

# Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear in Southwest Nova Scotia: Retrieval Results Summary (2022 - 2023)

April 2023



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# Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia: Year Three Retrieval Results Summary (2022 - 2023)

## Contributing Authors and Surveyors:

Zora McGinnis, MSc, Coastal & Marine Project Coordinator, Coastal Action

Matthew Molyneux, Coastal & Marine Sr. Field Technician, Coastal Action

Megan Burnett, BSc, Coastal & Marine Sr. Field Technician, Coastal Action

Abbey Duinker, MSc, Coastal & Marine Project Coordinator, Coastal Action

Ariel Smith, MEnv, Coastal & Marine Team Lead, Coastal Action

Alysa Czenze, BScH, Coastal & Marine Sr. Field Technician, Coastal Action

Kelly Mackarous, BSc (AgEnvSc), Coastal & Marine Team Lead, Coastal Action

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Coastal Action

45 School Street, Suite 403

Mahone Bay, N.S., B0J 2E0

Ph: (902) 634-9977

Email: [info@coastalaction.org](mailto:info@coastalaction.org)

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## 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 such as loss rates, ghost gear impacts, and regulatory retrieval barriers. To address these problems, Coastal Action undertook the *Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia* project funded by Fisheries and Oceans Canada (DFO)'s Ghost Gear Fund (GGF). Overall, this project aims to prevent, reduce, and assess ALDFG in Southwest Nova Scotia (Lobster Fishing Areas (LFAs) 33, 34, 35 – Nova Scotia only) collaboratively, working with stakeholders including industry, government, non-profit organizations, and academia.

This report aims to provide an overview of project retrieval methods and results. Results of retrieved gear and bycatch released are provided, with key findings summarized below. Future project activities and recommendations are provided.

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

- Captains from six vessels towed grapples for roughly **537 km**, searching the seafloor for ghost gear.
- A total of **17,829 kg** of ALDFG was retrieved from the ocean surrounding SWNS, **4,126 kg** from five shoreline cleanups in SWNS, and **10,951 kg** from 10 shoreline cleanups in Cape Breton, NS, totalling **32,906 kg** of ALDFG removed. Of this debris, **74.5% were lobster traps** and **14.2% were dragger cable** by weight.
- Traps with tags, ranged in age from **9 to 39 years old**, with a median age of **16.5 years**.
- Within 4 to 5 years lost gear may create habitats however until then, **lost traps continue to fish effectively on target and non-target species**.
- A total of **18 different species** were released from ALDFG, including **305 lobsters** and **15 fishes, 1 of which was a species-at-risk**.
- Carapace length measurements of lobster bycatch showed that **75% of lobsters released were market-sized**.

## 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, and entanglements (also known as *ghost fishing*), decreased catches, at-sea safety hazards, and vessel damage (Macfadgen 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 conditions, mismanagement accidents, ship strikes, and inappropriate disposal at sea. Losses can be accidental, and fishers are not always at fault, as the marine environment is shared by many industries (Goodman et al. 2019). For example, gear buoy lines can be cut by passing aquaculture or transport vessels and even pleasure craft. Further, Heather Mulock, Executive Director of Coldwater Lobster Association, explained that “the last thing that fishers want to do is lose their gear. The ocean is where they make their living, and protecting the marine environment and their fishing grounds is crucial for the long-term sustainability of all commercial fisheries” (personal communication with author, 2020; unreferenced).

The Fisheries Act (Government of Canada 1985), Environmental Protection Act (Government of Canada 1999), and Vessel Pollution and Dangerous Chemicals Regulations (Government of Canada 2001) govern the marine management of fishing gear loss and recovery. These acts and regulations prohibit disposal of ALDFG at sea, helping to protect marine life and habitat as well as mitigate environmental impacts. Fisheries and Oceans Canada (DFO) considers ALDFG a “wreck” under the Wrecked, Abandoned or Hazardous Vessel Act (WAHVA), that the Minister, on reasonable grounds, believes imposes a hazard defined under 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). For example, gear can be hard to relocate once it is lost, and existing license conditions prescribed by DFO limit retrieval of ALDFG. Mulock 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 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, previous studies have predicted ALDFG “hotspots”, areas where traps are commonly lost and found, using local knowledge from fishers (Goodman et al. 2019) and verified locations of lost gear using underwater video footage in Southwest Nova Scotia (SWNS) (Goodman et al. 2020).

Another factor contributing to the problem is that waste management of end-of-life-gear is disjointed with limited options for low-impact disposal methods (Goodman 2020; Dawe et al. 2021). Gear disposal options are 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.

To address known barriers contributing to the issue, Coastal Action undertook the *Collaborative Remediation of Abandoned, Lost, and Discarded Fishing Gear (ALDFG) in Southwest Nova Scotia*, a project funded through the Department of Fisheries and Oceans Canada's Ghost Gear Fund (GGF). 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 Lobster Fishing Areas (LFAs) 33 through 35 (Figure 1), continuing to promote and explore responsible gear disposal and recycling options, and developing and delivering educational materials on ghost gear and ocean conservation to the fishing community and public.

This season brought a special set of circumstances with the arrival of Hurricane Fiona in September 2022. Though the worst of the impacts were felt in Cape Breton and the Antigonish region, storm surge, high winds and heavy wave action were felt throughout the entire province. While very few Nova Scotian fishers had active lobster gear in the water, many traps were lost from wharves and shorelines. Many vessels were geared for fishing herring and groundfish and 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.

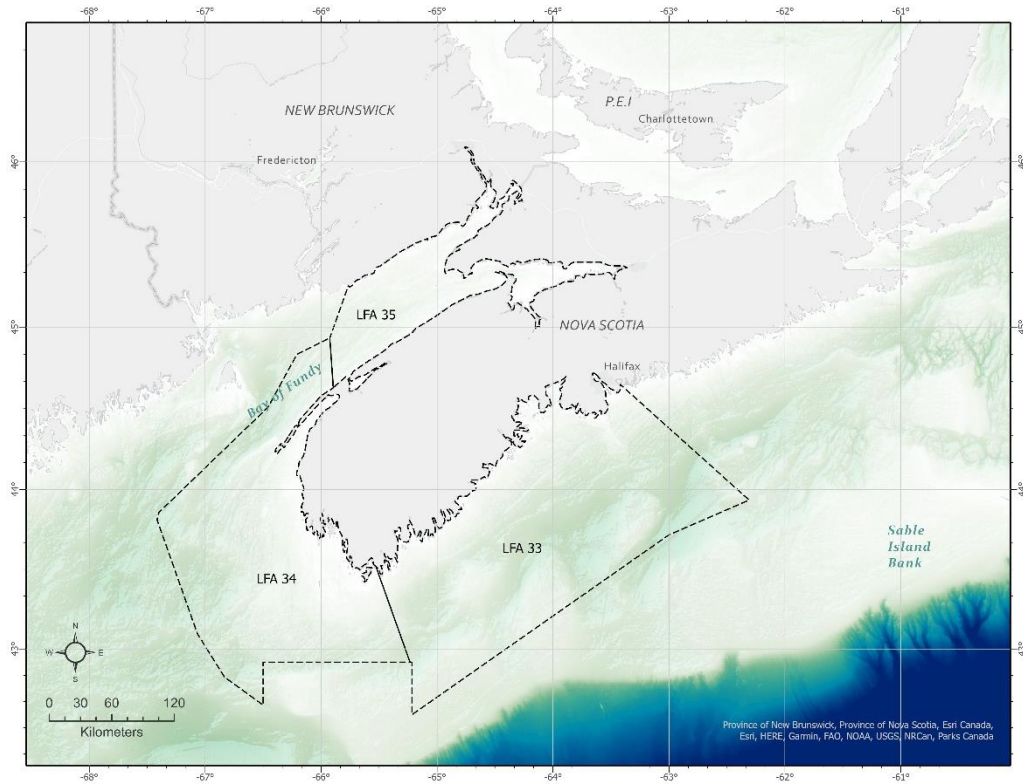


Figure 1. Lobster Fishing Areas 33, 34, and 35 in Southwest Nova Scotia. Colour indicates ocean depth.

## 2.0 Materials and Methods

### 2.1 Lost Gear Identification and Area Selection

To identify retrieval areas, several techniques were deployed. The results of focus group sessions held in 2020 with Brazil Rock Lobster 33/34 Association and with Coldwater Lobster Association were consulted. Conversations were held with previous seasons' captains about areas of previous retrieval success that might require further work and areas of frequent gear loss. As part of DFO licensing conditions, fishing license holders are to report any lost gear within 24 hrs of loss, which contributes to a national database of lost gear. This data was also utilized to further inform areas of retrieval (Figure 2). Additional information was also gathered from fishers through anonymous online surveys.

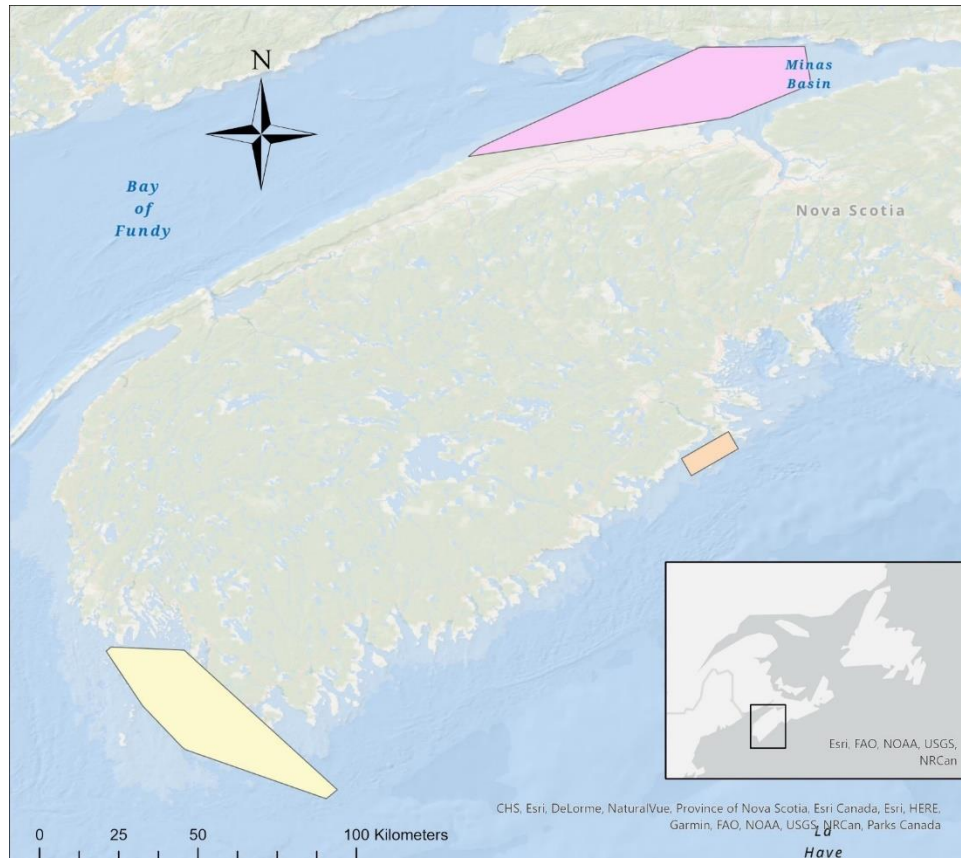


Figure 2. Polygons of at-sea retrieval areas. Retrieval in LFA 35 is in pink, LFA 34 is in yellow, LFA 33 is in orange.

Lastly, retrieval areas were compared with known species and habitat data, species identified under the Species at Risk Act (SARA) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and areas of fishing significance. Within the selected retrieval areas, nine fish species were listed under COSEWIC that would be bycatch potential in ALDFG, including American plaice (*Hippoglossoides platessoides*), Atlantic cod (*Gadus morhua*), Atlantic wolffish (*Anarhichas lupus*), cusk (*Brosme brosme*), lumpfish (*Cyclopterus lumpus*), Northern wolffish (*Anarhichas denticulatus*), spiny dogfish (*Squalus acanthias*), spotted wolffish (*Anarhichas minor*), and white hake (*Urophycis tenuis*). This list was not exhaustive of all species-at-risk present in retrieval areas, therefore implying that ALDFG could also impact other species not listed, such as migratory species and marine mammals.

Once retrieval areas were selected, they were approved by DFO under the *Fishery (General) Regulation* Section 52 Scientific Permit (Permit #361 225). Throughout the retrieval season, additional search areas were added as more information and additional funding became available.

## 2.2 At-sea Retrieval and Data Collection

Retrieval was conducted when winds were low (< 15 knots) and with a calm sea state (Beaufort scale < 5). The captains used span drags and grapples that they designed and constructed based on the success of the previous season (Figure 3). The captains towed their preferred span drag or grapple from the starboard side of their respective commercial vessels using a hydraulic hauler and winch. The preferred tow speed for retrieval was between 0.5 to 3 knots.



Figure 3. Grapples used in the 2022 season for gear retrieval. A. span drag, B. cylinder block grapple.

All retrieval trips were completed by commercial fisher captains and deckhands. Retrieval captains were chosen based on their area of interest, capacity, and interest in ocean stewardship. In September, October, and early November of 2022, 70 at-sea retrieval trips were completed in LFAs 33, 34, and 35. Of those trips, 11 were in LFA 33, 59 in LFA 34, and 10 in LFA 35. Trips in LFA 33 specifically targeted offshore islands. In this LFA, a Carolina skiff was used to access the LaHave Islands and West Ironbound Island to remove gear from their shorelines and safely transport it to the mainland for disposal. These island shorelines are rarely accessed by humans, so gear accumulation can be significant. Islands had been scoped by that captain previously and were chosen based on their accessibility and debris accumulation.

Standardized data on gear and bycatch was collected during every retrieval trip and recorded on DFO's Data Collection for Retrieval of Lost Fishing Gear form (Appendix A -

**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

Collector's Name: \_\_\_\_\_

Vessel Name & License #: \_\_\_\_\_

Position of the retrieved gear (See examples below):  NAD83 (preferred) |  WGS84 |  NAD27

Fixed Position coordinates								Notes
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	or	Degrees	Decimal Minutes
Longitude								
Gear Drag line coordinates Start point								
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	or	Degrees	Decimal Minutes
Longitude								
Gear Drag line coordinates End point								
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	or	Degrees	Decimal Minutes
Longitude								
<small>(DD) Example: 42.758 -62.545 Latitude: 42.758 Longitude: -62.545</small>		<small>(DMS) Example: 42°45'30" N 62°52'45" W Latitude: 42 45 30 Longitude: 62 52 45</small>			<small>(DDM) Example: 42° 45.480' N 62° 52.700' W Latitude: 42 45.480 Longitude: 62 52.700</small>			<input type="radio"/> "NL" 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*) <small>*specify for Other</small>	Approx. weight (kg)	Length of Rope (ft.)	Tag Number <small>FA plus vendor # if on tag, i.e. LFA36 29</small>	(Add 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 22). Trap age was recorded from trap tags by colour (2013 and newer) or by year (2013 and older); however, this method is based on DFO's tag management system and is an approximation, therefore where there was uncertainty no age was recorded. Tagged gear from 2018 or newer that was deemed to be reusable was returned to a designated Small Craft Harbour secure compound with the intent to be returned to the owners by DFO. Older tagged, untagged, or degraded gear was either disposed of at local landfills or repurposed by fishers.

Additional data was collected by Coastal Action and Clean Annapolis River Project (CARP) on 83% of retrieval trips (58 trips total) to assess the ecological impacts of ghost gear (Appendix A-Figure 23). When the gear was retrieved, additional metrics were recorded for gear and bycatch, 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, 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.

A tow map was created using the latitude and longitude coordinates. Point retrieval data was displayed using the *point conversion* tool. Tow lines were displayed using the *XY Table to Line* tool with data from the start and end point coordinates of each respective tow. The recovery effort area was calculated using the *bounding geometry* tool for each LFA. LFA 34 and 35 used convex bounding geometry while LFA 33 was given a rectangle as efforts were focused on island cleanups.

## **2.4 Shoreline Cleanups**

A total of 15 shoreline cleanups were conducted in southwest Nova Scotia and Cape Breton. Originally, four shoreline cleanups were conducted in LFA 34 and one cleanup in LFA 33. The event in LFA 33 was led by CARP with volunteers from a local high school. Cleanup activity was extended to include 10 retrievals in Cape Breton, as part of a Hurricane Fiona relief effort.

### **2.4.1 Southwest Nova Scotia**

A total of five shoreline cleanups were conducted in Southwest Nova Scotia. These were conducted in the Pubnico, Clark's Harbour, and Digby areas. Sites were selected using community knowledge of areas with high accumulation of debris. These retrievals were conducted with the aid of community volunteers and, in some cases, the use of all-terrain vehicles. Volunteers would traverse the shoreline while picking up debris. The debris would then be brought to a centralized collection point where Coastal Action staff would sort and catalogue the items.

The cataloguing process involved the use of the DFO data form (Appendix A-

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

Collector's Name: \_\_\_\_\_

Vessel Name & License #: \_\_\_\_\_

Collection Date (yyyy-mm-dd): \_\_\_\_\_

Position of the retrieved gear (See examples below):  NAD83 (preferred) |  WGS84 |  NAD27

Fixed Position coordinates								Notes
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	Degrees	Decimal Minutes	
Longitude								
Gear Drag line coordinates Start point								Notes
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	Degrees	Decimal Minutes	
Longitude								
Gear Drag line coordinates End point								Notes
Latitude	Decimal Degrees	or	Degrees	Minutes	Seconds	Degrees	Decimal Minutes	
Longitude								
<small>(DD) Example: 42.758 -62.545 Latitude: 42.758 Longitude: -62.545</small>		<small>(DMS) Example: 42°45'30" N 62°52'45" W Latitude: 42.145.150 Longitude: 62.132145</small>				<small>(DDM) Example: 42° 45.480' N 62° 52.700' W Latitude: 42.145.480 Longitude: 62.132.700</small>		<input type="radio"/> "NL" 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)

1	2	3	4	5	6	7	8	9	10	11	12
Gear Type (Trap, Pot, Trawl, Net, Longline, Seine, Buoy, Troll, Aquaculture, Other*) <small>*specify for Other</small>	Approx weight (kg)	Length of Rope (ft.)	Tag Number <small>FA plus vendor # if ontag, i.e. LFA36 25)</small>	(Add 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	

Approximate gear depth: \_\_\_\_\_

Gear Storage Location: \_\_\_\_\_

Fathoms |  Feet |  Metres

Comment Box: \_\_\_\_\_

Figure 22) which would capture general characteristics like weight, length and tag information. Lengths were measured in feet and weights in kilograms were captured using an Air Canada brand luggage scale.

### 2.4.2 Cape Breton

Supplementary funding was provided by the Department of Fisheries and Oceans Canada to support an additional 10 shoreline cleanups in Cape Breton, NS. These retrieval efforts were focused on the Sydney-Glace Bay area with two retrievals in Little Lorraine and one in Neil's Harbour. Sites were selected using suggestions from local environmental groups and by on-foot scouting conducted by Coastal Action team members. The methodology was the same as the SWNS shoreline retrieval efforts.

## **2.5 Data Analysis and Assessment**

Ghost gear and bycatch data were analyzed in Microsoft Excel and R version 4.2.3.

## **3.0 Results and Discussion**

### **3.0.1 Industry and Community Knowledge**

Retrieval captains contributed their knowledge of locations with ghost gear and gathered insight on areas of gear loss from other local fishers throughout the project. This knowledge was critical for retrieval success. DFO's database of reported gear losses was helpful in previous year's projects to determine broad-scale patterns but as community insight proved to be more effective for precise gear locations and areas warranting exploration, the database was not used this year. Increasing retrieval success could be accomplished through a combination of collecting more informal insight from fishers and conducting additional focus groups and surveys.

### **3.1 Retrieval**

A total of 823 tows were completed resulting in a total distance of 537.13 km searched. Approximately 43 % were successful tows, where some gear was retrieved. Tows varied in length depending on local conditions, search areas, and the captain's conducting retrieval. Some captains conducted tows in straight lines that were 30 minutes or shorter in duration (Figure 4). Whereas others completed only two tows in one day, leaving the grapple submerged and continuously towed (Figure 5). If gear was snagged, the grapple was pulled up and gear was brought aboard, if safe to do so. If gear was unsafe to retrieve, it was released, and the position of the loss was recorded and reported. Some surface debris, such as buoys, were also retrieved if spotted.

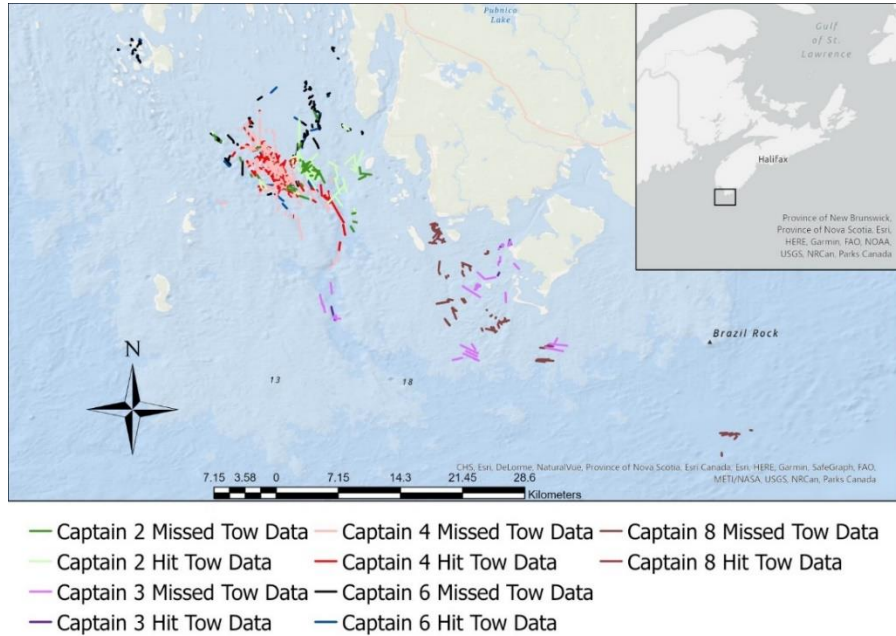


Figure 4. Submerged tow efforts for LFA 34. Missed tows, or nil tows, were retrieval efforts that resulted in no gear being retrieved.

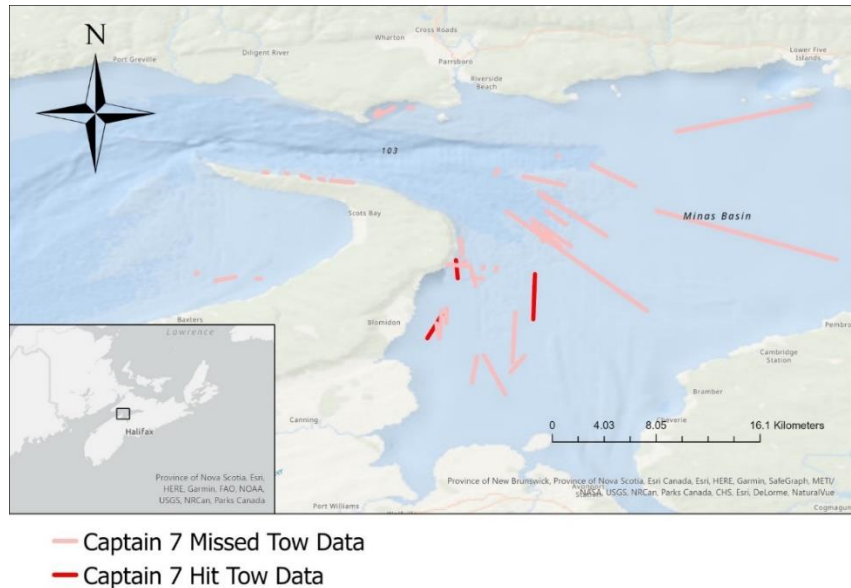


Figure 5. LFA 35 submerged tow efforts. Missed tows, or nil tows, were retrieval efforts that resulted in no gear being retrieved.

All captains were successful in retrieving debris from their search areas with only two of seven captains experiencing any “nil days” with no gear collected (Table 1). While this method of towing and grappling for gear from the seafloor was relatively successful, it is important to note that towing over large areas, with little knowledge of gear loss in the area,

proved to have mixed results. Therefore, knowing ALDFG hotspots ahead of time is critical to increasing the amount of gear retrieved.

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

<b>Fisher ID</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>6</b>	<b>7</b>	<b>8</b>
LFA	33	34	34	34	34	35	34
Total Distance Towed (km)	NA	100.13	63.31	148.46	66.55	118.32	40.35
Total Tows	NA	134	70	293	206	43	77
NIL Tows	NA	42	45	143	129	41	70
NIL Tows (%)	NA	31%	64%	49%	63%	95%	91%
Total Retrieval Trips	11	11	6	15	10	10	7
NIL Trips	0	0	0	0	0	2	2
NIL Trips (%)	0%	0%	0%	0%	0%	20%	29%

The captain in LFA 33 did not tow a grapple but instead retrieved gear off the shorelines of islands (Figure 6). This proved to be very effective as the captain had good knowledge of where debris accumulated in that area. This resulted in the removal of just over 2,900 kg of gear (Table 2). A single instance of floating debris during these island trips was also collected and recorded. 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 or beach users, or harming habitats on shore (Blettler and Mitchell 2021).

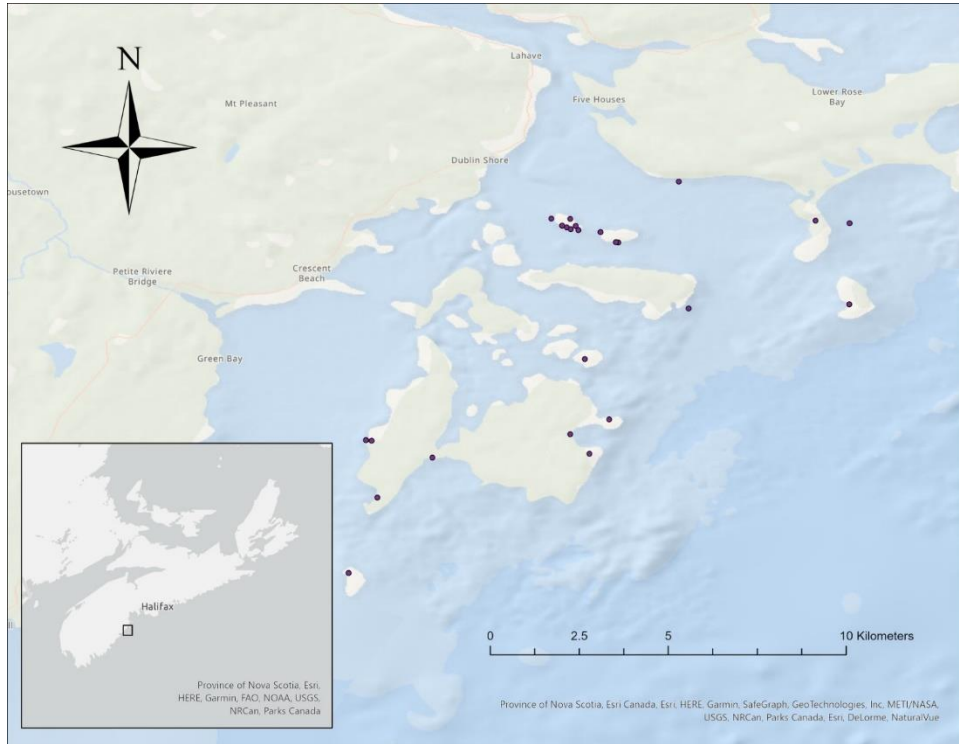


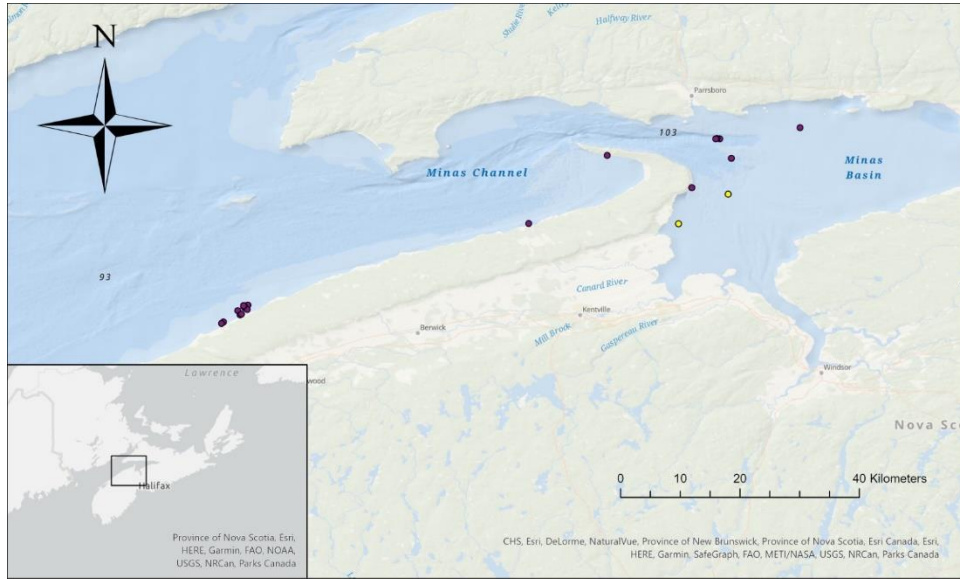
Figure 6. Retrieval efforts in LFA 33. Effort in LFA33 differed from other at-sea days as island shorelines were targeted instead of underwater retrieval.

### 3.1.1 At-sea Retrieval

Over 17 metric tonnes of debris, predominantly ALDFG, were removed from the Atlantic Ocean during 70 gear retrieval days across SWNS (Table 2). Gear retrieved ranged in type, age, condition, and weight. The spatial distribution of ALDFG retrieved was mainly influenced by the locations selected by the captains. Their choices were based on known locations of lost gear, local fishing effort, bottom type, and “retrievability” (i.e., safety considerations, boat access, etc.). A notable occurrence was that Minas Basin had the third lowest number of traps retrieved but the highest number of bycatch (Figure 7; Table 2). A large portion of gear retrieved was from Lobster Bay (Figure 8), an area with high historical fishing effort. This area should be pursued for future retrieval efforts, and areas with high historical fishing efforts could provide insight into other locations of ALDFG.

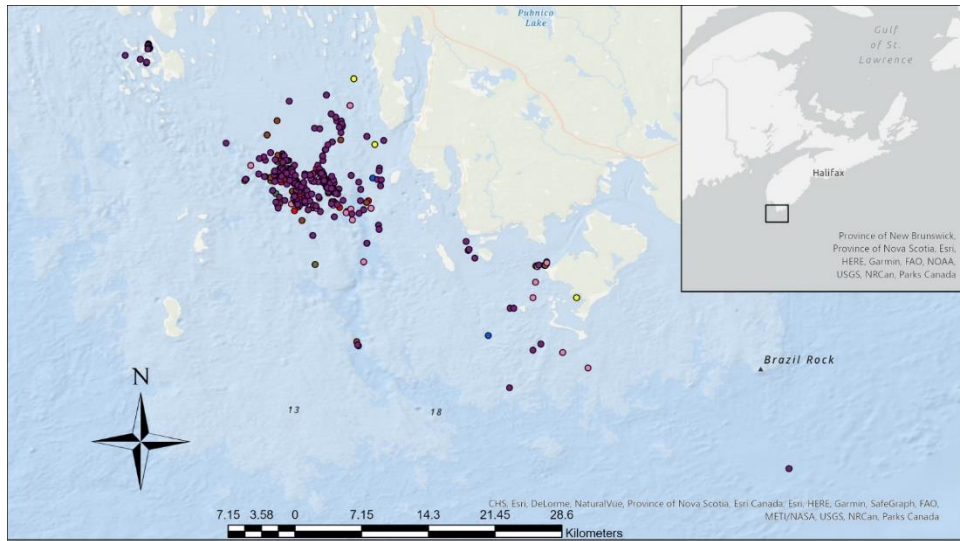
Table 2. Summary of the total at-sea retrieval effort from LFA 33 – 35.

Captains	1	2	3	4	6	7	8	Total	LFA 33	LFA 34	LFA 35
LFA	33	34	34	34	34	35	34				
<b>Effort</b>											
Distance Towed (km)	NA	100.13	63.31	148.46	66.55	118.32	40.35	<b>537.13</b>	NA	418.81	118.32
Tow Count (#)	NA	134	70	293	206	43	77	<b>823</b>	NA	780	43.00
Distance per Tow (km)	NA	0.747	0.904	0.507	0.323	2.752	0.524		NA		
Effort per Trap (km)	NA	0.691	7.034	0.990	1.091	2.415	5.765		NA		
<b>Total Traps</b>											
Total Traps	171	145	9	150	61	49	7	<b>592</b>	171	372	49
Functioned Traps	122	115	7	124	41	4	4	<b>417</b>	122	291	4
Did not Function Traps	27	7	1	1	11	40	2	<b>89</b>	27	22	40
No Escape Panel	6	12	1	18	6	0	0	<b>43</b>	6	37	0
Returned (illegal report)	0	0	0	0	0	5	0	<b>5</b>	0	0	5
Could not find	16	11	0	5	3	0	1	<b>36</b>	16	20	0
<b>Compound</b>											
Compounded	0	2	0	0	0	24	1	<b>27</b>	0	3	24
<b>Item Counts</b>											
Buoys	24	0	2	4	2	34	1	<b>67</b>	24	9	34
<b>Weight</b>											
Trap Weight (kg)	2352	3449.5	209	3270.2	1532.0	2238	227	<b>13277.7</b>	2352.0	8687.7	2238.0
Cable Weight (kg)	0	350.0	1994.5	194.4	0.0	0	0	<b>2538.9</b>	0.0	2538.9	0.0
Rope Weight (kg)	39.5	183.9	80	369.6	78.0	128	2	<b>880.9</b>	39.5	713.4	128.0
Net Weight (kg)	131	0.0	0	125.5	2.5	0	0	<b>259.0</b>	131.0	128.0	0.0
Partial Weight (kg)	185.5	31.0	15	4.5	1.0	0	0	<b>237.0</b>	185.5	51.5	0.0
Trap piece Weight (kg)	90	27.0	4	49.0	18.5	0	0	<b>188.5</b>	90.0	98.5	0.0
Other Weight (kg)	86.85	59.1	86.5	80.4	41.0	9.1	0	<b>362.9</b>	86.9	267.0	9.1
Bait Bag Weight (kg)	3.3	1.1	0	2.2	1.7	0	0	<b>8.3</b>	3.3	5.0	0.0
Buoy Weight (kg)	29.35	0.0	5	4.1	6.0	30.5	1	<b>76.0</b>	29.4	16.1	30.5
Total Weight (kg)	2917.5	4101.6	2394.0	4099.9	1680.7	2405.6	230.0	<b>17829.3</b>	2917.5	12506.2	2405.6
<b>Length</b>											
Rope Length (ft)	994	3320.0	1360	4794.0	2091.5	4779	66	<b>17404.5</b>	994.0	11631.5	4779.0
Cable Length (ft)	0	345.0	6690	760.0	0.0	0	0	<b>7795.0</b>	0	7795	0
<b>By-Catch</b>											
Lobster	1	10	4	14	7	264	5	<b>305</b>	1	40	264
Jonah	0	16	9	51	24	47	2	<b>149</b>	0	102	47
Rock	0	2	0	6	4	1	1	<b>14</b>	0	13	1
Cunner	0	0	0	10	0	0	0	<b>10</b>	0	10	0
Scallop	0	2	0	1	1	0	0	<b>4</b>	0	4	0
Sculpin	0	0	0	2	0	2	0	<b>4</b>	0	2	2
Cusk	0	0	0	0	1	0	0	<b>1</b>	0	1	0
Thorny Skate	0	0	0	0	0	1	0	<b>1</b>	0	0	1
Number of lobsters	1	10	4	14	7	264	5	<b>305</b>	1	40	264
Number groundfish released	0	0	0	12	1	2	0	<b>15</b>	0	13	2
Number of species at risk released	0	0	0	0	1	0	0	<b>1</b>	0	1	0
<b>Effort Details</b>											
Total days	11	11	6	15	10	10	7	<b>70</b>	11	49	10
Total tows	NA	134	70	293	206	43	77	<b>823</b>	NA	780	43
NIL tows	NA	42	45	143	129	41	70	<b>470</b>	NA	429	41
<b>Av. Total</b>											
NIL tow rate	NA	31%	64%	49%	63%	95%	91%	<b>66%</b>	NA	55%	95%
Mean age of traps	15.5	18.9	21.5	19.9	18	9	14.5	<b>16.8</b>	16	19	9
Median age of traps	13	19	21	20	19	9	14.5	<b>16.5</b>	13	19	9
Min age of traps	10	9	16	10	11	9	10	<b>10.7</b>	9	10	9
Max age of traps	33	34	28	37	39	9	19	<b>28.4</b>	33	39	9
Median Depth (fm)	0	17.3	7.5	18	13.3	11.8	11.3	<b>13.2</b>	0	13	11.8
Min Depth (fm)	0	11.2	4	11	2.2	3.3	6	<b>6.3</b>	0	7	3.3
Max Depth (fm)	0	27	28.3	30.3	26.3	24.2	21.2	<b>26.2</b>	0	27	24.2



- Rope Location
- Net Location
- Bait Bag Location
- Partial Trap Location
- Dragger Cable Location
- Trap Location
- Other Item Location
- Buoy Location
- Trap Piece Location

Figure 7. Retrieval efforts in LFA 35 by item type retrieved.



- Trap Location
- Trap Piece Location
- Buoy Location
- Rope Location
- Net Location
- Bait Bag Location
- Partial Trap Location
- Dragger Cable Location
- Other Item Location

Figure 8. Retrieval efforts in LFA 34 by item type retrieved.

Lobster traps comprised 74% of the total retrieved weight (Figure 9), weighing between ~ 2 and 62 kg along the south shore of Nova Scotia, and up to 135 kg in the Minas Basin. Traps retrieved ranged in age from nine years to thirty-nine years old (Table 2), although not all traps were tagged thus making it hard to determine the true distribution of the retrieved gears' age.

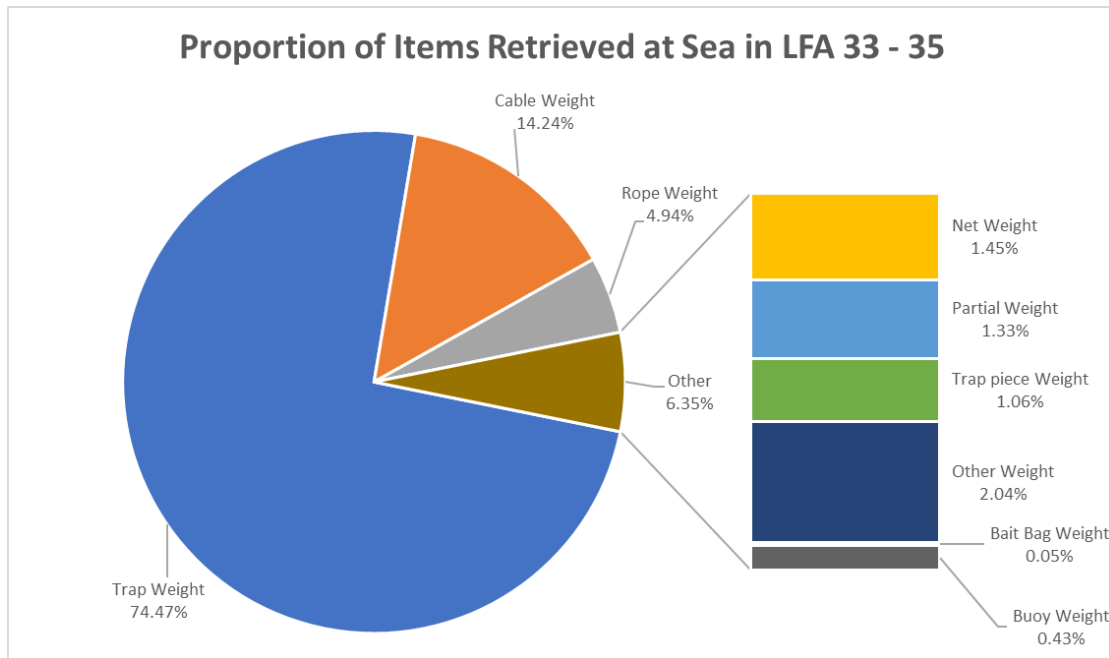


Figure 9. Proportions of all item types retrieved at sea in LFA 33 – 35 by weight.

Dragger cables also made up a significant portion by weight. The number of dragger cables obtained was higher than anticipated. Over 2,500 kg of cable were safely retrieved by fishers. Additional cable was initially grappled but ultimately unrecovered due to safety concerns, some of which included; heavy cable destabilizing the vessels, cables fracturing easily and sharp frayed edges becoming hazardous to handle. Local knowledge suggested that these dragger cables were commonly discarded at sea by commercial trawl vessels (draggers) instead of being hauled back ashore. A significant portion of this cable was retrieved at the mouth of harbours (e.g., Clark’s Harbour and Lobster Bay).

Overall, captains in LFA 34 retrieved the most gear by weight (Table 2), but this was likely due to higher retrieval effort in this region with four retrieval vessels designated to one area. In LFA 35, a total of 262 lobsters were released, traps were relatively new with less damage, tagged traps average age here was 9 years (Table 2;

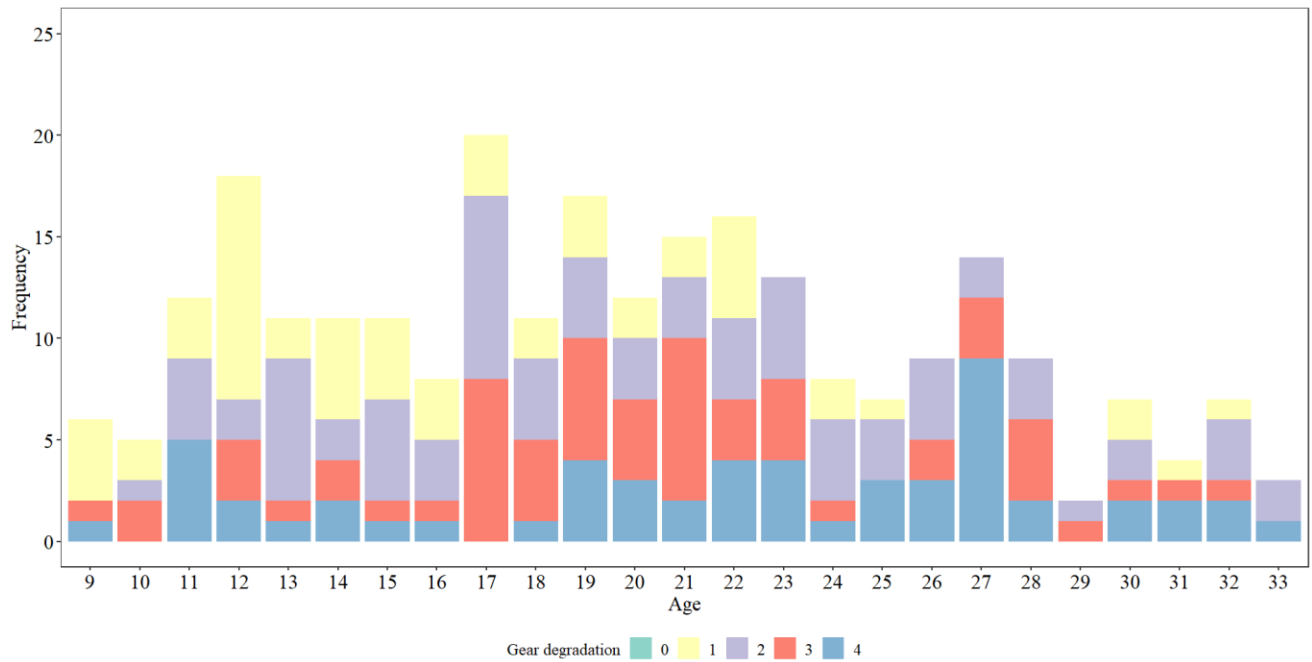


Figure 10). In comparison, many of the traps retrieved in LFA 34 were older and heavily degraded, with the average age of tagged traps being 20 years, which trapped fewer lobsters as

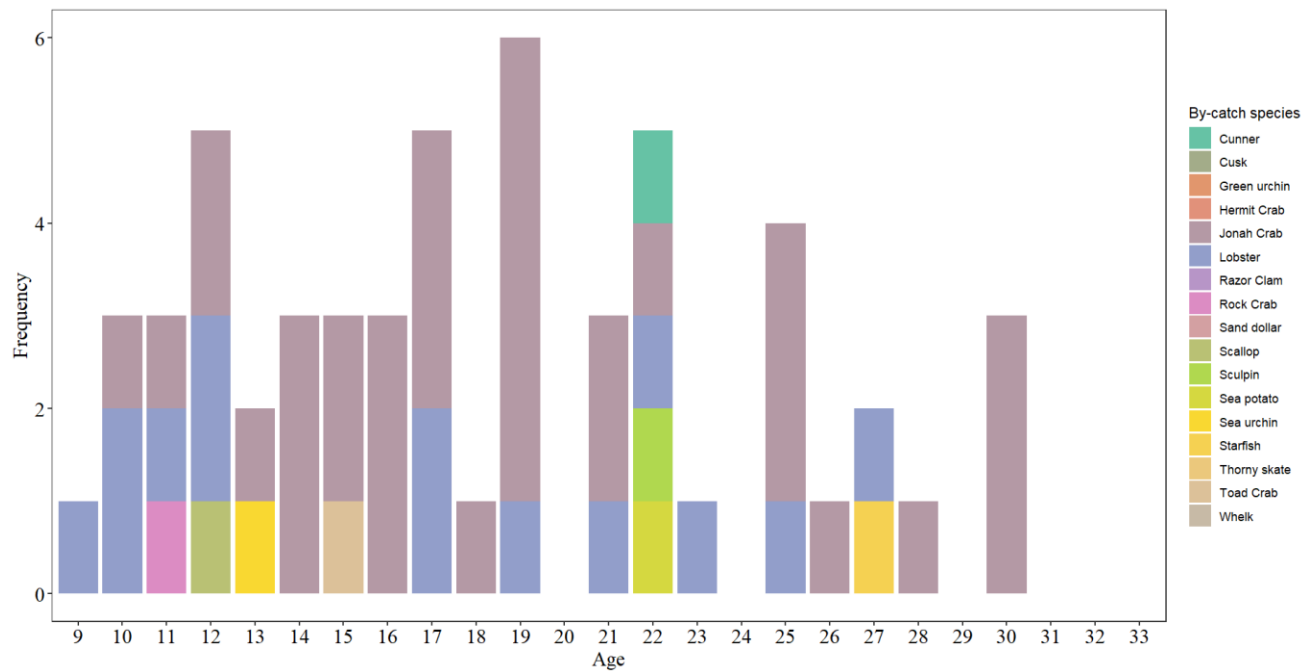


Figure 11). In LFA 33, a total of 1 lobster was released, as all recovery efforts in LFA 33 were conducted as island cleanups accessed via boat. The majority of these traps were older and heavily degraded. The former factors contributed to the differences in gear retrieved and lobsters released, between the three LFAs. We recommend targeting gear that is newly lost to reduce the continuous impacts of ALDFG (bycatch and marine debris).

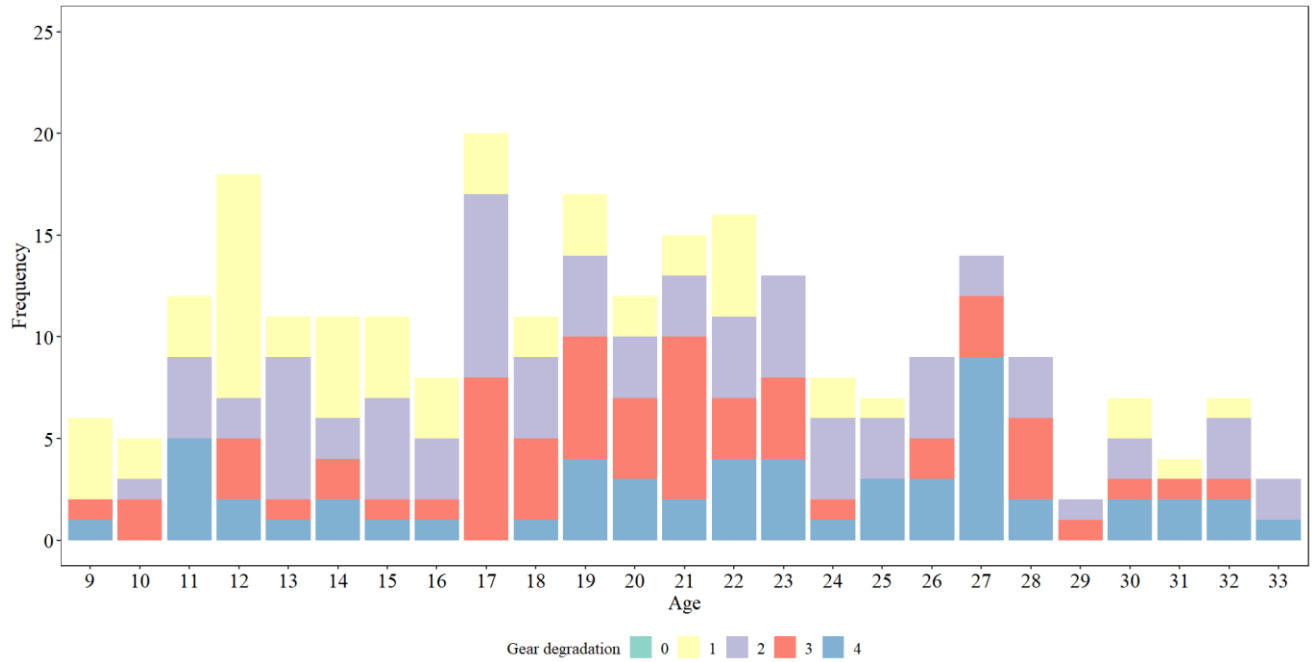


Figure 10. Frequency of each stage of gear degradation as gear ages. Level 1: 0 - 25% (little degradation); 2: 25 - 50%; 3: 50 - 75%, 4:>75% (heavily degraded).

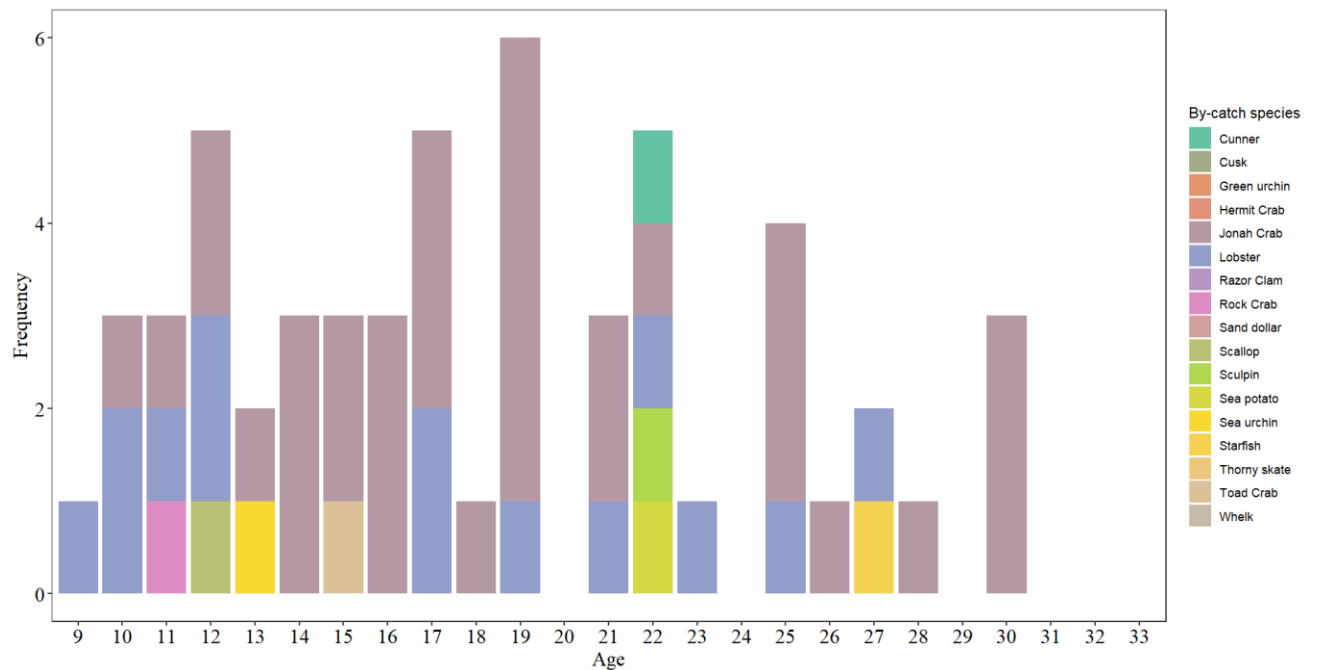


Figure 11. Frequency of By-catch species in relation to trap age.

### 3.1.2 Bycatch Released

A total of 305 lobsters were released from retrieved gear along with 15 fishes and 163 crabs (Table 2). In total, 17 species were observed and released (Figure 12). The only species-at-risk found was cusk (*Brosme brosme*). Other fishes released included thorny skate (*Amblyraja radiata*), sculpin (*Myoxocephalus* or *Hemitripterus* sp.), and cunner (*Tautoglabrus adspersus*). Other species released included toad crabs (*Hyas* sp.), hermit crabs (Paguroidea), starfish (*Asterias* sp.), brittle stars (Ophiuroidea), whelks (Buccinidae), sea urchins (Euechinoidea), sand dollars (Clypeasteroidea), and razor clams (Adapedonta). Further elaboration on a subset of bycatch data is covered in Section 3.5.1.

Jonah crab (*Cancer borealis*), cusk, and sculpin are among the common bycatch in active lobster fishing gear (Tremblay et al. 2013; Pezzack et al. 2014), which was consistent with bycatch released from ALDFG (Figure 12).

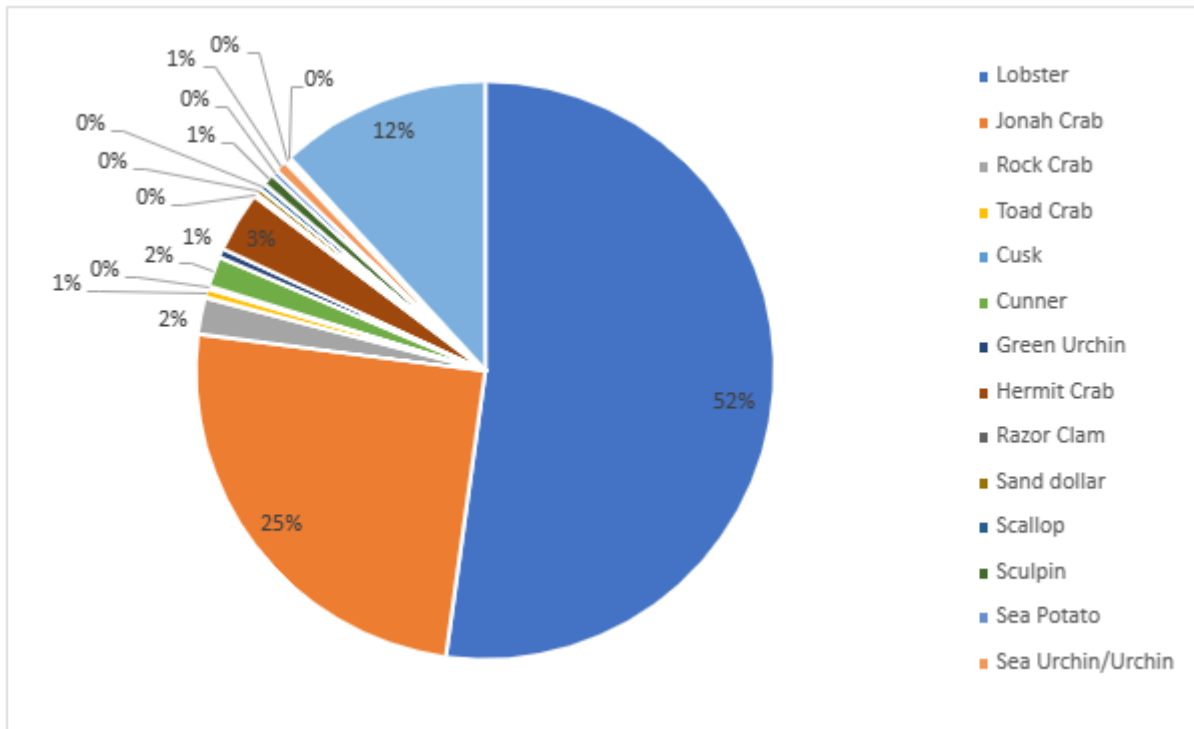


Figure 12. Proportion of bycatch in all ALDFG retrievals.

### 3.1.3 Shoreline Retrieval

Shoreline retrievals were conducted in Southwest Nova Scotia and along the Minas Basin coast (Figure 13). A total of just over 4 metric tons was removed from these areas which included over 1,200 ft of rope and 91 lobster traps (Table 3). West Pubnico had the largest

amount of ALDFG removed by weight, at almost 2,400 kg (Table 3). Retrieval results were high due to the ease of access, involvement of hardworking volunteers, and supporting equipment. This peninsula, located at the entrance of the Pubnico Harbour, is a hotspot for ALDFG to wash up on before travelling further into the harbour. Around 20 participants from the Pubnico Point Trail Association and surrounding communities came to help with retrievals efforts and provided the use of ATVs to assist with moving gear.

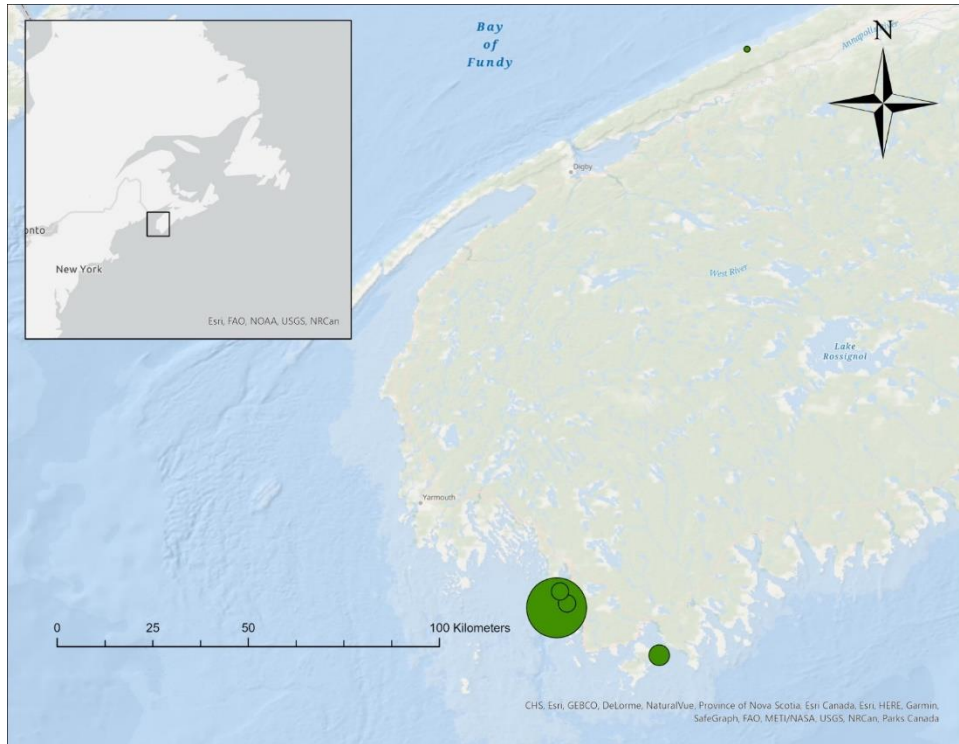


Figure 13. Proportional representation of Southwest Nova Scotia and Minas Basin shoreline retrieval efforts.

Table 3. Shoreline cleanup summary for Southwest Nova Scotia.

Query	Lower East Pubnico	West Pubnico	Hampton Beach	Middle West Pubnico	Clark's Harbour	Totals	Units
<b>Total Weight</b>	<b>528.4</b>	<b>2361.0</b>	<b>43.3</b>	<b>526.3</b>	<b>667.2</b>	<b>4126.2</b>	<b>Kg</b>
<b>Trap count</b>	<b>3</b>	<b>50</b>	<b>0</b>	<b>17</b>	<b>21</b>	<b>91</b>	<b>#</b>
<b>Buoy Count</b>	<b>6</b>	<b>9</b>	<b>0</b>	<b>4</b>	<b>1</b>	<b>20</b>	<b>#</b>
Trap Weight	100.0	1136.0	0.0	292.4	481.0	2009.4	Kg
Partial Trap Weight	23.6	383.4	0.0	8.4	107.0	522.4	Kg
Rope Length	98.0	54.0	0.0	546.4	530.0	1228.4	Kg
Rope Weight	37.0	227.5	41.0	22.1	37.5	365.2	Kg
Buoy Weight	3.9	17.9	0.0	2.3	0.5	24.5	Kg
Trap pieces, metal	5.0	36.3	2.0	22.5	28.0	93.8	Kg
Netting Weight	0.0	0.5	0.0	1.4	0.0	1.9	Kg
<b>Trash</b>	<b>359</b>	<b>559</b>	<b>0</b>	<b>177</b>	<b>13</b>	<b>1109</b>	<b>Kg</b>
Rubber	0	7.9	0	1.4	0	9.3	Kg
Domestic trash	21.8	18.2	0	0	0	40.3	Kg
Recyclables	5.0	18.9	0	0.9	1	26.0	Kg
hard plastic	85.0	120.8	0	10.6	6	221.9	Kg
metal	21.1	14.7	0	59.0	3	97.3	Kg
tires/rims	124.5	30.5	0	68.8	0	223.9	Kg
textiles/clothing	6.8	10.7	0	37	2	55.6	Kg
wood	64.1	325.2	0	0	0	389.3	Kg
Foam	9.3	5.5	0	0	0	14.8	Kg
Bait bags	0.7	2.7	0	0	0	3.5	Kg
Glass	0.9	0.2	0	0	0	1.1	Kg
Other	19.5	4.1	0	0	2	25.9	Kg

Additional shoreline retrievals were conducted in Cape Breton, NS (Figure 14) as a response to Hurricane Fiona. Over 10 metric tonnes of ALDFG and debris were removed from shoreline areas and included over 12,000 ft of rope and 437 lobster traps (Table 4). South Bar, Victoria Mines, and Little Lorraine each had multiple retrieval efforts due to a high accumulation of gear and debris. Neil's Harbour had the highest amount of gear retrieved by weight in a single event at ~ 2,400 kg, whereas Little Lorraine had the highest amount of gear retrieved by weight overall at ~ 4,000 kg (Table 4; Figure 14). These two areas had traps that washed onto roads during the storm and were easily accessible by trucks, making it easier to collect and dispose of ALDFG. At all other retrieval locations traps and debris had to be hand carried or dragged over larger distances and dug out of the substrate, therefore influencing the efficiency of retrieval efforts.

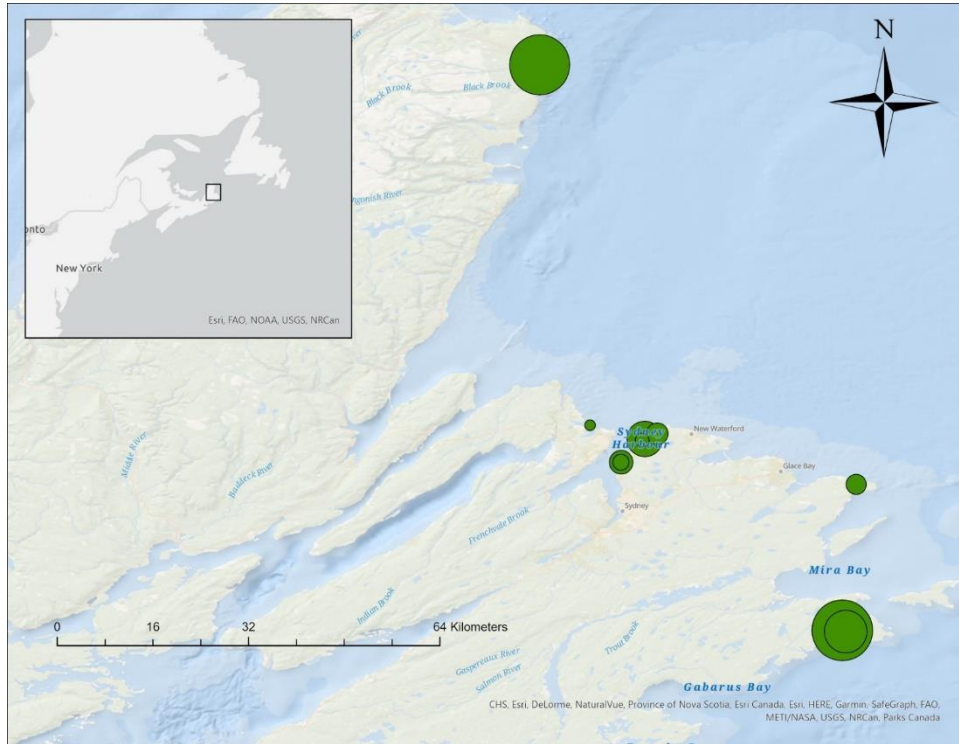


Figure 14. Proportional representation of Cape Breton shoreline retrieval efforts.

Table 4. Summary of the total collection efforts by location in Cape Breton. This effort was part of an extension of the initial retrieval efforts in the wake of Hurricane Fiona. A total of 10951.2 kg was collected including 12261 ft of rope and 437 traps.

Query	Florence Beach	South Bar 1	Schooner Pond	Victoria Mines	Victoria Mines 2	Neil's Harbour	Victoria Mines 3	Little Loraine	Little Loraine 2	South Bar 2	Total	Units
<b>Total Weight</b>	<b>249.75</b>	<b>468.25</b>	<b>645.75</b>	<b>702.75</b>	<b>372.2</b>	<b>2406.5</b>	<b>1311.5</b>	<b>2385</b>	<b>1609.5</b>	<b>800</b>	<b>10951.2 Kg</b>	
<b>Trap count</b>	<b>2</b>	<b>29</b>	<b>19</b>	<b>39</b>	<b>17</b>	<b>102</b>	<b>67</b>	<b>66</b>	<b>44</b>	<b>52</b>	<b>437 #</b>	
Wood trap count	0	3	0	1	1	24	1	66	44	0	140 #	
Metal trap count	2	18	12	32	15	69	62	0	0	44	254 #	
Partial trap count	0	8	7	6	1	9	4	0	0	8	43 #	
<b>Trap Weight</b>	<b>22</b>	<b>301</b>	<b>319</b>	<b>600</b>	<b>337</b>	<b>2197</b>	<b>1170</b>	<b>2296</b>	<b>1530</b>	<b>476</b>	<b>9248 Kg</b>	
Wood trap weight	0	61	0	12	40	781	40	2296	1530	0	4760 Kg	
Metal trap weight	22	206	218.5	558	292	1357	1111	0	0	444	4208.5 Kg	
Partial trap weight	0	34	100.5	30	5	59	19	0	0	32	279.5 Kg	
Rope Length	195	2686	550	489	250	741	2434	626	1960	2330	12261 Ft	
Rope Weight	7	77	11.25	15.25	0	13	52	15	38.5	45	274 Kg	
Lead Line Length	268	0	0	0	0	0	134	0	0	0	402 Ft	
Lead Line Weight	31	0	0	0	0	0	5	0	0	0	36 Kg	
Buoy Count	2	8	2	2	5	3	9	2	4	13	50 #	
Buoy Weight	2	10.75	1.25	0.5	4	5	2.9	0.5	1.5	7.5	35.9 Kg	
Trap pieces, wood	0	0	48	0	0	85	15	0	0	1	149 Kg	
Trap pieces, metal	1	26	133.5	76	24	46.5	33.6	38	0	119	497.6 Kg	
Netting Weight	98.5	0	2	0	0	1	1	1	3	0	106.5 Kg	
<b>Trash</b>	<b>88.25</b>	<b>53.5</b>	<b>130.75</b>	<b>11</b>	<b>7.2</b>	<b>59</b>	<b>32</b>	<b>34.5</b>	<b>36.5</b>	<b>151.5</b>	<b>604.2 Kg</b>	
Rubber	1	0	3.5	0	0	0	1	0	0	0	5.5 Kg	
Domestic trash	7.5	6	9	5	3	9	4	8	19	6	76.5 Kg	
Recyclables	0.5	0	1	0	1	0	1	0	2.5	4	10 Kg	
Aluminium cans	1.5	0	0.5	0	0.1	0	0	0	0	0	2.1 Kg	
hard plastic	13	44	5	0	2	16	7	6	12.5	11	116.5 Kg	
metal	20	1	6	6	0.1	5	7	0	1	40.5	86.6 Kg	
tires/rims	24	0	58.5	0	0	0	10	20	0	73	185.5 Kg	
textiles/clothing	6.5	1	15	0	0	15	1	0	0	15	53.5 Kg	
wood	8.5	0	27	0	0	0	0	0	1	0	36.5 Kg	
Foam	2	0.5	4	0	1	14	1	0.5	0.5	2	25.5 Kg	
Bait bags	0.25	1	1	0	0	0	0	0	0	0	2.25 Kg	
Glass	1	0	0	0	0	0	0	0	0	0	1 Kg	
Dragger cable	2.5	0	0	0	0	0	0	0	0	0	2.5 Kg	
Monofilament	0	0	0.25	0	0	0	0	0	0	0	0.25 Kg	

Construction and domestic debris items were also collected in both South Shore Nova Scotia and Cape Breton (i.e., food wrappers, shotgun shells, lighters, housing insulation), however, most of the debris by weight was fishing-related (i.e., rope, nets, longline, lobster trap escape panels, etc.) (Table 3; Table 4).

Overall, 84 volunteers participated in shoreline cleanup events, dedicating 341 hours to removing shoreline debris. These cleanup efforts provide strong evidence of community support for shoreline cleanup events. As most of the debris retrieved was associated with fishing industries, it is recommended that fishers and fishing associations participate and potentially lead shoreline retrievals, to foster industry stewardship like ALDFG at-sea retrievals.

### 3.2 Responsible Disposal

All retrieved gear was responsibly disposed of, either returned to owners (in collaboration with DFO and Harbour Authorities), repurposed, recycled, or brought to a municipal landfill. If lobster traps were in usable condition and tagged from 2018 onwards, they were taken to a Small Craft Harbour compound, with the intention of them being returned to owners. In

total, 27 traps from at-sea retrievals were compounded. Reusable gear without tags or out of the returnable age range was given to fishers to reuse and repurpose.

Unusable gear was taken to local waste management facilities. Inevitably, some gear went to landfill, and although this is still a medium-impact disposal method, some gear at waste management facilities in SWNS is separated and recycled (Dawe et al. 2021). Opportunities for gear repurposing were researched and pursued when feasible. Few options existed at scale for alternative uses of ghost gear and end-of-life gear in the region (Dawe et al. 2021) but new options are being introduced and will be used for future seasons. These developments are encouraging, but additional options with better geographical distribution are needed to reduce the environmental footprint of the fishing industry and to aid in ghost gear retrieval efforts.

### 3.3 Comprehensive At-sea Retrieval Results

#### 3.3.1 Lobster Bycatch

There were 18 different species of live bycatch recorded and released. These included 305 American lobsters, the most frequent bycatch, and 149 Jonah crabs, which were the second most frequent.

On trips with technician coverage, lobsters were weighed, sexed, and measured. Of those measured, 75% were market-sized or over the minimum legal carapace size (MLCS) of 82.5 mm (Tremblay et al. 2013; Table 5; Appendix B-

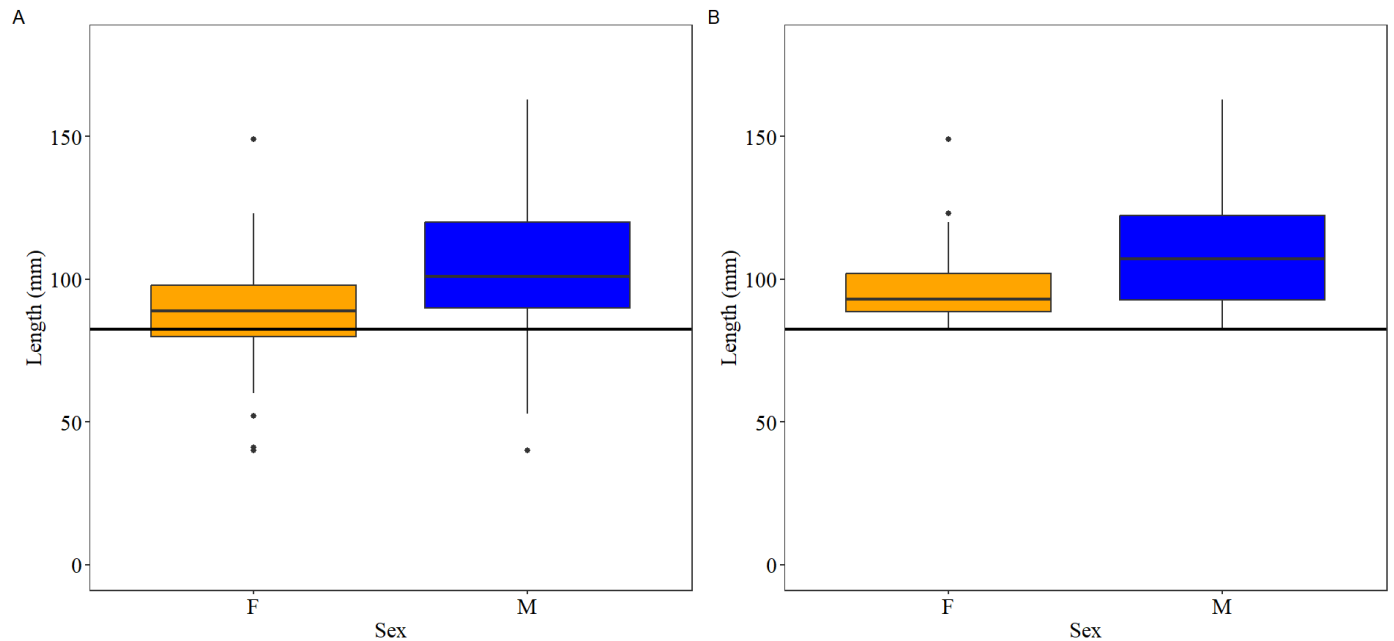


Figure 24). Twelve percent of lobsters were recorded as unknown sex due to, a missing tail or to the state of decomposition. Regardless of size, male lobsters were more frequently

found as bycatch and on average, measured and weighed more than females (Appendix B-

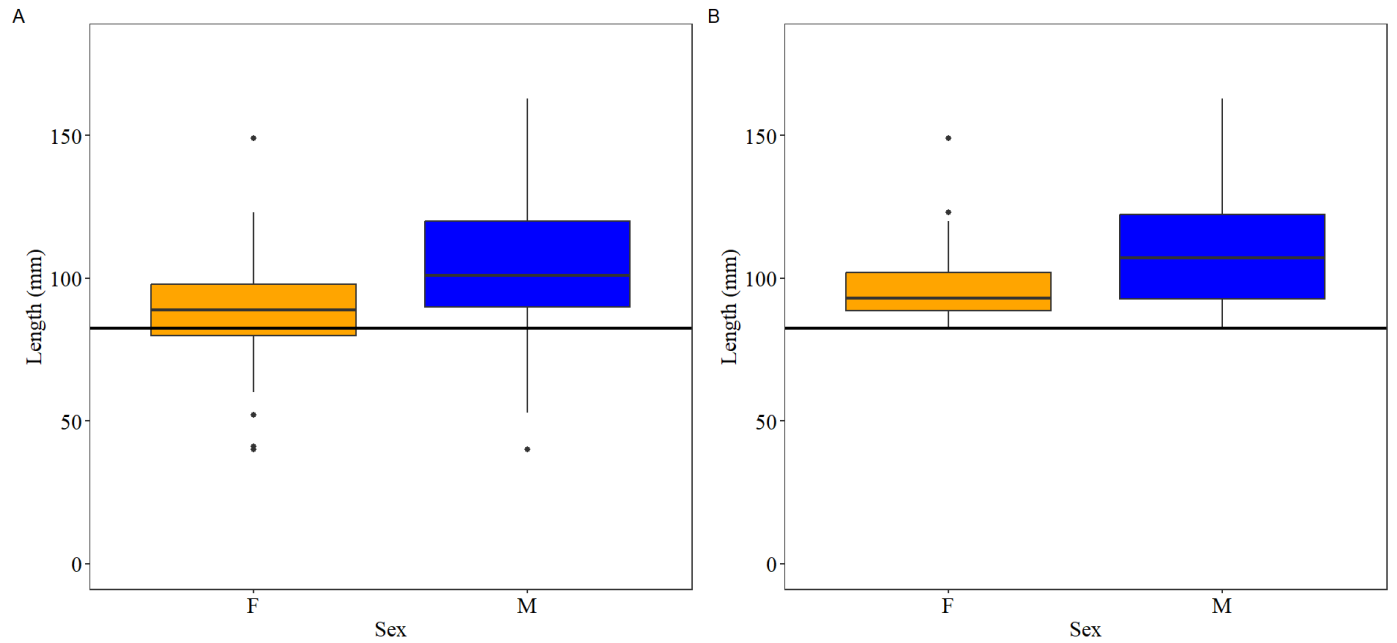


Figure 24,

Appendix B-

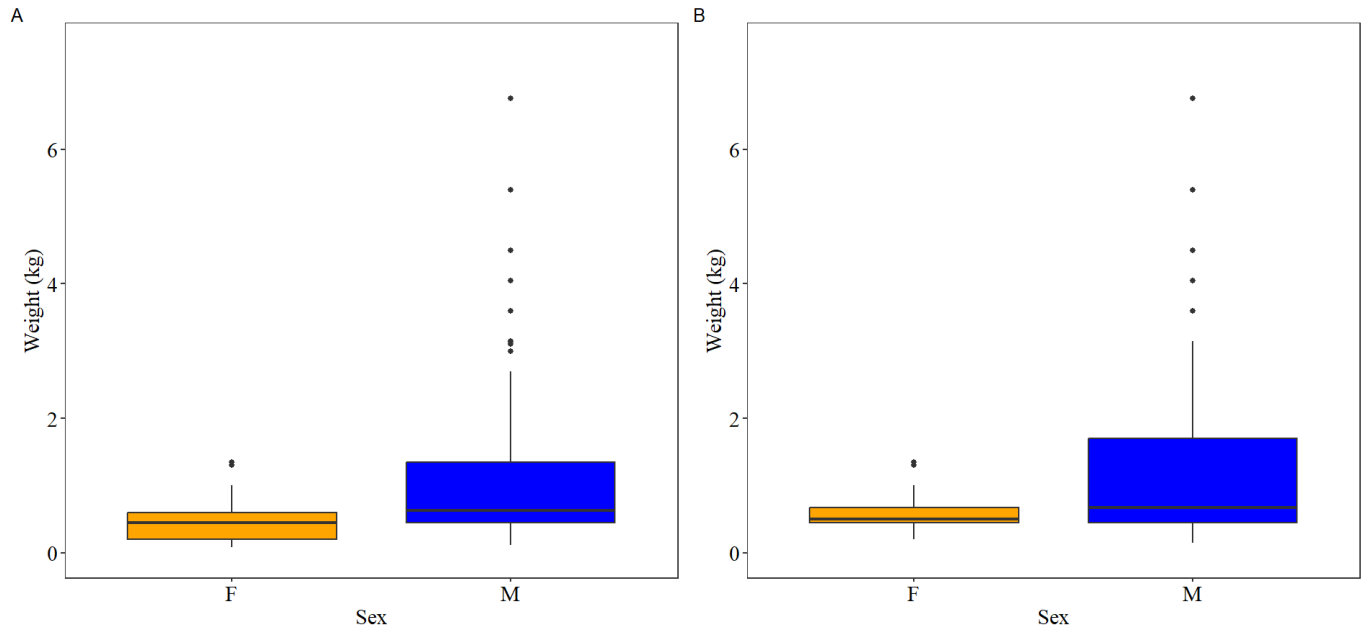


Figure 25). Of the 91 female lobsters released, 11 had eggs present ranging from new eggs to eggs that were near hatching.

Table 5. Carapace length (mm) and total weight (kg) summary statistics of lobster bycatch and market-sized bycatch from technician coverage, rounded to one decimal point.

Sex	n	Carapace length (mm)				Weight (kg)			
		Mean	Median	Min	Max	Mean	Median	Min	Max

<b>All</b>	F	91	88.5	89	40	149	0.46	0.45	0.09	1.35
	M	177	105.1	101	40	163	1.06	0.63	0.11	6.75
	Total	262	99.3	96	10	163	0.86	0.6	0.09	6.75
<b>Mark et- sized</b>	F	63	96.4	93	83	149	0.57	0.5	0.2	1.35
	M	156	109.6	107	83	163	1.15	0.67	0.15	6.75
	Total	219	105.7	100	83	163	0.99	0.6	0.15	6.75

Catch rate differences between male and female lobsters could be explained by several factors: male lobsters are generally more aggressive than females and predate on other individuals more during the self-baiting cycle (Huber and Kravitz 1995; Figler et al. 1998), catchability rates between sexes (Tremblay et al. 2011; Clark et al. 2015a), and thermal preferences (Jury and Watson 2013).

Lobsters reach MLCS at approximately 8 to 10 years of age and weigh roughly 0.45 kg (Tremblay et al. 2013). The average weight of all lobster bycatch in retrieved ghost gear was above the former estimate, therefore indicating that most were over the MLCS and could be harvested, if not caught in ghost gear. When carapace length is between 90 and 105 mm for females, 50% of them are estimated to be sexually mature (Tremblay et al. 2013). At least 30% of females caught during the project were between these lengths, potentially able to reproduce and contribute to population stocks. This highlights the importance of ghost gear retrieval work, as surviving females were released to continue to contribute to the overall population of the stock.

### 3.3.2 Escape Panels

As per fishery licence conditions, escape panels must be attached to the outer walls of all lobster traps as a conservation mechanism. These panels allow undersized lobsters to escape during the season while also reducing bycatch if the 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 2020a). 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). Escape panel functionality was assessed for each retrieved trap to see if panels were attached (not functioning) or had fallen off (functioning). It was found that 76% of escape panels had functioned and 16% had not functioned, the remaining 8% were categorized as illegal escape panels (Figure 16). Additionally, more bycatch was caught in traps where escape panels were still present (Figure 17), reflecting the results found in previous years. Many of the smaller bycatch species like toad crabs and brittle stars were found in traps where the escape panel had functioned (Figure 17). This may be a result of animals using the ALDFG as artificial reefs, which is discussed more in-depth in section 3.3.4. This warrants further research as

the timeline for traps to be settled by both encrusting organisms and smaller species taking shelter has not been studied.



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

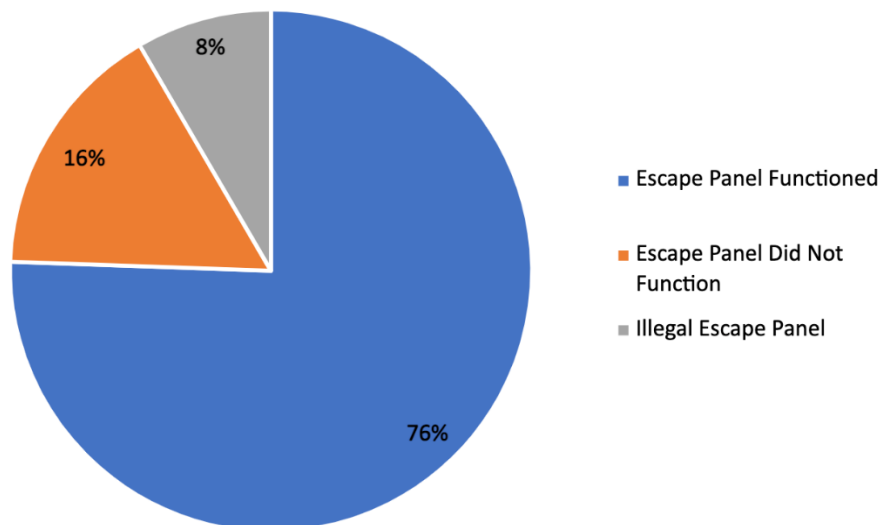


Figure 16. Functionality of escape panels from retrieved lobster traps. Illegal panels include any panels that were attached with something other than iron hog rings or cotton twine, or the trap did not have an escape panel at all.

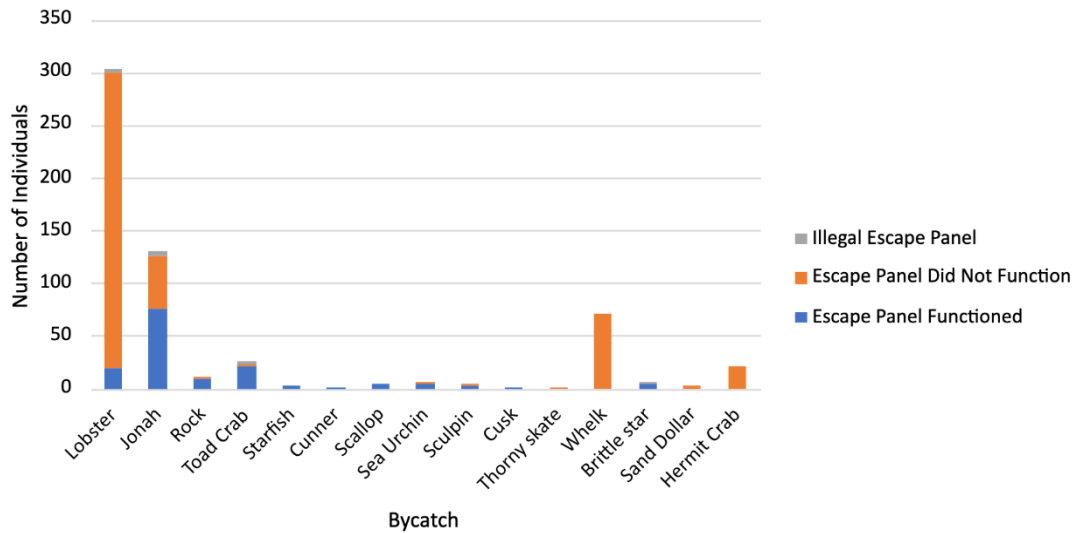


Figure 17. The number of bycatch organisms in retrieved lobster traps by escape panel functionality.

While escape panel attachments are estimated to degrade between six months and one year (Larissa Goshulak, DFO, email message to Coastal Action, October 30, 2020; unreferenced), some retrieval captains and fishers have confirmed needing to replace attachments throughout the fishing seasons, which can be six months in duration. Results presented in Figure 18 indicate that escape panels can remain attached for more than six months, and up to several decades, contrary to the previous estimates. This could be due to the conditions on the seafloor, which has lower oxygen levels causing slower oxidation and corrosion of ferrous metals, like iron hog rings (Venkatesan et al. 2002). When traps remain on the seafloor for longer periods of time they will degrade slower, contributing to the condition and accumulation of ALDFG. When these metals are exposed to the atmosphere they degrade faster, explaining why fishers need to replace these rings throughout the season. Research conducted by the National Fish and Wildlife Foundation in Maine and Massachusetts provides support for this explanation (2014). In this study, iron hog rings on traps that were regularly removed from the water lost an increasing amount of weight over six months, with an average of 24% loss. This was compared with a constant 10% loss in the weight of rings that remained on the bottom for over a year (National Fish and Wildlife Foundation 2014). Overall, 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).

It is primarily important to prevent the loss of gear and to target newly lost gear during retrievals, thus minimizing the effects of ghost fishing. However, our observations suggest that despite escape panels functioning, lost lobster traps can still catch market-sized

lobsters. Additional research on escape panel functionality is required to assess the efficiency of the conservation mechanisms over time. Furthermore, lost gear sheds plastic and rubber debris into the ocean as it degrades, which is of conservation concern.

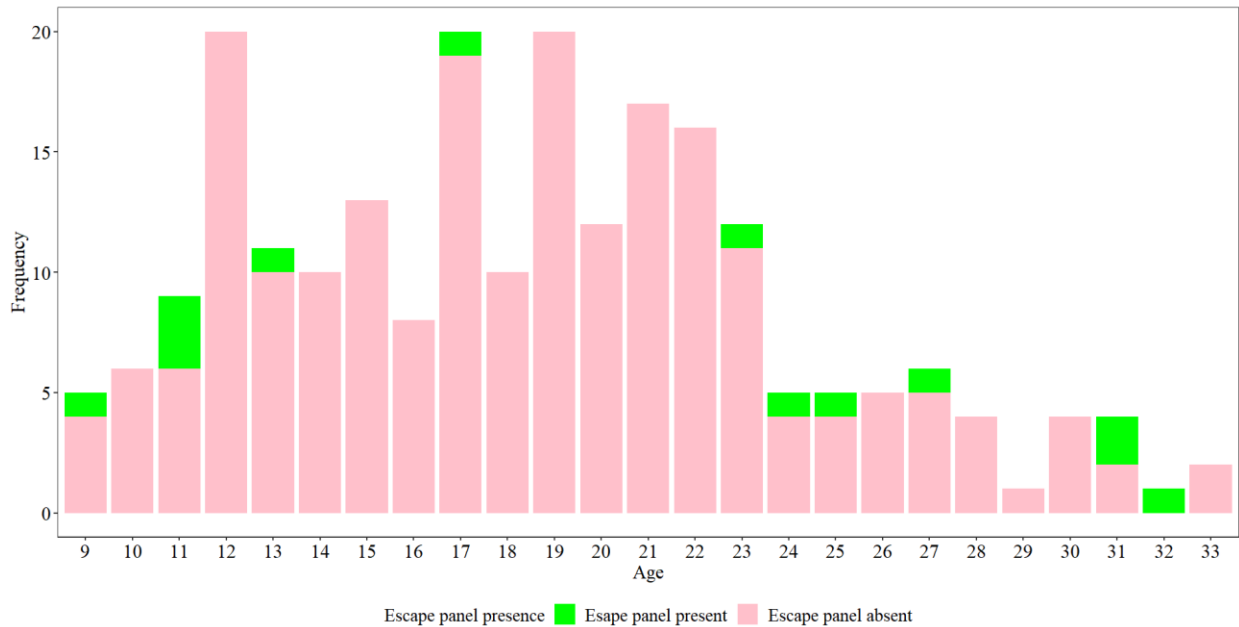


Figure 18. The frequency of escape panel presence or absence in relation to lobster trap age in retrieved traps. Only traps with the year on their fishing tag were able to be aged and graphed. Functional escape panels are in pink, and non-functional escape panels are in green.

### 3.3.3 Predation and Injury

To gain further insight into other impacts of ghost gear, bycatch predation and injuries were recorded for each organism. Of the 530 bycatch organisms, 53% were injured (Figure 17). Lobsters were the most frequently injured bycatch organism and sustained various injuries, such as missing and partially severed claws, missing antennas, missing legs, tail damage, shell disease, and total mutilation (Figure 19; Figure 20).

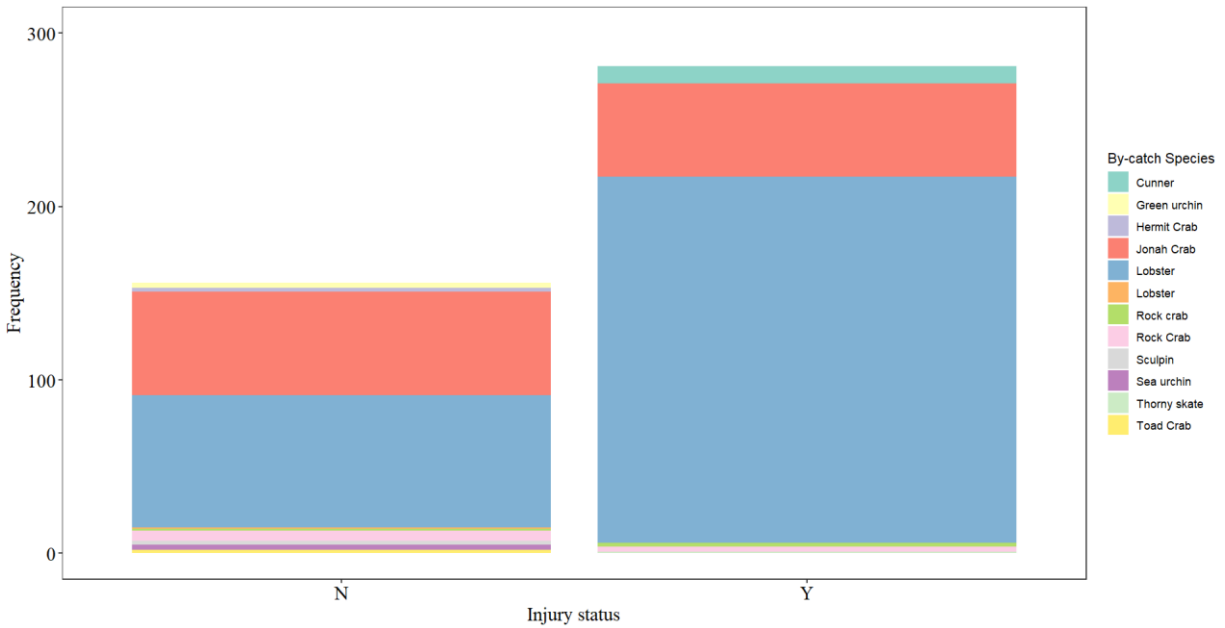


Figure 19. By-catch injury presence from retrieved gear. N indicates no injuries present, Y indicates injuries present.

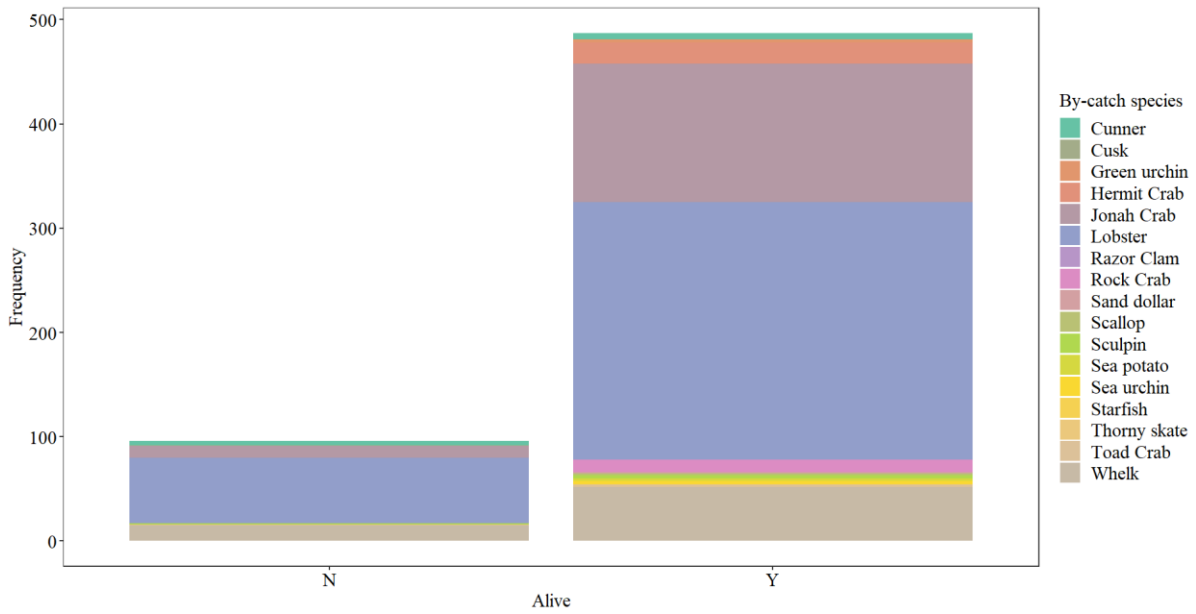


Figure 20. Proportion of dead and alive by-catch sorted by species.

A portion of observed injuries likely occurred due to the self-baiting cycle in traps and from organism predation while confined. It was difficult to determine how injuries were sustained or how remains were trapped. In some cases, when bycatch had injuries present, predation could also be noted depending on the conditions. Organisms may have received injuries from another organism (i.e., self-baiting cycle and predation), the gear itself (i.e., chaffing, and pinned and torn appendages), from natural causes or events that occurred before the organisms were caught. There were some instances where predation may have occurred, although there were none for most species released. When predation was present, it was either an observed injury (e.g., missing claws or legs, cracked carapace and/or tail, or was mutilated) or remains, and occurred in lobsters, Jonah crabs, and cunners. Additionally, remains could have drifted into traps, however, since lobsters are known to be aggressive towards each other and other species, some were likely predated upon in the traps (Jury et al. 2001).

Few partial organisms were found, which was expected as they would likely have been consumed by other bycatch or drifted out. Additionally, many traps contained multiple organisms, which may provide evidence of the self-baiting cycle. However, the full extent of self-baiting and predation in lost lobster traps cannot be determined without using other methods (i.e., diet analysis of bycatch or long-term video surveillance), as it is difficult to gather evidence of organisms that were ghost fished and consumed by others.

### **3.3.4 Degradation**

Assessing the condition and age of ghost gear retrieved provides further insight into how ALDFG degrades over time. Approximately 27% of the gear found was not highly degraded, with an estimated loss of <25% of the gear's original integrity (Figure 21). Degraded gear contained a higher proportion of Jonah crabs as bycatch than more intact gear (Appendix B-Figure 26), with the amount of biofouling on gear varying across all levels of gear degradation (Appendix B-Figure 27).

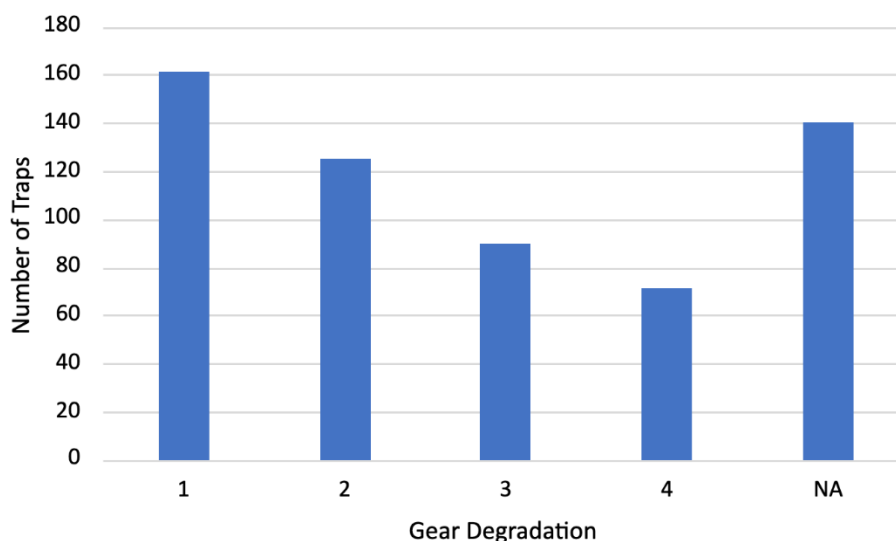


Figure 21. Gear degradation of traps retrieved during at-sea retrievals. Gear degradation 1: <25% degradation, 2: 25-50%, 3: 50-75%, and 4: >75%. This metric was only recorded when technicians were present during trips, so traps retrieved on trips with no coverage had no data and are represented by NA.

Less degraded gear appeared to have ghost-fished more lobsters and bycatch from a greater variety of species, in contrast to older and more degraded gear (Appendix B-Figure 26). Additionally, as gear age increased, fewer lobsters were ghost-fished (Appendix B-Figure 26). Bycatch species in older gear also contained smaller organisms (i.e., worm, starfish). These organisms likely used gear as a refuge which could be classified as new habitats over time.

Some fishers believe ALDFG can create habitat in the marine environment (Goodman et al. 2019). While results from this project show some support for this belief, there is evidence to suggest that until traps undergo degradation (>5 yrs), lobster traps continue to ghost fish relatively effectively. Lost gear may serve some ecological purpose as artificial reefs (Seaman 2007), but only after the gear is deactivated; it degrades, the escape panel detaches, and the gear ceases to fish target species.

Artificial reefs are submerged human-made structures that are used as a tool to help restore degraded ecosystems worldwide. These structures become colonized by sessile biofouling organisms (i.e., barnacles, algae, tunicates) that modify the structure and attract other species such as fish, crustaceans, and larger wildlife over time (Seaman 2007). This can be affected by a variety of factors, but generally, the number of biofouling species increases with time submerged (Svane and Petersen 2001; Brown 2005). Contrary to past years of this study, we found no relation between the number of biofoul species with the age of ghost gear. This result is likely due to data sparsity, as we were unable to age most of the traps recovered, due to the newer colour-coded tagging system. Lobsters often seek shelter from

predators in crevasses on a hard substrate (Ennis 1984), but traps may not represent suitable habitat (Goodman et al. 2019). Although they may provide some physical protection for lobsters (if they do not get caught in the gear), lost traps likely do not provide sufficient coverage from predators unless incorporated into a softer substrate (i.e., mud or cobble). ALDFG may provide some reef-like conditions, but since lost gear is not fixed to the seafloor or specifically weighted like artificial reefs (see Roy 2020 for examples of artificial reefs designed for lobsters), the mobility of gear may consequently inhibit habitats and injure organisms.

Additionally, marine life using synthetic plastic materials as a refuge can be hazardous in comparison to natural habitats. The industry's reliance on polypropylene rope, lobster traps made from synthetic materials with PVC wire coating, and plastic escape panels can all negatively impact the environment. Both PVC and polypropylene release microplastics as they degrade over time and are a concern due to their toxicity impacts on aquatic and marine organisms throughout the environment (Walker et al. 2006; Coastal Action 2018; Xue et al. 2020; Karbalaei et al. 2021). Specifically, Laufer et al. (2012) found that PVC coating on lobster traps can interfere with natural hormone production and disrupt endocrine function, causing shell disease when ingested by crustaceans. Microplastics have been shown to decrease the oxygen consumption of larval lobsters, which may have broad population and ecosystem-level effects (Woods et al. 2020). Further, research from other commercially fished species in Atlantic Canada has shown that target species ingest plastics from gear that is used to fish them; gear which was most likely ALDFG (Saturno et al. 2020).

To that end, even without considering the economic and ecological impacts of ghost fishing until gear deactivates, ALDFG ultimately generates marine debris which causes persisting environmental degradation when left at sea.

## 4.0 Conclusions and Recommendations

### ALDFG Locations

- Some general retrieval locations in LFA 34 were kept from the previous year's project (Lobster Bay, mouth of Clark's Harbour) but the exact locations were left up to the captains. This proved to be very effective as 4 out of the 5 captains in this LFA retrieved gear on every trip. Future ghost gear projects should continue relying on local fishers' knowledge of target areas. Annual meetings with fishers to discuss new and pre-existing hotspot areas would be beneficial for planning purposes. Lobster Bay and the mouth of Clark's Harbour should continually be targeted in future retrievals, due to the overwhelming number of traps and dragger cables found in each respective area from this past season.
- Another area that should be targeted again for future retrieval is the Minas Basin (LFA 35). Despite having the lowest number of traps retrieved, the highest number of bycatches were found and released, and the lobsters found this season in particular came from traps within this LFA.
- A new method of retrieval was conducted this season which used a skiff to target island shorelines (LaHave Islands) in LFA 33. This proved to be very successful as almost 3000 kg of ALDFG was removed. Success within this area can be attributed again to local knowledge from our captain as well as, the fact that these islands are rarely visited, leaving gear to build up on shore. Future ghost gear projects should consider targeting islands in various LFAs for comparison.

### Disposal

- Responsible disposal options and facilitation is necessary to help prevent and mitigate ALDFG. To support this, the project continued the rope recycling system implemented in the 2021 Ghost Gear project, in partnership with Sustane. Future projects should look to expand repurposing and recycling systems for all ALDFG by finding new partners that have innovative approaches.
- Previous collaborations with landfills were continued during this project and new ones were created in various regions of Cape Breton, helping to reduce costs associated with ALDFG disposal. Maintaining existing and creating new partnerships should be a priority in future projects.
- Easily assessable disposal locations for fishers at each wharf would ideally promote responsible gear disposal instead of dumping at sea, reducing ALDFG. Support from the Ghost Gear Fund could facilitate the implementation of these facilities.

## Federal Management

- Incorporating the year of operation back onto lobster tags would allow for better scientific analysis and more accurate tracking of lost gear. Any ALDFG traps found from the past nine years cannot be easily aged, leading to a large gap in the data.
- Recognizing the challenges of permitting captains to land ghost gear during an active fishing season, we recommend a policy change to allow mid-season retrieval. This would be advantageous to all parties involved. Returning ghost gear to the water during the fishing season is inefficient, detrimental to the environment, and not cost or time effective. This would require improvements to the FGRS reporting system to allow for this dual reporting purpose.

## 5.0 Acknowledgements

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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

Collector's Name: \_\_\_\_\_

Vessel Name & License #: \_\_\_\_\_

Collection Date (yyyy-mm-dd): \_\_\_\_\_

Position of the retrieved gear (See examples below):  NAD83 (preferred) |  WGS84 |  NAD27

Fixed Position coordinates								Notes	
	Decimal Degrees	or	Degrees	Minutes	Seconds	or	Degrees	Decimal Minutes	
Latitude									
Longitude									
Gear Drag line coordinates Start point									
Latitude									
Longitude									
Gear Drag line coordinates End point									
Latitude									
Longitude									
(DD) Example: 42.758 -62.545 Latitude: 42.758 Longitude: -62.545		(DMS) Example: 42°45'30" N 62°52'45" W Latitude: 42 45 30 Longitude: 62 52 45			(DDM) Example: 42° 45.480' N 62° 52.700' W Latitude: 42 45.480 Longitude: 62 52.700			<input type="radio"/> "NL" 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*) <i>*specify for Other</i>	Approx weight (kg)	Length of Rope (ft.)	Tag Number <small>FA plus vendor # if on tag, ie. LFA36 29</small>	(Add 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 22. Fisheries and Oceans Canada data collection summary form for retrieval of lost fishing gear.

Coastal Action Ghost Gear Retrieval Data Log



Collector name: \_\_\_\_\_  
 Vessel name: \_\_\_\_\_ Captain ID: \_\_\_\_\_ Hail Out Time: \_\_\_\_\_ Hail In Time: \_\_\_\_\_  
 Date: \_\_\_\_\_ Beaufort scale: \_\_\_\_\_ Retrieval numbers: \_\_\_\_\_ Grapple type: \_\_\_\_\_

Tow information					Gear information							By-catch information										Notes		
Event #	Time (24hr clock)	Depth (ft)	Latitude	Longitude	Bottom type	Tow speed (knots)	Gear weight (kg)	Type of ghost gear	Buoyancy (Y/N)	Biofouling	Escape panel (Y/N/NA)	Gear degradation	By catch species	Alive (Y/N)	Weight (kg)	Length (cm) or carapace width (mm)	Sex (M/F)	Clutch size	Egg stage	Shell hardness	Injury or disease		Predation evidence	

Page \_\_\_\_ of \_\_\_\_

Figure 23. Coastal Action ghost gear retrieval data form.

## 8.0 Appendix B – Retrieval Results

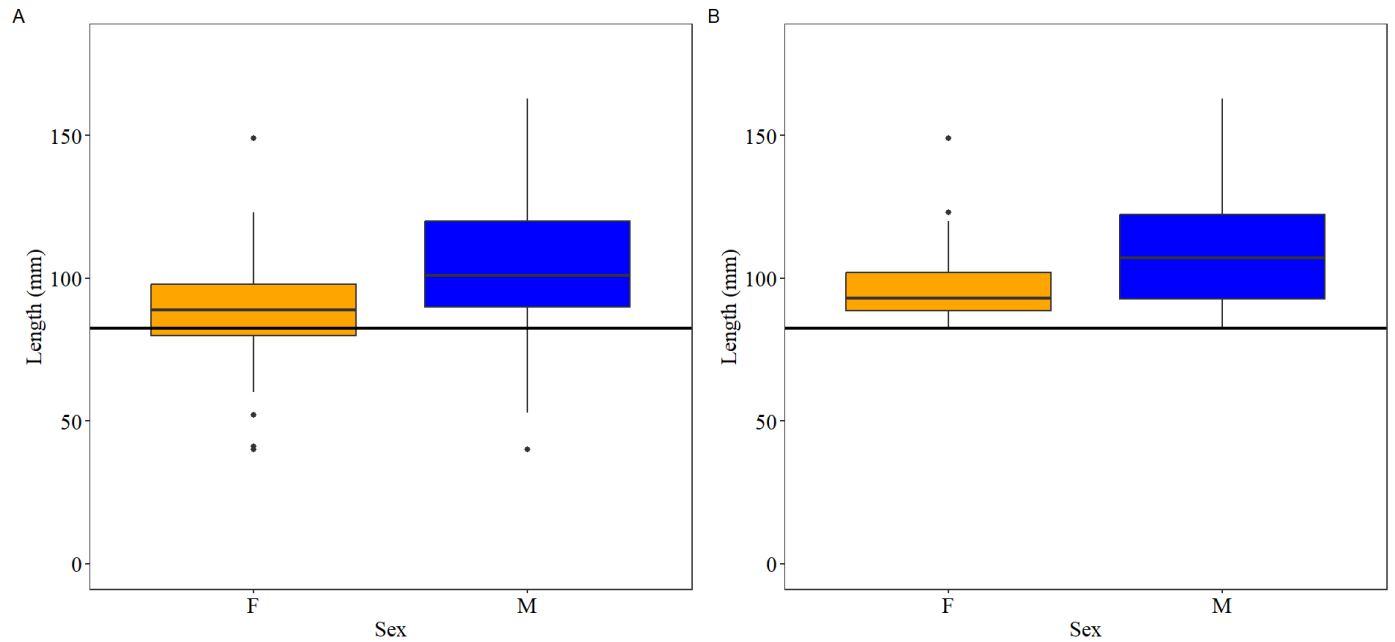


Figure 24. Length (mm) of lobster bycatch released by sex. Panel A: All lobsters; Panel B: Market-sized lobsters. The black line indicates MLCS (82.5 mm). The middle line of each boxplot indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, and the points are outliers.

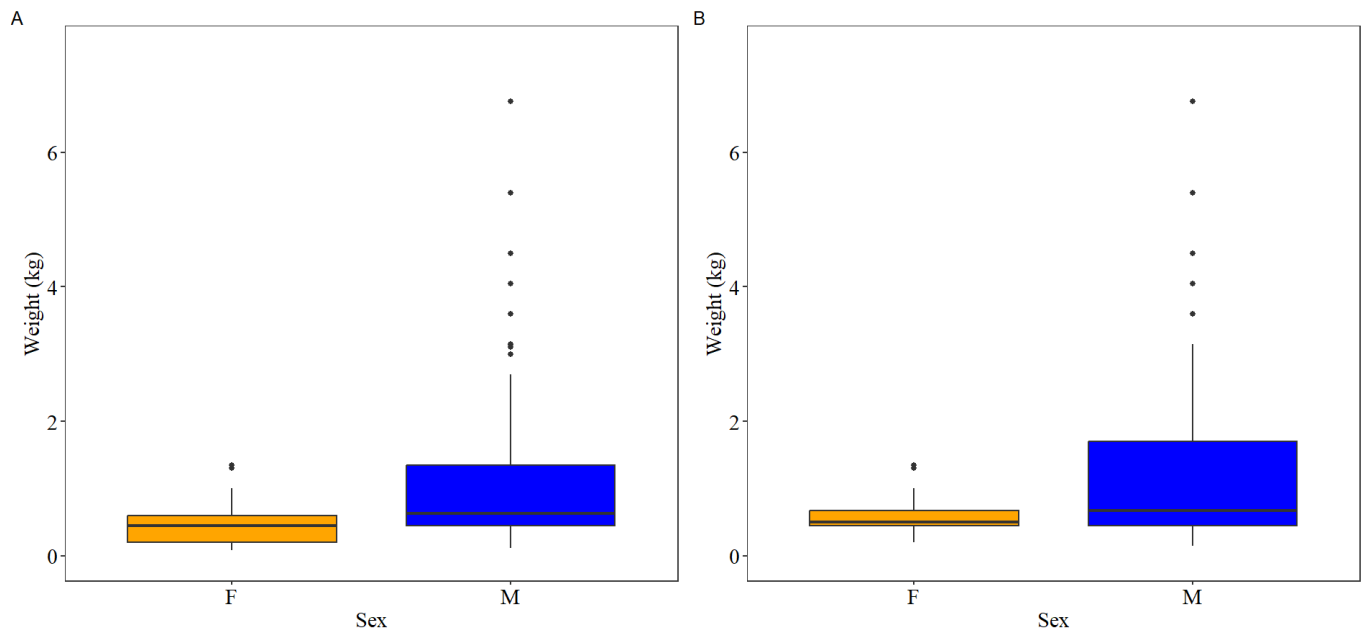


Figure 25. Weight (kg) of lobster bycatch released by sex. Panel A: All lobsters; Panel B: Market-sized lobsters. The middle line indicates the median, the boxes are the interquartile range (50% of data), the outer lines are the upper and lower 25% of data, and the points are outliers.

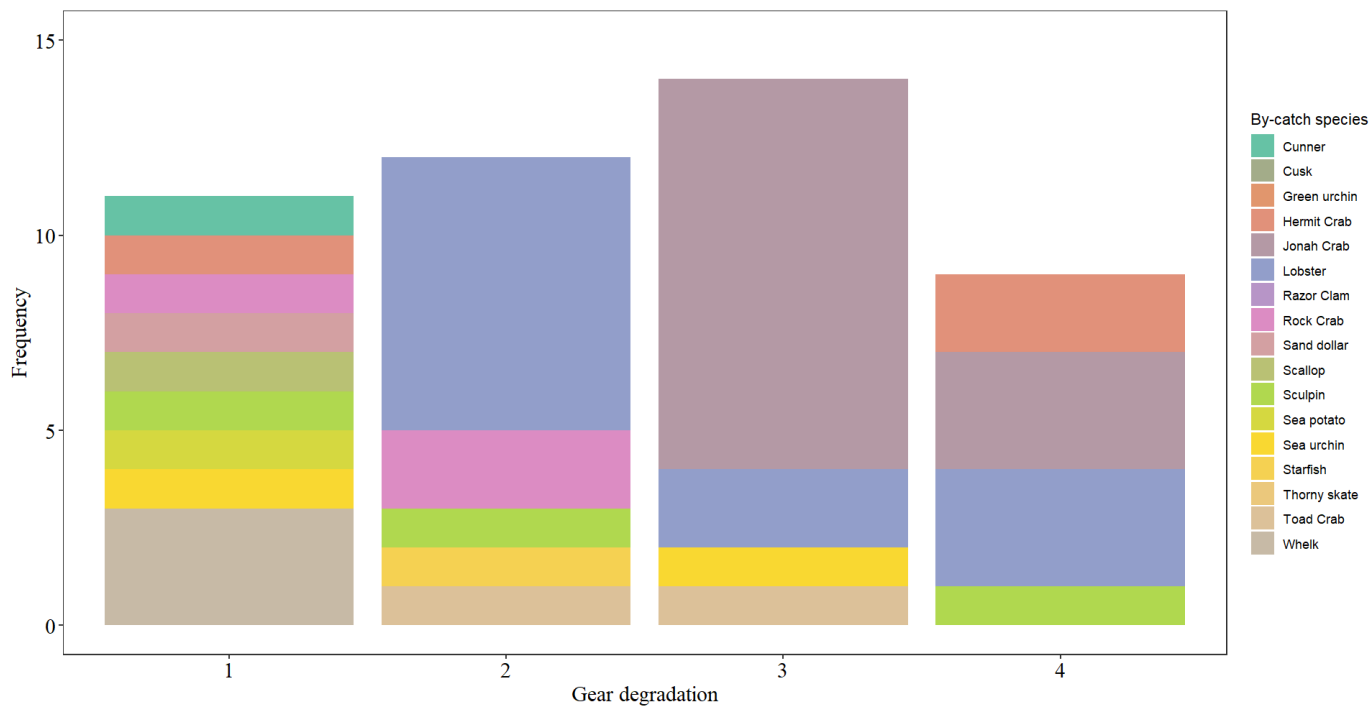


Figure 26. The number of bycatch organisms found in lobster traps by the level of gear degradation. Level 1: 0 - 25% (little degradation); 2: 25 - 50%; 3: 50 - 75%, 4:>75%.

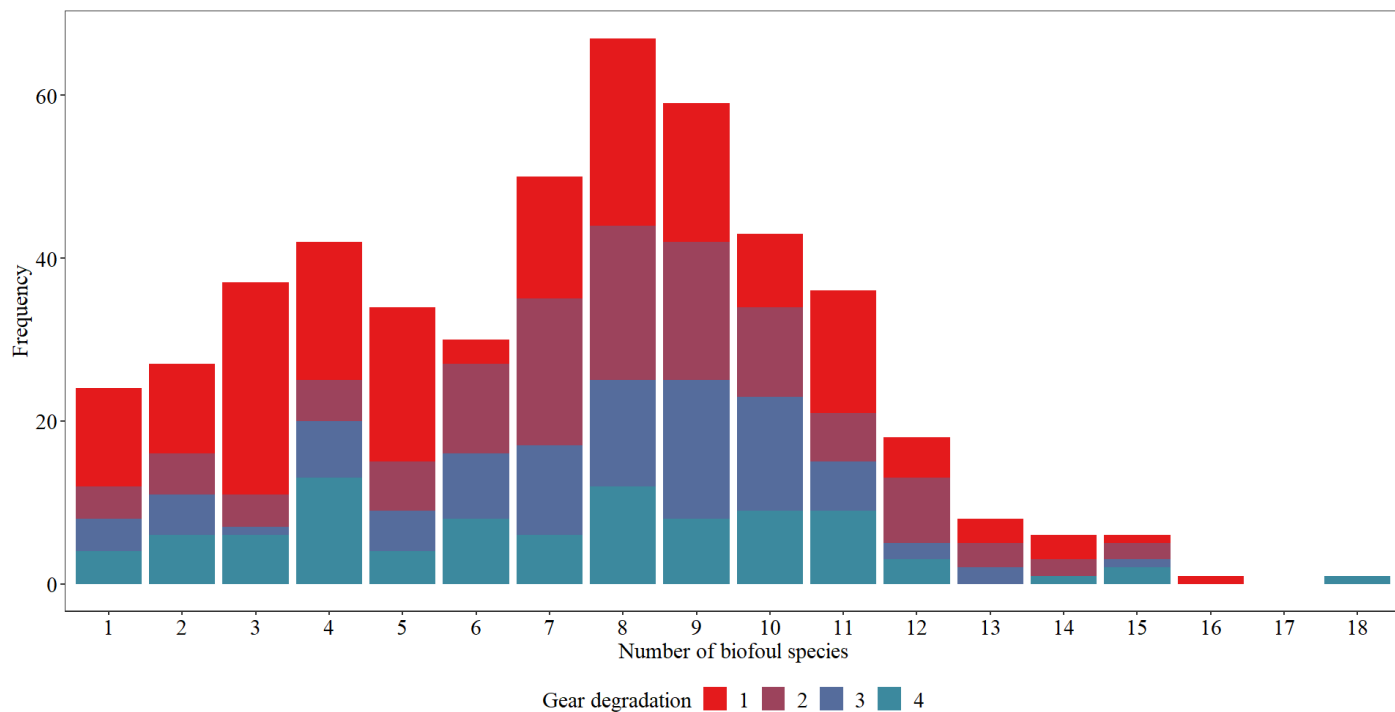


Figure 27. The number of biofouling species found on retrieved gear in relation to the state of degradation of the gear. Level 1: 0 - 25% (little degradation); 2: 25 - 50%; 3: 50 - 75%, 4:>75%.