COLLATERAL DAMAGE:

How to reduce bycatch in Canada's commercial fisheries

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ACRONYMS

CHP	Conservation Harvesting Plan
CITES	Convention on International Trade in Endangered Species
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
ETP	Endangered, Threatened or Protected
ICCAT	International Commission for the Conservation of Atlantic Tuna
IFMP	Integrated Fisheries Management Plan
IPHC	International Pacific Halibut Commission
LFA	Lobster Fishing Area
MPA	Marine Protected Area
MSC	Marine Stewardship Council
SARA	*Species at Risk Act*

1.0 EXECUTIVE SUMMARY

Bycatch, the catch of non-target organisms in a fishery, is one of the most pervasive conservation issues in commercial fisheries, impacting a diversity of marine life including mammals, seabirds, sharks, sea turtles, juvenile fish, crustaceans, corals and sponges. Most commercial fishing methods are not species-selective, resulting in unintentional catch. Bycatch is either retained on board for sale or personal use or discarded — either returned safely to the water or thrown overboard, damaged or dead. Bycatch in Canada's fisheries is not well documented, nor is the extent of its impact well understood. However, Canadian fisheries discards were estimated to range from 38,000 mt to 96,000 mt in 2009. Bycatch has been identified as a key driver of overfishing and a primary reason for the lack of recovery of numerous fish stocks, particularly those assessed to be at risk.

This report analyzes the bycatch of marine species in Canada to assess the potential impacts on marine life, as well as to identify current policy gaps and potential solutions to mitigate bycatch. First, it reviews Canada's management approaches to minimizing bycatch by analyzing Integrated Fisheries Management Plans (IFMPs) and associated Conservation Harvesting Plans (CHPs), as available. Second, it quantifies the extent of bycatch impacts, specifically the percentage of catch discarded and the potential for cumulative impacts, using the datasets available in Marine Stewardship Council (MSC) public certification reports for Canadian fisheries.

Oceana Canada has documented a total of 272 types of catch as recorded in 22 MSC datasets. Canada-wide, the species groups at greatest risk of cumulative impacts from bycatch in Canada's fisheries are groundfish (caught in 93 per cent of the 54 fleets examined), flatfish (83 per cent of fleets), rockfish (70 per cent of fleets) and skates and rays (55 per cent of fleets). In the Pacific, six species were caught as bycatch in every fleet we analyzed: sablefish, Pacific halibut, spiny dogfish, lingcod, shortraker rockfish and arrowtooth flounder. In the Atlantic, redfish species, haddock, pollock, unidentified cod-like species, white hake and Atlantic halibut were all caught in more than 50 per cent of the fleets we examined.

The North Atlantic Swordfish Canadian pelagic long line fishery was the fleet with the highest percentage of total catch discarded (44.8 per cent). This fleet also discarded the highest percentage of total catch with a conservation status of endangered, threatened or of special concern, as determined by the Committee on the Status of Endangered Wildlife in Canada, COSEWIC (40.5 per cent). The other two fisheries in the Atlantic with high discards were the Grand Bank Arctic surfclam (35.4 per cent), and the Eastern Canada offshore lobster (22 per cent). In Newfoundland, one of the newest MSC certifications is the Canada/Newfoundland 3Ps Atlantic cod fishery, which is notable as it targets a species from a population that COSEWIC has designated as endangered. This fishery represents four different fleets and has discards ranging from 13.6 per cent (gillnet) to 0.8 per cent (handline). In the Pacific, the three

fisheries with the highest percentage of discards were the Canada Pacific halibut (British Columbia) hook-and-line (44.7 per cent), the Canadian Pacific sablefish (*Anoplopoma fimbria*) (bottom long line, 40.8 per cent; Korean trap long line, 32.2 per cent), and the British Columbia hook-and-line spiny dogfish (inside directed, 29.2 per cent; outside directed, 14.3 per cent).

This analysis also highlights that available data is inconsistent in how it is collected, the units measured and reported, and that reporting varies from the level of observed trips to estimates for the entire fishery. Therefore, the percentage of catch discarded is used to compare bycatch rates across different fishing fleets. However, these numbers do not reflect the differences in biomass captured based on the gear types used, which can bias the interpretation of the results. A lower percentage of discards in a high-volume fishery could have a larger overall impact in terms of biomass than a low-volume fishery with a high percentage of discards. Nonetheless, with high discard rates among some of our best managed fisheries, and with hundreds of species captured, many in multiple fleets, this report concludes that the cumulative effects of bycatch is a significant problem in Canada that must be addressed with better data collection and management.

Canada has signed and recognized several international commitments that address sustainable fisheries and biological conservation, including the need to reduce bycatch. Despite this, there is no direct reference to bycatch in Canada's relevant legislation. Furthermore, the policies that are in place are generally not put into force. For example, bycatch measures outlined in Integrated Fisheries Management Plans are not legally binding. This has left gaps in the overall approach to bycatch, where legislative, policy and informal mechanisms are not well-aligned. Insufficient data collection, monitoring and reporting has led to data deficiency in Canadian fisheries.

Understanding the full scale and impact of bycatch requires improved standardized data collection and reporting, which can create consistency and allow comparisons and the assessment of cumulative impacts.

Fisheries and Oceans Canada (DFO) needs to improve the data collection and reporting of all retained and discarded bycatch in all commercial fisheries. These measures should be supported by developing and implementing a robust national catch monitoring policy in 2017. DFO also needs to review current policies, their implementation and whether they are enforced and effective at reducing bycatch. Priority should be put on protecting species at risk and stocks within the Critical and Cautious Zones by setting scientifically determined bycatch caps, as well as improving transparency through a public national bycatch status report and comprehensive Integrated Fisheries Management Plans.

Canada's approach to addressing bycatch incorporates participation of fishers and industry; however, the approach is fragmented and monitoring and oversight are limited. Providing clear and transparent standards for monitoring and enforcement mechanisms can improve ongoing data collection and improve coordination among enforcement agencies. Legislative and policy frameworks should be clarified to provide transparent and accountable measures for monitoring and to define the role of government, fishers and industry in bycatch management.

2.0 INTRODUCTION

WHY WE SHOULD CARE ABOUT BYCATCH

Fewer than 25 per cent of Canada's fisheries are currently known to be healthy and bycatch-related mortality continues to be a threat to populations at risk and marine life in general (Baum and Fuller 2016). In Atlantic Canada, there has not been a recent, comprehensive and quantitative overview of bycatch and the level of observer coverage is not sufficient to provide overall bycatch estimates (Gavaris et al. 2010, Fuller et al. 2008). For example, although bycatch in the Atlantic lobster fishery includes at-risk marine fish, the bycatch-related mortality on these species is not generally included in estimates of overall fishing mortality (Pezzack et al. 2014).

The majority of Canada's fisheries have a population status of critical, cautious or unknown, and many marine species are facing extinction (Baum and Fuller 2016). Yet even protected species are still caught as bycatch and are often thrown back into sea, injured or dying. Bycatch is one of the most pervasive marine conservation problems, posing a threat to marine life such as fish, crustaceans, corals, sponges, marine mammals, seabirds, sharks, sea turtles and juvenile individuals of fish (DFO 2013a). Most commercial fishing methods are not selective. Once a non-target organism is caught, it is either retained on board for sale or for use, or discarded at sea (DFO 2013a).

Global fisheries discards are estimated to average 10.3 million metric tonnes a year (2000–2010), or roughly 9 per cent of global catches (Pauly and Zeller 2016). In Canada, since bycatch is not always well documented (e.g., Gavaris et al. 2010, Fuller et al. 2008), the scale, extent and impact of bycatch and bycatch-related issues are not well understood (Chadwick 2012). Uncertainty aside, Canadian fisheries discards in 2009 were estimated to range from 38,000 mt (4 per cent) to 96,000 mt (10 per cent) discarded from total landings (Chadwick 2012). Although Canadian statistics on the impact of non-selective fishing gear are not available, it has been estimated that the use of non-selective fishing gear in the U.S. has reduced overall fisheries catch by as much as $4.2 billion in sales, costing 64,021 jobs annually (Patrick and Benaka 2013).

Bycatch has been identified as a key driver of overfishing and a reason for the lack of recovery of fish stocks, particularly those assessed to be at risk (McDevitt-Irwin 2015, Baum and Fuller 2016). In Canada, bycatch in commercial fisheries is also known to impact multiple trophic levels in marine ecosystems including: marine mammals, seabirds and sea turtles (Lewison et al. 2014, Ellis et al. 2009, Regular et al. 2013, Brazner et al. 2008, Nemiroff et al. 2010); sharks (Campana et al. 2011, Cosandey-Godin and Worm 2010); fish and invertebrates of commercial value (Van Eeckhaute et al. 2005, Sullivan et al. 1994); and fish and invertebrates of non-commercial value (Pezzack et al. 2014, Kenchington et al. 2007).

In the Pacific groundfish trawl fishery, discarded bycatch amounted to 20 per cent by biomass of the total catch between 1996 and 2006, 30 per cent of which were non-commercial species without management measures (Driscoll et al. 2009). Failing to take the bycatch of juvenile fish into account in fisheries has resulted in population decline. For example, the capture of juvenile Atlantic halibut in Atlantic cod fisheries before the 1990s groundfish collapse inhibited halibut's population growth (Trzcinski and Bowen 2016).

Bycatch is a conservation concern, particularly when populations of endangered and rare species are threatened, heavily exploited stocks are further pressured, and when there is the potential for ecosystem-level stresses. It continues to be a persistent problem in fisheries and is hard to remedy due to a lack of accurate catch monitoring and reporting (Kelleher 2005) — which limits our understanding of the scale of the issue (Gavaris et al. 2010, Fuller et al. 2008) and our ability to resolve and to monitor improvements.

THE FATE OF BYCATCH: RETAIN OR DISCARD

Fisheries can be permitted to retain a set amount of often commercially valuable species other than those that are the focus of the fishery. These are monitored as fisheries landings (Gavaris et al. 2010). Retained species can also include species caught as bait for the fishery, though this catch is not always recorded (e.g., Pezzack et al. 2014). All other species that are not permitted to be retained are considered discarded species and are returned to the water. Some discarding is required because of regulations with conservation objectives. For example, a number of fisheries have small fish protocols in place to ensure juvenile fish remain in the water and some protected species cannot be retained (e.g., sea turtles). Survival rates for discarded bycatch and the impacts on the ecosystem may vary (Hall et al. 2000); however the ecological impacts of bycatch are substantial (Kelleher 2005). In some fisheries, such as the mixed groundfisheries, discarding is not allowed, except for specifically authorized species. Often referred to as a discard ban, the fishers are obliged to retain bycatch.

THE ECOSYSTEM CONTEXT

High bycatch levels in fisheries through the use of unselective gear types, high-grading (discarding lower value fish in order to land ones of more value) and bottom contacting gear demonstrates that fisheries management regularly fails to consider fisheries in an ecosystem context.

Examples of measures to implement ecosystem-based fisheries management include mitigating fishing gear impacts on non-target life stages and species, closing coral and sponge areas to bottom fishing activity, protecting spawning grounds and establishing marine protected areas (MPAs) to protect key habitat (McDevitt-Irwin et al. 2015). Other measures are important to implement to reduce biodiversity and biomass loss. These include setting science-based catch limits for non-target species, precautionary harvest control rules, determining fisheries mortality to minimize cumulative impacts across fisheries and providing incentives for using lower impact gear types to minimize bycatch (Fuller et al. 2008, Keledjian et al. 2014, Baum and Fuller 2016). There is evidence of some of these measures in Canadian fisheries management plans. However, to date, bycatch management has been implemented piecemeal, without considering the ecosystem context, and without a broad understanding of bycatch impacts across all fisheries.

Despite Canada's commitments to implement ecosystem-based approaches to fisheries management, bycatch continues to be a significant issue, and the amount of bycatch in most fisheries is largely unknown. Differing regional approaches to bycatch management makes it impossible to assess the full extent of the issue on a national level. Bycatch affects a large range of species, from sand dollars to marine mammals, and many species in between. Most significantly, it continues to threaten the recovery and rebuilding of vulnerable species, as assessed by the scientific body the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) or protected under the *Species at Risk Act* (SARA) (McDevitt-Irwin et al. 2015, Baum and Fuller 2016).

CANADA'S COMMITMENTS

The Canadian government has committed to addressing bycatch in its fisheries, domestically through legislative provision and obligations, including legislative provisions and obligations concerning Aboriginal Peoples, and internationally, through commitments and arrangements with organizations such as the United Nations and Regional Fisheries Management Organizations. International agreements provide a foundation for national legislation, policies and measures that support sustainable fisheries management. Canada has signed and recognized several international commitments that address sustainable fisheries and biological conservation, such the *United Nations Convention on the Law of the Sea (1982)* and the *Agreement for the Conservation and Management of Straddling Fish Stocks and High Migratory Fish Stocks (Fish Stock Agreement) (1995)*. Canada is also a signatory to the *Convention on Biological Diversity (1992)*, and, as such, has committed to addressing fisheries issues such as bycatch and discards.

The Canadian Government is required to report on its progress towards the Convention on Biological Diversity's Aichi Target #6 by 2020 (CBD 2010). This target focuses on sustainably managing and harvesting all fish and invertebrate stocks by applying ecosystem-based approaches, including ensuring that the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits (CBD 2010). Canada has recently made progress to increase transparency in fisheries science and management: for example, by making the *Sustainability Survey for Fisheries* (DFO 2016b) publicly available in 2016, which summarized the status and management of 159 commercial fisheries in Canada. However, a low priority has been given to bycatch research and mitigation.

RELEVANT LAWS AND POLICIES

There is no direct reference to bycatch in relevant Canadian legislation. However, bycatch management must operate within the scope of the *Constitution Act (1867 and 1982)*, *Fisheries Act (1985)* (and the regulations that support the *Act*), *Oceans Act (1996)*, *Coastal Fisheries Protection Act (1985)* and *Species at Risk Act (2002)*. Although Canada has established some policies to manage bycatch, they are not derived from legislation.

The key policy employed is the *Sustainable Fisheries Framework* (DFO 2009a), which consists of policies and tools to support the sustainable use of Canada's fisheries. It includes the *Policy on Managing Bycatch* (Bycatch Policy) created in 2013 (DFO 2013a,b), which has its foundations in the Food and Agriculture Organization of the United Nations guidelines for responsible fisheries bycatch management (FAO 1995, 2011). Canada's *Policy on Managing Bycatch* is aspirational in design and intended to be implemented on a region-by-region basis. This regional approach is reflected in the varying degree to which to the policy is implemented, as reported in the *Sustainable Survey for Fisheries* DFO (2016b).

A *National Catch Monitoring Policy* (DFO 2013f) is being developed in 2017 to support the Bycatch Policy and is expected to address current issues with fisheries monitoring and scientific data collection.

THE NEED FOR MORE ACTION

Canada's approach to reducing bycatch must address ecosystem health, sustain fishing communities and livelihoods and increase food security. This report set out to estimate the level of bycatch in Canada and to identify current policy gaps and potential solutions to mitigate bycatch.

The Bycatch Policy can be strengthened by ensuring it is an extension of the legislation already in place to protect species. For example, if DFO recommends that an aquatic species not be listed under SARA, it is currently required to create work plans for recovery and rebuilding (Canada 2016). This requirement could prove to be a valuable tool, and Canada should take the opportunity to leverage it in the *National Catch Monitoring Policy*. Similarly, when appropriate, the *Oceans Act* or *Sensitive Benthic Areas Policy* (DFO 2009b) could be applied to protect habitat. For more information on laws, policy, regulations and commitments relevant to bycatch management in Canada, see Appendix I.

Canada's fisheries monitoring program requires redesign, increased resources and long-term planning. This would allow for the collection of meaningful, accurate data required to understand the bycatch issues in Canada, and apply this information to fisheries-management decision-making. There are currently no national standards or rationale for levels of fisheries monitoring at sea (observers), leaving most fleets under-sampled and under-represented in databases. The need for adequate and improved monitoring of fisheries was highlighted in a 2016 Auditor General of Canada report (OAG 2016).

By placing limits on bycatch and assessing cumulative impacts on species across and within fisheries — particularly those with populations at risk or within the Critical and Cautious Zones — the levels and impacts of bycatch discarded in commercial fisheries can decrease significantly. Greater access to the data, and interpretations of the data, including changes in bycatch levels both in individual fisheries and nationwide, will provide greater transparency, and benefit all who work to ensure sustainable fisheries, especially those who rely on fisheries for their livelihoods.

DFO can deliver on its policy commitments and international best practices by:

1. Making it mandatory to have sufficient monitoring to ensure accurate estimates of all retained and non-retained bycatch in all commercial fisheries by developing a national catch monitoring policy that requires standardized data collection. This would include statistically meaningful coverage levels and vessel logbooks that track all bycatch;

2. Requiring a comprehensive bycatch assessment in every Integrated Fisheries Management Plan (IFMP) that specifies enforceable management measures to be used to ensure bycatch levels do not exceed the stated target;

3. Strengthening Canada's policies related to bycatch to ensure best practices are followed, policies are enforced and all bycatch is accounted for; and

4. Publishing a national bycatch status report that includes annual estimates of bycatch, monitoring results by fishery and management area, progress on implementing policies and management plans and a cumulative impact review.

3.0 METHODS

To date, the extent of bycatch in Canada's fisheries is poorly understood, within DFO and even within fisheries which have been certified by the Marine Stewardship Council (MSC), which are among the most closely monitored of Canada's fisheries. In the absence of official estimates, Oceana Canada compiled Canadian bycatch data from more than 100 documents (Tables 1-7 in Appendix II).

First we examined the available Integrated Fisheries Management Plans (IFMPs) and the associated Conservation Harvesting Plans (CHPs) to document the specific measures described for fisheries in each ocean region. This analysis is necessary to understand both the level and effectiveness of existing measures and the main gaps that need to be filled. While not legally binding, the primary goal of an IFMP is to provide a planning framework for the conservation and sustainable use of fisheries resources and the process by which a given fishery will be managed for a period of time (DFO 2013c). A recent analysis of Canada's marine fisheries (Baum and Fuller 2016) found that 36 per cent of fish stocks (45 of 125 stocks) did not have an IFMP. (This analysis found strong regional differences, with only 48 per cent of Atlantic stocks having an IFMP, contrasting with 95 per cent in the Pacific.) From June to October 2016, we acquired IFMPs and CHPs through DFO regional websites, through DFO's library search engine WAVES and by requesting full versions from DFO managers and scientists (see Tables 1-5 in Appendix II).

Next we searched the MSC public certification reports for all marine fisheries that are, or have been, certified in Canada (n=32). Specifically, we sought data pertaining to the number of all species caught that were retained or discarded, broken down by fishing area or gear type, and, if possible, presented in table format (see Table 6 in Appendix II for rationale of data selected and any assumptions). Of the 32 marine fisheries that are, or have been, MSC certified in Canada, bycatch data was available in table format for 22 fisheries (Table 6 in Appendix II), presented as aggregates of several years or as year-by-year totals (spanning 1998 to 2014).

Two of these fisheries (Canadian Highly Migratory Species Foundation British Columbia albacore tuna North Pacific and the NAFO Division 4R Atlantic herring purse seine fishery) did not present data that allowed for the calculation of the percentage of total catch. These fisheries were therefore omitted from further summaries using percentages but were retained for tallies of species captured for cumulative impacts. Ten of the fisheries did not present bycatch data in table format. In these cases, we present summaries of bycatch information obtained from the text of the MSC reports (Table 7 in Appendix II).

The remaining 20 fisheries, comprising 54 fleets categorized by fishery, gear and fishing area, were analyzed to determine the percentage of catch discarded. Due to the variation in the type of data (e.g., biomass, counts of individuals), source

(e.g., observer, logbook or dockside monitoring) and scale (e.g., entire fishery or observed sets), we were limited to calculating percentages of catch discarded and retained to compare across fleets (Table 8 in Appendix II).

We ensured the species classifications were consistent across the dataset, assigned a higher-level species grouping and noted if the species had a COSEWIC conservation status (special concern, threatened or endangered). For all fisheries, we searched the most recent public certification report's "Endangered, Threatened or Protected" (ETP) section for noted interactions with ETP species (Table 13 in Appendix II) and noted the levels of coverage from at-sea observers (human or electronic) indicated in any section of the reports (Table 14 in Appendix II).

While this analysis was constrained by the data collected and presented in the MSC assessment and certification reports, this remains the best bycatch dataset available — at least to the public — since both DFO and industry provided data to the fisheries assessors. Unfortunately, the datasets were not as standardized or consistent as we had anticipated, making it challenging to compare bycatch across different fisheries. For example, the units were not consistent across the fisheries, the level of detail varied, the years were sometimes presented as aggregates of several years and sometimes as year-by-year totals, and some estimates were at the fleet level while others were rolled up to the entire fishery (Tables 6 and 7 in Appendix II). Ultimately, we were able to calculate the percentage of catch discarded for 20 of the 32 Canadian fisheries found on MSC's website. Focussing on the percentage discarded allows for some comparability across fisheries. However, it does not reflect the actual biomass impacted, since different gear types capture more marine life than others. Where metric tonnage data was available, we have included it (see Appendix II).

Furthermore, it is important to note that some fisheries regulations require discarding some catch for conservation reasons. For example, a number of fisheries have small fish protocols in place to ensure juvenile fish remain in the water. Conversely, some fisheries have discard bans in place, where adults of commercial species must be retained and the catch counted against bycatch quotas. Similarly, some fisheries are mixed-species fisheries with more than one target species retained. We focus here on discards as they are easily differentiated from retained catches, even in mixed species fisheries where the target of fishing trips, and thus the status of retained catches, can be difficult to ascertain. However, we also report the percentage of catches retained, the percentage of catches retained that were the MSC certification target species, and the species composition of catches in the appendices.

4.0 RESULTS

CANADIAN FLEETS DISCARD MORE THAN 250 SPECIES, INCLUDING THOSE AT RISK

Across all fleets (n=54), on average 6.5 per cent of the total catch was discarded (Table 8 in Appendix II). The North Atlantic Swordfish Canadian pelagic long line fishery was the fleet with the highest percentage of total catch discarded (44.8 per cent, Table 1 and Table 8 in Appendix II). This fleet also discarded the highest percentage of total catch with a COSEWIC conservation status (40.5 per cent, Table 8 in Appendix II) and used the gear type with the highest percentage of total catch discarded (Table 9 in Appendix II). Compared to other fleets in Canada, fleets in the Pacific Ocean discarded a high percentage of their catch (27.1 per cent) (Table 8 in Appendix II). However this difference is largely due to the nature of the mixed-groundfisheries in the Atlantic, where all groundfish species reported in the dataset are retained (Table 2, 3 and 5 in Appendix II, and documents cited within). In the Arctic, only two fleets were MSC certified (both part of the Canadian northern and striped shrimp fishery; 0.3 per cent average of total catch discarded).

MSC-certified fisheries make up approximately 66 per cent of fisheries by volume in Canada (Govender et al. 2016). Yet across all MSC-certified fleets, the retained and landed certification target species made up on average only 51.6 per cent of total catch, with the rest of the catch made up of other species for which they have quota, or bycatch (Table 8 in Appendix II).

The analysis of the available MSC data highlighted that fisheries can potentially have large cumulative impacts. This includes impacts on both target species and non-target species (Table 11 in Appendix II, see also Gavaris et al. 2010). A total of 255 unique types of catch were caught and reported in MSC assessments (Table 11 in Appendix II). These included 152 in the Atlantic and 103 in the Pacific, with eight species in the Atlantic also found in the Arctic. An additional 17 species were recorded in the Canadian Highly Migratory Species Foundation British Columbia albacore tuna North Pacific and the NAFO Division 4R Atlantic herring purse seine fishery (see Table 12 in Appendix II), bringing the tally to a total of 272 species. The species group that made up the highest average percentage of total catch discarded across fleets in which they were caught was echinoderms (5.1 per cent; Table 2 and Table 10 in Appendix II). Meanwhile, the individual species that made up the highest average percentage of total catch discarded across fleets in which they were caught was the sand dollar (19.0 per cent; Table 3 and Table 11 in Appendix II).

Table 1. Fisheries with the highest percentage of total catch discarded

Listed in decreasing order by ocean. Also indicated is the number of species caught, and the percentage of total catch discarded with a Committee on the Status of Endangered Wildlife in Canada (COSEWIC) conservation status of Special Concern (SC), Threatened (TR) or Endangered (EN), broken down by fleet (unique fishery, fishing area, gear type combination). See Table 6 in Appendix II for data sources and Tables 8 and 12 in Appendix II for further details on all fleets.

Ocean	Fleet		% of total catch discarded	% of total catch discarded with a COSEWIC conservation status (SC, TR, EN)	Number of species caught	Number of species caught with a COSEWIC conservation status (SC, TR, EN)
	Fishery	Fishing area/gear type				
Atlantic	North Atlantic swordfish	Pelagic long line	44.8%	40.5%	45	6
	Grand Bank Arctic surfclam	Hydraulic dredge	35.4%	0.0%	16	0
	Eastern Canada offshore lobster	Baited trap	22.0%	2.6%	13	4
	Average (n=46 fleets)		**4.1%**	**1.2%**	**13**	**4**
Pacific	Canada Pacific halibut (British Columbia)	Hook-and-line (bottom long line, troll or handline)	44.7%	14.3%	51	8
	Canadian Pacific sablefish	Bottom long line	40.8%	10.4%	30	9
		Korean trap long line	32.2%	0.5%	11	2
	British Columbia spiny dogfish	Inside directed - bottom long line	29.2%	28.4%	57	7
		Outside directed - bottom long line	14.3%	9.8%	73	12
	Average (n=6 fleets)		**27.1%**	**10.6%**	**40**	**7**
TOTAL AVERAGE (n=54 fleets)			**6.5%**	**2.2%**	**16**	**4**

Table 2. Average percentage of total catch that was discarded for each species group

Calculated across all fleets in which they were caught (n=54 fleets; 46 Atlantic, six Pacific, two Arctic, from n=20 fisheries), listed in descending order of average per cent total catch discarded. Only species groups with an average above one per cent of total catch discarded are included below. For further details on all species groups, see Table 10 in Appendix II. For details on data sources, see Table 6 in Appendix II.

Species group	Number of fleets with species group caught				Average % of total catch discarded
	Total	Atlantic	Pacific	Arctic	
Echinoderm	6	6	0	0	5.1%
Shark	13	8	5	0	3.1%
Sea turtle	1	1	0	0	2.8%
Large pelagic	2	2	0	0	2.5%
Groundfish	50	43	6	1	2.4%
Crustacean	21	17	2	2	1.9%
Flatfish	45	38	6	1	1.3%

Table 3. The five species in each ocean with the highest average per cent total catch discarded

Calculated across all fleets in which they were caught (unique fishery, fishing area, gear combination, n=54 fleets; 46 Atlantic, six Pacific, two Arctic, from n=20 fisheries). See Table 11 in Appendix II for further details on all species included. For details on data sources, see Table 6 in Appendix II.

Ocean	Species group	Species	Number of fleets with species caught	Average % of total catch discarded
Atlantic	Echinoderm	Sand dollar (*Echinarachnius parma*)	1	19.0%
Atlantic	Shark	Blue shark — Atlantic	5	7.0%
Atlantic	Echinoderm	Sand dollar (sp. unidentified)	1	5.4%
Atlantic	Crustacean	Rock crab	4	4.6%
Atlantic	Crustacean	Jonah crab	2	3.0%
Pacific	Groundfish	Spiny dogfish shark — Pacific	6	10.5%
Pacific	Flatfish	Pacific halibut	6	6.4%
Pacific	Groundfish	Sablefish	6	5.1%
Pacific	Flat fish	Arrowtooth flounder	6	3.0%
Pacific	Skate or ray	Longnose skate	5	1.3%
Arctic	Groundfish	Arctic cod	1	0.3%
Arctic	Rockfish	Redfish (sp. unidentified)	1	0.2%
Arctic	Flatfish	American plaice	1	0.0%
Arctic	Groundfish	Atlantic cod	1	0.0%
Arctic	Groundfish	Atlantic wolffish	1	0.0%

A wide range of species were recorded as bycatch in the different fleets (Tables 11 and 12 in Appendix II), including seabirds, invertebrates, sharks, fish and marine mammals. Several of the species caught have been designated by COSEWIC as species at risk. The British Columbia hook-and-line spiny dogfish fishery outside directed bottom long line caught the highest number of species (73; Table 12 in Appendix II). It also tied with the 3Ps cod bottom long line fleet for catching the highest number of species with a COSEWIC conservation status (12; Table 12 in Appendix II). Among MSC-certified fisheries, the Canada Pacific halibut (British Columbia) fishery had the highest number of ETP species with interactions noted (seven species; Table 13 in Appendix II). At-sea observer coverage (either human or electronic) in the 32 MSC fisheries ranged from none to complete coverage (Table 14 in Appendix II).

The groups most at risk of cumulative impacts in Canada's fisheries (Table 10 in Appendix II) are groundfish (caught in 50 of 54 fleets; 93 per cent), flatfish (45 of 54; 83 per cent), rockfish (38 of 54 fleets; 70 per cent), skates and rays (30 of 54; 56 per cent), crustaceans (21 of 54; 39 per cent), and sharks (13 of 54; 24 per cent).

Of the 32 Canadian fisheries that have been MSC certified, 15 require the use of bait to fish, and seven have some quantification of the bait use (as reported in MSC reports cited in Tables 6 and 7 in Appendix II). There is much room for improvement, standardization and consideration of cumulative, ecosystem impacts of bait fisheries that catch forage species, which are important as prey in marine food webs.

PACIFIC FLEETS THROW AWAY ONE IN FOUR FISH

The six Pacific Ocean fleets discarded the highest average percentage of total catch (27.1 per cent; median: 30.7 per cent; Table 8 in Appendix II) — more than one fish out of every four caught. There were four MSC reports in this region, representing six different fleets that provided data allowing for percentage of total catch summaries. The three fisheries, or five fleets, with the highest percentage of discards (Table 1 and Table 8 in Appendix II) were the Canada Pacific halibut hook-and-line (44.7 per cent; case study 7.1.1), the Canadian Pacific sablefish (Bottom long line, 40.8 per cent; Korean trap long line, 32.2 per cent; case study 7.1.2), and the British Columbia hook-and-line spiny dogfish (inside directed; 29.2 per cent, outside directed; 14.3 per cent; case study 7.1.3). The British Columbia hook-and-line spiny dogfish outside directed fleet caught the most species (73), of which the majority were rockfish (29), followed by groundfish (14) and flatfish (10) (Table 12 in Appendix II).

The Pacific species most at risk of cumulative impacts by being caught across fisheries and fleets were sablefish, Pacific halibut, spiny dogfish, lingcod, shortraker rockfish, redbanded rockfish, shortspine thornyhead and arrowtooth flounder. These species were caught in all six fleets in the analysis (Table 11 in Appendix II). The Pacific halibut fishery has recorded interactions with seven ETP species (either designated under SARA or the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Appendix I; Table 13 in Appendix II), the highest recorded in the reports. These consisted of three species of rockfish (longspine thornyhead and rougheye rockfish type I and II), three species of sharks (basking shark, bluntnose six gill shark and tope shark) and a seabird (black footed albatross).

ATLANTIC FLEET BYCATCH HAS CUMULATIVE IMPACTS

In the Atlantic there were 16 MSC reports, representing 46 different fleets, which contained data allowing for percentage of total catch summaries. The three fisheries with the highest percentage of discards (Table 1 and Table 8 in Appendix II) were the North Atlantic swordfish Canadian pelagic long line fishery (44.8 per cent, case study 7.2.1), the Grand Bank Arctic surfclam fishery (35.4 per cent, case study 7.2.2) and the Eastern Canada offshore lobster (22.0 per cent, case study 7.2.3). In Newfoundland, one of the newest MSC certifications is the Canada/Newfoundland 3Ps Atlantic cod fishery, which is notable as it is a fishery targeting a species from a population that COSEWIC has designated as endangered. This fishery represents four different fleets (case study 7.3) and

has discards (Table 8 in Appendix II) ranging from 13.6 per cent (gillnet) to 0.8 per cent (handline). The North Atlantic swordfish Canadian pelagic long line caught the greatest number of species (45; Table 12 in Appendix II), of which the majority were large pelagic species (15), followed by other fish (six) and sea turtles (five). The Canada/Newfoundland 3Ps Atlantic cod fishery bottom long line caught the greatest number of species with a COSEWIC conservation status (12; Table 12 in Appendix II).

Atlantic fish at the greatest risk of cumulative fishing impacts (Table 4 and Table 11 in Appendix II) were redfish species (caught in 31 fleets), Atlantic cod (caught in 16 fleets) and cod that was unidentified (25 fleets), haddock (28 fleets), and pollock (28 fleets). Blue shark, a species listed as Near-Threatened by the International Union for Conservation of Nature (IUCN), was also caught in a number of fisheries (five fleets). A number of Atlantic fleets had zero discards (Table 11 in Appendix II), reflecting the complex nature of the multispecies groundfishery, where groundfish are not allowed to be discarded, even though they may not be the target for the specific fishing trip (Tables 2, 3 and 5 in Appendix II).

The North Atlantic swordfish fishery has a large potential for cumulative impacts with protected species. It has recorded interactions with six ETP species (designated either under SARA or CITES Appendix I; Table 13 in Appendix II), the second highest recorded in the reports. The list consists of two marine mammal species (pilot whale and dolphin) and four species of sea turtle (leatherback, loggerhead, green and Kemp's Ridley's), as well as a number of unidentified hard-shelled turtles.

Table 4.

Species in the Atlantic Ocean caught in 10 or more fleets

Based on unique fishery, fishing area, gear combination, n=46 fleets in the Atlantic from n=16 fisheries. See Table 11 in Appendix II for further details. For details on data sources, see Table 6 in Appendix II.

Species	Number of fleets with species caught
Redfish (sp. unidentified)	31
Haddock	28
Pollock	28
Cod (sp. unidentified)	25
White hake	25
Atlantic halibut	24
Cusk	22
Monkfish	22
Skate (sp. unidentified)	20
American plaice	18
Greenland halibut	17
Atlantic cod	16
Witch flounder	16
Yellowtail flounder	15
Atlantic wolffish	11
Spiny dogfish shark	10

ARCTIC SHRIMP FISHERIES HAVE FEW DISCARDS

In the Arctic portion of the Atlantic there was one MSC report (Canada Northern and striped shrimp) containing data that allowed us to calculate the percentage of total catch summaries. This report covered two different Arctic fleets: NAFO division 0A – Shrimp Fishing Area 1 and NAFO Division 0B – Eastern Assessment Zone. The 0B fishery discarded only 0.5 per cent of its total catch (Table 8 in Appendix II), while the 0A fishery discarded 0.0 per cent. The 0B fishery caught more species (eight), of which five have a COSEWIC conservation status: American plaice (COSEWIC threatened), Atlantic cod (COSEWIC endangered), Atlantic wolffish (SARA special concern), spotted wolffish (SARA threatened) and redfish (COSEWIC threatened) (Powles et al. 2016).

FISHERIES MANAGEMENT PLANS AND MONITORING ARE INADEQUATE

Across all DFO regions we found 98 fisheries and fleets described in IFMPs or CHPs (Table 5). These represented a variety of target species including invertebrates, groundfish, pelagic fish and forage fish pursued using a variety of gear types. Most plans were current through to 2016 or were evergreen, although a number were out of date. The most common bycatch management measures across regions were logbooks and gear restrictions, and a number of plans included temporal and spatial closures. Less than half of the plans included specific bycatch quotas or caps, and even fewer contained move-on rules or gear modifications specifically designed to address bycatch. A little more than two-thirds of plans defined some level of at-sea observer coverage. It should be noted that the prevalence of these measures in the plans is likely overestimated, as some CHPs included fall under IFMPs, and both are included here. For further details on IFMPs and CHPs included, and other management measures pertaining to bycatch see Tables 1 to 5 in Appendix II.

Table 5. Summary of select fisheries management measures

Drawn from Integrated Fisheries Management Plans (IFMP) and associated Conservation Harvesting Plans (CHP) in Canada that apply to bycatch. For further details on each IFMP/CHP, data sources and other management measures pertaining to bycatch, see Appendix II, Tables 1 to 5.

DFO designated region	Number of IFMP/ CHPs	% of IFMP/CHPs with:							
		At-sea monitoring*	Logbooks/fish slips	Gear restrictions (general)	Gear modifications (to reduce bycatch)	Temporal closures	Spatial closures	Quotas/caps	Move-on rules
Central and Arctic	3	67%	100%	100%	33%	33%	67%	67%	67%
Maritime	7	71%	86%	100%	57%	71%	100%	43%	29%
Newfoundland and Labrador	19	89%	100%	84%	21%	68%	32%	5%	26%
Pacific	33	61%	97%	100%	55%	97%	100%	70%	12%
Quebec and Gulf	36	61%	97%	100%	19%	39%	53%	36%	14%
COMBINED	**98**	**67%**	**97%**	**97%**	**35%**	**66%**	**68%**	**43%**	**18%**

*Either with at-sea observers or electronic monitoring

A recent Auditor General's review of Canada's fisheries found that DFO does not require a clear rationale for the level of at-sea monitoring needed to provide information for managing fish stocks (OAG 2016). In the 32 MSC fisheries analyzed here, at-sea monitoring ranged from none to 100 per cent (Table 14 in Appendix II). Six had no monitoring, the level of monitoring in three was unknown, 19 had varying levels (more commonly 25 per cent or less), and only four had 100 per cent. Even where monitoring exists, it may not be adequate. Dockside monitoring does not record species discarded at sea, whereas at-sea observer monitoring often provides inadequate sampling to achieve meaningful estimates of bycatch levels (DFO 2007). Fishers that report on bycatch using identification guides may not report accurately (DFO 2007) and there is the potential for incentivized misreporting (DFO 2013g).

Although fisheries on Canada's West Coast have had 100 per cent at-sea video monitoring under the Groundfish Program since 2006 (DFO 2012b) and electronic monitoring in the crab-by-trap fishery (DFO 2016g), there are deficiencies in missing and unreliable data related to bycatch and discards, coverage of a fishery and reporting issues (DFO 2012b). Meanwhile, in Atlantic Canada, reporting on bycatch comes primarily from at-sea observers but varies annually by fishery, gear type and location (Ecology Action Centre 2016). Examples of this variation are approximately two per cent coverage for the 4X groundfish fishery, five to 10 per cent coverage for the pelagic long line fishery and 60 per cent coverage for the 5Z groundfish mobile-gear sector (Ecology Action Centre 2016). Dockside monitoring is also used, either with self-reporting or by a third party, with different system requirements for data reporting and monitoring according to the fishery (Ecology Action Centre 2016). Video monitoring in Atlantic Canada has been proposed in addition to the current monitoring measures (Ecology Action Centre 2016).

Ecosystem impact information is lacking in many Canadian fisheries. Because at-sea observers are often only required to report on discarded species of commercial value, non-commercial discards are often ignored, particularly in Atlantic Canada (Gavaris et al. 2010). A systematic review of current practices and gaps is required on a national scale to address issues with data collection, quality and application. One hundred per cent at-sea coverage is not feasible or statistically required for all fisheries, as it can be logistically and financially difficult to achieve, and is likely not needed for low bycatch risk fisheries. Literature suggests that coverage levels of at least 20 per cent for common species and 50 per cent for rare species would give reasonably accurate estimates of bycatch (Babcock and Pikitch 2004).

While the percentage of fisheries with observer coverage in the Atlantic Region fisheries is quite low (Tables 1,2,3,5 and 14 in Appendix II), there is 100 per cent at-sea monitoring in the mixed-groundfisheries of the Pacific (Table 4 and 14 in Appendix II). In the Atlantic, the monitoring levels haven't changed in at least 10 years (Fuller et al. 2008) and often fail to meet at-sea monitoring targets and commitments in all fisheries. For example, the Scotia-Fundy mobile and fixed-gear fleets currently do not meet all monitoring targets (DFO 2015a). Over this same 10-year period, change has taken place in the Pacific. For example, in 2005, observers covered approximately 20 per cent of the bottom long line sablefish caught as part of British Columbia's mixed groundfish fishery (Fuller et al. 2008). Today, coverage is 100 per cent (Tables 4 and 14 in Appendix II). Other measures have been put into place in the Pacific. For example, the footprint of bottom trawl activity was frozen (Wallace et al. 2015), and Rockfish Conservation Areas were implemented (DFO 2006). A closer look is required to determine how these measures have reduced bycatch and improved science-based decision-making (e.g., Haggarty 2014).

5.0 SUMMARY OF KEY FINDINGS

The uncertainty around bycatch in Canada's fisheries is a significant issue, as differing regional approaches to bycatch management make it impossible to assess the full extent of bycatch on a national level. Due to the variation in the type of data available (e.g., metric tonnes, counts of individuals), source (e.g., observer, logbook or dockside monitoring) and scale (e.g., entire fishery or observed sets), this analysis was limited to calculating percentages of catch discarded to compare across fisheries, rather than the actual biomass impacted. (The available tonnage figures are presented in Appendix III). While the uncertainty and data availability is a challenge, this report is based largely on MSC-certified fisheries. These fisheries represent a significant number of Canada's major and best-managed stocks, accounting for 80 per cent of Canadian seafood production by value and 66 per cent by volume (Govender et al. 2016).

Of all the fleets and gear types examined, the North Atlantic swordfish Canadian pelagic long line fishery discarded the highest percentage of total catch (44.8 per cent, Table 8 in Appendix II). This fleet also discarded the highest percentage of total catch with a COSEWIC conservation status (40.5 per cent, Table 8 in Appendix II). A wide range of species were recorded as bycatch in the different fleets (Tables 11-13 in Appendix II), including seabirds, invertebrates, sharks, fish, marine mammals, and species with at-risk designations from COSEWIC and protected under SARA. The British Columbia hook-and-line spiny dogfish fishery outside directed bottom long line caught the highest number of species (73, Table 11 in Appendix II). It, along with 3Ps cod bottom long line fleet, caught the highest number of species with a COSEWIC conservation status (12, Table 11 in Appendix II). Of all the MSC fisheries examined, the Canada Pacific halibut (British Columbia) fishery had the highest number of ETP species with interactions noted (seven) (Table 13 in Appendix II).

A total of 255 unique types of catch were caught and reported in tables in the MSC assessments (152 in the Atlantic and 103 Pacific; with eight species in the Atlantic also found in the Arctic) (Table 11 in Appendix II). Additional species were found in the Canadian Highly Migratory Species Foundation British Columbia albacore tuna North Pacific and the NAFO Division 4R Atlantic herring purse seine fishery (see Table 12 in Appendix II), bringing the species tally to 272. Overall, the groups at greatest risk of cumulative impacts in Canada's fisheries (Table 10 in Appendix II) are groundfish (caught in 50 of 54 fleets; 93 per cent), flatfish (45 of 54; 83 per cent), rockfish (38 of 54 fleets; 70 per cent), skates and rays (30 of 54; 56 per cent), crustaceans (21 of 54; 39 per cent) and sharks (13 of 54; 24 per cent). The Pacific species at greatest risk of cumulative impacts by being caught across fisheries and fleets were sablefish, Pacific halibut, spiny dogfish, lingcod, shortraker rockfish and arrowtooth flounder. Each of these species was caught in all six fleets analyzed (Table 11 in Appendix II). The Atlantic species at greatest risk of cumulative impacts were redfish species

(caught in 31 of 46 fleets; 67 per cent), Atlantic cod (16 of 46; 35 per cent) and cod that was unidentified (25 of 46; 54 per cent), haddock (28 of 46; 61 per cent), and pollock (28 of 46; 61 per cent).

Meanwhile, at-sea observer coverage (either human or electronic) in the 32 MSC fisheries ranged from none to complete coverage (Table 14 in Appendix II), indicating inconsistencies and lack of rigorous rationale for coverage levels. Canada's fisheries monitoring and reporting program requires better design, defined goals, increased resources, and long-term planning and commitments. This would allow for the collection of the meaningful and robust data required to understand and manage the bycatch issues in Canada and the application of this information to decision-making around fisheries management.

There are currently no national standards or rationale for the levels of fisheries monitoring at sea (observers), leaving most fleets under-sampled and under-represented in bycatch statistics. Canada's lack of standardization and consideration of cumulative impacts of the capture of all catch, including retained species for bait fisheries on the ecosystem is a significant failure of fisheries management. Moving forward, DFO must ensure that logbook data is validated so it can be used reliably by scientists and fisheries managers and that all retained and discarded catches of all species are recorded. Dockside monitoring is also an important tool for fisheries monitoring. However, because it usually only provides data pertaining to retained catches, it is important that is paired with other tools used to monitor discards.

Bycatch remains a problem even in the most closely monitored fisheries, including those with updated IFMPs, advanced fisheries management regimes and MSC certification. Despite the fact that Canada has signed and recognized several international commitments that address sustainable fisheries and conservation, there is no direct reference to bycatch in Canada's relevant legislation. Insufficient data collection, monitoring and reporting have led to data deficiency in Canadian fisheries. Understanding the full scale and impact of bycatch requires improved, standardized data collection and reporting to create consistency and enable comparisons and assessments of cumulative impacts.

6.0 RECOMMENDATIONS

To effectively reduce bycatch in Canada's fisheries, Fisheries and Oceans Canada must implement the following measures, backed by adequate funding and resources:

1. Make it mandatory for all commercial fisheries to have sufficient monitoring to ensure accurate estimates of all retained and discarded bycatch. To do this, Fisheries and Oceans Canada should develope a national catch monitoring policy that requires:
   a) Standardized data collection methods for the entire catch;
   b) Observer coverage levels that are statistically meaningful to allow determination of bycatch impacts within fisheries and cumulative impacts across fisheries; and
   c) Vessel logbooks that track all bycatch.

2. Require a comprehensive bycatch assessment in every Integrated Fisheries Management Plan (IFMP). These assessments should specify the management measures that should be used to ensure bycatch levels do not exceed the stated target. Moreover, these measures should be enforceable – for example, through license conditions.

3. Strengthen Canada's policies related to bycatch to ensure:
   a) That Canada follows international best practices, such as those outlined by the United Nations' Food and Agriculture Organization;
   b) That the policies are enforceable; and
   c) That all bycatch is accounted for, including: pre-catch losses, "ghost fishing" and any species that currently fall outside the scope of the Bycatch Policy or other related policies.

4. Increase transparency through a public national bycatch status report that includes:
   a) Annual estimates of bycatch;
   b) The results of bycatch monitoring, broken down by fishery and management area;
   c) Progress on implementing policies and management plans;
   d) Compliance rates for bycatch mitigation measures; and
   e) A review of the cumulative impact of bycatch.

7.0 CASE STUDIES

EXISTING DATA CONFIRMS PERVASIVE BYCATCH IN CANADA

This review confirms that bycatch remains a problem even among the most closely monitored fisheries, including those with updated IFMPs and MSC certification. The following case studies provide further details on the MSC-certified fisheries with the highest discard rates.

The Pacific halibut (case study 7.1.1) and sablefish fisheries (7.1.2) have high discard rates despite operating under some of the most advanced management regimes. The number of sharks and other species at risk in the Pacific spiny dogfish (7.1.3) and Atlantic swordfish (7.2.1) fisheries catch is of serious concern. Arctic surfclam fisheries (7.2.2) damage the seafloor in the process of dredging, to the extent of actually removing rock with each trip. The offshore lobster fishery (7.2.3) does not have a current IFMP available and interacts with several species of concern. The 3Ps cod fishery (7.3) discards sharks, skates and rays and catches 12 species at risk, including cod.

7.1 MSC-CERTIFIED PACIFIC FISHERIES WITH THE HIGHEST BYCATCH

7.1.1 Fishery: Canadian Pacific halibut

Species: *Hippoglossus stenolepis*
Fishing area: British Columbia
Gear(s): Hook and line (bottom long line, troll and hand-line)
Average discarded: 44.7 per cent (Figure 1)

Species and Fishery Description:
Pacific halibut are the largest species of flatfish in the world, reaching up to 2.7 m in length and weighing up to 300 kg (DFO 2015b). Pacific halibut mature at a relatively late age (8–12 years). This is around the time that they reach legal fishing size, making them vulnerable to fishing pressure (DFO 2015b).

The Canadian Pacific halibut fishery occurs along the coast of British Columbia, primarily using hook-and-line gear (DFO 2015b). Since 1923, Pacific halibut fisheries have been managed by the International Pacific Halibut Commission (IPHC), a joint management board of the United States and Canada (DFO 2015b). The IPHC conducts annual assessments and provides management recommendations, including catch limits, which are then adopted by the U.S. and Canada. These measures are agreed upon at an IPHC annual meeting in January, and the commercial fishing season is open from mid-March to early November (IPHC Secretariat 2017).

In British Columbia there were 230 active commercial licences for halibut, including First Nations Communal licences and licences to catch halibut in other fisheries (IPHC Secretariat 2017). Commercial landings in 2015 and 2016 were a little over 11,000 t (US and Canada); however, these represent only about 58 per cent of total catches (IPHC Secretariat 2017). Commercial landings in British Columbia in 2016 amounted to 2,744 t, which was slightly under the approved catch limit (IPHC Secretariat 2017). The stock is not overfished as of the latest assessment (2016); however, it is recommended that harvest levels be decreased for 2017 to prevent future declines (IPHC Secretariat 2017).

Bycatch Analysis:
The Pacific halibut commercial hook-and-line fishery discards nearly half of its total catch each year (Table 8 in Appendix II; Figure 1). Of particular concern are interactions with SARA-listed shark species, including the endangered basking shark (Table 13 in Appendix II). Additionally, retained bycatch includes 7 species of COSEWIC-designated rockfish. The majority of discards consist of undersized Pacific halibut, spiny dogfish, sablefish, arrowtooth flounder and longnose skate (see Figures 96–98 in Appendix III). For the Canadian Pacific halibut fishery, we were limited to using data from the initial MSC certification report, rather than the more recent recertification report, because the data included in the latter did not differentiate between retained and discarded amounts, nor did it present the amount discarded for non-quota species (for a comparison, see Figures 98 and 99 in Appendix III).

Retention and Discard Rates in Pacific Halibut Fishery

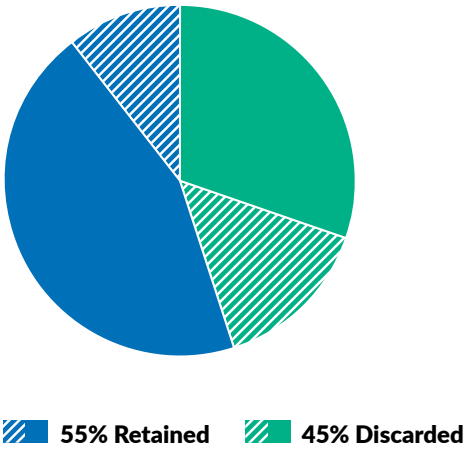

Figure 1: Percentage of discarded and retained catch in the Pacific halibut hook-and-line fishery
Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the sum of individuals entered in logbooks from 2006 to 2008. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
As with all of the Pacific groundfish fisheries in Canada, the Pacific halibut fishery is subject to 100 per cent at-sea monitoring through electronic or on-board observers (Tables 4 and 14 in Appendix II). In addition, there is 100 per cent dockside verification of catches. Several measures are in place to prevent and reduce seabird bycatch, including mandatory use of streamer lines or towed buoys; weighted ground lines; thawed bait; and bait handling and offal discharge procedures to avoid attracting seabirds to fishing hooks (DFO 2015b). A rockfish discard ban is in place for the Pacific halibut fishery to ensure that all rockfish bycatch is monitored and accounted for (Table 4 in Appendix II).

The majority of discards in this fishery are Pacific halibut itself. Some of these discards include fish that are below the minimum size and must be released according to regulations designed to help ensure younger fish remain in the water. Halibut catch is calculated by adding both the landed weight and the estimated mortality of any halibut released at sea. This is far better than those fisheries that do not account for bycatch mortality in management.

7.1.2 Fishery: Canadian Pacific sablefish

Species: *Anaplopoma fimbria*
Fishing area: British Columbia
Gear(s): Bottom long line/Korean trap
Average discarded: 40.8 per cent (Figure 2)

Species and Fishery Description:
Sablefish, also known as black cod, are a Pacific groundfish species found on mud bottoms on shelves and slopes from the Bering Sea to Japan and California; they have the largest distribution of any groundfish in the North Pacific (DFO 2013d, DFO 2017). Sablefish can migrate long distances and are highly mobile throughout their lives. This means all sablefish in the northeast Pacific are part of one population, including fish residing in coastal areas and seamounts (DFO 2013d, DFO 2017). Sablefish can grow up to 110 cm and live for up to 92 years, but they grow relatively quickly and reach maturity around 55 cm and three–five years (DFO 2013d, DFO 2017, Froese and Pauly, 2017).

The sablefish stock in British Columbia is in the mid-Cautious to low-Healthy Zone, with the biomass estimated at 28,000 t – 57,000 t (DFO 2017). The sablefish stock indices have decreased from 2003 to 2012, and DFO recommends a moderate harvest rate (DFO 2017). The commercial quota was set at 2,225 t for the 2012/2013 season, and landings amounted to 1,951 t in 2013 and 2,281 t in 2012. The long line (trap and bottom long line) fishery is allocated 91.25 per cent of the commercial total allowable catch, with approximately one-third of this being caught by bottom long line and two-thirds caught using the Korean trap long line (DFO 2016). In 2016 the hook-and-line fishery was allocated a total allowable catch of 1,698 t (DFO 2016).

Sablefish have been commercially fished since the 1970s, and the Canadian fishery is now valued at $16–20 million (DFO 2017). The fish are primarily harvested along the continental shelf and slope of British Columbia using bottom long line and trap gear, while trawls are employed to a lesser degree (DFO 2017). The coastal commercial fishing season is year-round, and the entire sablefish fishery is limited to 48 licences (DFO 2017). Sablefish are caught as bycatch and landed in fisheries targeting Pacific halibut, rockfish, lingcod, spiny dogfish and other demersal species (DFO 2013d). All sablefish bycatch must be deducted from the total allowable catch (DFO 2013d). This fishery withdrew its MSC certification after its second surveillance audit in 2012.

Bycatch Analysis:
The Pacific sablefish fishery discards about one-third of its total catch each year (Table 8 in Appendix II; Figure 2). Included in these discards are a number of species listed as of Special Concern under SARA. For two of these species — the bluntnose sixgill shark and the black-footed albatross (Table 13 in Appendix II) — fisheries are considered the most significant concern to their future populations (Anon. 2017). In addition, several species of COSEWIC-designated rockfish are caught as bycatch in this fishery (Table 12 in Appendix II). The largest portions of the discards consist of spiny dogfish, juvenile or otherwise non-quota Pacific halibut, juvenile sablefish, arrowtooth flounder and longnose skate (see Figures 156–161 in Appendix III).

Retention and Discard Rates in Pacific Sablefish Fisheries

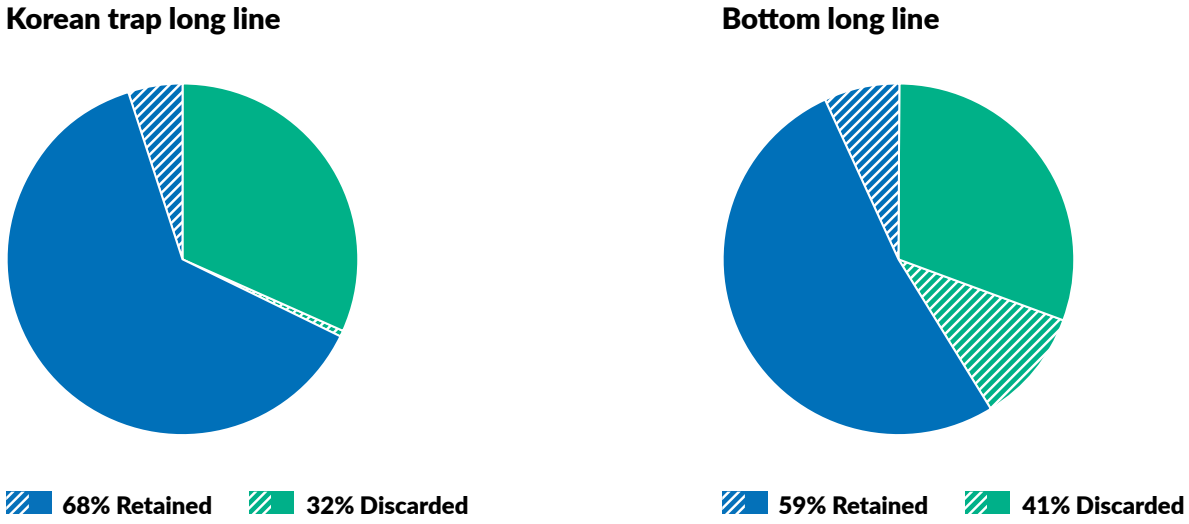

Figure 2: Percentage of discarded and retained catch in the Pacific sablefish bottom fisheries
Long line: right panel; Korean trap long line: left panel. Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the sum of individuals entered in logbooks from 2006 to 2008. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
As with all of the Pacific groundfish fisheries in Canada, the Pacific sablefish fishery is subject to 100 per cent at-sea monitoring through electronic or on-board observers (Tables 4 and 14 in Appendix II). In addition, there is 100 per cent dockside verification of catches. Traps are modified with escape holes and biodegradable panels to reduce the retention of undersized and immature fish and to prevent "ghost" fishing. Seabird deterrents are also used during deployment and retrieval of bottom long line gear. As part of the licensing conditions, fishers are required to adhere to a legal size limit by releasing all sablefish under 55 cm (fork length). Closed areas and limited entry also help to reduce overall effort and protect important habitats.

7.1.3 Fishery: British Columbia spiny dogfish

Species: *Squalus suckleyi*
Fishing area: British Columbia
Gear(s): Bottom long line inside and outside directed
Average discarded: Bottom long line inside, 29.2 per cent and outside directed, 14.3 per cent (Figure 3)

Species and Fishery Description:
Spiny dogfish (*Squalus suckleyi*) are widely distributed throughout the coastal waters of the North Pacific and are considered distinct from dogfish in the Atlantic Ocean (*Squalus acanthias*). This species has been designated by COSEWIC as of special concern (COSEWIC 2011). Spiny dogfish females take about 35 years to mature and have the longest gestation period of any vertebrate, making them vulnerable to fishing pressure (COSEWIC 2011). Dogfish can live in a wide range of habitats, from shallow to deep, nearshore to offshore. In British Columbia, there are two distinct populations: an inside stock primarily in the Strait of Georgia and an outside migratory stock, which is fished primarily off the west coast of Vancouver Island (Vincent et al. 2012).

The last assessment for spiny dogfish in the Pacific, conducted in 2010, concluded that there was no immediate concern for the stock but recommended that an updated assessment be prioritized (Vincent et al. 2012). Although

this was scheduled to be completed in 2015, it has not yet been published (Vincent et al. 2012). Pacific spiny dogfish is designated as a species of Special Concern by COSEWIC (COSEWIC 2011).

Spiny dogfish have a long history of commercial fishing in British Columbia. They were initially sought for their liver and body oil but are now caught primarily as a food source for Asian and European markets (Vincent et al. 2012). Approximately one-third of the commercial allocation goes to the trawl fishery and two-thirds to the hook-and-line fishery (DFO 2016). Approximately 86 per cent of the catch in the hook-and-line fishery comes from the outside stock, while the remainder comes from the inside Strait of Georgia (DFO 2016). In 2016, the coast-wide total allowable catch for the hook-and-line fishery amounted to 9,520 t (DFO 2016). However, actual catches are far below the total allowable catch, amounting to only 365 t, worth $236,000 in 2015 (DFO 2015c, d). Very few vessels actively target dogfish. In 2013 this fishery voluntarily suspended its MSC certification due to market conditions.

Bycatch Analysis:
Discard rates for both the inside and outside hook-and-line fisheries for dogfish are relatively low, at 29 per cent and 14 per cent, respectively (Table 8 in Appendix II; Figure 3). In the inside directed fishery, the vast majority of discards are spiny dogfish themselves (a COSEWIC-designated species, as noted above), with small amounts of halibut and skates also caught and discarded. In the outside directed fishery, although the overall discard rate is lower, greater amounts of Pacific halibut are caught as bycatch. As with other Pacific groundfish fisheries, the spiny dogfish fishery includes interactions and incidental mortality of at-risk shark species — including the bluntnose sixgill and tope sharks — and at-risk rockfish species (Table 13 in Appendix II) are of concern (see Figures 7–12 in Appendix II).

Retention and Discard Rates in Pacific Spiny Dogfish Fisheries

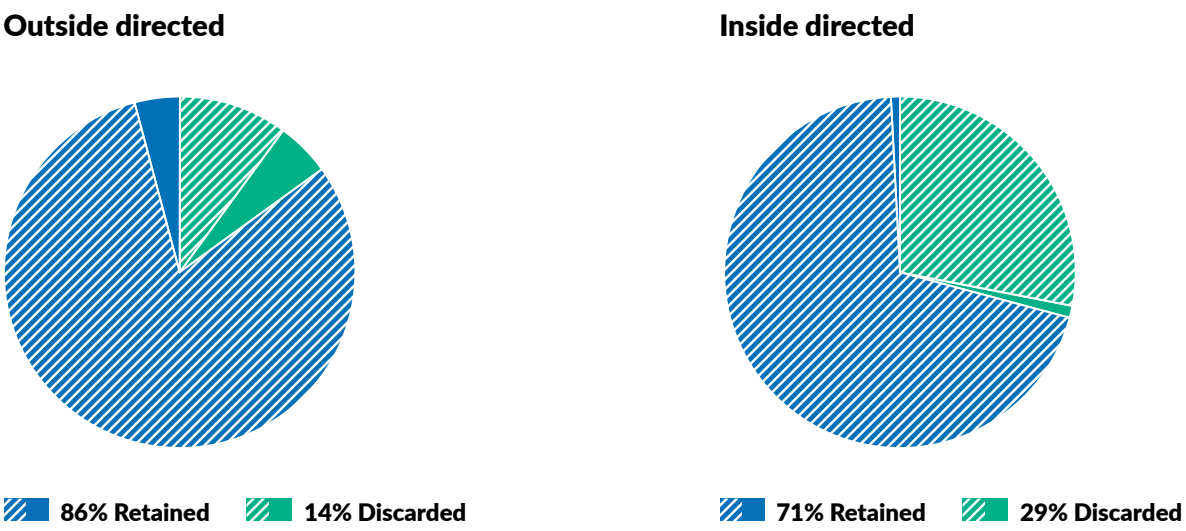

Figure 3: Percentage of discarded and retained catch in the Pacific spiny dogfish hook-and-line fisheries
Inside directed: left panel; outside directed: right panel. Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the sum of individuals entered in logbooks from 2006/07 to 2009/10. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
As with all of the Pacific groundfish fisheries in Canada, the Pacific spiny dogfish fishery is subject to 100 per cent at-sea monitoring through electronic or on-board observers (Tables 4 and 14 in Appendix II). In addition, there is 100 per cent dockside verification of catches. There is a discard ban and quota management system in place for any rockfish caught as bycatch (Tables 4 and 14 in Appendix II). In addition, DFO has published a combined management plan for the bluntnose sixgill shark and the tope shark to address fishery bycatch concerns. Updated bycatch information is needed to know whether the release of these species — mandatory since 2012 — has been implemented.

7.2 MSC-CERTIFIED ATLANTIC FISHERIES WITH THE HIGHEST BYCATCH

7.2.1 Fishery: Atlantic swordfish (pelagic long line)

Species: *Xiphias gladius*
Fishing area: North Atlantic
Gear(s): Pelagic long line
Average discarded: 44.8 per cent (Figure 4)

Species and Fishery Description:
Swordfish are a highly migratory, large, predatory fish at the top of the food web, found in tropical and temperate waters of all oceans (Devitt et al. 2012). Their distribution is linked to environmental conditions, and their presence in Canadian waters to forage is seasonal and related to water temperature (Devitt et al. 2012).

Swordfish are caught by two fleets: the harpoon fleet and pelagic long line fleet. Although swordfish is the primary target, the pelagic long line fleet also targets tunas (yellowfin tuna, bigeye tuna and albacore) (DFO 2013e). Overall, swordfish annual landings average 1,200 to 1,300 t in the last decade (DFO 2015e). All swordfish landed in Canada are exported to the United States, representing $12.3 million in export value in 2013 (DFO 2015e). There is limited entry into the pelagic long line fishery, which currently consists of about 56 active licences (77 total) with individual transferable quotas (DFO 2013e).

Fishing operations extend from Georges Bank, south of Nova Scotia to beyond the Flemish Cap, east of Newfoundland (DFO 2013e). Fishing effort generally occurs from April to December, when the seasonal northward movement of the edge of the Gulf Stream warms water surface temperatures, encouraging swordfish to migrate into Canadian waters (DFO 2013e). Swordfish and tuna are managed by the International Commission for the Conservation of Atlantic Tunas (ICCAT). In 1999, ICCAT introduced a 10-year recovery plan to rebuild the stock and recent assessments indicate it has succeeded (ICCAT 2014). Canada's total allowable catch was set at 1,348 t for 2014–2016 (ICCAT 2013), with 90 per cent allocated to the pelagic long line fleet (DFO 2013e).

The pelagic long line gear consists of a main line, along which a series of shorter lines (gangions) attached at intervals with hooks baited with mackerel or squid (Devitt 2012). The lines are set near the surface and are free to drift. The gear is deployed off the vessel as it moves with a buoy line attached to either end with floats and flags marking its location (Devitt 2012). Gear is usually set at night, with an average of 30–50 miles of gear and 600–1,100 hooks (Devitt 2012).

Bycatch Analysis:
The Atlantic swordfish pelagic long line fleet discarded the highest percentage (44.8 per cent) of the total catch among all fisheries in this report (Table 8 in Appendix II; Figure 4). Blue sharks are by far the dominant discard (34.6 per cent of the total catch), while eight other shark species are also caught, including the threatened short-fin mako (COSEWIC 2006) and endangered porbeagle (COSEWIC 2014). All four species of sea turtle (Table 12 in Appendix II) occurring in Canadian waters (see Figures 144–146 in Appendix III)

are also discarded. The MSC report also noted interactions with seven endangered, threatened or protected species. The greatest number of these interactions involves sea turtles (540 interactions) but also include dolphins and a pilot whale. These results are not surprising, given this fishery's MSC certification received some of the most strenuous objections to date due to interactions with sharks and sea turtles (Table 13 in Appendix II; Christian et al. 2013). This fishery has been estimated to interact with approximately 1,200 endangered loggerhead turtles (COSEWIC 2010b) each year (Brazner and McMillan 2008). It is also responsible for about 99 per cent of blue shark discards in Canadian fisheries, along with more than two-thirds of mako and more than half of porbeagle discards (Campana et al. 2011).

Retention and Discard Rates in Atlantic Swordfish Fisheries

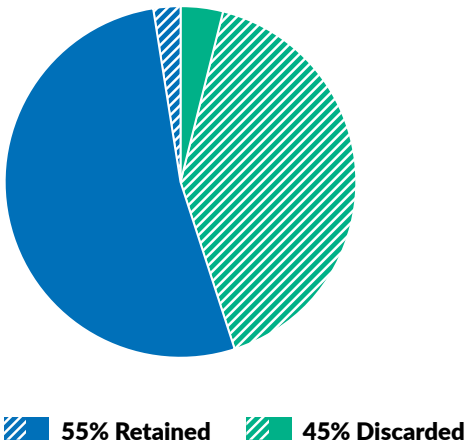

Figure 4: Percentage of discarded and retained catch in the Atlantic swordfish pelagic long line fishery
Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the sum of weights in observed sets from 2002 to 2009. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
DFO and the fleet have been aware of bycatch issues in this fishery for more than a decade (DFO 2013e) and the fleet has implemented a number of licence conditions and voluntary measures to mitigate bycatch. These include: minimum size restrictions, a requirement to hail in and out for all fishing trips, dockside monitoring of all landings, requirements for the proper handling and release of identified species at risk, carrying de-hooking kits and dip nets and following a code of conduct for the handling and release of sea turtles, using circle hooks to reduce non-target bycatch rates and increase post-release survival, increasing the length of the gangion lines to allow captured turtles to breathe, and time/area closures to protect swordfish broodstock, to prevent bycatch of bluefin tuna and to protect sensitive areas (Table 2 in Appendix II; DFO 2015e, DFO 2013e). There are also bycatch quota caps for sharks (porbeagle 50 t, blue shark 250 t, and shortfin mako 100 t) and quota assigned for bluefin tuna to reduce bycatch and eliminate discards (Table 2 in Appendix II; DFO 2013e). The fleet has an at-sea observer coverage target of five per cent (Table 2 in Appendix II). In recent years, this coverage has typically been near or above target (DFO 2013e).

7.2.2 Fishery: Grand Bank Arctic surfclam

Species: *Mactromeris polynyma*
Fishing area: Northwest Atlantic
Gear(s): Hydraulic dredge
Average discarded: 35.4 per cent (Figure 5)

Species and Fishery Description:
The Arctic surfclam (*Mactromeris polynyma*) is a large clam species found in coarse sandy bottoms (DFO 2010). It is a strong burrower, often found several inches below the surface (DFO 2010). It is slow growing and long lived. Many reach 40 years of age, and one clam on the Grand Banks was assessed to be 73 years old (DFO 2010). Arctic surfclams are found in waters colder than 15 degrees Celsius in subtidal regions of the Atlantic, Arctic and Pacific oceans, ranging from Labrador to Rhode Island in the Northwest Atlantic, in depths of up to 110 m (Brand et al. 2012b).

The fishery for Arctic surfclams on the Grand Bank began in 1989, following two years of exploratory fishing and the development of the fishery on Banquereau Bank in 1986 (DFO 2010). The number of vessels has varied over time but currently consists of three factory freezer-processors owned by Clearwater Seafoods that fish year-round, with varying levels of effort at Banquereau and Grand Banks (Knapman et al. 2016, Brand et al. 2012b). Although there were no fishing trips for Arctic surfclams on the Grand Banks in 2014 and 2015, in 2016 one of the vessels primarily fished the Grand Banks (Knapman et al. 2016). The stock is considered to be in the Healthy Zone (DFO 2016b), and the total allowable catch for 2016 was set at the same levels as in recent years (14,756 t), which was much higher than the 199 t landed in 2013 (Knapman et al. 2016). Combined landings from the Grand Banks and Banquereau are valued at $38 million (DFO 2015f) and are exported to markets in Japan (41 per cent), North America (20 per cent), China (29 per cent) and elsewhere (10 per cent) (Brand et al. 2012b).

The vessels tow two hydraulic dredges, which are essentially large rectangular steel boxes or cages with skis, each weighing about 9 t and measuring about 3.8 m wide by 6 m long and 1.2 m high (Brand et al. 2012b). Sea water is pumped from the vessel to a manifold on the front of the dredge, where a series of nozzles shoots high-powered water into the sediment, liquefying it and exposing and lifting the clams (Brand et al. 2012b). A cutting blade spanning the width of most of the dredge then scoops the clams up and moves them towards the back of the cage, where they pass over variously spaced bars allowing undersized clams to escape (Brand et al. 2012b). Typically, each tow lasts 12 minutes, conducted at a speed of two knots (Brand et al. 2012b).

Bycatch Analysis:
We found that this fleet discarded 35.4 per cent of its total catch (Table 8 in Appendix II; Figure 8). This could be an underestimate given that we assumed the fleet retained every individual of all retainable species (Arctic surfclam, ocean quahog, Greenland cockle, northern propeller clam, and whelk *Bucchinum* sp.) (see Figures 137–139 in Appendix III). It is encouraging that the fleet did not catch any species with a COSEWIC conservation status, and there were no noted interactions with endangered, threatened or protected species (Table 13 in Appendix II). However, the high percentage of total catch discarded is worrisome.

The sand dollar (*Echinarachnius parma*) represented the majority of discards (19.0 per cent of total catch) (Table 12 in Appendix II), which is not surprising since they also burrow and tend to be a large component of the biomass of the region (DFO 2012, Christian et al. 2010). The sand dollar is a major factor in the physical structuring and species composition of the soft-bottom communities in which Arctic surfclam dredges operate, and it is an important prey item for some commercially significant groundfish species (DFO 2012, Christian et al. 2010). Thus, any impacts upon them could have negative implications, particularly if the footprint of the fishery were to expand. This highlights the importance of considering the impacts to all species, whether or not they are at risk of extinction or of commercial value.

Retention and Discard Rates in Grand Bank Arctic Surfclam Fisheries

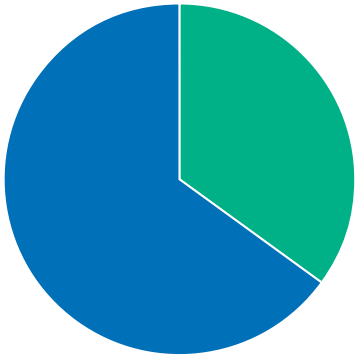

Figure 5: Percentage of discarded and retained catch in the Grand Bank Arctic surfclam fishery
Percentages were calculated from the sum of weights in observed sets from 2002 to 2009. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
The fleet is required to submit fishing logbooks and is subject to 100 per cent dockside monitoring of landings. It is also required to use vessel monitoring systems, and there is limited on-board observer coverage with protocols to monitor catch and species (Brand et al. 2012b). However, levels of on-board observer coverage are not publicly available, and neither is the most recent IFMP. The dredge employs a bar spacing of 28 mm, which is expected to reduce the bycatch of immature and small individuals of both the target and non-target species, and a 60–70 cm gap is present between the cutting blade and the top of the dredge, allowing fish and mobile animals to escape (Brand et al. 2012b).

7.2.3 Fishery: Eastern Canada offshore lobster

Species: *Homarus americanus*
Fishing area: Northwest Atlantic
Gear(s): Trap (lobster pot)
Average discarded: 22.0 per cent (Figure 6)

Species and Fishery Description:
The American lobster (*Homarus americanus*) is found from Labrador to Cape Hatteras in North Carolina. They usually live in coastal waters but are also found in deeper warm-water areas of the Gulf of Maine and the outer edge of the continental shelf (Blyth-Skyrme et al. 2015a, DFO 2014). Lobsters mate in midsummer. The following summer the female attaches the eggs to the underside of her tail, where she carries them for 10–12 months before they hatch in July or August (DFO 2014). The larvae go through three planktonic stages, followed by a post-larval stage that eventually settles to the bottom, about a month after hatching (DFO 2014). It takes about 8–10 years for them to achieve a legal carapace length of 82.5 mm, and lobsters can live more than 50 years (DFO 2014). Mature lobsters in the Gulf of Maine and offshore regions of the Scotian Shelf often undertake long-distance migrations of tens to hundreds of kilometres from the shallower banks in summer to deeper water in winter (DFO 2014).

The offshore fishery in Canadian waters is on Browns Bank and the northern edge of Georges Bank and there is an adjacent U.S. fishery on Northeastern Georges Bank (Blyth-Skyrme et al. 2015a). The Canadian fishery is entirely within Lobster Fishing Area (LFA) 41. Although this includes Northwest Atlantic Fisheries Organization (NAFO) Subareas 4Vs, 4W, 4X and 5Z, fishing is authorized only in 4X and 5Zc (DFO 2014). Currently there are eight licences in the fishery, all held by Clearwater Seafoods and pursued by a single vessel. The fishery operates on an enterprise allocation strategy. Each licence accounts for 12.5 per cent of the total allowable catch, with quotas running from January to December. This is the only lobster fishery managed with a total allowable catch (DFO 2014, DFO 2016c), which was initially set in 1985 at 720 t. It remained at this level until 2013, when a multi-year management system began with a three-year quota of 2160 t (3 x 720 t), with no more than 828 t to be fished in a given year

(DFO 2014). In the last decade, landing have generally been around total allowable catch, with 654 t landed in 2012 (DFO 2014).

The fleet uses traditional lobster traps constructed of wire (approximately 120 cm long, 40 cm wide and 28 cm tall) and baited with herring (Blyth-Skyrme et al. 2015a). The traps are set in strings of 100 that are joined by ground lines about 14 fathoms apart, with each end of the string having a surface line attached to a buoy and high-flyer (Blyth-Skyrme et al. 2015a). The vessel sets about 30 strings over about 1.2 miles, and they remain in the water for four to five days before retrieval. Typical offshore trips last about nine days (Blyth-Skyrme et al. 2015a). All traps are fitted with escape vents to allow small lobsters to escape, and the trap panels are connected with biodegradable clips to prevent "ghost" fishing if traps are lost (Blyth-Skyrme et al. 2015a).

Bycatch Analysis:
This fleet discards the third-highest percentage of total catch (22.0 per cent) of all Atlantic fleets (Table 8 in Appendix II; Figure 6). The majority of these discards were retainable species discarded due to regulations or voluntary measures (lobster: 12.4 per cent of total catch discarded, Jonah crab: 6.1 per cent of total catch discarded). However, 3.2 per cent of the total catch consisted of discards of species with a COSEWIC conservation status, two of which are designated as endangered (cusk, Atlantic cod) (see Figures 128–130 in Appendix III). The fleet also interacts with northern wolffish (*Anarhichas denticulatus*), a species listed as threatened under SARA (Table 13 in Appendix II). COSEWIC has identified bycatch as a threat to the recovery of all these species of conversation concern (COSEWIC 2010, 2012a, b).

Retention and Discard Rates in Atlantic Offshore Lobster Fisheries

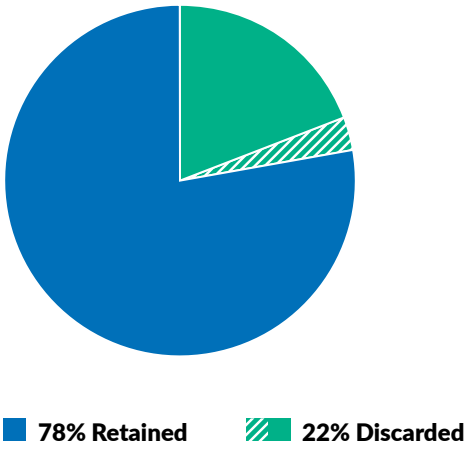

Figure 6: Percentage of discarded and retained catch in the Eastern Canada offshore lobster fishery
Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the average of weights in 2006 and 2012. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
There are a number of bycatch mitigation measures in place in this fleet. All species other than lobster, male Jonah crab and male rock crab must be returned to the water immediately. In addition, all female Jonah crabs must be returned to the water, along with egg-bearing female lobsters, V-notched female lobsters (previously identified as egg bearing) and individuals of both species that don't meet minimum size limits. The fleet voluntarily returns "jumbo" lobster (i.e., more than six pounds) to the water as well (DFO 2014, Blyth-Skyrme et al. 2015a). The fleet has developed standard operating procedures for setting and retrieving gear, primarily to minimize the risk of right whale entanglements (Blyth-Skyrme et al. 2015a). Landings and effort are monitored through logbooks, vessel monitoring systems, 100 per cent dockside monitoring, and at-sea observer coverage of approximately 15 per cent of fishing trips (six trips per year) (DFO 2014, Blyth-Skyrme 2015a). There is also a lobster fishery exclusion zone (LFA 40 on Browns Bank) to protect brood stock (DFO 2014, Blyth-Skyrme et al. 2015a). This fishery is in need of an updated IFMP.

7.2.4 Fishery: Southern Newfoundland 3Ps cod

Fishery: 3Ps Cod
Species: *Gadus morhua*
Fishing area: Northwest Atlantic
Gear(s): Handline, bottom long line, demersal gillnet, and mobile bottom gears (otter trawl and Danish seine)
Average discarded: Handline, 0.8 per cent; bottom long line, 1.9 per cent; demersal gillnet, 13.6 per cent; otter trawl/Danish seine, 0.9 per cent (Figure 7)

Species and Fishery Description:
The Atlantic cod (*Gadus morhua*) is a groundfish 45–55 cm long found in cool shelf waters at depths to 600 m in the Northwest Atlantic from Cape Hatteras in North Carolina to Greenland, and in similar waters of the Northeast Atlantic from the Barents Sea to the Bay of Biscay (MarineBio Conservation Society 2016, DFO 2016d, Blyth-Skyrme et al. 2016). Age at maturation has been decreasing in the 3Ps stock in recent decades, with about 50 per cent of females maturing by age five and males generally maturing about a year before females (DFO 2016e, Blyth-Skyrme et al. 2016). Spawning is generally variable, occurring between March and August over a widespread area, close to shore as well as on Burgeo Bank, St. Pierre Bank and the Halibut Channel (DFO 2016e). Each female produces millions of eggs, and the eggs and larval stages are planktonic (Blyth-Skyrme et al. 2016). By about six months old, juvenile cod are about 7 cm in length and found in waters near the bottom where they are opportunistic feeders on crustaceans, molluscs, other invertebrates and fish (Blyth-Skyrme et al. 2016). Growth is generally faster in this stock than others farther north, but has been variable over time (Blyth-Skyrme et al. 2016). Recently, length-at-age has been lower than in the past (DFO 2016e). COSEWIC has identified six designatable units, or separate populations, of Atlantic cod in Canada. The Laurentian North designatable unit has been designated as endangered (COSEWIC 2010).

The commercial fishery for Atlantic cod in 3Ps is part of a mixed groundfish fishery pursued by seven distinct fleets using a mixture of fixed and mobile gear in the nearshore, midshore and offshore areas (DFO 2016f). There were 813 licences issued (fixed and mobile gear combined) in 2012, with about 586 active harvesters, 81 per cent of which were in the inshore fixed-gear fleet (Blyth-Skyrme et al. 2016). The majority of fleets are managed with an individual quota (inshore fleets) or enterprise allocation (midshore and offshore fleets) (DFO 2016f, Blyth-Skyrme et al. 2016). The French islands of Saint-Pierre and Miquelon are within 3Ps and negotiations occur annually between Canada and France to establish the total allowable catch (DFO 2016f, Blyth-Skyrme et al. 2016). In 2015/2016, the total allowable catch was set at 13,490 t, with approximately 83 per cent allocated to Canadian commercial fisheries (DFO 2016e, Blyth-Skyrme et al. 2016). For 2016/2017, DFO science advised the catch be decreased to 13,043 t based on the Harvest Control Rules developed for the stock while it remains in the Cautious Zone (DFO 2016e). Reported landings have been well below total allowable catch since 2009/2010, with only about 54 per cent landed (7,166 t) in 2014/2015. Fixed gear (mostly gillnets) was the primary method, with about one-third of landings by the otter trawl fleet. Cod catches in 2015 were valued at about $7 million, representing more than two-thirds of the total value of all landings in the 3Ps mixed groundfish fishery (DFO 2016f).

There are four different gear types that are used to catch Atlantic cod within NAFO Subdivision 3Ps: 1) handline, 2) demersal long line 3) demersal gillnet and 4) mobile bottom gears (otter trawl and Danish seine) (Blyth-Skyrme et al. 2016). They each constitute a unit of MSC certification.

Bycatch Analysis:
The percentage of the total catch that was discarded in the 3Ps cod fishery ranged from 0.8 (handline) to 13.6 per cent (gillnets) (Table 8 in Appendix II; Figure 7). The majority of these discards were groundfish, skates or rays and sharks, many of conservation concern. The bottom longline fleet catches 12 different species designated by COSEWIC, with all fleets in this fishery having between one-quarter and two-thirds of the species caught designated with a COSEWIC conservation status (Table 12 in Appendix II). This includes the target, Atlantic cod, and five other species designated as endangered (porbeagle - *Lamna nasus*, smooth skate - *Malacoraja senta*, winter skate - *Leucoraja ocellata*, white hake - *Urophycis tenuis*, and cusk - *Brosme brosme*). As a result, the 3Ps cod fishery ties with the British Columbia hook-and-line spiny dogfish fishery for catching the greatest number of COSEWIC-designated species. The 3Ps cod

fishery also interacts, or has the potential to interact, with two species listed under the *Species at Risk Act*: the Atlantic wolffish (*Anarhichas lupus*) (special concern) and the leatherback sea turtle (*Dermochelys coriacea*) (Table 13 in Appendix II). Additional conservation concerns relate to the capture of commercial species currently under moratorium (haddock, American plaice and pollock) (DFO 2016f) and the capture of corals (see Figures 112–123 in Appendix II).

Retention and Discard Rates in Atlantic 3Ps Cod Fisheries

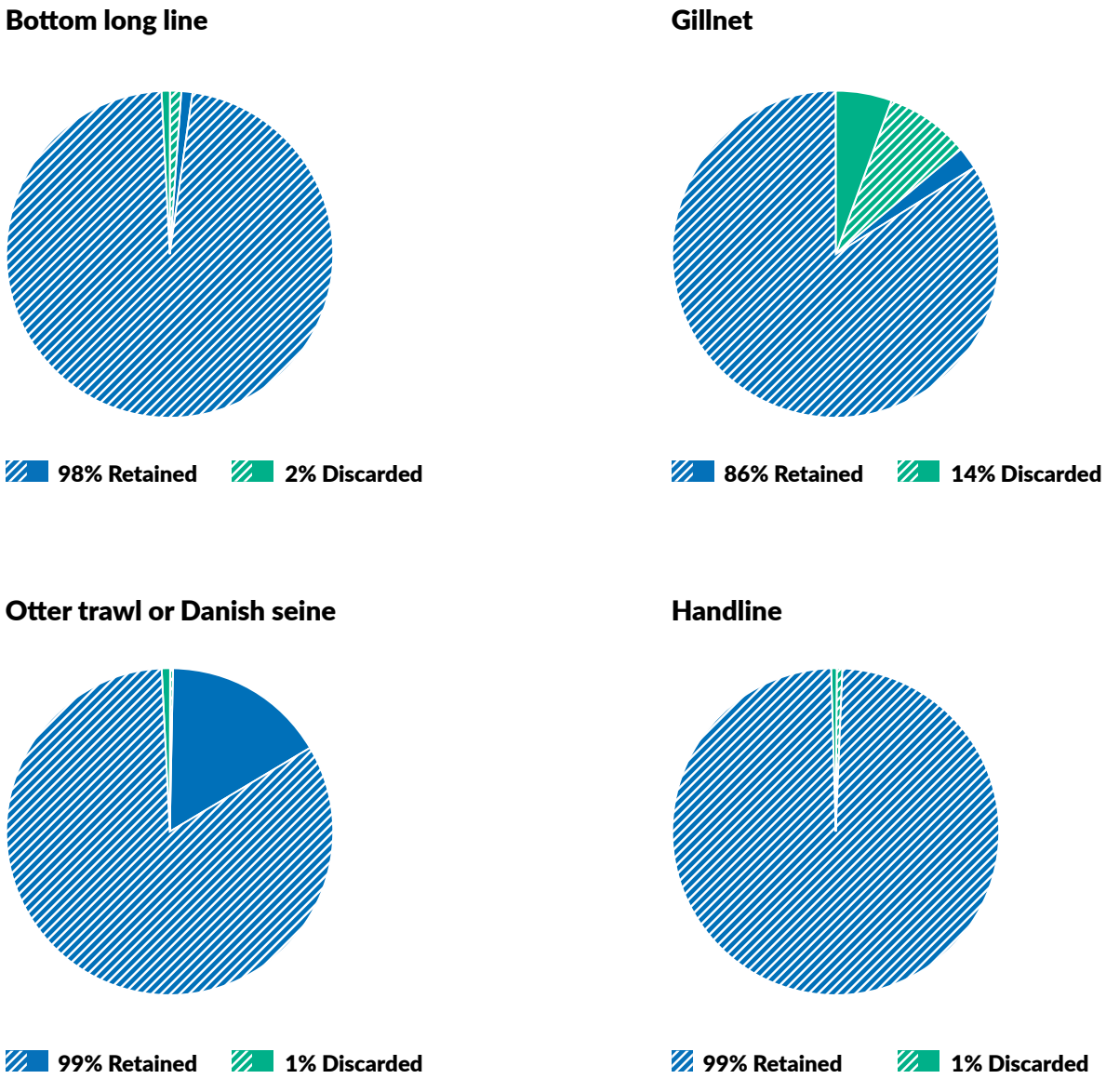

Figure 7: Percentage of discarded and retained catch in the 3Ps cod fisheries by gear type
Bottom long line: top left; demersal gillnet: top right; otter trawl and Danish seine: bottom left; handline: bottom right. Hatched areas correspond to percentages of COSEWIC-listed species retained and discarded. Percentages were calculated from the sum of weights in observed trips from 2010/11 to 2011/12. See Table 6 in Appendix II for further details.

Monitoring and Mitigation Measures:
Catch monitoring occurs through logbooks, mandatory 100 per cent dockside monitoring, vessel monitoring systems on all vessels greater than 35 feet long and at-sea observer coverage (1.5 per cent for fixed gear, and 14 per cent for mobile gears) (Table 3 in Appendix II) (DFO 2016f, Blyth-Skyrme et al. 2016). Detailed conditions for each fishery include gear to be used, area restrictions and species that are authorized to be fished (DFO 2016f). Only specific species of groundfish may be discarded in the 3Ps cod fishery: dogfish, lumpfish, live winter flounder less than 25 cm long, live American plaice less than 20 cm long, skates in the mobile bottom gear fleet and "unregulated" species (e.g., sculpins, sea urchins) in fixed-gear fisheries (Blyth-Skyrme et al. 2016). There are also limits to the quantities of incidentally caught groundfish that may be retained, which vary by fleet.

In the fixed-gear fleet, the volume of incidentally caught groundfish that are retained cannot exceed 10 per cent of the weight of the directed catch (Blyth-Skyrme et al. 2016). There are also species-specific caps (in weight or percentages of directed catch weight) in this fleet for pollock, American plaice, witch flounder, haddock, sharks and Atlantic wolffish. In addition, no Atlantic halibut may be retained when its season is closed (Blyth-Skyrme et al. 2016). The mobile-gear fleet, retained incidental catch of species for which the fishery has been closed is not permitted to exceed 10 per cent of the weight of the directed catch, or 200 lbs., whichever is greater. There are also species-specific caps (in weight or percentages of directed catch weight) in this fleet for Atlantic halibut, pollock and sharks. There is also a minimum landing size (45 cm) for Atlantic cod in the 3Ps groundfish fishery, and parts of it may be closed for 10 days if small fish exceed 15 per cent of the catch. If an area is closed twice in a season because of higher than allowable levels of incidental catch or small fish, it may remain closed for the rest of the season (Blyth-Skyrme et al. 2016).

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