Maritime Commercial Incidents and Accidents

June 2021

About Us

Clear Seas Centre for Responsible Marine Shipping is an independent, not-for-profit research centre that provides impartial and fact-based information about marine shipping in Canada.

Led by a Board of Directors and advised by a Research Advisory Committee, Clear Seas' work focuses on identifying and sharing best practices for safe and sustainable marine shipping in Canada, encompassing the human, environmental and economic impacts of the shipping industry.

All Clear Seas reports are publicly released and made available at clearseas.org

About this Report

Clear Seas Centre for Responsible Marine Shipping (Clear Seas) conducted this study, **Maritime Commercial Incidents and Accidents**, to better understand the historical record of commercial marine shipping incidents and accidents in Canadian and adjacent waters. This technical report, authored by Clear Seas, conveys the background information on and serves as a reference for users of the *Marine Incidents and Accidents* online dashboard and supporting dataset.

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Message from the Executive Director

Sailing Towards Safer Waters

Biennial surveys by Clear Seas show that the safety of commercial marine shipping is a key concern for Canadians. This is especially true when it comes to vessels carrying oil and other hazardous materials, whether or not it's the cargo or just the fuel oil that propels them.

To enhance the safety of the marine shipping industry, regulators and ship operators try to mitigate foreseeable risks to prevent accidents. They seek to ensure the health and welfare of crews and residents of coastal and Indigenous communities, safeguard fragile marine ecosystems and protect the vessels and their contents making the voyage.

Key to assessing the current risks of marine shipping is understanding the historical record of marine incidents and accidents. Simply, we need to look to what happened in the past to anticipate and prevent what could happen in the future.

While the Transportation Safety Board of Canada (TSBC) maintains a comprehensive database of marine incident and accident information, the data is not easily searchable or readily available in a spatial format. Moreover, it doesn't include many incidents that happen just across the border within the United States (U.S.). This is especially important because some of the heaviest marine shipping traffic areas such as the Salish Sea and Great Lakes include transboundary waters in both Canadian and U.S. territory. With changing winds and tides, disabled ships and pollutants don't respect international boundaries. Luckily the U.S. Coast Guard maintains a similar database to the TSBC, but the data has never been presented together in a single place.

A resource for risk analysts and the public

Clear Seas initiated the *Maritime Commercial Incidents and Accidents* study to fill these gaps and bring information from Canadian and U.S. sources together for the first time in one easy-to-access online location. We produced an interactive web-based dashboard and mapping application which provides a wealth of information to all users, from interested members of the public to professional risk analysts. The data are presented as points on a map and can be filtered by location, the type or level of severity of incident, or the kind of vessel involved. This offers users the opportunity to view and interpret the data in a personalized, meaningful way.

This technical report is intended as reference material for users of the *Marine Incidents and Accidents* dashboard and dataset, providing descriptive information on how they were created, what they contain, their limitations, and other supporting information. It provides the unique definitions for marine incidents and accidents applied in this project, how the Canadian and U.S. datasets were combined, and the relationships between the different source data. In this way, this report serves as a resource for users to apply this data in their own research and analysis.

We are confident that this powerful new resource will enable users to analyze previous trends, allowing them to learn from past events, better assess risk, and help build safer, responsible marine shipping.

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Acronyms and Abbreviations

B.C.	British Columbia
EEZ	Exclusive Economic Zone
GIS	Geographic Information System
IMO	International Maritime Organization
MARSIS	Marine Safety Information System database
MISLE	Marine Information for Safety and Law Enforcement database
NTSB	National Transportation Safety Board
TSBC	Transportation Safety Board of Canada
U.S.	United States
USCG	United States Coast Guard

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Maritime Commercial Incidents and Accidents

1.0 Introduction

Clear Seas completed the Maritime Commercial Incidents and Accidents project to explore the risks related to marine shipping in Canada, in particular marine occurrences. The report outlines the methods used to gather and process data relating to historical marine incidents and accidents that have occurred in and around Canada's navigable waters. In addition, this report introduces the Marine Incidents and Accidents dashboard tool, which was built to provide an interactive geospatial environment in which users may access the marine occurrence data. By presenting marine occurrence data from various sources in a spatial way, this project seeks to support effective marine spatial planning and inform the public on some of the risks related to marine traffic in Canadian waters.

1.1 Purpose

The purpose of this project is to provide a more complete understanding of the marine incidents and accidents that have occurred in, or close to, Canadian waters. Integrating marine occurrence data from Canadian and United States (U.S.) sources and visualizing the data in a spatial environment are some of the ways this project leverages publicly available information to gain insight into the safety of marine shipping. The results from this project can help us understand the risks involved with commercial marine shipping across Canada.

1.2 Scope

This study focuses primarily on marine occurrences in Canada; however, to more fully represent the marine incidents and accidents that could impact Canadian waters, it was important to include marine occurrences happening in adjacent U.S. waters. The study area for this project encompasses all the waters within Canada's Exclusive Economic Zones (EEZs), territorial seas and internal waters, as well as inland waterways where commercial shipping traffic occurs. In addition to Canadian waters, the study area was expanded to involve the EEZs, including the territorial seas, of the U.S. coastal states adjacent to Canada, including Maine, Washington, and southeastern Alaska, as well as the U.S. regions of the Great Lakes.

Figure 1. Maritime Commercial Incident and Accidents Project Study Area

Although Canada also shares maritime boundaries with Greenland and Saint Pierre and Miquelon, these jurisdictions do not have publicly accessible government databases for marine occurrences. Therefore, data on marine occurrences in the waters of the Greenland and Saint Pierre and Miquelon were not recorded. While this study focuses on data from government sources, there are additional sources that record marine occurrence information, such as marine insurance companies and Lloyd's Register. These sources are not usually publicly accessible, and therefore were not included in this project.

Marine occurrence data were gathered primarily from the Marine Safety Information System (MARSIS) and Marine Information for Safety and Law Enforcement (MISLE) databases, maintained by the Transportation Safety Board of Canada (TSBC) and the U.S. Coast Guard (USCG), respectively. Marine accident investigation reports from the TSBC and the U.S. National Transportation Safety Board (NTSB) and other government data sources were used to supplement the database extracts.

Marine occurrence records from January 2009 to December 2018 were gathered for this study. This time period was selected to understand the most recent available statistics for incidents and accidents, while still incorporating enough data to analyze historical trends over the years. At the time of the project, data was not available after August 31st, 2019, for some MARSIS database outputs, so December 2018 was chosen as the end of the study's time frame. Future iterations of the dashboard and dataset could include updated marine occurrence data as they become available.

For this project, only commercial shipping vessels, ferries, and cruise ships are included in the study. The types of commercial shipping vessels include various types of solid and liquid cargo ships, tugs, and barges. Fishing vessels (both commercial and non-commercial), government vessels, pleasure crafts, and other types of vessels are not included in the dataset. While Clear Seas is focused on issues related to commercial marine shipping traffic, the visibility and importance of ferries and cruise ships justifies their inclusion in this dataset. Incidents involving small passenger vessels, like harbour passenger ferries and non-ocean-going cruise ships, are excluded. For some parts of the country, these smaller passenger vessels make up a significant amount of traffic and incident reports. In the future, a more comprehensive analysis that includes these vessel types may be completed.

2.0 Characterization of Marine Incidents and Accidents

2.1 Recording and Investigating Marine Occurrences

The processes and policies on reporting marine incidents and accidents vary around the world. In Canada, any marine occurrence that meets the criteria outlined in the TSBC must be reported to the TSBC. All incidents or accidents occurring in Canadian waters, or those occurring in foreign waters but involving Canadian vessels, must be reported. In the U.S., a marine casualty that meets the criteria outlined in Title 46 Code of Federal Regulations (CFR), Part 4.03-1 must be reported to the USCG. Any occurrence that happens in U.S. waters or in foreign waters but involving an American vessel must be reported. Both the TSBC and the USCG encourage the master, owner, operator, or person in charge of the vessel involved in the occurrence to file a written report as soon as possible. For the TSBC, a written report should be submitted no later than 30 days after the reportable marine occurrence. For the USCG, a written report should be filed within five days. Both organizations provide downloadable versions of the marine occurrence report template online, which can be submitted by email, fax, or courier.

To develop the marine incidents and accidents dataset used in this project, Clear Seas gathered information from the TSBC's MARSIS database, and the USCG's MISLE database:

- MARSIS database[1]: The TSBC gathers and reports information on marine incidents and accidents in Canadian waters, and in foreign waters involving Canadian vessels. The data is available publicly, in table format, on the TSBC website. Multiple tables can be downloaded and linked together through unique occurrence identifiers and vessel identifiers, creating a detailed record for vessels involved in marine incidents and accidents. The TSBC's regulations on reporting marine occurrences were updated in 2014, resulting in improvements to reporting and data collection for marine occurrences (TSBC, 2016).

- MISLE database[2]: For vessels involved in marine incidents and accidents in U.S. waters, or American vessels involved in marine occurrences abroad, the USCG gathers data and reports on marine occurrences. The MISLE database is maintained by the USCG and contains information on marine casualties for the last several decades up to 2015. Data extracts are publicly available in table format, through the Marine Casualty and Pollution Data for Researchers website, hosted by the USCG and the U.S. Department of Homeland Security. Additional marine casualty information for years after 2015 can be accessed by submitting a Freedom of Information request, which may be fulfilled through the U.S. Department of Homeland Security.

Clear Seas also gathered information from investigation reports on marine occurrences, which are published by the TSBC in Canada, and the NTSB in the U.S. Depending on the circumstances and

[1] MARSIS database available here.
[2] MISLE database available here.

outcomes of a marine occurrence, an investigation may be required. The TSBC will conduct an investigation if there is a high probability that the investigation can "advance transportation safety and reduce risks to persons, property or the environment" (TSBC, 2013). Investigation reports are published separately from the MARSIS database extracts, located on the TSBC's Marine Transportation Safety Investigations and Reports web page. In the U.S., investigations into marine casualties are performed by the NTSB, not the USCG. The investigation reports are published online and are accessible for download through the NTSB Accident Reports website. Investigation reports from the TSBC and the NTSB contain an in-depth look into the causes and outcomes of an occurrence. Only a small percentage of marine incidents and accidents warrant investigation reports.

2.2 Defining a Marine Incident, Marine Accident, and Serious Marine Accident

The definition of a marine incident or accident differs between countries and reporting organizations, making it challenging to combine data sources and compare statistics internationally. Because Canada and the U.S. do not define or report marine occurrences the same way, aligning and integrating marine occurrence information from the various data sources was essential for this project.

The International Maritime Organization (IMO) (2008) defines a **marine casualty** as an event, or multiple events, that results in one of the following:

- A person being seriously injured, killed, or gone overboard.
- The loss or abandonment of a ship.
- Material damage to the ship or the marine infrastructure around the ship.
- The stranding or disabling of a ship, or a collision involving a ship.
- Severe damage to the environment from a ship, or the potential for severe damage.

According to the IMO, a **marine incident** means "an event or sequence of events, other than a marine casualty, which has occurred directly in connection with the ship, its occupants, or any other person in the environment" (2008). **Very serious marine casualties** are events where there was a total loss of a ship, a death, or severe damage to the environment (IMO, 2008).

In Canada, the TSBC defines a reportable **marine occurrence** as an incident or accident occurring within Canadian waters or in foreign waters involving a Canadian flagged vessel. While there are two categories for marine occurrences, **marine incidents** and **marine accidents**, there is no classification for serious marine accidents. However, some occurrence records found in the MARSIS database include information on the level of seriousness recorded by the IMO. Marine incidents tend to be less severe; examples include situations where there is a risk of an accident, a failure of a system or machinery onboard, or the loss or shifting of cargo. Examples of marine accidents include a collision, grounding, sinking, or fire onboard. For a more in-depth overview, visit the TSBC's policy on occurrence classification.

In the U.S., the USCG defines a **marine casualty** as an event involving a vessel occurring within U.S. waters, or in the waters of its territories and possessions, or in foreign waters involving an American vessel (46 CFR-4.03-1, 2005). Examples of a marine casualty include the loss of power or propulsion of a vessel, any event that results in harm to the environment, or the stranding of a vessel. **Serious marine**

incidents are defined as an event that results in one or more deaths, damage to property over $100,000, a discharge of oil of 10,000 gallons or more, and more (46 CFR-4.03-2, 2018).

The definitions of marine occurrences and casualties are generally similar between the TSBC and the USCG. However, minor differences in word choice and unique occurrence types from both organizations necessitate the alignment of the data by Clear Seas. In the context of this project, Clear Seas uses the following terms to describe marine incidents and accidents:

- **Marine occurrence**: Refers to any marine incident, accident, event, or casualty that has been recorded by the TSBC or USCG.
- **Marine accident**: Refers to any marine occurrence that presents a more serious risk of damage to the ship and/or the environment. The occurrence types classified as accidents by Clear Seas are also classified as accidents by the TSBC, which supports this classification strategy. Marine accidents also include any occurrence, regardless of occurrence type, that is identified as a serious marine accident, based on the Clear Seas classification.
    - **Serious marine accident**: Refers to a marine occurrence with serious impacts, particularly in terms of damage to the ship, damage to the environment, or other damage. The following criteria were used to define a serious marine accident:
        - A marine occurrence (i.e., incident or accident) that resulted in a TSBC or NTSB investigation.
        - A marine casualty identified as a serious marine accident in the USCG MISLE database extract.
        - A marine occurrence with an IMO Classification of "Serious Incident" or "Very Serious Incident" according to the USCG reports, or an IMO Class Level of "Very Serious Marine Casualty" according to the MARSIS database.
- **Marine incident**: Refers to any marine occurrence that is not an accident or serious accident. Incidents are perceived to be less severe than accidents.

The definitions for marine occurrences and casualties from the IMO, TSBC, and USCG all account for events where people experience injury, loss of life, or are sent overboard vessels. For this project, people-related incidents or accidents are out of scope, since this work is not intended to analyze passenger and crew safety.

2.3 Marine Occurrence Data Alignment – TSBC and USCG

Because the TSBC and USCG classify marine occurrences differently, Clear Seas developed a classification process to align the data from both sources. Table 1 shows the alignment of occurrence type categories.

Table 1. Data Alignment of Marine Incident and Accident Categories, Ranked by Seriousness of Occurrence as Defined by Clear Seas

Rank	Clear Seas Incident or Accident	Clear Seas Occurrence Categories	TSBC Occurrence Categories	USCG Occurrence Categories
1	Accident	Sank	• Sank	• Sinking
2	Accident	Capsize	• Capsizes	• Capsize
3	Accident	Explosion/fire	• Explosion • Fire	• Explosion • Fire – initial
4	Accident	Collision	• Collision	• Collision
5	Accident	Grounding	• Grounding	• Grounding
6	Accident	Allision	• Striking	• Allision
7	Incident	Flood	–	• Flooding – initial • Flooding – progressive
8	Incident	Sustains damage render unseaworthy /unfit for purpose	• Sustains damage render unseaworthy/unfit for purpose	–
9	Incident	Total failure of any system	• Total failure of any machinery or technical system	• Loss of electrical power • Loss/reduction of vessel propulsion/steering • Material failure/malfunction
10	Incident	Cargo shift/ damage/loss	• Cargo shift/cargo loss	• Cargo/fuel transfer/shift • Damage to cargo • Loss of stability
11	Incident	Fouling	• Fouls underwater object	• Fouling
12	Incident	Risk of incident (e.g., capsizing, collision, grounding, sinking, striking)	• Risk of capsizing • Risk of collision (near collision) • Risk of grounding • Risk of sinking • Risk of striking (near allision)	• Set adrift • Vessel yawl/pitch/roll/heel • Wave(s) strikes/impacts
13	Incident	Bottom contact	• Bottom contact	–
14	Incident	Other	• Dangerous goods released • Intentional beaching /grounding/anchoring to avoid occurrence	• Discharge/release – pollution • Vessel maneuver • Abandonment

A ranking system was developed by Clear Seas to create a hierarchy of incident and accident types in the new dataset. This ranking system was designed to identify the most severe occurrence, if multiple different types of occurrences were reported for the same event. In the TSBC and USCG databases, multiple records could be found for the same vessel in the same occurrence, with different occurrence types listed. In order to create an integrated dataset with one record per vessel per incident or accident,

the record listing the most severe occurrence type was selected and any other occurrence types were listed in the record as secondary or tertiary occurrence types using additional fields. If more than three occurrence types were listed for a single vessel in a single occurrence, only the three most severe occurrence types were included for the record.

As seen in Table 1, there are 14 marine occurrence types that contain a value of 1 (the least serious) to 14 (the most serious). The marine occurrence types were ranked according to their designation by the TSBC as a marine incident or accident, and their perceived severity by Clear Seas. Examples of the most serious accidents include sinking, capsizing, and grounding of vessels. Some less serious examples of incidents include abandoned vessels, a vessel making contact with the bottom without running aground, and a vessel at risk of an incident.

For example, if a vessel grounded and then sank, there could be two entries for the same vessel in the TSBC database: a record with a 'Grounding' value in the Occurrence Type category and a record with a 'Sank' value. In the Clear Seas dataset, there would be one record for this vessel, and it would be categorized as 'Sank', because it ranks higher than 'Grounding'. 'Grounding' would be listed as a secondary marine occurrence type in an additional field.

3.0 Characterization of Vessels

3.1 Vessel Types and Subtypes

Although many other types of marine traffic exist within Canadian waters, only vessels involved in the transportation of people and goods, at a commercial level, were included in this project. Cargo ships, including bulk carriers, vehicle carriers, container ships, tankers, and other cargo ships, are all included in this dataset. Tugs and barges are also included, as well as ferries and cruise ships.

Examples of vessels that are not included in this dataset are research vessels, sailing vessels, pleasure crafts, fishing vessels, small passenger vessels that are not ferries or ocean-going cruise ships, and more. While some of these types of vessels make up a significant portion of reported marine incidents and accidents in Canada, they are not involved in marine shipping activities, or as highly visible to the public, and thus are out of scope for this project.

3.2 Vessel Type Data Alignment – TSBC and USCG

Because the TSBC and USCG classify vessels differently, Clear Seas developed a classification process to align the data from both sources. The vessel type categories include tugs, barges, cargo ships, ferries, and cruise ships. The cargo ships are broken down into subtypes: bulk carriers, vehicle carriers, container ships, tankers, and other.

Table 2. Aligned Vessel Categories for the Combined Dataset

Aligned Clear Seas Vessel Categories	TSBC Vessel Categories	USCG Vessel Categories
Barge	• Barge – Cargo Solid, Cargo Liquid, Other, Self Dumping	• Barge
Cargo – Bulk Carrier	• Cargo – Solid – Bulk Carrier	• Bulk Carrier
Cargo – Vehicle Carrier	• Cargo – Solid – Ro-Ro Cargo	• Ro-Ro Cargo Ship
Cargo – Container Ship	• Cargo – Solid – Container Ship	• General Dry Cargo – Container Ship
Cargo – Other Cargo	• Cargo – Solid – General Cargo, Dredger/Hopper, Refrigerated Cargo	• General Dry Cargo Ship – General, Heavy Load Carrier
Cargo – Tanker	• Tanker – Chemical/Ore/Oil/Crude • Tanker – Other • Cargo – Liquid – Product Tanker, Chemical Tanker, Crude Tanker, Combination Carrier, Liquefied Gas Carrier, Chemical/Product Tanker	• Tank ship
Ferry[1]	• Ferry	• Passenger (Inspected) – Ferry
Cruise[2]	• Passenger	• Passenger Ship (Uninspected) – General • Passenger (Inspected) Ocean Cruise Vessel • Cruise Ship Launcher/Tender
Tug	• Tug	• Towing Vessel

[1] All records were reviewed and filtered to include only ferries.
[2] All records were reviewed and filtered to include only ocean-going cruise ships.

4.0 Creating the Dataset

4.1 Defining the Timeframe, Study Area and Map Regions

For this project, it was necessary to gather historical marine occurrence data that was recent enough to reflect the current state of marine traffic while still providing a comprehensive dataset. A lack of complete data after 2018 and concerns around the manageability of a large geospatial dataset contributed to the choice to include records of vessels involved in marine occurrences from January 1st, 2009 to December 31st, 2018.

To create the study area boundary for this project, spatial files for Canadian and U.S. EEZs were loaded into a geographic information system (GIS). The transboundary waters included in the study area are the Salish Sea, the Great Lakes, the St. Lawrence River, and around the Bay of Fundy. On the west coast, the waters within the Canadian and U.S. EEZs and territorial seas were included in the study area, extending from the southern state border of Washington State northwards to the southeastern continental state border of Alaska. On the east coast, the waters within the Canadian EEZ and territorial seas were included in the study area, in addition to the U.S. EEZ waters and territorial seas up to the southwestern state border of Maine. In addition to coastal regions, the study area is comprised of inland waters and waterways that are used for marine shipping traffic, such as the Great Lakes, Baker Lake and major rivers (i.e., the Saguenay River, St. Lawrence River, Mackenzie River, and Fraser River). See Figure 2 for a visual representation of the study area.

Clear Seas classified the incident and accident data into different regions based on their locations within the study area. This regional classification aligns the records from both TSBC and USCG data sources and allows the data to be filtered spatially to understand the specific data trends of different areas. The regions are the Pacific, Northern, Great Lakes, and Atlantic.

The Pacific Region:

- Includes EEZs and territorial seas from the southern border of Washington State to the southern border of Alaska
- Inland waterways such as the Fraser River in southwestern British Columbia

The Northern Region:

- Includes EEZs and territorial seas in the Arctic, including Hudson Bay
- Inland waters and waterways in the territories (Yukon, Northwest Territories, and Nunavut)

The Great Lakes Region:

- Includes inland waters and waterways including the Great Lakes (Canadian and U.S. sections), and the St. Lawrence River up to the St Lambert Lock and the east side of Île Sainte-Hélène

The Atlantic Region:

- Includes EEZs and territorial seas in the Atlantic Ocean around the maritime provinces, from north of Labrador to the western border of Maine
- Inland waters and waterways including the St. Lawrence River and the Saguenay River, downstream from the Port of Montreal on the west side of Île Sainte-Hélène

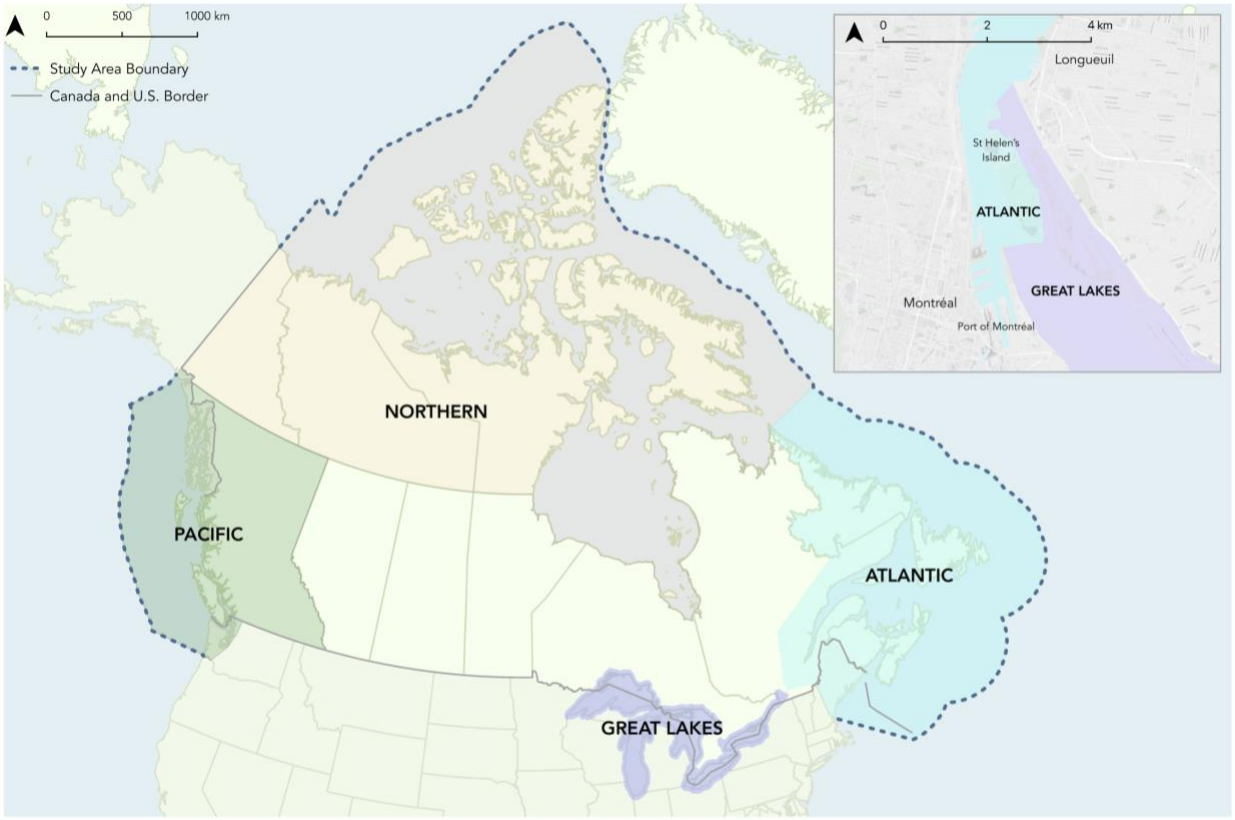

Figure 2. Regions as Defined for the Marine Incidents and Accidents Dashboard

The marine occurrence records for this study were filtered to include only the records whose location coordinates fall within the study area boundary. Like many large geospatial point datasets, some of the coordinates do not correctly represent the location of the marine occurrence. To remove some of the records whose coordinates were inaccurate for the U.S. marine occurrence data, the data were first filtered to include only records that overlapped with the USCG districts in the study area. The following USCG districts were included in the dataset: District 1, District 9, District 13, and District 17.

The remaining records were reviewed manually to remove any data points that were not within the study area. Some of the clearly mislocated points were removed, however, records with incorrect coordinates still exist in the dataset. In situations where a data point was located on land, but right next to a body of water (within the study area), it was assumed the point was mislocated and therefore the record was included in the dataset. Other records whose locations were on land, but farther away from waters within the study, were removed from the dataset. This process was performed manually, on an individual basis, aiming to be as consistent as possible in reviewing the mislocated records.

4.2 Gathering and Processing the Data

As previously mentioned, information on marine occurrences in Canadian waters was gathered from the MARSIS database, maintained by the TSBC. Other data tables containing relevant information related to marine occurrences were also downloaded from the TSBC website and linked to the data table of vessel records using the unique vessel or occurrence identifier. For marine occurrences in U.S. waters, data extracts from the MISLE database were used, and can also be downloaded from the USCG website. However, since the time frame of data used in this project extends past 2015, a request for data was submitted to the U.S. Department of Homeland Security for the more recent MISLE data extracts. This request was fulfilled, and the data table of vessels involved in marine casualties was used as the base data for U.S. occurrences. Additional information about marine casualties from the other data tables was linked to the vessel records extract through the unique vessel or occurrence identifier. Some other information on U.S. occurrences, such as event descriptions, was available through the USCG Maritime Information Exchange Incident Investigation Reports website. This database was searched for reports related to the USCG records that fit the project scope, and any relevant information was extracted.

The marine incidents and accidents dataset, created from the TSBC and USCG database extracts, is comprised of more than 5,000 records of vessels involved in unique occurrences. Using Clear Seas' classification processes, the extracts were aligned to create one holistic geospatial dataset for incidents and accidents (see Table 1 and Table 2). Records lacking latitude, longitude, identification information, or other key information were removed from the TSBC and USCG extracts. Before integrating the extracts, any duplicate records within each extract were removed.

The TSBC database structure was used as the framework for this new dataset. When the USCG was integrated into this base structure, there was not enough information to complete all of the TSBC fields, so the USCG records have blank values in some of these fields.

Because both the TSBC and USCG marine occurrence data extracts contain records in neighbouring waters, sometimes the organizations reported on the same vessel involved in the same occurrence. To identify these duplicate entries, the name of the vessel and date of the occurrence were cross referenced between the data extracts. The identified duplicates were then manually reviewed to determine which record to keep in the integrated dataset. If the marine incident or accident occurred within Canadian waters, the TSBC record was used, and if it occurred in U.S. waters, the USCG record was used. Due to misreporting of occurrence dates or misspellings of vessel names, it is possible that some duplicates still exist in the integrated dataset.

While most of the records were easily reclassified into the Clear Seas categories, some records needed to be manually reviewed to ensure the correct classification. All "passenger" vessels were reviewed to determine whether the vessel was a large ocean-going cruise ship, or a ferry, or a smaller passenger vessel. Only large ocean-going cruise ships and ferries were included in this dataset. During the data review process, several records were found with misclassified vessel types. These records were then manually corrected where possible. Common examples of vessel reclassification include:

- Some vessels were misclassified as "Cargo – Solid – Container Ship", and manually corrected to "Cargo – Bulk Carrier"

- Some vessels were misclassified as "Cargo – Solid – General Cargo", and manually corrected to "Cargo – Vehicle Carrier"

In addition, all marine occurrences that were identified as serious marine accidents, using the specific definitions applied in this study, were reviewed and verified as serious or not serious depending on the details of the accident. The following factors were considered when reviewing the seriousness of the accident:

- The type of occurrence
- The extent of damage to property
- The extent of damage or risk to the environment

In cases where misclassifications or inaccuracies were identified in the record attributes, which also lacked information to make manual corrections to the data, no edits were made. Instead, the organization responsible for reporting the event was contacted to review and correct the database record. Although a data review process was completed for this project, it should be noted that other misclassified or incorrect records may still exist in the dataset.

4.3 Calculating Additional Fields

After the TSBC and USCG data extracts were integrated together, several additional fields were added to the dataset. These fields were calculated using other TSBC and USCG data sources, the TSBC and NTSB investigation reports, and the classifications developed by Clear Seas.

The additional data fields were created for various reasons, such as creating unique identifiers for each record, helping to integrate the data from Canadian and U.S. sources, or displaying the existing data in an appropriate way for the Clear Seas' dashboard. The 'Occurrence ID + Vessel ID' and 'Vessel Name + Date' fields were added to identify unique records and remove any duplicate records in the dataset. The 'Clear Seas Vessel Type', 'Clear Seas Occurrence Type', 'Occurrence Ranking' and 'Region' fields were calculated as a result of the new classification schemes that were developed to integrate the data from the TSBC and USCG. This reasoning also applies to the 'Marine Accident' and 'Serious Marine Accident' fields.

Some of the data fields that were created by Clear Seas were added to help break down the data by topics of interest. For example, the 'Pollution Indicator' field was created to identify the records where pollution occurred as a result of the incident or accident. The TSBC MARSIS database extract already included a field that indicated if pollution occurred as a result of the occurrence, but the USCG MISLE database extract did not contain a comparable field. In the MISLE database, one of the occurrence types listed in the system is "pollution – discharged or released". To complete the pollution indicator field on the integrated dataset, the values were manually changed to include all USCG records that listed "pollution – discharged or released" as any of the primary or subsequent occurrence types.

Table 3 provides an overview of the data fields available in the marine incidents and accidents dataset, and the source of the information found in the column or if it was a new data field created by Clear Seas.

Table 3. Vessel and Occurrence Attributes and Sources

Attribute	Description	Canadian Source	U.S. Source
Occurrence ID	Occurrence identifier, in a combination of letters and/or numbers	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence ID + Vessel ID	Occurrence and vessel identifier, in a combination of letters and/or numbers	Clear Seas	Clear Seas
Vessel ID	Vessel identifier, in number format	TSBC MARSIS database extract	USCG MISLE database extract
Vessel Name + Date	Name of vessel and the date	Clear Seas	Clear Seas
Vessel Name	Name of vessel	TSBC MARSIS database extract	USCG MISLE database extract
Vessel Flag	Country where vessel is registered	TSBC MARSIS database extract	USCG MISLE database extract
Clear Seas Vessel Type	Vessel type, as defined by Clear Seas classification process	Clear Seas	Clear Seas
Vessel Type	Vessel type, as per the database extract	TSBC MARSIS database extract	USCG MISLE database extract
Vessel Subtype	Vessel subtype, as per the database extract	TSBC MARSIS database extract	USCG MISLE database extract
Gross Tonnage	Volume of internal spaces of the ship	TSBC MARSIS database extract	USCG MISLE database extract
Year Built	Year vessel was built	TSBC MARSIS database extract	USCG MISLE database extract
Vessel Age	Number of years since vessel was built	TSBC MARSIS database extract	USCG MISLE database extract
Clear Seas Occurrence Type	Occurrence type, as defined by Clear Seas classification process	Clear Seas	Clear Seas
Occurrence Type	Occurrence type, as per the database extract	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Subtype	Occurrence type, as per the database extract	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Ranking	Ranking of severity of occurrence, as defined by Clear Seas	Clear Seas	Clear Seas
Occurrence Type 2	If present: secondary occurrence type, ranked lower than primary occurrence type	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Subtype 2	If present: secondary occurrence subtype	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Type 3	If present: third occurrence type, ranked lower than secondary occurrence type	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Subtype 3	If present: third occurrence subtype	TSBC MARSIS database extract	USCG MISLE database extract

Attribute	Description	Canadian Source	U.S. Source
Occurrence Year	Year of occurrence	TSBC MARSIS database extract	USCG MISLE database extract
Occurrence Date	Date of occurrence	TSBC MARSIS database extract	USCG MISLE database extract
Region	Region of occurrence, as defined by Clear Seas spatial regions	Clear Seas	Clear Seas
Pollution Indicator	'Yes' or 'No' value to indicate if pollution happened as a result of the occurrence	TSBC MARSIS database extract	Clear Seas
Time	The time of the occurrence	TSBC MARSIS database extract	USCG MISLE database extract
IMO Classification	IMO classification of severity	TSBC MARSIS database extract	USCG Marine Information Exchange
Summary	Description of the occurrence	TSBC MARSIS database extract	USCG Marine Information Exchange
Number of Pilots on Board	The number of pilots onboard vessel during the occurrence	TSBC MARSIS database extract	Blank – information not available
Organization	The organization that recorded the occurrence	TSBC MARSIS database extract	USCG MISLE database extract
Vessel Length	The length of the vessel	TSBC MARSIS database extract	USCG MISLE database extract
Serious Marine Accident	'Yes' or 'No' value to indicate if the occurrence was a serious marine accident according to Clear Seas	Clear Seas	Clear Seas
Marine Accident	'Yes' or 'No' value to indicate if the occurrence was a marine accident according to Clear Seas	Clear Seas	Clear Seas
Investigation Report URL	URL web link to investigation report, if present	TSBC Investigation Report website	NTSB Investigation Report website

4.4 Limitations

Although efforts were made to create a comprehensive, cleaned dataset, there are still several limitations to the data that must be considered. The MARSIS and MISLE databases are populated from public reports, and many of the reports do not require investigations from the regulatory organizations. Because some of the reports are not verified, the quality and reliability of the data cannot be guaranteed. The following limitations should be acknowledged:

- The location coordinates of some of the marine records are sometimes inaccurate, leading to incorrect geographic placements of the data points. When incorrectly located points are

identified, the organization responsible for the report (i.e., TSBC or USCG) can be contacted to request a correction to their database record.

- Some of the marine occurrence and vessel attributes are mislabeled or appear to be conflicting for some of the records. Details such as the type of vessel involved or the presence of a pilot on board may not have been correctly inputted in the MARSIS or MISLE databases. Where possible, Clear Seas has attempted to manually correct these data issues, however, inaccuracies in the dataset still exist.
- There are some records from the USCG database of vessels involved in occurrences in Canadian waters, however, there is no report recorded by the TSBC for the occurrence (and vice-versa). This situation may reflect non-compliance in reporting incidents and accidents, or different standards in reporting marine occurrences between the USCG and TSBC organizations.
- As previously mentioned, the USCG publishes marine casualty information from the MISLE database for marine casualties that have occurred up to 2015. For this project, marine casualty data extracts from the USCG's MISLE database were gathered through a Freedom of Information request to the U.S. Department of Homeland Security, so data for the full study period from 2009-2018 could be included. In these extracts, the number of marine casualty records per year dropped significantly in 2015 and continued to show fewer records than average for the subsequent years. The cause of this drop in reports is unknown but may be attributed to a lack of reporting or collecting of data related to marine casualties after 2015.
- In 2014, the TSBC made improvements to their regulations on reporting marine occurrences. Because reporting incidents and accidents became easier and more streamlined after these changes, this may have led to an increase in reporting compared to previous years.

While the completeness and accuracy of the data are adequate for this study, the Clear Seas dataset may not be the appropriate data source for other projects, depending on the context. There are some limitations of the methodology applied by Clear Seas:

- The extracts from the MARSIS and MISLE databases were filtered and processed by Clear Seas before being combined as the dataset for the Marine Incidents and Accidents dashboard. Only records involving specific commercial vessels are included in this study, so this dataset does not represent all incidents and accidents occurring in Canadian waters.
- The study area includes some interior waterways that support commercial maritime shipping activity, but not all interior waterways. Some records in minor interior waterways with less commercial shipping traffic were not included in this dataset; for example, incidents involving tugs, barges, and ferries that operate on some lakes and rivers were excluded from the dataset. The exclusion of these vessels was determined on a case-by-case basis by Clear Seas.
- New definitions were created by Clear Seas to describe and classify marine occurrences and vessels. These classification schemes were developed specifically for the dataset that is displayed in the Marine Incidents and Accidents dashboard and may not be appropriate for other uses.

- The manual processing of the data may make it difficult to compare records from the Clear Seas dataset to the information found in the MARSIS and MISLE databases.
- While this study focuses on marine occurrence information from publicly available government data sources, other organizations also gather and report data on marine incidents and accidents. A more complete picture of maritime safety in Canadian waters could be achieved by integrating data from additional sources, as occurrence reports may not be submitted to every organization that gathers data on marine incidents and accidents.
- This study displays the absolute number of vessels involved in marine incidents and accidents and does not account for the differences in vessel traffic patterns across space and time. This should be considered when viewing the Marine Incidents and Accidents dashboard, as the number of incidents and accidents can be related to the amount of traffic and number of vessels present in a certain area. In the future, there are opportunities to build on this study by contextualizing the marine occurrence data with vessel traffic information.

5.0 ArcGIS Online Dashboard

The geospatial dataset of marine incidents and accidents in Canadian waters was created to be displayed in an interactive, mapping application. The application is in the form of a dashboard, with an interactive map as the focus. As the industry standard for web-based GIS, ArcGIS Online was selected to host the Marine Incidents and Accidents dashboard.

The Marine Incidents and Accidents dashboard allows users to engage with marine occurrence data spatially, through the interactive map element, and non-spatially, through charts, graphs, and other visuals. The dashboard elements act as filters, enabling users to break down the data by region, year, vessel type, occurrence type, and more.

By amalgamating marine occurrence data from various sources and displaying the data in a spatial environment, the Marine Incidents and Accidents dashboard presents an opportunity for the public to better understand historical marine occurrences related to commercial shipping. This dashboard and the geospatial dataset are intended to be a dynamic tool. Future iterations could include additional features as requested by users and updated marine occurrence data as they become available for more recent years.

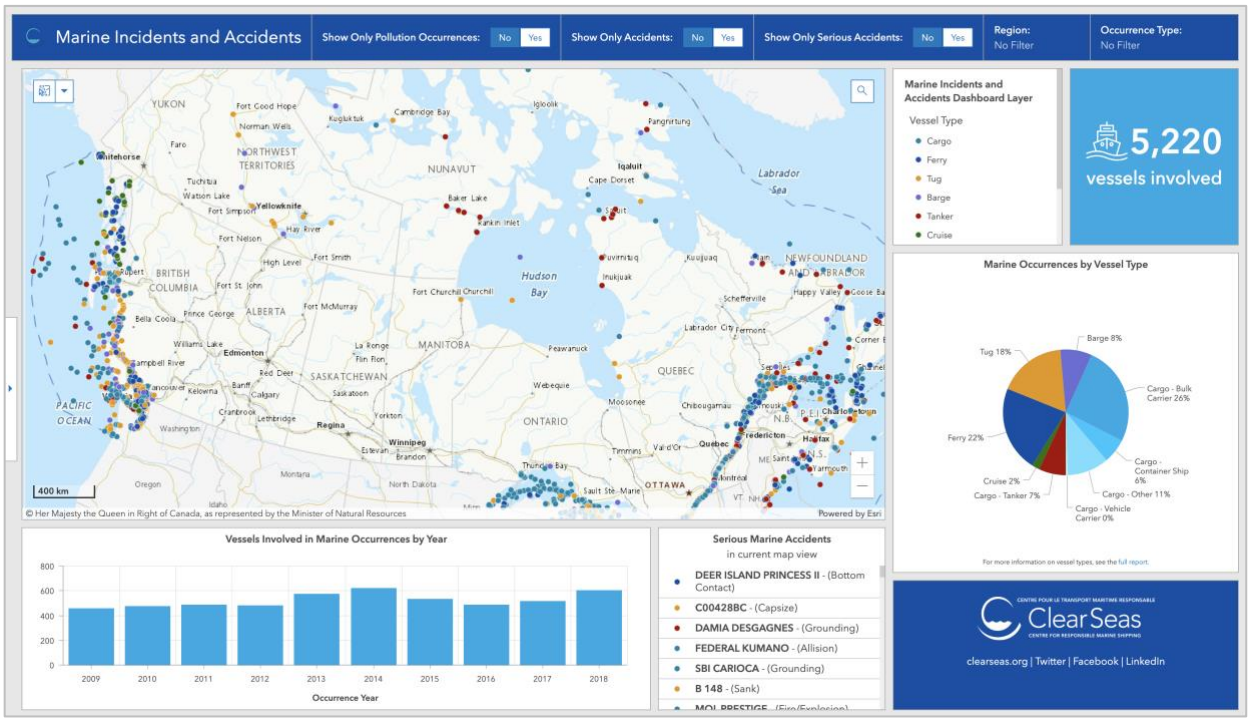

Figure 3. Clear Seas' Marine Incidents and Accidents Dashboard, hosted on ArcGIS Online

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