishing gear in relation to the state of degradation of the gear. Level 1: 0-25% (little degradation); 2: 25-50%; 3: 50-75%, 4:>75%.

## 3.2 Responsible Disposal

All retrieved gear underwent responsible disposal. Gear was either returned to owners through collaborative efforts with DFO and Harbour Authorities, repurposed, recycled, or disposed of at municipal landfills. Our recycling efforts were greatly improved this season, with 62% of the material retrieved being recycled or repurposed (Figure 22).

Lobster traps in usable condition and tagged from 2018 onwards were transferred to Small Craft Harbour compounds, for a potential return to their owners. A total of 60 traps were compounded, effectively doubling the quantity returned compared to the previous season. Gear deemed reusable but lacking tags or outside the returnable age range were distributed to fishers for repurposing. Reusable gear items included bait bags, bait spikes, buoys, anchors, rope, and swivels.

All unusable metal traps retrieved during the project were recycled. These traps were taken to collection sites within municipal waste centres, facilitated through the FGCAC program. Additionally, dragger cable and metal crab pots were recycled through this program, contributing to 41% of our overall recycling efforts (Figure 22).

A collaboration with Sustane Technologies facilitated the recycling of rigid plastics (both industry and domestically generated), some Styrofoam, plastic films (eg. plastic bags or tarps), bait bags, and some rope and nets.

Additionally, our partnership with Ocean Legacy facilitated the recycling of rope and nets. Retrieved rope collected during this project was amalgamated with rope obtained through our wharf-side rope collection program, as detailed in Section 3.2.1 below. This combined rope was then transported to the processing depot at Scotian Recycling to be shredded and sent on to be recycled into durable goods.

Conventional recyclables such as food and beverage containers, scrap metal, oil containers, and tires were recycled through respective municipal programs. Nevertheless, a portion of the retrieved material (38%) inevitably ended up in landfills.

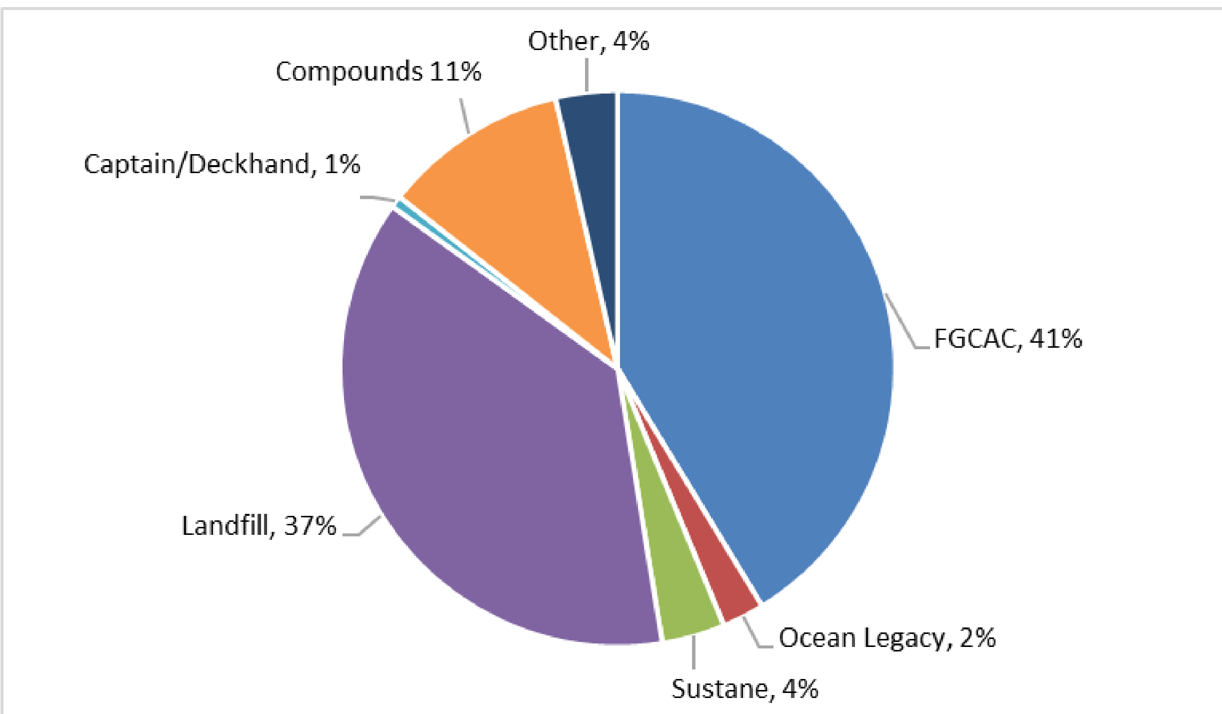


Figure 22. Proportion breakdown of final locations of at-sea and shoreline retrieved ghost gear and marine debris.

The implementation of several new recycling initiatives by partner organizations this season is an encouraging development. However, there remains a need for additional recycling options with better geographical coverage to lessen the environmental impact of the fishing industry and assist in the retrieval of ghost gear.

### 3.2.1 Rope Recycling

During this year's project, we solidified a partnership with Ocean Legacy to facilitate the collection and recycling of end-of-life rope and net. The pilot initiative focused on recycling polyethylene and polypropylene fishing rope and netting, which enhanced our recycling efforts throughout the retrieval season.

Our collaboration with Ocean Legacy led to the establishment of collection depot sites and the placement of rope recycle bins, aiding fishing communities and other retrieval groups in their rope and netting recycling efforts. Over a 9-month period, a total of 109 tonnes of rope and netting material were collected, with 68% processed through this pilot project thus far. With support from Mersey Seafoods, we established a primary depot in Liverpool, where the collected material could be sorted before being transferred to a local processing facility in Truro, NS. This processing facility, managed by Scotia Recycling, handled the final sorting, shredding, bailing, and shipping to local Canadian companies for the manufacturing of new durable plastic products, thereby completing a circular plastic economy cycle.

## 4.0 Conclusions and Recommendations

ALDFG Locations

- Some productive retrieval locations in LFA 34 were retained from the previous year's project (Lobster Bay, mouth of Clark's Harbour), with captains determining the exact areas. This approach proved highly effective, as all four captains within LFA 34 retrieved gear on every trip. Future ghost gear projects should continue relying on local fisher's knowledge of target areas. Annual meetings with fishers to identify new and pre-existing hotspot areas would aid in planning. Lobster Bay and the mouth of Clark's Harbour should remain a priority for future retrievals due to the significant volume of traps and dragger cables found in each respective area during the past two seasons.
- Using a skiff to target island shorelines in LFA 33 remained effective, resulting in the removal of 1,183 kgs of ALDFG. Success within this area can be attributed to local knowledge from fishers and the isolation of these islands, allowing gear to accumulate onshore undisturbed. Future ghost gear retrieval projects should consider targeting islands in other LFAs for comparison.
- Retrievals in Cape Breton (LFA 27) varied significantly by hail out port.

- In the Louisbourg area, a high proportion of reusable compounded traps were retrieved. Conducting retrieval efforts in these areas shortly after the closure of LFA 27's fishing season enabled the team to detect floating buoy markers before they became biofouled, submerged, or accidentally cut off. Future seasons should aim to conduct retrievals in this area as close to the season's closure as possible.
- In the Ingonish area, debris was found to be highly concentrated within the harbours themselves. While not all material was ALDFG, collection efforts were logistically simple and not dependent on favorable wind conditions. Further efforts in this area could positively impact harbour environments.
- In the Neil's Harbour area, a record amount of Danish seine line was retrieved. Despite its suspected age, this gear had very little degradation and in many cases ensnarled itself with other material (traps, monofilament, rope, buoys), impacting benthic habitats. Due to its weight, using a larger vessel for retrievals in areas with large accumulations is advisable.
- All three captains from Cape Breton noted that ghost snow crab traps entangle with their active lobster gear every season, posing risks to the crew and often resulting in the loss of some lobster traps. We recommend expanding the LFA 27 retrieval area into deeper offshore waters in future seasons, with a portion of retrieval days allocated to searching for and retrieving these crab pots.

- PEI (LFA 24) proved challenging for gear retrieval, with many trips returning empty. We hypothesize that the ever-shifting sandy bottom near Malpeque could be burying traps before they are discovered. Retrieving after storm events may uncover debris on the bottom and be an effective, yet challenging solution.
- Newfoundland (LFA 11 and LFA 12) retrievals presented grapple-use challenges due to the hard rocky bottom. Though over 2000 kgs of material were retrieved, diver-based retrievals, especially in the shallow coastal regions, would be more effective.

Disposal

- Responsible disposal facilitation and options are crucial to prevent and mitigate ALDFG. This project reinstated our rope recycling system in partnership with the Ocean Legacy Foundation, leading to the collection of 109 tonnes of rope. Future projects should seek to expand repurposing and recycling systems for all ALDFG by collaborating with partners with innovative approaches.
- Previous collaborations with landfills were renewed and fresh ones were created in partnership with the FGCAC in various regions of Cape Breton, PEI, and Newfoundland. These partnerships assist in reducing costs associated with ALDFG disposal. Maintaining and establishing partnerships should remain a priority in future projects.

- Easily accessible disposal locations at each wharf could promote responsible gear disposal, reducing ALDFG. Support from the Ghost Gear Fund could facilitate the implementation of these facilities.

Federal Management

- A new colour rotation with a numeric code to signify trap year has been incorporated into lobster trap tags starting in 2023. Dates were removed from the 2013-2022 seasons' tags, and this addresses many of the issues that had caused. However, interpreting these tags is still not as straightforward as a printed year would be.
- Recognizing the challenges associated with permitting captains to land ghost gear during an active fishing season, a policy change allowing retrieval during the season is recommended. This would benefit all parties involved and prevent inefficient and environmentally detrimental practices. Improvements to the FGRS reporting system would also be necessary to facilitate this dual reporting purpose.
- As of the time of report writing, DFO has not confirmed the continuation of the Ghost Gear Fund and no funding has been issued for a 2024-25 retrieval season. A permanent loss of this program would be a significant setback for Canada's ghost gear remediation efforts, the fishing industry, and the ocean environment. Over the last four years, this project has placed a strong emphasis on cultivating partnerships and networks, engaging local communities, and collaborating with the fishing industry to tackle the issue of ALDFG. However, without further funding and support, vital institutional knowledge will be lost as retrievers and captains seek alternative employment and crucial education and recycling initiatives will come to a halt.
- Efforts to manage waste have improved, but gear loss or improper disposal remains a persistent issue, exacerbated by severe weather events linked to climate change. Without continued funding, the amount of ghost gear in the ocean will increase, impacting the environment and commercial stocks. Efforts to address the issue of ghost gear must be funded to prevent further harm to marine ecosystems and industries that rely on them.

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A huge thanks to Mersey Seafood for hosting our rope recycling depot and lending us staff and equipment whenever needed.

Finally, our deepest gratitude to the captains and crew of our retrieval vessels, whose tireless efforts, flexibility, and good cheer made this project possible, and our team feel at home no matter where we are.

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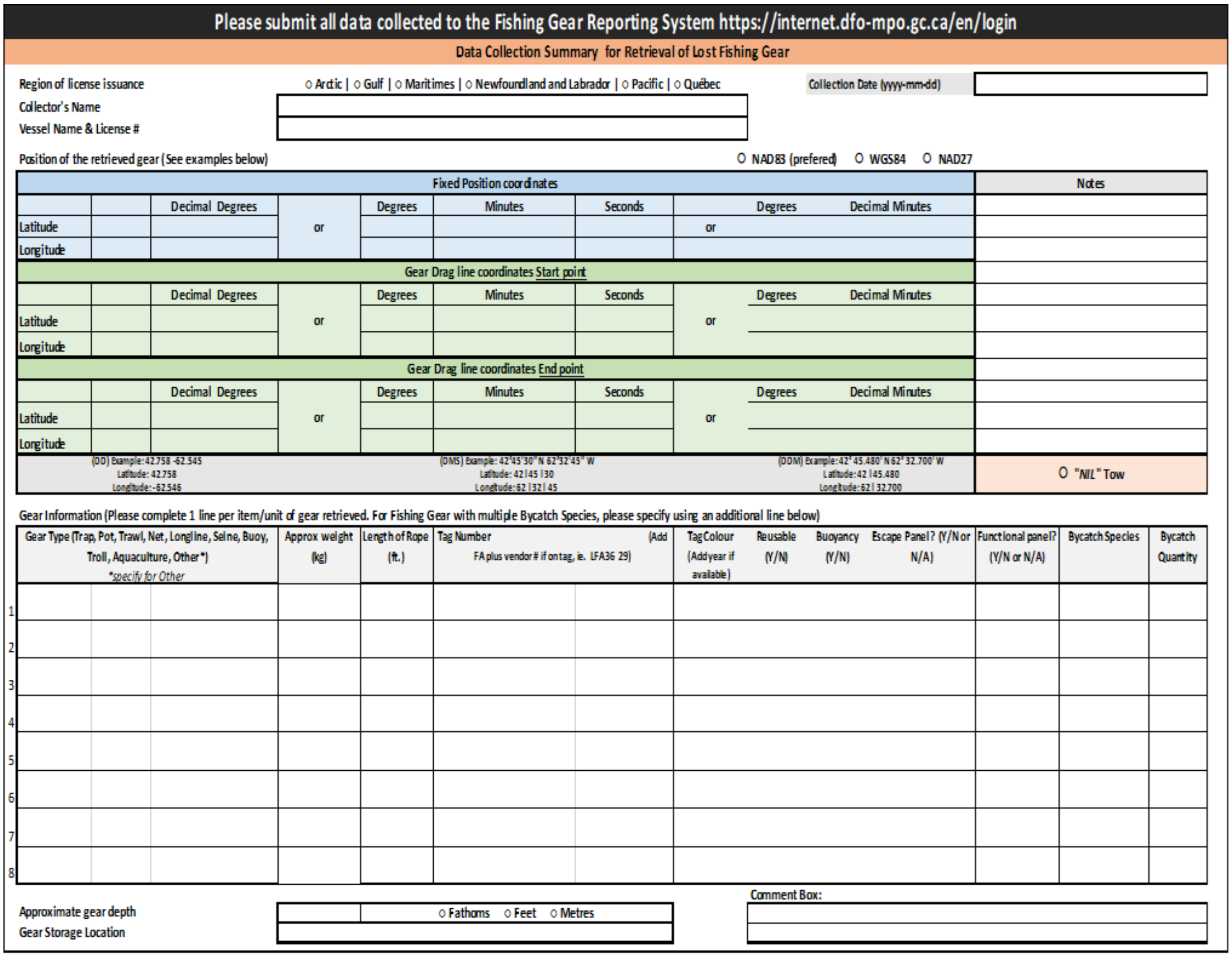
# 7.0 Appendix A – Field Data Forms



**Please submit all data collected to the Fishing Gear Reporting System https://internet.dfo-mpo.gc.ca/en/login**

**Data Collection Summary for Retrieval of Lost Fishing Gear**

Region of license issuance ○ Arctic | ○ Gulf | ○ Maritimes | ○ Newfoundland and Labrador | ○ Pacific | ○ Québec

Collection Date (yyyy-mm-dd)

Collector's Name

Vessel Name & License #

Position of the retrieved gear (See examples below) ○ NAD83 (prefered) ○ WGS84 ○ NAD27

| Fixed Position coordinates | | | | | | | | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Decimal Degrees | | Degrees | Minutes | Seconds | | Degrees | Decimal Minutes | |
| Latitude | | | or | | | | or | | | |
| Longitude | | | | | | | | | | |
| **Gear Drag line coordinates Start point** | | | | | | | | | | |
| | | Decimal Degrees | | Degrees | Minutes | Seconds | | Degrees | Decimal Minutes | |
| Latitude | | | or | | | | or | | | |
| Longitude | | | | | | | | | | |
| **Gear Drag line coordinates End point** | | | | | | | | | | |
| | | Decimal Degrees | | Degrees | Minutes | Seconds | | Degrees | Decimal Minutes | |
| Latitude | | | or | | | | or | | | |
| Longitude | | | | | | | | | | |
| (DD) Example: 42.758 -62.545<br>Latitude: 42.758<br>Longitude: -62.546 | | | | (DMS) Example: 42°45'30" N 62°32'45" W<br>Latitude: 42 \| 45 \| 30<br>Longitude: 62 \| 32 \| 45 | | | | (DDM) Example: 42° 45.480' N 62° 32.700' W<br>Latitude: 42 \| 45.480<br>Longitude: 62 \| 32.700 | | O "NIL" Tow |

Gear Information (Please complete 1 line per item/unit of gear retrieved. For Fishing Gear with multiple Bycatch Species, please specify using an additional line below)

| | Gear Type (Trap, Pot, Trawl, Net, Longline, Seine, Buoy, Troll, Aquaculture, Other*) *specify for Other | Approx weight (kg) | Length of Rope (ft.) | Tag Number (Add FA plus vendor # if on tag, ie. LFA36 29) | Tag Colour (Add year if available) | Reusable (Y/N) | Buoyancy (Y/N) | Escape Panel? (Y/N or N/A) | Functional panel? (Y/N or N/A) | Bycatch Species | Bycatch Quantity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| 7 | | | | | | | | | | | |
| 8 | | | | | | | | | | | |

Approximate gear depth ○ Fathoms ○ Feet ○ Metres

Gear Storage Location

Comment Box:

Figure 23. Fisheries and Oceans Canada data collection summary form for retrieval of lost fishing gear.

COASTAL ACTION

Coastal Action Ghost Gear Retrieval Data Sheet

**Collector Name**: ____________ **Vessel Name& License #:** ____________ Hail Out Time: ________ Hail In Time: ________ **Coordinate System**: ◯ NAD83 ◯ WGS84 ◯ NAD27

**Lat/Long Format**: ◯ DD ◯ DMS ◯ DDM **Date:** ________ Beaufort Scale: _____ Grapple Type: ____________ Captain ID:______ **Region of License**: ◯ Maritimes ◯ Newfoundland & Labrador ◯ Gulf

| Tow Information | | | | | | | Gear Information | | | | | | | | | | By-catch Information | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Event # | Time in/out (24h) | Depth in/out (m) | Latitude in/out | Longitude in/out | Bottom type | Tow speed (kn) | Type of gear | Gear weight (kg) | Gear Length (ft) | Buoyancy (Y/N) | Reusable (Y/N) | Escape panel (Y/N/NA) | Functional? (Y/N/NA) | Tag Number | Tag colour & year | Biofoul (#) | Gear degradation | By-catch species | Alive (Y/N) | Weight (kg) | Length (cm) or carapace (mm) | Lobster sex (M/F) | Clutch size | Egg stage | Shell hardness | Injury and/or disease | Predation evidence (Y/N) | Notes |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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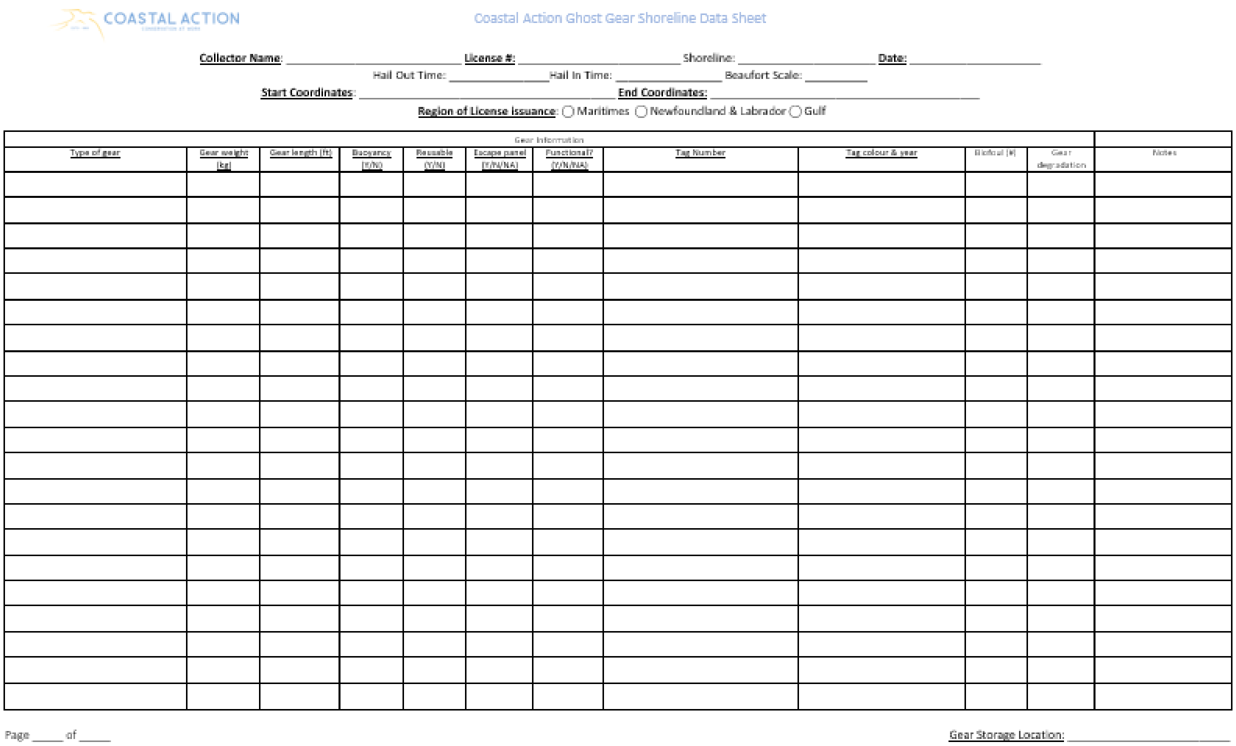
**Gear Storage Location:** ____________

Figure 24. Coastal Action’s harmonized ghost gear retrieval data form for at sea retrievals.



COASTAL ACTION

Coastal Action Ghost Gear Shoreline Data Sheet

**Collector Name**: ______________ **License #**: ______________ Shoreline: ______________ **Date**: ______________

Hail Out Time: ______________ Hail In Time: ______________ Beaufort Scale: __________

**Start Coordinates**: ______________ **End Coordinates**: ______________

**Region of License Issuance**: ◯ Maritimes ◯ Newfoundland & Labrador ◯ Gulf

| Gear Information | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Type of gear | Gear weight (kg) | Gear length (ft) | Buoyancy (Y/N) | Reusable (Y/N) | Escape panel (Y/N/NA) | Functional? (Y/N/NA) | Tag Number | Tag colour & year | Biofoul (#) | Gear degradation | Notes |
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Page _____ of _____ Gear Storage Location: ______________

Figure 25. Coastal Action harmonized ghost gear retrieval data form for shoreline retrievals.

# 8.0 Appendix B – Retrieval Results

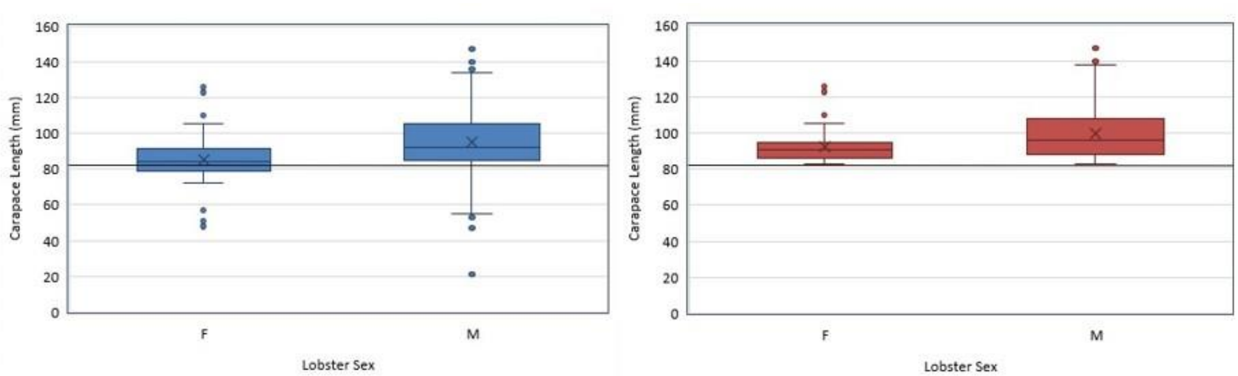


Figure 26. Carapace length (mm) of lobster bycatch released in Nova Scotia in LFA 27, 33, and 34 and Newfoundland in LFA 11 and 12 by sex. Panel 1 (blue): All lobsters; Panel 2 (red): Market-sized lobsters. The black line indicates MLCS (82.5 mm) used by both provinces in these fishing areas. The middle line of each boxplot indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, the points are outliers, and the X is the mean.

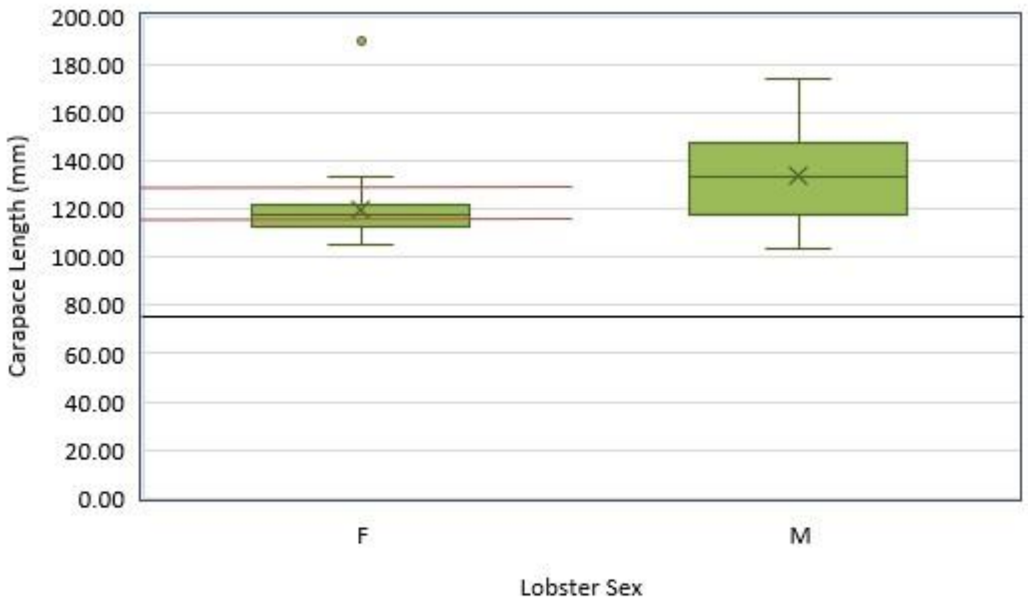


Figure 27. Carapace length (mm) of all lobster bycatch released in PEI in LFA 24 by sex. The black line indicates MLCS (75 mm) used in this fishing area. The two red lines indicate the release window for females (115 mm to 129mm) in this fishing area. The middle line of each boxplot indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, the points are outliers, and the X is the mean.

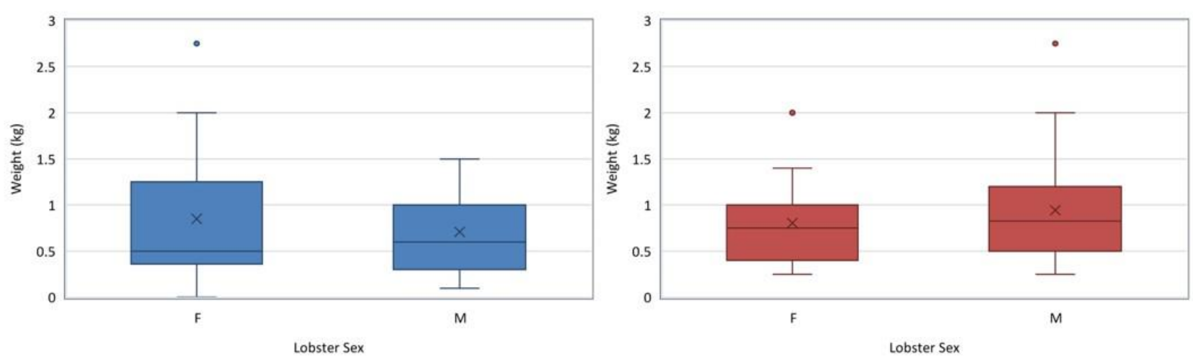


Figure 28. Weight (kg) of lobster bycatch released by sex. Panel 1 (blue): All lobsters; Panel 2 (red): Market-sized lobsters. The middle line indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, the points are outliers, and the X is the mean.

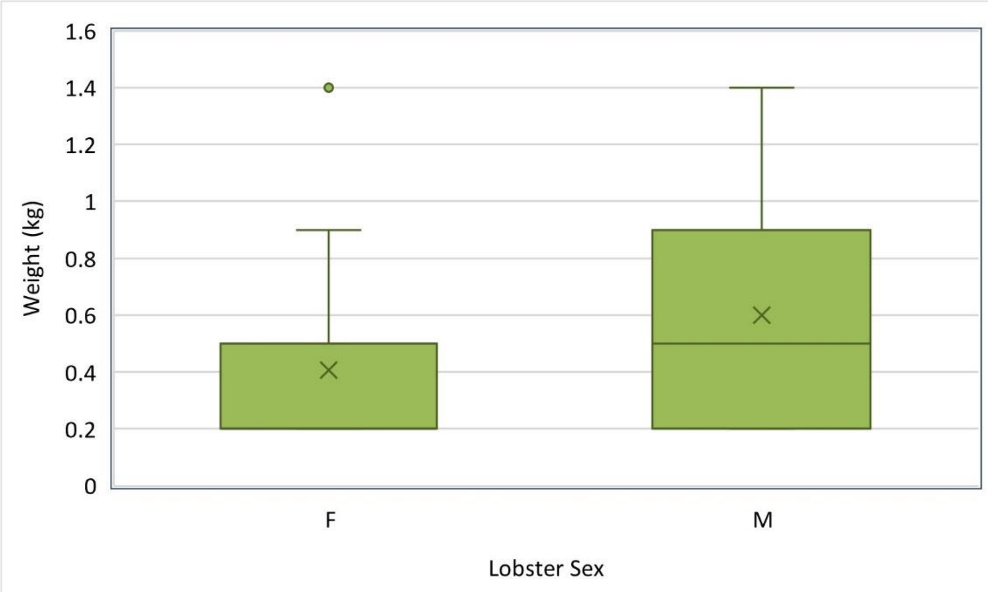

Figure 29. Weight (kg) of lobster bycatch released by sex in PEI LFA 24. The middle line indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, the points are outliers, and the X is the mean.