Final Report: Sept 25th,2014

ABSTRACT

Report on the findings of the Pilotage Risk Management Methodology PRMM) to assess the Use of Escort Tugs in Haro St and Boundary Pass for Liquid Bulk Vessels, In Product, less than 40,000 SDWT

Chris Badger
Author

Contents

Acronyms

Throughout this document a number of acronyms are used. To assist the reader a list of acronyms and their meaning is given below:

AIS: The **Automatic Identification System** (**AIS**) is an automatic tracking system used on ships and by vessel traffic services (VTS) for identifying and locating vessels by electronically exchanging data with other nearby ships, AIS base stations, and satellites. When satellites are used to detect AIS signatures then the term Satellite-AIS (S-AIS) is used. AIS information supplements marine radar, which continues to be the primary method of collision avoidance for water transport.

ATB: ATB is the acronym for **Articulated Tug Barge**, which is a tug-barge combination system capable of operation on the high seas, coastwise and further inland. It combines a normal barge, with a bow resembling that of a ship, but having a deep indent at the stern to accommodate the bow of a tug.

DNV: **Det Norske Veritas** is a non-governmental organization that establishes and maintains technical standards for the construction and operation of ships and offshore structures.

GPS: The **Global Positioning System** (**GPS**) is a space-based satellite navigation system that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.[1] The system provides critical capabilities to military, civil and commercial users around the world. It is maintained by the United States government and is freely accessible to anyone with a GPS receiver.

PPA: **The Pacific Pilotage Authority** is a crown corporation, mandated to provide safe, reliable and efficient marine pilotage and related services in the coastal waters of British Columbia including the Fraser River

PPU: A **Portable Pilot Unit** is a portable computer based system that a pilot brings on board a vessel to use as a decision support tool for navigating in confined waters. Interfaced to a positioning sensor such as a GPS, and using some form of electronic chart display, it shows the vessel's position and movement in 'real-time'

PMV: **Port Metro Vancouver** is a non-shareholder, financially self-sufficient corporation, established by the government of Canada, pursuant to the Canada Marine Act, and accountable to the Federal Minister of Transport.

SDWT: **Summer Deadweight Tonnage**- 'Deadweight Ton' is the unit for the variable weight of the total contents of a ship under any particular condition of loading given in terms of the defined weight system, i.e. Metric or Long Tons, and is the difference between the Displacement Tons and the Lightweight Tons of the ship. The ship's 'Deadweight Tonnage' is typically quoted as being the maximum deadweight applicable under the International Load Line Regulations when floating at her Summer Load Line draught. The 'Deadweight Cargo Capacity Tonnage' is the Deadweight Tonnage less bunkers, water and constant weights

SOA: **Special Operating Areas**- are non-regulatory geographic maritime navigation areas that are established to enhance order and predictability, the efficient and safe movement of goods and services, and to further reduce the risk of accidents with respect to vessels transiting. They are established in conjunction with waterway users to establish specific standard operating procedure navigating through an area. Whereas they are not regulatory in nature such that operators could be found in violation, they do however result in close to the same adherence as vessel operators could be found negligent in court should an accident occur and the operator was not following standard operating procedures that were established in a published and charted Special Operating Area.

TSS: A **Traffic Separation Scheme** or **TSS** is a traffic-management route-system adopted by the International Maritime Organization or IMO. The traffic-lanes (or clearways) indicate the general direction of the ships in that zone; ships navigating within a TSS all sail in the same direction or they cross the lane in an angle as close to 90 degrees as possible.

Executive Summary

The Pacific Pilotage Authority, in consultation with the marine industry, conducted a risk assessment, using the Pilotage Risk Management Methodology (PRMM), on the use of escort tugs in Haro Strait and Boundary Pass for bulk liquid vessels less than 40,000 SDWT. Boundary Pass and Haro Strait are the most challenging portions of the route for vessels sailing to and from Port Metro Vancouver. The route transitions across the Canada/US border and these waterways are jointly managed by CCG and USCG. The area requires a number of significant alterations of course involving relatively tight turns implemented in otherwise restricted waters. Laden tankers (over 40,000SDWT) are escorted by a tethered tug through Boundary Pass and Haro Strait. At present the use of escort tugs is only required for bulk liquid vessels over 40,000 SDWT. The objectives of the PRMM were as follows:

- To establish a baseline of facts and stakeholder needs, issues and concerns on the subject of whether escort tugs should be used for liquid bulk vessels less than 40,000SDWT when transiting Haro Strait and Boundary Pass in the waters of British Columbia.
- To ensure all significant stakeholders have an opportunity to participate in the PRMM process
- To provide a report to the PPA management summarizing the situation and, based on the outcome of the PRMM process, make recommendations on a course of action.
- To provide transparency during the process

As part of this process, a fast time simulation for liquid bulk vessels under 40,000SDWT was undertaken to assess their maneuvering characteristics both with and without tugs in Haro Strait.

The Risk Assessment was conducted in three modules:

1. Module one consisted of Project scoping and planning; stakeholder identification; Data identification and sourcing; and establishment of a Risk Assessment Team.
2. Module two consisted of Risk scenario development, Risk estimation, Risk evaluation and Risk control strategies. This was achieved through one and a half days of workshops
3. Module three consisted of a summarization of the two workshops that was distributed to the Risk Assessment Team for comment, and the preparation of a final report

During module one, 30 stakeholders were approached of which 24 accepted interviews. While none of the stakeholders interviewed were experts, their range of knowledge in the PRMM process ranged from none to some. The general feeling amongst the stakeholders was that there were a number of facility projects being considered in the region (LNG, Coal, Oil, etc.) which gave the perception that there would be a significant increase in vessel traffic and therefore increased risk. It was also generally felt by the stakeholders that Haro St and Boundary Pass were critical environmental areas (from endangered species to traditional fishing grounds) and there was broad concern about shipping in general. Some also felt that the present cutoff of 40,000 SDWT for the use of tethered tugs for tankers seemed arbitrary and some felt that the use of tugs for tankers under 40,000SDWT would be an overreaction and caused by political pressure. Also during the course of the project a considerable amount of data was collected. A consolidation of the data was prepared and provided to the Risk Assessment Team as reference material for use in the workshops.

An initial Risk Assessment question was developed and reviewed by all the stakeholders interviewed and by the Risk Assessment Team. Based on this feedback a final 'question' was developed and utilized during the risk assessment workshops.

Will the use of Escort Tugs in Haro St and Boundary Pass for bulk liquid vessels, in product, less than 40,000SDWT, materially improve safe navigation"

A Risk Assessment Team, of industry experts, was formed and over the course of one and a half days of workshops, the Risk Assessment Team conducted a risk assessment utilizing the Pilotage Risk Management Methodology (PRMM) risk assessment process.

The Pilotage Risk Management Methodology was developed by Transport Canada's risk specialists in consultation with the four Pilotage Authorities. It provides a structured approach to:

- Defining the issues;
- Identifying and consulting with project stakeholders;
- Developing risk scenarios;
- Estimating and evaluating risks; and
- Developing risk mitigation and control strategies, if required

The PRMM also provides for full documentation of the process, analysis and outcomes. The Objectives and Priorities of this particular PRMM were to:

- Establish a baseline of facts.
- Ensure all significant stakeholders have an opportunity to participate in the PRMM process
- Provide a report to the PPA management and make recommendations on a course of action.
- Ensure transparency in the process is a priority

As a result of the findings of the workshops, the Risk Assessment Team made a number of observations and recommendations:

1. The most probable worst case scenario for a tanker under 40,000 SDWT navigating in Haro St and Boundary Pass, would be a steering failure on a vessel rounding Turn Point
2. Small (less than 40,000 SDWT) tankers, unlike larger tankers, are generally not designed to have tethered escort tugs and there have been instances of hard point failure (ships, hardware, such as bitts, being pulled out) due to the force of a tethered tug pulling on the lines
3. Keeping tankers of less than 40,000 SDWT a minimum of 0.5 nautical miles off shore would likely greatly reduce the chances of a hard grounding and a subsequent cargo spill, because at this distance from the shore, the manoeuverability of small tankers would allow them to come to a hard (full) stop before the vessel ran aground. However a much more in depth analysis, likely including a full simulation would need to be conducted to confirm the accuracy of this finding. Furthermore a number of vessel types would have to be assessed based on their manoeuvering characteristics
4. The danger of a drift grounding occurring after a vessel comes to a complete stop only occurs at certain high risk points when it is maneuvering close to land and where the prevailing currents could push the vessel on shore. These would include Turn Point and East Pt. At all other times in the passage the vessel would likely, after coming to a hard stop, drift with the current parallel to the land giving time for a standby tug to provide assistance. As such it is recommended that a standby tug be available, close to tankers less than 40,000 SDWT as they round Turn Pt, and East Pt. Furthermore, it was determined that the use of a standby tug at key high risk points would

likely provide the same overall benefit as an escort tug, when coupled with the 0.5 mile buffer zone.

5. The various analyses reviewed by the Risk Assessment Team suggest that that the risks of a spill from the bunker tanks of non- double hulled cargo vessel are much higher than the risks of cargo spill from tankers. This suggests that the positioning of a Stand-by tug within Haro St and Boundary Pass may be of equal or even greater advantage to non-tanker vessels transiting this area than to tankers less than 40,000SDWT. However the Risk Assessment Team would not see a standby tug replacing the need for tethered escort tugs on tankers over 40,000SDWT
6. There are a number of other mitigation options that could potentially provide an enhancement to safety in the area of Haro St and Boundary Pass. These include:
    a. The requirement for all vessels, including recreational vessels, to have AIS Transponders
    b. The encouragement of ship owners to provide redundancy in the design of their vessels
    c. Greater use of government patrol vessels to police safety in narrow shipping lanes
    d. The use of moving safety zones around tankers, particularly if implemented in conjunction with mandatory AIS

Background

The Pacific Pilotage Authority, in consultation with the marine industry, conducted a risk assessment, using the Pilotage Risk Management Methodology (PRMM), on the use of escort tugs in Haro Strait and Boundary Pass for bulk liquid vessels less than 40,000 SDWT. Boundary Pass and Haro Strait are the most challenging portions of the route for vessels sailing to and from Port Metro Vancouver. The route transitions across the Canada/US border and these waterways are jointly managed by Canadian Coast Guard and the United States Coast Guard. The area requires a number of significant alterations of course involving relatively tight turns implemented in otherwise restricted waters. Laden tankers (over 40,000SDWT) are escorted by a tethered tug through Boundary Pass and Haro Strait. At present the use of escort tugs is only required for bulk liquid vessels over 40,000 SDWT. The objectives of the PRMM were as follows:

- To establish a baseline of facts and stakeholder needs, issues and concerns on the subject of whether escort tugs should be used for liquid bulk vessels less than 40,000SDWT when transiting Haro Strait and Boundary Pass in the waters of British Columbia.
- To ensure all significant stakeholders have an opportunity to participate in the PRMM process
- To provide a report to the PPA management summarizing the situation and, based on the outcome of the PRMM process, make recommendations on a course of action.
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As part of this process, a fast time simulation for liquid bulk vessels under 40,000SDWT was undertaken to assess their maneuvering characteristics both with and without tugs in Haro Strait.

Sequence of Events

The following outlines the sequence of events that were undertaken to produce this Report. (A copy of the Project initiation document can be found in Appendix 1): The sequence of events followed three main modules:

Module One

Module one consisted of Project scoping and planning; stakeholder identification; Data identification and sourcing; and establishment of a Risk Assessment Team. This was achieved through the following:

Initiation Meeting

On 15th January, 2014 a project initiation meeting was held at the Offices of the Pacific Pilotage Authority to discuss the following items

- The PPA lead
- Objectives and Priorities
- Time Table
- The PRMM Question
- Stakeholders to be interviewed
- Stakeholder Interview Questionnaire
- Data Sources
- The makeup of the Risk Advisory Team

The record of discussion for this meeting can be found in Appendix 1

Stakeholder Interviews Phase 1

Between January 13th and February 28th, 18 Stakeholder interviews were undertaken. A standard questionnaire was developed and each stakeholder interview took about 1 hour. More detail on the findings of the interviews will be given later in this document. A copy of the questionnaire along with a covering letter sent to the stakeholders can be found in Appendix 2

Data Collection

During the course of the project a considerable amount of data was collected. A full list of data sourced can be found in the Bibliography of Data at the end of this report. A consolidation of the data was prepared and provided to the Risk Assessment Team as reference material for use in the workshops. A copy of the consolidated data can be found in Appendix 3.

Module One meeting

On 28th February on completion of module 1 of the project, a second meeting was held with the PPA to discuss the following items.

- Feedback from first round of stakeholder interviews
- Data collection to date
- Additional stakeholder interviews
- Updated timetable
- Changes to the PRMM Question

During this meeting it was decided to increase the scope of stakeholders to be interviewed. A copy of the record of discussion from that meeting can be found in Appendix 1

Stakeholder Interviews Phase 2

Between March 3rd and April 11th, a second phase of stakeholder interviews was undertaken in which an additional 6 interviews were undertaken. In total 30 stakeholders were approached of which 24 accepted interviews. The breakdown of the stakeholders is as follows:

- Industry 5
- Government 8
- Mariners 5
- First Nations and Tribal 4
- Waterway Users 4
- Environmental 2
- Academic 1

22 of the stakeholders approached were Canadian and 8 from the United States

Module Two

Module two consisted of Risk scenario development, Risk estimation, Risk evaluation and Risk control strategies. This was achieved through one and a half days of workshops

Risk Assessment Workshop One

On April 14th an initial full day Risk Assessment workshop was held with the Risk Assessment Team in the offices of the British Columbia Coast Pilots. Present at this workshop were representatives from:

- The Pacific Pilotage Authority
- British Columbia Coast Pilots
- Chamber of Shipping of BC
- The Shipping Federation
- Canadian Coast Guard
- United States Coast Guard
- Transport Canada

Plus three PRMM trained facilitators

Risk Assessment Workshop Two

A second half day workshop was held with the Risk Assessment Team on the 27th June again in the offices of the British Columbia Coast Pilots. Present at this workshop were representatives from:

- The Pacific Pilotage Authority
- British Columbia Coast Pilots
- Chamber of Shipping of BC
- Canadian Coast Guard
- Transport Canada

Plus three PRMM trained facilitators one of whom is a retired U.S. Coast Guard Captain.

Agendas for these two meetings can be found in Appendix 4. Information on the findings of these workshops is contained in the body of this report.

Module Three

Module three consisted of a summarization of the two workshops that was distributed to the Risk Assessment Team for comment, and the preparation of a final report.

Main Body of Report

The following sections of this report provide:

1. A summary of the feedback from the stakeholder interviews,
2. Summaries of the findings of the Risk Assessment Workshops
3. Observations and recommendations arising from stakeholder feedback, and the findings of the two Risk Assessment Workshops

Stakeholder Interview Feedback

As mentioned earlier in this report, 30 stakeholders were approached of which 24 accepted interviews. While none of the stakeholders interviewed were experts, their range of knowledge in the PRMM process ranged from none to some. The general feeling amongst the stakeholders was that there were a number of facility projects being considered in the region (LNG, Coal, Oil, etc.) which gave the perception that there would be a significant increase in vessel traffic and therefore increased risk. It was also generally felt by the stakeholders that Haro St and Boundary Pass were critical environmental areas (from endangered species to traditional fishing grounds) and there was broad concern about shipping in general. Some also felt that the present cutoff of 40,000 SDWT for the use of tethered tugs for tankers seemed arbitrary and some felt that the use of tugs for tankers under 40,000SDWT would be an overreaction and caused by political pressure.

Finally it is worth noting that some stakeholders questioned why ATBs[1] were being exempted from the process as it was noted that they were presently being used for the carriage of crude oil.

The stakeholder feedback identified a number of perceived or real hazards associated with Haro Strait and Boundary Pass. These included:

- **Natural**: Wind, Weather, Currents, Rocky shoreline
- **Man made**: International border w/different regulations, crossing ferry, recreational boaters
- **Human**: Inexperienced boaters, Rule 10 violations, complacency
- **Technical**: Slower speeds of tethered vessels, over dependence of AIS/GPS, smaller tankers not built for tethered operations – tugs not built for smaller tankers. No smaller crude tankers: more maneuverable, double hulls less risky.
- **Economic**: Main passage for Canadian commerce, $70-$90K per tethered trip, Economy of local area tied to pristine environment.

Stakeholder feedback noted a number of perceived or real consequences that might result from a cargo spill in Haro St and Boundary Pass. These included:

- Oil spill – Loss of wildlife and endangered species – food chain.
- Branding of area: Political, trust, regulatory ramifications
- Economic: Tourism, Commerce, Local villages, Fisheries - Closure of waterway for a certain amount of time would have economic consequences to Canada

[1] ATB is the acronym for Articulated Tug Barge, which is a tug-barge combination system capable of operation on the high seas, coastwise and further inland. It combines a normal barge, with a bow resembling that of a ship, but having a deep indent at the stern to accommodate the bow of a tug

Pilotage Risk Management Methodology (PRMM) on the Use of Escort Tugs In Haro St and Boundary Pass for Liquid Bulk Vessels, In Product, less than 40,000SDWT

Stakeholders provided feedback on the advantages and disadvantages of using a tethered tug for vessels under 40,000SDWT carrying liquid bulk cargoes. Among the advantages listed were:

- Immediate response.
- Having tug in immediate area.
- Building public trust.

Among the disadvantages listed were:

- Limits quick response to one scenario.
- Slows vessel transit.
- Close proximity of tug increases risk of incident between vessels.
- Tugs may not be designed for this size vessel.
- Vessel may not be designed for this type of operation.
- Tethered tug not available to assist with another vessel incident in the area.
- Untethered escort might provide more flexibility

Stakeholder feedback also provided a number of other potential mitigation options that might be considered instead of or in lieu of escort tugs, these included:

- Use of “bubble zones”
- Use of standby tugs instead of escort tugs
- Differentiate mitigation options based on danger of type of cargo
- One way routing
- Built in redundancy and maneuverability of vessels
- Joint U.S. Canada Harbour Safety Committee
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Some stakeholder feedback suggested that the bunker fuel on large cargo ships might pose a greater risk than small tankers under 40,000SDWT. It was noted by some that a tethered tug only mitigates one type of risk namely to bring a vessel back on track if it suffers a malfunction that prevents its ability to maintain its designated course.

Finally, understanding that the nature of the decision of the PRMM was dependent on asking the right initial question, stakeholders were asked to review the PRMM question for validity. There was some concern expressed by some of the stakeholders regarding the efficacy of the question and therefore it was decided that before undertaking the risk scenarios at the workshop the Risk Assessment Team should review and confirm the question.

A full compilation of the feedback from these interviews can be found in Appendix 2. A copy of this compilation was provided to all the stakeholders interviewed.

Risk Assessments

14th April Workshop

The first Risk Assessment Workshop was held on Monday 14th April, 2014 at the offices of the BC Coast Pilots to assess whether the use of tethered tugs[2] would materially improve the safe navigation of tankers under 40,000 SDWT transiting Haro Strait and Boundary Pass. In attendance at the workshop were industry and government representatives from:

BC Coast Pilots

Canadian Coast Guard

Canadian Shipping Federation

Chamber of Shipping of BC

Pacific Pilotage Authority

Transport Canada

United States Coast Guard

The Meeting was facilitated by Capt Chris Badger, and Mr Gordon Hudson with support from Capt William Devereaux, USCG Rtd. All three facilitators are trained in the Pilotage Risk Management Methodology

The PRMM Methodology

The Pilotage Risk Management Methodology was developed by Transport Canada's risk specialists in consultation with the four Pilotage Authorities. It provides a structured approach to:

- Defining the issues;
- Identifying and consulting with project stakeholders;
- Developing risk scenarios;
- Estimating and evaluating risks; and
- Developing risk mitigation and control strategies, if required

The PRMM also provides for full documentation of the process, analysis and outcomes. The Objectives and Priorities of this particular PRMM were to:

- Establish a baseline of facts.
- Ensure all significant stakeholders have an opportunity to participate in the PRMM process
- Provide a report to the PPA management and make recommendations on a course of action.
- Ensure transparency in the process is a priority
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The workshop began with a review of the "*Haro Strait Product Tanker Escort Tug Force Analysis Final Report (2)*" undertaken by the Pacific Pilotage Authority. This report provided simulation information on how a tanker under 40,000 SDWT would respond if its rudder were to fail hard over when an escort tug was present and when an escort tug was not present. This report was considered a key piece of

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[2] Tethered Escort of tankers is performed by a specially designed tug connected by a towline (tethered) to the tankers "strong point" aft. The purpose of the tug is to assist the tanker in the event that the tanker loses power and or has steering problems. The tug is available to improve the steering and arresting properties of the tanker by means of a tow line connected from the tug's towing winch to the tanker's center bollard aft.

information for the Risk Assessment Team to be aware of when estimating and evaluating the risks posed in this particular PRMM. A copy of this report is provided in Appendix 4.

The next part of the process was to confirm whether the right PRMM question was being asked.

The PRMM Question

The PRMM risk question that was originally posed was:

"Will the use of Tethered Escort Tugs in Haro Strait and Boundary Pass for bulk liquid vessels, in product, less than 40,000 SDWT, materially impact safe navigation?"

Upon review of the question, the Risk Assessment Team felt that there were four areas that should be addressed. The first was that stating the tug was to be tethered restricted the options available for reviewing escort tugs. The second was that the term "in product" should be defined as it was unclear as to its meaning. The third was that the term "material" may also be too subjective and the fourth was that the word "impact" should be changed to "improve"

Agreement was reached that the word "tethered" be removed from the question, similarly it was agreed that the word "improve" should be inserted instead of "impact". The use of the word 'material' was discussed at some length but in the end it was agreed that no word could be identified that would be more appropriate or less subjective. The word 'material' was therefore kept with the understanding that it meant that any improvement resulting from the use of a tug whether tethered or otherwise must show a meaningful and measureable benefit. Finally it was agreed that the term "in product" was a recognized term for a vessel carrying some quantity of cargo and was already used in rules for tankers over 40,000SDWT.

The amended question that was therefore used to guide the rest of the Risk Assessment Workshop was:

"Will the use of Escort Tugs in Haro St and Boundary Pass for bulk liquid vessels, in product, less than 40,000SDWT, materially improve safe navigation"

Risk Scenarios

The risk scenario process designed by the Transport Canada's Risk Specialist requires the development of risk scenarios that are designed to answer the PRMM question. The process first requires the identification of Hazards, and then the identification of existing current defences designed to mitigate the hazards. A number of worst case scenarios including "what if" conditions are then developed by the risk assessment team and from these are chosen a number of most likely worst case scenarios. Finally the assessment team assesses the probability of occurrence and consequence of that occurrence for each scenario based on a set of definitions.

Hazards

The unique hazards identified by the Risk Assessment Team using their own expertize coupled with the feedback from stakeholders were:

- Variable weather, visibility and currents
- Narrow Channels with two way traffic and complex shoreline
- An increase in commercial traffic if all planned projects are implemented
- Malfunction of steering and Propulsion (both ship and tug)
- Small tankers not designed for tethered tugs

Based on their knowledge and expertise, and the unique hazards associated with the area, the Risk Assessment Team determined that the following four scenarios should be evaluated:

1. A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over
2. A laden tanker with a tug escort is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over
3. A laden tanker with a tethered escort tug is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over
4. A laden tanker with a tethered escort tug is proceeding outbound passed East Point when the tethered tug fails causing an inability of the tug to manoeuvre or maintain station

The next step was to identify the current defences in place at the moment that would mitigate the hazards associated with these scenarios and then to assess what the ***most probable worst case potential outcome*** would be of these scenarios if they should occur.

Identification of Defences

Although most of the current defences designed to mitigate the hazards were similar for all the scenarios there were some differences. To see a complete list of the defences that were considered pertinent to each scenario please see the risk scenario spreadsheets in the appendices.

Risk Scenario 1

A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The Risk Assessment Team identified that the ***most probable worst case potential outcome*** of this scenario would be the vessel strikes a rock causing a breach of the vessels double hull and subsequent loss of cargo. (see Risk scenario 1 spreadsheet in the appendix 4)

Probability of Event Occurring

The Risk Assessment team determined that it is unlikely that this event will occur. The Transport Canada definition of **"unlikely"** is ***it is not expected that the event will occur over a ten year period.*** In reviewing this decision it is worth noting that there are a number of risk studies, including the recent Transport Canada sponsored *Risk Assessment For Marine Spills in Canadian Waters; Phase 1; Oil Spills South of the 60th Parallel; January 2014,* and the U.S. based *Vessel Traffic Risk Analysis (VTRA); February 13th, 2014,* that suggest Haro St and Boundary Pass are within high risk areas for oil spills from tankers. However data from the Transport Canada report indicates no return period[3] (ie: no average recurrence period) for an oil cargo spill of less than 10 years for crude oil or refined oil cargoes, with the shortest return period being 135 years for a refined oil cargo spill of between 10 and 99.9 cubic meters. The only return period indicated that is less than 10 years is for a fuel oil spill with spill size of 9-99.9 cubic meters. The possibility of a fuel oil spill is not restricted to tankers less than 40,000SDWT and could occur from any type of vessel, thereby making the risk of a fuel oil spill significantly higher than that of a cargo oil spill.

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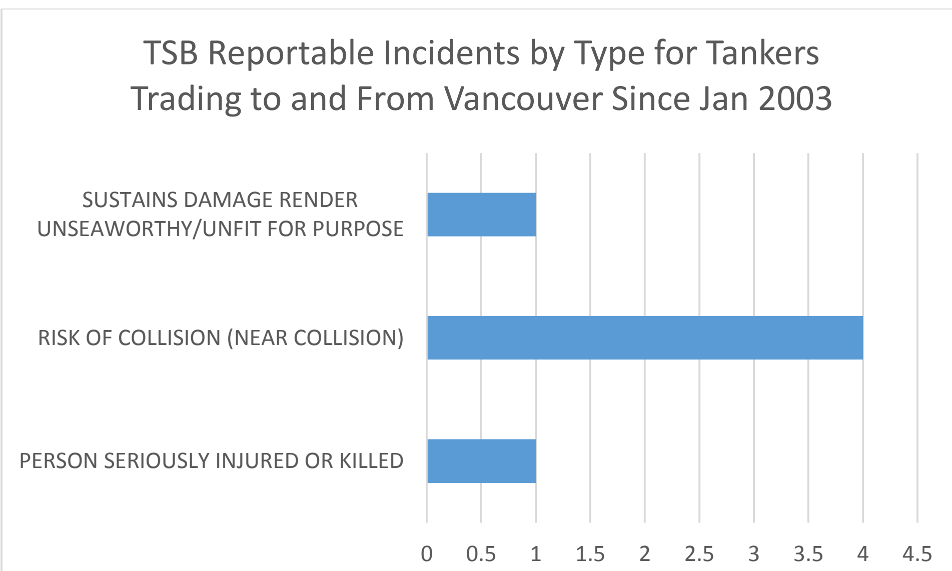
[3] A return period is a statistical measurement typically based on historic data denoting the average recurrence interval over an extended period of time

Estimated Return Periods for Oil Spills[4]

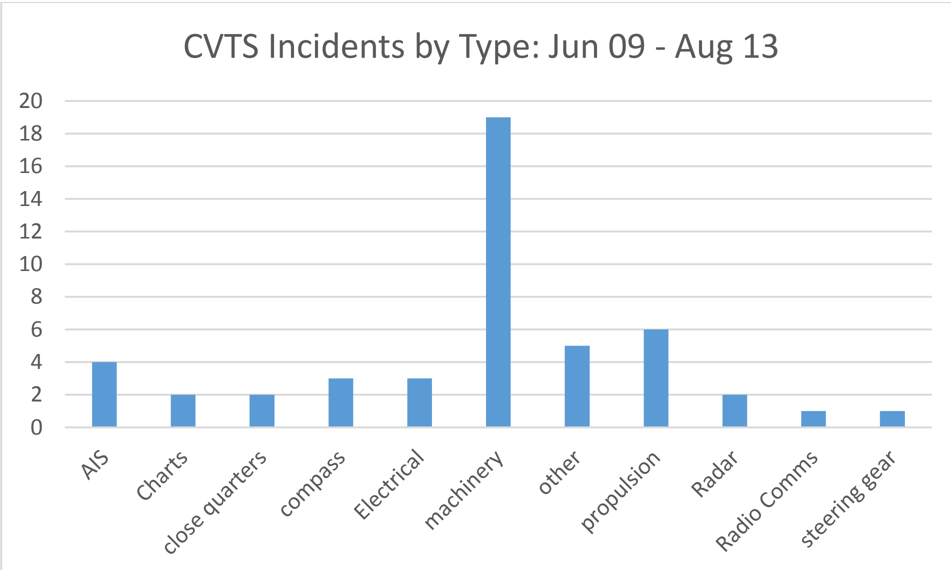
	(Size of Spill in Cubic Metres from 10->10,000)			
Type of Oil	**10-99.9**	**100-999.9**	**1000-9999.9**	**>10000**
Crude Oil	719 years	1,074 years	800 years	3,758 years
Refined Oil	135 years	811 years	3,423 years	N/R
Fuel Oil	7 years	23 years	2,143 years	N/R

Similarly, in the last ten years there have been no Transportation Safety Board reportable incidents involving a breach of hull and subsequent loss of cargo from tankers of any size including those under 40,000 SDWT. Of the six reportable incidents for tankers trading to and from Vancouver since January 2003, one involved a crew member who sustained injuries whilst the vessel was alongside, one involved damage to a fairlead whilst the vessel was docking and the rest were reports from tankers that pleasure or other smaller craft had come too close to them. None of these incidents occurred in Haro St and Boundary Pass[5].

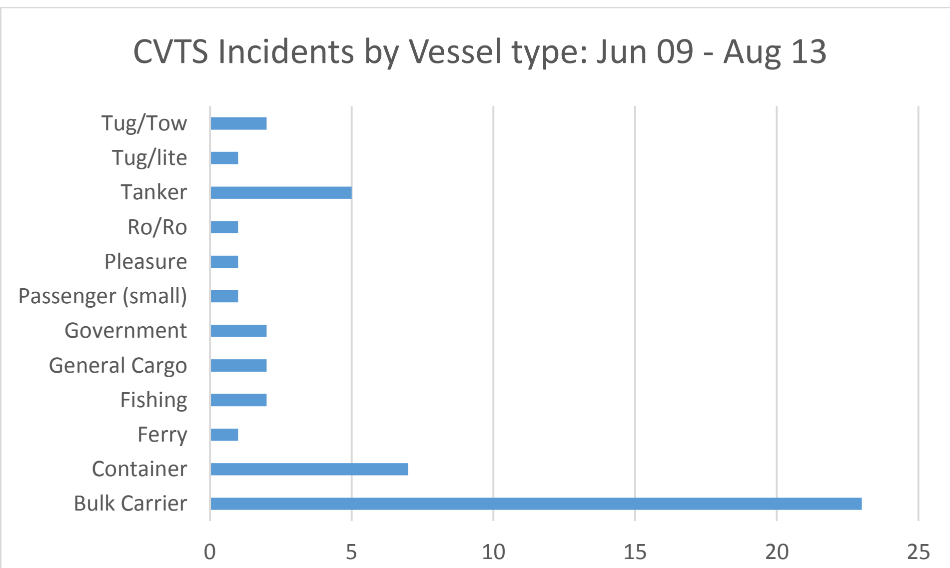


[4] Information Extracted from *the Transport Canada Risk Assessment for Marine Spills in Canadian Waters: Phase 1, Oils Spills South of the 60th Parallel, Jan 2014 Report)*
[5] Extracted from Transportation Safety Board *All Reportable Occurrences Involving a Tanker or Cargo-Liquid Vessel Since 2003 in Western Region. 2014-04-02*

In addition, a review of the Coast Guard CVTS Marine occurrence data from June 09 to Aug 13 for the Haro St and Boundary Pass area, shows there were 48 incidents in the area. The graph below shows the incidents by type[6].



This next graph shows that of the 48 incidents 5 involved tankers of all sizes.[7]



Of the 5 incidents involving tankers, 3 were machinery malfunction, 1 was a radar malfunction and 1 was identified as other. USCG Vessel Traffic Services Seattle advised that the term 'machinery' covers any equipment failure that would not have an impact on the vessel's ability to maintain course. If a

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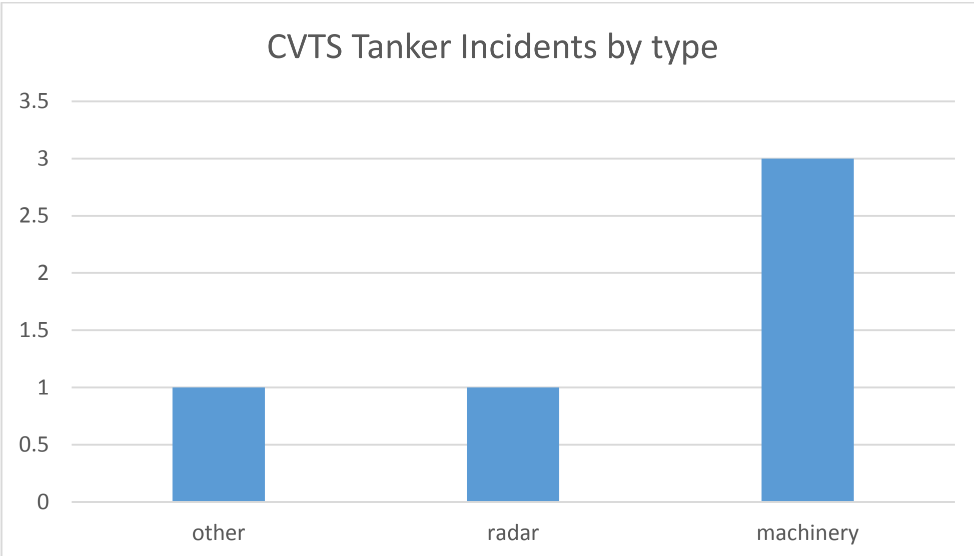
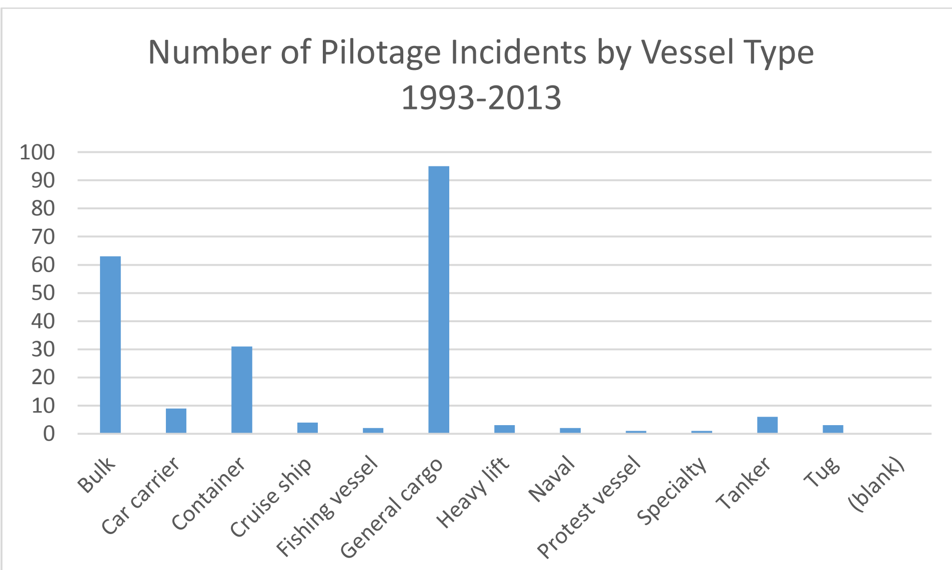
[6] Data extracted from *CVTS Incident Trend Analysis Report (Jun 09-Aug 13): USCG, Feb 20, 2014*

[7] Data extracted from *CVTS Incident Trend Analysis Report (Jun 09-Aug 13): USCG, Feb 20, 2014*

vessel's ability to maintain course was impacted (Including gyro failure) it would be classed a propulsion or a steering gear failure[8].

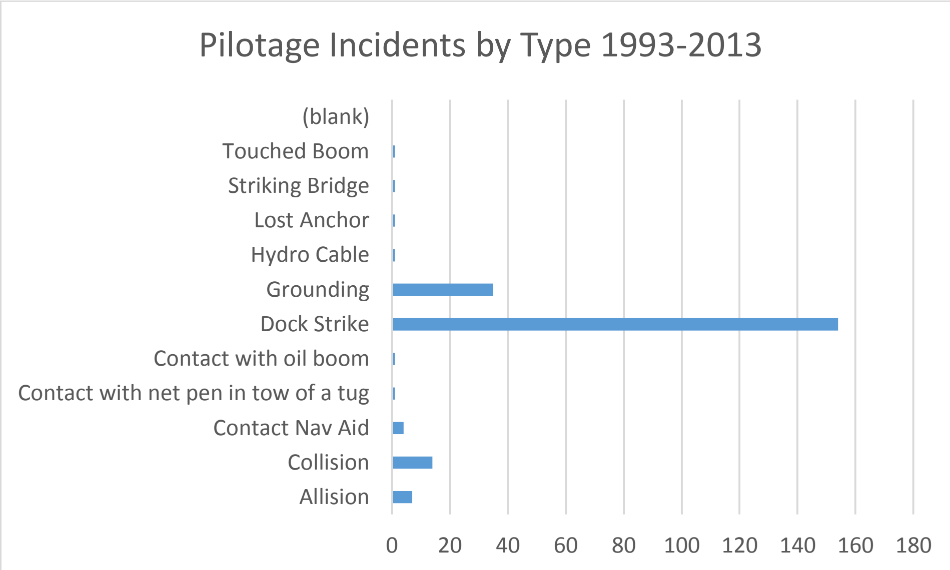


A review of the Pacific Pilotage Authority Incident Data from 1993 – 2013 shows there have been 220 pilotage incidents around the whole of the British Columbia Coast, of which 6 have involved tankers of all sizes[9].



The next graph shows the incidents by type

[8] Data extracted from *CVTS Incident Trend Analysis Report (Jun 09-Aug 13): USCG, Feb 20, 2014*
[9] Data Extracted from *Pilotage Incident Report 1993-2013*: Pacific Pilotage Authority



Of the six pilotage incidents over the last 20 years involving tankers, 4 where dock strikes, one involved striking a travel line[10] and one involved striking an oil boom (a temporary floating barrier used to contain an oil spill) . None of the incidents occurred in the vicinity of Haro St and Boundary Pass.

In summary, although the standard for likelihood of an incident is a forward looking measure not an historical measure, in reviewing the return periods calculated by the Transport Canada and DNV studies, plus the actual incident data over the last 10 to 20 years, the Risk Assessment Team determine that it was **unlikely** that this event would occur over the next ten years

Consequence of event happening

The consequence of such an event as this happening is considered by the Risk Assessment team to be **Very High to Extreme**. The incident would likely cause medium to long term harm to the environment (ie damage lasts longer than a month) with front page adverse national and international media coverage. As indicated in the feedback from the majority of stakeholder interviews, the Haro St Boundary Pass area is considered environmentally and ecologically very important. In large degree the economy of the Southern Gulf Islands and San Juan islands is dependent on the pristine nature of the surrounding environment. This includes traditional native fishery, commercial fishery including crab, prawns, shell fish harvesting plus herring and oolichan stocks. Eco-tourism is also a significant part of the economy being one of the most important whale watching areas in the region. It is also a popular destination for kayaking and pleasure boats. The economy of many of the islands is linked to tourism and a significant impact on the environment is expected to have a negative impact on that tourism. It should however be noted that, to date, there are no tankers under 40,000SDWT that carry crude oil. The

[10] It is not clear from the data what a travel line is but is assumed to be a wire or other type of cable running at or near a docking berth

following table shows the number of tankers under 40,000 SDWT that transit the area on an annual basis[11].

Year	number of tankers calling PMV with dwts less than 40,000
2008	165
2009	146
2010	147
2011	139
2012	126
YTD November 2013	118

The number of vessels has been steadily decreasing over the last five years. The types of cargoes generally carried by these small tankers include chemicals, refined petroleum products and animal and vegetable oils.

In addition to the environmental impact, the vessel itself would be expected to sustain damage significant enough to result in towing to dry dock and loss of operations of up to one month. Furthermore, operations at nearby facilities such as marinas may cease for up to two weeks with a financial loss of $1-$5 million. There may be minor injuries occurred to people with the possibility of one person with serious long-term injury.

The Risk Level

The Risk Level is ***"an estimate of the probability that a hazard will involve an adverse consequence and the severity of that adverse consequence"***. The probability and consequence of this event happening were plotted on a Risk Matrix. The intersection of the two factors is the overall scenario risk. The Risk level for this scenario is plotted on the next graph

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely	X ←	X[12]			
Improbable					

[11] Data extracted from *Port Metro Vancouver Tanker Statistics 2008*-Nov 2013; Port Metro Vancouver, Feb 09, 2014

[12] The arrow indicates that the Risk Assessment Team estimated the consequence as being between Very High and Extreme

Risk Scenario 2

A laden tanker with a tug escort is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The Risk Assessment Team determined the most probable worst case potential outcome of this scenario is the vessel grounds before the tug can render adequate assistance causing a breach of the vessels double hull and there is loss of cargo. (see Risk scenario 2 spreadsheet in the appendix 4)

Probability of Event Occurring

With this scenario The Risk Assessment Team assessed that the probability of this event occurring is considered **Unlikely to Improbable**. As with Scenario 1 the available data shows no such incident occurring in the last 10 years. It should also be noted that, as with the Transport Canada Oil Spill Report, the recent absolute risk analysis undertaken by DNV for the Kinder Morgan pipeline also does not show any return period for an incident like this that is less than 10 years. As important, the VTRA analysis carried out in the US in conjunction with the United States Coast Guard (USCG), which is a relative risk analysis, would not show an increased risk from these tankers over the existing base line, and in fact may show a reduced risk as the number of tankers less than 40,000 SDWT has been dropping over the last five years.

Consequence of event happening

The Risk Assessment Team determined that the consequence of this event happening is considered **High to Very High**. The incident would be expected to cause medium term harm to the environment lasting from between two weeks and one month. There would likely be adverse national coverage with intermittent international coverage. The environmental consequences of this scenario would not be considered as high as for scenario 1. This is because a tug is in attendance and even if it was unable to render sufficient assistance to prevent the vessel from grounding and causing a loss of cargo, some assistance would have been rendered thereby reducing the impact of the grounding, and the subsequent damage to the vessel, resulting in a smaller loss of cargo than in scenario 1.

In addition to the environmental damage, the vessel would likely sustain significant damage with dry docking required and loss of operations for two weeks; operations at nearby marinas and other facilities may cease for up to two weeks causing financial loss of $1-$5 million; and the impact on people would likely be low with single or multiple injuries requiring on site First Aid and or off-site treatment.

It should be further noted that although all the tankers under 40,000 SDWT doing trade in British Columbia are double hulled, concerns have been raised that double hulls are not a panacea and that there have been incidents where both hulls have been penetrated and cargo spilt. The organization Living Oceans have addressed its concerns in a report called *Tanker Technology: Limitations of Double Hulls* (a copy of this report can be found in Appendix 4)

Incidents Worldwide Involving Double Hulled Tankers

In their report, Living Oceans discuss a number of what they perceive as limitations to double hull tankers and state that double hull tankers are susceptible to a range of design, construction, operation and maintenance issues that they feel may increase the risk of a spill occurring. This report will not discuss these claims as they fall outside of the parameters of the report and as Living Oceans suggests, the relatively recent introduction of double hull tankers, means there is insufficient service experience to ascertain what if any issues there will be with double hull tankers as they age. The Living Ocean report also provides, in Appendix A to the report, a list of 33 incidents of what they refer to as double hull, double bottomed and double sided spills since 1960. They state that the aim of their table is to "dispel claims there have been no major spills from double hull tankers". There is no doubt that there have been spills from double hull tanker incidents, however the inclusion of double sided and double bottomed vessel incidents in their table is somewhat misleading as they are not by definition double hull vessels. But it is reasonable to conclude that if a double sided vessel or double bottomed vessel is breached in an incident through its double side or double bottom and loses cargo, then that would constitute a failure of that double skin to prevent a cargo spill. What is less clear though is if there has been a cargo spill as a result of a true "double hulled" vessel grounding, which is the scenario being assessed in this PRMM report. In their table, Living Oceans list four incidents of cargo spills that have occurred as a result of a double hulled tanker grounding. They are:

1/12/92 *Aegean Sea* – Grounded in bad weather

18/11/86 *Kowloon Bridge*- Hull failure, steering loss, grounded then sank

17/05 86 *Valparaiso* – Grounded

31/01/79 *Exotic* – Cargo tank explosion then grounding

In all four incidents the vessels involved were OBO (Oil/Bulk/Ore) vessels. The OBO design of vessel pre-dates the double hull design. OBOs were designed to carry full deadweight when trading as tankers and also for ores. Heavy ores can be can be carried only in the center holds. ***But oil can be carried either in center holds & also in cargo wing tanks***. These type of ships are exclusively designed to carry high-density ores, and oil similar to Ore-Oil carriers. In addition to that they are capable of carrying other cargoes of dry-bulk in nature. i.e grains, fertilizers etc...The holds are arranged to extend to almost full breadth of the ship, enabling full access to the cargo hold when handling dry cargoes. These types of ships have upper & lower hopper tanks with double bottom tanks. Mostly the cargo holds carry Oil/ Dry ore as cargo. ***The upper hoppers carry oil as cargo*** and water in ballast voyage. Certain designs of these ships also have wing tanks. If wing tanks are present, they may be used as slop tanks too. These wings tanks may be located aft of the cargo holds. The hatches may be similar to bulk carriers, with side rolling arrangements, with special type of sealing might be fitted[13]. Therefore unlike a double hulled vessel an OBO was designed to carry cargo within its 'double hull'. The modern standards for double hulled tankers are fairly recent. In fact the Canadian standards for double hulls did not come into effect until 1993[14] which is after the most recent of the alleged 'double hull' groundings listed in the Living Oceans list. As such it was determined that the Risk Assessment Team was not aware of any grounding of a modern double hulled tanker (of the type under 40,000SDWT presently transiting Haro St and Boundary Pass) that has resulted in a cargo spill.

[13] Description of OBO extracted from *http://www.brighthubengineering.com/*
[14] See Transport Canada, *Standards for the Double Hull Construction of Oil Tankers*, Ottawa. July 1993

The Risk Level

As with Scenario 1, the risk level was estimated and plotted on a risk matrix:

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely					
Improbable			X[15]		

[15] The arrows indicate that the Risk Assessment Team estimated the consequence as being between High and Very High and the probability between improbable and unlikely

Risk Scenario 3

A laden tanker with a tethered escort tug is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The Risk Assessment Team assessed the most probable worst case potential outcome of this scenario is a hard point failure on the ship that prevents the tug from assisting and the vessel grounds. (see Risk scenario 3 spreadsheet in the appendix 4)

Probability of Event Occurring

With this scenario the probability of this event occurring is considered by the Risk Assessment Team to be **Unlikely to Improbable**. As with Scenarios 1 and 2 the available data shows no such incident occurring in at least the last 10 years. It should be noted however, that small (less than 40,000 SDWT) tankers, unlike larger tankers, are generally not designed to have tethered escort tugs and there have been instances of hard point failure (ships, hardware, such as bitts, being pulled out) due to the force of a tethered tug pulling on the lines.

Consequence of event happening

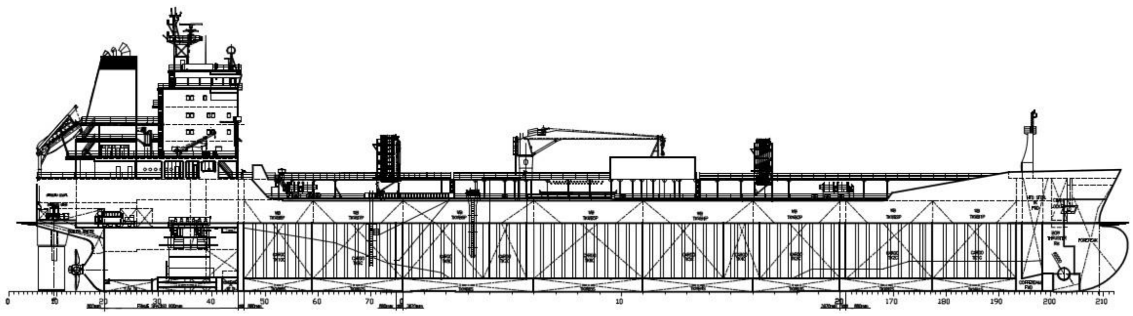
The consequence of this scenario happening is considered by the Risk Assessment Team to be **High**. It is expected that the impact on the environment would be minimal with intermittent harm to the environment over a period of time. There would likely be intermittent adverse national media coverage due to the failure of an important risk mitigation defence namely the failure of the tethered tug to prevent the vessel from grounding. The vessel itself would be expected to sustain significant damage from the grounding, with the need for subsequent dry docking and a loss of operations for two weeks. Impact on people may be medium due to the hard point failure and the possibility of serious long-term injury to a person plus minor injuries should be considered

It was felt that there was a need to establish some empirical basis to the determination that the damage to the vessel would be less in scenario 3 compared to scenario 2 and therefore result in a minimal to intermittent harm to the environment. There has been little academic study on the impact required to breach the double hull of a ship, however the most relevant study appears to be the Sormunen, Ehlers and Kujala *Collision consequence estimation model for chemical tankers* that appeared in the *Journal of Engineering for the Maritime Environment, 227 (2) pp. 98 – 106* and is awaiting Peer Review. (A copy of this paper can be found in Appendix 4)

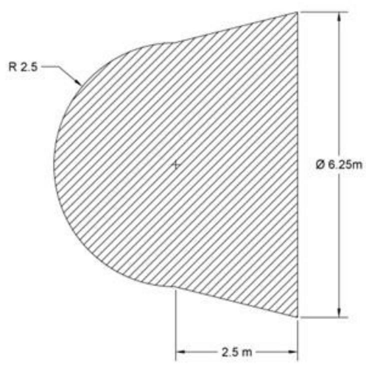
Collision Consequence Estimation

Sormunen et al propose a spill model, which for any given collision scenario can model the penetration, spill probability and size caused by a ship striking the side of a chemical tanker at right angles (a normal situation in the event of a collision). The starting point of their model is a 180 m long, 40 000 DWT chemical tanker with a double hull width of 2 m, which is penetrated by the bulbous bow of another vessel[16]. The chemical carrier and the bulbous bow are illustrated below:

[16] This specification of vessel resembles very closely the type of tanker under 40,000 SDWT that is transiting Haro St and Boundary Pass



Double-hulled chemical tanker layout used in the simulation



Rigid bulb used in simulations

The model suggests that the energy required to penetrate both hulls of a chemical tanker of this size by 3 m (ie beyond the second hull) would be approx. 48 Mega Joules. From this it could be inferred that in the case of the same tanker running aground on a pinnacle of rock similar in size to a bulbous bow a similar amount of energy would be required to penetrate to 3m.[17] Using the formula for Kinetic energy KE = (Mass X Speed X Speed)/2, where the KE is 48MJ and the vessel is 40,000 tons, it is estimated that

[17] This is by no means an exact inference because in the Sormunen model the bulbous bow penetrates the tanker at right angles (perpendicular) to the tanker, whereas the likelihood of the tanker colliding at right angle to a rock is likely low

the vessel would need to be going approx. 4.6 kts in order to penetrate the inner hull[18]. Taking into account that this speed is required for a perpendicular penetration of a rock into the side or bottom of the vessel which is an unlikely event (an angle of penetration much less than 90 degrees would be likely) it was determined that it was reasonable to expect the actions of the vessel with the assistance of the tug would have reduced the speed of the tanker such that the penetration of the tanker's hull upon grounding would result in minimal to intermittent harm to the environment.

The Risk Level

As with the other scenarios, the risk level was estimated and plotted on a risk matrix:

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely			X[19] ↓		
Improbable					

[18] Caution. these numbers have not been verified and may be inaccurate. They should be viewed as assumptions only.

[19] The arrow indicates that the Risk Assessment Team estimated the probability as being between unlikely and improbable

Risk Scenario 4

A laden tanker with a tethered escort tug is proceeding outbound passed East Point when the tethered tug fails causing an inability of the tug to manoeuvre or maintain station. The Risk Assessment Team determined that the most probable worst case scenario is a momentary departure of the tanker from its intended course and a resultant delay for the tanker at anchor until another escort can be arranged (see Risk scenario 4 spreadsheet in the appendix 4)

Probability of Event Occurring

With this scenario the probability of the event occurring is considered by the Risk Assessment Team to be **Possible**. That is a failure of a tethered tug could occur over 10 years.

Consequence of event happening

The consequence of such an event is considered by the Risk Assessment Team to be **Low**. The incident would cause minimal harm to the environment and there may be some adverse but intermittent local media coverage. There would minor damage to either the vessel or the tug resulting in loss of operations of no more than 72 hours. The financial impact is not likely to exceed $500,000 and some possibility of single or multiple minor injuries requiring on-site and or off-site First Aid treatment.

The Risk Level

As with the other scenarios, the risk level was estimated and plotted on a risk matrix:

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					X
Unlikely					
Improbable					

Scenario Risk Ranking

After completing the 4 scenarios the Risk Assessment Team then used the Transport Canada PRMM Risk Ranking process to rank each scenario based on probability and severity. The probability of the event occurring was considered by the Risk Assessment Team to be **unlikely** for scenario one and **unlikely to improbable** for scenarios two and three. This is based on the input of the risk assessment team as well as the fact that Transportation Safety Board, CVTS Marine Occurrence Data and PPA Pilotage Incident data for at least the last ten years has been relatively positive. The fourth scenario was rated **possible** by the Risk Assessment Team because an assist tug failure has occurred within the last ten years. The consequence for scenario 4 was considered **Low**, for scenario 3 was considered **High,** scenario 2 was considered **High to Very High** and for Scenario 1 **Very High to Extreme**

The charting of the scenario probabilities against severity of occurrence produced the following risk rankings:

Scenarios	Probability of Occurrence	Severity of Occurrence	Risk
Scenario 1	Unlikely	Very High to Extreme	Medium
Scenario 2	Unlikely to Improbable	High to Very High	Low
Scenario 3	Unlikely to Improbable	High	Low
Scenario 4	Possible	Low	Low

Observations

The Risk Rankings produced by the probability and severity assessments is **Low** for all the scenarios except Scenario 1 where it is **Medium**. Based on the results of this risk assessment and stakeholder feedback, the following observations were also made by the Risk Assessment Team:

1. *There is no clear material improvement in risk rating between using a tethered Escort Tug versus a non-tethered Escort Tug*.

That there is no clear material improvement in risk rating between using a tethered escort tug versus a non-tethered escort tug does not imply that one is not more beneficial than the other. The severity ratings show that a tethered tug would likely reduce the consequence of an occurrence more than an escort tug. In Scenario 2, which involved the use of a non-tethered tug, the consequence was rated as **High to Very High**, whereas in Scenario 3, which involved the use of a tethered tug, the consequence was only rated as **High**. This was because the Risk Assessment Team determined that Scenario 3 would not result in a breach of the double hull, whereas Scenario 2 would result in a breach resulting in a higher level of environmental consequence. However, when viewed within the context of the parameters for consequence including consequences to vessel, property, human and reputation plus the probability of the event occurring, the ranking for both is Low and therefore there is no material difference.

2. *The results would suggest that some mitigation would be required over and above the already existing defences to reduce to **Low** the risk level in scenario 1, where no escort tug was in attendance*.

The Risk Assessment Team determined that a second workshop should be undertaken to review in more detail potential risk mitigation strategies for improving the probable worst case potential outcome and/ or reducing the risk level of scenario 1 from **Medium** to **Low**

June 27th Workshop

A second workshop was held in the offices of the British Columbia Coast Pilots on Friday 27th June, 2014 to review potential Risk Mitigation Strategies in order to determine the best options, if any, of improving on what the Risk Assessment Team determined to be the **probable worst case potential outcome** of an incident involving a tanker of less than 40,000SDWT in Haro St and Boundary Pass (known as Scenario 1) namely**:** ***A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The vessel strikes a rock causing a breach of the vessels double hull and subsequent loss of cargo***

The Risk Assessment Team consisted of Representatives from:

Chamber of Shipping of BC

Canadian Coast Guard

United States Coast Guard[20]

British Columbia Coast Pilots

Transport Canada

British Columbia Coast Pilots

Pacific Pilotage Authority

The workshop was facilitated by Mr. Gord Hudson and Capt Chris Badger

Also in attendance were observers from the British Columbia Coast Pilots and the Pacific Pilotage Authority

Review of Potential mitigation Options

The Risk Assessment Team spent the first part of the workshop reviewing the mitigation options. With the exception of one option, all the potential mitigation options reviewed were derived from feedback from stakeholder interviews and or from the Risk Assessment Team. Background information on the potential mitigation options was, where available, provided to the Risk Assessment Team prior to the workshop for their review (A list of the background information on mitigation options can be found in Appendix 4)

Mitigation Options

1.0 The nature and quantity of cargo onboard the vessel should be assessed for its consequential impact if it is spilled;

The types of cargo carried by tankers under 40,000SDWT over the last ten years can be categorized into three categories- chemicals, base chemicals and minerals; refined petroleum products; processed food products. The amounts of each carried over the last ten years has varied, however the total amount has remained fairly constant at around 3.5 to 4 million tons. In the last three years the amounts of each have been on average equal: 1/3 Chemicals, 1/3 refined petroleum products and 1/3 processed food products. The Risk Assessment Team noted that no tankers under 40,000SDWT carried crude oil, but

[20] A serving representative of the USCG was not available, so Captain Devereaux USCG (Rtd) represented the USCG.

determined that this was not in itself an appropriate mitigation for this PRMM and therefore concluded that type of cargo carried was not effective mitigation option.

2.0 Safety Zones around vessels

Moving safety zones are in use in other parts of the world and have been reviewed for use in Canada, including at the recent Termpol application submitted by Kinder Morgan for its Trans Mountain Pipeline project. It generally involves a 'no go zone' being implemented around a moving tanker in which all vessels without a licenced pilot on board would have to keep clear. It was noted that in the last ten years, 4 out of the 6 Transportation Safety Board reportable incidents for tankers of this size involved a close quarters situation with a small vessel and that provided enforcement mechanisms were in place to ensure compliance, moving safety zones would be effective. As such the Risk Assessment Team determined that this may prove to be a valuable procedure to improve the overall safety of navigation for tankers, but would not provide a high level of mitigation for the type of scenario (rudder failure) being assessed in this PRMM.

3.*0 The requirement for AIS (class B) on recreational vessels*

An AIS transponder is a mandatory item for larger vessels but is not a requirement for all vessels especially recreational vessels. The Class B AIS is designed for recreational vessels and the Risk Assessment team determined that making AIS mandatory and Class B AIS mandatory for vessels under 20m, would likely improve navigational safety in general as it would allow the enforcement of safety zones (as mentioned above) and would provide valuable information to shipping regarding the movements of recreational vessels especially in narrow channels such as Haro St and Boundary Pass. The Risk Assessment Team did not determine that mandatory AIS would provide a high level of mitigation for the type of scenario being assessed (rudder failure) but considered it would be an important recommendation to put forward to improve overall safety.

4.0 The improvement of Navaids and in particular the possible use of virtual Navaids

The overall assessment of navaids in the area of Haro St and Boundary Pass was not reviewed by the Risk Assessment Team as it was considered outside of the scope of the risk scenario being assessed. In addition the use of virtual (computer generated) as opposed to physical navaids is presently under review by both the Canadian and United States Coastguard. However, any future enhancements to navaids could provide an overall benefit for navigation.

5.0 An SOA for East Pt similar to the SOA at Turn Pt

In areas of elevated risk due to particular geographic, environmental, traffic density, or other issues unique to a particular waterway, SOAs can be developed that are designed in conjunction with waterway users to improve the safety of navigation. An example of this is the SOA at East Pt (a copy of which is provided in appendix 4). The Risk Assessment Team agreed that SOAs are an important part of ensure the safety of navigation, but they are generally a combination of a number of mitigation options rather than a mitigation option themselves. Therefore an SOA per se was not determined to be a mitigation option but could by definition be the name given to any collection of mitigating actions that are subsequently recommended in this report.

6.0 The use of enhanced traffic windows for tankers under 40,000SDWT, recognizing that this may cause clustering of vessels.

In areas such as the Second Narrows in Vancouver Harbour, traffic windows are required for large vessels in particular Aframax sized tankers restricting them, in particular, to transits when the tide is slack or near slack. These measure have been determined to be very beneficial for improving transit safety in extremely narrow channels for large vessels. Although Haro St and Boundary Pass are not open waterways and are subject to strong currents they are not by definition "narrows" such as at Second Narrows. The Risk Assessment Team noted there are already tidal window restrictions in place for tankers of over 40,000SDWT. It was determined however for tankers under 40,000SDWT which are relatively maneuverable the use of windows would not provide a high level of mitigation in the scenario being assessed (rudder failure) and may in increase the potential risk by causing vessels to cluster while they wait for a tidal window.

7.0 A review of gaps in radar coverage to ensure 100% coverage where required, particularly in the peripheries of the traffic lanes

There was some concern raised in the stakeholder feedback that there was not 100% radar coverage for the passage of vessels through Haro St and Boundary Pass. Utilizing a colour coded map (of which a copy is available in appendix 4) the Canadian Coastguard representative of the Risk Assessment Team satisfied the Risk Assessment Team that this was not the case and that there was indeed close to 100% radar coverage for deep sea vessels approaching Juan de Fuca Strait inbound to Vancouver, as far as Admiralty Head, plus more coverage in the US radar system.

8.0 The use of Patrol vessels to clear recreational vessels from the main shipping channels

The use of patrol vessels to enforce safety requirements and to clear shipping lanes has been proven in certain areas, such as First Narrows in Vancouver Harbour, to be beneficial to overall safety and The Risk Assessment Team would be supportive of the use of government vessels to patrol Haro Strait and Boundary Pass and enforce navigational safety. However The Risk Assessment Team did not consider that the use of patrol vessels would provide a high level of mitigation for the scenario being assessed.

9.0 The permanent positioning of an appropriately designed standby tug within Haro Strait and Boundary Pass

The positioning of a standby tug specifically to respond to vessels that require assistance is already in place in the US waters and is located at Neah Bay. Neah Bay is at the opposite end of the Juan de Fuca Straits to Haro St and Boundary Pass. The Risk Assessment Team determined that the positioning of a stand by tug in Haro St and Boundary Pass would possibly provide a high level of mitigation for the risk scenario being assessed (rudder failure). It was also noted that the provision of a standby tug appeared many times in the feedback from government, industry and general public during stakeholder interviews.

10.0 The amount of existing built in redundancy of vessels ie duplicate steering and main propulsion systems.

The Risk Assessment Team determined that having redundancy built in to vessels such as duplicate steering and main propulsion systems would provide a very high level of mitigation for the risk scenario being assessed. However it was also noted that a very small proportions of the world fleet had this kind of redundancy and therefore although a 'nice to have' could not be seriously considered as a mitigation option at this time. However it was felt that the beneficial owner of any ship arriving in BC waters with built in redundancy should in some way be acknowledged for implementing such a system into their ship design.

11.0 The use of a buffer zone around shorelines such that a tanker under 40,000SDWT with rudder hard-over would crash stop before suffering a hard grounding

Unlike the preceding mitigation options, this final option did not arise as a result of feedback from stakeholder interviews nor from discussion at the first Risk Assessment workshop, but from a review of the Haro St Product Tanker Escort Tug Force Analysis conducted by the Pacific Pilotage Authority (for a complete copy of this analysis please see appendix 4). In the analysis a 142 metre and 147 metre Handy Size tanker (similar to the types of vessels under 40,000DSWT that transit through Haro St and Boundary Pass) were simulated rounding East Pt with a 2 knot flood tide where they suffer a hard over rudder failure, resulting in the vessels instigating a 'hard Stop' (full emergency stop). In both cases the vessels come to a rest approximately 2.5 cables (1/4 of a nautical mile) off their original track. The proposed mitigation option was therefore that vessels transiting Haro St and boundary Pass do so at a distance off shore of greater than 2.5 cables. The Risk Assessment Team determined that providing a buffer zone off shore of greater than 2.5 cables would possibly provide a high level of mitigation for the scenario being assessed.

Estimation and Evaluation of Risk Scenario 1, with Mitigation

Following completion of the evaluation of the risk options the Risk Assessment Team then proceeded to estimate and evaluate whether the risk Outcome of Scenario 1 changed if certain preferred mitigation options are introduced. For ease of reference below is the original analysis of Scenario 1 Risk Level, without any additional mitigation options, followed by three scenarios with mitigation options included.

Risk Scenario 1

The Risk Level is ***"an estimate of the probability that a hazard will involve an adverse consequence and the severity of that adverse consequence"***. The probability and consequence of this event happening were plotted on a Risk Matrix. The intersection of the two factors is the overall scenario risk

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely	X ←	X[21]			
Improbable					

[21] The arrow indicates that the Risk Assessment Team estimated the consequence as being between Very High and Extreme

Risk Scenario 1A

For this scenario the Risk Assessment Team Introduced the potential mitigation option of having a stand-by tug in the vicinity.

A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. There is a standby tug located close to Turn Pt 45 mins away . The Risk Assessment Team identified that the <u>most probable worst case potential outcome</u> of this scenario would be the vessel strikes a rock causing a breach of the vessels double hull and subsequent loss of cargo

The Risk Assessment Team determined that providing a standby tug close to the vicinity of the vessel would not change the outcome of the scenario. 45 mins was considered an appropriate time for a standby tug to reach the scene of the incident. It should be noted that a standby tug differs from an escort tug in as much as an escort stays close to a vessel and remains with the vessel through the passage. A standby tug would be available to respond to a vessel if it requires assistance.

As a result of there being no change to the outcome of the scenario there was subsequently considered to be no change in the consequence or in overall risk.

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely	X ←	X[22]			
Improbable					

Risk Scenario 1B

For this scenario the Risk Assessment Team introduced the potential mitigation option of maintaining a distance of 0.5 miles off the shoreline and other grounding hazards at all times.

A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The vessel is maintaining a distance off shore of at least 5 cables. And the vessel initiates a hard stop. The Risk Assessment Team identified that the <u>most probable worst case potential outcome</u> of this scenario would be the vessel suffers a drift grounding due to drift of vessel after it stops with some loss of cargo.

In this situation the Risk Assessment Team determined that there would be a change in outcome. Instead of hard grounding the vessel drifts aground with a subsequent loss of cargo but with less cargo loss than in scenario 1A. This would in the opinion of the Risk Assessment Team move the consequence of the incident to the same level as that of Scenario 2 derived in the first workshop in April 2014.

[22] The arrow indicates that the Risk Assessment Team estimated the consequence as being between Very High and Extreme

Scenario 2 (see pages 17-18) was as follows:

A laden tanker with a tug escort is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The Risk Assessment Team determined the <u>most probable worst case potential outcome</u> of this scenario is the vessel grounds before the tug can render adequate assistance causing a breach of the vessels double hull and there is loss of cargo

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely			↑		
Improbable		←	X[23]		

The Risk Assessment team further recommended that in this scenario the vessel remain on manoeuvering speed which would allow a hard stop to be initiated more effectively and have the anchors at all times ready for letting go

The Risk Assessment Team then proceeded to update the overall risk rankings for the four original scenarios plus the two new scenarios.

Updated Risk Rankings

Scenarios	Probability of Occurrence	Severity of Occurrence	Risk
Scenario 1	Unlikely	Very High to Extreme	Medium
Scenario 2	Unlikely to Improbable	High to Very High	Low
Scenario 3	Unlikely to Improbable	High	Low
Scenario 4	Possible	Low	Low
Scenario 1A	Unlikely	Very High to Extreme	Medium
Scenario 1B	Unlikely to Improbable	High to Very High	Low

It was determined therefore that introducing the mitigation option of providing a buffer zone of 0.5 nautical miles off shore to the track of the vessel (option 1B) brought the risk ranking of Scenario 1 from **Medium** to **Low** which was in line with scenarios 2,3 and 4.

The Risk Assessment Team then proceeded to determine if additional options could be introduced that would bring the risk ranking even lower. The Following Risk Scenario 1C was therefore introduced:

[23] The arrows indicate that the Risk Assessment Team estimated the consequence as being between High and Very High and the probability between improbable and unlikely

Risk Scenario 1C

A laden tanker is proceeding inbound passed Turn Point in a strong flood at midnight when its steering system malfunctions and its rudder goes hard over. The vessel is maintaining a distance off shore of at least 5 cables. And the vessel initiates a hard stop. There is a standby tug positioned for immediate assistance. The vessel is on manoeuvering speed and the anchors are ready for letting go. The Risk Assessment Team identified that the most probable worst case potential outcome of this scenario would be the vessel stops and is assisted from not going aground by the standby tug.

In this instance, the Risk Assessment Team determined that the vessel would not go aground and there would consequently be no loss of cargo.

Probability of Event Occurring

Because the basis of Scenario 1C is the same as 1 the probability of a vessel losing steering when rounding Turn Point remains the same. It was determined to be unlikely in Scenario 1 ie: ***it is not expected that the event will occur over a ten year period,*** and therefore remains unlikely for scenario 1C. However the consequence of the event is reduced from **Very High/Extreme** in Scenario 1 to **Low** in Scenario 1C. As such there may be some intermittent adverse local media coverage, minimal harm to the environment with possible minor effects to the vessel and minimal loss of operations whilst the vessel inspected. The overall Risk level is shown below:

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					
Unlikely					x
Improbable					

Risk Levels for All Scenarios

The Risk Assessment Concluded that when the risk levels for all seven scenarios conducted over the two workshops were plotted, five provided a low risk but that Scenario **1C** provided the lowest risk level. As such it was determined by the Risk Assessment Team that by utilizing the mitigation options of requiring tankers less than 40,000SDWT to keep a minimum of 0.5 nautical miles off land, to have a tug standing close by at critical point, to keep the vessel on maneuvering speed and the anchors ready for letting go, would result in the lowest risk of the ***probable worst case potential outcome*** ie that of a vessel losing steering when rounding Turn Point and grounding. The figure below shows the plot of all 7 scenarios

	Extreme	Very High	High	Medium	Low
Highly Probable					
Probable					
Possible					4
Unlikely		1[24] 1A[25]	2[26] 3[27] 1B[28]		1C
Improbable					

The next figure shows the risk ranking for all 7 scenarios:

[24] The arrow indicates that the Risk Assessment Team estimated the consequence as being between Very High and Extreme

[25] The arrow indicates that the Risk Assessment Team estimated the consequence as being between Very High and Extreme

[26] The arrows indicate that the Risk Assessment Team estimated the consequence as being between High and Very High and the probability as being unlikely to improbable

[27] The arrow indicates that the Risk Assessment Team estimated the probability as being between unlikely and improbable

[28] The arrows indicate that the Risk Assessment Team estimated the consequence as being between High and Very High and the probability as unlikely to improbable

Scenarios	Probability of Occurrence	Severity of Occurrence	Risk
Scenario 1	Unlikely	Very High to Extreme	Medium
Scenario 2	Unlikely to Improbable	High to Very High	Low
Scenario 3	Unlikely to Improbable	High	Low
Scenario 4	Possible	Low	Low
Scenario 1A	Unlikely	Very High to Extreme	Medium
Scenario 1B	Unlikely to Improbable	High to Very High	Low
Scenario 1C	Unlikely	Low	Low

Observations and Recommendations:

In reaching the above determinations, the Risk Assessment Team makes the following observations and recommendations:

1. The mitigation option of keeping a minimum distance of 0.5 nautical miles off shore was based on the results of the Haro Strait Product Tanker Escort Tug Force Analysis. A much more in- depth analysis, likely including a Full mission Bridge Simulation, would need to be carried out to confirm the accuracy of these findings. Furthermore additional vessel types would have to be assessed based on their manoeuvering characteristics.
2. Although the probable worst case potential outcome involved a steering failure rounding Turn Point, the Risk Assessment Team recommends that the practice of keeping the track of Tankers under 40,000SDWT at least 0.5 nm offshore should be imposed for the full transit of the vessel through Haro St and Boundary Pass. In addition it is recommended that the vessel remain on maneuvering speed for the full transit and at all times have anchors at immediate readiness for letting go.
3. The use of the 0.5 mile buffer zone would also reduce the probability of grounding for a vessel with a tethered escort tug. However, because small (less than 40,000 SDWT) tankers, unlike larger tankers, are generally not designed to have tethered escort tugs and there have been instances of hard point failure (ships, hardware, such as bitts, being pulled out) due to the force of a tethered tug pulling on the lines, the use of tethered tugs would seem to provide a higher overall risk than having a tug available to assist the vessel once it has come to a hard stop.
4. The danger of the vessel drift grounding after coming to a full hard stop only occurs at certain high risk points when it is maneuvering close to land where the prevailing currents could push the vessel on shore. These would include Turn Point and East Pt. At all other times in the passage the vessel would likely, after coming to a hard stop, drift with the current parallel to the land giving time for a standby tug to provide assistance. As such it is recommended that a standby tug be available, close to the vessel, as it rounds Turn Pt, and when it rounds East Pt as well. In fact the use of a standby tug close

by at key high risk points would likely provide the same overall benefit as an escort tug, when coupled with the 0.5 mile buffer zone.

5. The Stand by tug itself should be sufficiently sized to meet the demands that may be required of it in the event it needs to assist a vessel from drift grounding.
6. Although outside the scope of this PRMM, the Risk Assessment Team did note that risk analyses conducted by both the federal government and by industry seem to indicate that the risks of a spill from the bunker tanks of non- double hulled cargo vessel are much higher than the risks of cargo spill from tankers. The assumption seems to be borne out by the incident occurrence data collected by the United States Coast Guard, Canadian Coast Guard, and the Transportation Safety Board. This would suggest that the positioning of a Stand-by tug within Haro St and Boundary Pass may be of equal or even greater advantage to non-tanker vessels transiting this area than to tankers less than 40,000SDWT. However the Risk Assessment Team would not see a standby tug replacing the need for tethered escort tugs on tankers over 40,000SDWT.
7. Finally the Risk Assessment Team noted that some of the other potential mitigation options that were reviewed would, even though they do not provide the same level of risk mitigation as a standby tug and a buffer zone from the shore, potentially provide an enhancement of safety in the area. These include:
    a. The requirement for all vessels to have AIS Transponders
    b. The encouragement of ship owners to provide redundancy in the design of their vessels
    c. Greater use of government patrol vessels to police safety in narrow shipping lanes
    d. The use of moving safety zones around tankers, particularly if implemented in conjunction with mandatory AIS

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Appendices

1.0 Project Initiation Documents

a. Minutes of PRMM Initiation Meeting
b. Minutes of PRMM Module 1 Meeting
c. PRMM Schedule

2.0 Stakeholder Interviews

d. PPA Cover Letter
e. Stakeholder Feedback
f. Interview Questionnaire

3.0 Data Consolidation Document

4.0 Risk Assessment Workshops

g. Background Information on Mitigation Options
h. Risk Scenario Defences
i. Agendas for Risk Assessment Workshops
j. Collision Consequence Estimation Model
k. Haro St Product Tanker Escort Tug Force Analysis
l. Report on Double Hull Tankers by Living Oceans