Availability of Tugs of Opportunity in Canada's Pacific Region

July 2019

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.

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About this Report

As an element of its Marine Transportation Corridors initiative, Clear Seas Centre for Responsible Marine Shipping commissioned Nuka Research and Planning, LLC to develop the analysis, *Availability of Tugs of Opportunity for Canada's Pacific Region* to examine the availability and capability of commercial tugs – known as tugs of opportunity – to respond to a request for an emergency tow from a disabled ship in Canada's Pacific Region. This report, prepared by Nuka Research and edited by Clear Seas, conveys the results of that analysis.

Board of Directors of Clear Seas Centre for Responsible Marine Shipping

Message from the Executive Director

While the discretionary offer of assistance at sea is one of the oldest maritime traditions available to a ship's captain, the reality is that towing disabled ships in our nation's waterways is an essential emergency service. Its importance is attracting attention as Canada's shipping traffic continues to flourish while at the same time Canadians are demanding better protection and stewardship of our coastal ecosystems.

In response to this issue, this Clear Seas report, the third to be released in the context of the Marine Transportation Corridors initiative in Canada's Pacific Region, examines the availability and capability of commercial tugs — known as tugs of opportunity — to respond to a request for an emergency tow. This report builds on Clear Seas' analyses presented in *Vessel Drift and Response Analysis* and *Emergency Towing Vessel Needs Assessment*.

Emergency tow services in Canada's Pacific Region are provided through a combination of dedicated capability and ad hoc employment of commercial tugs. As of May 2019, the dedicated capability includes the Canadian Coast Guard's two leased emergency towing vessels (ETVs), the *Atlantic Eagle* and *Atlantic Raven*, and the ETV stationed at Neah Bay in Washington.[1] The tugs of opportunity system is an ad hoc approach to contract tugs that are otherwise engaged in routine commercial activity to respond to emergency situations. This report reviews that ad hoc system and provides observations on the presence, availability, and capabilities of commercial tugs in Canada's Pacific Region.

Most compellingly, this report demonstrates that while the tugs of opportunity system has been used successfully in the past, it is an inadequate layer of protection for the size and type of ships now transiting our coast and ought to be complemented with dedicated capability. The tugs available as tugs of opportunity have limited capabilities to respond in severe weather and to large, high windage ships. To mount an effective rescue, tugs need to be able to navigate the waves safely and efficiently. Severe conditions can prevent a tug from reaching a ship in distress in time or at all. Additionally, severe weather conditions can limit a tug's capability, particularly for the large ships that are becoming common along Canada's coastline: large or very large container ships, LNG carriers, passenger (cruise) ships, and bulk carriers. Without adequate response capacity, these large ships pose a risk of severe damage to the coast.

1 Since 1999, a tug has been stationed at Neah Bay to respond to disabled ships and keep them from drifting aground. This dedicated tug is managed by the Marine Exchange of Puget Sound and was initially funded by the Washington State Department of Ecology. Since 2010, it has been funded by industry through a fee levied from ships transiting to or from a Washington port.

Another issue with relying on the tugs of opportunity system is the disparity between the areas these tugs most often transit as they engage in trade (near-shore waters) and the more exposed and remote off-shore areas where commercial ships commonly travel either en route to a Canadian port or on innocent passage (not calling at a Canadian port). A tug of opportunity could take a day or more to reach a disabled ship, unless the ship in distress happens to be in an area where many tugs of varying capabilities are present, such as the Salish Sea or near the Port of Prince Rupert. This transit time represents a risk which is mitigated somewhat by the dedicated ETV capability provided by the Canadian Coast Guard and Neah Bay vessels.

A potential limitation of the analysis is consideration of response scenarios involving only one tug. Within the Salish Sea in particular, emergency response could benefit from the mobilization of more than one tug, as there are many tugs in an area sheltered by its adjacent islands. In areas further from shore, the paucity of capable tugs and the more severe wind and wave conditions make a multiple-tug rescue scenario unlikely.

The results of this study support the Canadian Coast Guard's lease of two ETVs under the Oceans Protection Plan (OPP) and their current concept of employment and patrol areas. The off-shore areas where these dedicated ETVs are present are the most exposed to severe weather and furthest from commercial tug routes. The more sheltered Salish Sea area already benefits from the routine proximity of many tugs of varying capability. The bollard pull of the Canadian Coast Guard's ETVs is expected to be sufficient to respond to all current and expected ship types in 95th percentile historical weather conditions, and all except for the large and very large container ships in 99th percentile weather conditions. Leasing these two ETVs has done much to abate risks from drifting ships; however, based on research presented in *Emergency Towing Vessel Needs Assessment* (shown herein in Table 2), consideration should be given to acquiring vessels on a permanent basis capable of 213 metric tonnes bollard pull.

This research fulfills Clear Seas' mandate to support safe and sustainable marine shipping by providing objective, trustworthy information. With an accurate picture of the Pacific coast's risk profile related to the tugs of opportunity system, policy makers and those who rely on marine shipping can make informed decisions about necessary and appropriate strategies to support safe shipping. The results of this study continue Clear Seas' dedication to a comprehensive and transparent analysis of shipping practices for the benefit of all Canadians and the protection of our coastal resources.

Clear Seas is confident that this report marks an important milestone in the development of a robust strategy for an emergency towing system and will contribute to informed discussion as Canada continues to build a leading prevention and response system for marine shipping in the Pacific Region.

July 2019

Executive Summary

Clear Seas Centre for Responsible Marine Shipping (Clear Seas) commissioned Nuka Research and Planning Group, LLC (Nuka Research) to prepare this report as part of Clear Seas' Marine Transportation Corridors Initiative. This report characterizes both the potential capability and the availability of commercial tugs engaged in their normal trade for emergency towing use in Canada's Pacific Region. These tugs are referred to as "tugs of opportunity" as they are not dedicated to rescue purposes. The analysis seeks to answer the following research question:

What is the availability and distribution of tugs of opportunity to assist disabled ships in Canada's Pacific Region?

To answer the research question, automatic identification system (AIS) data from 2016 were used to identify the tugs present in Canada's Pacific Region during that year. Because tug traffic patterns remain relatively consistent from year to year,[2] the results from 2016 represent typical tug activity. Each tug's location and route were determined from AIS data and its capability was established based on its bollard pull.

It should be noted that this study was conducted before the 2019 deliveries of new escort tugs *Orca* and *Grizzly* to Vancouver, and *Tsimshian Warrior* to Prince Rupert. These newly-built tugs replace older tugs and each has a bollard pull greater than 80 metric tonnes, expanding overall fleet capability. It is assessed that these new tugs do not materially affect the conclusions of this report.

While many different vessel characteristics contribute to a tug's suitability for emergency towing, bollard pull, which measures the force a tug can apply when pulling against a fixed object, is a key indicator of tug power and was used as a proxy for towing capability for the purpose of this analysis. Bollard pull was determined either through research or by using a linear regression calculation based on engine horsepower. (If neither bollard pull nor horsepower was available for a particular tug, it was excluded from the analysis. However, based on the length and gross tonnage of the excluded vessels it is unlikely that any of them would have had adequate power or equipment for emergency towing purposes).

Following the methodology outlined in Clear Seas' *Emergency Towing Vessel Needs Assessment* report (2018), tugs were divided into four categories:

1. All tugs present in Canada's Pacific Region in 2016 for which bollard pull or horsepower was known. Data were insufficient to estimate bollard pull for 47 tugs, but all of these were less than 150 GT and 30 m in length and thus likely not suited to emergency towing operations. Sufficient data were identified to estimate the bollard pull of 232 tugs.
2. 50 metric tonnes (MT) or greater includes the minimum bollard pull required for an emergency towing vessel (ETV) as mandated by Washington State. Previous examinations of emergency towing needs for the region have concluded that tugs with less than 60 MT of bollard pull are unlikely to be suitable for emergency towing. Of the 232 tugs in the first category, 76 were included in this second category.

2 See cargo statistics for Port of Vancouver and Northwest Seaport Alliance. Year-over-year change is roughly 5%. Port of Prince Rupert grew by 28% in 2017, largely due to a deep-water facility expansion.

3. 70 MT or greater represents the minimum bollard pull required to respond in sustained winds of 21 knots (93rd percentile weather conditions) as determined by Robert Allan Ltd. (2013). This category included 35 of the 76 vessels greater than 50 MT.
4. 90 MT or greater represents the tugs with the highest bollard pulls active in the Pacific region, and those most likely to be able to provide effective rescue assistance. This category included 12 of the 76 vessels examined.

The distribution of tugs of different capabilities is presented using tug routes. The proportion of time tugs in each bollard pull category are likely to be present was determined by frequency of travel in 40 km x 40 km grid cells on a map, or the frequency with which tugs cross analytical passage lines drawn on the map of the region:

- North end of Hecate Strait;
- Queen Charlotte Strait near Port Hardy; and
- West entrance of the Strait of Juan de Fuca.

Due to the nature of their trade, tugs are most commonly found in near-shore waters from Vancouver to Alaska. The majority are east of Vancouver Island but some also transit the outside waters along western Vancouver Island. Tugs of all sizes follow this general pattern of movement, but larger tugs are present in all areas with less frequency than smaller tugs as there are fewer of them.

Tugs of opportunity with bollard pull greater than 70 MT travelling along typical transit routes were present less than 10% of the time on average within any 40 km x 40 km area. On average, tugs in this category crossed the passage lines with the following frequencies:

- Hecate Strait passage line near Prince Rupert every 1.4 days (every 34 hours);
- Queen Charlotte Strait passage line near Port Hardy every 1.1 days (every 26 hours); and
- Strait of Juan de Fuca passage line every 2.0 days (every 48 hours).

When comparing winter and summer, there were only minor seasonal differences in the distribution of tugs with greater than or equal to 70 MT bollard pull.

In 2016, there were no tugs of opportunity able to rescue the largest ships in the study in severe conditions (sustained winds greater than 33 knots or 99th percentile). These at-risk ships include large or very large container ships, LNG carriers, passenger (cruise) ships, and bulk carriers. In less severe conditions, the number of ship types that were rescuable in 2016 increased. In sustained winds of 27 knots (95th percentile conditions), tugs of opportunity would have been capable of rescuing all except the large and very large container ships. It is not known whether any tugs of opportunity would have been available if needed. Tugs of opportunity are generally towing barges and will require time to hand off or moor their tow before proceeding to the aid of any disabled ship. Even after a tug of opportunity secures its tow, the time required to transit from the common towing routes to the likely location of a disabled ship in outside waters can be significant, sometimes more than 24 hours.

The report is intended to demonstrate how often tugs of a given bollard pull may be available based on historical data, but does not assess all factors that would determine the outcome of an incident requiring an emergency tow.

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Availability of Tugs of Opportunity in Canada's Pacific Region

1.0 Introduction

Clear Seas Centre for Responsible Marine Shipping (Clear Seas) commissioned Nuka Research and Planning Group, LLC (Nuka Research) to prepare this report as part of Clear Seas' Marine Transportation Corridors Initiative. This report characterizes the potential availability and capability of commercial tugs engaged in their normal trade for emergency towing use in Canada's Pacific Region. These tugs are referred to as tugs of opportunity as they have the potential to be used in an emergency but are not dedicated to that purpose.

1.1 Purpose and Scope

This report identifies the number, distribution and towing capability of potential tugs of opportunity throughout Canada's Pacific Region in 2016.[3] The purpose of this study is to inform the maritime community about the availability of tugs of opportunity should they be needed to provide emergency towing for a ship in distress. The analysis seeks to answer the following research question:

What is the availability and distribution of tugs of opportunity to assist disabled ships in Canada's Pacific Region?

This report demonstrates how often tugs of a given capability may be present at any location along the coast, but does not assess all factors that would determine the outcome of an incident requiring an emergency tow. Among other things, the study does not assess the ability of tug operators to engage in a rescue operation. Every incident requiring emergency towing is unique, and the response of the disabled ship's captain and owners, the maritime authorities and operators of any tugs of opportunity will be situation dependent.

1.2 Background

Ships may suffer a loss of power for a variety of reasons, resulting in the ship drifting under the influence of the winds and seas. A ship adrift may be able to be repaired or stop its motion using an anchor before any harm is done, or it may sink or drift aground, creating the potential for injury, loss of life, and the release of cargo or fuel into the marine environment. A ship in distress may seek or be offered assistance from other vessels nearby. If possible, a disabled ship can be given an emergency tow to a port or a place of refuge, or be held off the shore to prevent a grounding.[4]

At some locations along the coast, emergency towing vessels (ETVs) are on standby to be dispatched to the aid of a disabled ship. A "dedicated" ETV may be publicly or privately owned or operated. Public

3 **The year 2016 was used because automatic identification system (AIS) data was available for this year. There have been no major changes to tug boat traffic patterns since 2016, so the authors believe that these results would be similar to a study conducted with more recent data. It should be noted that this study was conducted before the 2019 deliveries of new escort tugs *Orca* and *Grizzly* to Vancouver, and *Tsimshian Warrior* to Prince Rupert. These newly-built tugs are replacing older tugs and each provides expanded capabilities and bollard pull greater than 80 tonnes. It is assessed that these deliveries do not materially affect the conclusions of this report.**

4 **Although mariners will traditionally aid other mariners, emergency towing services in Canada are usually conducted under a commercial contract between the owners of the disabled ship and the towing vessel.**

vessels include government vessels such as those operated by the Canadian Coast Guard. Private vessels include ETVs funded to be on standby for emergency towing duties. Tugs of opportunity are not dedicated ETVs but are typically engaged in trade and may divert course to lend assistance to a disabled ship. Because tugs are built for towing, they are better suited than most other vessel types to provide emergency towing assistance.

However, a tug of opportunity in proximity to a disabled ship is not necessarily capable of rendering safe and effective assistance; tugs have many different capabilities depending on their intended use. Some tugs are built to assist docking ships, while others are intended to tow barges in open waters, or tow barges or log rafts in confined or shallow waters. This study's assessment of tug capability is limited only to potential for emergency tow purposes, not how well suited a tug is to its intended trade.

One metric of a tug's capability for towing is bollard pull. Bollard pull is a commonly used measure of a tug's pulling power and is expressed in metric tonnes (MT) for this report. Bollard pull is the measure of the pulling force that a tug can apply when tied to a fixed object such as a dock. It is measured using a set of test protocols such as those developed by Det Norske Veritas (2001) and a load cell instrument that measures the force of pull exerted on a tow line.

Bollard pull is an important indication of tug capability and a useful proxy, but is not the only factor influencing whether a tug will be able to rescue a disabled ship. Other factors include but are not limited to equipment on both the tug[5] and the disabled ship, tug length, general seaworthiness and seakeeping ability, the training and experience of the tug's crew, and weather conditions at the time of rescue.

1.3 Other Studies

This report draws on the results of three studies of various aspects of rescue towing capability and availability applicable to the vessel traffic in the Pacific Region. Clear Seas commissioned one of these studies specifically to determine towing needs for ship types common to Canada's Pacific Region. The other studies, Robert Allan Ltd. (2013) and Glosten Associates (2014), were developed for other clients and purposes but are relevant to this analysis. While the parameters of each study are slightly different, the results of the three studies are consistent.

1.3.1 Emergency Towing Vessel Needs Assessment (Clear Seas, 2018)

Clear Seas commissioned Vard Marine to conduct an analysis, entitled *Emergency Towing Vessel Needs Assessment*, to determine the ETV capabilities required to provide a rescue tow for the largest disabled ships under various wind conditions and associated sea states. The study assessed seven ship types and sizes found or expected in Canada's Pacific Region using data recorded by Environment and Climate Change Canada wind buoys. The ships and wind conditions selected were intended to illustrate worst-case or near worst-case scenarios for emergency towing. The ships that were selected for the *Emergency Towing Vessel Needs Assessment* represented some of the largest ships for each ship type calling at western Canadian ports. Ship types such as container ships and vehicle carriers represent particularly difficult cases for emergency towing because they have high windage areas (percentage of ship area above the water line) that require additional towing power to execute an emergency tow. Table 1 contains the characteristics of the seven ship types that were evaluated. Table 2 contains the bollard pull requirements estimated for each ship type in five different wind conditions.

5 For example, towing winch, tow wire, tow line, and roller pins.

Table 1. Ship types and characteristics used in analysis

Ship Type	Gross Tonnage[6]	Deadweight Tonnage[7]	Cargo Capacity	Additional Information[8]
Large Container Ship	154,300	153,811	14,500 TEU	Largest container ship to call on a Canadian port (Prince Rupert, 2017).
Very Large Container Ship	210,890	191,422	21,413 TEU	World's largest container ship (not currently operating in Canadian waters)
LNG Carrier	163,922	130,102	~265,000 m^3	Largest LNG carrier identified in the "LNG Canada" project TERMPOL review
RO/RO Vehicle Carrier	75,251	41,820	138,000 m^3	One of the largest roll-on/roll-off vehicle carriers in operation
Passenger Ship	167,800	11,700	4,000 passengers	Largest cruise ship to call in Vancouver in 2018
Bulk Carrier	107,054	209,996	221,478 m^3	Largest bulk carrier to call on Canada's Pacific ports
Aframax Tanker	62,929	115,525	124,167 m^3	Largest oil tanker entering the Port of Vancouver

Table 2. Calculated bollard pull requirements for an emergency tow for different ship types in different weather conditions

Weather Conditions		ETV Bollard Pull (MT)						
Wind Conditions	Wind (knots)	Large Container Ship	Very Large Container Ship	LNG Carrier	RO/RO Vehicle Carrier	Passenger Ship	Bulk Carrier	Aframax Tanker
50th Percentile	14	34	40	26	19	27	22	16
75th Percentile	19	54	64	44	30	43	35	26
85th Percentile	22	68	81	55	38	54	43	32
95th Percentile	27	112	134	92	64	89	73	55
99th Percentile	33	179	213	148	101	142	116	87

6 Gross tonnage is a nonlinear measure of a ship's overall internal volume.

7 Deadweight tonnage is a measure of how much weight a ship can carry: the sum of the weights of cargo, fuel, fresh water, ballast water, provisions, passengers, and crew.

8 To find out more about different types of ships, refer to: https://clearseas.org/en/tankers/

The assessment also found that aside from bollard pull there are other considerations necessary to evaluate the suitability of an ETV, including:

- Tug size, length overall, freeboard, stability;
- Propulsion system;
- Free-running speed and speed loss in waves;
- Endurance range;
- Winch type and towing gear (both fore and aft);
- Crew motion limits;
- Crew certification and training.

Additionally, Det Norske Veritas has published guidance that vessels below 40 m in length should not be used for open-ocean towing in harsh areas and seasons, which applies to most of Canada's Pacific coast.

1.3.2 An Evaluation of Local Escort and Rescue Tug Capabilities in Juan de Fuca Strait (Robert Allan Ltd., 2013)

Robert Allan Ltd. conducted a regional evaluation of local escort and rescue tug capabilities in the Strait of Juan de Fuca for the proposed Trans Mountain Expansion Project. This study used a 120,000 DWT tanker ship (Aframax Tanker) as the potential disabled ship and two sets of wind conditions, 99th percentile winds (defined as 34 knots in this study) and 93rd percentile winds (21 knots). The study determined that an ETV would require the following towing capabilities:

- 110 MT of bollard pull in 34 knots of wind;
- 68 MT of bollard pull in 21 knots of wind.

Based on this evaluation, Robert Allan Ltd. determined that a vessel used for emergency towing should meet the following requirements:

- Gross tonnage greater than 150;
- Bollard pull greater than or equal to 70 MT in winter months and 60 MT in summer months;
- Indirect steering forces at 10 knots equal to bollard pull;[9]
- Towline with breaking strength greater than 200 MT and at least 610 m in length.

1.3.3 Aleutian Islands Risk Assessment Phase B — Minimum Required Tug for the Aleutian Islands (Glosten Associates, 2014)

Glosten Associates conducted a study for the Aleutian Islands area to determine the minimum required tug for emergency towing in different wind and wave conditions. This study evaluated a 90,000 DWT tanker and an 83,000 DWT container ship in a range of weather conditions. Table 3 presents the study's findings.

9 This would only apply to a tug engaged in rescuing a disabled ship with forward motion, i.e. not adrift.

Table 3. Bollard pull requirements for an ETV based on different ship types (Glosten Associates, 2014)

Wind (knots)	Wave Height (ft)	Bollard Pull Required for 90,000 DWT Tanker (MT)	Bollard Pull Required for 83,000 DWT Container Ship (MT)
13	5	5	10
18	10	12	19
23	15	23	34
28	20	34	50
33	25	39	68
38	30	34	91
41	33	41	109

2.0 Method and Inputs

This section describes the method, inputs, assumptions and limitations of this analysis. The general approach was to:

- Identify tugs operating in the Pacific Region;
- Determine the capabilities of those tugs, either through research or estimation;
- Show the presence of tugs of different capabilities.

The analysis used automatic identification system (AIS) data to identify tugs' key characteristics in Canada's Pacific Region waters in 2016. AIS data also provided tug location and route (identified by AIS records of consecutive locations) any time the tug was present in the study area throughout the year.

To evaluate the ability of tugs to rescue disabled ships, the bollard pull of each tug was used as an indicator of towing capability. Where possible, bollard pull and other vessel specifications (length, gross tonnage, and horsepower) for each tug were obtained from AIS data and research of publicly available information. In cases where the bollard pull for a vessel was unknown, but horsepower was available, bollard pull was estimated using a linear regression which resulted in the following equation:

$$BP = 0.0114 \times HP + 6.1563$$

where: BP = Bollard Pull (MT) and HP = Horsepower generated for propulsion

A regression analysis of 141 tugs for which both horsepower and bollard pull were known produced an R-squared statistic of 0.82, meaning that 82% of the variability in bollard pull was accounted for by horsepower. This equation, which was derived directly from the tugs in the study, compares favorably with the more generalized equation used in the *Emergency Towing Vessel Needs Assessment*. Thus, the method for determining bollard pull based on known horsepower was determined to be appropriate for the purpose of this analysis.

Tugs were categorized by bollard pull as follows:[10]

- All tugs;
- Tugs with bollard pull equal to or greater than 50 MT;
- Tugs with bollard pull equal to or greater than 70 MT;
- Tugs with bollard pull equal to or greater than 90 MT.

Although many of the tugs are not suitable for emergency towing, the category of "all tugs" was included to show the overall pattern of tugs moving through the Pacific Region. Studies indicate a bollard pull of at least 70 MT is required for a tug to assist a large disabled ship in open ocean conditions, because most tugs without this level of power also lack sufficient tow gear and crew training to be respond effectively in an emergency (Clear Seas, 2018; Robert Allan Ltd., 2013). However, the category of tugs with at least 50 MT bollard pull was included because tugs with less than 70 MT of bollard pull have previously been used as tugs of opportunity.[11] For example, the analysis presented in Table 2 indicates that a tug would require bollard pull of 55 MT to respond to an Aframax Tanker in 95th percentile conditions (winds of 27 knots).

Results are presented both as maps showing the proportion of time a tug is likely to be present in an area and as passage lines. Figure 1 shows the study area, the map with grid cells, and the locations of the passage lines used in the study.

The maps show the proportion of time that at least one tug spends in a given area (grid cell), based on the fraction of time tugs spent there over the year. These percentages are calculated using the 2016 average traffic, and so do not account for slight seasonal variations. Slightly more traffic occurs in the summer months, but the variation depends on the size of tug. Smaller tugs (less than 70 MT bollard pull) display more seasonal variability and have fewer transits occurring in winter than larger tugs.

Each grid cell is 40 km x 40 km (an area of 1,600 km^2), roughly the size of a square covering Vancouver from Point Roberts to Bowen Island, and extending east to the Golden Ears Bridge. The map covers the entire study area: all waters of the Pacific Region for which satellite AIS data were available. The colour of each grid cell in the map represents the proportion of time that a tug is present, averaged across the entire year, using categories of 0-1%, 1-10%, 10-50%, 50-75% and 75-100%. It is important to note that these densities are averages: at some times there may be multiple tugs of a certain bollard pull category in the cell and at other times there may be none.

Passage lines are an analytical "trip wire" used to record whenever a tug crosses a particular line of interest (a virtual line drawn between two points across a body of water). As seen in Figure 1, passage lines were selected in areas where tugs pass as they move along the coast in typical voyages. The following passage lines were used for this analysis:

- Hecate Strait passage line (Rose Spit to Chell Point) to record tugs moving north or south through Hecate Strait at the northern end of Haida Gwaii;
- Queen Charlotte Strait passage line (Duval Island to Stuart Point) to record tugs moving north or south in the waters east of the northern end of Vancouver Island;
- Strait of Juan de Fuca passage line (Bonilla Point to Neah Bay) to record tugs moving east or west at the western end of the strait between Vancouver Island and the Olympic peninsula.

10 These categories are inclusive. The tugs in the >50 MT category are also contained in the All Tugs category. Likewise, the tugs in the >70 MT category are also contained in the >50 MT category.

11 See Appendix C for descriptions of three recent rescues.

Appendix A includes the number of tugs that crossed each passage line for each tug category, with data for year-round averages and also for summer and winter average traffic patterns.

Passage line data were used to calculate a return rate, which is the average length of time between tugs crossing a particular line. A return rate of 2 means that on average a tug crossed every two days; a return rate of 0.5 means that on average a tug crossed the passage line every half day or 12 hours. Passage line return rates used in this analysis represent the time between tug crossings averaged over the entire year. At some times the times between crossings will be shorter and at others they will be longer.

40 km Grid and Passage Lines in AIS Study Area

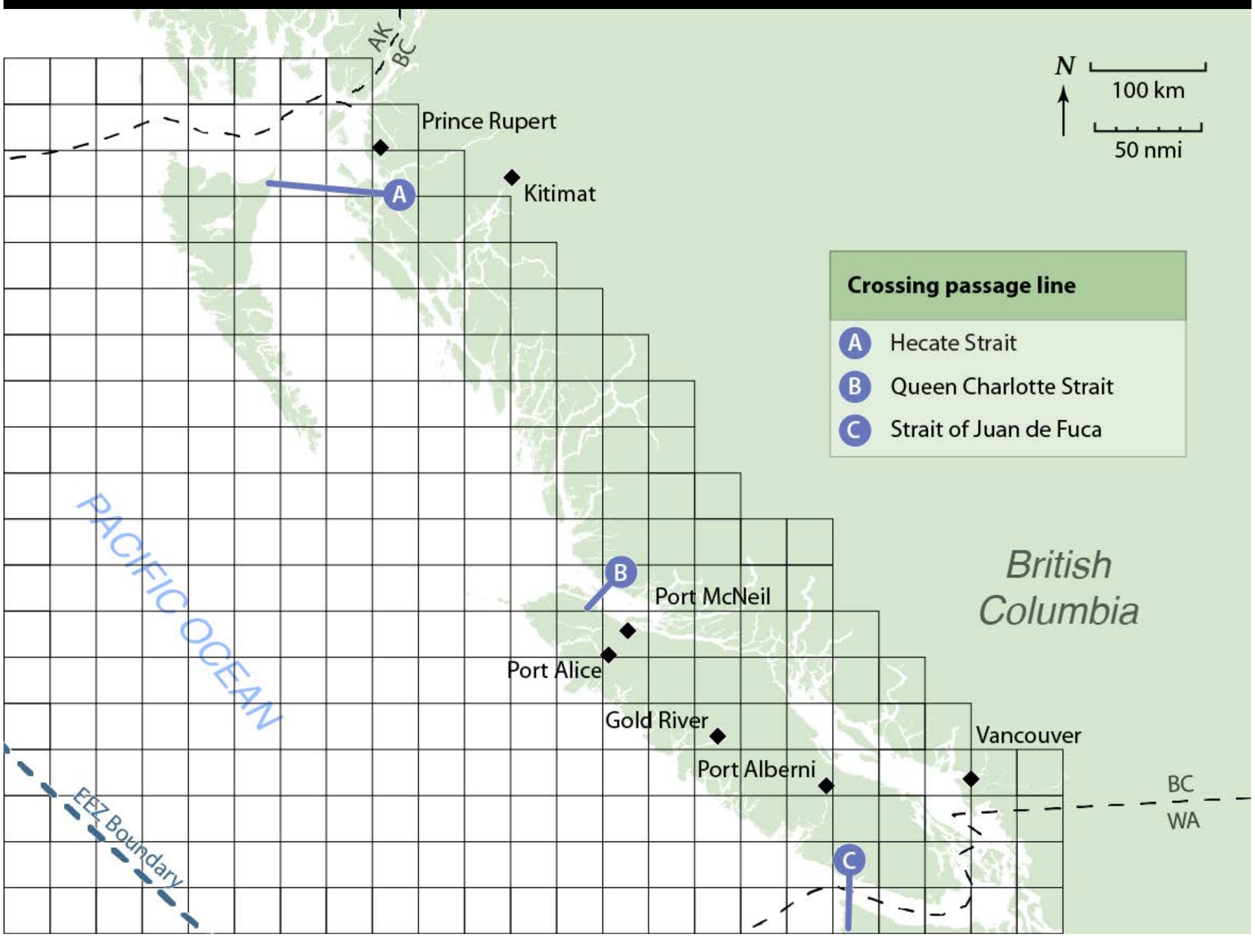


Figure 1. Map depicting the study area with 40 km x 40 km grid cells and three passage lines.

3.0 Results

Fully 279 individual towing tugs[12] greater than 15 m in length were identified from AIS data as having operated in the study area in 2016. Sufficient data were identified to estimate bollard pull of 232 tugs, either as reported or using the regression based on horsepower. Data were insufficient to estimate bollard pull for 47 tugs, but all of these were less than 150 GT and 30 m in length and thus likely not suited to emergency towing operations.

The 232 tugs for which bollard pull was known were categorized as shown in Table 4. The ≥ 50 MT class includes those with the minimum bollard pull for an ETV as required by Washington State, the ≥ 70 MT class includes the minimum tug required to rescue ships in 93rd percentile winds according to Robert Allan (2013), and the ≥ 90 MT class includes the most powerful tugs examined in this study. Appendix B contains a list of the 76 tugs with greater than 50 MT bollard pull as determined by the methods described in this report. The maximum bollard pull identified in the dataset was 109 MT.

Table 4. Total number of tugs in dataset for each bollard pull category (inclusive)

Bollard Pull Category	Number of Tugs in Dataset
All Tugs (>0 MT)	232
≥ 50 MT	76
≥ 70 MT	35
≥ 90 MT	12

3.1 Number of Tugs That Meet Emergency Tow Vessel Requirements

As noted previously, Clear Seas' *Emergency Towing Vessel Needs Assessment* identified the bollard pull necessary to conduct an emergency tow for different types of ships operating in the Pacific Region under different wind conditions. Table 5 identifies the number of tugs found in the dataset that have at least the minimum required bollard pull to assist these ships in each weather scenario.

In 99th percentile weather conditions (winds of 33 knots), only two vessel types – RO/RO Vehicle Carrier and Aframax Tanker – could have been rescued by a tug of opportunity based on the criteria of sufficient bollard pull. In 95th percentile weather conditions (winds of 27 knots), the more powerful tugs are likely to be able to rescue every ship except for Large and Very Large Container Ships. In less severe weather conditions (50th to 85th percentile), many tugs have the requisite bollard pull to rescue all ship types. It is important to note that although they have the required bollard pull, not all of these tugs are necessarily suited to emergency towing. Clear Seas' *Emergency Towing Vessel Needs Assessment* highlights the importance of factors such as crew training, proper equipment, and seakeeping ability when determining ETV suitability (refer to Section 1.3.1 for a complete list of factors).

12 **Pusher tugs were excluded from the analysis.**

Table 5. Tugs in the 2016 AIS dataset for the Pacific Region that meet or exceed bollard pull requirements established by Clear Seas' *Emergency Towing Vessel Needs Assessment*.

Number of Tugs Identified in Study Area that Meet the Bollard Pull Requirements for Each Ship Type Based on Clear Seas' ETV Assessment								
Wind Conditions	Wind Speed (knots)	Large Container Ship	Very Large Container Ship	LNG Carrier	RO/RO Vehicle Carrier	Passenger Ship	Bulk Carrier	Aframax Tanker
50th Percentile	14	137	120	167	206	167	197	220
75th Percentile	19	64	41	95	147	99	131	175
85th Percentile	22	35	18	64	125	67	99	140
95th Percentile	27	0	0	7	43	12	32	64
99th Percentile	33	0	0	0	2	0	0	12

< 50 MT Required Bollard Pull	≥ 50 MT Required Bollard Pull	≥ 70 MT[13] Required Bollard Pull	≥ 90 MT Required Bollard Pull	≥ 109 MT[14] Required Bollard Pull

3.2 Spatial Distribution of Tugs and Proportion of Time in Area

Figure 2 shows the spatial distribution and proportion of time spent in grid cell areas of all 232 tugs identified in the study area throughout 2016. Each grid cell is colour coded to indicate the average proportion of time that a tug is likely to be present. Actual tug routes are depicted as gray lines on the map. The average return rate at the three passage lines is listed in the table within Figure 2.

When considering all tugs, the primary tug routes are along the central coast Inside Passage and along the east coast of Vancouver Island. The proportion of time a tug of any size spends in any single grid cell along Johnstone Strait and Discovery Passage is high, mostly greater than 40% in any given hour. This means that a tug is expected in this area, on average, every few hours. However, the proportion of time a tug of any size is expected to be present along the west coast of Vancouver Island is less than 10%.

The return rate at the Hecate Strait passage line indicates on average a tug passes every 0.4 days (10 hours). At the Queen Charlotte Strait passage line a tug passes every 0.3 days (7 hours) and at the west entrance to the Strait of Juan de Fuca a tug in this category passes every 0.6 days (14 hours).

13 The fleet capacity continues to increase, with three escort tugs received by SAAM Smit in early 2019 with bollard pulls of 84 MT: *Orca*, *Grizzly*, and *Tsimshian Warrior*. The *Tsimshian Warrior* operates out of Prince Rupert, while the other two vessels are based in or near Vancouver.

14 This represents the highest bollard pull of any tug in the study; any scenario requiring higher bollard pull is considered unlikely to be able to be rescued by a tug of opportunity.

Figure 2 shows what most waterway observers would conclude: there are many tugs moving through the near-shore waters of the Pacific Region, but tugs of any size are rarer in off-shore waters.

To identify the impact of seasonality on tug distribution and capability, traffic data for five winter months (November through March) were compared with that of seven summer months (April through October) for tugs greater than 70 MT. There was slightly lower probability of a tug of this size being available in the winter months, but the differences were minor[15] and so are not represented here. Tugs with less bollard pull tend to have greater variability in their distribution across the year, with typically fewer smaller tugs transiting in the winter months.

Distribution of All Tugs

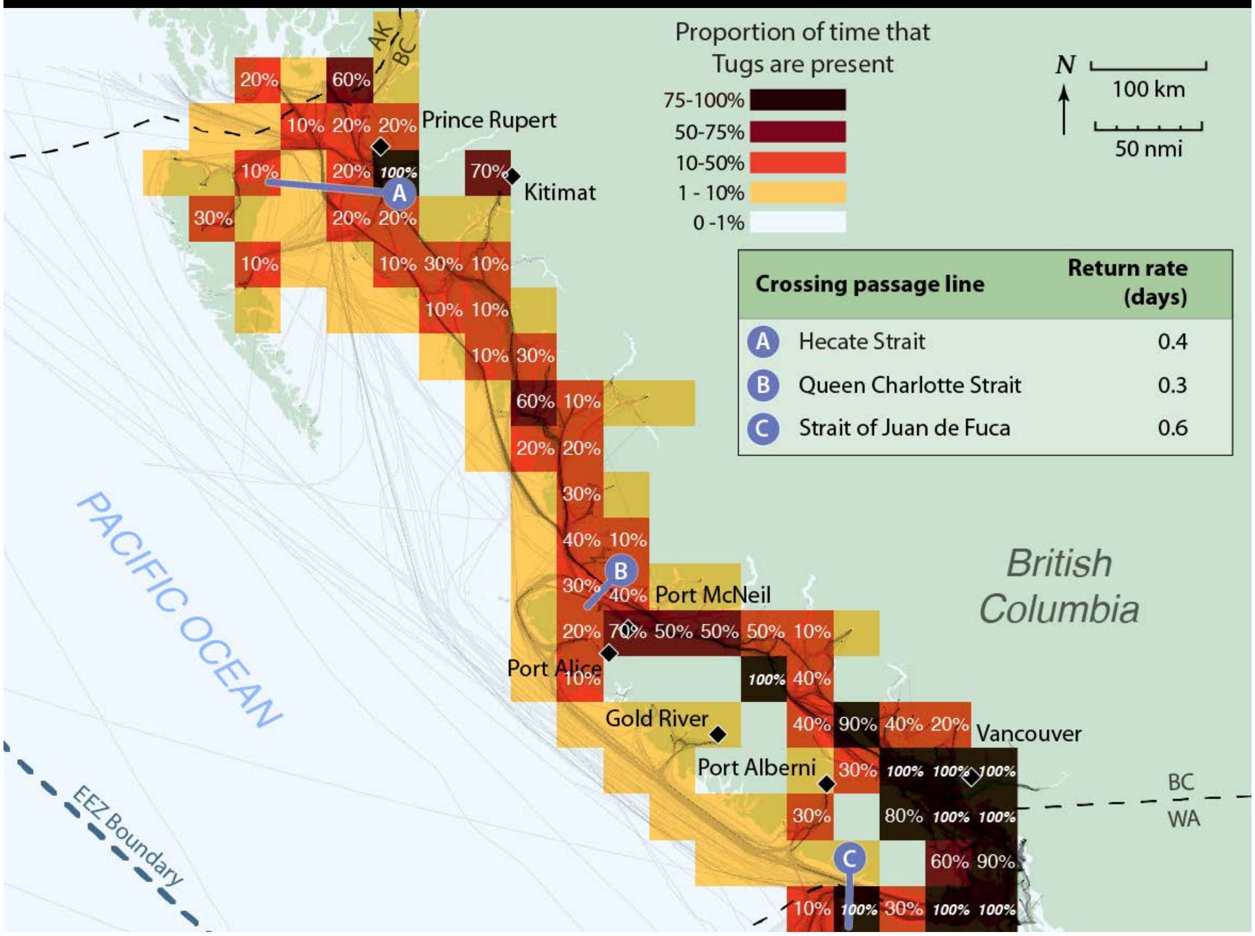


Figure 2. Average proportion of time tugs are present and return rate for all tugs identified by AIS in the study area in 2016.

Figure 3 shows the spatial distribution and traffic patterns (grey tracks) of the 76 tugs with a bollard pull greater than or equal to 50 MT. Routes for these tugs are typically along the central coast Inside Passage and along the east coast of Vancouver Island. Note the cells with tugs present 100% of the time are the ports of Prince Rupert and Vancouver and the western entrance to the Strait of Juan de Fuca. The western entrance to the Strait of Juan de Fuca is where a dedicated ETV is stationed at Neah Bay, WA.

15 Tugs with bollard pull >70 MT on average crossed the Hecate Strait passage line 4% less often in winter, the Queen Charlotte Strait passage line 3% more often in winter, and the Strait of Juan de Fuca passage line 13% less often in winter. However, tugs with bollard pull >90 MT on average crossed the Hecate, Queen Charlotte, and Juan de Fuca Strait passage lines more often in winter, 4%, 4% and 11%, respectively. The finding that the largest tugs are more likely to be present in winter, when more severe weather conditions are common, is not unexpected.

The proportion of time at least one tug greater than or equal to 50 MT of bollard pull is present along the east coast of Vancouver Island is mainly between 10% and 20%, on average. Along the central coast Inside Passage the proportion of time a tug is present is less than 10%, with the exception of the area around Prince Rupert. Along the west coast of Vancouver Island, the average proportion of time a tug is present in any grid cell is also less than 10%, meaning a tug is likely present at most a few hours each day.

The return rate data at the Hecate Strait and Queen Charlotte Strait passage lines indicate a tug with bollard pull greater than or equal to 50 MT passes on average every 0.7 days (17 hours). At the western entrance to the Strait of Juan de Fuca, a tug in this category on average passes every 1.2 days. As mentioned above, some of the tugs at the lower end of this category would not be capable of performing an emergency tow under certain weather conditions responding to larger disabled ships.

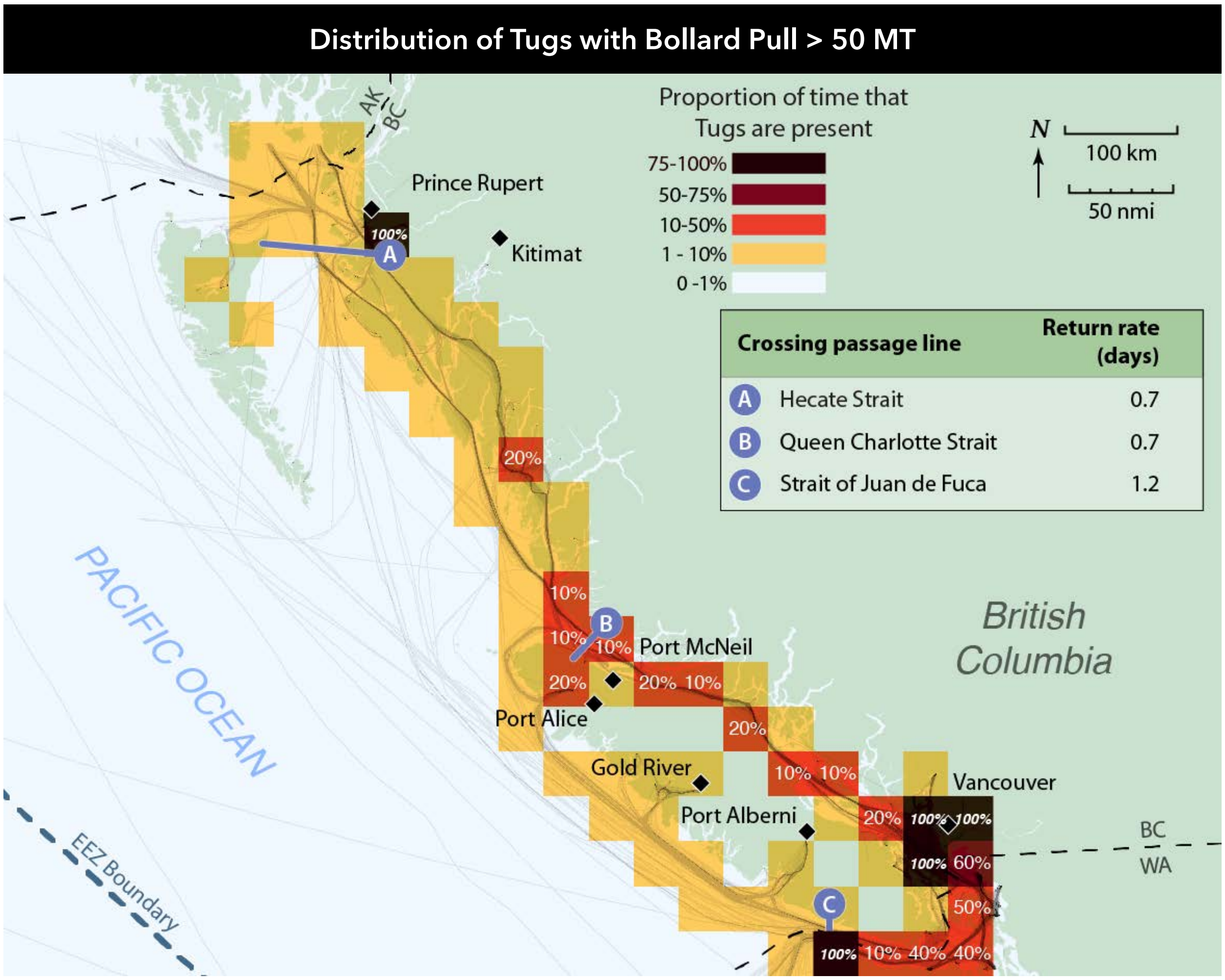


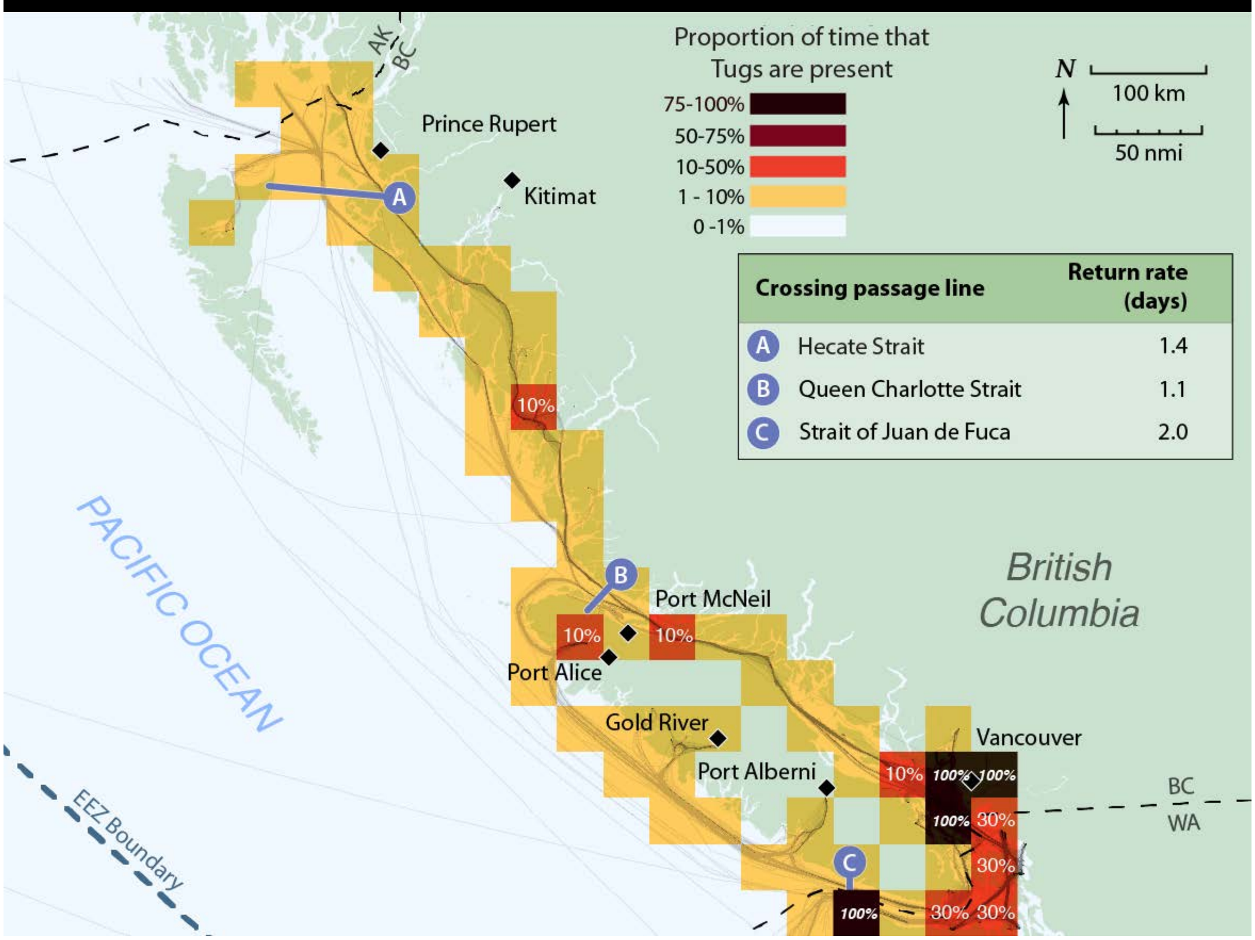
Figure 3. Average proportion of time tugs are present and return rate for tugs with a bollard pull greater than 50 MT identified by AIS in the study area in 2016.

Figure 4 shows the spatial distribution and traffic patterns (grey tracks) of the 35 tugs with a bollard pull greater than or equal to 70 MT identified in the study across the entire 2016 year. Tug routes for this category are typically along the central coast Inside Passage and along the east coast of Vancouver Island.

The proportion of time a tug with a bollard pull greater than or equal to 70 MT is likely to be present in any grid cell outside the Salish Sea (the area encompassing the eastern half of the Strait of Juan de Fuca, Puget Sound, and the Southern Gulf Islands to the Port of Vancouver) is approximately 10%, except in Neah Bay where a dedicated ETV is stationed.

Return rate data at the Hecate Strait passage line indicates on average a tug in this category passes every 1.4 days. At the Queen Charlotte Strait passage line a tug with bollard pull greater than or equal to 70 MT passes every 1.1 days on average and at the Strait of Juan de Fuca passage line, a tug in this category passes every 2 days on average. Tugs in this category meet the requirements to perform emergency towing duties for all ship types in 85th percentile weather conditions (22 knots of wind), as shown in Table 5, and are more likely than tugs in the 50 MT bollard pull category to be suitably equipped and crewed for emergency towing situations.

Distribution of Tugs with Bollard Pull > 70 MT



Crossing passage line	Return rate (days)
A Hecate Strait	1.4
B Queen Charlotte Strait	1.1
C Strait of Juan de Fuca	2.0

Figure 4. Average proportion of time tugs are present and return rate for tugs with a bollard pull greater than 70 MT identified by AIS in the study area in 2016.

Figure 5 shows the spatial distribution and traffic patterns (grey tracks) of the 12 tugs with a bollard pull greater than or equal to 90 MT. These tugs are predominately present around the southern tip of Vancouver Island, in Johnstone Strait and Discovery Passage, as well as in most western Vancouver Island sounds. They can also be found in Masset Sound on Haida Gwaii. However, the proportion of time a tug is present in most of these areas is less than 10%.

On average, return rate data at passage lines indicates one crossing every 15.9 days in Hecate Strait, one crossing every 4.8 days in Queen Charlotte Strait and one crossing every 7 days in the Strait of Juan de Fuca.

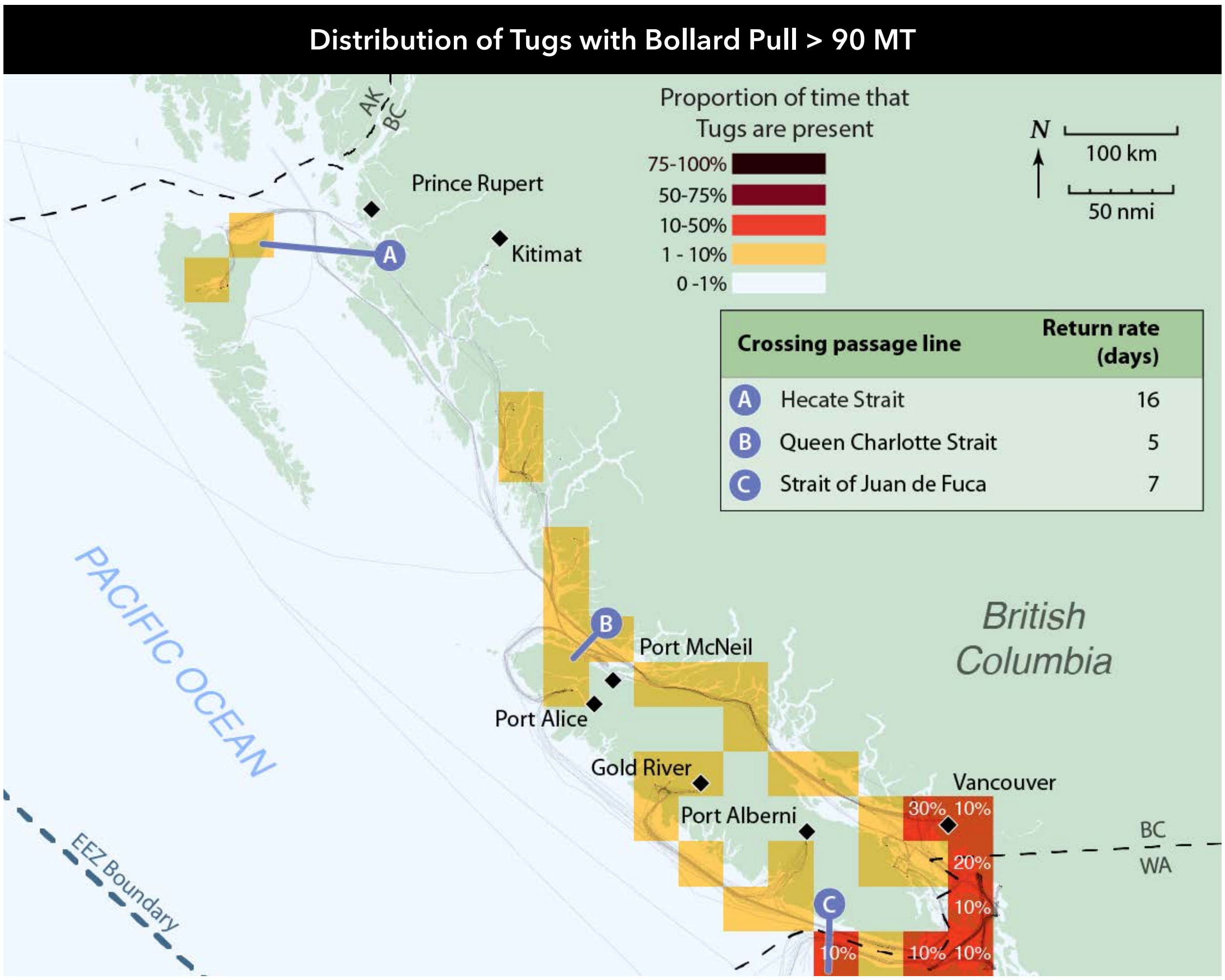


Figure 5. Average proportion of time tugs are present and return rate for tugs with a bollard pull greater than 90 MT identified by AIS in the study area in 2016.

Figure 6 shows the spatial distribution and traffic pattern (grey tracks) of the single tug *Seaspan Royal* with a bollard pull of 93 MT, which regularly trades in the Pacific region. When compared with Figure 5, Figure 6 demonstrates that, outside the Salish Sea, this one tug represents the majority of the spatial distribution of the tugs in the category of greater than 90 MT bollard pull.

On average, return rate data at passage lines for this tug indicates one crossing every 20.3 days in Hecate Strait, one crossing every 5.2 days in Queen Charlotte Strait, and one crossing every 12.6 days in the Strait of Juan de Fuca. This tug represents the higher end of emergency towing capability in the areas where a tug of opportunity is likely to be called upon.

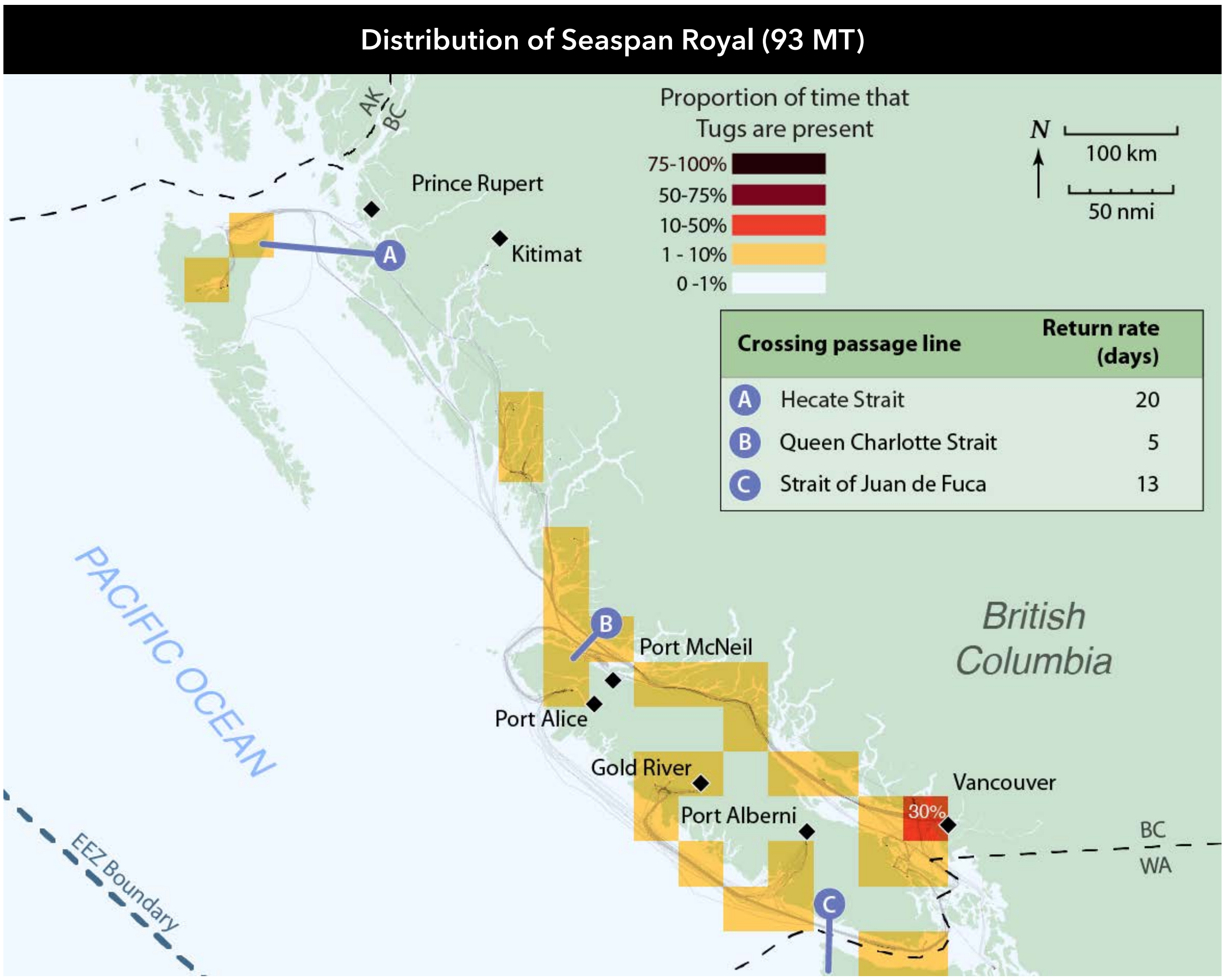


Figure 6. Average proportion of time tug is present and return rate for the *Seaspan Royal* as identified by AIS data in the study area in 2016.

The maps in Figures 2 through 6 show that tugs are mainly found in the near-shore waters of the Pacific Region. Because large ships in need of rescue are not usually close to typical tug of opportunity travel routes, it is important to include the factor of travel time from where a suitable tug is likely transiting to where an emergency tow is likely needed.

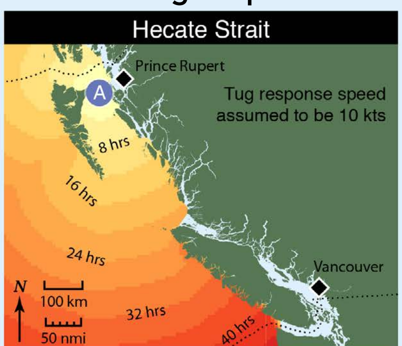
Figure 7 shows the time required for a tug to travel from each of the three passage line locations toward the open ocean at a rate of 10 knots. This is a useful approximation, but it is incomplete. A more accurate assessment of whether a tug of opportunity could respond to a particular incident requires consideration of several factors:

- The time required to identify the tug of opportunity;
- The time required for the tug of opportunity to hand-off or moor the barge it is towing;
- The wind and wave conditions in the area the tug has to travel;
- The time the tug would take to reach the passage line; and
- The travel times shown in Figure 7.

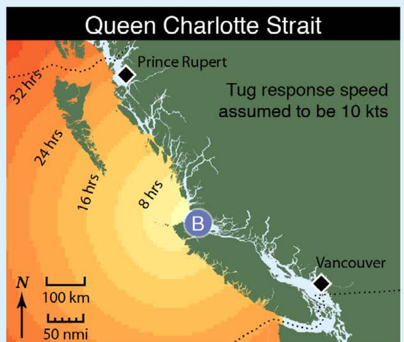
The sum of the above times must then be compared to the expected time it would take for a particular ship type to run aground during particular weather conditions to determine if a tug of opportunity is likely to reach the disabled ship in time to respond. A full evaluation of ship drift times can be found in Clear Seas' report titled *Vessel Drift and Response Analysis for Canada's Pacific Coast*.

However, the presence of a dedicated ETV at Neah Bay (at the western entrance of the Strait of Juan de Fuca) with a mandated <20 minutes mobilization time means the likely response time from passage line C would be very close to the time indicated in Figure 7.

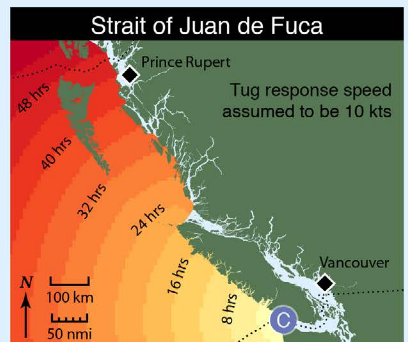
Minimum Tug Response Times from Three Locations



A Hecate Strait	Return rate (days)
All Tugs	0.4
All Tugs with > 50 MT Bollard Pull	0.7
All Tugs with > 70 MT Bollard Pull	1.4
All Tugs with > 90 MT Bollard Pull	16
Seaspan Royal (93 MT Bollard Pull)	20



B Queen Charlotte Strait	Return rate (days)
All Tugs	0.3
All Tugs with > 50 MT Bollard Pull	0.7
All Tugs with > 70 MT Bollard Pull	1.1
All Tugs with > 90 MT Bollard Pull	5
Seaspan Royal (93 MT Bollard Pull)	5



C Strait of Juan de Fuca	Return rate (days)
All Tugs	0.6
All Tugs with > 50 MT Bollard Pull	1.2
All Tugs with > 70 MT Bollard Pull	2.0
All Tugs with > 90 MT Bollard Pull	7
Seaspan Royal (93 MT Bollard Pull)	13

Figure 7. Maps showing the travel time from each passage line to areas on the outer coast and the return rate for each tug category.

4.0 Discussion

Clear Seas' *Emergency Towing Vessel Needs Assessment* concluded that, as a general rule, tugs capable of exerting a force of 70 MT bollard pull or greater are likely to have sufficient winches, tow gear, crew training and seakeeping ability to safely perform an emergency tow of a large ship in severe weather conditions. While all bollard pull categories are presented in Section 3, discussion here is focused primarily on those tugs with bollard pull of 70 MT or greater.

Tugs with less than 70 MT bollard pull have proved able to rescue disabled ships; Appendix C provides two case studies — the *Simushir* cargo ship and *Jake Shearer* articulated tug and barge — where tugs of opportunity with slightly less than 70 MT were able to successfully effect a rescue. However, in both of these situations, the disabled ships were small compared to the average ship operating in the Pacific Region. These examples should not be taken as evidence that smaller tugs can be relied upon to provide emergency rescue services. In the rescue of the *MOL Prestige* (also described in Appendix C), a dedicated ETV with 98 MT of bollard pull successfully towed this average-size container ship.

Of the 232 tugs identified in the study, 85% have a bollard pull of less than 70 MT. The maximum bollard pull identified was single tug with 109 MT. The 35 tugs with a bollard pull between 70 MT and 109 MT are generally distributed along the typical towing routes of the central coast Inside Passage from Vancouver to Prince Rupert and along the outer coast of Vancouver Island. There are very few tugs operating in waters west of Haida Gwaii. Tugs of opportunity with bollard pull between 70 MT and 109 MT travelling along typical routes were present less than 10% of the time on average within any 40 km x 40 km area. On average, tugs in this category crossed passage lines with the following frequencies:

- Hecate Strait passage line (near Prince Rupert) every 1.4 days (34 hours);
- Queen Charlotte Strait passage line (near Port Hardy) every 1.1 days (26 hours); and
- Strait of Juan de Fuca passage line (near Neah Bay) every 2.0 days (48 hours).

When comparing winter and summer, there were only minor seasonal differences in distribution of tugs with greater than or equal to 70 MT of bollard pull and proportion of time spent in an area.

Twelve of the 35 tugs in the Pacific Region in 2016 with bollard pull greater than 70 MT had a bollard pull in excess of 90 MT. These tugs were recorded crossing the passage lines with the following frequencies:

- Hecate Strait passage line (near Prince Rupert) every 16 days;
- Queen Charlotte Strait passage line (near Port Hardy) every 5 days; and
- Strait of Juan de Fuca passage line (near Neah Bay) every 7 days.

The majority of these vessel movements were attributed to a single tug, the *Seaspan Royal*, with 93 MT of bollard pull.

All tugs of opportunity with greater than 70 MT of bollard pull are generally towing barges and would require time to secure their tow before proceeding to the location of any disabled ship. Even after a tug of opportunity secures its tow, the time required to transit from the common towing routes to off-shore waters can be significant, sometimes more than 24 hours, further delaying the tug's response time.

5.0 Conclusions

This study identifies three gaps of varying severity in the current tug of opportunity system. A gap is defined as either a scenario in which ships are unable to be rescued effectively or an aspect of the rescue process that is not fully understood. The gaps are described as follows:

5.1 Gap of Capability

As shown in Table 2, of the ship types and wind conditions discussed in Clear Seas' *Emergency Towing Vessel Needs Assessment* report, there were no tugs of opportunity in 2016 with sufficient towing capability to rescue the following ship types in sustained winds of greater than 33 knots (99th percentile conditions):

- Large Container Ship
- Very Large Container Ship
- LNG Carrier
- Passenger Ship
- Bulk Carrier

Although these conditions only are recorded about 1% of the time in the Pacific Region, the Large and Very Large Container Ships are also not able to be rescued by the tug of opportunity fleet in sustained winds of greater than 27 knots, which occur about 5% of the time. However, as of 2019, the Canadian Coast Guard is operating two leased ETVs to make additional emergency towing capacity available. At least one of these vessels, the *Atlantic Eagle*, has a bollard pull of 158 MT,[16] enough to singly rescue all but Large and Very Large Container ships in 99th percentile winds, significantly reducing this gap of capability.

5.2 Gap of Availability

Tugs follow typical transit routes in near-shore waters most of the time, leaving much of the commercial shipping traffic (in off-shore waters) far from potential rescue tugs. This spatial disparity is exacerbated by the fact that near-shore waters are less in need of a tug of opportunity system; a tug is less likely to have sufficient time to rescue a drifting ship before it runs aground in the narrow channels of the central coast Inside Passage, for example.

The distribution of tugs with bollard pull greater than 90 MT is notably sparser in the northern half of the region than that of tugs with lower bollard pull. The median proportion of time tugs with 90 MT bollard pull are present is less than 1% in most of Queen Charlotte Sound and Hecate Strait, whereas the median proportion of time tugs in this category are present in the southern half of the region is between 1% and 10%. Based on this distribution of tugs of opportunity, any disabled ship north of Queen Charlotte Strait requiring rescue from a tug with greater than 90 MT bollard pull has a low likelihood of finding a suitable tug of opportunity nearby. Ship types that would require response from this category of tug include those identified in Section 5.1 and also LNG Carriers in 27 knot winds (occurring 5% of the time) and RO/RO Vehicle Carriers in 33 knot winds (occurring 1% of the time).

As shown in Figure 7, travel times to off-shore waters can be anywhere from 4 hours to 48 hours, depending on where the tug is, where the disabled ship is, and what the weather conditions are at the

16 Det Norske Veritas Certificate of Bollard Pull for "Atlantic Eagle".

time. Given the significant drift rates for disabled ships identified in Clear Seas' *Vessel Drift and Response Analysis for Canada's Pacific Coast* report (2018), the time taken to respond to a ship in distress is crucial for a successful rescue. Further, actual travel times are usually higher than the minimum travel times estimated here. Three recent examples include the *Jake Shearer* (18 hours before a tow was established), *Simushir* (42 hours), and the *MOL Prestige* (several days). More detail on these incidents can be found in Appendix C.

However, the risk presented by this gap is substantially mitigated by the Canadian Coast Guard's deployment of two dedicated ETVs, the *Atlantic Raven* and *Atlantic Eagle*, to patrol the off-shore areas west of Vancouver Island and west of Haida Gwaii that have particularly low tug of opportunity availability.[17]

5.3 Gap of Understanding

The average proportion of time a tug is likely to be present in any grid cell is useful for knowing where tugs are likely to be most of the time, but this information does not predict whether any tug of opportunity will be able to conduct a successful rescue. A successful emergency towing effort involves many different factors not addressed in this report, including the wind and wave conditions affecting both the drift rate of the disabled ship and the speed of the responding tug, the time to establish a contract and a connection between the ship and the tug, and the capacity of the tug to effect a rescue. The analysis conducted here provides the likely distribution of different categories of tugs of opportunity. This information can be used to support a final determination of the probability of rescue for disabled ships, but is not in itself a full measure of the strengths or failings of the tug of opportunity system.

17 **Public Services and Procurement Canada. (2018). Government of Canada awards contract under the Oceans Protection Plan to increase emergency offshore towing capability off British Columbia coast.**

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Appendix A – Passage Line Crossings

Tug traffic was assessed as it crossed three virtual passage lines on the Pacific coast. Analysis of these passage line crossings reveals variations in tug traffic patterns by season and by tug size.

When comparing average monthly traffic from April through October (seven months) and that of November through March (five months) to year-round average monthly traffic, two patterns are evident:

1. Average monthly passages are fewer in the winter than in the summer; however,
2. In the Strait of Juan de Fuca, tugs with >90 MT bollard pull transit more frequently in winter; these tugs make approximately 10% more trips in the winter and 8% fewer trips in the summer than the year-round average, but tugs with bollard pull >70 MT make approximately 13% fewer trips in the winter and 9% more trips in the summer than the year-round average.

Year Round					
Passage Line	2016 Total Passages				
	All tugs	BP >30 MT	BP >50 MT	BP >70 MT	BP >90 MT
Hecate Strait	907	722	518	252	23
Queen Charlotte Strait	1255	734	526	332	76
Strait of Juan de Fuca	625	550	304	184	52

Winter (November Through March)					
Passage Line	2016 Winter Passages				
	All tugs	BP >30 MT	BP >50 MT	BP >70 MT	BP >90 MT
Hecate Strait	337	272	195	101	10
Queen Charlotte Strait	462	288	214	143	33
Strait of Juan de Fuca	214	189	109	67	24

Summer (April Through October)					
Passage Line	2016 Summer Passages				
	All tugs	BP >30 MT	BP >50 MT	BP >70 MT	BP >90 MT
Hecate Strait	570	450	323	151	13
Queen Charlotte Strait	793	446	312	189	43
Strait of Juan de Fuca	411	361	195	117	28

Seasonal Variation in Passage Line Crossings from Baseline										
Passage Line	Seasonal % change from year-round average (Winter | Summer)									
	All tugs		BP >30 MT		BP >50 MT		BP >70 MT		BP >90 MT	
Hecate Strait	-11%	8%	-10%	7%	-10%	7%	-4%	3%	4%	-3%
Queen Charlotte Strait	-12%	8%	-6%	4%	-2%	2%	3%	-2%	4%	-3%
Strait of Juan de Fuca	-18%	13%	-18%	13%	-14%	10%	-13%	9%	11%	-8%

Appendix B – List of Tugs in the Study with at Least 50 MT of Bollard Pull

Tug Name	Length (m)	Estimated Bollard Pull (MT)
CHIEF	31.4	50
POLAR STORM	36.9	50
PROTECTOR	36.6	50
WESTERN RANGER	31.9	50
GUIDE	31.4	50
WEDELL FOSS	30.5	50
HENRY FOSS	30.5	50
KLIHYAM	36.0	51
OCEAN RANGER	35.7	54
AMERICAN CHALLENGER	33.8	54
MOUNT BONA	26.3	54
ALASKA MARINER	37.0	55
PACIFIC FREEDOM	34.9	55
RICHARD BRUSCO	34.1	55
MILLENNIUM STAR	30.0	56
ADRIATIC SEA	38.4	58
MILLENNIUM DAWN	32.6	59
SMIT VENTA	28.8	59
POLAR ENDURANCE	38.4	60
BO BRUSCO	24.0	60
GULF CAJUN	39.2	60
POLAR CLOUD	46.3	60
SMIT SABA	28.7	60
EL LOBO GRANDE II	41.5	60
POLAR RANGER	36.6	60
POLAR VIKING	36.6	60
GRETCHEN DUNLAP	30.8	60
NAVAJO	41.4	60
KOOTENAY	19.0	60
SMIT MISSISSIPPI	30.6	61
TUG POLAR KING	42.0	62
MILLENNIUM FALCON	32.0	63
GULF TITAN	36.6	64
TAKU WIND	36.6	64
BARBARA FOSS	38.7	65

Tug Name	Length (m)	Estimated Bollard Pull (MT)
SMIT HUMBER	30.6	65
SST CAPILANO	21.7	65
SMIT CLYDE	30.6	65
SST SALISH	21.7	65
RESPONSE	39.2	66
SST TIGER SUN	21.7	70
SEASPAN EAGLE	28.2	70
SEASPAN RAVEN	28.2	71
MONTANA	36.6	73
GUARDSMAN	41.5	78
BULWARK	41.5	78
MARSHALL FOSS	29.9	78
LINDSEY FOSS	47.2	79
BERING TITAN	36.0	80
ALASKA TITAN	36.6	80
SEASPAN KESTREL	25.0	80
SEASPAN OSPREY	28.2	80
OCEAN TITAN	36.6	80
PACIFIC TITAN	33.0	80
WESTERN TITAN	30.6	80
ARCTIC TITAN	36.7	80
SIRIUS	39.2	80
SEASPAN COMMODORE	43.9	82
SEASPAN RESOLUTION	29.9	82
PHYLLIS DUNLAP	37.0	82
WASHINGTON	36.6	82
DELTA LINDSEY	30.0	85
SST ORLEANS	30.5	85
TUG VIGILANT	31.0	92
SEASPAN ROYAL	43.0	93
BRITOIL 72	47.0	94
BRITOIL 70	47.0	94
NATOMA	38.8	95
LAUREN FOSS	45.7	96
CORBIN FOSS	45.7	96
GUARD	36.6	99
MICHELE FOSS	39.6	99
DENISE FOSS	39.6	100
SEA VOYAGER	43.2	109

Appendix C – Rescue by Tug Scenarios

C.1 Emergency Towing Event: Simushir

The Russian-flagged cargo ship *Simushir* was built in 1998 with the following specifications:

- 135 m Length
- 9,405 Deadweight Tons (DWT)
- 6,540 Gross Tons (GT)
- 639 m^3 Persistent Fuel Capacity (heavy fuel oil).

The *Simushir* is a small ship when compared to other cargo ships traveling through Pacific Region waters, only about 15% of the average by DWT or GT.

During a voyage from Everett, Washington to Russia the *Simushir* lost power in gale force winds (99th percentile weather conditions)[18] near the southwestern shore of Haida Gwaii on October 16, 2014 (CBC News, 2014). The Canadian Coast Guard (CCG) first recognized the situation at 23:10 PDT and contacted the *Simushir*. The CCG patrol vessel Gordon Reid responded to the incident, along with a U.S.-flagged tug of opportunity *Barbara Foss* (McDiarmid, 2015). The *Barbara Foss* was towing a barge and diverted to Prince Rupert where the barge was moored before proceeding to the scene. The *Gordon Reid* reached the *Simushir* at 15:15 PDT on October 17, almost 17 hours after the incident began.

After several attempts, the *Gordon Reid* took the *Simushir* in tow, but had difficultly controlling the tow and making headway. At its closest point, the ship was less than 9 km (4.9 nautical miles) from shore (McDiarmid, 2015). The *Barbara Foss* set out from Prince Rupert at about 10:00 PDT on October 17 and arrived at the scene about 17:00 PDT on October 18, about 42 hours after the incident began.

The *Barbara Foss* relieved the *Gordon Reid* and successfully towed the *Simushir* to Prince Rupert (McDiarmid, 2015). The *Barbara Foss* is rated at 64 MT bollard pull (FOSS Maritime Company, 2017), able to tow most ship types in up to 85th percentile conditions, excepting large and very large container ships according to Clear Seas' *Emergency Towing Vessel Needs Assessment* report (2018); towing a relatively small cargo ship like the *Simushir* in 99th percentile conditions is well within its capabilities.

18 Clear Seas' Emergency Towing Vessel Needs Assessment report (2018).

C.2 Emergency Towing Event: Jake Shearer

The U.S.-flagged articulated tug *Jake Shearer* was built in 2015 with the following specifications:

- 35m Length
- 368 Deadweight Tons (DWT)
- 497 Gross Tons (GT)
- 254 m^3 estimated Non-Persistent Fuel Capacity

A barge of this size has very low freeboard and would require much lower bollard pull than a tanker to enact a successful rescue.

The *Jake Shearer* was pushing the 143-metre-long tank barge *Zidell Marine 277*, carrying 10,500 metric tonnes of oil cargo (fuel oil and gasoline), or roughly 10% the volume carried by an Aframax tanker. At approximately 15:40 PDT on November 26, 2017 as she was proceeding northbound in Queen Charlotte Sound on a voyage from Washington to Alaska in heavy weather, the connection between the tug and barge was lost. The barge went adrift, and the tug was unable to attach a tow line. However, two crew members were able to board the barge and deploy an anchor (Moore, 2017).

The CCG dispatched the patrol boat *Gordon Reid* to the scene, but she was also unable to take the barge in tow. The U.S.-flagged tug of opportunity *Gulf Cajun*, towing a barge in the vicinity, transferred that barge to another tug and proceeded to assist the *Zidell Marine 277*. The *Gulf Cajun* towed the *Zidell Marine 277* to Norman Morrison Bay (Moore, 2017). Data used for this analysis indicates that the bollard pull of the *Gulf Cajun* is 60 MT, able to tow most ship types in up to 85th percentile conditions, excepting large and very large container ships according to Clear Seas' *Emergency Towing Vessel Needs Assessment* report (2018).

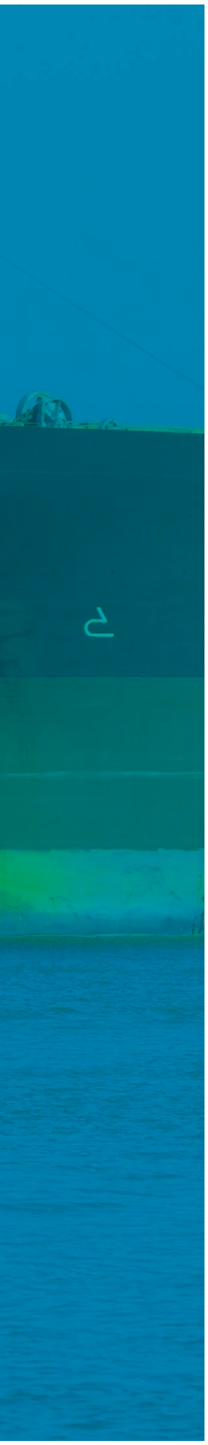
C.3 Emergency Towing Event: MOL Prestige

The Singapore-flagged container ship *MOL Prestige* was built in 2006 with the following specifications:

- 293 m Length
- 72,968 Deadweight Tons (DWT)
- 71,902 Gross Tons (GT)
- 7,800 m^3 estimated Persistent Fuel Capacity (heavy fuel oil).

The *MOL Prestige* is an average-size ship when compared to other container ships travelling through Pacific Region waters. Container ships represent 23% of traffic through the Strait of Juan de Fuca.

The *MOL Prestige* was disabled by an engine fire onboard during a voyage from Vancouver, Canada to Tokyo on February 1, 2018. It went adrift approximately 352 km (190 nautical miles) west of Haida Gwaii (FleetMon, 2018). The container ship drifted for several days before it was taken under tow by the U.S.-flagged *Denise Foss*, a dedicated ETV on standby in Neah Bay, WA. The ETV was dispatched by the Marine Exchange of Puget Sound and the *MOL Prestige* was towed to Seattle for repairs (Schuler, 2018). The *Denise Foss* is rated at 100 MT bollard pull (FOSS Maritime Company, 2017), able to tow most ship types in up to 95th percentile conditions, excepting large and very large container ships according to Clear Seas' *Emergency Towing Vessel Needs Assessment* report (2018).



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