Safety in the Canadian commercial fishing industry: Over a decade on the Transportation Safety Board Watchlist, what has changed?

By

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Definitions and abbreviations

- TSB: Canada's Transportation Safety Board.
- TC: Transport Canada.
- DFO: Fisheries and Oceans Canada.
- Gross tons (GT): A measure of vessel capacity in cubic feet of the spaces within the hull, and of enclosed spaces above deck available for cargo, stores, fuel, passengers and crew, with certain exclusions. One hundred cubic feet is equivalent to one gross ton.
- LSA: Life Saving Appliances.
- EPIRB: Emergency Position Indicating Radio Beacon.
- VHF: very high-frequency radiotelephone.
- Fishing vessel: a vessel that is used or is to be used for commercially catching, harvesting, or transporting fish or other living marine resources.
- Small fishing vessel: a fishing vessel that is not more than 24.4 m in length and not more than 150 tons, gross tonnage.
- Large fishing vessels: a fishing vessel that is more than 24.4 m in length or 150 tons, gross tonnage.
- Marine accident: an accident resulting directly from the operation of a ship other than a pleasure craft.
- Accident aboard ship: a person is killed or sustains a serious injury as a result of boarding, being on board or falling overboard from the ship, or coming into direct contact with any part of the ship or its contents.
- Shipping accident: the ship sinks, founders or capsizes, is involved in a collision (includes striking and contacts), sustains a fire or an explosion, goes aground, sustains damage that affects its seaworthiness or renders it unfit for its purpose, is missing or abandoned.
- Serious injury: a fracture of any bone, except simple fractures of fingers, toes or the nose, lacerations that cause severe hemorrhage or nerve, muscle or tendon damage, an injury to an internal organ, second or third-degree burns, or any burns affecting more than 5% of the body surface, a verified exposure to infectious substances or injurious radiation, or an injury that is likely to require hospitalization.
- Fishing vessels: include vessels involved in commercial fishing.
- Non-fishing vessels (commercial and other): include cargo vessels, ferries, passenger vessels, tugs and barges, research vessels, oil exploration, exploitation and support vessels, government vessels and pleasure craft.
- Pacific Region: area of responsibility that consists of the provinces of British Columbia, Alberta, Saskatchewan, and Manitoba, the Yukon and the Northwest Territories south of the 70th parallel, as well as the waters adjacent to these provinces and territories.
- Central Region: area of responsibility that consists of the provinces of Ontario and Quebec (including the Magdalen Islands), the territory of Nunavut, and the Northwest Territories north of the 70th parallel, as well as James Bay, Hudson Bay, the St. Lawrence Seaway, and the Great Lakes waterways up to the Canada-US border.
- Atlantic Region: area of responsibility that consists of the provinces of New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador, as well as the waters adjacent to these provinces.

Abstract

Commercial fishing is considered one of the most dangerous occupations in Canada, as dozens of fishermen lose their lives or get seriously injured every year. Since 2010 fishing safety has been on the Transportation Safety Board of Canada's (TSB) Watchlist. This research explores whether the Canadian federal government has made any progress in enhancing fishing safety a decade after it was listed on the TSB's Watchlist by looking at fishing accident statistics and policy changes. A secondary data (descriptive statistical and thematic) analysis was used in this research. The results indicate a decline in fatalities among fishermen in the past decade. However, safety issues contributing to fishing accidents remain similar to those identified two decades ago, specifically issues related to vessel stability and lifesaving appliances. Moreover, most fishing accidents involve small fishing vessels, a pattern that has not changed for decades. Canada has made notable progress in the policy work to improve fishing safety in the past few years, especially with the development of new fishing vessel safety regulations (FVSR). However, this progress can be jeopardized by exempting certain small fishing fleets from essential stability and lifesaving equipment requirements and a lack of adequate oversight and enforcement.

Keywords: Commercial fishing, safety, regulations, FVSR, marine accidents, Canada, Atlantic region, pacific region, risks, fishing fatalities, safety deficiencies

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Chapter 1: Introduction

1.1 Commercial fishing Importance

Fisheries have significant importance globally. Over half a billion people depend, directly or indirectly, on fisheries for their livelihood (FAO, 2020; Meybeck, Lankoski, Redfern, Azzu, & Gitz, 2012). Additionally, fish provide essential nutrition and protein to billions of people worldwide. In Canada, fishing is part of the country's culture and identity, and it has a significant socioeconomic impact, especially on coastal communities (DFO, 2022b; Weeratunge et al., 2014). The commercial fishing industry makes considerable contributions to the country's national economy, with its impacts being felt more at the provincial level, where it employs about 45 000 fish harvesters and generates billions of dollars in annual revenues (DFO, 2021c; TSB, 2020a). The fishing industry generated over 31.2 billion in the last decade, an 180% increase from a decade earlier from seafisheries and 0.7 billion from freshwater fisheries (DFO, 2021c). Most seafisheries' landings come from the Atlantic region, while freshwater fisheries come from Ontario. Canada exports a significant portion of its fish and seafood production, worth 8.7 billion annually, to foreign markets, particularly the United States, Asia, and Europe (DFO, 2022a). In the past ten-year period, Canada's supply of fish products has increased by about 15 %, reflecting the increased demand for fish products (DFO, 2021a). The value of Canadian exports is projected to increase to about 20% of the current rate by 2025, which will add gains exceeding 8B dollars (DFO, 2021b). The top exported fish species are lobster, crab, and salmon. Despite a decline in fishing activity due to resource depletion in some parts of the country and other factors, commercial fishing remains a thriving industry with substantial impacts on coastal communities' economy, culture, and way of life.

1.2 Commercial fishing safety

Fishing is considered one of the most dangerous occupations globally as it has one of the highest numbers of accidents and fatal and non-fatal injuries (FAO, 2021; McDonald & Kucera, 2007; TSB, 2012a). The global average number of fatalities in commercial fishing is estimated at over 24,000 annually (ILO, 2022). Fishermen are engaged in physically and mentally demanding job tasks performed on moving platforms in an inherently dangerous and often hostile marine environment (Chircop, Goerlandt, Aporta, & Pelot, 2020; Coulthard et al., 2020). In Canada, commercial fishing is also regarded as one of the riskiest professions. According to statistics from the Transportation Safety Board of Canada (TSB), the average number of marine accidents in the past decade is 289, and fatalities are 15.4, of which the majority are in the commercial fishing industry (TSB, 2022).

Fishing safety has been a hot topic for decades, and various research works have been published on it. However, the research body on fishing occupational health and safety remains small compared to other sectors, despite the large scope, complexity and rate of fatalities and accidents in the commercial fishing industry. Shewmake et al. (2018) conducted a scoping review of literature on fishing OHS in industrialized states and found that about half of the 200 plus available literature was published in the first decade of this century, and almost a third was published between 2014 and 2018. Research on fishing safety in Canada includes the work of both academic researchers and government agencies, but the focus was mostly on fishing accident rates and prominent causal factors. This work includes a broad review of fishing safety by the Newfoundland region search and rescue center (Wiseman, 2000a), Memorial university's SafeCatch project (SafetyNet, n.d.), and the Transportation Safety Board (TSB) broad Safety Issues Investigation into Fishing Safety in Canada (SII) and others (TSB, 2012a). The Maritime

Search and Rescue Newfoundland Region's broad review into fishing safety in Newfoundland was triggered by concerning figures of fishing accidents and fatalities in the nineties. This review, completed in 2000, focused on identifying safety deficiencies in fishing fleets less than 65ft since most vessels requested assistance from St. John's Maritime Rescue Sub-Centre (MRSC) are under 65 ft, specifically those of lengths between 45 to 65 ft. In this review, it was noted that only a quarter of the fishing vessels that applied to be members of the Coast Guard Auxiliary (CCGA) passed the initial safety equipment inspection, indicating the presence of serious issues with the seaworthiness and safety of small fishing fleets. SafeCatch project is focused on fishing vessels' safety and fishermen' occupational health. This project highlighted several important issues impacting fishing safety, such as the influential role regulations and policies initiated by different governmental agencies have on health and safety in the commercial fishing industry.

It is very well understood that fisheries management policies have a significant influence on fishermen' actions and behaviours, as these policies determine who gets a fishing license and when and where to use it as well as how much can be fished; however, multiple fisheries management policies have traditionally been developed without regard for their potential impacts on the health and safety of fishermen (Windle, Neis, Bornstein, Binkley, & Navarro, 2008). The adverse effects of some of the DFO policies on fishing safety have been highlighted in various TSB investigations into fishing accidents (TSB, 2012a). Regulations and policies can improve safety or encourage unsafe practices, making it essential for agencies, particularly those that may indirectly influence fishing, to include safety objectives in relevant policies. The TSB SII broad investigation and other studies highlighted systemic factors affecting health and safety in the Canadian commercial fishing industry. These factors include the failure to use or lack of

lifesaving equipment (personal flotation devices, immersion suits and emergency alerting devices); inadequate regulatory oversight; unsafe work practices; vessel modifications affecting stability, inadequate experience and training, labour conditions, attitudes towards safety, economic pressures, and weather conditions (SafetyNet, n.d.; Shewmake et al., 2018; TSB, 2012a; Windle et al., 2006).

The weather condition has been cited in many studies as a significant factor affecting fishing safety. This is noted by Wu et al. (2009), who found a strong correlation between the rate of fishing incidents and factors such as low air temperature, high waves, low sea surface temperature, and the presence of ice. Similar highlights were noted by Rezaee et al. (2016) in their work examining the relationship between extreme weather conditions and the level of fishing activity and rate of incidents in the Atlantic region. They also found that high Laplacian of pressure and strong winds influence the rate of fishing incidents. Different weather factors can have different impacts on fishing vessels, depending on their sizes. For instance, fishing activity levels for vessels of less than 45 ft in length are significantly influenced by wind speed, while activity levels of vessels more than 45 ft are affected only by ice presence (Rezaee et al., 2016). Weather factors' role in fishing safety is also the subject of new research, such as Finnis et al. (2019), whose work is focused on understanding the relationship between weather, fishing activity and safety and Reid-Musson et al. (2021), who built on Finnis et al. work to explore the role of weather briefings in fishermen' decision-making process, especially concerning fisheries opening season in Nova Scotia. Finnis et al. noted that for fishermen, weather-related decision-making is based chiefly on interpretations of hazards such as winds and, to a lower degree, waves. Both studies pointed out potential benefits to fishing safety through providing forecasts

tailored to fishermen' needs and having operationalized interactions between forecasters and fishermen which help improve the decision-making process of fishermen.

As more marine resources become depleted or new fisheries open, fishermen move to new waters that they are not familiar with, do not have adequate training or experience for, or do not have the proper vessels or fishing equipment; thus, creating new risks that lead to an increase in fishing accidents (Chircop et al., 2020; Neis et al., 2020). Shahrabi (2003), in his Ph.D. thesis, explored how fishing incidents are influenced by the fishing location and time of fishing activity. Using temporal and spatial analysis of fishing incidents and activity in the Atlantic region, Shahrabi found a strong relationship between location and fishing activity and incidents distribution. Additionally, the distribution of fishing activity and incidents is time-sensitive.

Risks in the commercial fishing industry are enormous, and even with improved safety standards, fishing will remain a dangerous profession, especially in areas characterized by extreme conditions (Chircop et al., 2020; Rezaee et al., 2016). Additionally, fishermen' attitude toward safety (which involves denial, diverting blame, or trivializing safety problems and risks) creates an obstacle to establishing a good safety culture and thus exacerbates risks to fishermen' health and safety (Eggert & Martinsson, 2004; Windle, Neis, Bornstein, Binkley, & Navarro, 2008).

1.3 Management problem

Commercial fishing in Canada has always been a dangerous occupation. Many fishermen get injured or lose their lives while working at sea. In the past ten-year period (2011 to 2020), 104 fishermen lost their lives, and around 470 were seriously injured, almost all of them in accidents involving small (under 24.4 meters in length and 150 gross tonnages in size) fishing

vessels which underscores the presence of serious safety problems in the commercial fishing industry, especially in the small fishing vessel fleets. Safety in Canadian commercial fishing has been the focus of the TSB since 1999, and in 2010 it was listed on its watchlist for the most concerning safety issues that pose a threat to Canadians in the transportation sector. The TSB also issued 48 recommendations concerning fishing vessel safety, some were addressed decades after they were made, and others are still active. Fishing vessels have been governed primarily by two sets of regulations for over four decades. These regulations are the Large Fishing Vessel Inspection Regulations (LFVIR) and the Small Fishing Vessel Safety Regulations (SFVSR) (Government of Canada [GC], 2007; Government of Canada [GC], 2021). These regulations have not kept up with the changes in fisheries conditions and technological advancements in vessel design and fishing gear. In 2017, however, new amendments to the SFVSR entered into force as the first of three phases approach to modernizing fishing vessels regulations. Research on the current condition of commercial fishing safety and Canada's government's work in improving fishing safety, particularly after 2010, is limited. This research project aims to bridge this knowledge gap.

1.4 Research objectives

This research project aims to explore if Canada has made any progress in enhancing fishing safety a decade after it was listed on the TSB's Watchlist, in 2010, by addressing the following two questions:

1- Has the rate of shipping accidents involving fishing vessels, the number of fatal, and non-fatal accidents and known safety issues contributing to these accidents changed in the past decade compared to a decade earlier?

2- Has the government(s) made any significant policy changes to improve fishing safety, and if it has, do these changes address prominent safety issues in the commercial fishing industry and the TSB recommendations on fishing safety?

This study will inform policymakers and interested stakeholders on the current safety condition in the commercial fishing industry in Canada, provide insights on prominent safety issues impacting fishermen' health and safety and identify areas where more work can be done to enhance fishing safety.

The research questions will be addressed through a secondary data (statistical and thematic) analysis of commercial fishing fleets, accidents, fatalities and other relevant information and a thematic analysis of safety issues and progress to address them using TSB investigation reports, governmental documents, and grey literature.

1.5 Report outline

This report is structured in five chapters. Chapter one corresponds to the introduction, which provides context to the subject matter, identifies the management problem addressed in this project and outlines the research objective and topic questions. In Chapter Two, the methodology used in this research is explained together with the scope of the project and its limitations. Chapter three presents research findings, while Chapter four provides interpretation and discussion of the findings addressing the research topic outlined in the first chapter. Chapter five is a summary of the report in addition to recommendations based on the research's results.

Chapter 2: Methodology

2.1 Methods

The research questions are addressed by conducting secondary data analysis. The first step was a descriptive statistical analysis of the Canadian commercial fishing industry (industry size, fleets and their distribution, vessels size, accidents, fatalities and injuries). The second step is a thematic analysis of safety issues identified by the TSB in its investigations into accidents involving small fishing vessels and governmental regulatory work addressing fishing safety. The geographical scope of the study is all regions in Canada where commercial fishing exists, while the temporal scope is from 2010 to 2020. The research project is focused on small fishing vessels (less than 24m in length and under 150 GT) as they represent about 98% of the fishing fleets in Canada. The analyses of safety issues build on the TSB broad Safety Issues Investigation into fishing safety in Canada (SII) published in 2012. The SII investigation, which was conducted by a team of investigators from the TSB with expertise in commercial fishing, human factors, safety and statistical analysis, naval architecture and marine engineering, identified numerous problems affecting fishing safety which were grouped under ten main safety issues or themes: Stability, Lifesaving appliances, Fatigue Cost of safety, Safety information, Training, Regulatory approach to safety, Fisheries resource management, Fishing industry statistics, and safe work practices.

The thematic analysis focuses on two main issues: vessel stability and lifesaving equipment. These safety issues were selected due to their substantial adverse effects on fishing safety, being identified as contributing factors in many fatal accidents and due to the scope and time limitation of the research project. In the statistical analyses, two periods were compared to each other (2001-2010 and 2011-2020) to identify any changes in the rate of accidents, fatalities, and the number of fishing vessels (registered and active), which provides a clear picture of the

safety conditions in the commercial fishing industry a decade after fishing safety listed on the TSB watchlist for the most pressing issues in the transportation sector.

2.1 Data collection

The data used in the descriptive statistical analysis is collected from publicly accessible governmental databases and reports: the TSB and DFO websites were the primary data sources. These sources were selected because they provide the most accurate data on the commercial fishing industry in Canada. The TSB website provided data on fishing accidents (shipping accidents and accidents onboard) and details on their distribution by region, accidents type, vessels size, age, flag, date of the accident, number of causalities and injuries, and other relevant information. The DFO website provided information on the number of registered and active fishing vessels, fleets distribution, vessel size categories, number and regional distribution of fishing licenses, landed fish species, and data on landings quantity and value (seafisheries and freshwater fisheries) from 2001 to 2020. The thematic analysis is based on data from the TSB investigation reports on fishing accidents for the study period (2010-2020) and Transport Canada (TC) and other government publications and reports. This analysis provided insights into the casual and contributing factors to fishing accidents.

2.2 Limitations

Limited Access to Information

Data about the type of gear used in vessels involved in shipping accidents were limited. Additionally, fishing activity was measured by a vessel making at least one landing, and no data about the duration fishing vessels spend at sea; thus, their level of exposure to risks cannot be measured. This limitation prevented exploring whether there is a relationship between the time fishermen spend on the water, the use of different fishing gear and the level of risk.

Data limitations

Getting fishermen' perspectives on safety, risks, and view on or awareness of current safety regulations and policies, in addition to their view on the impacts current fisheries management policies have on their safety, were not possible due to Covid restrictions that made it challenging to conduct interviews, especially with fishermen who are not familiar, do not have access to or do not prefer online meeting tools. Fishermen' point of view on safety issues, risks, and regulations and policies that apply to them is essential to understand the issues they believe impact their safety as they are the ones on the water dealing with all sorts of risks.

The publicly accessible TSB investigation reports into fishing accidents only cover a small portion of fishing accidents in Canada. Consequently, the safety issues identified in these investigations may not be exhaustive or capture all safety deficiencies in the commercial fishing industry. Further, the information provided in the TBS investigation reports may be missing some important information due to privacy concerns or due to cognitive bias, or challenges in acquiring all relevant information during the investigation.

Chapter 3: Findings

This chapter presents findings from the descriptive statistical analysis and the thematic analysis of accidents and safety issues involving small fishing vessels in Canada from 2011 to 2020.

3.1 Commercial Fisheries in The Past Two Decades

In a continuation of a long downtrend, registered and active fishing vessels declined in the past two decades (see Fig 1). At the beginning of 2001, registered and active fishing vessels were 23,360 and 17,326, respectively, and at the end of the second decade of this century, the

number of registered fishing vessels declined by 28% and active vessels by 31.3%. The percentage of the decline in registered and active vessels a decade ago is similar to the decade prior, with only a marginal difference in registered vessels percentage, which was 4% higher in the period from 2001 to 2010.

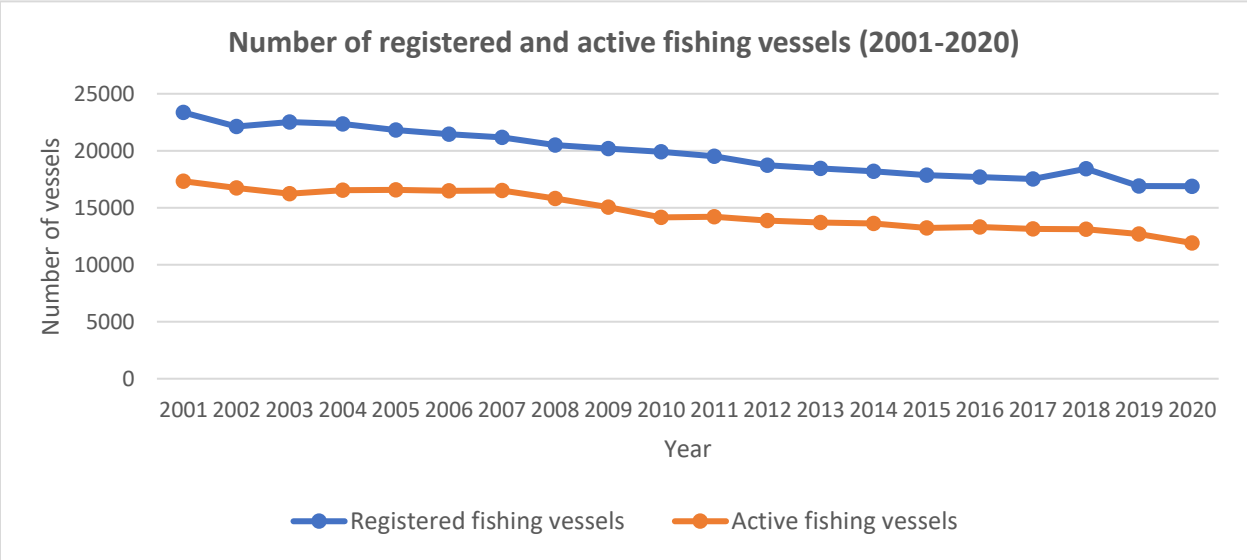

Figure 1-Registered and active fishing vessels in Canada from 2001 to 2020

3.2 Fishing fleet distribution

The top two regions with the most fishing ships in Canada are the Atlantic region (88%) and the pacific region (12%), as shown in Figure 2. Looking at the fleet distribution in the Atlantic region, we can see that Newfoundland has the biggest fishing fleet at 40%, followed by Nova Scotia at 27%, New Brunswick at 16%, Prince Edward Island at 9% and Quebec at 8% (see Figure 3).

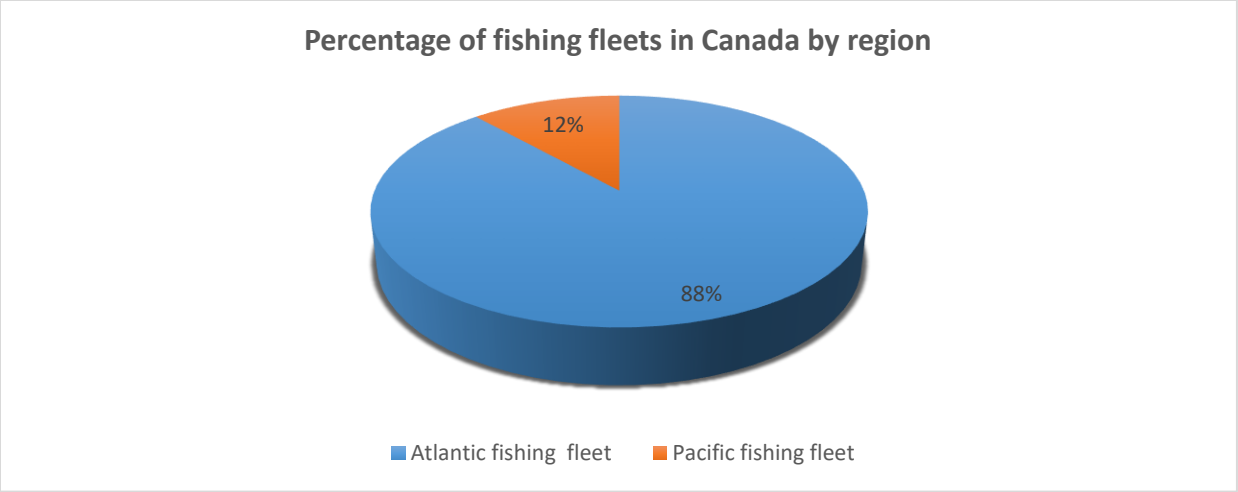

Figure 2-Fishing fleets in Canada's commercial fishing top regions

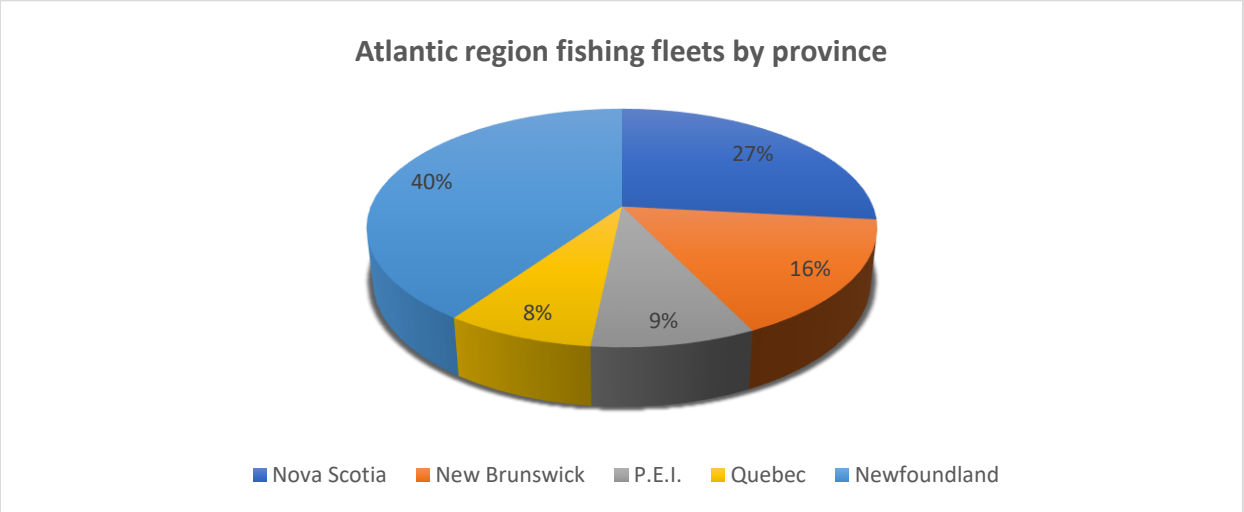

Figure 3- Distribution of commercial fishing fleets in the Atlantic region by province

Atlantic region fishing fleets (registered vessels) have decreased by about 12.4% since 2011 and 27% since 2001. Fishing fleets in the pacific region have similarly decreased in the same periods by19.5% and 31.8%, respectively. For the period 2011-2020, there has been only

one increase in the number of fishing vessels in the Atlantic region, which occurred in 2018 when 931 vessels in the 11-20 m/ 35-65 ft range were added, while the Pacific region added 148 vessels in 2011 in the 20-30m/65-99.11 ft category.

3.3 Fishing vessels size categories

Canada's fishing fleet's size has been in a constant decline mainly due to the decline in fishing vessels 20m (65 ft) in length, which compromise the majority (99%) of fishing vessels. However, there has been an increase in vessels that are more than 11m (35ft). The highest increase of registered fishing vessels happened in 2018, when a total of 1,103 ships were added to the industry, as seen in Figure 4. The increase in the number of registered ships in the past two decades has not affected the overall trend of declining fishing fleets as this decline is mainly driven by the decline in the fishing vessels in the under 10m (35ft) length category, which only saw an increase in the pacific region in 2014 with seven ships being added.

Figure 4- Number of fishing vessels in Canada by size for the period 2011-2020

In the Atlantic region, most of the fishing fleet consists of ships with lengths under 20 m (65 ft) (99%), of which 93% have a length under 13m (45 ft), 6% are between 14-20m (45-65 ft), and 1% are over 20 m (65ft) as shown in Figure 5. In the last decade, the Atlantic region saw a decline in fishing vessels of all sizes. However, vessels under 10 m (35 ft) made up most ships that exited the industry. The increase in fishing vessel fleets was in the 11-13m, 14-20m and 20-30m lengths categories. Most vessels that exited the Atlantic commercial fisheries in the last decade are under 20m (65 ft), which is not very different from 2001 to 2010.

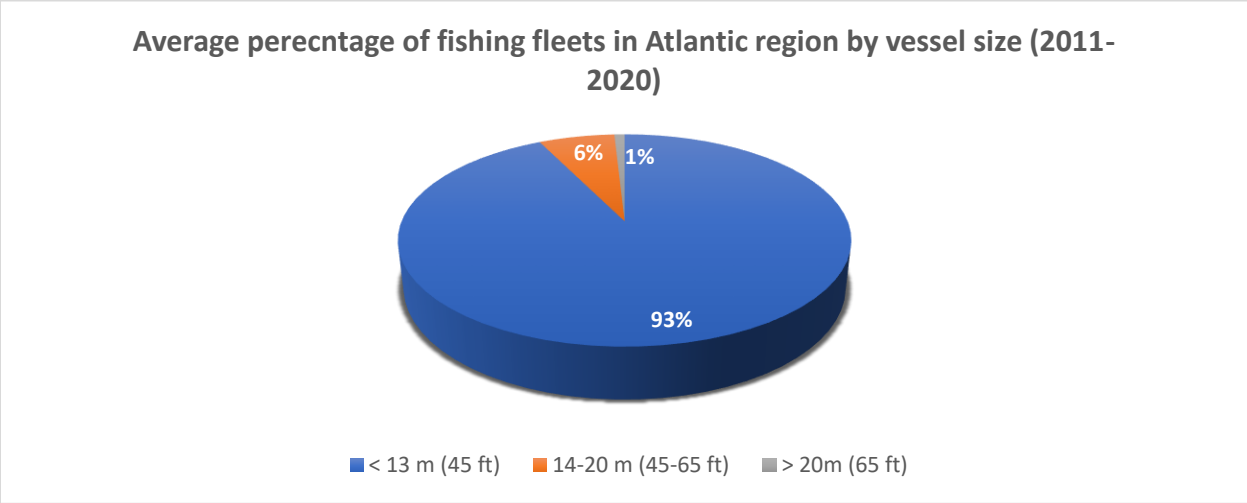

Figure 5- Percentage of fishing vessels by size in the period 2011 to 2020

Similarly, in the Pacific region, most of the fishing fleet consists of ships with lengths less than 13m (45 ft) but at a lower percentage than in the Atlantic region (80%), followed by vessels that have a length between 14-20 m (45-65) at 13% and the remaining 7% are vessels greater than 20m (65 ft) (see Figure 6).

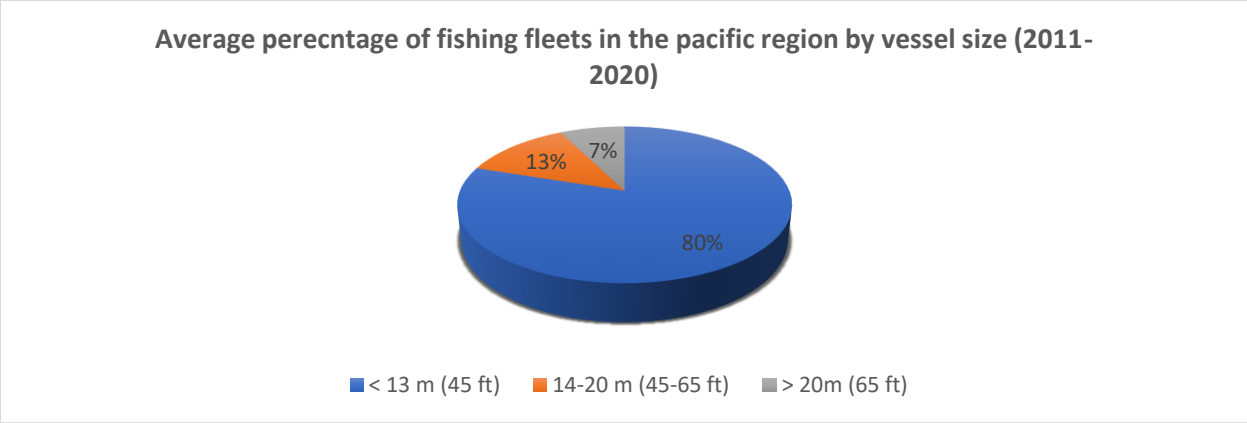

Figure 6- Atlantic region fishing fleets by size in the period 2011-2020

3.4 Marine Accidents

Marine accidents are categorized as:

1- Accidents aboard ship: a person is killed or sustains a serious injury as a result of boarding, being on board or falling overboard from the ship, or coming into direct contact with any part of the ship or its contents.
2- Shipping accident: the ship sinks, founders or capsizes, is involved in a collision (includes striking and contacts), sustains a fire or an explosion, goes aground, sustains damage that affects its seaworthiness or renders it unfit for its purpose, is missing or abandoned.

In 2021, a total of 214 marine accidents were reported to TSB. A decrease by 50 accidents compared to the previous year and by 52 accidents compared to the ten-year (2011-2020) average of 266. During the period 2011 to 2020, there were 2,661 ships involved in shipping accidents. Canadian flagged ships comprise the majority of these 2,089 ships, and commercial fishing vessels represent about a third (28%) of the total Canadian-flag vessels involved in marine accidents during the past decade and represent the single largest ship category involved in shipping accidents (2011-2020) (Figure 8). Fishing accidents in the past decade increased in some years and declined in others. However, there was a downward trend in the

number of fishing vessels involved in marine accidents between 2016 and 2019. This trend ended with an increase in the number (72) of fishing vessels involved in marine accidents in 2020. The years 2011, 2014, and 2016 have some of the highest numbers of fishing vessels involved in marine accidents, 90 accidents or more.

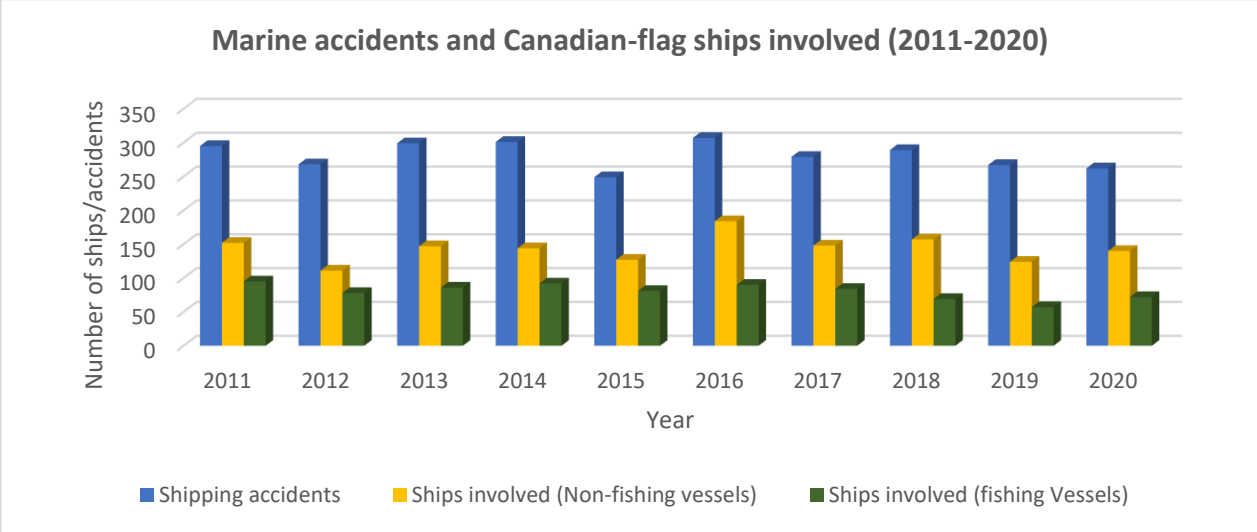

Figure 7- Number of marine accidents and Canadian ships involved in these accidents both fishing and non fishing vessels.

3.5 Type of Accidents

In the past ten years, there were more than five times as many shipping accidents as there were accidents aboard ships which is not so different from a decade earlier (see Figure 9). The year 2016 has the highest number of shipping accidents (264), followed by 2011 (254) and 2013 (238), while the years with the lowest number of shipping accidents were 2019 (207), 2012 (216) and 2015 (214) respectively. The number of accidents aboard ships showed an upward trend between 2015 and 2019, and shipping accidents showed a similar trend from 2012 to 2014 before moving to a relatively downward trend starting in 2016 until 2019.

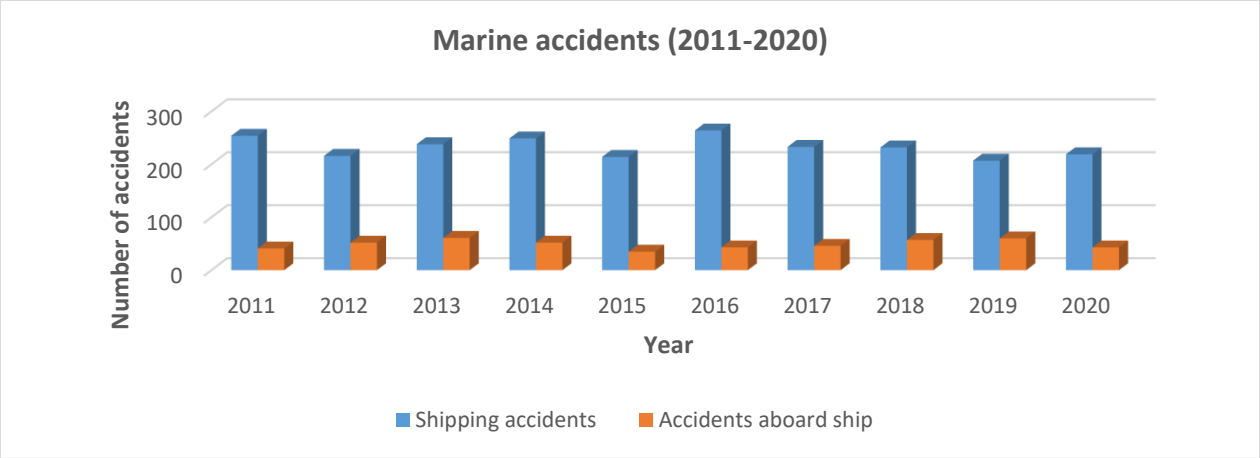

Figure 8- Number of shipping and aboard ship accidents from 2011 to 2020

Fishing vessels are involved in different types of accidents, but most accidents in the period (2011-2020) were grounding, fire/explosion, collision, sinking, sustaining damage that makes them unseaworthy and capsizing (see Figure 10).

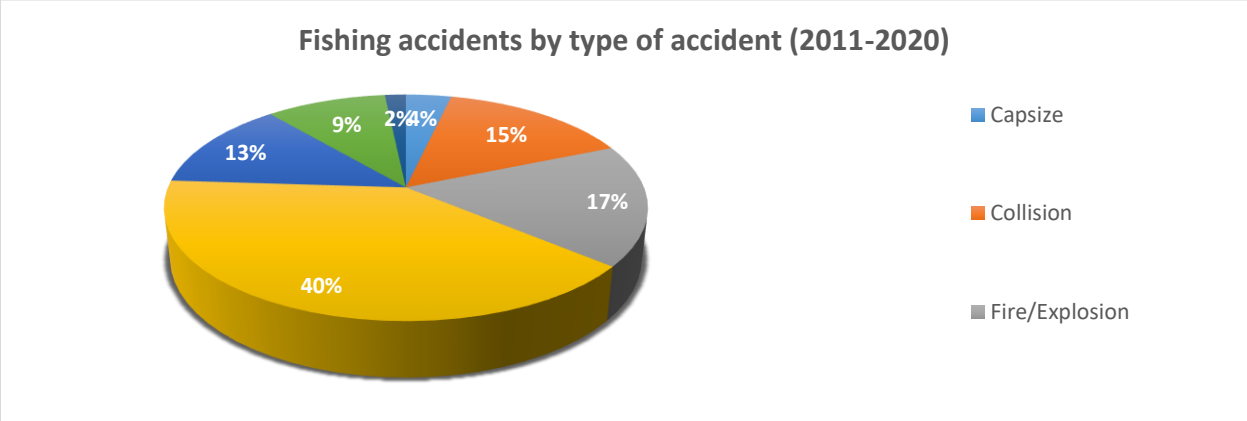

Figure 9- Types of fishing accidents for the period 2011 to 2020

Canadian flag vessels lost in marine shipping accidents in the past decade are mostly made up of small fishing vessels: under 15 GT (49%), 15-59 GT (29%), and 60-149 GT (22%). These percentages indicate that ships under 15 GT are more susceptible to getting lost when involved in shipping accidents. The years 2011, 2012 and 2015 had the highest number of ships

under 15 GT being lost at sea due to accidents, while ships under the category (15-59 GT) saw the biggest number of lost ships in 2011 and 2012 (see Figure 12). Most of the lost ships in marine accidents in Canada (95%) are commercial fishing vessels.

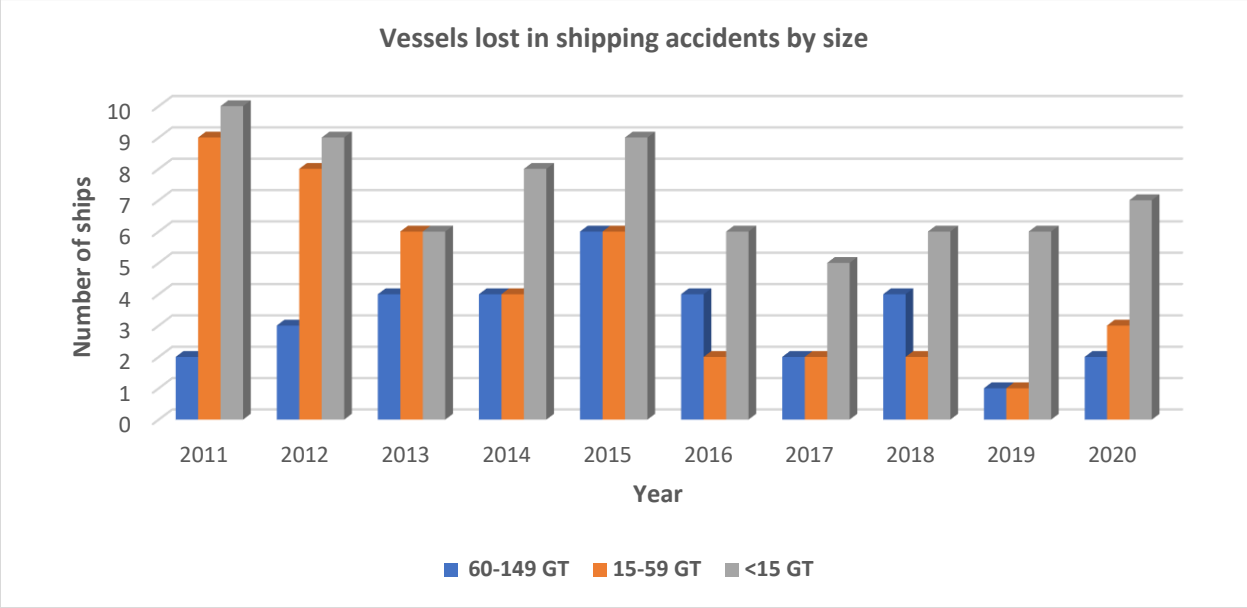

Figure 10- Number of Canadian-flag ships (fishing and non-fishing) lost in shipping accidents in the period 2011-2020.

When looking at the breakdown of lost fishing vessels by age, we can see the age category with the highest number of lost ships is 30 years and more (25%), followed by the unknown category, which is assumed to be older ships (25%), the ships 25-29 years old (14%) and 15-19 years with 14% of the total fishing vessels lost between 2011 and 2020. Older ships are not built to established modern vessel construction standards. Additionally, their stability is often compromised due to various modifications throughout the life span of these ships. There is a clear indication that the ship's age has a notable factor in the high number of ships lost in the analyzed period (See Figure 12).

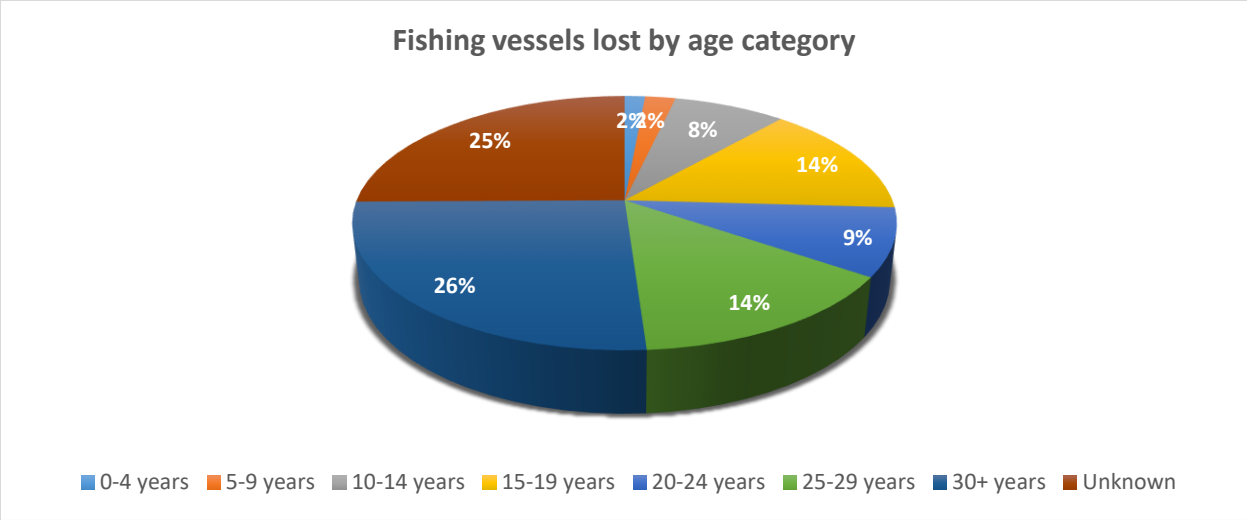

Figure 11- This pie chart shows the distribution of lost fishing vessels in the period (2011-2020) by the age of the vessel.

3.6 Fatalities and Injuries

From 2011 to 2020, a total of 2816 shipping accidents occurred in Canada and fishing vessels made up over a third (36%) of the Canadian flagged ships involved in these accidents. Additionally, fishing vessels represented 56% of vessels involved in shipping accidents with fatalities or serious injuries, 72% of persons fatally injured in shipping accidents, 64% of shipping accidents with serious injuries, and 39% of vessels involved in accidents aboard ships with fatalities or serious injuries. In the same period, the fishing industry sustained 104 fatalities, predominantly in the Atlantic region (51%), followed by the Pacific region (35%) and the central region (14%). As shown in Figure (12), there were fewer fatalities in the past decade (104), representing an 18% decrease compared to the 2001 to 2010 period, which saw 127 fatalities among fishermen. The average number of fatalities in the last decade was ten fatalities per year,

while in the decade before, it was 13.

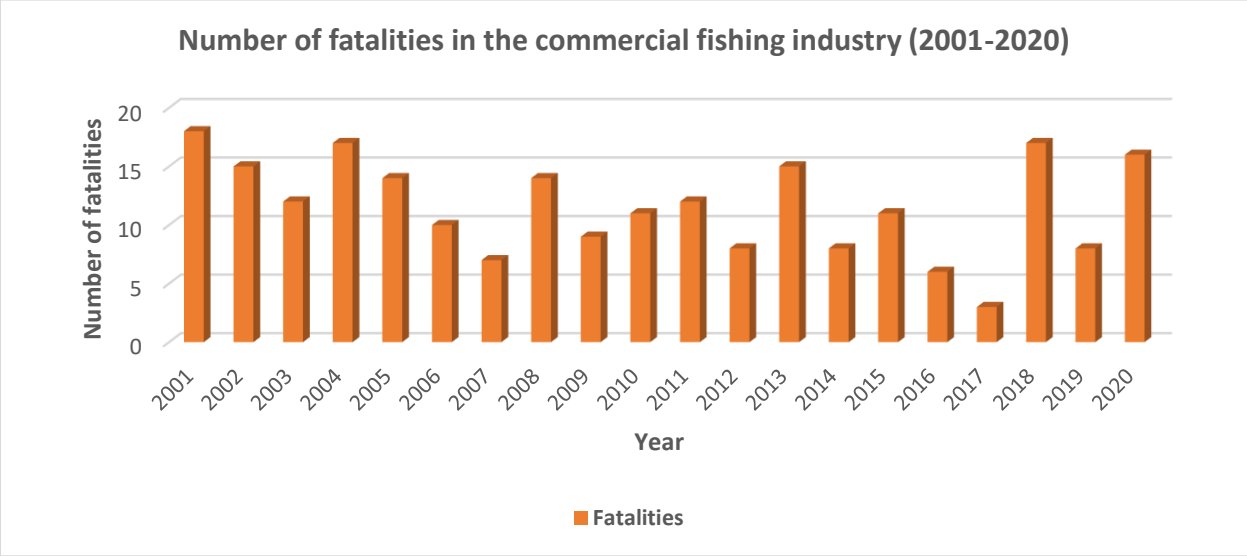

Figure 12-This bar graph shows the fishing fatalities in Canada in the period 2001 to 2020.

3.7 TSB Investigations (2010-2020)

As of early 2022, the TSB has completed and released 39 reports of its investigations into fishing accidents since 2010. Of these investigations, 31 were for small fishing vessels, seven for large fishing vessels, and one was for commercial sport fishing. Most of the investigations into small fishing vessel accidents (8) were made for accidents in 2018, followed by those in 2015 (4). The rest of the reports cover accidents from 2010 to 2020. The investigated accidents include collision, capsizing (10), floodings (3), taking on water (2), grounding (4), mechanical failure (1), person overboard (5), fire (2), and loss of vessel at sea (1). These accidents combined resulted in the sinking of 15 fishing vessels and 32 fatalities. Except for two, the fishing ships involved in these accidents are all small fishing vessels (less than 20.4m in length); most of them are in the (10-13m/35-45ft) category, followed by those under 10m (35ft) in length. In terms of

these ships' age, the majority have unknown age, followed by 30 years and older. The Atlantic region had most of these accidents (Nova Scotia 7, Newfoundland 4, Quebec 4), followed by the Pacific region (British Columbia 7). Safety issues identified in these investigations are grouped under the nine themes as seen in Figure (14) and Table (1).

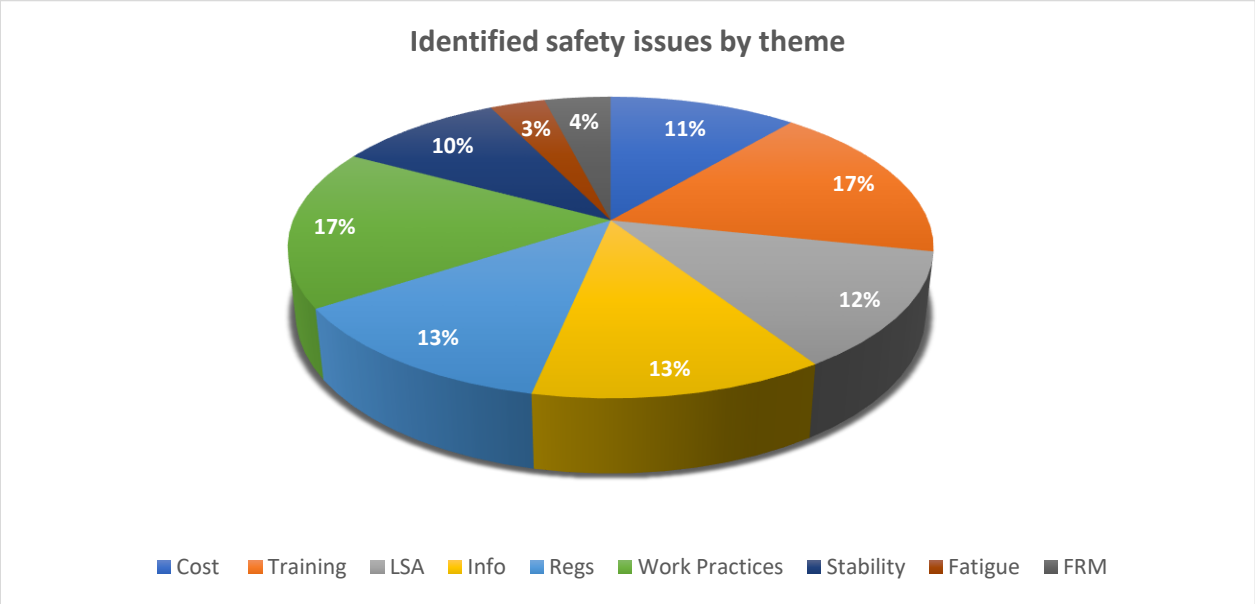

Figure 13-This pie chart shows the distribution of safety issues identified in the TSB investigation into fishing vessels accidents for the period 2010-2020.

As shown in table 1, safety issues are interconnected, and every accident involves multiple root causes that interact to create an unsafe environment allowing for accidents to occur. Although issues with stability and lifesaving appliances significantly contribute to most fatal fishing accidents, they do not exist in isolation and are often influenced by other factors. These factors that contribute to the safety deficiencies regarding vessel stability and the use and carriage of lifesaving appliances include fisheries management policies by the DFO (Vessel

length limitation and fishing season opening and closing times etc.), lack of training and safety drills, inadequate knowledge of ship stability and applicable regulations, fatigue, commercial pressure, and cost of acquiring safety equipment and their maintenance. Additional causes include fish harvesters, fishermen' attitude, lack of enforcement, and the absence of adequate safety regulations.

Chapter 4: Discussion

Fishing remains the deadliest occupation in Canada, with fatal occupational injuries at 27.32 per 100,000 workers (Canadian Occupational Safety, 2021). Over the examined period in this research project (2011-2020), the number of fishing vessels and the number of fish harvesters continued their long-term downtrend, most notably in the Atlantic region, which saw a 12.4 % decline in the number of registered fishing vessels since 2011. Similarly, the Pacific region's fishing vessel fleets declined by 19.5%. This decline in the number of registered vessels is primarily driven by a decline in ships with lengths of 10m (35ft) and less as they make up the bulk (92%) of the Canadian commercial fishing fleets. The drop in the number of active ships and fish harvesters in the past decade is accompanied by a drop in fishing accidents and fatalities among fishermen. For instance, average fishing accidents rate (the number of fatal accidents per 1000 active vessels) in the four-year period (2017-2020) is 5.5 while in the same period from 2007 to 2010 it was 7.4. These statistics show some improvements in the safety condition in fishing industry; however, the risk of fishermen losing their lives while at sea remains high. Factors such as vessel stability, age, and size played a significant role in the fishing accidents and their severity. For instance, grounding accounts for almost half of the reported fishing accidents (2011-2020), yet it represents only a fraction of fishing fatalities, most resulting from vessel stability accidents such as sinking, capsizing, and falling overboard. Additionally, small fishing

vessels under 15 GT make up about half of the total lost ships, while those in the 15-59 GT category represent a third, and the remaining are between 60-149 GT. Old fishing vessels (30 years and older) and ships with unknown ages account for more than half of the total lost vessels, followed by those between 25 to 29 years old at 14%. Moreover, most fishing fatalities occur in 7.6 m (25 ft) and under vessels. This trend mirrors the findings from the (2000) Canadian Coast Guard (CCG) review of accidents involving Newfoundland registered fishing fleets under 19.8 m (65ft) in length between 1993 and 1999 and TSB statistics of accidents and fatalities involving commercial fishing vessels registered in the same province for the period 2000 to 2015 (TSB, 2015b; Wiseman, 2000b).

The TSB has monitored safety in the commercial fishing industry for decades, and in 2010 fishing safety was included in the TSB watchlist for the most critical safety issues in the transportation sector that pose significant risks to Canadians. The high number of fatalities (an average of 13 each year) in marine accidents involving commercial fishing vessels from 1999 to 2008 triggered the TBS to conduct a broad safety issues investigation (SII) into fishing accidents in 2009. In this investigation, the TSB identified various issues impacting safety in the Canadian commercial fishing industry. These issues include modifications impacting vessel stability; not donning or lack of carriage of lifesaving and distress alerting equipment; lack of regulatory oversight; negative impacts of fishing resource management plans and policies; inadequate training; lack of risk management; lack of awareness of safety information and compliance with safety regulations; and lack of industry code of best practices and safety culture. The identified issues were grouped under ten main safety issues (themes): stability, lifesaving appliances, training, cost of safety, safe work practices, regulatory approach to safety, fisheries resource management, safety information, fishing industry statistics, and fatigue. Safety deficiencies

identified in the study period (2010-2020) are similar to those identified by TSB in its (2009) broad SII investigation.

4.1 Inadequate vessels stability

As defined by TC, vessel stability is "the measure of its ability to withstand high winds, waves and other forces resulting from its operations (lifting, trawling, towing, etc.) and resist capsizing by returning to an upright position after being heeled over" (Transport Canada, p1, 2019). A vessel's stability is impacted by various factors that include inadequate vessel design, using the vessel in areas or in operations the vessel was not designed for, modifications of ship structure to alter its size or adding anti-roll devices (Anti-Roll Tank and paravane stabilizers), weight creep (accumulation of fishing gear, equipment, spare parts and stores overtime), windage, and free surface effect caused by inadequate load distribution (Engineers Canada, 2022; Transport Canada [TC], 2013; WorksafeBC, 2022). According to the TSB statistics, about 80% of deaths on fishing vessels are related to stability, such as vessel capsizing, sinking, foundering, or falling overboard (Transport Canada, 2018). Stability issues are prevalent in small fishing fleets. This type of fishing vessel has been exempted from safety requirements like conducting stability assessment, the provision of adequate information on stability to the crew, and exemption of the requirement to undergo regular TC inspections (15GT and under) and other requirements that apply to large fishing vessels and are more prone to swamping and capsizing in rough weather conditions (Obeng et al., 2022; TC, 2017; TSB, 2016).

Issues jeopardizing vessel stability persist in the Canadian commercial fishing industry. In recent (2010-2020) investigations into shipping accidents involving small fishing vessels, the TSB identified the following stability issues that played a direct or indirect role in the majority of accidents it investigated: vessel modifications; overloading and improper load distribution;

inadequate vessel design; absence of stability booklets onboard ships, stability information not being presented in a practical and clear format and no official guidelines to ensure they are presented in such manner, ship current configuration and type of operation are not reflected in the stability booklet, and fishermen lack understanding of stability principles and how to use stability information for effective risk management; and sailing in poor weather conditions (TSB, 2010, 2011, 2012b, 2012c, 2018f, 2018b, 2018a, 2018e, 2019a, 2020b).

4.1.1 Vessel design and modification

Fishermen modify their vessels for regulatory compliance, economic, operational, or other purposes. These modifications often impact vessel stability and put the vessel and its crew at risk (TSB, 2018d). For example, the fishing vessel Charlene A added a permanent stern ramp extension with a hinged tailgate to increase the vessel's length for carrying fishing gear. This modification altered the vessel's center of gravity and changed its trim and stability from the original condition. Additionally, the initial protection offered by the vessel's transom against water ingress over the stern diminished (TSB, 2018d). While on its way to lobster fishing grounds, Charlene A rapidly took on water over the tailgate, decreasing the freeboard and allowing downflooding to occur. Eventually, the vessel sank off the coast of Nova Scotia. In this occurrence, the Charlene A master had neither conducted an assessment before the modifications to determine if the vessel had enough reserves of stability for safe modification nor conducted an assessment after the modifications as required.

Similarly, the fishing vessel Five Star had a stern extension, and the fishing vessels Pacific Siren and Jessie G underwent modifications to carry different gear for multiple fisheries and to comply with length restrictions set out by the type of fishing license they had (TSB, 2012b, 2012c, 2014). The Five Star and Pacific Siren capsized and sank, and Jessie G capsized

and grounded, all in British Columbia. None of these vessels had its stability formally assessed, the modifications recorded or reported despite being required by TC as detailed in Ship Safety Bulletins SSB 04/2006 (Safety of Small Fishing Vessels: Information to Owners/Masters about Stability Booklets) and SSB 01/2008 (Fishing Vessel Safety Record of Modifications) that were in effect at the time of the occurrence of these accidents (TC, 2006, 2008).

Fishing vessels built to standards have the required buoyancy and stability to operate in different weather and operations conditions (TC, 2018b). However, those that are built to no standards often have compromised stability and are more likely to be involved in serious accidents. In 2019 an unregistered fishing vessel capsized off the coast of NS due to poor weather conditions and its unconventional structure that was built without engineering drawings, a lines plan, or any standards (TSB, 2019d). Moreover, its stability limits were unknown, and no stability assessment was conducted when the vessel was built or after. Stability issues in rough weather conditions are not inherent to just fishing vessels with unstandardized construction; they also involve widely accepted vessel designs such as undecked vessels. The watertight hull provides stability and buoyancy for the undecked vessel, such as the Pop's Pride, making it more vulnerable to swamping when water is shipped over the sides. Additionally, as this type of vessel does not usually have additional flotation in the form of airtight compartments, no inherent buoyancy that would allow it to remain afloat in the event it capsizes or gets swamped is provided. The issue of constructing fishing vessels in ways that do not follow standards has not changed much in the past number of decades. However, the federal government is focusing phase two of the new fishing Vessel Safety Regulations (FVSR) on fishing vessels construction requirements.

4.1.2 Unsafe Operation Practices

Overloading a vessel beyond its allowable safe limits is one of the most common safety issues impacting vessel stability. Fishermen knowingly and unknowingly load their vessels past their load limits and adversely impacting the vessel's ability to stay afloat in varying sea conditions. The issue of fishing vessels overloading can be seen in recent stability-related shipping accidents. In 2018 the fishing vessels Atlantic Sapphire sank in NS, Western Commander sank in BC the same year, and in 2016, Pop's Pride in NL. Overloading was the primary contributing factor in all these accidents. The geographical distribution of these accidents signifies that the practice of overloading fishing vessels with cargo, gear, supplies, spare parts, and stores is not a region-specific issue but rather a common problem across the country. The Atlantic Sapphire load, at the time of the occurrence, exceeded the vessel's full load condition by nearly 19 long tons. This excess weight consisted of fuel, fish, freshwater, and ice (TSB, 2018e). Although the stability booklet provided information about the safe load of the vessel, the crew frequently caught more fish than deemed safe, disregarding the risk of downflooding and capsizing posed by this practice. Unsafe working practices in the commercial fishing industry have improved in recent years due to safety campaigns and other initiatives directed at enhancing fishing safety culture. Nevertheless, this improvement is insufficient, and many fishermen get injured or lose their lives due to unsafe work practices. In the case of the Western Commander, the crew loaded the vessel with urchins in bags of different sizes and shapes. Some of these bags were stacked on the vessel's hatch covers as they did not fit through hatches, consequently blocking access to the lazarette and holds and eliminating the ability to identify water ingress or use portable pumping arrangements in these areas (TSB, 2018f). Additionally, the urchin bags stacking on top of the hatches affected the vessel's stability by

raising the center of gravity and reducing freeboard, making the vessel susceptible to downflooding. Safety concerns concerning unsecured or inaccessible hatches have been raised in various TSB investigations, and a recommendation (M00-06) was issued to address this safety issue over 20 years ago (TSB, 1998). Unlike the Atlantic Sapphire, the Western Commander's stability booklet did not reflect the vessel's current configuration and operation of transporting urchins as it was made for the ship when it was used for catching and transporting herring.

Similarly, Pop's Pride stability was compromised by the excessive load while also sailing in rough weather conditions. Carrying loads beyond a vessel's safe limits, especially on undecked vessels such as the Pop's Pride, makes a vessel more vulnerable to swamping since its reserve buoyancy and stability can be adversely impacted by reduced freeboard or the height of the downflooding points (TSB, 2016b). In addition to the unsafe work practice of overloading, some fishermen operate their vessels in a manner that jeopardizes vessel stability and puts them at risk. An example of these practices is facing sea swells by the stern, especially when hauling fishing gear in rough weather conditions. This practice has contributed to several capsizing and sinking accidents (TSB, 2017b, 2018a, 2020c). When the vessel faces the coming waves by the stern, the stern is more likely to be swamped and the vessel to be flooded as the stern is not designed to provide the same protection the bow provides against sea waves (The United Kingdom Marine Accident Investigation Branch [MAIB], 2015; TSB, 2020c). The adverse effects on vessel stability and fishermen' safety by these unsafe operation practices are exacerbated by sailing in poor weather conditions. For instance, when the Pop's Pride sank, it was sailing in a 25-30 knot wind and seas of up to 2 m weather conditions. In about two-thirds of the fishing accidents investigated by TSB since 2011, poor weather had a direct or indirect role in these accidents.

4.1.3 Stability Assessment and Information

A common issue that has been identified in most stability-related fishing accidents is the lack of stability assessment during the construction of the vessel, after modifications and throughout the service life of a vessel, in addition to the inadequacy of the stability information if provided. In 2017 the small fishing vessel Miss Cory capsized and sank off the coast of BC due to progressive downflooding and a raised centre of gravity caused by increased load on the vessel's boom. Miss Cory did not undergo any stability assessment for operations using the boom although it was required by TC, and no information regarding this was provided in the vessel's stability booklet. Therefore, the vessel's crew had no means to recognize that the load they put on the boom would cause the vessel to list and capsize rapidly. Following this accident, the TSB reviewed the stability booklets for Miss Cory and 37 other vessels operated in the 2017 fishing season and found that over two-thirds of these booklets were older than 20 years, the vessels' lightship weights were not verified, and none of the 38 booklets contained information for loading conditions for boom operations (TSB, 2017a).

Furthermore, Miss Cory's crew was not aware of the importance of watertight compartments to stop progressive flooding or the adverse effects of a raised centre of gravity on the vessel's stability, and only one crew had taken stability education provided by the BC Fish Safe program. These findings were not unique to Miss Cory, as numerous other vessels had stability assessment and information issues. Many fishermen lack the understanding of stability principles and lack awareness of available stability education tools. Between 2013 and 2018, the TSB investigated stability-related fishing accidents that resulted in 21 fatalities and found that most of these accidents were due in part to stability information not being available, not current, or were not presented in a clear and practical format for the crew to understand (TSB, 2019d).

Until very recently, TC has not established any guidelines to ensure that the information provided in small fishing vessels' stability booklets is presented in a clear, easy-to-understand and practical format despite the TSB's (M94-33) recommendation titled "Guidelines for small fishing vessel stability booklets" which was issued almost three decades ago (TSB, 1990b, 2019c). Although TC has required fishermen to undergo formal training to obtain a Fishing Master Class certificate since 2007, this training can be ineffective when it is not applied or when fishermen do not know the stability limits of their vessels due to the lack of stability assessment. Furthermore, despite the boom being integral to some fishing operations, TC requirements for stability booklets do not include a requirement for a routine assessment of the use of boom (TSB, 2017a). TC's Transport Publication (TP 7301), titled "Stability, Subdivision and Load Line Standards" (1975), lists the requirements for stability assessment for fishing and other types of vessels (TC, 2019a). However, the requirements to undergo an inclining test, develop and provide stability information (stability booklet) of the vessel in specified loading conditions and carry the booklet onboard the vessel applies only to large fishing vessels (TSB, 2017a). Small fishing vessels must undergo a stability assessment and have a stability booklet on board only if they are involved in caplin or herring fishing, and the ship was built after 1977 or has undergone significant modifications.

Additionally, the new Fishing Vessels Safety Regulations (FVSR) require that a vessel (new and existing) of 9 m or more in length undergo stability (complete or simplified) assessment by a competent person if it is fitted with anti-roll tanks or has undergone modifications or repairs that changed its size and capacity, substantially changed any system onboard or a change in activity that likely to adversely affect the vessel's stability or watertight integrity from the coming to force date of the FVSR, 13 July 2017. If a simplified stability

assessment is conducted, a record of stability (stability notice) must be issued to the vessel, and if a full stability assessment is conducted, a stability booklet must be prepared and kept on board (TC, 2018a). To reflect the changes brought by the FVSR, TC replaced SSB 01/2008 with SSB 03/2019, which is titled: "Fishing Vessel Safety Regulations: Stability, major modifications and record of modifications" (TC, 2019b). These requirements apply to small (new and existing) fishing vessels of 15-150 GT and 9m to 24.4 meters in length. However, existing small fishing vessels under 15 GT (under 9 m) and new 9 m or under vessels are exempted from the requirement to undergo any assessment for stability, buoyancy, and flotation or carry stability information. Moreover, although fishing vessels' stability is adversely affected by frequent modifications throughout their life span to suit the needs of different fisheries, they are not required to undergo surveys to verify changes in their lightship weight and center of gravity that could impact their stability, as required for passenger ships (TC, 2017; TSB, 2017a). Most fishing vessels in Canada are under 15 GT. Exempting them from the stability requirements means that most fishing vessels will continue to operate without a stability assessment and information that would have been provided through it. Consequently, fishermen will have no means to determine their vessels' safe operating limits to ensure that their operating practices do not compromise vessel stability and will likely continue unknowingly putting their vessels and themselves at risk. Authorities have often left this category of fishing vessels in a regulatory "no man's land," which has contributed negatively to the poor safety in the commercial fishing industry (Wiseman, 2000a). Therefore, TC should exercise its mandate to include vessels not exceeding 15 GT in periodic inspection requirements and eliminate any exemptions of the requirement to have stability assessment for vessels built after 2017.

The stability issues are linked to other problems such as lack of training. Several TSB investigations found fishermen's lack of knowledge of stability to be a factor in fishing accidents. This factor is also highlighted by Davis et al. (2019) in their study exploring the relationship between the causes of the fishing vessel capsizing and crew stability training. They found a strong link between fishermen's knowledge of stability and the quantity of formal training they had received and capsizing accidents. Those who have undergone stability training were better at avoiding or controlling potential vessel capsizing situations. Human error has been blamed for many capsizing accidents of fishing vessels, and fishermen who have no stability training were more prone to make errors based on a lack of information or common misconceptions about the vessel's stability. TC requirements for stability and other training to obtain a certificate, a training certificate for Fishing master and any other person in charge of the deck watch came into effect gradually. In 2008 the requirements came into force for vessels with LOA of over 15 m (49 ft 02 in); in 2009 for vessels with LOA of over 14 m (45 ft 11 in); in 2010, vessels with LOA of over 13 m (42 ft 08 in); in 2012 vessels with LOA of over 12 m (39 ft 04 in); in 2015 vessels with LOA of over 6 m (19 ft 08 in); and in 2016 vessels of all lengths. Additionally, TC, in collaboration with FishsafeBC, have approved a stability training program for fishermen and issued several documents to help fishermen understand stability concepts and how to apply them to their own vessels, including the Small Fishing Vessel Safety Manual (TP 10038), A Best Practices Guide to Fishing Vessel Stability, Fishing Vessel Stability – Make it Your Business handbook and others (TC, 2019 a).

4.2 Issues with Lifesaving appliances

Drowning after falling overboard or entering the water due to a vessel capsizing, foundering, sinking, or flooding is the primary cause of death in Canada's fishing industry (TSB,

2012a, 2019d). The absence of lifesaving and distress signalling equipment onboard small fishing vessels and the lack of their use is one of the most concerning safety issues in the commercial fishing industry.

4.2.1 Personal Floatation Device (PFD)

Despite knowing that wearing a lifejacket or personal floating device (PFD) can mitigate the consequences of being immersed in the water and increase fishermen' chances of survival, many fishermen fail to use them. The role of PFDs in saving lives at sea is evident in various accidents, such as the recent sinking of an unnamed fishing vessel off the coast of Newfoundland in 2020, in which a crew member who was wearing a PFD survived after spending about 20 hours on the water while the master of the vessel who did not have a PFD on drowned (TSB, 2020c). The TSB has identified the unsafe practice of not wearing a PFD in many of its investigations over the years. The period 2011 to 2017 witnessed 63 fishing fatalities resulting from 47 accidents involving fishing vessels, and almost half of these fatalities resulted from persons falling overboard: PFDs use could not be ascertained in most (80%) of these fatal accidents. In comparison, the period 1999-2010 saw a total of 41 fatalities, of which a third of them were due to falling overboard, indicating an increase in the number of fatalities due to falling overboard in recent years.

Traditionally, small fishing vessels have been exempted from requirements to carry lifesaving equipment such as PFDs and have been only required to carry lifejackets. The issue of the carriage and use of PFDs has been the focus of several TSB recommendations, notably M16-05. This recommendation was made following the investigation into the capsizing of the fishing vessel Caledonian in 2015, calls on TC to require wearing suitable PFDs on commercial fishing vessels without a deck or deck structure and when working on the deck of decked vessels and

that TC develops programs to ensure compliance (TSB, 2015a). The new FVSR partially addressed this recommendation by requiring all persons on board an open-deck fishing vessel involved in a Class 2 Near Coastal voyage to wear a PFD at all times if the vessel does not carry lifejackets (GC, 2021b). This requirement is certainly a significant improvement from previous ones; however, it falls short in addressing risks from falling overboard as it does not require fishermen to wear PFDs at all times and merely carrying lifejackets satisfies the requirement. As highlighted in numerous TSB investigations into fishing accidents, small fishing vessels can capsize very rapidly, leaving little to no time for the vessel crew to don their Lifejackets or PFDs, thus putting them at a higher risk of drowning.

Some of the most recent examples of accidents where fishermen carried lifejackets or PFDs on board but did not have a chance to wear them include the sinking of the small fishing vessels Ocean Star II a couple of miles off Nova Scotia in 2018 and the capsizing of a small fishing vessel C19496NB off the coast of New Brunswick in 2016. Many fishermen do not carry lifesaving (Life jackets or PFDs) onboard, and those who do often carry them for compliance purposes only which is a reflection of both poor safety culture and regulatory oversight and enforcement. Aside from the Quebec Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST) and British Columbia's WorksafeBC, neither TC nor any other provincial regulator of workplace safety requires wearing PFDs at all times on commercial fishing vessels (TSB, 2019d).

Fishermen resist wearing PFDs, citing problems such as the risk of entanglement, discomfort, and the perception that it is not customary to use and impractical. Moreover, fishermen often underestimate the risk of falling overboard. In recent years PFD manufacturers have improved PFD design addressing fishermen' concerns about constant wear and comfort, and

there is a variety of PFDs options in the market that can always be worn without restriction to movement, unlike lifejackets. However, many fishermen have not changed their attitude towards using the PFDs and continue to work on deck without wearing them even when they are available. In their study to predict PFD use among fishermen in Alaska, Davis et al. (2019) found that fishermen who believe PFDs are an entanglement hazard or interfere with work are less likely to use them.

Additionally, they noted that fishermen' use of PFD may increase if they are familiarized with newer ones that have been tested and accepted by their peers. Fishermen' resistance to wearing PFDs also comes from their attitude toward safety, which is characterized by trivializing risks and accepting them without taking any safeguard measures. This attitude was displayed during the sinking of the small fishing vessel Bessie E. in 2016, in which the crew abandoned the vessel without donning their lifejackets or PFDs (TSB, 2016a).

Various education and awareness initiatives and programs were created within the fishing community to promote the use of PFDs. These initiatives include Fish Safe's "Real Fishermen" campaign in British Columbia, which uses promotional materials featuring fishermen wearing PFDs (FishSafeBC, 2020). In Nova Scotia, the Fisheries Safety Association, with consultation with fishermen, planned wharf visits, family pledges, school poster contests, and advertising to increase awareness of the importance of wearing PFD (FishSafeNS, 2021). Additionally, the Safe at Sea Alliance of Nova Scotia collaborated with government and industry representatives in developing a plan for the local fishing industry that aims to improve safety through awareness, education, and enforcement. Even with these initiatives and many others, many fishermen still oppose wearing PFDs.

4.2.2 Anti-exposure and immersion suits

Falling overboard risk to fishermen' safety is not limited to drowning; it also exposes them to cold shock and hypothermia, which can be lethal. When a person falls into the water with a temperature less than 15 °C, they experience cold followed by exhaustion due to trying to remain afloat, which happens rapidly without the help of a PFD (Brooks, 2008). Within 35 minutes from the time a person is immersed in the water, hypothermia can occur, causing body functions to slow down and eventually leading to death (Deussen, 2007). Even if a fisher has donned a PFD, their chances of survival can be reduced the longer they remain in the water without thermal protection or help. These risks underscore the importance of thermal protection, survival suits, and distress alerting equipment. The lack of carriage of thermal protection, immersion suits and distress alerting equipment is widespread in the commercial fishing industry, specifically on small fishing vessels (TSB, 2019d). For instance, the recovered bodies of the Pop's Pride fishing vessel's crew were found wearing PFDs; however, their survivability had been compromised by the amount of time they spent in low-temperature water (TSB, 2016b). This incident is not an exception; it is one of many that the TSB has investigated in the past three decades. In 1990, following the sinking of the fishing vessel Straits Pride II and the loss of life of three fishermen, the TSB made recommendation M92-07 which calls on TC to speed up its revision of the Small Fishing Vessel Inspection Regulations (SFVIR) to require fishermen to carry survival suits or anti-exposure worksuits (TSB, 1990a).

The previous SFVIR had no requirement for small fishing vessels to carry anti-exposure or immersion suits; this, however, changed in 2017 with the coming into force of the new FVSR. The new regulations require fishing vessels of more than 12 m to carry an immersion suit or an anti-exposure worksuit for each person on board if the water temperature is less than 15°C (GC,

2021b). In comparison, fishing vessels less than 12 m in length operating in near-coastal (Class 2) voyages can carry alternatives to anti-exposure and immersion suits. These vessels could carry a life raft or recovery board sufficient to carry the number of persons on board if they chose not to carry an immersion or anti-exposure suit (GC, 2021a). This alternative means fishermen may not necessarily enter the water; however, they may still be exposed to the risk of hypothermia if they are in a cold environment for a long time (TSB, 2021b).

Many fishermen do not comply with the requirement to carry immersion suits due to costs and lack of space to store them, and those who do often do not conduct regular drills to practice using them. Consequently, fishermen may don ill-fitting immersion suits, increasing the risk of drowning or hypothermia. The adverse impact of not conducting safety drills is emphasized in the sinking accident of the fishing vessel Atlantic Sapphire in 2018: two crew members donned immersion suits that were the wrong size which allowed for a significant amount of water to enter their immersion suits (TSB, 2018e). The TSB investigation into this accident identified that the crew did not regularly practice using immersion suits or other lifesaving equipment. Since small fishing vessels are not required to carry out frequent drills or conduct a formal risk assessment, they often lack adequate preparation for emergencies and react to them as they come using their intuition.

4.2.3 Distress-alerting equipment

Providing help quickly to fishermen in distress is very crucial to their survival. However, without carrying an appropriate distress-alerting device, such as a personal locator beacon (PLB) and an Emergency Position Indicating Radio Beacon (EPIRB) that can automatically broadcast a distress signal to search and rescue centers and nearby vessels, the likelihood of receiving timely help may reduce. The delay or the absence of rescue efforts has been identified as a contributing

factor in many fatalities in the fishing industry. From 2010 to 2020, the TSB received ten reports of fatal accidents involving small fishing vessels less than 12m (resulting in 19 deaths) in which none of these vessels had an EPIRB or transmitted a distress signal to SAR resources or other vessels (TSB, 2018c). As accidents such as falling overboard, ship capsizing and sinking can happen rapidly, it is imperative to have an EPIRB on board all small fishing vessels.

In the old SFVI regulations, small fishing vessels were not required to carry distress alerting devices. However, the new Navigation Safety Regulations in 2020 require fishing vessels less than 12 m operating near coastal (Class 2) voyages to carry a float-free EPIRB, a manually activated EPIRB, or a portable VHF-DSC/GPS radio or a 406 MHz PLB (GC, 2021c). These regulations require fishing vessels less than 12m, which are the largest fleets, to carry one of the devices listed above, which may not include an EPIRB leaving fishermen at risk of not receiving help promptly, if at all, in the event of an accident where the crew cannot send an emergency alert manually.

4.3 Government efforts to improve fishing safety

TC is the federal government's department with the regulatory authority over marine transportation in Canada (TC, 2019a). The responsibilities of this department include creating a maritime safety program and setting standards for staffing, registration, and inspection of vessels. This includes licenses, certificates, issuance of registrations and permits, auditing, inspection and monitoring, and enforcement of regulations and standards. TC has been actively working on various regulatory initiatives to improve fishing safety, especially in the past decade. The most significant policy change concerning fishing safety was the introduction of the new FVSR, which amended the previous SFVI regulations and changed its name to FVSR in 2017. The FVSR is a result of extensive consultation with various stakeholders, including fishing

safety associations from across the country, vessel owners, and provincial and territorial safety groups (TC, 2017a). The current FVSR is the first phase of three to modernize fishing vessel regulations. The second phase is updating small fishing vessels' construction requirements, and the third phase is focused on updating the Large Fishing Vessel Inspection Regulations (LFVIR) to have them align with international treaties on fishing safety, mainly the Cape Town Agreement (CTA) (IMO, 2019).

4.3.1 FVSR

The FVSR came into force in July 2017 to amend the decades-old SFVI regulations. The FVSR applies to all Canadian small fishing vessels of up to 24.4 m in length and not exceeding 150 GT. These regulations brought significant changes to the previous regulations. The FVSR now explicitly states that the responsibility for ensuring that vessels meet regulatory requirements lies on authorized representatives and the masters of the vessels. Additionally, it included new requirements for the safe operation of fishing vessels, vessel stability, maintenance and safety equipment, lifesaving appliances, records of modifications and maintenance, and written operational procedures (GC, 2021a).

Concerning fishing vessel stability, the new requirement states that the stability, floatation, and buoyancy of an existing fishing vessel that is not required to undergo a stability assessment should be adequate to safely carry out its intended operation (TC, 2018b). Additionally, fishing vessels of 9 m and more are required to undergo a stability assessment if it is fitted with anti-roll tanks or has undergone significant modifications, and a record of stability must be stored onboard if the vessel underwent a simple stability assessment and it should carry a stability booklet if a full stability assessment were conducted (TC, 2018a). These requirements apply to small (new and existing) fishing vessels that are 15-150 GT and 9m up to 24.4 meters in length;

however, existing (constructed before July 2017) small fishing vessels under 15 GT and vessels (old and new) under 9 m are excluded (TC, 2017; TSB, 2017a).

Additionally, the new FVSR has addressed several TSB recommendations. The M94-33 and M03-07 recommendations regarding the establishment of guidelines for stability booklets and establishing a code of best practices for loading and stability were addressed through the publishing of stability guidelines (TP 15393) and guidelines for fishing vessel modifications or a change in activity (TP 15392), which also includes a form to record modifications (TC, 2018b, 2018a; TSB, 2019b). Additionally, TSB's M00-09 and M92-07 recommendations to TC to require small fishing vessels engaged in coastal voyages to carry an EPIRB or other appropriate equipment were addressed through the 2020 Navigation Safety Regulations, which now require all vessels that are 12 m and under operating on near-coastal (Class 2) voyages to carry a float-free EPIRB, a manually-activated EPIRB, a portable VHF-DSC/GPS radio, or a 406 MHz PLB, and all vessels engaged on near-coastal (Class 1) voyages to carry a float-free EPIRB (GC, 2021c; TSB, 2021a, 2021b). Furthermore, TSB M92-07 recommendation calling on TC to require fishermen to carry survival suits or anti-exposure worksuits was addressed in the new FVSR by requiring fishing vessels greater than 12 m, irrespective of the voyage type, to carry immersion suits or anti-exposure worksuits of adequate size for each individual on board (GC, 2021a; TSB, 2021b). Some of the positive impacts on fishing safety that the FVSR brings include ensuring fishermen have the means to call for help when in an emergency and substantially reducing the length of time they must wait for rescue to arrive. New vessels would have their stability assessed and information readily available for the crew to ensure that their cargo loading, distribution, and other operating practice do not adversely impact the vessel stability and thus mesmerizing the risk of capsizing, flooding, and other stability related risks.

Furthermore, the requirement for carrying immersion or anti-exposure suits will significantly reduce the risk of hypothermia in the event of a fall overboard. The introduction of the FVSR is a great step toward improving fishing safety. However, these regulations will not be effective if federal and provincial regulators do not have adequate oversight and enforcement, especially for small fishing vessels, which have been exempted from the requirements to undergo periodic inspection as large fishing vessels.

Conclusion

The commercial fishing industry in Canada has undergone various changes in the past few decades, and the workforce and number of vessels have been in a steady decline. This decline is also noticed in the number of fatalities and, to a lesser extent, in the number of marine accidents involving fishing vessels since 2010. Work in the past to improve fishing safety, to a large extent, has been unsuccessful particularly before fishing safety was listed in the TSB watchlist. The safety issue in the commercial fishing industry is a multifaceted and complicated problem and addressing safety deficiencies on an issue-by-issue basis in a patch repair approach proved unsuccessful. Issues impacting fishing safety and contributing to fishing accidents are numerous and have not changed in the past decades. This study highlighted two significant issues that directly impact fishermen' health and safety and contribute to most fatal fishing accidents. These issues are inadequate vessel stability and the lack of carriage and use of lifesaving-saving appliances. Since listing fishing safety on the TSB watchlist, the federal government of Canada has made notable progress in improving fishing safety through policy changes. This progress is best reflected in TC's new fishing safety regulations. TC introduced the FVSR a few years back and is currently completing the remaining phases of the modernizing fishing safety initiative. These regulations are expected to make a significant impact on fishing

safety. However, several issues may limit the effectiveness of these regulations to enhance fishing safety. These issues include exempting some small fishing vessels from the new requirements that address stability and lifesaving equipment issues and the lack of oversight and enforcement of these regulations.

Recommendations

Based on the results of this research, the following recommendations are provided to inform policymakers and decision-makers on areas that can be strengthened to address fishing safety.

- TC may utilize DFO data on vessels' landings for oversight of vessel stability, particularly concerning the practice of vessel overloading.
- TC may coordinate with other federal (CCG, CCGA and DFO officers) and provincial (OHS inspectors) authorities in commercial fishing vessels oversight: conducting education, safety promotion and courtesy inspections.
- TC and provincial authorities should consider requiring fishermen to wear suitable PFDs on commercial fishing vessels without a deck or deck structure and when working on the deck of decked vessels.
- TC should consider requiring all existing small fishing vessels to undergo stability assessment after 20 years from their built date, remove exemptions on stability assessment requirements for new vessels, and set a requirement for periodic stability assessment at adequate intervals.
- DFO should consider reviewing its fisheries management policies in consultation with fishermen to identify those that have adverse impacts on fishermen' health and safety

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Appendix I: Fishing accidents and identified Safety issues

This table mentioned in chapter 3 shows the fishing accidents investigated by the TSB from 2010 to 2020 and the safety issues identified in every accident. These accidents are listed chronologically with the most recent at the top.

	Identified safety issues								
Accident type	Cost	Training	LSA	Info	Regs	Work Practices	Stability	Fatigue	FRM
Sinking and loss of life	X	X	X	X	X	X	X		
Capsizing and loss of life	X	X	X	X	X	X	X		
Downflooding and sinking	X	X	X	X	X	X	X	X	
Taking on water and sinking	X	X	X	X	X	X	X	X	
Collision and sinking		X			X	X			
Capsizing			X		X	X	X		
Capsizing with loss of life		X	X			X	X		
Grounding				X	X	X			
Sinking and loss of life	X			X	X	X	X		
Vessel grounding and subsequent fatality			X	X		X	X		
Capsizing	X		X	X			X		
Flooding	X	X		X	X	X	X		
Capsizing and sinking with loss of life		X		X	X	X	X		
Sinking and subsequent loss of life	X	X	X		X	X	X		X
Capsizing and loss of life		X			X		X		
Mechanical failure and sinking		X	X		X	X			

Person overboard and subsequent loss of life		X	X			X			
Loss of vessel at sea with 3 fatalities			X		X				X
Person overboard and subsequent loss of life		X	X			X			
Fire aboard fishing vessel - sinking	X	X			X	X			
Capsizing and subsequent loss of life	X	X	X			X			
Sinking and loss of life		X	X			X	X		X
Man overboard and subsequent loss of life	X	X	X	X					
Grounding and subsequent sinking		X	X		X	X			X
Collision	X	X		X	X	X		X	
Capsizing and sinking	X	X		X	X	X	X	X	X
Capsizing and grounding	X	X		X	X	X	X	X	X
Taking on water and abandonment	X	X	X	X	X	X	X		
Fire and sinking	X	X		X	X	X			
Crew Member Lost Overboard	X	X	X	X	X	X			
Capsizing and sinking	X		X	X	X	X	X		