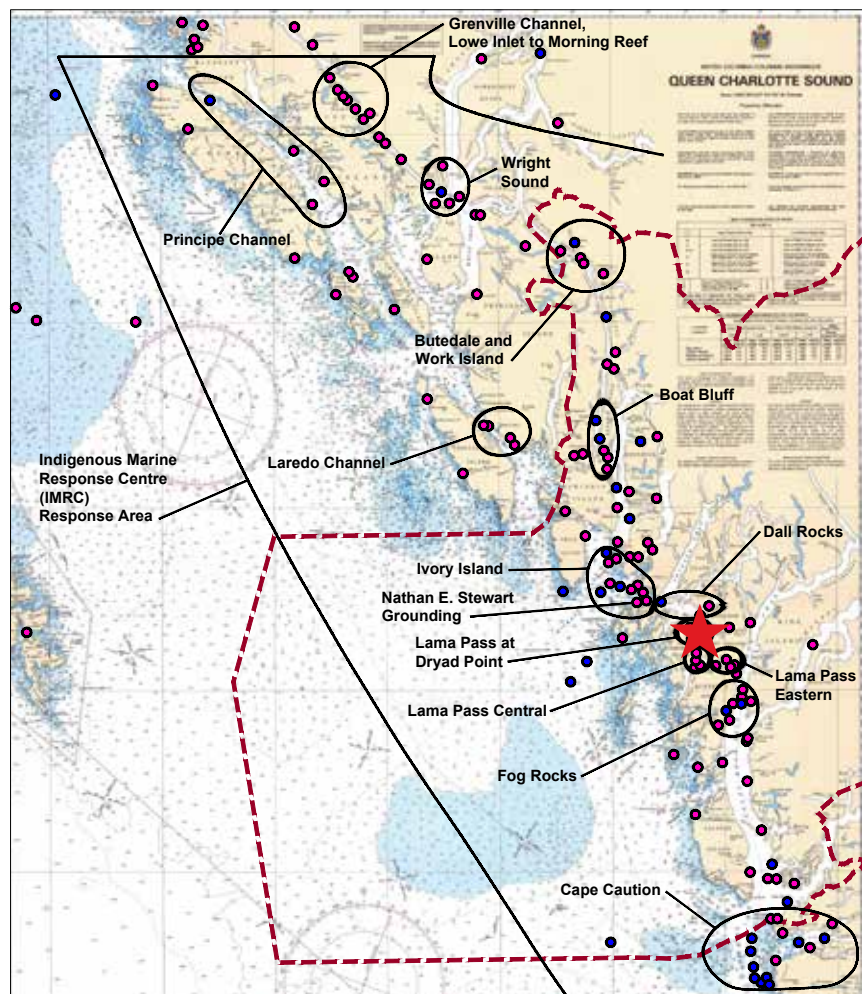


**HEILTSUK TRIBAL COUNCIL**  
**INDIGENOUS MARINE**  
**RESPONSE CENTRE (IMRC)**  
**Creating a World-Leading Response System**

NOVEMBER 2017



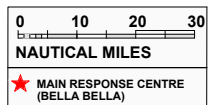


HEILTSUK TRADITIONAL  
TERRITORY BOUNDARY

ALL GROUDINGS/  
NEAR GROUDINGS

BARGES - GROUDINGS/  
NEAR GROUDINGS

CHOKE POINT IDENTIFIER



PPA GROUDINGS / NEAR GROUDINGS WITH IMRC IDENTIFIED CHOKE POINTS

REPORT PREPARED BY





# Λάχvιsληts Mímáλuala

## “Standing Together”

Though the Heiltsuk Nation has long warned of the threat of oil spills on our coast, our experience responding to the *Nathan E. Stewart* oil spill was a devastating wake-up call.

We watched diesel pour into our waters and onto the shores of our ancient village site of Q'vúqvai – onto clam gardens abundant with clams, other shellfish, and near shore fish species that our ancestors stewarded for millennia and our community relies on for food sustenance. Many hours passed before spill response equipment arrived.

When it did, equipment that was not broken was poorly deployed and failed to contain the spill. Beyond that, safety instructions and gear for Heiltsuk first responders exposed to diesel and dangerous marine conditions were lacking or altogether absent. Especially in the early hours of the response, there was confusion on all sides over who was in charge.

Throughout the chaos of the spill response, marine traffic continued around us, unabated, forcing us to acknowledge the likelihood of future disasters and the necessity for a solution.

Weeks after the spill, we commissioned this report and asked experts to:

- assess the likelihood and distribution of various types of marine incidents on the central north coast;
- examine best spill response practices around the world; and, ultimately,
- develop a plan for an Indigenous Marine Response Centre to vastly improve marine safety and safeguard the environment.

The report that follows describes a truly world-leading Indigenous Marine Response Centre that would respond to incidents in Heiltsuk territory and beyond within a few hours with a fleet well-equipped to prevent disasters and to offer the best clean-up efforts local knowledge and technology allow.

From Ahousaht with the *Leviathan II* to Gitga'at with the *Queen of the North* to Heiltsuk with the *Nathan E. Stewart*, Indigenous communities have shown that we are and will continue to be the first responders to marine incidents in our waters. The time has come to meaningfully develop our capacity to properly address emergencies in our territories as they arise.

This report corresponds with the Government of Canada's National Oceans Protection Plan, which, likewise, recognizes the need to put Indigenous communities at the forefront of efforts to protect oceans and the communities that rely on them. This report also shares the plan's number one priority: the creation “of a world-leading marine safety system that improves responsible shipping and protects Canada's waters, including new preventive and response measures.”

We are pleased to share this report with our community, our neighbouring nations, the federal government, and other partners. We look forward to standing together with you all to turn this vision to reality by delivering an Indigenous Marine Response Centre in Heiltsuk territory that will meaningfully improve the safety of our waters and the protection of the environment.

Sincerely,

Chief Councillor Marilyn Slett  
Heiltsuk Tribal Council

Hereditary Chief Harvey Humchitt  
Heiltsuk Nation

# EXECUTIVE SUMMARY

## BACKGROUND

As was demonstrated with the *Nathan E. Stewart* oil spill response efforts, the current oil spill response capability on the central coast of BC is inadequate, slow, and unsafe.

This report highlights where the need for emergency response capability along the central and north coast of British Columbia is most urgent and outlines a plan for an Indigenous Marine Response Centre (IMRC) near Bella Bella to address this need.

## STUDY DESIGN

The study area of interest for this report is spatially defined as from the north end of Vancouver Island to the north end of Principe Island and to Morning Reef in Grenville Channel (i.e., the “response area”).

Data considered in this report includes but is not limited to:

- vessel transit data from Canadian Coast Guard Marine Communications and Transit Services Data;
- incident data from the Transportation Safety Board and Pacific Pilotage Authority; and
- a global review of best practices and guiding principles regarding safety, incident prevention, and environmental protection.

What follows is a discussion of results and associated recommendations.

## RESULTS & PROPOSAL

The IMRC proposed in this document strives for excellence in oil spill clean-up *and* prevention.

Unlike typical spill response for the central coast, which is only deployed once a spill occurs, the IMRC will respond to a wide variety of marine incidents that could lead to oil contaminating the environment in the response area such as those classified as groundings, fires, bottom contacts, and capsizes.

The IMRC will be located on Denny Island across from Bella Bella, with satellite stations throughout the central coast.

The IMRC will be prepared to respond at a moment’s notice, and will consist of crew who are stationed at the centre, who live in the area, and who are familiar with the region, waterways, and weather conditions.

### *Incident response times*

Approximately three incidents occur per month in the study area, with 80% of all incidents to date having occurred within Heiltsuk Territory.

**In this scenario, 100% of incidents in the study area can be reached in five hours or less with fast response vessels travelling at 30 knots from Bella Bella.**



The proposed site for the IMRC is the former BC Packers Site on Denny Island. It is a large waterfront property with sufficient space to house the land-based operation and mooring facilities for a fleet of response vessels. This site is conveniently located adjacent to the existing Canadian Coast Guard base, allowing for easy communication and co-operation between the two organizations.

Establishing the IMRC at the BC Packers site ensures:

- 40%-50% of incidents will be responded to within **1 hour**;
- 75% of incidents will be responded to within **2 hours**;
- 80% of incidents will be responded to within **3 hours**; and
- 100% of incidents will be responded to within **5 hours**.

Other jurisdictions in the world have published response times of 3 to 11 hours, with an average of 7.5 hours. The IMRC response time of 5 hours or less falls well within the current definition of “world-leading” response times.

### ***Fleet & equipment***

Based on expert advice and consultation with suppliers around the world, Sections 5 and 7 identify the vessels and supplies that are necessary and suitable for rapid and comprehensive response in BC’s central and north coast.

In brief, the IMRC’s effectiveness hinges on a fleet of fast response vessels capable of oil clean-up and containment, and a tug and barge system providing storage and additional oil spill clean-up capabilities. The barge – equipped with a range of safety gear, clean-up equipment, provisions, and living quarters – ensures the response team is able to work on site for up to three weeks without outside support.

**Currently, there do not appear to be booms and skimmers available that would perform well in central coast marine conditions.**

Inshore booms and harbour booms, like much of what was deployed (and failed) in the *Nathan E. Stewart* response – simply do not stand up to the large waves and fast currents typical of central coast waters. Until specialized equipment is developed for containment in fast-flowing waters, offshore booms would make up a predominate part of the IMRC boom inventory, along with high strength Spectra fibre rope and high load anchors on the shoreline.

The development and testing of new and innovative oil boom designs is urgently needed. The IMRC will seek industry partnerships and local knowledge to help develop and field test designs, materials, and deployment on an on-going basis.

**Staff & crew**

The IMRC will employ 37 full time staff and crew, with vessel operators and response centre workers conducting shift work.

All crew will undergo a comprehensive training program, reviewed every three years (approximately) to ensure it is up to date. Prerequisites for crew will be that they live in the area and are familiar with the region, waterways, and weather conditions.

**Costs**

The annual operating cost of the IMRC is estimated to be \$6.8 million.

Start-up costs include:

- Development of an IMRC with Interim Response Capability: \$99.8 M
- Three Satellite Storage Depots: \$11.7 M

To enable response to incidents while the construction of the land and marine infrastructure is being completed, interim response capabilities can be put in place immediately. This includes the purchase of vessels and equipment, the recruitment and training of crew, and research and development to support immediate and future IMRC operations.

**CONCLUSION**

In light of the remote, challenging environment, this proposal for a Heiltsuk-led IMRC provides the closest option to an instantaneous response to incidents that could lead to an oil spill.

The IMRC builds on Heiltsuk’s millennia-long tradition of environmental stewardship and leverages the best-available western and traditional knowledge. Together with the federal government, industry, and neighbouring nations, the IMRC represents an Indigenous-led response to vastly improve environmental protections and marine safety to the benefit of Heiltsuk, the central coast, British Columbia, and Canada.

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# GLOSSARY

## ACRONYMS

<b>AASHTO</b>	American Association of State Highway and Transportation Officials
<b>ABS</b>	American Bureau of Shipping
<b>AIS</b>	Automatic Information System
<b>AMOSC</b>	Australian Marine Oil Spill Centre
<b>ASTM</b>	American Society for Testing and Materials
<b>BSEE</b>	Bureau of Safety and Environmental Enforcement
<b>CCG</b>	Canadian Coast Guard
<b>CDN</b>	Candidate Document Number
<b>CIP</b>	Call In Point
<b>CSA</b>	Canada Shipping Act
<b>DFO</b>	Fisheries and Oceans Canada
<b>DVS</b>	Domestic Vessel Safety
<b>ECRC-SIMEC</b>	Eastern Canada Response Corporation
<b>FRV</b>	Fast Response Vessel
<b>GT</b>	Gross Tonnes
<b>HTC</b>	Heiltsuk Tribal Council
<b>HTT</b>	Heiltsuk Traditional Territory
<b>IMO-OPRC</b>	International Maritime Organization – Oil Pollution Preparedness Response and Coordination
<b>IMRC</b>	Indigenous Marine Response Centre
<b>IOSA</b>	Island Oil Spill Association
<b>IUA</b>	Inter-municipal Committee for Oil Spill Response
<b>MCTS</b>	Marine Communications and Traffic Services
<b>MED</b>	Marine Emergency Duties
<b>MNZ</b>	Maritime New Zealand
<b>MSDS</b>	Material Safety Data Sheet
<b>MSRC</b>	Marine Spill Response Corporation
<b>NCA</b>	Norwegian Coastal Administration
<b>NES</b>	Nathan E. Stewart
<b>NOFO</b>	Norwegian Clean Seas Association for Operating Companies
<b>OPP</b>	Oceans Protection Plan
<b>OSRL</b>	Oil Spill Response Limited
<b>PPA</b>	Pacific Pilotage Authority
<b>ROC-MC</b>	Restricted Operator's Certificate – Maritime Commercial
<b>SAR</b>	Search and Rescue
<b>SCAT</b>	Shoreline Cleanup Assessment Techniques
<b>SEAPRO</b>	Southeast Alaska Petroleum Response Organization
<b>STCW</b>	Standards of Training, Certification and Watchkeeping for Seafarers
<b>SVOP</b>	Small Vessel Operator Proficiency
<b>TC</b>	Transport Canada
<b>TSB</b>	Transportation Safety Board
<b>WCMRC</b>	Western Canada Marine Response Corporation
<b>WHMIS</b>	Workplace Hazardous Materials Information System
<b>WMI</b>	Western Maritime Institute
<b>WSMC</b>	Washington State Maritime Cooperative



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# 1. PROJECT TEAM

We are pleased to provide this report for the Heiltsuk vision of an Indigenous Marine Response Centre (IMRC) in British Columbia. This study has developed a sound concept supported by field data, technical analysis, and guiding principles around safety, incident prevention and environmental protection.

The work was outlined in a proposal provided in December 2016, and a contract was signed on February 22, 2017. A Purchase Order was established with the Heiltsuk Tribal Council (HTC), PO Number 1010894. Marilyn Slett, Chief Councillor, is the HTC Contact, and Norman Allyn, CMO Consultants Ltd. is the Vendor Contact.

The project team is presented below:

**Emily Chu, In.Tent Planning Inc, Project Sponsor**

Emily is a community planner with over 25 years of experience working for local governments and First Nations.

**Norman Allyn, PEng., CMO Consultants Ltd, Project Director**

Norman has over 40 years of experience in the analysis and design of coastal, maritime, aquaculture, floating and Arctic offshore structures. He has extensive knowledge of the BC coast including marine projects at Bella Bella and Shearwater.

**Russ Tyson, TYPLAN Planning and Management, Vessel Data and Reporting**

Russ has 30 years of experience and has compiled the most comprehensive and extensive vessel inventory in the province. He has undertaken navigational assessments, including navigational channel design. Russ has also authored Transport Canada federal guidelines on how proponents undertake navigational assessments to satisfy requirements from the Navigation Protection Act. Most recently he prepared a benchmark review of the best practices associated with the TERMPOL review process, for Transport Canada Marine Safety Group.

**Peter Brown, Principal, Swiftsure Marine Services Ltd, Marine Vessels and Coastal Navigation**

Peter has 50 years of tugboat and barge experience on the BC coast. He worked his way up from a deckhand on tugboats, to running Kingcome Navigation for MacMillan Bloedel, and 23 years as partner/owner of Sealink Marine Services where he built the company up to 9 tugboats and 15 barges. Peter is from Prince Rupert originally, and has extensive experience navigating all of the BC coastal waterways.

**Scott Lima, PEng, Marine Facilities and International Oil Spill Response Data**

Scott Lima worked with Norman for many years on marine projects, and recently worked in the offshore marine environment in Norway, which has an extensive Oil Spill Response Network. Scott has researched information on the Norway facilities, as well as those in Alaska, Washington State and New Zealand, all with similar coastlines to BC.

**Dr. Ricardo Foschi, PEng, UBC Professor Emeritus, Probabilistic Analysis**

Ricardo has worked with Norman and Russ on the probabilistic analysis of vessel impacts on bridges, including the new Port Mann and Pitt River Bridges. Ricardo has built a probability analysis program called RELAN which will be used in Phase 2 to determine the probability of vessel impacts with rocks, reefs and shorelines utilizing the statistics on vessel aberrancy as developed in Phase 1.

**Dr. Hammad Mir, PEng, CMO Consultants Ltd, Metocean Computer Modelling**

Hammad has developed hydrodynamic models for a number of sites on the BC coast to determine winds, waves and currents, and has developed a model of the north coast from Vancouver Island to north of Prince Rupert. Hammad can refine the bathymetry at any site to determine locally generated wind waves and tidal currents, while retaining the far field structure that drives the tidal currents. The model has been used to simulate oil spill trajectories, including for the Nathan E. Stewart.

**Capt. Ron Burchett, Burchett Marine Inc., Vessel Concept Designs**

Ron has 50 years experience in the marine industry, including work in shipyards and at various towing companies. His work on vessel design has led to the development of the Fast Response Vessel (FRV), the Oil Spill Response Barge, and Tow Vessel concepts for the world-leading response centre developed herein. Ron has developed a world-wide reputation for the design and construction of Tractor Tugs and small-scale Training Tractor Tugs, and for providing operator training.

**Sara Matthews, Engineering Student, Research and Reporting**

Sara has completed 3 years of Mechanical Engineering at the University of Alberta, and has researched oil spill clean up equipment specifications and pricing.



## 2. BACKGROUND

### 2.1 NATHAN E. STEWART

The *Nathan E. Stewart* (NES) tug ran aground shortly after 1:00 am on Thursday October 13, 2016, near Bella Bella, in the heart of the Great Bear Rainforest. The NES was pushing the empty fuel barge DBL 55, when it grounded on Edge Reef, in Seaforth Channel near Athlone Island. While the fuel barge was empty, the grounding resulted in the tug leaking diesel and lubricant oil into the environment.

The NES eventually sank, and approximately 110,000 liters (110 m<sup>3</sup>) of diesel fuel oil entered into the marine environment, and the NES was not recovered for more than a month after it sank. Heiltsuk Tribal Council (HTC) voiced concern regarding the effect of the oil spill on aboriginal rights and title especially around the marine use activities traditionally undertaken by Heiltsuk Nation.

In a report produced by the HTC entitled: *INVESTIGATION REPORT: The 48 hours after the grounding of the Nathan E. Stewart and its oil spill*, (Heiltsuk Tribal Council, 2017), HTC notes that many aspects of the spill response were inadequate, specifically noting: slow response time, insufficient and ineffective facilities and equipment, inadequate safety gear, a lack of communications, and confusion about who was in charge. The report documents that numerous separate requests were made for information to the foreign owner of the tug (Kirby Corporation) and various government agencies, including Transport Canada, the Transportation Safety Board (TSB), and the Canadian Coast Guard (CCG). The HTC indicated that all but two of those requests were either denied or ignored. Images, seen in Figure 1, of the spill response to the NES incident also show that the responders were working against the elements (wind, waves, and current) rather than with them, the pictures also show that the vessels, booms and skimmers were positioned incorrectly to contain and pick up the diesel fuel slicks. Both of these examples of a poor response are most likely due to a lack of training about the use of the spill equipment.



**Figure 1. Nathan E. Stewart Spill Response.**

Images by Kyle Artelle, April Bencze, Tavish Campbell.



The boom size initially deployed was 24" (0.61 m) as given in the Seaforth Channel Resource Summary (Resource Summary for the Seaforth Channel Incident, 2016) provided by the HTC; this size of boom is below the guidelines for the boom size provided in Appendix D, given the current speeds and wave heights at the site that are given in the Period 2 Incident Action Plan for the Seaforth Channel Incident. The wind speeds and wave heights in South Hecate Strait (Buoy C46185) were 12.4 m/s (24 knots) and 3.6 m, respectively (Reference Department of Fisheries and Oceans Canada), and the reported wind speed from the Period 2 Incident Action Plan was 15 to 35 knots, while the wave heights were forecast to be 4 m. The current speeds would have been in the order of 2 knots as given in Appendix B. Using this information, the boom size that should have been deployed is 42 inches (1.07 m) minimum, and this size was eventually placed around the NES (Resource Summary for the Seaforth Channel Incident, 2016).

Had the proposed IMRC been in place before October 13, 2016, it could have prevented the loss of oil into the environment as it has the following features:

- Mitigation measures including the tracking of vessels and eliminating dead spots would enable automatic monitoring of vessel location, and the NES would have been notified once they deviated from the navigation channel.
- The IMRC would be run in a similar manner as fire departments in large centres on the mainland, with the fast response vessels (FRVs) crew stationed on the oil spill barge, and once the incident, distress or Mayday call came in, they would walk across the dock into the FRVs. This near instantaneous response would have enabled them to be at the NES site in about 30 minutes after the barge grounding call was received at around 1:15 am on October 13, 2016.
- Heavy weather booms would be ready to go on reels on the FRVs.
- The oil spill barge and tug would have arrived at the site at about 3:30 am.
- The landing craft would have been launched from the barge to enable the deployment of beach protection booms, and would have brought skimmers to the vicinity of the NES once the beach had been boomed off.
- When the NES sank shortly after 9:26 am, it happened in seconds, and the water around it was covered in diesel fuel oil. With the proposed IMRC approach, the vessel would have been boomed off, and there would have been a number of skimmers with diesel fuel oil capability ready to be deployed by lifting into the boomed off area using gear on the vessels, to remove the oil before it spread to the nearby shores and Gale Creek, and oily water would be pumped into bladders.
- The bladders would then be towed to the oil spill barge for pumping the contents into holding tanks for processing by oil/water separators.
- The process of removing oily water from within the boomed off area would continue uninterrupted into empty bladders while the full bladders were being discharged.

## 2.2 NATIONAL OCEANS PROTECTION PLAN

In November of 2016 the Government of Canada launched the \$1.5 billion National Oceans Protection Plan (OPP). As part of that plan, the Government of Canada is developing measures that will enhance marine safety and prevent and improve the response to marine pollution incidents. Part of the OPP is that the government will seek Indigenous and coastal communities' advice in a number of areas, including the development of training programs to increase participation of Indigenous community members in marine safety jobs. Another part of the OPP is that the OPP will form new Indigenous Community Response Teams in British Columbia that will offer training for search and rescue, environmental response, and incident command. OPP also states that it will provide funding for on-the-ground marine safety equipment and infrastructure for northern coastal communities. Another part of the OPP is that it will create a new chapter of CCG Auxiliary in British Columbia to support Indigenous Communities. It is within the context of the OPP that this proposed IMRC has been prepared. The IMRC is a strong candidate for OPP funding as this study demonstrates using traffic and incident data, technical analysis, and guiding principles around safety, incident prevention and environmental protection.

## 2.3 ALIGNMENT OF HEILTSUK AND FEDERAL OBJECTIVES

British Columbia (BC) has one of the three Canadian Coast Guard (CCG) Regional Operations Centers in Canada, located in Victoria. The Operation Centre in Victoria is operated by highly trained CCG personnel that are equipped to respond to marine incidents. As part of the creation of a "world-leading marine spill prevention system" the CCG have been mandated under the NOPP to create 24/7 patrolling and monitoring of Canada's marine environment within the regional operations centers. The objective is to reduce delays in communications and information exchange to partners, stakeholders, and the public, as well as to improve the ability to respond to environmental concerns in the case of a vessel incident or spill.

The HTC is pursuing the development and implementation of an IMRC to address safety, incident prevention, and environmental protection. The IMRC is focused on satisfying HTC concerns related to response times, facilities and equipment, and communications as well as fulfilling the eleven features for a world class spill prevention plan that can be found in Section 8. The area of interest is spatially centered around the Heiltsuk Traditional Territory (HTT) and extends from Cape Caution in the south to the north end of Principe Channel and to Morning Reef in Grenville Channel, as can be seen in Figure 2 and Figure 4.

The federal government acknowledges that emergency response planning along the Pacific Coast is a critical issue in the global marketplace and paramount for local stakeholders and First Nations. Prevention and preparedness for the potential of such incidents and spills must be planned for, and local responders and stakeholders must be equipped and trained to form part of the solution. Federal support of the IMRC would further mutual objectives of improved marine emergency prevention and response.



HEILTSUK NATION  
PHOTO: KYLE ARTELLE  
OCT. 28, 2016

## 2.4 THE INDIGENOUS MARINE RESPONSE CENTRE CONCEPT

The Indigenous Marine Response Centre (IMRC) concept is intended to provide as close as possible to an instantaneous response to incidents that could lead to an oil spill as developed in Appendix B to this report. The IMRC is focused on the protection of the environment, which Heiltsuk has stewarded since time immemorial. On the west coast, the ocean is the highway, and the IMRC will operate similar to how fire departments operate on the mainland. The crew will be on the Oil Spill Response Barge, and when the emergency or incident call comes in they will just pull on their survival suits, walk across the dock, and into the two FRVs. To achieve the optimal response on the Central Coast, HTC and the IMRC need to develop close working relationships with the CCG, Transport Canada, Environment and Climate Change Canada, Fisheries and Oceans Canada (DFO), BC Parks, BC Ministry of Environment, and animal rehabilitation organizations, as well as a functional working relationship with other marine response organizations. There will also be a need to have relationships and agreements with companies that provide environmental services in British Columbia, and with organizations or companies that handle oil waste disposal. It is recognized that Geographic Response Plans will need to be developed.

### 3. VESSEL INCIDENT DATA

There are two data sets that have been utilized in this study:

- The Transportation Safety Board (TSB) data set provides 6 years of data (2011-2016, inclusive) from the North end of Vancouver Island to the Alaskan Border. This data set provides the type and number of incidents that occurred, for each incident type. From that data set, 603 incidents are of the type that the IMRC would respond to, including: Fire, Total Failure of Any Machinery or Technical System, Sank, Grounding, Collision, Person Overboard, Sustains Damage Render Unseaworthy/Unfit for Purpose, Risk of Sinking, Abandoned, Bottom Contact, Intentional Beaching/Grounding/Anchoring to Avoid Occurrence, Capsizes, and Dangerous Goods Released. The data are provided Table 1.
- The Pacific Pilotage Authority (PPA) data set provides 20 years of data (1997-2016, inclusive) for the area between Cape Caution in the South, to the North end of Principe Channel and to Morning Reef in Grenville Channel, considered to be the IMRC Response Area, as can be seen in Figure 4. The PPA data were extracted from the maps in a PPA Waivers Risk Assessment presentation that was made to the Heiltsuk Tribal Council on March 21, 2017 (Greenwood Maritime Ltd., 2017). The maps that were presented by the PPA, with the identified choke points, can be seen in Figure 2 and Figure 3, where choke points are areas of concentrated groundings/near groundings due to narrow waterways and/or exposure to unfavourable weather, and which were developed in Appendix B for performing a probabilistic risk assessment of future groundings/near groundings due to increased vessel traffic. The PPA data set provides the spatial reference for the number of groundings/near groundings that occurred on the BC central coast. From the data set 157 groundings/near groundings were found to have occurred in the HTT waters, as can be seen in Table 2. The conversion to the approximate number of incidents over 6 years was done by multiplying the PPA total groundings and near groundings of all vessels over 20 years by the ratio 6/20.

In discussions with Heiltsuk, it is noted that the data sets do not include some known incidents, and so are not considered comprehensive. The data are, however, considered adequate for the identification of choke points and the number of types of incidents that the IMRC would respond to.



**Table 1. Transportation Safety Board Data (2011 to 2016, inclusive)**

TYPE OF INCIDENT	TOTAL	IMRC WOULD RESPOND (Y/N)	TOTAL RESPONDING TO
Fire	34	Y	34
Total Failure of Any Machinery or Technical System	357	Y	357
Person Seriously Injured or Killed <sup>1</sup>	49	?	0
Sank	22	Y	22
Grounding	106	Y	106
Striking <sup>2</sup>	26	N	0
Risk of Grounding	20	N	0
Collision	28	Y	28
Person/Crew Member Physical Incapacitation <sup>1</sup>	3	?	0
Risk Of Striking	13	N	0
Person Overboard	7	Y	7
Cargo Shift/Cargo Loss	6	N	0
Sustains Damage Render Unseaworthy/Unfit for Purpose	16	Y	16
Risk of Sinking	14	Y	14
Abandoned	1	Y	1
Bottom Contact	14	Y	14
Intentional Beaching/Grounding/Anchoring to Avoid Occurrence	2	Y	2
Risk of Collision (Near Collision)	12	N	0
Fouls Underwater Object	1	N	0
Capsizes	1	Y	1
Risk of Capsizing	1	N	0
Dangerous Goods Released <sup>3</sup>	1	Y	1
<b>Total</b>	<b>734</b>		<b>603</b>

Notes:

(1) It is assumed that the vessel will attend to the injured person using on-board First-Aid

(2) It is assumed that this is a glancing blow to some object and that it does not require response by the IMRC

(3) This is assumed to be the Nathan E. Stewart grounding that occurred on October 13, 2016

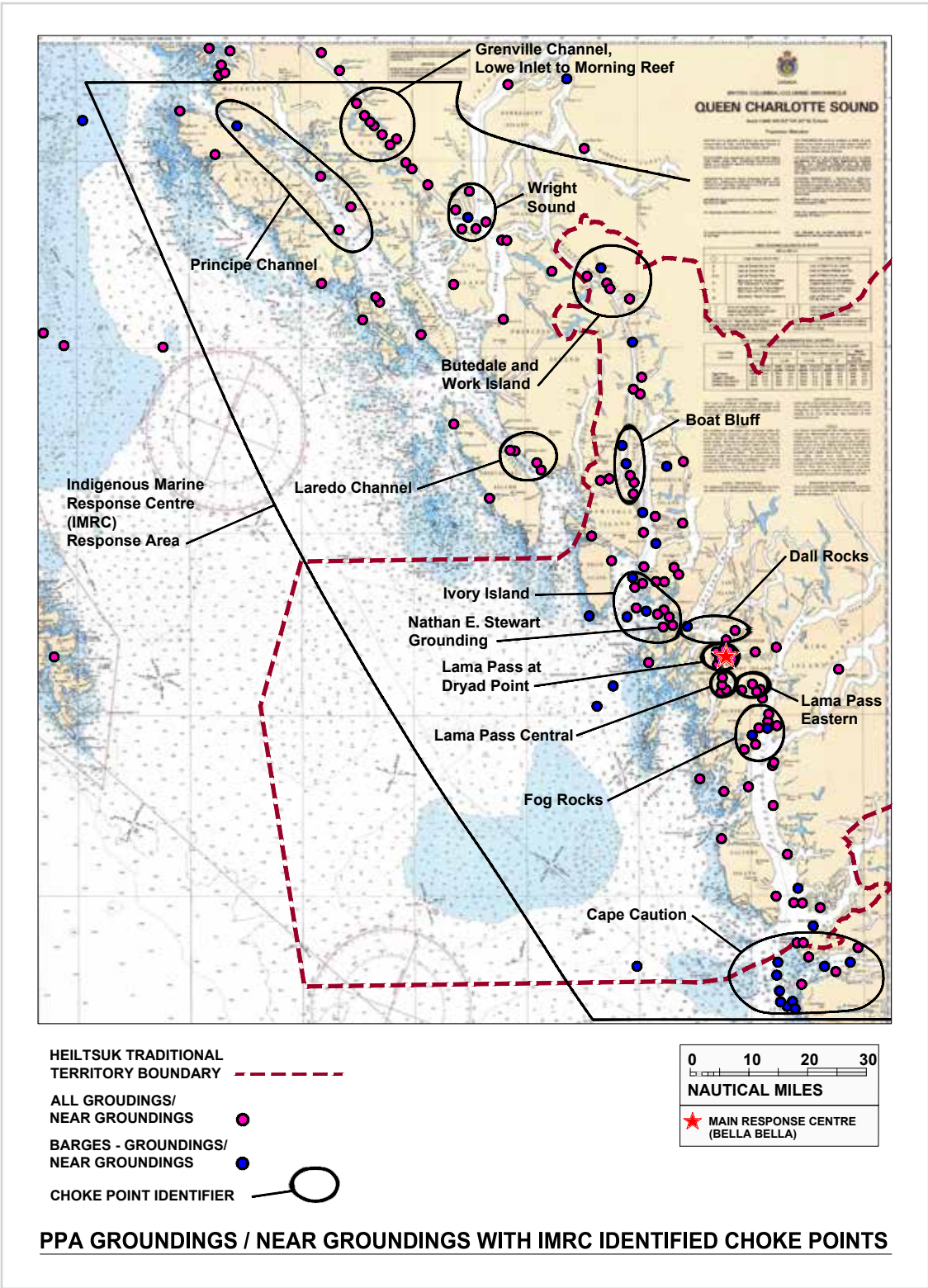


Figure 2. PPA Groundings and Near Groundings (1997 to 2016, inclusive. This dataset is not considered comprehensive)

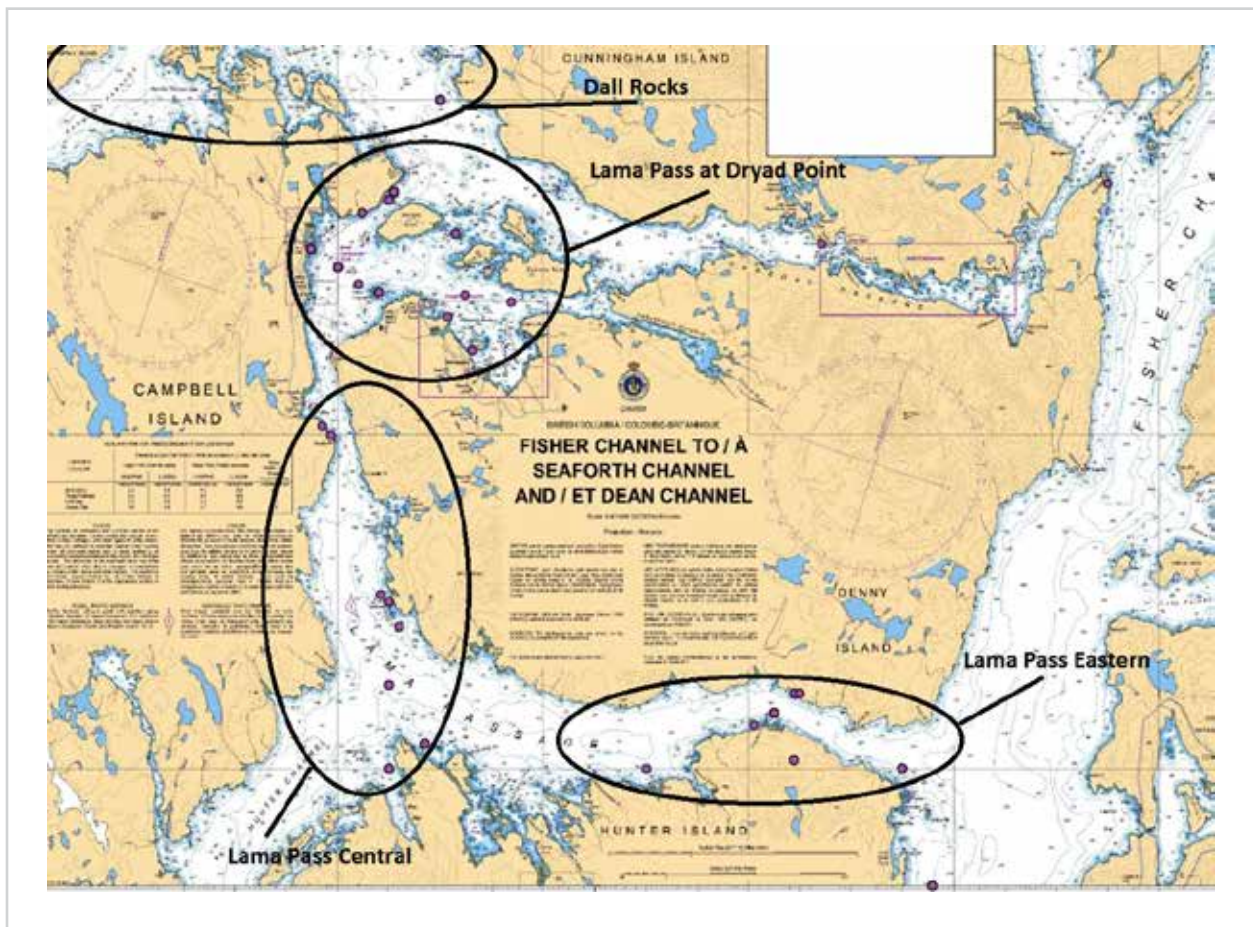


Figure 3. PPA Groundings and Near Groundings Near Bella Bella (1997 to 2016, inclusive. This dataset is not considered comprehensive)



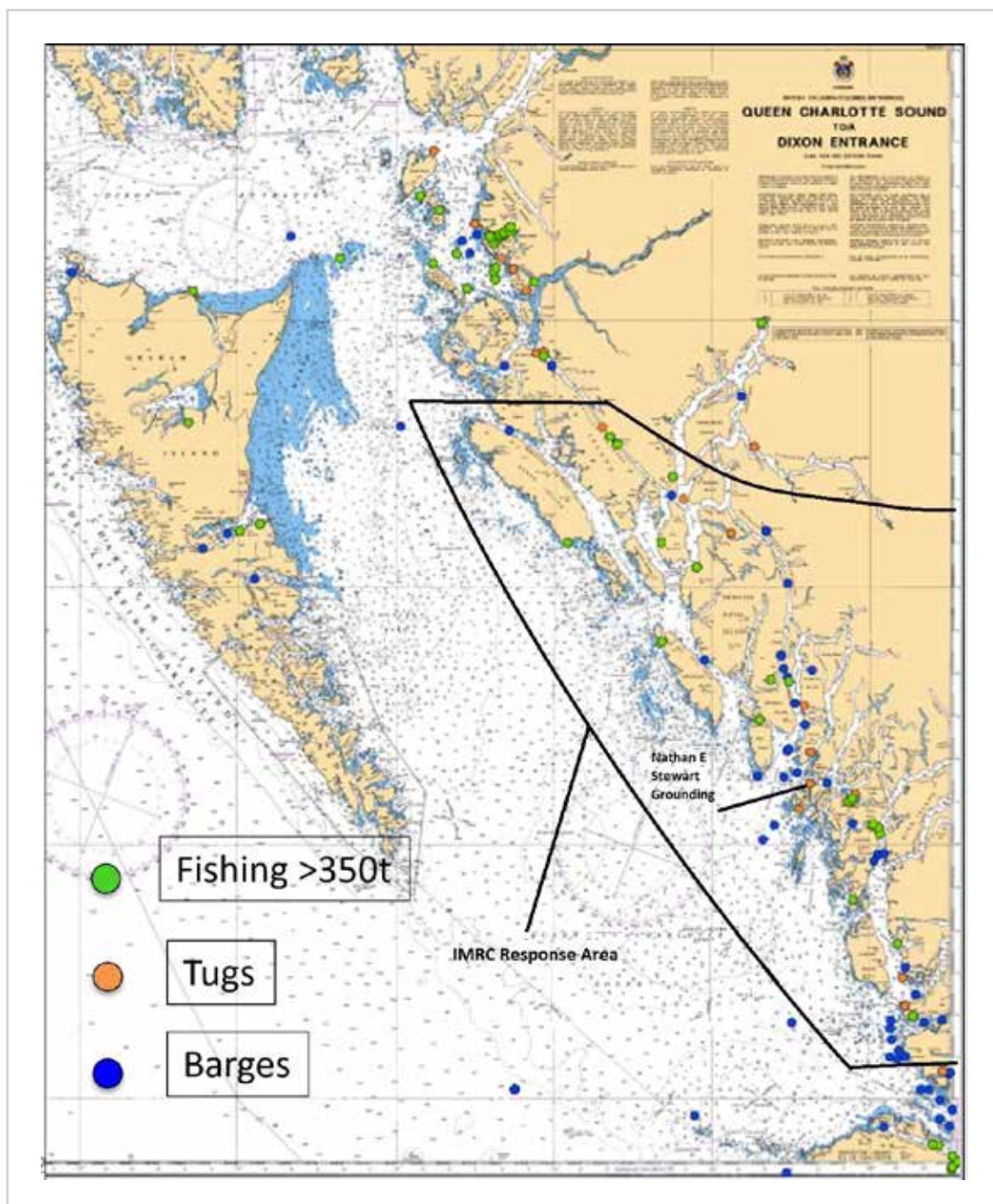


Figure 4. PPA Groundings and Near Groundings by Vessel (1997 to 2016, inclusive. This dataset is not considered comprehensive)



Table 2. PPA Groundings and Near Groundings (1997 to 2016, inclusive)

CHOKE POINT	PPA TOTAL GROUNDINGS/ALMOST GROUNDINGS ALL VESSELS 20 YEARS	PROPORTION OF INCIDENTS IN AREA(%)	PPA TOTAL GROUNDINGS/ALMOST GROUNDINGS ALL VESSELS 6 YEARS
Cape Caution	16	10.2	4.8
Fog Rocks	8	5.1	2.4
Lama Pass Central	8	5.1	2.4
Lama Pass Eastern	7	4.5	2.1
Lama Pass at Dryad Point	12	7.6	3.6
Dall Rocks	3	1.9	0.9
Ivory Island	13	8.3	3.9
Boat Bluff	5	3.2	1.5
Laredo Channel	4	2.5	1.2
Butedale and Work Island	5	3.2	1.5
Wright Sound	5	3.2	1.5
Grenville Channel <sup>a</sup>	8	5.1	2.4
Principe Channel	4	2.5	1.2
Rest of Coast <sup>b</sup>	59	37.6	17.7
<b>Total</b>	<b>157</b>	<b>100.0</b>	<b>47.1</b>

Notes:

a. The Grenville Channel Choke Point is considered to be from Lowe Inlet to Morning Reef.

b. The "Rest of Coast" refers to the waters between choke points, from Cape Caution to the North End of Principe Channel, and to Morning Reef in Grenville Channel.

From the PPA and TSB data, it was determined that the IMRC would respond to approximately three incidents a month with current traffic within the IMRC Response Area. Table 3 shows how this would change with an increase in traffic and with mitigation. The methodology to develop these values are provided in Appendix B. From the TSB data presented in Appendix A, the number of incidents that occurred per year increased by almost 100% from 2011 to 2016.

**Table B5. Calculated Expected Number of Trips with Grounding Incidents per Choke Point, over 6 Years**

$N_{mo}$	$N_{mo,m}$	$N_{m,10}$	$N_{mo,10m}$	$N_{mo,25}$	$N_{mo,25m}$	$N_{mo,100}$	$N_{mo,100m}$
3	2	3	3	5	3	8	5

Notes:

$N_{mo}$  applies if the current annual traffic is maintained with no mitigations

$N_{mo,m}$  applies if the current annual traffic is maintained with mitigations

$N_{m,10}$  applies if the current annual traffic is increased 10% with no mitigations

$N_{mo,10m}$  applies if the current annual traffic is increased 10% over 20 years, with mitigations

$N_{mo,25}$  applies if the current annual traffic is increased 25% over 20 years, with no mitigations

$N_{mo,25m}$  applies if the current annual traffic is increased 25% over 20 years, with mitigations

$N_{mo,100}$  applies if the current annual traffic is increased 100% over 20 years, with no mitigations

$N_{mo,100m}$  applies if the current annual traffic is increased 100% over 20 years, with mitigations



HEILTSUK NATION  
PHOTO: APRIL BENCZE

## 4. BELLA BELLA, MAIN RESPONSE CENTRE

### 4.1 BELLA BELLA - THE OPTIMAL LOCATION

The following points are evidence as to why Bella Bella can be considered the optimal location for the main IMRC response centre:

- Bella Bella is central to central and north coast incidents, as can be seen in Figure 3 above.
- The envelopes of the distance travelled by the FRVs in 1, 2, 3, 4 and 5 hours are shown in Figure 6, assuming 30 knot (kn) speed, from the IMRC at Bella Bella.
- Figure 7 shows the envelopes of distance travelled from the IMRC at Bella Bella, superimposed on the PPA data.
- The percentages of the incidents that are responded to for each time envelope can be seen in Figure 7, and are provided below:
  - In 1 hr, 42.7%
  - In 2 hrs, 74.5%
  - In 3 hrs, 82.2%
  - In 4 hrs, 96.8%
  - In 5 hrs, 100%
- From Bella Bella an FRV travelling at 30knots/hr would have been on site at the *Nathan E. Stewart* grounding location in approximately 30 minutes.
- With a population of approximately 1,500, Bella Bella has the human resources to operate the response centre and vessels. The maritime culture of the area and knowledge of the central coast that the Heiltsuk community possess, provide a good base for training for operating the FRVs, Tug, Barge, Landing Craft, oil spill equipment such as booms and skimmers, and sophisticated communication equipment.
- The proposed site, the Ex-BC Packers site, is a large property with sufficient space to house the land based operation, and is waterfront, which will provide mooring facilities for the vessels. The Ex-BC Packers site is also adjacent to the existing Bella Bella CCG base, which will allow for easy communication and co-operation between the two organizations. There is a plan to have a boardwalk between the two sites in addition to road access.



- The Ex-BC Packers site is also well located for multi-modal transportation outside of the area, as shown in Figure 8, with access:
  - By Air:
    - The Bella Bella airport
    - Denny Island aerodrome
    - The proposed heliport at the Ex-BC Packers site
  - By water:
    - McLoughlin Bay BC Ferries terminal
    - Shearwater BC Ferries terminal
    - Passenger ferry between Bella Bella and Shearwater
    - Easy small boat connection between Bella Bella and the Ex-BC Packers site, a distance of less than 1 nautical mile (nm)
  - By road:
    - Road connections between Shearwater to the Ex-BC Packers site
    - Road connections between the Ex-BC Packers site and the CCG station
    - Road connections between Ex-BC Packers site and the Denny Island Aerodrome
  - The waterfront of the property offers a sheltered, deep water location



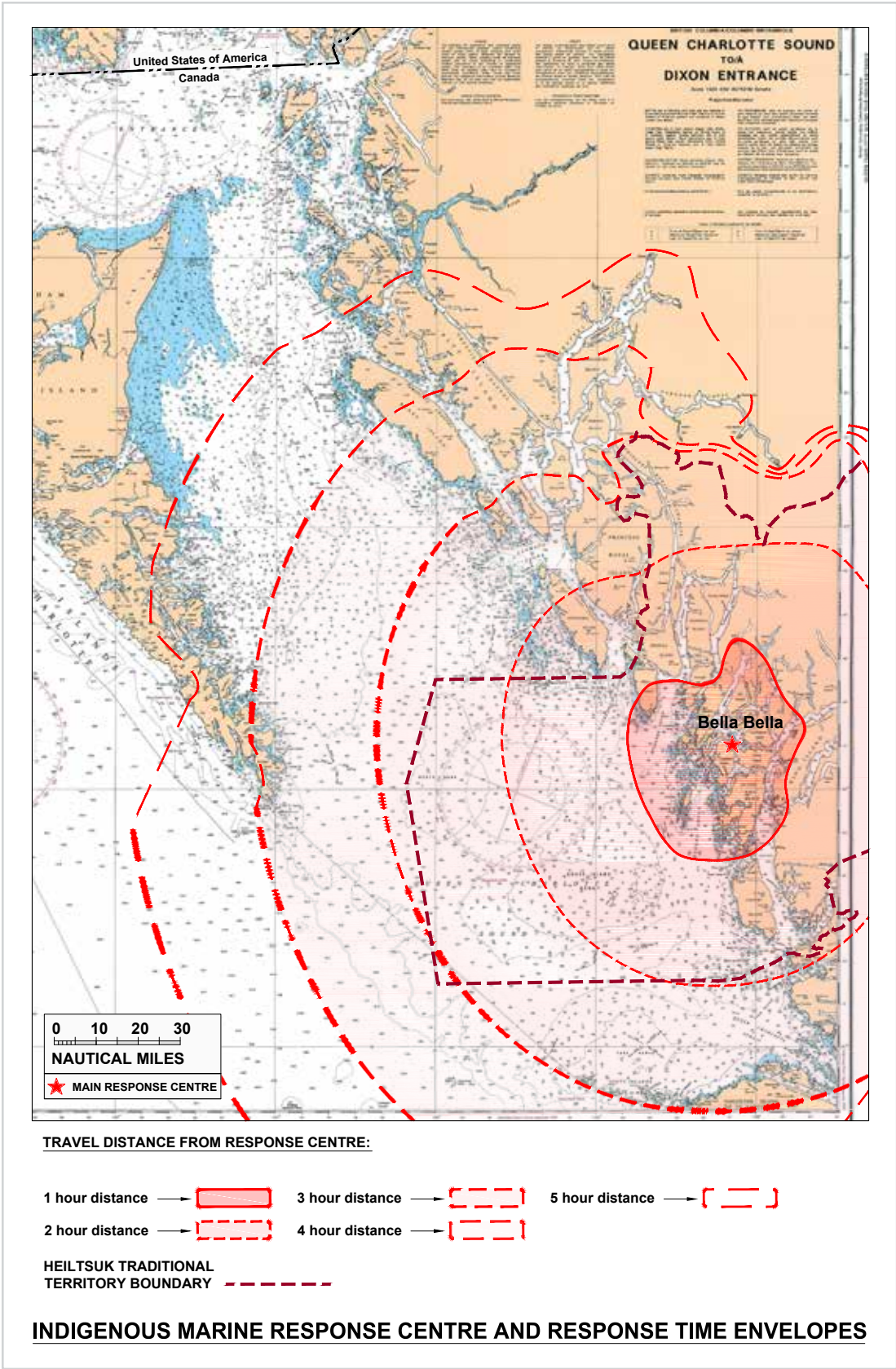
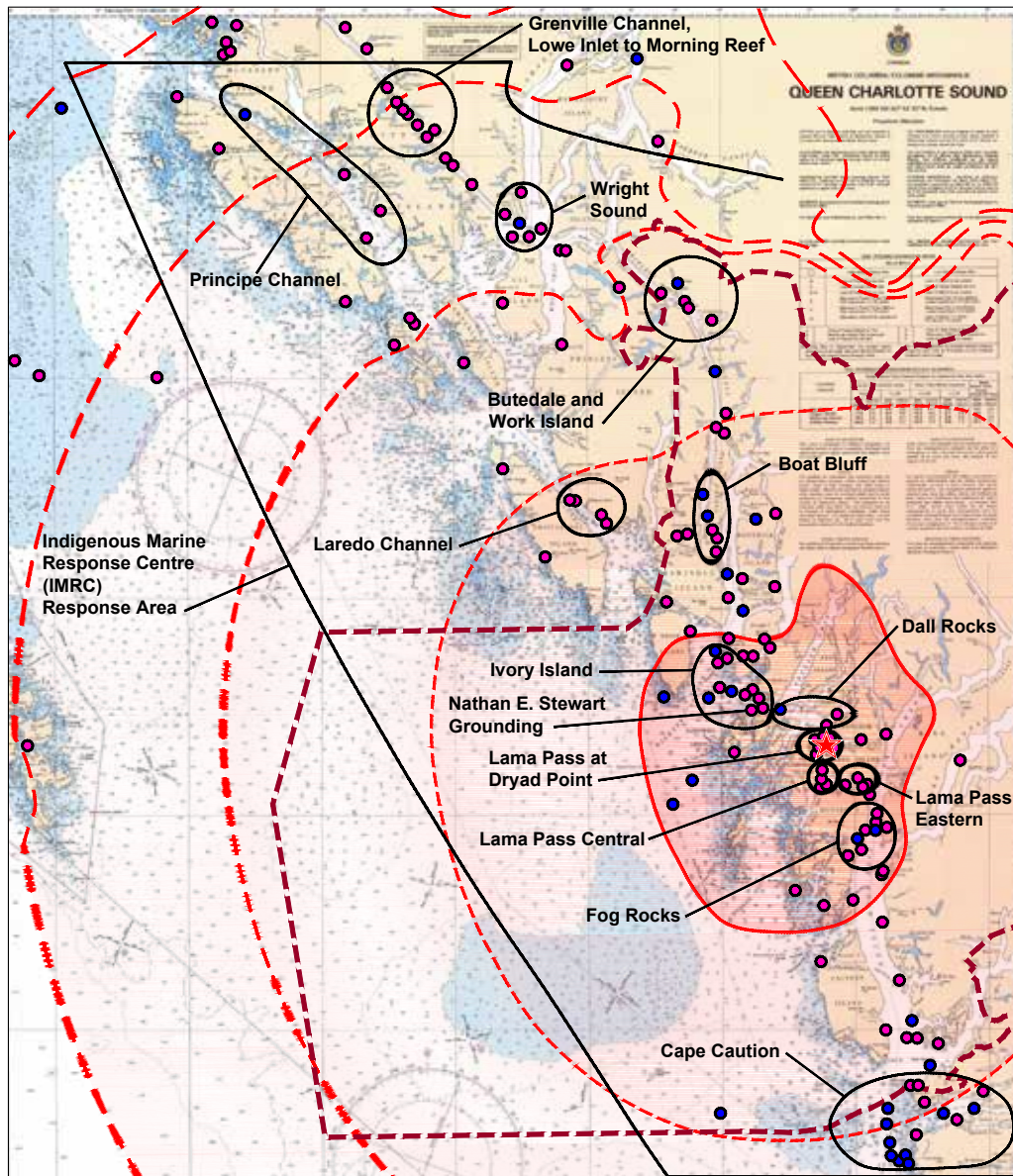
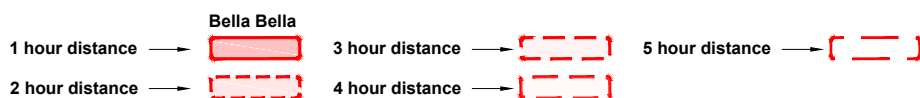


Figure 5. Indigenous Marine Response Centre Travel Time Distances



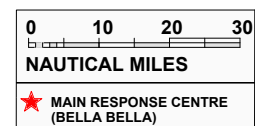
TRAVEL DISTANCE FROM RESPONSE CENTRE:



HEILTSUK TRADITIONAL  
TERRITORY BOUNDARY

ALL GROUDINGS/  
NEAR GROUDINGS

BARGES - GROUDINGS/  
NEAR GROUDINGS



## IMRC RESPONSE TIMES AND GROUDINGS / NEAR GROUDINGS AREAS

Figure 6. Overlay of Response Times with PPA Groundings and Near Groundings (data points are for 1997 to 2016, inclusive)



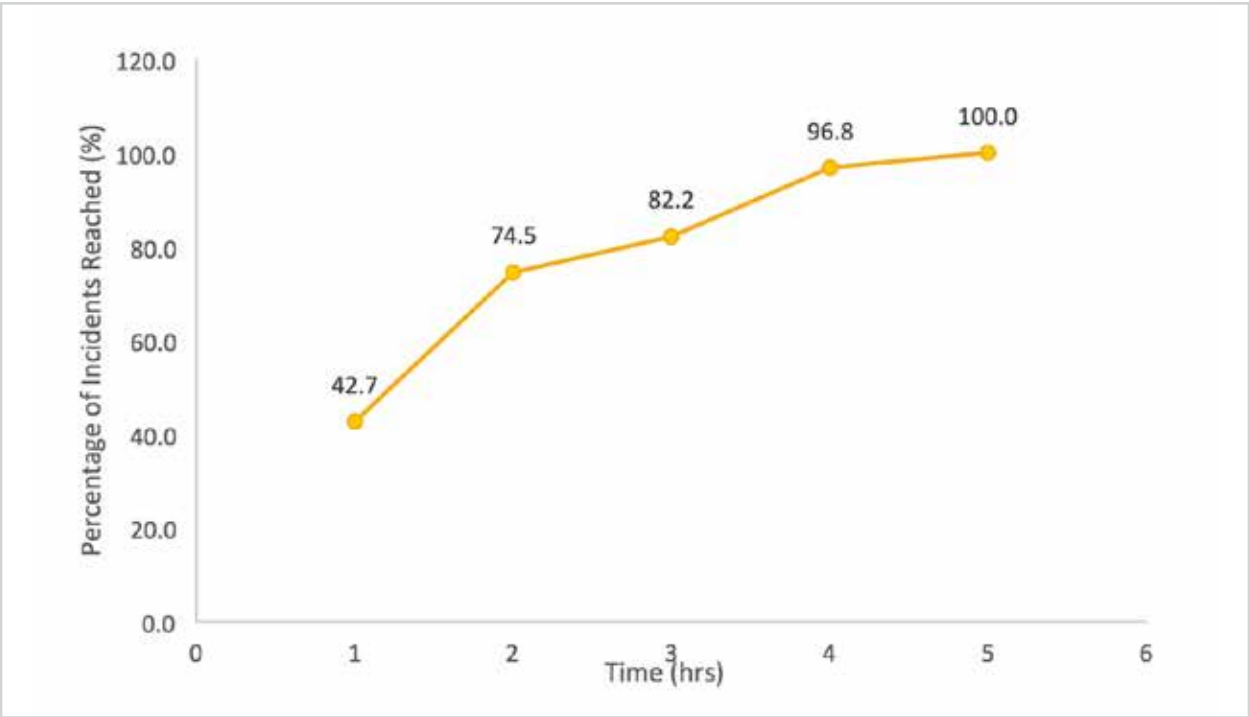


Figure 7. Percentage of Incidents Reached in Each Time Envelope

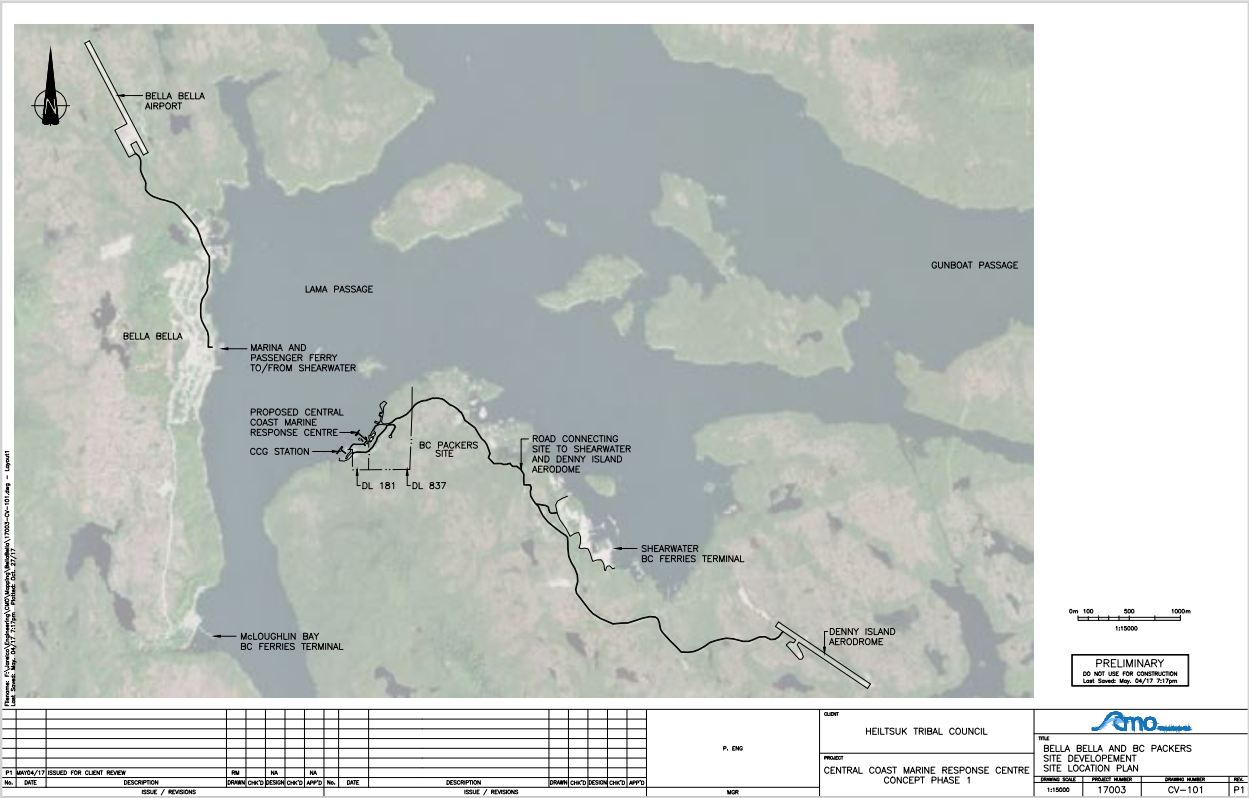


Figure 8. Proposed Location of Bella Bella Indigenous Marine Response Centre (IMRC)

## 4.2 BELLA BELLA RESPONSE CENTRE PLANS

The layout of the Bella Bella Site is shown in Figure 9 below. The response centre building has a footprint of 37 m x 25 m and is to be 2 stories with 7 individual bedrooms, a kitchen and dining room, bathroom/showers and closets upstairs, and 2 large conference/class rooms, office spaces, bathrooms, and closets on the main floor. The floating dock will be a minimum of 6 m width, built of fully connected concrete units, held in place with chain and anchors or piles, and it will be serviced with potable water, fire protection, electrical, communications and sewage pump-out. The main float dimensions are provided in Figure 9, and the gangway will be 25 m or longer as required to span over shallow water and to provide disability access, and will be able to support a forklift.

The storage and workshop building has the same footprint as the main response centre building, and will be a single storey steel framed structure on a concrete base, with drainage and oily waste collection for cleaning equipment, and is situated for easy access by forklift to the gangway and floats.

Other features include a barge ramp, a boat launch ramp, a storage and laydown area, a road connecting the response centre to the road to Shearwater and the CCG station, a heliport, vehicle parking, two floating buildings to provide space for a workshop and storage of safety gear, a water treatment system including collection of rainwater, and sewage treatment including pump out from the floats and vessels tied up to the floats.

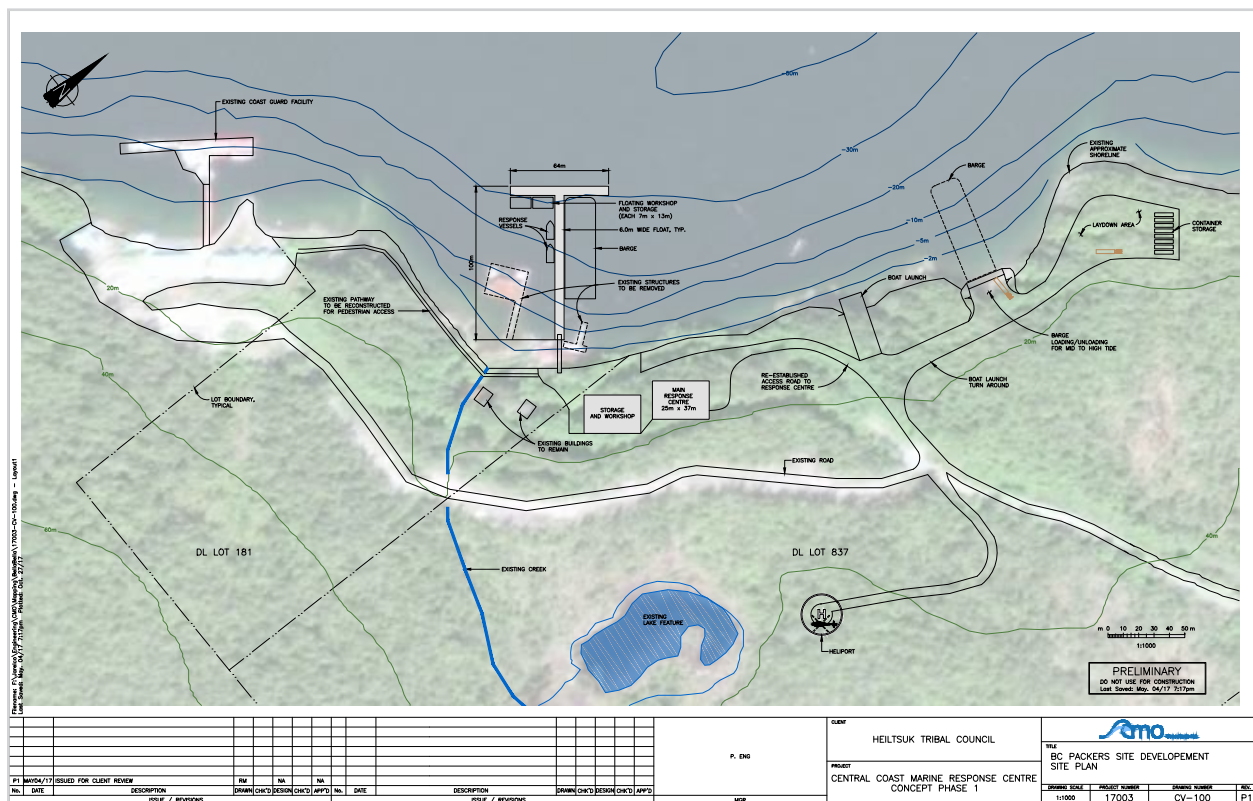


Figure 9. Bella Bella Indigenous Marine Response Centre (IMRC) Schematic

## 5. VESSELS

The Canada Shipping Act, 2001, S.C. 2001, c. 26 (CSA) outlines Canada's present marine oil spill preparedness and response regime. The private sector regime seeks to ensure Canada is better prepared to respond to ship-source oil pollution incidents. An important component is ensuring an appropriate level of response infrastructure is in place in the event of an incident. The standards are intended to be used in the planning process in preparation for a response to an oil spill incident. Each response plan will be unique considering the geographic nature of the regions. As noted, since the response to an incident will be influenced by environmental and other factors, the standards should not be used as a yardstick against which to measure appropriateness of the response. The Government of Canada has categorized a tiered response according to capability and the proposed IMRC standards are compared to Canadian regulations.

What separates the IMRC from other spill response organizations is the operation of the facility like fire halls in larger communities on the mainland, so that once the incident or Mayday call comes in, the crew, who will be stationed on the oil spill response barge, will pull on their safety gear such as survival suits, and walk across the dock to the fast response vessels (FRVs). The IMRC would respond to all incidents that could lead to oil contaminating the environment; current organizations respond after a spill occurs. The IMRC is based on the establishment of FRVs, that are capable of the cleanup and containment of oil, and a tug and barge system capable of providing additional oil spill cleanup capabilities and storage.

The vessels and their equipment were specifically engineered to address the unique nature of the central and north coast of British Columbia, where the ocean is the highway. The key objective is that the response vessel team must be self-contained and be able to work on site for three weeks without outside support. In order to achieve the best possible design, we collaborated with the world-wide suppliers who defined the equipment based on the equipment needed for our concept. Because of the need for high speed, the Cummings Engine Company ran dyno-testing to validate the horsepower and torque needed for the required speeds that we will attain. The jet propulsion system was modeled in tandem with the engines and the hull form, which required modelling with specialized computer software. This involved six separate tests to achieve the speed required. In addition, we had to model the super structure with an aerodynamic computer program to reduce the wind resistance and drag. The next phase was to ergonomically lay out the working deck and the wheel house and the crew accommodation. Because we intend to run twenty-four hours a day, the fatigue factor was addressed with sound deadening and air cushioned seating for high speed travel. We work with the lighting suppliers to come up with a package that will surpass the status quo. We've integrated the new LEDs and the FLIR night vision technology (this technology is adapted from the military to be able see the oil spill at night) and what we call the "halo" effect for peripheral lighting on all the boats and the barge. We have the capability to dim the lights to suit the conditions. This gives us the ability to work 24 hours a day. The ability to respond to 100% of incidents in the HTT within 5 hours is world-leading, and would provide less than 1 hour response time for incidents such as the NES.

Detailed information on the design of the vessels has not been included in this report due to the proprietary nature of the information. Overviews are provided below.

## **5.1 THE FAST RESPONSE VESSEL**

Two FRVs are needed as a minimum for a successful operation. The vessels are 16.64 m (54 ft) in length, 5.76 m in width, and have a depth of 1.52 m, and have a top speed of more than 35 knots, although 30 knots has been conservatively utilized in response time distance calculations. This fast response is the key to the success of the system. These vessels will be deployed to the incident and will start the preparations, containment and cleanup immediately without any additional assistance, as time is of the essence. The FRVs will also have crew accommodations in the forward of the vessel. The boats will have a dual purpose, they will be able to deploy booms and recover oil using skimmers integrated into the vessel. They will be able to carry approximately 305 m of medium containment boom. The two FRVs will work as a team until the rest of the equipment arrives. The FRVs have been specifically designed for use in these challenging waters and conditions. They will be built to a very high level of functionality, strength and ease of use. The FRV will have four crew members, a captain, a watchman/deckhand, an engine room rated crew member, and a fourth crew member that has their marine advanced first aid in addition to their deckhand or engine room rating certificate.

## **5.2 THE BARGE**

The barge functions as a home base and is designed to supply all of the needed resources and equipment to support the oil spill cleanup. The barge will be towed to site by its own tug which is also part of the cleanup team. The barge is 65 m long by 15 m wide and has a molded depth of 3.66 m. The barge is a special design which can be towed at a sustained speed of 10 knots. The barge functions as a self-contained unit accommodating 15 crew. The barge will also be able to carry four landing crafts and will have a crane capable of loading and unloading the landing crafts.

In addition to carrying the landing crafts, the barge will also have a helipad. The barge can also re-provision the other vessels with fuel, as it will have two fuel tanks that can hold a total of 205 m<sup>3</sup>. In addition to storing fuel for other vessels, the barge will have six tanks that total to 1,800 m<sup>3</sup> of storage for recovered oil/water waste from the oil spill. The oil/water waste will be treated on board. There will be a forward hold, serviced by the crane, which will store all of the consumables required for cleanup and the spare containment booms. The barge will carry approximately 4,500 m to 6,000 m of containment boom on boom drums.

The barge, along with all of the other vessels, can maintain continuous oil clean-up for up to three weeks. Skimmers can also be used directly from the barge to contribute directly to oil spill cleanup efforts. The barge will have an engineer on board, and four extra crew members or trainees.

The barge will be outfitted with dual azimuthing thrusters - one in the bow and one in the stern which will give the ability to maneuver the barge in tight quarters without the tug and to hold station in a dynamic positioning (DP) mode. This will be an advantage for the barge to come alongside an oil boom to pump oil in tight quarters and offer a margin of safety when moored in an exposed area where anchoring is difficult.

There will be the option for the barge to serve as the Incident Command Post (ICP) for the duration of the oil spill clean up.

### **5.3 THE TUG**

The tug is designed as a multi-functional vessel to tow and anchor the barge, and to assist with boom deployment and moving of supplies once the tug and barge are on the scene of the spill. The tug will also have the ability to act as a salvage vessel, with the necessary equipment to pump out and tow a distressed vessel. The tug will also operate an external skimmer, with a towable bladder for the waste storage. The tug is 15 m long by 7.21 m wide and has a depth of 2.93 m. It will be designed to be under 60 gross tonnage (GT) to facilitate being operated with a reasonable Masters license related to training. The tug will have 1,600 hp, sufficient to move the barge at an average speed of 10 knots empty, while on the way to the incident location. The tug will have 4 crew members: a captain, a watchman/deckhand, an engine room rated crew member, and a fourth crew member that has their marine advanced first aid certificate in addition to their deckhand or engine room rating certificate.

### **5.4 THE LANDING CRAFTS**

The landing crafts are designed to be 12 m (39.8 ft) in length and 3 m (10 ft) wide, with a light draught of 0.6 m. The landing crafts will use twin jet drives, which will provide a speed of more than 30 knots. The landing crafts are intended to tow booms and bladders, use smaller skimmers, assist with the set-up of shore booms, and act as a shuttle for personnel, supplies, and waste. The vessels will be outfitted to work in this extreme environment for an extended period of time with a heated wheelhouse and overhanging shelter for weather. The crew members and trainees stationed on the barge will be those designated to operate the landing crafts, and will rotate as required. The landing crafts will return to the barge for crew change and to off load oily water and reload empty bladders and supplies.

### **5.5 OPERATION OF VESSELS**

The success of the operation requires a trained team to be available 24/7 and be tested for continuing proficiency at least once per year. Special training will be required to integrate the new technology which will require training at night. The electronics for navigation will be picked specifically for this type of operation. The new radars are tunable to the weather conditions we would be working in. The full fleet will be connected by satellite communications to facilitate the acquisition of the latest computer models of the spill and be able to update RCC real time. There is no operation in the world that meets this level of response that exhibits readiness and is deployable in such a remote area. As the area involved has very challenging conditions the use of local First Nations people with their knowledge of the conditions that they will be faced with will only further enhance success and oil recovery. The boats will be crewed with four people - two will be on watch for six hours while the other crew rest for six hours. If additional crew are required, they will be brought in from the barge.



## 6. TRAINING

Relationships with the CCG, the Canadian Coast Guard Marine Communications and Traffic Services (CCG MCTS), and Fisheries and Oceans Canada (DFO) will be a key aspect to the IMRC operation. In addition to an open and transparent communication strategy, it is imperative that the federal, provincial, and First Nations agencies and organizations involved in spill response have a clear understanding of the roles and responsibilities of each group. All on call responders and vessel operators must have up to date training, and therefore the types of training must be reviewed approximately every three years. From the Marine Oil Spill Preparedness and Response Regime – TP 14539, the types of training for the different Response Organizations in Canada are outlined, and overall the main types of training are:

- Basic Spill Responder
- Spill Equipment Operation
- Shoreline Cleanup
- Equipment Specific
- Basic Wildlife
- Vessel Specific
- Navigation
- Communication
- Incident Command System
- First Aid
- Workplace Hazardous Material Information System (WHMIS)
- Transportation of Dangerous Goods
- Health and Safety

Most ROs in Canada maintain the training by doing different training each year, such that no certificates expire, but also so that not all training must be renewed in one year, for all of the staff.





## 6.1 OIL SPILL RESPONSE TRAINING

Training for specific oil spill equipment models can be provided through private companies and often through equipment suppliers.

The International Marine Organization- Oil Pollution Preparedness Response and Coordination (IMO-OPRC) model courses have been developed to train responders and management in all aspects of oil spill planning (International Maritime Organization, n.d.). Training can be provided on site by most companies offering the IMO-OPRC training. The training can also be customized for the needs of the IMRC. Not all companies that offer this training are accredited for IMO-OPRC training; most that are accredited are based out of Europe and are accredited by the Nautical Institute. The course descriptions vary between companies that provide the training; however, most offer multiple courses that encompass the aspects described below. The description below is from Desmi (Desmi, n.d.):

- First Responders and Operational Staff- Level 1 (approximately 24 hrs of course work)
  - Oil spill properties, behavior and fate
  - Health and safety
  - Environmental sensitivity and impacts
  - Response organisations and control strategies
  - Containment booms
  - Failure of containment booms
  - Oil boom selection
  - Deployment and configuration of containment booms
  - Recovery devices
  - Deployment and operation of skimmers
  - Use of dispersants (although Canada does not allow for the use of dispersants, the United States does)
  - New technologies
  - Waste management
  - Shoreline cleanup
  - Cleaning, maintenance and storage of equipment
  - Wildlife response
  - With practical activities:
    - Deployment of booms and skimmers
    - Site setup and zoning
    - Decontamination and waste management
    - Shoreline assessment

- Supervisors and On-Scene Commanders- Level 2 (approximately 32 hrs of course work)
  - Overview of spill response
  - Contingency planning
  - Response management and organisation
  - Environmental sensitivity and impacts
  - Behavior and fate of an oil spill
  - Environmental and economic impacts
  - Spill assessment
  - Operations planning
  - Oil spill response options
  - Shoreline cleanup
  - Site safety
  - Waste management
  - Communications and information sharing
  - Liability and compensation
  - Media relations
  - Post-incident debriefing
  - With practical activities:
    - Boat safety
    - Boom deployment
    - Skimmer operations
    - Contingency planning
    - Tabletop exercises
- Administrators and Senior Managers- Level 3 (approximately 16 hrs of course work)
  - Causes, fate, and effects of spilled oil
  - The contingency planning process
  - Spill response strategies
  - International cooperation and legal frameworks
  - Liability and compensation
  - Spill management
  - Communications and media issues
  - Spill response objectives and policy issues
  - Termination of response
  - With practical activities
    - Tabletop exercises
    - Media briefing exercise

In an ideal circumstance, on-water clean up methods would be sufficient to recover the oil released in an incident; however, this may not be the case, and some of the oil may end up on shorelines. For incidents where shorelines are contaminated with oil, a large amount of manpower may be required for shoreline cleanup, in which case there must be people trained in advance. The operational staff of the shoreline cleanup team should be trained with both the Level 1 IMO-OPRC and Shoreline Cleanup Assessment Techniques (SCAT). An outline of a SCAT course (~3 days) is provided below, which can be included as part of a broader training program:

- Physical Processes and Coastal Character
  - Physical coastal processes and physical character of shorelines
  - Character of the area coasts
- Behaviour of Spilled Oil in the Coastal Zone
  - Oil movement - land vs water spills
  - Weathering and fate of spilled oil
- Spill Management- Response Decision Process
  - Management by objectives
  - Minimum regret strategy
  - Environmental sensitivity, response priorities, and Net Environmental Benefit
  - Treatment end points
- Shoreline Cleanup Assessment Technique (SCAT)
  - Shoreline Response Program Objectives and Management
  - SCAT forms and terminology
  - Traditional data capture and electronic data capture and review
  - SCAT: Pre-spill and Response
- Shoreline Treatment
  - Decision process - management issues
  - Treatment techniques
  - STR and SIR forms
  - Data management
- Operations
  - Field operations
  - Waste management

Many manufacturers also offer specialized training for the use of their equipment, this kind of training is very useful for containment booms and skimmers.

When an oil spill occurs, it can affect many aspects of the surrounding environment; one of the aspects is that it has the potential to harm wildlife. The Oiled Wildlife Society of BC offers training for first responders. The course modules cover (Oiled Wildlife Society of BC, n.d.):

- Overview of the Incident Command System, the role of First Responders
- Overview of the agencies involved in dealing with an oil spill
- First Responder health and safety
- Wildlife handling techniques
- Temporary housing options for oiled wildlife
- Critical animal care and stabilization during the first 48 hours in captivity

The Oiled Wildlife Society of BC also provides some of the necessary resources required in oiled wildlife response and rehabilitation for its members, in addition to assisting in the selection of stockpile equipment and contingency planning.



## 6.2 VESSEL OPERATOR TRAINING

To operate a vessel in Canadian waters there are different certificates necessary depending on the size of vessel and the purpose of the vessel. For the purpose of this report we are assuming that the final vessels chosen for the IMRC will be less than 60 Gross Tonnes (GT); with this in mind, there are many different responsibilities on the vessels that will be managed by different responders.

For the FRVs and the Tug, there will need to be a minimum of one person with their Master Limited (60GT) Certificate, and one with their Deckhand Certificate. In addition, there must also be one engineer available on shift. For each vessel, it would be beneficial to have a crew member on each watch with an Engine Room Rating. The Engine Room Rating Program at the Western Marine Institute (WMI) fulfills the requirements to meet the minimum standard of competence for ratings forming part of an engineering watch as set out by the Standards of Training, Certification and Watchkeeping in Seafarers (STCW). For the three responders listed above the following program courses and requirements are listed below (Western Marine Institute, n.d.).

Master Limited (Under 60GT) (near coastal, class 2, sheltered waters voyages) requires the following:

- Marine Emergency Duties (MED) Domestic Vessel Safety (DVS)
- Restricted Operator Certificate – Marine Commercial (ROC-MC)
- Marine Basic First Aid
- Chartwork and Pilotage, Level 1
- Navigation and Safety, Level 1
- Pass a Transport Canada Oral Exam on Subject matter appropriate to the area of operation and the vessel type and gross tonnage, to which the certificate relates
- Must have 2 months of sea time performing deck duties on vessel (s) (after the age of 16), performing deck duties on vessel(s) of at least the same gross tonnage to the one for which he/she is seeking the certificate
- Must be at least 18 years old on the day he/she receives the certificate



## Deckhand Certificate

- Need a Candidate Document Number (CDN) from Transport Canada
- Grade 12 or mature student status
- Bridge Watch Rating course
- MED STCW Basic Safety training certificate;
- MED Survival Craft and Rescue Boats training certificate;
- Marine Basic First Aid Certificate;
- Restricted Operator Certificate – Marine Commercial (ROC-MC)
- 2 months of sea time
- Steering testimonial showing 10 hours of experience steering a vessel
- Writing an examination conducted by a Transport Canada Examiner

## Engine Room Rating

- Grade 12 preferred, or mature student status
- Seafarer's Medical from Transport Canada doctor before the program start date
- Candidate Document Number from Transport Canada
- Engine Room Rating Course
- MED STCW Basic Safety Training certificate
- MED Survival Craft and Rescue Boats training certificate
- Marine Basic First Aid Certificate
- 3 months of sea service after completing the program
- Transport Canada ERR exams



On each vessel one person (one of the crew) should have the secondary position as being the designated first aid. For all personnel in charge of a radio watch within approximately 50 miles from the shore the ROC-MC is a requirement under the Global Maritime Distress and Safety Systems. It is likely that all crew members that will be on shift will be responsible for radio watch at times during their watch, therefore all fulltime crew would require the ROC-MC. In an ideal IMRC, all crew members for the FRVs, tug, and barge can be interchangeable, such that they are certified and capable are doing multiple jobs, however certifications can be time consuming and costly. There would likely be 4 crew members on each FRV, 4 members on the Tug, and 1 engineer that would be stationed on the barge for vessel operation. The current concept for the crew on each FRV and Tug is to have 1 captain (with a Masters Limited Certificate), and 3 crew that have either a deckhand certificate, an engine room rating, or both. All of the crew should have their Small Vessel Operator Proficiency (SVOP) to operate the landing crafts/ work boats, including those who are considered to be human resources/dispatch.

Additional vessel management and operation training will be available by the vessel supplier. All personnel operating vessels will have the appropriate training and certification necessary as a minimum.



## 6.3 FIRST AID AND SAFETY TRAINING

To be able to obtain most vessel operating certificates, a basic marine safety course is a requirement. The MED STCW Basic Safety Training course (formerly MED A1+B2) offered by the WMI fulfills the requirements for the vessel operating certificates. This course is made up of classroom lectures, and also has practical firefighting, lifesaving, survival, and rescue exercises. A refresher for this course is also available from WMI. The MED STCW Basic Safety and Training course fulfills the STCW minimum standards of competence in personal survival techniques, minimum standard of competence in fire prevention and fire fighting, and the minimum standard of competence in personal safety and social responsibilities (International Maritime Organization, 2000) (Western Marine Institute, n.d.) as outlined in the STCW chapter about emergency, occupational safety, medical care, and survival functions. The MED STCW Basic Safety refresher must be taken every five years to maintain a certificate of proficiency (CoP) (Transport Canada, 2015). The MED STCW Basic Safety Training is recommended for any persons that are going to be working on the barge and any of the vessels. A description of the MED STCW Basic Safety Training course can be seen below:

- Principles of Safety
- The hazards and emergencies that may be encountered at sea
- The chemistry of fire and the extinguishing process
- Emergency response process: alarm signals on small vessels, where muster lists must be used and how on-board safety drills should be conducted and when. Action upon discovering
- Description and use of Lifesaving appliances, survival craft and its equipment requirements, and methods of abandonment
- Factors relating to survival: cold water environment, medical aspect, actions to take when on his/her own or as a group after abandonment
- Understanding the different rescue methods and rescue equipment from sea or air
- Distress signals carried on ships and in survival crafts, how to operate them, how to use them effectively in an emergency
- Practical training exercises:
  - Don and function in the water in a lifejacket and an immersion suit
  - Don and use immersion suits and lifejackets in the water as an individual and as part of a group
  - Exercises on methods of: being hoisted with a helicopter strop, climbing net, and the techniques used to jump off a vessel with a life jacket or immersion suit
  - Toss a lifebuoy to a crew lost over board and use a lifebuoy to keep afloat in the water
  - Launch, board, operate and right an inverted life raft
  - Select, prepare and use a small bore fire hose for boundary cooling

For the responders that are to only be called in the case of a large incident, the MED A3 course from WMI will be sufficient as it is the minimum basic personal safety training for seafarers working as crew members on small fishing vessels, workboats, or passenger vessels operating near shore.

The minimum standard of competence in elementary first aid as set out by the STCW Marine Advanced First Aid, is a mandatory course for those designated to provide first aid onboard an STCW vessel. The CoP for marine advanced first aid must be refreshed every five years. For all other crew members, the Marine Basic First Aid course would be necessary. (Transport Canada, 2015)

Because oil spills often occur due to a vessel impact, there is a risk that the crew onboard the vessel involved in the incident are hurt; as a result, a close relationship and understanding of the CCG search and rescue could potentially be useful. The Maritime Search and Rescue Branch of the CCG provides training to agencies that respond to maritime accidents, the program provides a Search and Rescue (SAR) course called the Coastal SAR. The Coastal SAR is a 20 hour course and provides an overview of the SAR system, elements of a search plan, tasking information, risk/benefit of rescue operations, and vital information during mission conclusion. This training is delivered onsite. (Canadian Coast Guard, n.d.)

To follow the Canadian Occupational Health and Safety Regulations all responders and crew must have a Workplace Hazardous Materials Information System (WHMIS) certificate. With respect to WHMIS, an up-to-date Material Safety Data Sheet (MSDS) must be available on site. WHMIS training is available through many companies in Canada.

With many vessels carrying what are defined as Dangerous Goods, the crew operating the vessels or any equipment that is used for the transportation of any kind of oil or chemical, are required to have a Transportation of Dangerous Goods Certificate. Transportation of Dangerous Goods Certificates are available from many companies in Canada. All of the regulations for the Transportation of Dangerous Goods must be followed during the recovery process and the transport for the waste. (Transport Canada).

Fall Protection Training may be necessary depending on the final design of the response centre structure.

Respiratory Protection and Safety training would be necessary, as respiratory protection is likely to be necessary for the possible large amounts of hazardous substances that the crew and responders have the potential to be exposed to. The IMRC would be required to provide workers with appropriate respirators whenever there are hazardous substances in the air. (Work Safe BC, n.d.). Work Safe BC provides information for choosing and safely using respiratory protection.

## **6.4 OTHER**

Additional training may be required for cranes, and for any land based vehicles, a Forklift certification may be needed for those operating one. Additional training may also be required if the IMRC would provide divers, drone operators, and Travel Lift Operators for emergency responses.

## 7. EQUIPMENT

For this conceptual stage of development, information on booms and skimmers has been collected, including test data. The material presented herein is primarily for consideration of what may work and what won't work in this environment, and what the approximate costs are. Based on experience with the NES oil spill clean up efforts, and the performance of equipment from testing and provided in Appendix D to this report, there does not appear to be truly robust booms and skimmers available at this time that would perform well in Central Coast marine conditions. Spill prevention is an important part of the IMRC operational strategy, as is research and development of improved equipment.

### 7.1 CONSIDERATIONS FOR BOOM AND SKIMMERS

The proposed booms for consideration are presented in Table 4. These booms were chosen based off of their use in other areas, and their specifications. Note that the boom failure in currents as referenced below are the currents at which the boom begins to plane, submerge, or break, and are not the 1<sup>st</sup> loss currents when the oil captured in the boom will start to move under or over the boom. The specifications of these booms can be found in Table 5. Summarized results of containment boom tests as performed by various agencies can be seen in Appendix D.



Table 4. Containment Booms for Consideration

MAKE	BEACH/ShORELINE	COASTAL/PROTECTED	OFFSHORE
NOFI		NOFI 450S and 600S <ul style="list-style-type: none"> <li>Inflatable (needs a hydraulic blower,</li> </ul>	NOFI 800S, and 1000S OS <ul style="list-style-type: none"> <li>Air floatation (needs a hydraulic blower,</li> </ul>
		MONSUN XII valve) <ul style="list-style-type: none"> <li>1.2 knots limiting</li> </ul>	MONSUN XII valve) <ul style="list-style-type: none"> <li>1.2 knots limiting</li> </ul>
		Current Buster 2 and 4 <ul style="list-style-type: none"> <li>#2- harbours (boom failure at 3knots)</li> <li>#4- coastal (boom failure at 4 knots)</li> <li>Require air blower/pump</li> <li>Require a Paravane Boom Vane (Orc AB) for single vessel use</li> </ul>	Current Buster 6 and 8 <ul style="list-style-type: none"> <li>#6-coastal (boom failure at 5 knots)</li> <li>#8- offshore (boom failure at 5 knots)</li> <li>Require air blower/pump</li> <li>Require a Paravane Boom Vane (Orc AB) for single vessel use</li> </ul>
		NOFI 250→500 EP Series <ul style="list-style-type: none"> <li>Only for very protected areas</li> <li>Optional boom bag, but it can only be dragged at 15 knots</li> <li>Solid flotation</li> </ul>	
Expandi	Shore Sealing (BS3000_15 and BS3000_25) <ul style="list-style-type: none"> <li>Needs an air pump</li> <li>Needs a water pump</li> <li>Mud/sandy areas</li> <li>Needs care for hazards that could puncture the boom</li> </ul>	Expandi M2000→M7000 <ul style="list-style-type: none"> <li>Air buoyancy</li> <li>Auto inflates</li> <li>Would want a “roto pack” with each one for easy deployment</li> </ul>	
DESMI	Troilboom Beach <ul style="list-style-type: none"> <li>Needs an air pump</li> <li>Needs a water pump (Water ballast)</li> <li>Cannot go on rocky shores</li> </ul>	Ro-Boom 1000→3200 <ul style="list-style-type: none"> <li>Require reel and high capacity air blowers</li> <li>Ro-skim weirs can be attached</li> <li>Some come with single point inflation options</li> <li>1000→2000 are for protected waters, and 2200→3200 are best for offshore use</li> <li>boom failure at 3 knots</li> <li>limiting current of 1.2 knots</li> </ul>	
	Ro-boom Beach 800 <ul style="list-style-type: none"> <li>Needs an air pump</li> <li>Needs a water pump (Water ballast)</li> <li>Can handle rocky shorelines</li> </ul>		



**Table 5. Containment Boom Specifications**

MANUFACTURER	MODEL	WEIGHT (kg/m)	LIMITING CURRENT (knots)	LIMITING WAVE HEIGHT (m)	FREEBOARD HEIGHT (m)	DRAUGHT (m)	COSTAL/OFFSHORE/SHORELINE	PACKED DIMENSION
NOFI	Off Shore 1000 S	20.5	1.2	6-7	1	unknown	offshore	4m ^ 3
	Off Shore 600 S	12.9	1.2	4	0.6	0.75	Costal	2.75m ^ 3
	Off Shore 800 S	19	1.2	5-6	0.8	0.95	off Shore	3.5m ^ 3
	EP-Serien NOFI 250 EP	2.7			0.25	0.35	Harbours, Bays	
	EP-Serien NOFI 350 EP	4.7			0.35	0.5	Fjord	
	EP-Serien NOFI 400 EP				0.4		Fjord	
	EP-Serien NOFI 500 EP	11.6			0.5		Coast	
	Current Buster 2	3300/27	3-regular,					
	1.5-2.5- chop			1	harbours and Fjords			
	Current Buster 4	3800/34	4- calm sea			1.5	Coastal	
	Current Buster 6		5			2	Coastal	
	Current Buster 8		5			2.6	offshore	
Desmi	Ro-Boom 1000	6.4	3	2	0.36	0.38	harbours, terminals, and sheltered costal areas	1.0 m (width)
	Ro-Boom 1100	8	3	2	0.37	0.54	Ports, terminals, coast-lines, and open bays	1.1 m (width)
	Ro-Boom 1300	9	3	3	0.45	0.63		1.3 m (width)
	Ro-Boom 1500	12	3	3.5	0.52	0.72		1.5 m (width)
	Ro-Boom 1800	13.5	3	3.5-4	0.59	0.9		1.8 m (width)
	Ro-Boom 2000	14	3	4	0.59	1.1	Off shore	2.0 m (width)
	Ro-Boom 2200	16	3	4.5	0.83	0.95	Off shore	2.2m (width)
	Ro-Boom 3200	38	3	6	1.2	1.4	Off shore	3.2 m (width)
	Ro-Boom Beach 800	6			0.31	0.32	Shoreline/ beaches with shallow water	0.8m (width)
	Globe Boom 36 ED (fence boom)	8,4			0.30	0.61	Fast running water	

MANUFACTURER	MODEL	WEIGHT (kg/m)	LIMITING CURRENT (knots)	LIMITING WAVE HEIGHT (m)	FREEBOARD HEIGHT (m)	DRAUGHT (m)	COSTAL/OFFSHORE/SHORELINE	PACKED DIMENSION
Vikoma	HI- Sprint 1500				0.6	0.9	Open water, coastal, ports and harbor, offshore, ocean ice	
	HI-Sprint 2000				0.75	1.25	Open water, ocean m ice	
Expandi	M2000	2.52			0.23	0.33		0.2 m ^ 3
	M3000	3			0.3	0.47		0.28 m ^ 3
	M4300	6.05			0.45	0.65		0.39 m ^ 3
	M7000	11.7			0.7	1.05		0.66 m ^ 3



The skimmers considered can be seen below in Table 6. These skimmers were chosen based on their use in other areas, their capacity, their ability to be used in different areas, and the range of oil viscosities that they operate best in. The capacities shown below are the de-Rate capacities, which are 0.2x the name plate capacity given by the manufacturer. Crucial made skimmers are also predominantly used, however their specifications are not available on their website.

**Table 6. Skimmer Recommendations**

MULTI-SKIMMER	WEIR-SKIMMER	BELT-SKIMMERS	ROPE-MOP SKIMMERS	DISC SKIMMERS
<b>Aquaguard RBS Triton 35, 60, 150, 150T, 150 OS, 300 OS</b> <ul style="list-style-type: none"> <li>Brush, drum and disk changeable Oleophilic options</li> <li>Have floating pontoons</li> </ul>	<b>Foilex TDS 200 or 250</b> <ul style="list-style-type: none"> <li>200→14 m<sup>3</sup>/hr</li> <li>250→28 m<sup>3</sup>/hr</li> <li>Free floating and crane options</li> <li>Hydraulically driven</li> </ul>	<b>Lamor Bow Collector</b> <ul style="list-style-type: none"> <li>8-12 m<sup>3</sup>/hr capacity</li> <li>4 knots skimming speed</li> <li>To be mounted on a vessel 7-15 m in length</li> </ul>	<b>Henriksen Foxtail Series</b> <ul style="list-style-type: none"> <li>Capacities range for 3 to 16 m<sup>3</sup>/hr</li> <li>Perform well in rough seas</li> <li>Single wire suspension</li> <li>The lowest capacity foxtail is optimal for beach use as well</li> </ul>	<b>Elastec/American Marine grooved disc skimmers</b> <ul style="list-style-type: none"> <li>The X30 Cassette is a custom skimming system for side-channel equipped oil recovery vessels</li> <li>The X150 has 10 grooved discs, and has a de-rated recovery rate of 30 m<sup>3</sup>/hr as was tested at the Ohmsett facility, according to ASTM F2709</li> <li>Has a recovery efficiency of approximately 89.5% as was tested at the Ohmsett facility</li> <li>Has been tested in both calm water and with waves at the Ohmsett facility in the Wendy Schmidt Oil Cleanup Facility, and won top honor (results available upon request)</li> </ul>
<b>Vikoma Komara Multi</b> <ul style="list-style-type: none"> <li>Large capacity (30 m<sup>3</sup>/hr )</li> <li>Combination of a disk/brush with a weir</li> </ul>	<b>DESMI Terminator and Tarantula</b> <ul style="list-style-type: none"> <li>Terminator→25 m<sup>3</sup>/hr</li> <li>Tarantula→50 m<sup>3</sup>/hr</li> <li>Needs specific pump and power pack</li> </ul>			
<b>Lamor Multi Skimmer 50/70</b> <ul style="list-style-type: none"> <li>Capacity of 18.1 m<sup>3</sup>/hr</li> <li>Changeable brush, disk and drum</li> <li>Good for off shore and harbour use</li> <li>Free floating</li> <li>Needs a Lamor GTA 50 or 70 pump</li> </ul>	<b>Lamor Weir Skimmer 500/800</b> <ul style="list-style-type: none"> <li>500→14 m<sup>3</sup>/hr</li> <li>800→22 m<sup>3</sup>/hr</li> <li>Light weight</li> <li>Can be used offshore</li> </ul>			
	<b>DESMI Ro-skim</b> <ul style="list-style-type: none"> <li>Attaches to the Ro-boom</li> <li>Needs specific pump and power pack</li> <li>Capacity of 30→25 m<sup>3</sup>/hr depending on the size</li> </ul>			

## 7.2 WCMRC AND EARLY STAGE IMRC PROPOSED EQUIPMENT COMPARISON

Table 7. WCMRC vs IMRC Equipment

WCMRC (SPECIFICATIONS FROM WCMRC WEBSITE)	IMRC (SPECIFICATIONS IN DE-RATE FROM MANUFACTURERS' WEBSITES)
<b>Skimmers</b> <ul style="list-style-type: none"> <li>Crucial Fuzzy Disc Skimmer (unknown model, "fuzzy disc" is not listed on the Crucial website) <ul style="list-style-type: none"> <li>3-6 m<sup>3</sup>/hr</li> </ul> </li> <li>Aquaguard Multi Head Skimmers <ul style="list-style-type: none"> <li>RBS 05 (No longer available on Aquaguard website)</li> <li>RBS10 (No longer available on Aquaguard website)</li> <li>RBS Triton 35</li> <li>RBS Triton 150 (OS and trailer mounted)</li> <li>2-3 m<sup>3</sup>/hr</li> </ul> </li> <li>Lamor GT-185 with a Desmi Helix 1000 brush adaptor <ul style="list-style-type: none"> <li>Lamor GT-185 is no longer listed on the Lamor Website</li> <li>8 m<sup>3</sup>/hr</li> </ul> </li> <li>Lamor In-built Oil Recovery System (LORS) Brush Pack <ul style="list-style-type: none"> <li>integrated into Rozema Skimming vessels MJ Green, Eagle Bay, GM Penman and the Hectate Sentinel</li> <li>Unknown capacity</li> </ul> </li> <li>Disk Skimmer T12/T18 (unknown make) <ul style="list-style-type: none"> <li>3-6 m<sup>3</sup>/hr</li> </ul> </li> <li>Rope Mop (unknown make) <ul style="list-style-type: none"> <li>1-2 m<sup>3</sup>/hr</li> </ul> </li> </ul> <b>Containment Booms</b> <ul style="list-style-type: none"> <li>Kepner Sea Curtains (Self Inflating) <ul style="list-style-type: none"> <li>Ocean Harbor: 0.25 m freeboard, 0.40 m draft,</li> <li>Offshore: 0.4 m freeboard, 0.65 m draft</li> <li>Hi-Seas 600: 0.55 m freeboard, 0.90 m draft</li> </ul> </li> <li>Desmi Ro-Boom (Pressure Inflatable) (unknown model) <ul style="list-style-type: none"> <li>0.75 m freeboard, 1.25 m draft</li> <li>For "Protected and Open Water" (WCMRC website)</li> </ul> </li> <li>NOFI Vee Sweep (Pressure Inflatable) <ul style="list-style-type: none"> <li>1.0 m Freeboard (from WCMRC website)</li> <li>0.60 m freeboard 1.0m draft (Ohmsett reports)</li> </ul> </li> <li>NOFI Current Busters <ul style="list-style-type: none"> <li>Current Buster 4: 0.80 m freeboard at the stern, 1.5 m draft at stern</li> <li>Current Buster 6: 1.0 m freeboard at the stern, 2.0 m draft at stern</li> </ul> </li> <li>Zoom Boom (Self Inflating) <ul style="list-style-type: none"> <li>0.25 m freeboard, 0.45 m draft</li> </ul> </li> <li>"General Purpose Boom" (calm water) <ul style="list-style-type: none"> <li>0.15 m freeboard, 0.3 m draft option (0.45 m total)</li> <li>0.5, 0.6, and 0.75 m total height options</li> </ul> </li> <li>"Inshore" <ul style="list-style-type: none"> <li>0.45 m and 0.6 m total height options</li> </ul> </li> <li>"River" <ul style="list-style-type: none"> <li>0.45, 0.5, and 0.6 m total height options</li> </ul> </li> <li>"Air Boom" <ul style="list-style-type: none"> <li>No background information</li> </ul> </li> <li>"Shore Seal Boom" (Pressure Inflatable) <ul style="list-style-type: none"> <li>0.3 m freeboard</li> <li>For "Intertidal" (WCMRC website)</li> </ul> </li> </ul>	<b>Proposed Skimmers</b> <ul style="list-style-type: none"> <li>Aquaguard RBS Triton Multi Skimmers <ul style="list-style-type: none"> <li>Brush, drum and disk changeable Oleophilic options</li> <li>Have floating pontoons</li> <li>35→7.6 m<sup>3</sup>/hr and 300 OS→60.4 m<sup>3</sup>/hr</li> </ul> </li> <li>Desmi Terminator and Tarantula weirs <ul style="list-style-type: none"> <li>Terminator→25 m<sup>3</sup>/hr</li> <li>Tarantula→50 m<sup>3</sup>/hr</li> </ul> </li> <li>Lamor 500/800 weirs <ul style="list-style-type: none"> <li>500→14 m<sup>3</sup>/hr</li> <li>800→22 m<sup>3</sup>/hr</li> <li>Can be used offshore</li> </ul> </li> <li>Foilex TDS Weirs <ul style="list-style-type: none"> <li>200→14 m<sup>3</sup>/hr</li> <li>250→28 m<sup>3</sup>/hr</li> <li>Free floating and crane options</li> </ul> </li> <li>Vikoma Komara multi skimmer <ul style="list-style-type: none"> <li>Capacity of 30 m<sup>3</sup>/hr</li> <li>Combination of a disk/brush with a weir</li> </ul> </li> <li>Foxtail rope/mop skimmers <ul style="list-style-type: none"> <li>Capacities range for 3 to 24 m<sup>3</sup>/hr</li> <li>Single wire suspension</li> </ul> </li> <li>Elastec/ American Marine Grooved Disc Skimmers <ul style="list-style-type: none"> <li>~3 m<sup>3</sup>/hr for each disc</li> </ul> </li> </ul> <b>Proposed Containment Booms</b> <ul style="list-style-type: none"> <li>Desmi Ro-Booms 2000, 2200, 3200 (pressure inflatable) <ul style="list-style-type: none"> <li>2000 has a freeboard of 0.59 m and draft of 1.1 m</li> <li>2200 has a freeboard of 0.83 m and a draft of 0.95 m</li> <li>3200 has a freeboard of 1.2 m and a draft of 1.4 m</li> <li>Fast Deployment</li> </ul> </li> <li>Desmi Ro-Boom Beach 800 (pressure inflatable) <ul style="list-style-type: none"> <li>Shore Sealing boom with water ballast</li> </ul> </li> <li>NOFI Current Busters 6 and 8 (pressure inflatable) <ul style="list-style-type: none"> <li>6 has a freeboard of 1 m and a draft of 2 m</li> <li>8 has a draft of 2.6 m</li> <li>The current buster 4 was tested at Ohmsett, and had a 94% throughput efficiency at 2 kn in calm water, and 81% throughput efficiency at 2 kn in waves</li> </ul> </li> <li>NOFI 800S and 1000S OS (pressure inflatable) <ul style="list-style-type: none"> <li>800S has a freeboard of 0.8 m and a draft of 0.95 m</li> <li>1000S has a freeboard of 1 m, the draft is currently unknown.</li> <li>The NOFI 1000S OS is used in Norway, and was tested at Ohmsett to have a limiting current of 1.2 kn in calm water for the NOFI 600S.</li> </ul> </li> <li>Expandi M4300 and M7000 (Self Inflating) <ul style="list-style-type: none"> <li>M4300 has a freeboard of 0.45 m and draft of 0.65 m</li> <li>M7000 has a freeboard of 0.7 m and a draft of 1.05 m</li> </ul> </li> <li>Vikoma HI sprint 1500, and 2000 (Single Point Inflation) <ul style="list-style-type: none"> <li>1500 has a freeboard of 0.6 m and a draft of 0.9 m</li> <li>2000 has a freeboard of 0.75 m and a draft of 1.25 m</li> </ul> </li> <li>Desmi Globe-boom ED 36 or I36 (fence boom) <ul style="list-style-type: none"> <li>Both models have a freeboard of 0.3 m and a draft of 0.61 m</li> <li>The difference is the mass and type of fabric used</li> </ul> </li> </ul>

The amount of each type of boom that the IMRC will require is dependent on the environmental conditions for the area of their response. Information pertaining to the selection of booms based upon environmental factors can be found in Appendix D. For the purpose of the current IMRC response area, it is likely that booms that are often labeled as off shore would make up a predominate part of the boom inventory because of the large waves and fast currents that often occur in the Central Coast. Shore sealing booms will also likely be an important inventory of equipment because of the large amount of shoreline that has the potential to be affected by a spill, especially with the large amount of environmentally and traditionally sensitive shorelines, as shown in Figure 3. Note that Table 6 does not include all of the equipment that would be required to support the IMRC, but only the skimmers and booms. Sorbent boom, shoreline cleanup, auxiliary, and storage equipment are just a few more of the types of equipment necessary for oil spill clean up. For general information on the equipment and space necessary for oil contaminated birds, the Oiled Wildlife Society of BC has general information (Shelodon, Doucette, & McQuillan, 2011).

For containment of oil in fast flowing waters, such as in Gale Creek, where none of the booms deployed succeeded in protecting the sensitive shoreline, specialized equipment will be required, including high strength Spectra fibre rope and high load anchoring on the shoreline. It is proposed that the development of new and innovative oil boom designs and field testing of equipment be included in the IMRC scope.

Oil spill booms were developed in the 1920s and 1930s, and have not significantly been improved since. In discussions with experienced Heiltsuk marine personnel, several design concepts were explored, which outlined the basis for a research and development (R&D) strategy. The R&D strategy would include field testing of new designs, materials, shape and deployment strategies and formations.





### 7.3 NATHAN E. STEWART INCIDENT EQUIPMENT INFORMATION

During the response to the Seaforth Channel Incident approximately 10,000 m of containment boom was deployed and staged, while approximately 16,000 m of sorbent boom was deployed and staged (Resource Summary for the Seaforth Channel Incident, 2016). Of the 10,000 m of containment boom approximately 1,935 m was destroyed within 13 days of the NES grounding. There are many possible reasons for the failure of the containment booms used that caused approximately 107 m<sup>3</sup> of diesel and 2.24 m<sup>3</sup> of lubricants to be released into the environment. With the large waves of approximately 3 m (offshore in Hecate Strait), and high wind and current speeds that occurred shortly after the NES incident, only containment booms of over 1.06 m (42") were likely to retain oil that had been released from the NES (see Appendix D for more details). As noted below, not all of the boom used was larger than 1.06 m in total height. Containment boom failure can also occur due to entrainment, in which case the formation in which the containment booms are set up in plays a crucial role in containing the spill, as the oil droplets travel under the first boom as the water gets turned up from the waves. The knowledge of which formation and which booms to use would be gained during the training specified in Section 6.1. Below is a list of the types of booms and skimmers that were used during the Seaforth Channel Incident (Resource Summary for the Seaforth Channel Incident, 2016):

- 0.6 m (24") general purpose boom, inshore boom, or river boom (not listed)
  - This size of boom was used around the NES, and near the mouth of Gale Creek and was destroyed (marked as demobilized with a status date of 10/30/2016)
- Kepner "Harbor" 0.9 m (36") boom (not listed on the WCMRC equipment lists, and there is no Kepner sea boom with a total height, or a draft of 0.9 m. Kepner Harbor boom is dimensioned as 0.66 m (26") in height with a draft of 0.41 m and a freeboard of 0.25 m)
- 0.105 m (42") Kepner Offshore boom (assumed to be the Offshore Sea Boom by Kepner, with a 0.4 m freeboard, and a 0.65 m draft.
- Current Buster 4
- Sorbent boom (5")
- 0.45 m (18") unlisted type of boom (area marked as staging)
- Crucial "Fuzzy" Disc skimmer
- Grooved Disc (Internal skimmer on Eagle Bay) of an unknown make.

## 8. WORLD-LEADING RESPONSE

Figure 10, from Nuka Research and Planning Group LLC.'s West Coast Spill Response Study (2013), provides a base for what a World Class Spill Response Plan looks like.



Figure 10. World Class Oil Spill Response System Criteria (Nuka, July 2013)

With respect to Figure 10, Table 8 describes how the IMRC will surpass the criteria and support a world leading Spill Response System.

**Table 8. How the IMRC will support world-leading spill response**

WORLD CLASS RESPONSE PLAN CRITERIA REQUIREMENTS		WORLD-LEADING INDIGENOUS MARINE RESPONSE CENTRE
Prevention Elements		
1.	Vessel operations surpass international safety and spill prevention standards	The proposed fast response vessels (FRV) are new, innovative equipment and exceed current Canadian and International standards.  The barge will carry all the equipment needed in the field and will have 1,800 m3 of capacity for contaminated fuel or oil, and will meet and exceed Transport Canada safety requirements. The FRV vessels exceed the requirements outlined in section two of Transport Canada (TP 12401E) Response Organizations Standards Marine Safety Directorate.
2.	Vessel Traffic is monitored and in higher risk areas actively managed to prevent accidents	Mitigation is a vital component of a World-Leading system and will include eliminating “dead spots” on the coast for AIS and VHF transmission/reception, so that continuous monitoring of location, direction, and speed will be available. It is the intent of the IMRC to work with the federal government to resolve this issue of federal significance and to create through partnerships with CCG MCTS the Software for continuous vessel tracking and automatic alarms for vessels moving outside of the navigation channel. The mitigation of spills will also be aided by the work boats having repair capability for vessels to minimize the amount of oil leaked into the environment.
3.	Rescue and salvage resources can be on scene quickly enough to be effective in the event of an incident or spill	The tug boat which will deliver the barge to the response site will have towing capability for salvage operations inclusive of a fire monitor and the ability to remove the vessel from the site. The tug/response team will work with the Canadian Coast Guard re training for rescue and firefighting.
4.	Geographic areas are prioritized for protection from oil spills.	Through an analysis of CCG MCTS and TSB data, 13 choke points were identified as areas of potential incidents and oil spill locations. A probabilistic analysis was undertaken at each choke point to identify the probability of such an occurrence, and the likely future number of incidents per year at each choke point has been determined.
5.	Contingency planning is comprehensive, integrated and well understood by all parties	Contingency planning will be addressed in the Response Manuals that will be developed in conjunction with the Canadian Coast Guard and other jurisdictions and agencies.
6.	Sufficient equipment can be deployed quickly to respond quickly to a worst-case spill	Response inventories are up to date, accessible and accurate. Resources are tracked during a response.  Response caches are strategically located, stocked, and maintained.  Equipment is the best available for the operating environments, environmental conditions, and potential spill substances.  Logistical support is in place to support the response.  Spills can be detected, tracked, and modeled as needed to perform the response.
7.	Sufficient personnel are available to respond to a worst-case spill	Training is a big part of developing a World-Leading system, and sufficient crew and other staff will be trained to Transport Canada and other certification levels.
System Elements		
8.	A process is in place to restore damaged resources and promote ecosystem recovery after a spill	A manual will be developed to enable emergency wildlife, shoreline, seabed, and water column clean up and rehabilitation. This will be directed by trained professionals on staff and on call from various agencies as outlined in the manuals.
9.	Government ensures compliance and transparency	Response equipment inventories and manuals will be developed in conjunction with Canadian Coast Guard and other agencies, to follow Transport Canada Guidelines. The response manuals are envisioned to be living documents, and are proposed to reside on a server that the response centers will have available on-line, and can be viewed at any time by Transport Canada and other government agencies with clearance.
10.	All parties actively pursue continuous improvement through research and development and the testing of planning assumptions	Research and development (R&D) is very important in this area where new products and equipment are continuously being developed at various institutions and organizations, and the IMRC will have a R&D component to develop and test new and innovative equipment in the field in conjunction with world leading experts and organizations. Attendance at international oil spill equipment conferences and other educational opportunities will be encouraged.
11.	Financial mechanisms and resources meet needs from initiating the response through recovery	It is very important that the federal government provide funding for the estimated capital costs for IMRC infrastructure as well as the ongoing operating cost. Work has been completed to ensure that a system is in place to fund the response through the assessment phase.

In comparison to current Marine Spill Response Plans from other areas, the IMRC would surpass other Marine Response centres in many attributes as can be seen below in Table 9.

**Table 9. Benchmark Review of Marine Emergency Response Facilities**

AUTHORITY REVIEWED	RESPONSE COVERAGE		FACILITY EQUIPMENT			
	RESPONSE TIME [hrs] <sup>10</sup>	SPATIAL COVERAGE [nm]	WORK BOATS [ea]	OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m <sup>3</sup> ]
State of Washington (MSRC)	3	15	4	4	6	1,380 <sup>1</sup>
State of Alaska (SEAPRO, Main)	4	25	2	8 <sup>2</sup>	10	1,200
State of Alaska (SEAPRO, Satellite)			1	4 <sup>2</sup>	2	55
Norway (NCA, Main)	8	90	2	13	8	45 <sup>3</sup>
Norway (IUA, Satellite)	6	58	1	3 <sup>4</sup>	1	10 <sup>3</sup>
New Zealand (North Island)	11 <sup>5</sup>	120	-	12	4	45 <sup>6</sup>
New Zealand (South Island)	9 <sup>5</sup>	100	-	9	3	50 <sup>6</sup>
Proposed IMRC at Bella Bella	1 to 5 <sup>11</sup>	180	37	5 <sup>2</sup>	9 <sup>8</sup>	1,800 <sup>9</sup>

Notes:

1. Volumes do not include oil spill response barges at Tacoma (1,890 m<sup>3</sup>) and Port Angeles (6,040 m<sup>3</sup>) and storage onboard response vessels.
2. Estimated number based on total boom lengths of 3,150 m and 1,700 m for main and satellite depots, respectively.
3. Additional storage from response vessels not included, e.g. 90 – 160 m<sup>3</sup> for NCA vessels and up to 1,100 m<sup>3</sup> for Coast Guard vessels.
4. Based on a total of 1,300 m light-weight oil booms.
5. Response times do not include use of dispersant systems - 7,000 and 5,000 litres of dispersants are typically stored for North and South Island depots, respectively.
6. Storage capability of response vessels not included.
7. The work boats includes the FRVs and the Tug
8. Oil skimmer systems include the 4 that are integrated into the two FRVs
9. Includes internal storage capacity in the Barge only.
10. These times include the mobilization and boom deployment times
11. This time includes the deployment of the sweep boom system on the FRVs, longer times would be required for the deployment of containment booms around a vessel, or for deflection.



## 9. COSTS AND STAGES

In discussions with HTC, a plan to develop equipment better suited to the Central Coast was discussed, due to the poor performance of the equipment deployed for the NES, and a Research and Development (R&D) component is included in the costs. In addition an Interim Response Capability to respond to oil spills has been incorporated into the IMRC development by having stages of, principally, delivery of vessels and equipment.

### 9.1 COMMENTS

- The costs are considered to be very preliminary at this stage and are provided for discussion purposes only.
- Amounts have been rounded off to the nearest \$1,000.
- The contingency is for items not specifically identified in this cost estimate.
- The accuracy of this estimate is in the order of  $\pm 50\%$  (Class D estimate) due to the preliminary and conceptual nature of the work, and due to there being no detailed design done to date.
- Costs for the vessels are still under development, and are likely to change.
- Costs for equipment has been provided by Rocky Mountain Environmental and by Canflex Inc.
- Towable bladder prices are from Sea Slug.
- All other equipment prices are from Rocky Mountain Environmental Ltd.
- Prices for Wildlife Rescue Equipment were not found; however, the Oiled Wildlife Society of BC would be able to supply training and equipment.
- Marine mob/demob is based on delivering on a crane barge that will pick up a return cargo from another customer.
- Site tree falling, clearing and burning, site stripping, and waste removal are assumed to be required.
- Rock drilling/Blasting includes: rock processing, hauling and placing for the internal road, heli pad, building pads, boat launch, barge ramp and container laydown areas.
- Storage/workshop building, main response centre, sanitary/water systems, and the boat ramp and barge loading/unloading structure all include the supply and installation costs.
- Building size was based on a response centre in Norway.
- Costs for the response centre building were estimated by scaling the costs of a recent store built in Bella Bella.



## 9.2 INTERIM RESPONSE CAPABILITY

This section provides the basis for an interim oil spill response capability, including the purchase of equipment in stages to be incorporated into the final IMRC build-out.

The plan is to incorporate training, purchase of oil spill response equipment, and the purchase of the two landing crafts within six months of the start of the project (Stage 1), and within eight to 12 months of the project start, two FRVs could be deployed to the site (Stage 2). The tug and oil spill barge will be purchased in Stage 3.

The location of the equipment could be at the BC Packers site on and adjacent to an anchored rental barge until the marine facilities are complete.

### 9.2.1 Training

Training for spill response is to include the following:

- Operation of the vessels, which for Stage 1 entails a small vessel operator permit, which is a 1 week course, and would be conducted in Bella Bella with 12 people trained.
- Operation of the equipment including field deployment of Current Buster and other booms, reels, bladders, pumps and oil/water separators.
- Hazardous materials handling and protection – WHMIS.
- First aid.
- Shoreline cleanup.
- Section 6 provides further details on training applicable to all stages of development.

### 9.2.2 Oil Spill Equipment

The vast majority of the diesel oil that was released from the NES was dissipated by natural attenuation, and so the initial stages of the development of the IMRC will involve testing and evaluation.

### 9.2.3 Research and Development

An important element of a world leading oil spill capability is to develop booms and other equipment that will work in the field, particularly under high currents and wave action that can be expected in the region. High strength booms and anchors will be designed utilizing the marine expertise and local knowledge available with the Heiltsuk community, and will be tested at several sites such as Gale Creek where none of the booms deployed during the NES spill survived the high currents, and were not effective in preventing damage to the shoreline.

It is proposed that HTC would team up with CCG and the National Research Council Canada (NRCC) to advance the technology of the design of oil booms for both operating in high currents and waves, and to collect oil water for later processing.

This joint venture on R&D with the Coast Guard and NRCC should be started as soon as possible. This will build the team work and validate the technology that works. This would require acquiring the booms and the gear to start training the crews which will lead into the R&D part and utilization of the vessels. Out of this should come new and better methods and gear that works in this environment. This could lead into manufacturing of patented systems that work in the real world environment having been thoroughly tested.

#### 9.2.4 Cost

##### STAGE 1 COST TO 6 MONTHS

• Vessels		\$ 1,800,000
◦ 2 Landing crafts	\$ 1,300,000	
◦ 1 Work Boat	\$ 500,000	
• Equipment estimated as per a storage depot	\$ 3,533,000	
• Rental of barge and anchors at \$10,000 per month	\$ 60,000	
• Total without Contingency and Engineering		\$ 5,393,000
• Training for 12 and 2 staff		\$ 400,000
• Contingency (25%)		\$ 1,448,000
• Total with Contingency		\$ 7,241,000
• Engineering (10%)		\$ 724,000
• Total with Contingency and Training		\$ 7,965,000

##### STAGE 2 COST FROM 6 MONTHS TO 12 MONTHS

• Vessels		\$13,500,000
◦ 2 FRVs	\$13,500,000	
• Rental of barge and anchors at \$10,000 per month	\$ 60,000	
• Research and Development Start-up	\$ 350,000	
• Total without Contingency and Engineering		\$13,910,000
• Training for 16 and 2 staff		\$ 370,000
• Contingency (25%)		\$ 3,570,000
• Total with Contingency		\$17,850,000
• Engineering (10%)		\$ 1,785,000
• Total with Contingency and Training		\$19,635,000

## STAGE 2 COST FROM 6 MONTHS TO 12 MONTHS

• Vessels		\$27,300,000
◦ 2 Landing Craft	\$ 1,300,000	
◦ 1 tug boat	\$ 7,500,000	
◦ 1 tank barge	\$18,300,000	
• Rental of barge and anchors at \$10,000 per month		\$ 40,000
• Research and Development Start-up 4 x 350K		\$ 1,400,000
• Total without Contingency and Engineering		\$28,940,000
• Training for tug and barge and 2 staff at 2 x \$250K		\$ 500,000
• Contingency (25%)		\$ 7,360,000
• Total with Contingency		\$36,800,000
• Engineering (10%)		\$ 3,680,000
• Total with Contingency		\$40,480,000

#### STAGE 4 COST TO IMRC COMMISSIONING

• Vessels (already purchased in 3 previous stages)		\$ 0
• Equipment		\$ 1,169,000
◦ 2 Offshore Skimmers	\$ 60,000	
◦ 5,000 m Containment Boom	\$ 900,000	
◦ 1 Boom Reels	\$ 25,000	
◦ 2 Pumps	\$ 2,000	
◦ 2 Power Packs	\$ 20,000	
◦ 10 Shoreline clean up kits	\$ 15,000	
◦ 1x 15 m <sup>3</sup> Towable Bladders	\$ 19,700	
◦ 100 lb Absorbing Powders	\$ 1,000	
◦ First Aid and Safety equipment	\$ 11,300	
◦ Misc. Equipment Allowance	\$ 15,000	
◦ Post Cleanup Equipment	\$ 92,500	
◦ 1 Cranes	\$ 7,500	
• Marine Facilities		\$ 4,527,000
◦ Mob/De Mob	\$ 200,000	
◦ Float	\$ 948,000	
◦ Floating Workshops	\$ 546,000	
◦ Pilings/Anchors	\$ 2,260,000	
◦ Gangway	\$ 100,000	
◦ Electrical	\$ 177,000	
◦ Fire Fighting	\$ 70,600	
◦ Lighting	\$ 10,900	
◦ Sewage Pump	\$ 20,000	
◦ Sewage Pump Piping	\$ 46,000	
◦ Oil Waste Pump	\$ 20,000	
◦ Oil Waste Pump Piping	\$ 46,000	
◦ Potable Water	\$ 46,000	
• Land Side Facilities		\$ 14,356,000
◦ Mob/De Mob	\$ 500,000	
◦ Site Tree Falling, Clearing and Burning	\$ 194,400	
◦ Site Stripping and Waste Removal	\$ 154,000	
◦ Rock Drilling/ Blasting	\$ 1,941,000	
◦ Demolition of existing structures	\$ 115,000	
◦ Storage/Workshop Building	\$ 1,989,000	
◦ Main Response Centre	\$ 7,186,000	
◦ Sanitary/Water Systems	\$ 800,000	
◦ Boat Ramp and Barge (Un)Loading Structure	\$ 450,000	
◦ Indirect Costs of Project	\$ 1,028,000	
• Communications - This is very preliminary, and will require consultation with CCG MCTS et al		\$ 3,000,000
◦ The Centre	\$ 2,000,000	
◦ Tie Ins	\$ 1,000,000	
• Sum of Capital Costs		\$23,052,000
• Training		\$ 0
	(already done in previous 3 stages)	
• Contingency (25% of Capital Costs)		\$ 5,763,000
• Total including Training and Contingency		\$28,815,000
• Engineering (10%)		\$ 2,882,000
• Total		\$31,697,000

### 9.3 MAIN RESPONSE CENTRE AT BELLA BELLA WITH NO INTERIM RESPONSE CAPABILITY

This section is intended for comparison purposes only, to compare cost for the IMRC with and without interim response capability. The preferred approach is to develop the IMRC in stages of increasing response capability.

The suggested equipment is a minimum and is subject to testing, R&D and final selection.

• Vessels			\$42,600,000
◦ 2 FRV (FRV is Fast Response Vessel)	\$13,500,000		
◦ 1 Tug boat	\$ 7,500,000		
◦ 1 Tank barge	\$18,500,000		
◦ 4 Landing craft	\$ 2,600,000		
◦ 1 work Boat (small landing craft)	\$ 500,000		
• Equipment			\$ 3,534,000
◦ 5 Offshore Skimmers	\$ 150,000		
◦ 15,000 m Containment Boom	\$ 2,700,000		
◦ 2,500 m Shore Line	\$ 350,000		
◦ 2,500 m Light	\$ 350,000		
◦ 10,000 m Heavy	\$ 2,000,000		
◦ 4 Boom Reels	\$ 100,000		
◦ 5,000 m Sorbent Boom	\$ 200,000		
◦ 4 Pumps	\$ 4,000		
◦ 4 Power Packs	\$ 40,000		
◦ 15 Shoreline clean up kits	\$ 22,500		
◦ 3x 15 m³ Towable Bladders	\$ 59,600		
◦ 100 lb Absorbing Powders	\$ 1,000		
◦ First Aid and Safety equipment	\$ 22,500		
◦ Misc. Equipment Allowance	\$ 30,000		
◦ Post Cleanup Equipment	\$ 184,920		
◦ 2 Cranes	\$ 15,000		
◦ 4 Storage Containers	\$ 4,000		
• Marine Facilities			\$ 4,527,000
◦ Mob/De Mob	\$ 200,000		
◦ Float	\$ 948,000		
◦ Floating Workshops	\$ 546,000		
◦ Pilings/Anchors	\$ 2,260,000		
◦ Gangway	\$ 100,000		
◦ Electrical	\$ 177,000		
◦ Fire Fighting	\$ 70,600		
◦ Lighting	\$ 10,900		
◦ Sewage Pump	\$ 20,000		
◦ Sewage Pump Piping	\$ 46,000		
◦ Oil Waste Pump	\$ 20,000		
◦ Oil Waste Pump Piping	\$ 46,000		
◦ Potable Water	\$ 83,000		



• Land Side Facilities		\$ 14,356,000
◦ Mob/De Mob	\$ 500,000	
◦ Site Tree Falling, Clearing and Burning	\$ 194,400	
◦ Site Stripping and Waste Removal	\$ 154,000	
◦ Rock Drilling/ Blasting	\$ 1,941,000	
◦ Demolition of existing structures	\$ 115,000	
◦ Storage/Workshop Building	\$ 1,989,000	
◦ Main Response Centre	\$ 7,186,000	
◦ Sanitary/Water Systems	\$ 800,000	
◦ Boat Ramp and Barge (Un)Loading Structure	\$ 450,000	
◦ Indirect Costs of Project	\$ 1,028,000	
• Communications - This is very preliminary, and will require consultation with CCG MCTS et al		\$ 3,000,000
◦ The Centre	\$ 2,000,000	
◦ Tie Ins	\$ 1,000,000	
• Sum of Capital Costs		\$68,017,000
• Training		\$ 600,000
	(up to start up of IMRC)	
• Contingency (25% of Capital Costs and Training, \$68.617M)		\$17,154,000
• Total including Contingency		\$85,771,000
• Engineering (10%)		\$ 8,577,000
• Total		\$94,348,000

Figure 11, below, shows the Travel Distances for 1, 2, 3, 4, and 5 hrs for the main response Bella Bella, and the location of potential satellite storage depots.

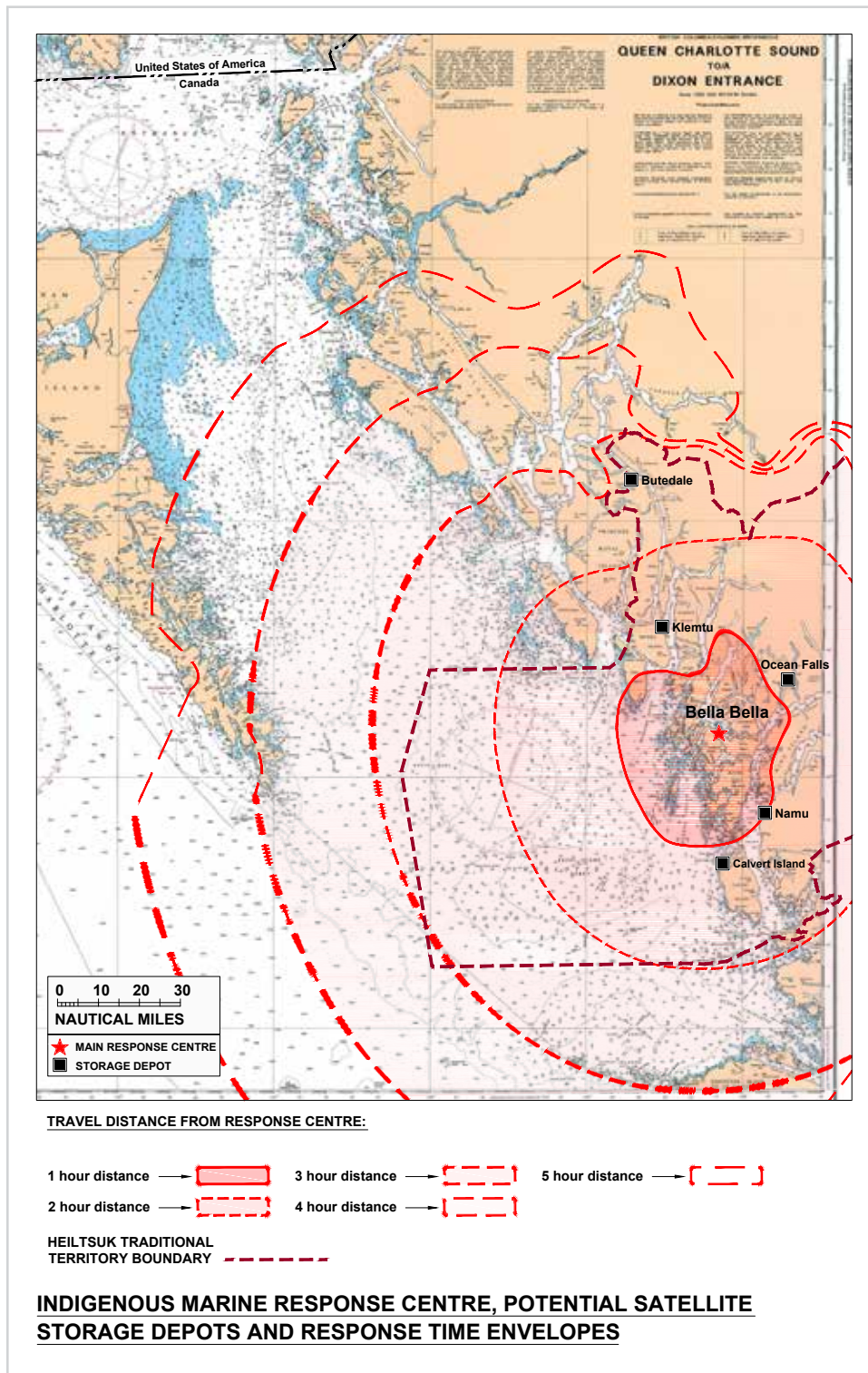


Figure 11. Bella Bella Response Times and Proposed Satellite Storage Depots (from which 3 will be selected)

## 9.4 SATELLITE STORAGE DEPOTS

The IMRC will have three satellite depots to be selected from five potential locations shown in Figure 11.

### GENERIC STORAGE DEPOT COST ESTIMATE

• Equipment			\$ 2,385,000
◦ 3 Offshore Skimmers		\$ 90,000	
◦ 10,000 m Containment Boom		\$ 1,820,000	
• 1000 m Shore Line	\$ 140,000		
• 2000 m Light	\$ 280,000		
• 7000 m Heavy	\$ 1,400,000		
◦ 3 Boom Reels		\$ 75,000	
◦ 5000 m Sorbent Boom		\$ 200,000	
◦ 2 Pumps		\$ 2,000	
◦ 2 Power Packs		\$ 20,000	
◦ 5 Shoreline clean up kits		\$ 7,500	
◦ 2x 15 m³ Towable Bladders		\$ 39,700	
◦ 100 lb Absorbing Powders		\$ 1,000	
◦ First Aid and Safety equipment		\$ 11,300	
◦ Misc. Equipment Allowance		\$ 15,000	
◦ Post Cleanup Equipment		\$ 92,500	
◦ 1 Cranes		\$ 7,500	
◦ 4 Storage Containers		\$ 4,000	
• Land Side Facilities			\$ 450,000
◦ Boat Ramp and Barge (Un)Loading Structure		\$ 450,000	
• Sum of Capital Costs			\$ 2,835,000
• Contingency (25%)			\$ 709,000
• Total Including Contingency			\$ 3,544,000
• Engineering (10%)			\$ 354,000
• Total			\$ 3,899,000

Depending on the sites chosen, cost may vary due to existing site conditions and any need for breakwaters, dredging, etc.

## 9.5 COMPLEMENTARY RESPONSE CENTRE

These costs could be applied to any large response centre on the central coast. These costs do not include the marine and land side facilities that may be necessary, as they would be dependent on the location of the response centre. With Bella Bella as a main response centre, a full communication centre would most likely not be necessary. A large workshop may also not be necessary, as any maintenance could be done in Bella Bella.

• Vessels		\$42,600,000
◦ 2 FRV (FRV is Fast Response Vessel)	\$13,500,000	
◦ 1 Tug boat	\$ 7,500,000	
◦ 1 Tank barge including DP (DP is dynamic positioning)	\$18,500,000	
◦ 4 Landing craft	\$ 2,600,000	
◦ 1 work Boat	\$ 500,000	
• Equipment		\$ 3,533,000
◦ 5 Offshore Skimmers	\$ 150,000	
◦ 15000 m Containment Boom	\$ 2,700,000	
• 2500 m Shore Line	\$ 350,000	
• 2500 m Light	\$ 350,000	
• 10000 m Heavy	\$ 2,000,000	
◦ 4 Boom Reels	\$ 100,000	
◦ 5000 m Sorbent Boom	\$ 200,000	
◦ 4 Pumps	\$ 4,000	
◦ 4 Power Packs	\$ 40,000	
◦ 15 Shoreline clean up kits	\$ 22,500	
◦ 3x 15 m <sup>3</sup> Towable Bladders	\$ 59,600	
◦ 100 lb Absorbing Powders	\$ 1,000	
◦ First Aid and Safety equipment	\$ 22,500	
◦ Misc. Equipment Allowance	\$ 30,000	
◦ Post Cleanup Equipment	\$ 184,920	
◦ 2 Cranes	\$ 15,000	
◦ 4 Storage Containers	\$ 4,000	
• Total without Contingency and Engineering		\$46,133,000
• Training		\$ 600,000
• Contingency (25%)		\$11,683,000
• Total with Contingency		\$58,416,000
• Engineering (10%)		\$ 5,842,000
• Total with Contingency and Training		\$64,258,000

## 9.6 OPERATING COSTS

### 9.6.1 Estimated Costs for Staff Salaries

All staff costs are assuming full time shifts and rotation work, the vessel on call crew would consist of boats that are contracted to the IMRC to provide assistance in the case of a large spill, while the shoreline on-call crew would consist of people that can be called upon for shoreline cleanups, sign ins, equipment decontamination, and other miscellaneous jobs that do not require operating a vessel. The on-call personnel would go through training, and would also participate in exercises for boom deployment, skimmer operation, and for run throughs of how a spill response would be operated.

#### BELLA BELLA

FRVs	16 full time
Tug	8 full time
Barge	10 full time
Landing Crafts	0
Response Centre	3 full time
Vessel Crew On-Call	90 (only on site for training, and drills)
Shoreline Crew On-Call	80 (only on site for training, and drills)
<b>Total Full Time</b>	<b>37</b>

Average Salary for Full Time	\$ 100,000
Total On-Call	170
Average Salary for On-Call Staff	\$ 5,000
<b>Total Salary Costs</b>	<b>\$ 4,550,000</b>

### 9.6.2 Total Operating Cost

Salaries	\$ 4,550,000
Training	\$ 250,000
Maintenance <sup>1</sup> , Consumables (fuel, food, etc), Services (hydro, telecommunications, internet etc.)	\$ 2,000,000
<b>Total</b>	<b>\$6,800,000</b>

Note:

1. Maintenance to keep equipment, vessels and centre up to date with existing CCG Procedures.

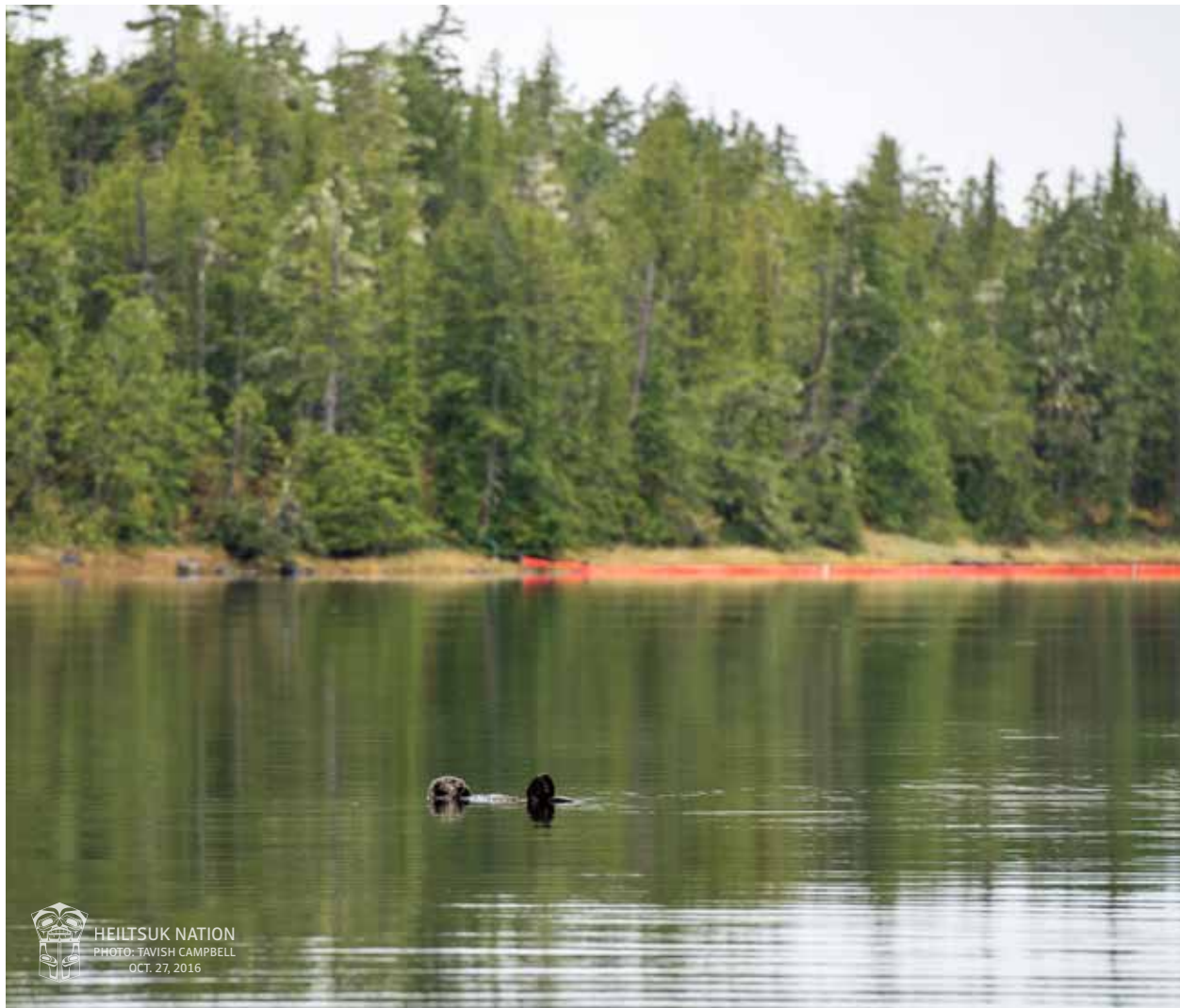


## 9.7 OVERALL

Table 10. Summary of Costs

LOCATION (PHASE #)	COST
Develop IMRC with IRC	\$ 99.8 M
Develop IMRC with no IRC	\$ 94.3 M
Three Generic Storage Depots	\$ 11.7 M
Total for IMRC with IRC and 3 storage depots	\$111.5 M
Total Operating Costs Per Year	\$ 6.8 M

Note:  
IRC = Interim Response Capability



## 10. SCHEDULE FOR THE NEXT PHASES

The schedule for a staged approach where an Interim Response Capability (IRC) and Research and Development (R&D) is built into the program is as follows:

### 2017:

1. Commence detailed design of vessels and equipment.
2. Perform land, water, test pile and contaminated site surveys.
3. Perform geotechnical evaluation of soils for pile and anchors.
4. Commence preliminary engineering involving Civil Engineers, Marine Structural Engineers, Geotechnical Engineers, Architects, Naval Architects, Planners, Archeologists, Environmental Consultants, Communications Consultants, Oil Spill Response Consultants, and Heliport Designers.

### 2018, Start of Stage 1:

5. Tender two Landing Craft and one Crew Boat.
6. Tender two FRVs.
7. Tender the tug and oil barge.
8. Commence training and R&D.
9. Continue preliminary design of marine and land infrastructure.
10. Rent a barge and anchors for tying up the vessels and install in front of the ex-BC Packers site.

### Mid-2018:

11. Take delivery of two Landing Craft, a Crew Boat and equipment.

### Start of Stage 2:

12. Commence field testing of equipment and R&D on new equipment.
13. Commence detailed design.
14. Perform Class B Cost Estimate ( $\pm 15-25\%$ ) for funding.
15. Confirm additional funding.
16. Commence permitting.

### 2019:

17. Tender the remaining Landing Craft.
18. Detailed design of the marine and land infrastructure.

### **Mid-2019, Start of Stage 3:**

19. Take delivery of the two FRVs.
20. Commence field trial of the FRVs and equipment.
21. Develop and tender new and improved oil spill equipment.
22. Permitting.
23. Perform a Class A Cost Estimate ( $\pm 10-15\%$ ).
24. Confirm additional funding.
25. Tender the marine and land infrastructure.

### **2020:**

26. Take delivery of the remaining Landing Craft.
27. Monitor construction of the marine and land infrastructure.
28. Continue of R&D and field testing of new and improved oil spill equipment.
29. Tender remaining equipment.

### **2021, Start of Stage 4:**

30. Take delivery of tug and oil spill barge.
31. Opening of the full IMRC.
32. Tender the remaining equipment for the selected satellite storage depots.

### **2022, full build-out of the Bella Bella IMRC.**

33. Satellite Storage Depots and possible Complementary Response Centre become operational



The proposed schedule for development of the IMRC without IRC or R&D built in is provided below, for comparison with the schedule for the IMRC with IRC and R&D built in.

**2017:**

1. Land survey
2. Sounding survey of water lot to determine the bathymetry of the water lot at the Ex-BC Packers Site
3. Geotechnical evaluation for pilings and anchors
4. Contaminated sites soil sampling and testing
5. Drive test piles
6. Preliminary engineering (start)
  - Preliminary Engineering will require: Civil Engineers, Marine Structural Engineers, Geotechnical Engineers, Architects, Naval Architects, Planners, Archeologists, Environmental Consultants, Communications Consultants, Oil Spill Response Consultants, and Heliport Designers

**2018:**

7. Continue Preliminary engineering
8. Detailed Design
9. A Class B Cost Estimate ( $\pm 15\text{-}25\%$ ) for funding
10. Funding approval
11. Permitting

**2019:**

12. Tenders for:
  - Vessels
  - Floats
  - Floating Facilities
  - Anchors and/or Pilings
  - Site Preparation
  - Site Services
  - Buildings
  - Boat Launch Ramp
  - Barge Loading/ Unloading Structure
  - Heliport
13. Class A Cost Estimate ( $\pm 10\text{-}15\%$ )
14. Finalize Funding
15. Award of Contracts
16. Construction

**2021:**

17. Commission opening at limited capability.

**2022: Full Build-out of Bella Bella IMRC**

18. Satellite Storage Depots and possible Complementary Response Centre become operational

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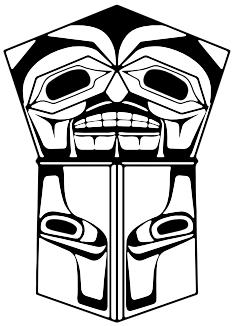
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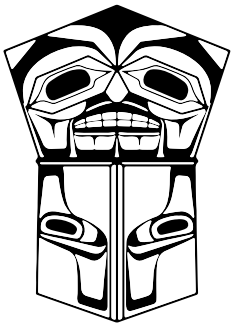
HEILTSUK NATION  
PHOTO: APRIL BENCZE



# **HEILTSUK TRIBAL COUNCIL**

## **APPENDICES**





**HEILTSUK TRIBAL COUNCIL**

APPENDIX A

Vessel Transit Patterns Along The North  
Coast; Vancouver Island To Alaskan Border

## A.1 INTRODUCTION AND BACKGROUND

### A.1.1 PURPOSE

The Heiltsuk Tribal Council (HTC) is pursuing the development and implementation of an Indigenous Marine Response Centre (IMRC) to address safety, incident prevention and environmental protection associated with marine traffic on the Pacific coast. The study area of interest is spatially defined from the north end of Vancouver Island to the north end of Principe Channel and to Morning Reef in Grenville Channel.

Emergency response planning along the Pacific coast is becoming increasingly important to local stakeholders and First Nations that are potentially affected by incidents and spills that impact environmentally sensitive areas, cultural practices, resource harvesting and subsistence lifestyles.

This Appendix provides the input data for the probabilistic analysis in Appendix B.

### A.1.2 BACKGROUND LITERATURE

Literature regarding current approaches to spill management associated with increasing marine traffic has been studied by the British Columbia government. The British Columbia (BC) Ministry of Environment (Ministry) published a series of reports to quantify spill prevention, response, and vessel traffic and to provide recommendations regarding a spill prevention system. The report entitled: *West Coast Spill Response Study* (Nuka Research and Planning Group, LLC, 2013) produced three separate volumes:

- **Volume 1:** An assessment of the existing spill prevention and response regime in place for the West Coast of Canada;
- **Volume 2:** A vessel traffic analysis that assesses the current and projected levels of shipping on the West Coast of Canada; and
- **Volume 3:** A recommendation regarding the constituents of a world-class oil spill prevention and response system commensurate with present and future oil spill risks from marine vessels.

Volume 2: Vessel Traffic Analysis, has been referenced to provide the team with preliminary data from a vessel traffic perspective and has been referenced as a starting point to this study.

As shipping through BC coastal waters continues to increase and several major marine transportation projects have been proposed, the risk of a potential incident or spill also increases. The BC government and First Nations, in recognition of this, have a strong interest in understanding the risks associated with increased shipping and are pursuing the development of a world class oil spill preparedness and response regime.

The West Coast Spill Response Study Volume 2: Vessel Traffic Study provides a high-level summary of vessel transit data for the West Coast. The report describes vessel movements along the West Coast of BC for the 2011 - 2012 calendar years and estimates these traffic volumes as well as quantities of petroleum being transported as cargo and fuel, as well as providing potential changes in this type of vessel traffic from a forecast perspective. The data were compiled from different sources of data: Automatic Information System (AIS) data for the area, including satellite AIS, and information on barge movements (not included in AIS data) based on Canadian Coast Guard key informant interviews. The movement of vessels with AIS transponders was aggregated based on specific navigational passages that essentially frame the BC coast.



The data provide overall information and trends associated with traffic patterns, noting the following key observations:

- The clear majority of transits (78%) occur in southern BC through the Strait of Juan de Fuca at the Neah Bay and Point Roberts passage lines.
- From 2011-2012 the volume of traffic across all passage lines increased by approximately 17%.
- The increase in transits in 2012 compared to 2011 was most dramatic for Dixon entrance (northern port access).

The study highlighted that while the overall traffic is forecast to remain much higher in the Vancouver area than further north, the greatest change could be seen based on the traffic going in and out of Prince Rupert, Stewart and Kitimat. Long term increases in marine traffic are dependent upon which proposed marine projects go forward.

While Volume 2 provides a high-level overview of vessel transits and future forecasts, it does not present specific vessel transit data and patterns within the various intercoastal navigational passages around the central coast (Bella Bella to Kitimat). It is within these intercoastal waterways that is the subject area of this review.

Background research and analysis of vessel traffic have been compiled to further define marine traffic and vessel characteristics within these intercoastal waterways. Such vessel data are required for probabilistic analysis of the IMRC concept, in which a probabilistic risk analysis of marine incidents will be evaluated. Key data required to undertake this analysis include the number and type of vessel transits, the length of vessels by type and the type of tow and towline potentially deployed, as well as the speed of the vessels.

### **A.1.3 STUDY METHODOLOGY**

To support the probabilistic analysis associated with potential marine traffic risk, TyPlan Consulting (TYPLAN) was retained to compile available vessel transit data between Vancouver Island and Prince Rupert (Alaskan Border) as well as vessel incident data. The study methodology consisted of:

- Compiling vessel transit data based on Canadian Coast Guard Marine Communications and Traffic Services Data (CCG MCTS); noting vessels transits and characteristics via the call-in points (CIP) CCG MCTS has established along the coast.
- Defining Intercoastal Navigational Routes in relation to the above.
- Defining navigational routes and related vessel transit characteristics needed for the probability analysis (i.e. type of vessel transits by number and type of vessel, length of vessel by type, and type of tow being pulled by tug transits).
- Summarizing vessel incident data by type of incident based on Transportation Safety Board (TSB) Marine Incident Data specific to those incidents between Vancouver Island and the Alaskan border.
- Defining vessel speeds and the combined length of tug and tow (towline length) required to undertake phase B of this review.

#### **A.1.3.1 Compiling Vessel Transit Data**

To compile vessel transit data, team members met with CCG MCTS in Sidney, Vancouver Island. The team would like to thank the CCG MCTS for their cooperation.

The traffic volumes provided are specific to a series of CIPs along the coast upon which the data had been collected. Key CIPs were identified in collaboration with CCG MCTS that would provide details of vessel movements and characteristics within each coastal waterway to improve the accuracy of the assessment and base understanding and knowledge of the types of vessels transiting each passage.

The CCG MCTS CIP's along the entire coast line are illustrated on the Figure A.1 below:

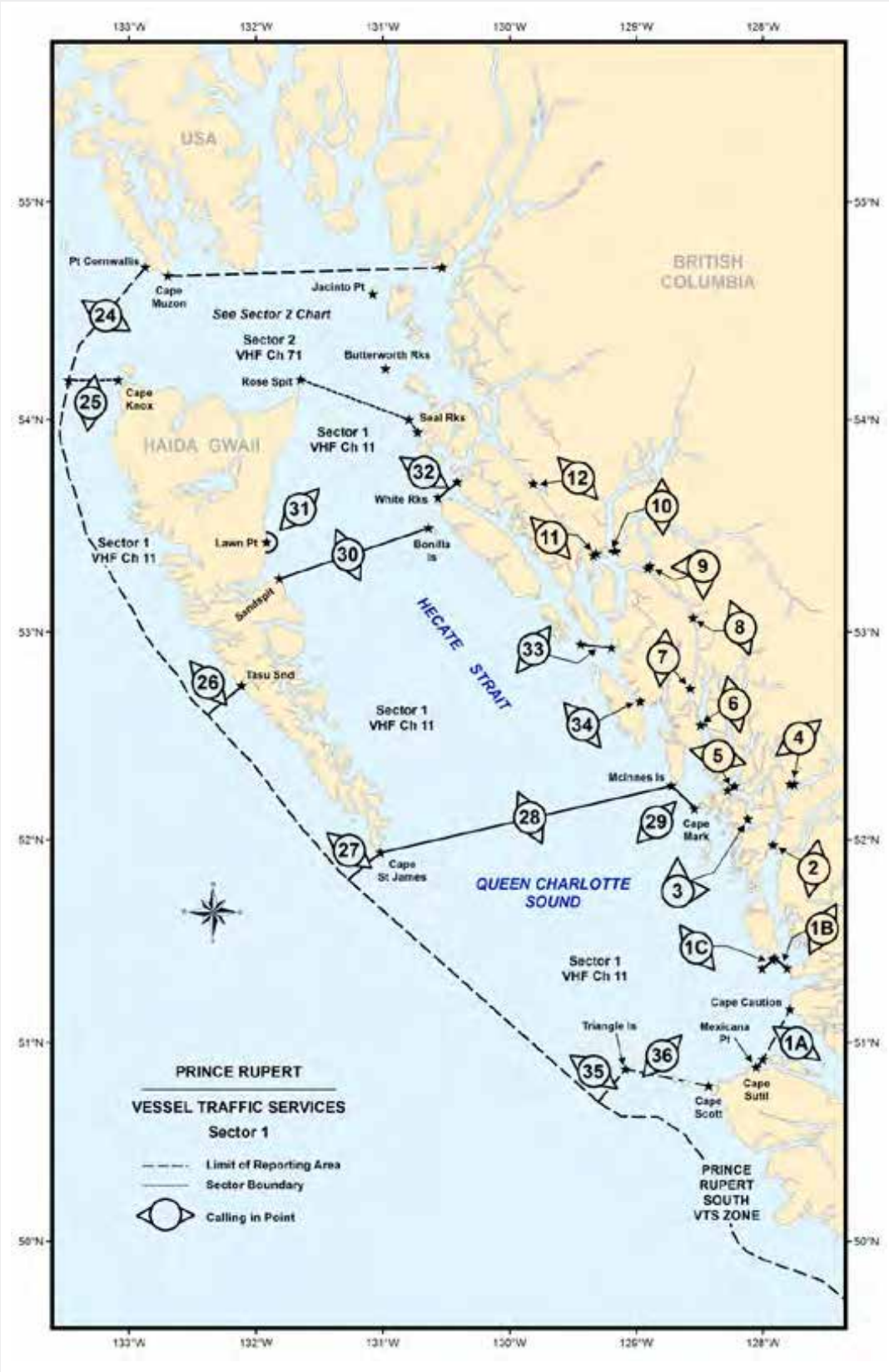


Figure A1. Vessel Traffic Services – Prince Rupert – North – Sector 1  
Source: Department of Fisheries and Oceans, Radio Aids to Marine Navigation, 2016

### A.1.3.2 Navigational Routes and Related CIP Vessel Transit Data

The BC Coast has been characterized as the “Gateway to the Pacific”. BC ports and waterways provide a major shipping corridor between Asia and North America. As part of the Asia Pacific Gateway Council Initiative, the Government of Canada and the private sector have invested more than \$14 billion in infrastructure and development projects to improve the supply chain and foster expansion (BC Chamber of Shipping).

Mariners that operate in western Canada encounter a range of operational environments from open ocean to sheltered inland waters. Some vessels transit along the coastline while others follow designated intercoastal routes. Larger commercial vessels tend to follow major ocean shipping routes and are subject to mandatory traffic schemes. Vessel activity on Canada’s west coast also includes significant transits along the intercoastal waterways and includes recreational vessels, fishing vessels, ferries, car ships, tankers and tugs and barges. It is noted that while tug and tow traffic represents one of the key vessels transiting the waterways, it is important to gain an understanding of the type of tow and the topline length (i.e. length of tow) to support the probabilistic analysis. Such data have been compiled for this review by intercoastal waterway.

The major coastal shipping routes and intercoastal waterways along the BC coast are provided on Figure A2, derived from Volume 2: West Coast Spill Response Study.

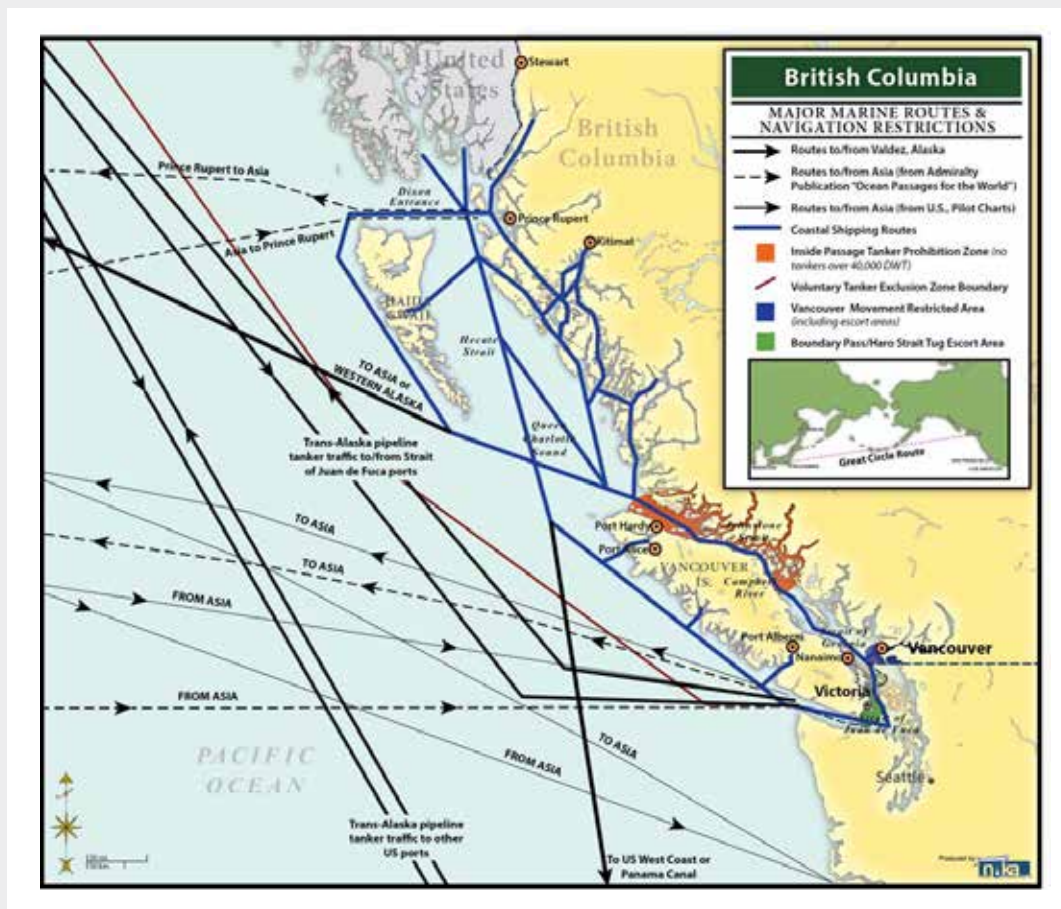


Figure A2. Major Marine Routes and Navigational Restrictions

Source: West Coast Spill Response Study Volume 1: Assessment of British Columbia Marine Oil Spill Prevention and Response Regime (Nuka Research and Planning Group), 2013

### A.1.3.3 Marine Occurrences

The TSB report: *Statistical Summary-Marine Occurrences 2015* (Transportation Safety Board, 2016), provides provincial level information regarding marine occurrences and provides a starting point regarding the types of incidents/occurrences. A follow up request was made to TSB to provide similar data set specific to the area between Vancouver Island to the Alaskan Border, which TSB prepared for the study team.

The data presented by the TSB are based on a period from 2011-2016 (to assist with defining short term trends) and are based on defined accident/incident types (Note: only the accident/incident types of interest to this review are presented. Refer to the Marine Occurrences report for details and definitions). Section A.3 of this Appendix provides a detailed analysis of the types of incidents and occurrences to provide further context to the potential types of incidents.

Vessel data (from CCG MCTS), based on CIPs, are correlated to intercoastal waterways and provide an indication of vessel incident occurrences within the study area between 2011 through 2016. This sets the context upon which the probabilistic analysis of this review will be undertaken.



# A.2 NAVIGATIONAL ROUTES AND VESSEL TRANSIT ANALYSIS

## A.2.1 REGIONAL OVERVIEW

Figure A3 provides a regional overview of all the various navigational routes being considered as part of this review, as well as identifying the CCG MCTS CIPs upon which the vessel transit and characteristic data are based.

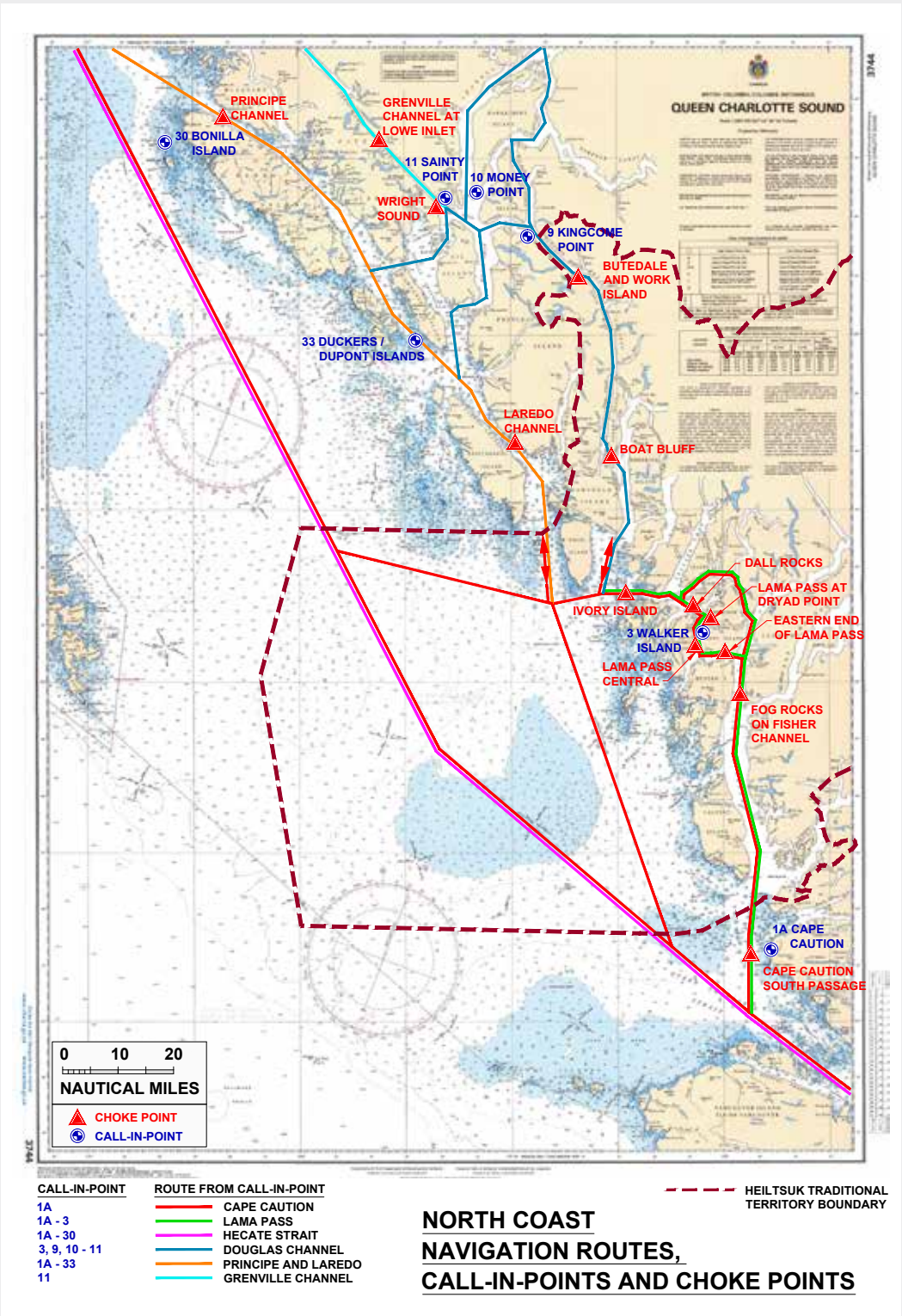


Figure A3. Vessel Traffic Services – Prince Rupert – North – Sector 1



The following sections provide a detailed summary of vessel transit characteristics for each navigational route.

## A.2.2 CAPE CAUTION

The Cape Caution CIP illustrated on Figures A3 and A4, and the corresponding navigational routes upon which the data are based are also illustrated on both Figures. Please note that the Cape Caution CIP captures all vessel transits northbound and southbound via Cape Caution. North of Cape Caution, vessels either transit Hecate Strait or navigate Lama Pass, along the more protected waters past Bella Bella. As presented in the data, the types of vessels transiting each navigational route vary and therefore have a significant effect on the probability of an occurrence within the intercoastal waterways.

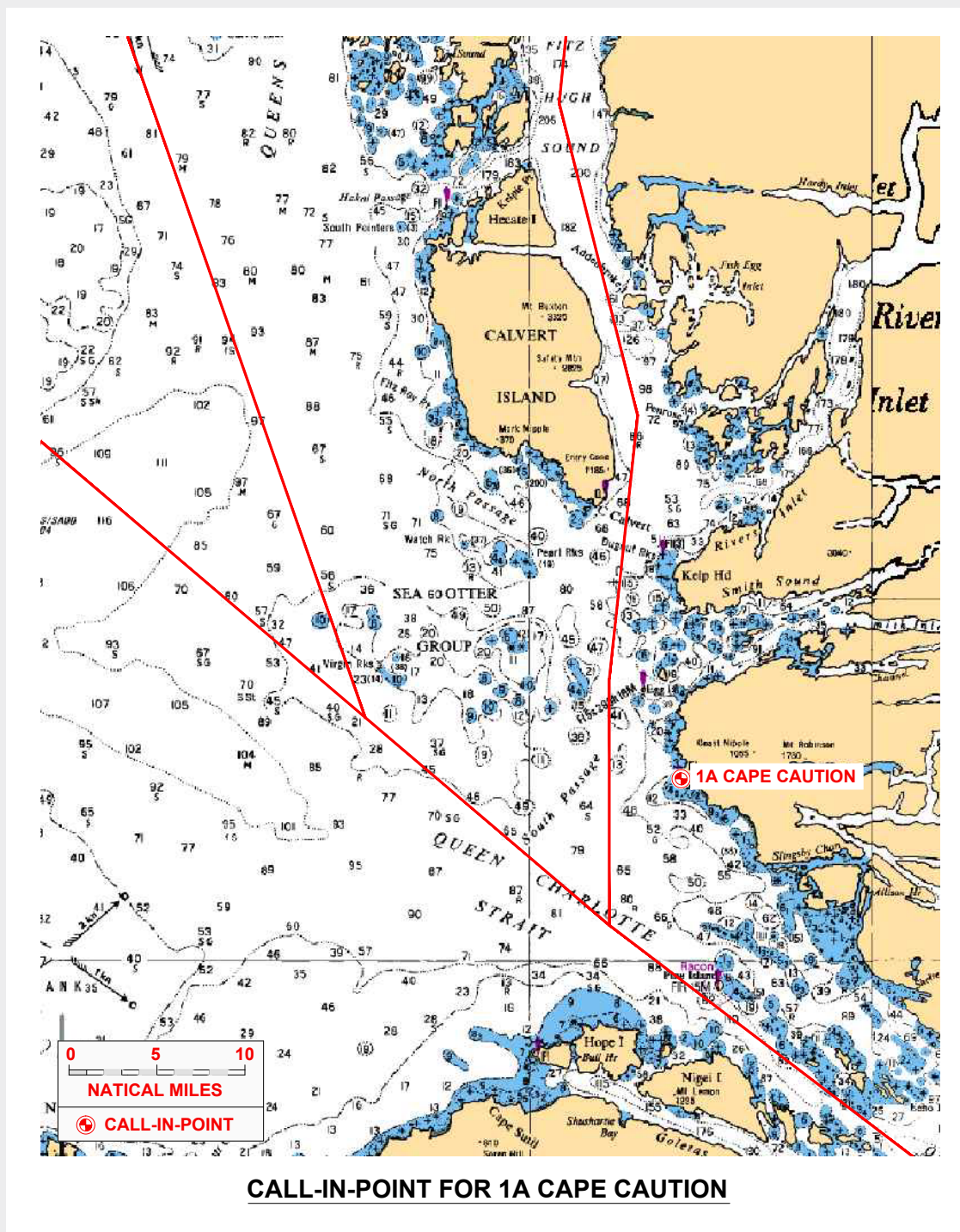


Figure A4. Cape Caution CIP

Information pertaining to the number of transits by type of vessel, length of vessel by vessel type and the type of tow being pulled by tugs is presented in the following Figures.

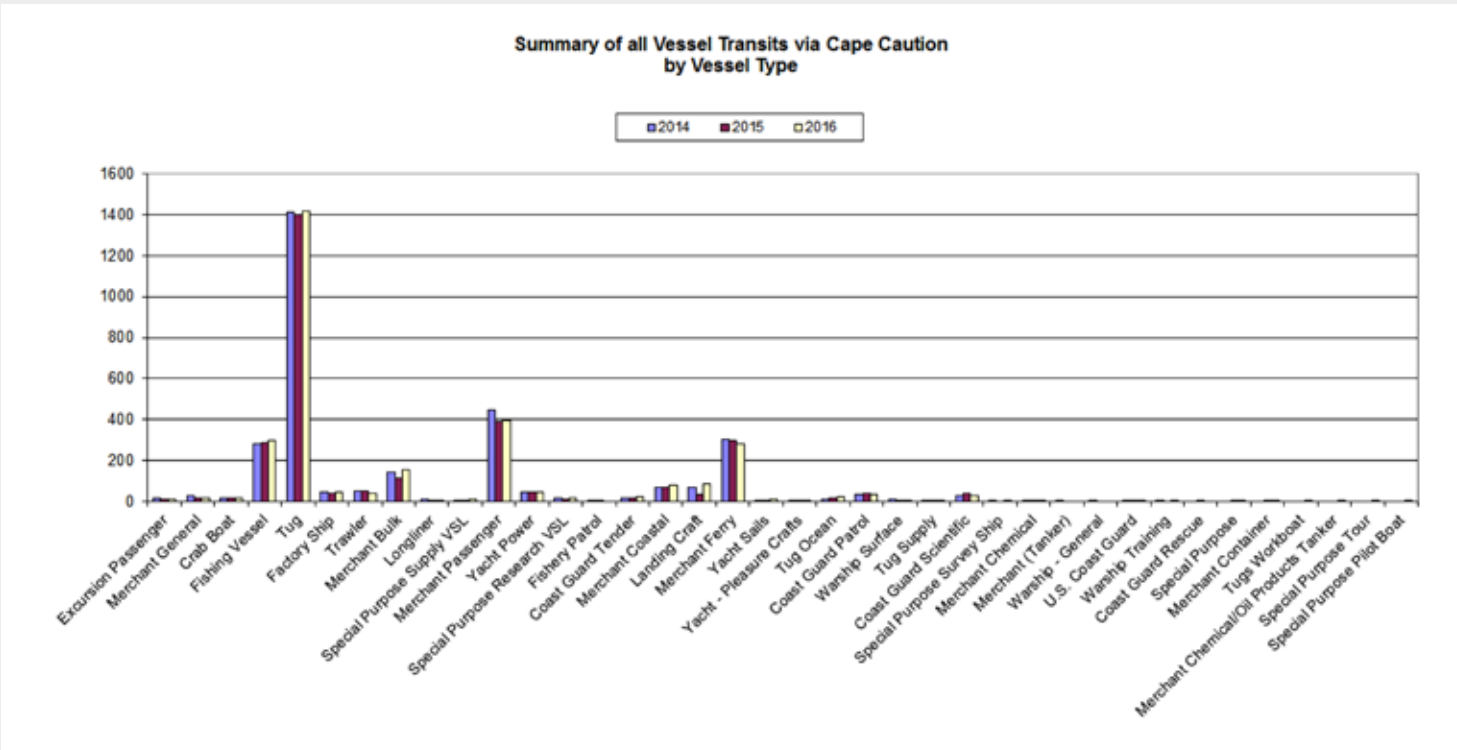


Figure A5. Transits by Vessel Type

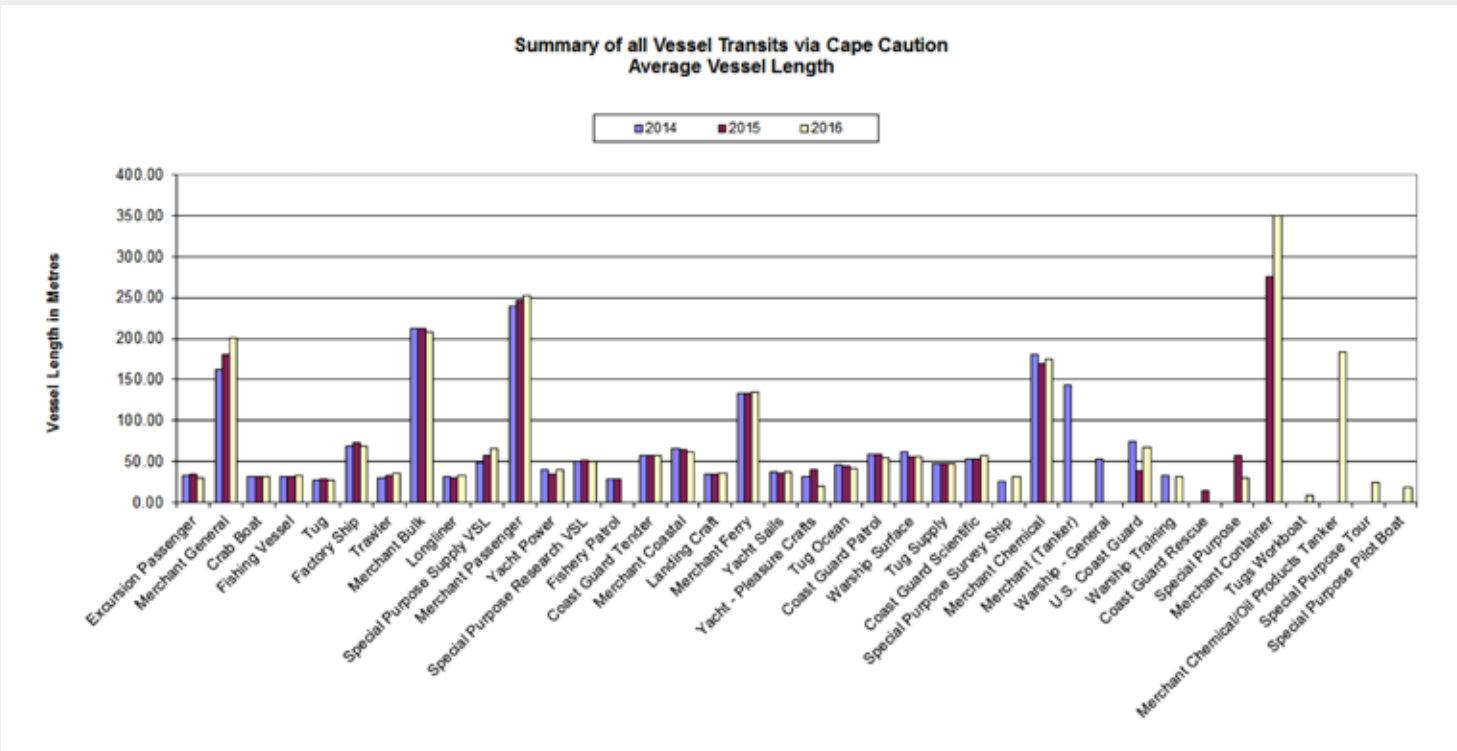


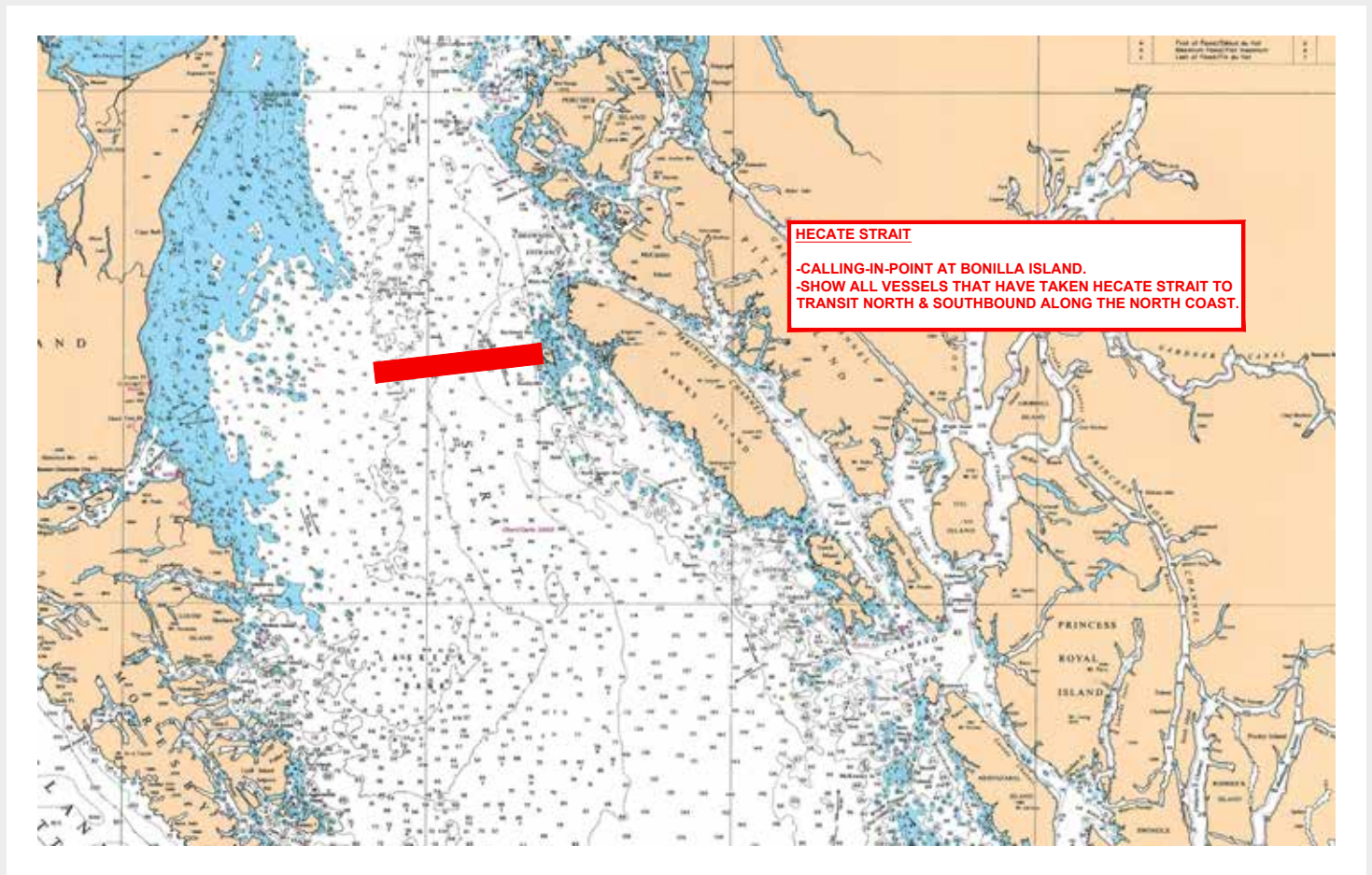
Figure A6. Transits by Vessel Type and Length





### A.2.2.1 Hecate Strait

Vessels transiting the Hecate Strait include all vessels that have transited Hecate Strait to transit north and south on the coast. All traffic using Hecate Strait either northbound or southbound is tracked via the CIP at Bonilla Island illustrated on the Figure A8 below.



**Figure A8. Close up of Hecate Strait**

Source: Canadian Coast Guard (CCG) Marine Communications and Traffic Services (MCTS)

Information pertaining to the number of transits by type of vessel, length of vessel by vessel type and the type of tow being pulled by tugs is presented in the following Figures:

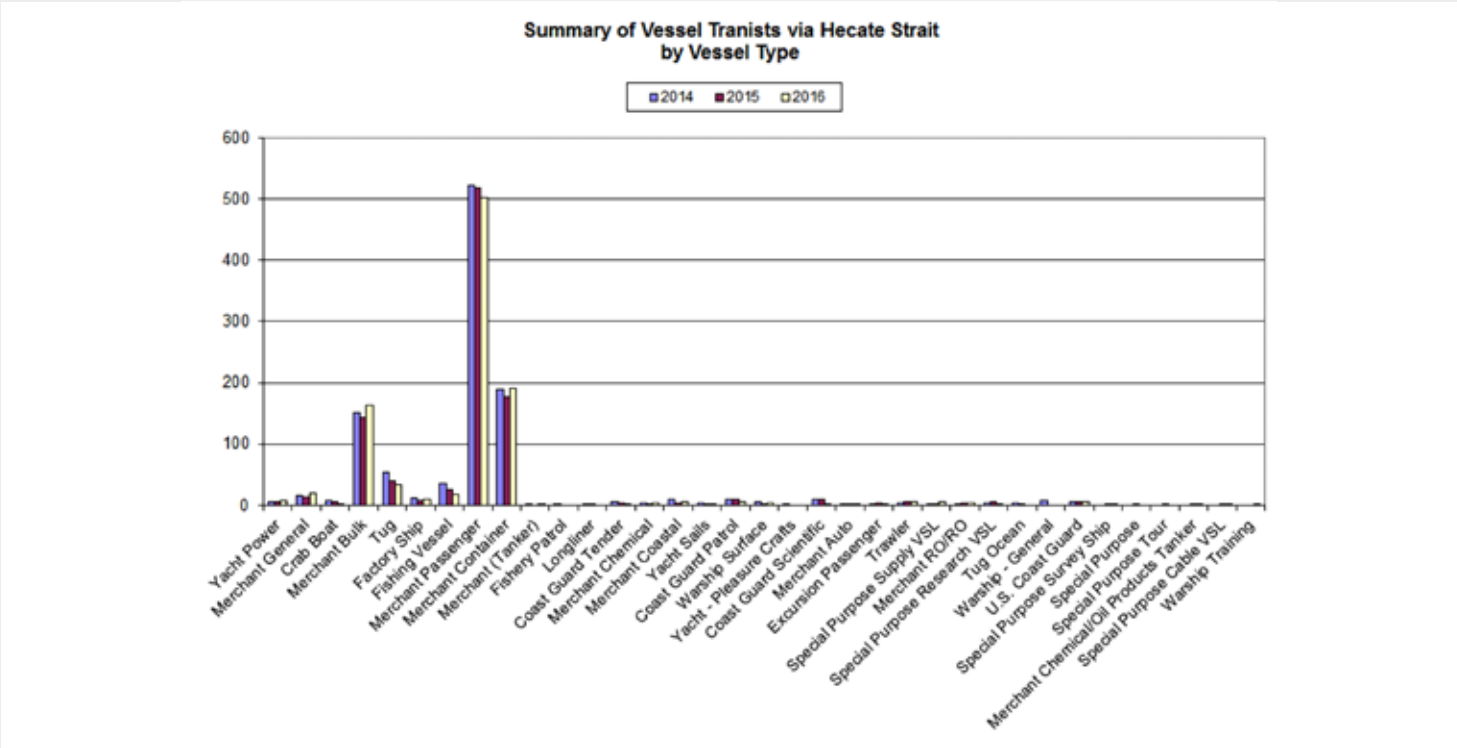


Figure A9. Transits by Vessel Type

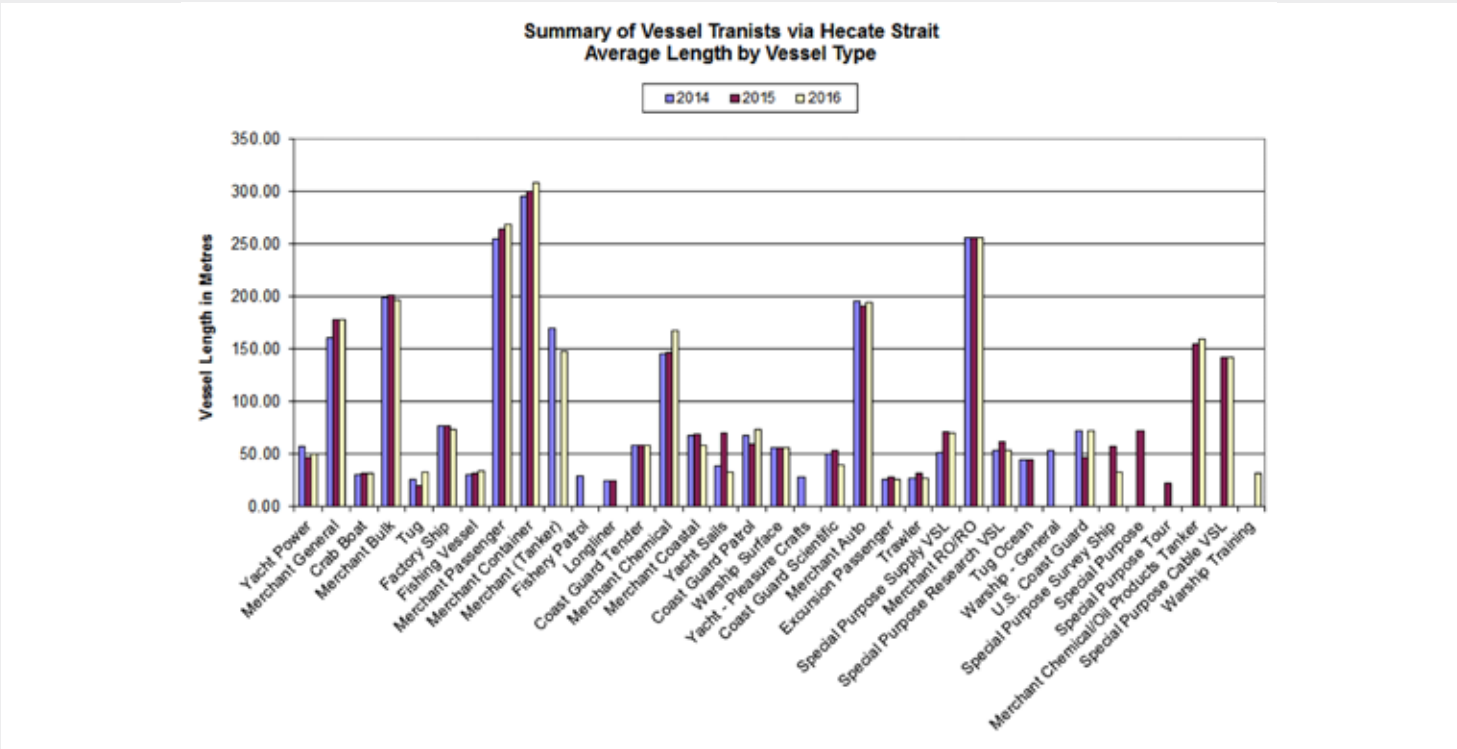
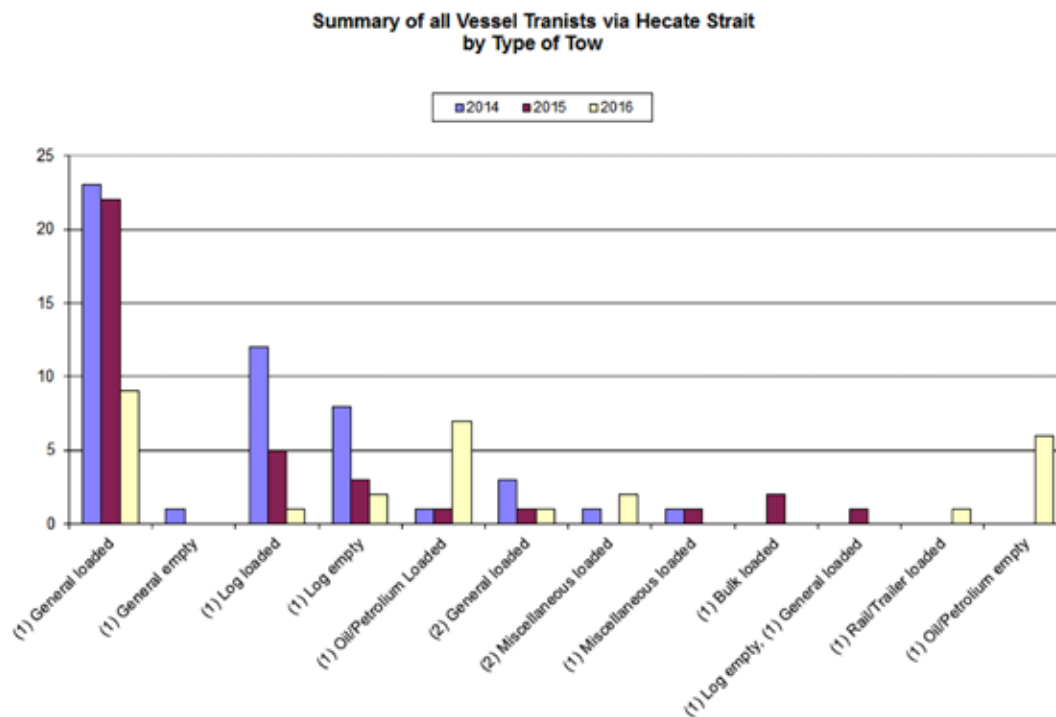


Figure A10. Transits by Vessel Length



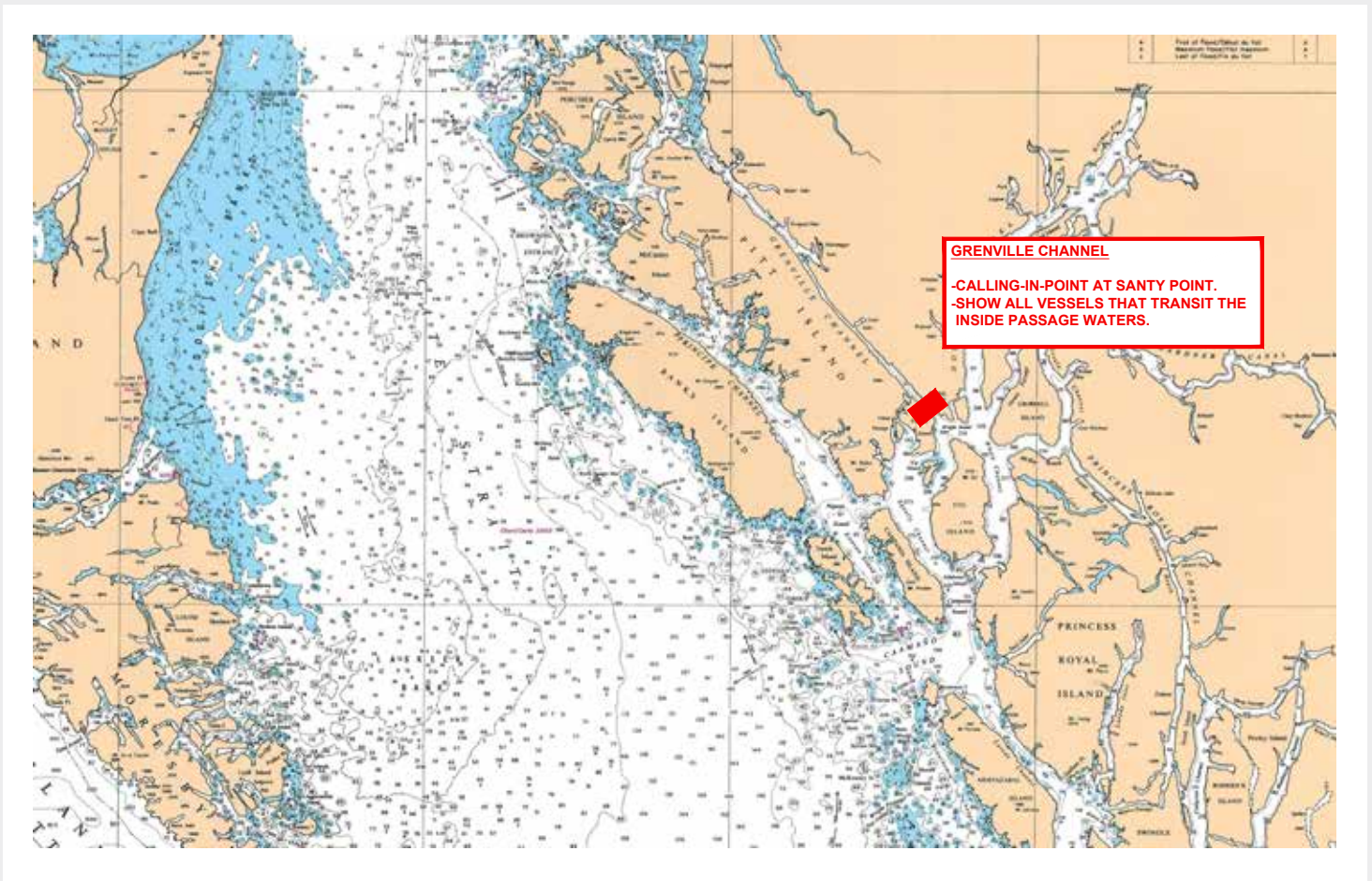


**Figure A11. Summary Towed Vessel by Type of Tow**

A review of the vessel type and length of vessels transiting Hecate Strait reveals different characteristics of vessels transiting this waterway reflective of the open ocean transits of the larger vessels. Merchant Passenger (260 m in length), Merchant Container (310 m in length), and Merchant Bulk ships (200 m in length) are the most predominant type of vessel transiting this waterway, followed by Tugs (30 m in length). In terms of tugs, the predominant tow type is general, logs and oil/petroleum products.

### A.2.2.2 Grenville Channel

All vessels transiting Grenville Channel are picked up via the CIP at Sainty Point. The Channel and the CIP are illustrated in Figure A12 below.



**Figure A12. Grenville Channel**

Source: Canadian Coast Guard (CCG) Marine Communications and Traffic Services (MCTS)

Information pertaining to the number of transits by type of vessel, length of vessel by vessel type and the type of tow being pulled by tugs is presented in the following Figures.

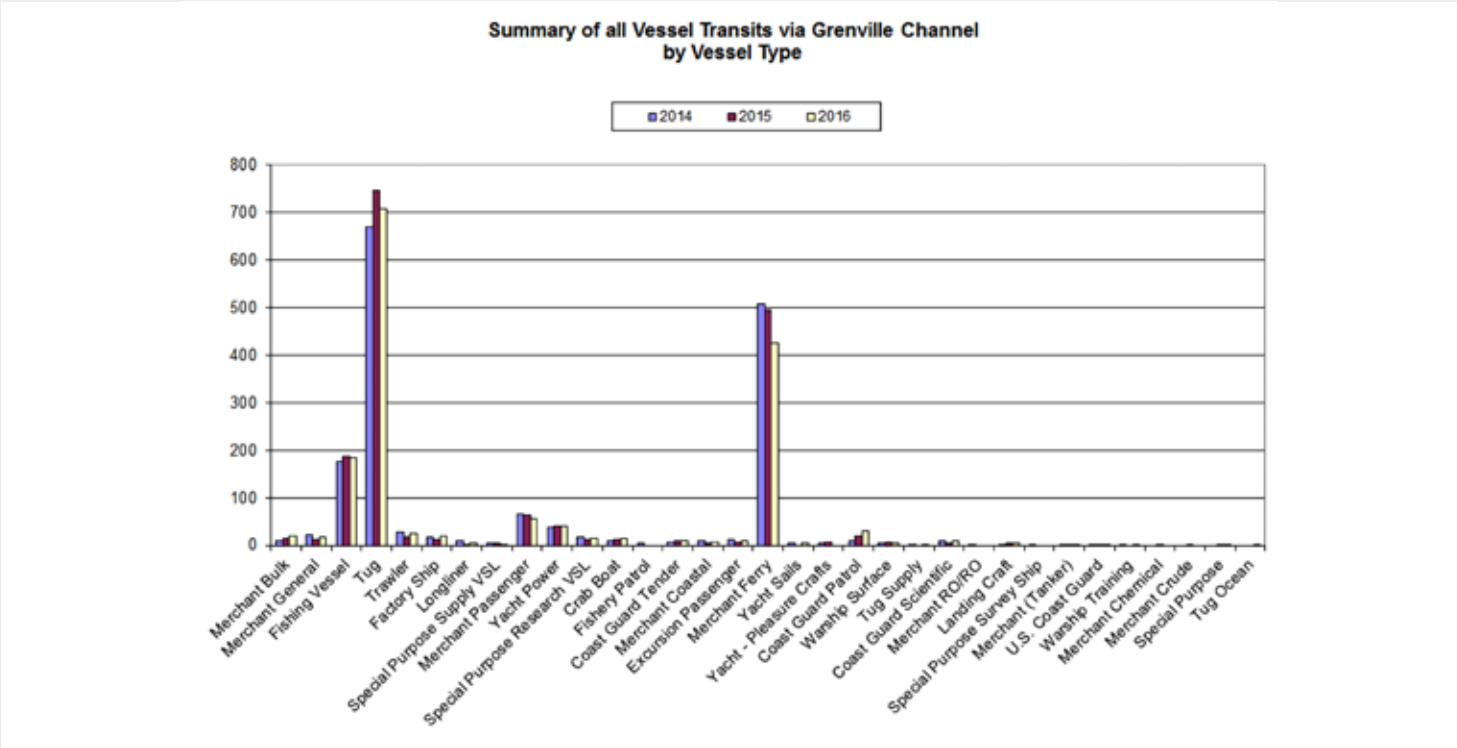


Figure A13. Transit by Vessel Type

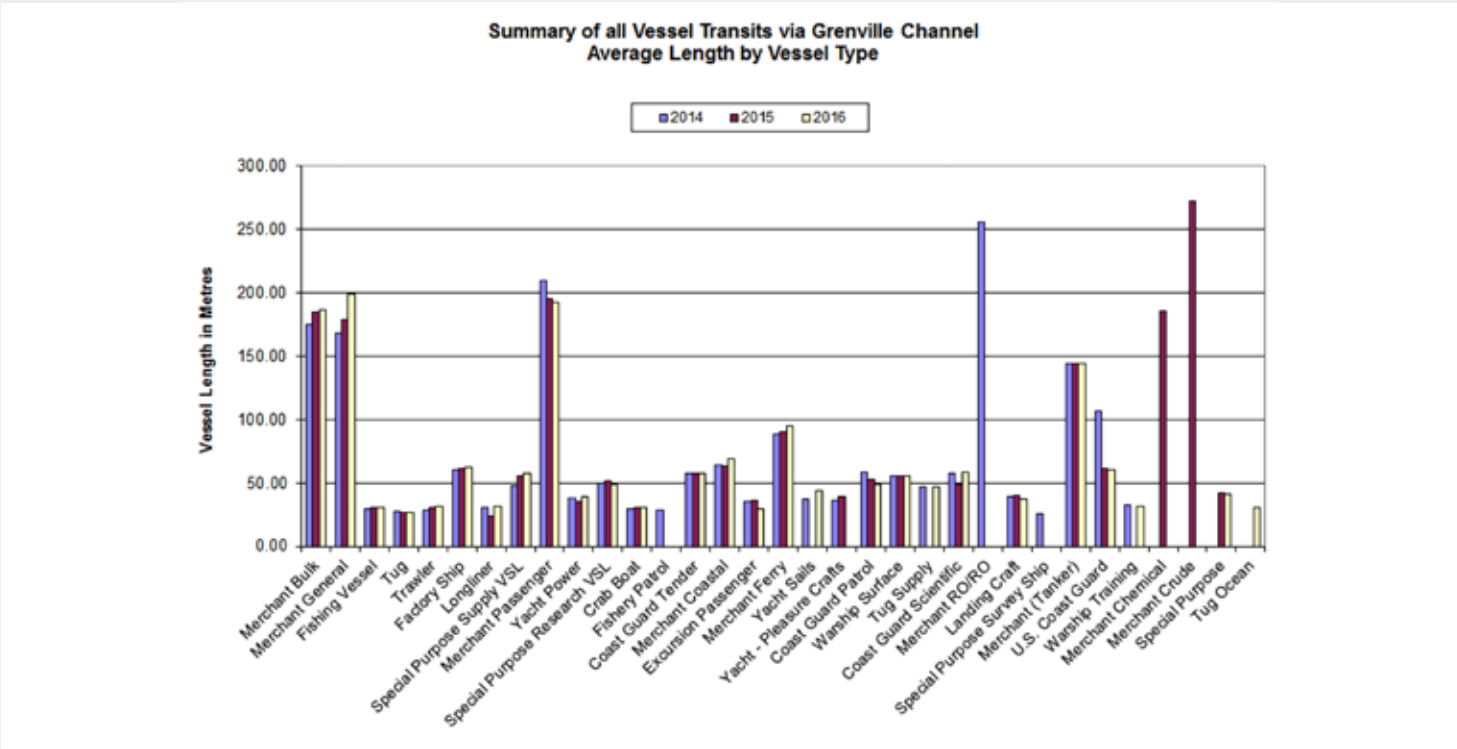


Figure A14. Transits by Vessel Length

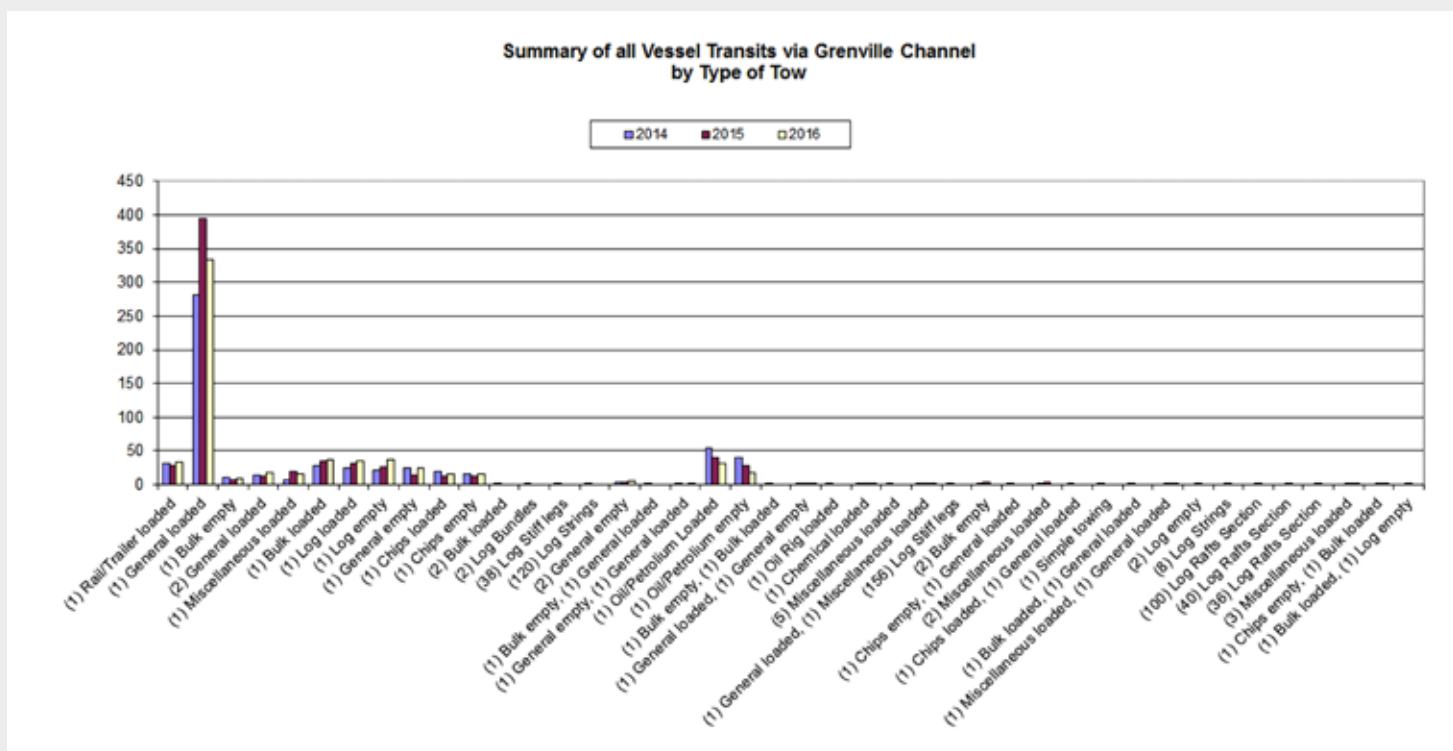


Figure A15. Transits by Type of Tow

A review of the vessel type, length, and type of tow for the Grenville Channel reveals that the predominant type of vessel transits consists of Tugs (30 m in length), Merchant Ferry (90 m in length), and fishing vessels (30 m in length), followed by Merchant Passenger Vessels. It is noted that in 2015, both merchant crude and merchant chemical vessels transited the passage.

The predominant type of vessel transiting Grenville Channel is Tugs, most of which are towed general cargo, as well as both loaded and unloaded petroleum barges.



A.2.2.2 Douglas Channel

Douglas Channel includes all vessel transits to and from Kitimat and is denoted via CIPS Money Point and Kingcome Points, as illustrated below.

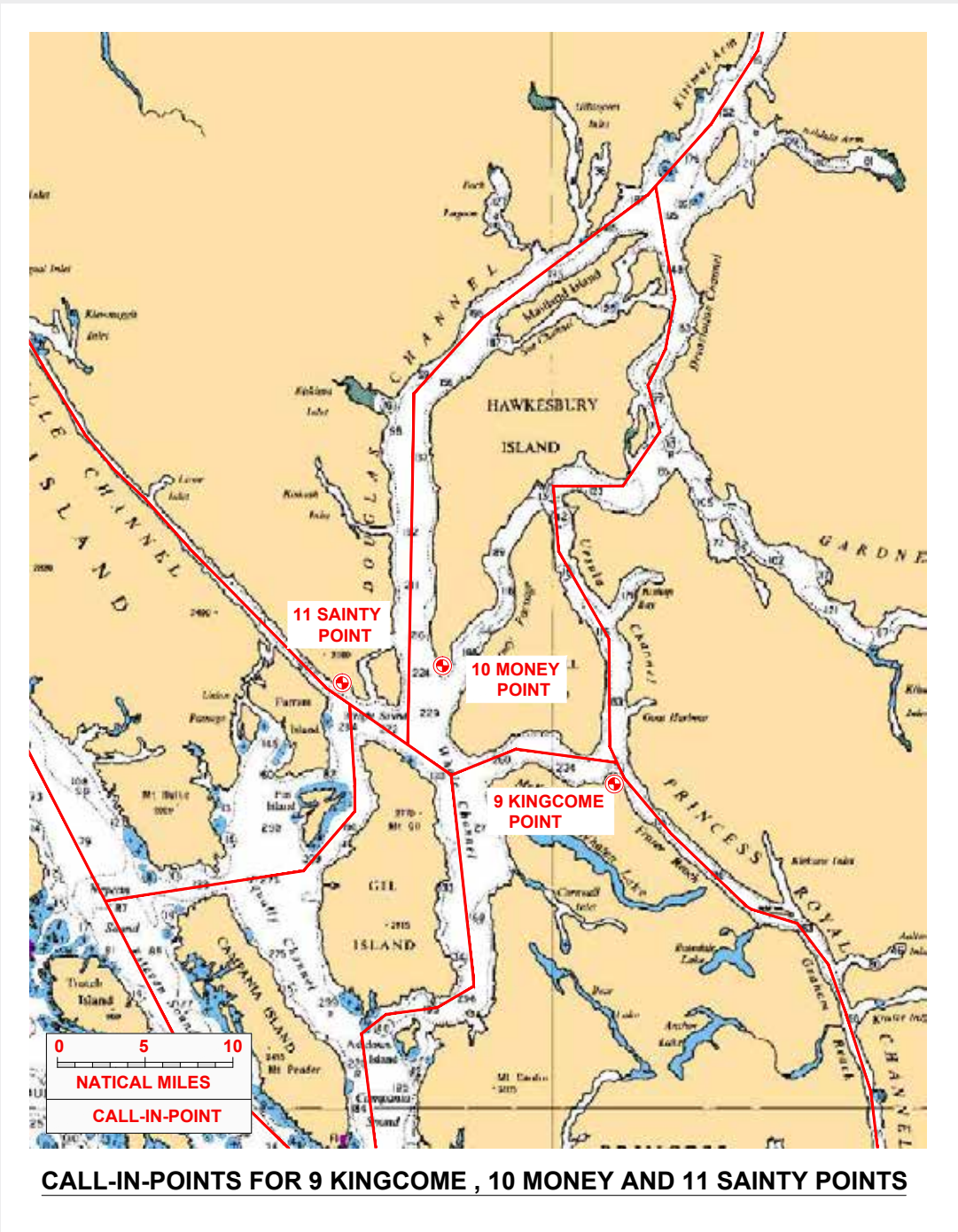


Figure A16. Douglas Channel



Information pertaining to the number of transits by type of vessel, length of vessel by vessel type and the type of tow being pulled by tugs is presented in the following Figures.

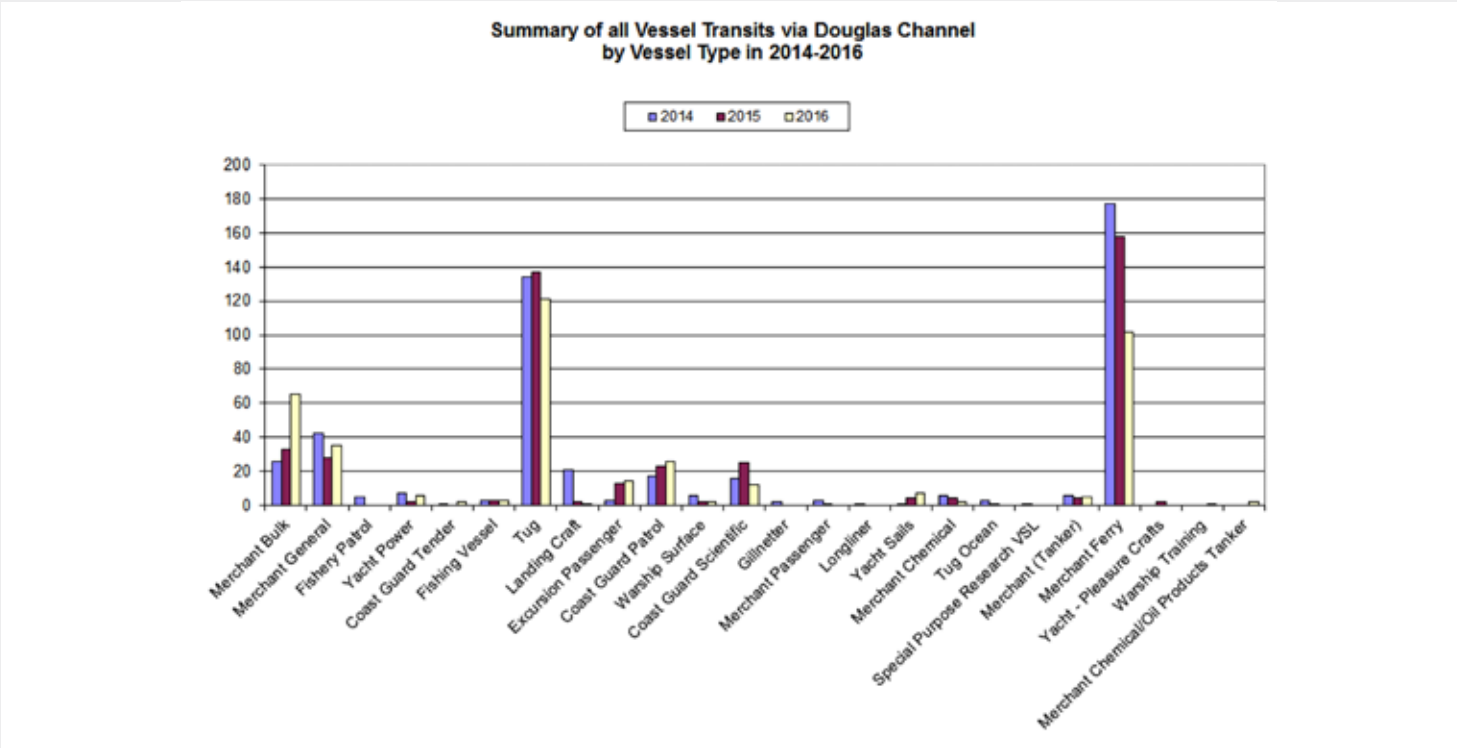


Figure A17. Transits by Vessel Type

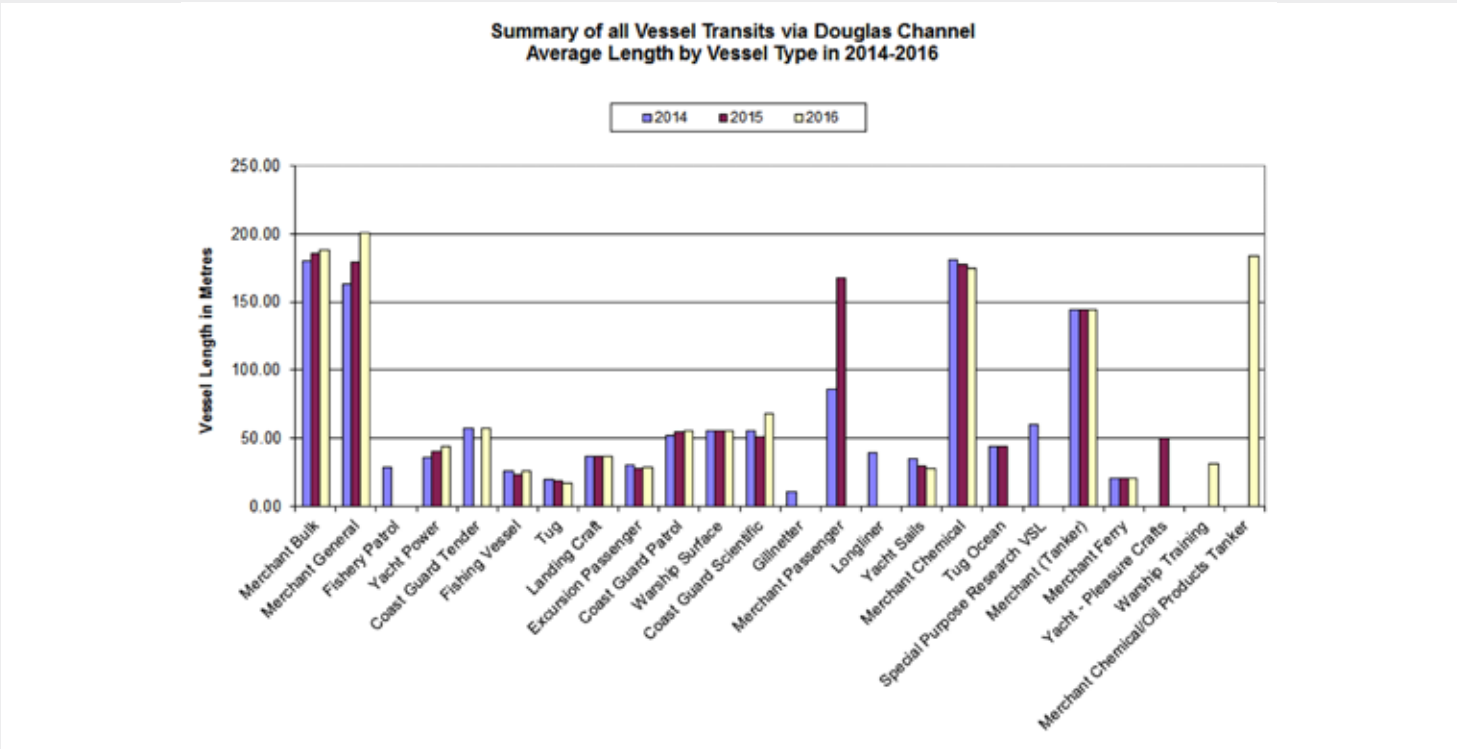


Figure A18. Transits by Vessel Length

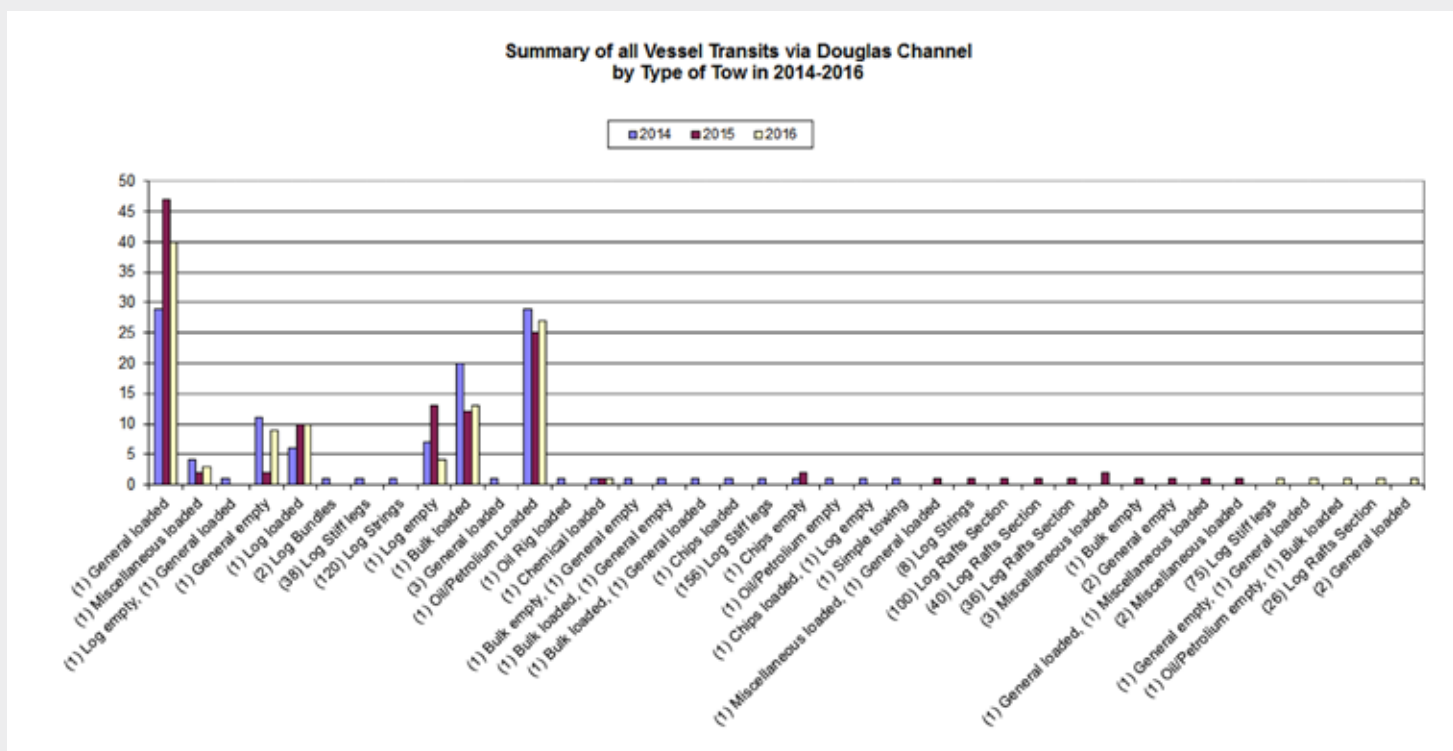
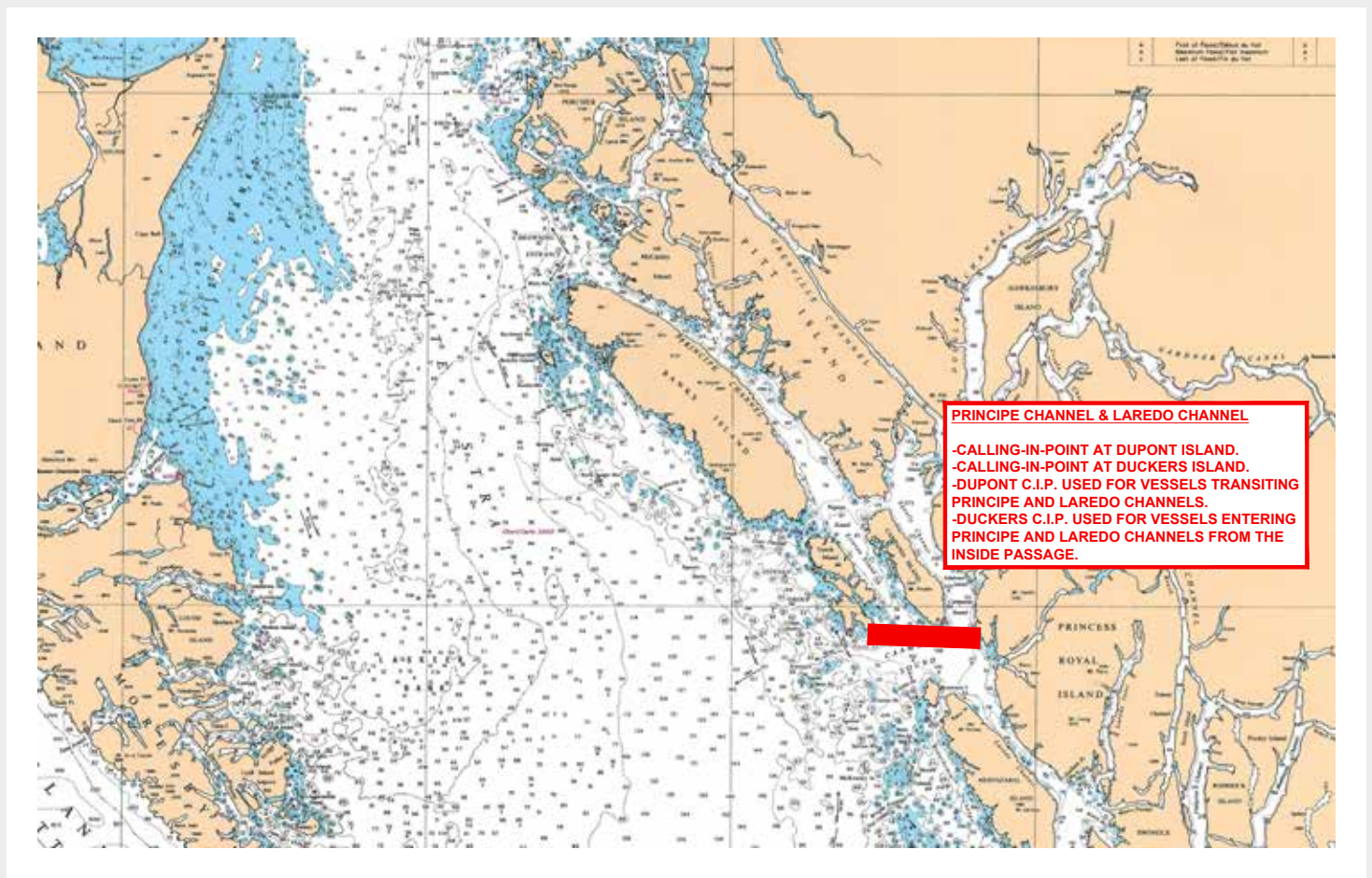


Figure A19. Summary Towed Vessel by Type of Tow

A review of the vessel type, length, and type of tow for the Douglas Channel indicates that the predominant type of transits is represented by Merchant Ferry (40 m in length), Tug (30 m in length), and Merchant Bulk (180 m in length), followed by Merchant General vessels. It is noted that larger merchant tankers and merchant chemical vessels have transited this passage and are between 140-180 m in length. Tug transits are one of the key types of vessel using this passage; most transits are general cargo, but also include oil and petroleum products transits.

#### A.2.2.4 Principe and Laredo Channels

For Principe and Laredo Channel, the line between Dupont Island and Duckers Island light is designated the Duckers Island CIP, and is used to track vessels through these channels. This CIP is shown in the following figure.



**Figure A20. Principe and Laredo Channel**

Source: Canadian Coast Guard (CCG) Marine Communications and Traffic Services (MCTS)

Information pertaining to the number of transits by type of vessel, length of vessel by vessel type and the type of tow is presented in the following graphs.

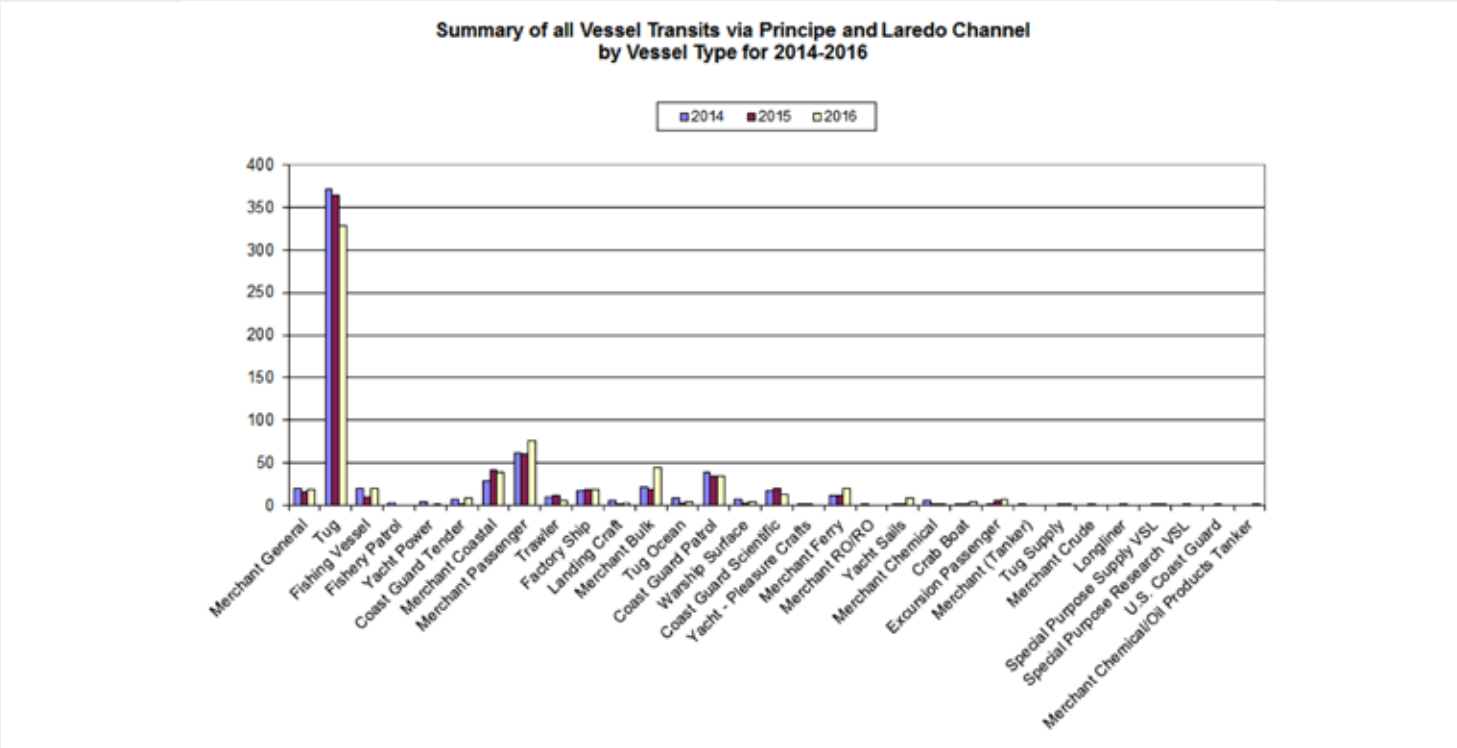


Figure A21. Transits by Vessel Type

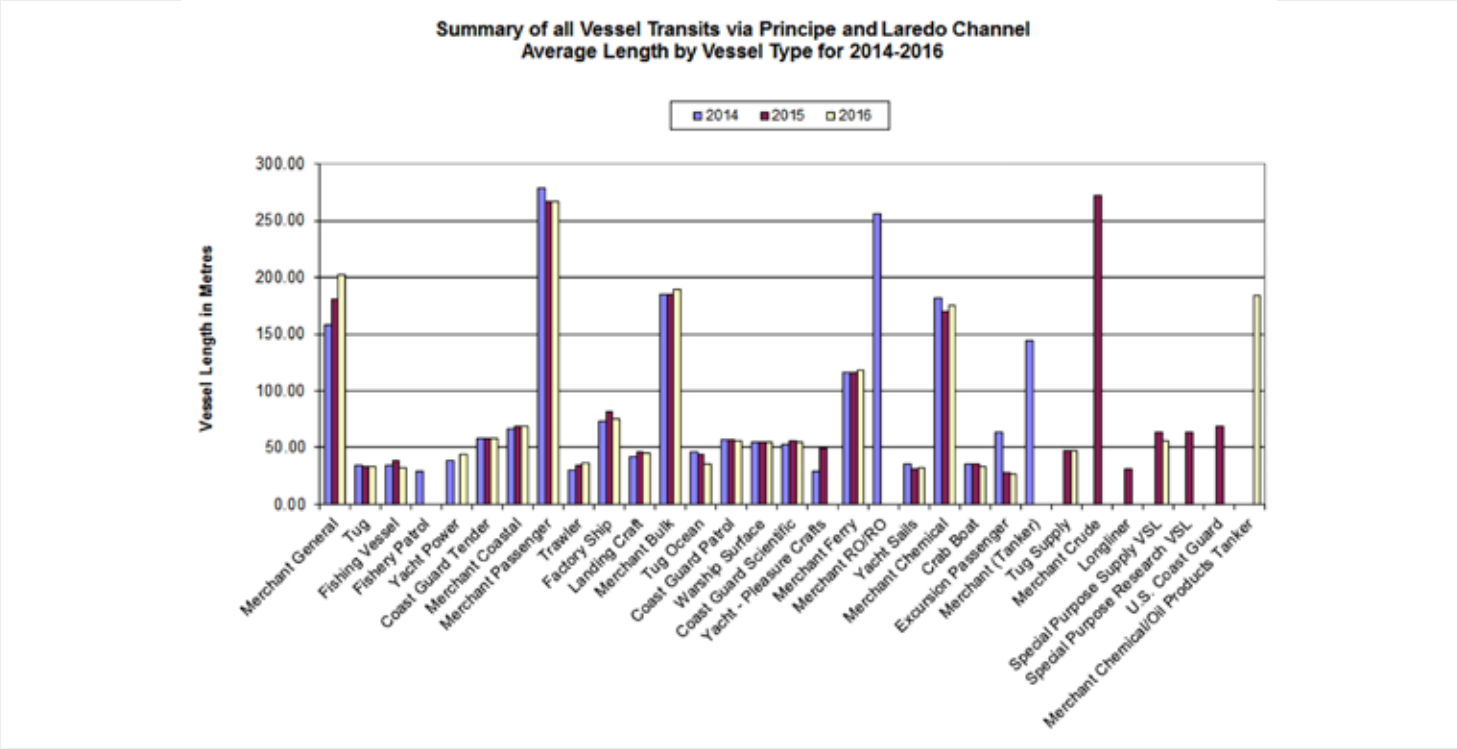


Figure A22. Transits by Vessel Length

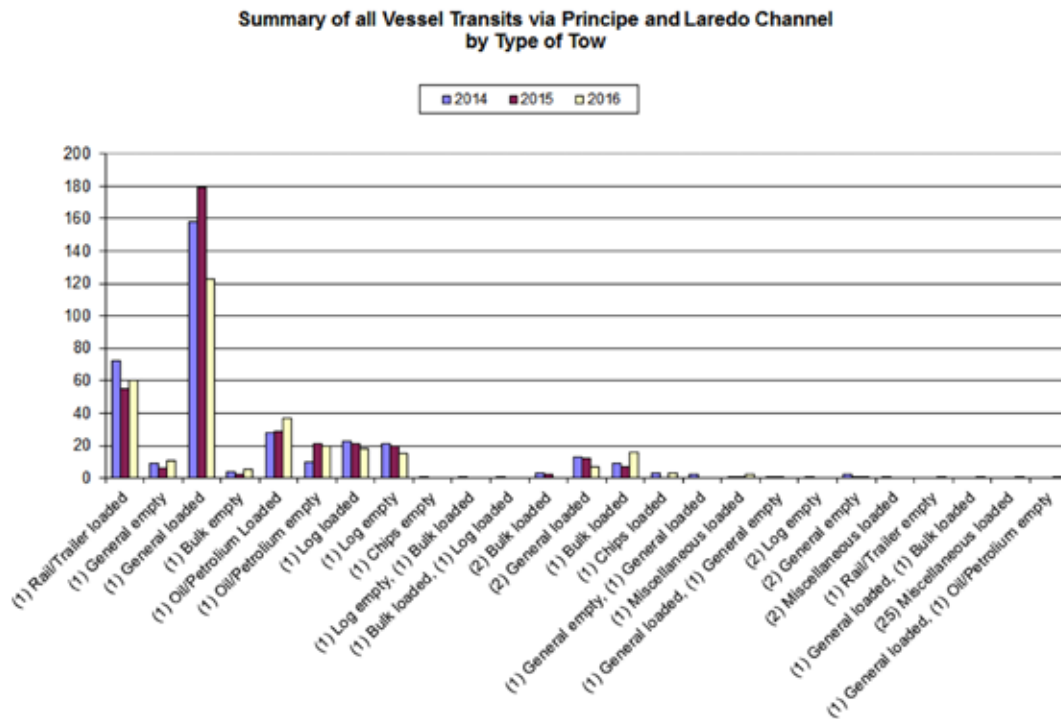


Figure A23. Summary Towed Vessel by Type of Tow

A review of the vessel type, length, and type of tow for Principe and Laredo Channels reveals that the predominant type of vessel transits consist of Tug (30 m in length), Merchant Passenger (250 m in length), and Merchant Bulk (180 m in length) followed by Coast Guard Patrol (50 m in length). While not frequent, Merchant Crude, Merchant Tankers and Merchant Chemical transits have been noted in these waters. Tug transit is the most predominant transit type, and most tug and tows are defined as having general cargo, petroleum loaded, bulk loaded and log tows.



A.2.2.5 Lama Pass

The CIP for Lama Pass is at Walker Island. This call-in point captures all transits via Bella Bella.

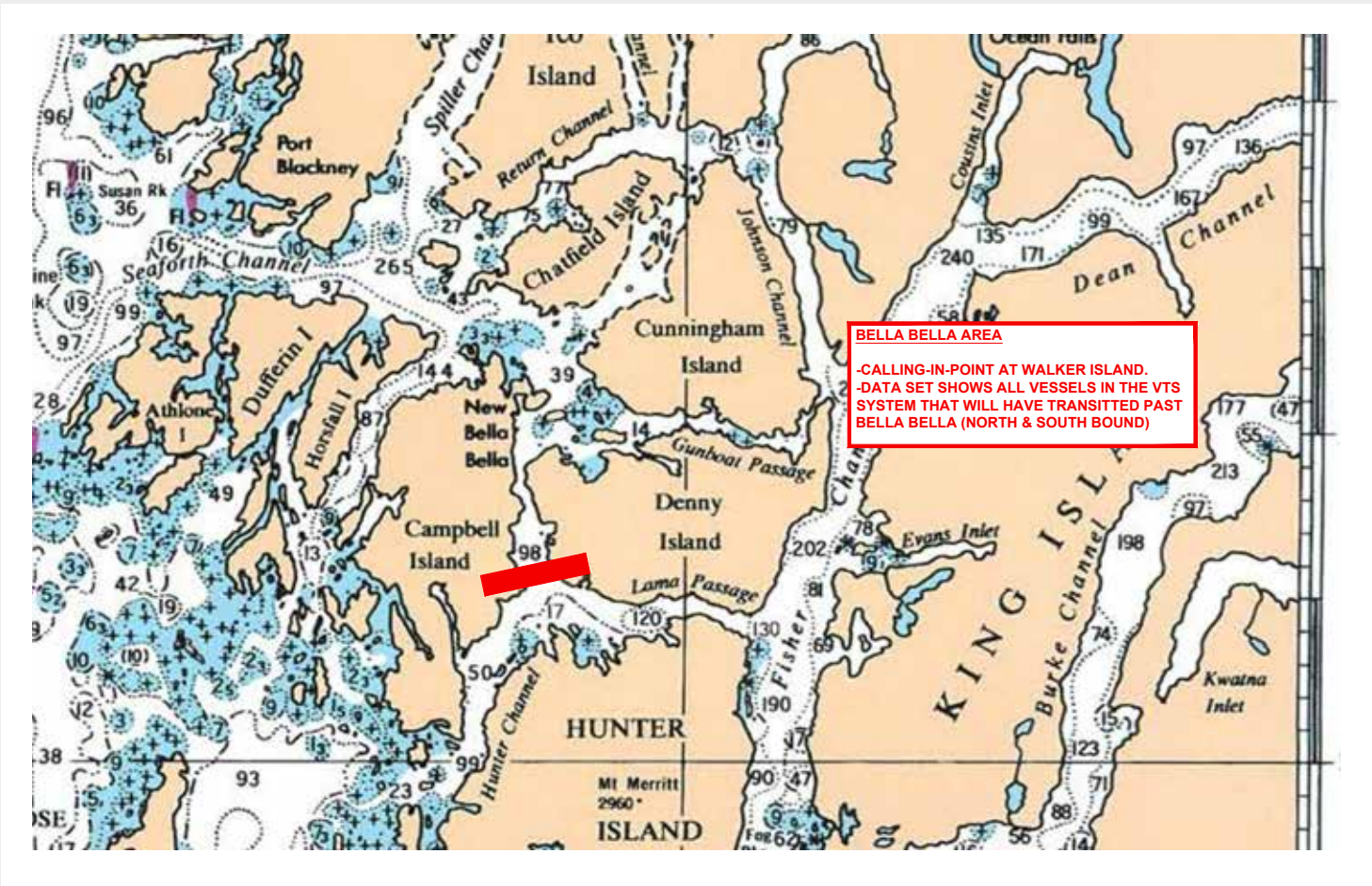


Figure A24. Close up of the Area Surrounding Bella Bella  
Source: Canadian Coast Guard (CCG) Marine Communications and Traffic Services (MCTS)

Information pertaining to the number of transits by type of vessel, length of vessel by vessel type, and the type of tow is presented in the following figures.

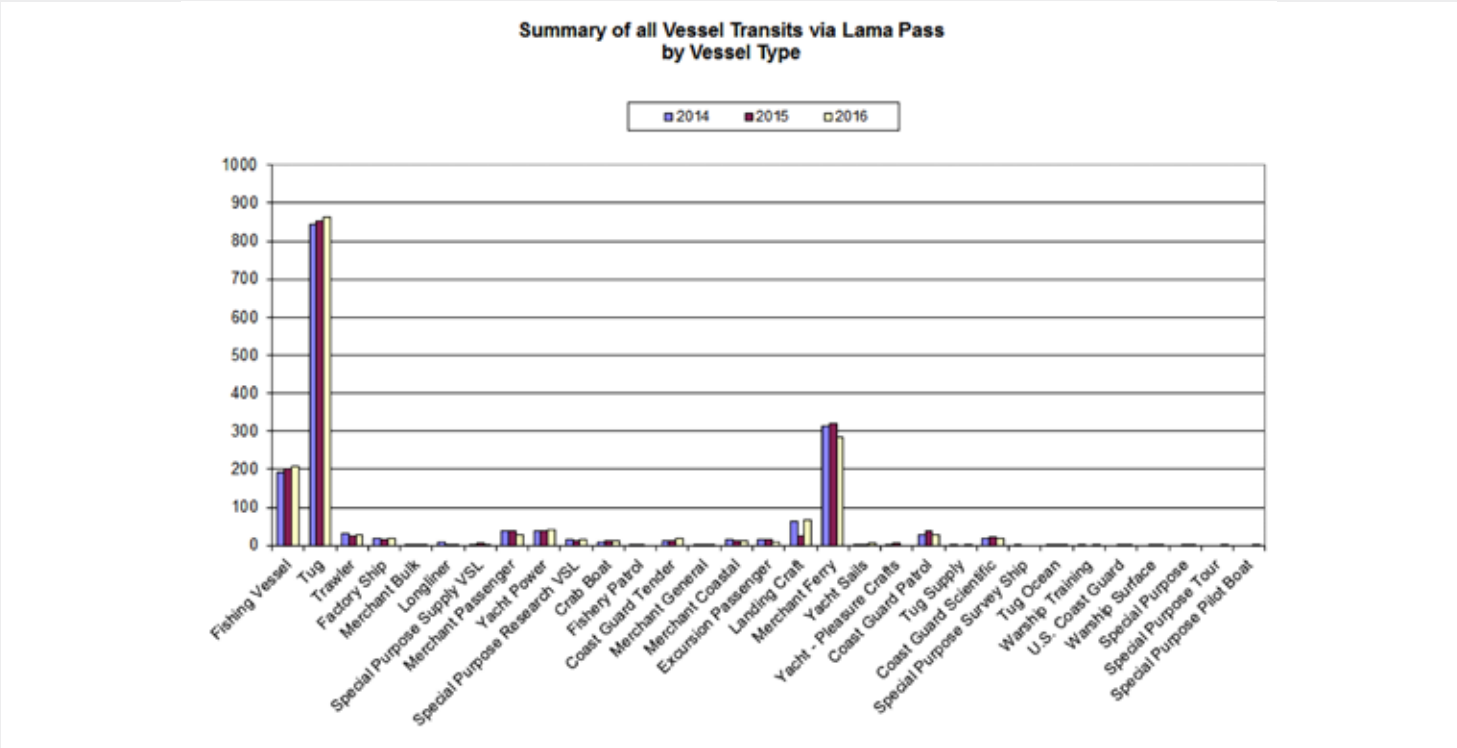


Figure A25. Transits by Vessel Type

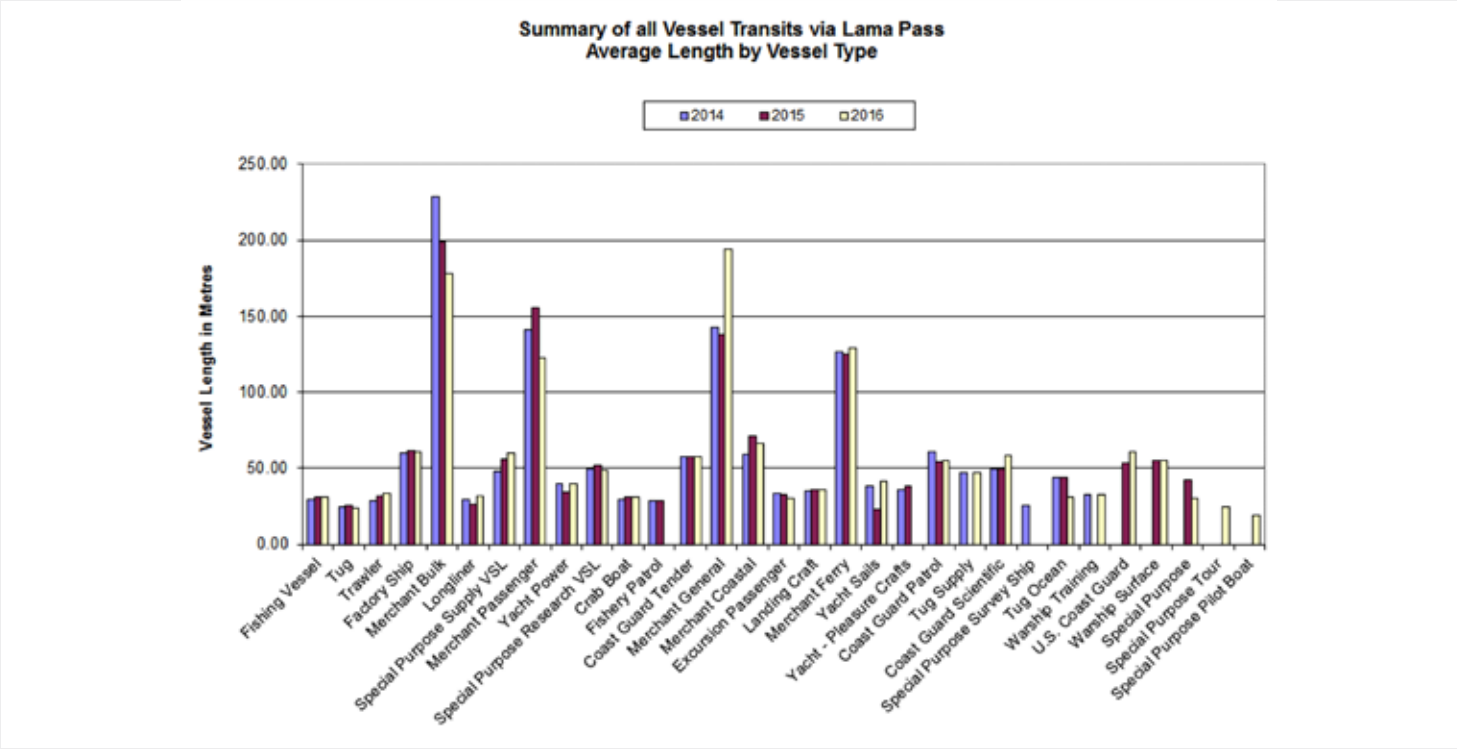
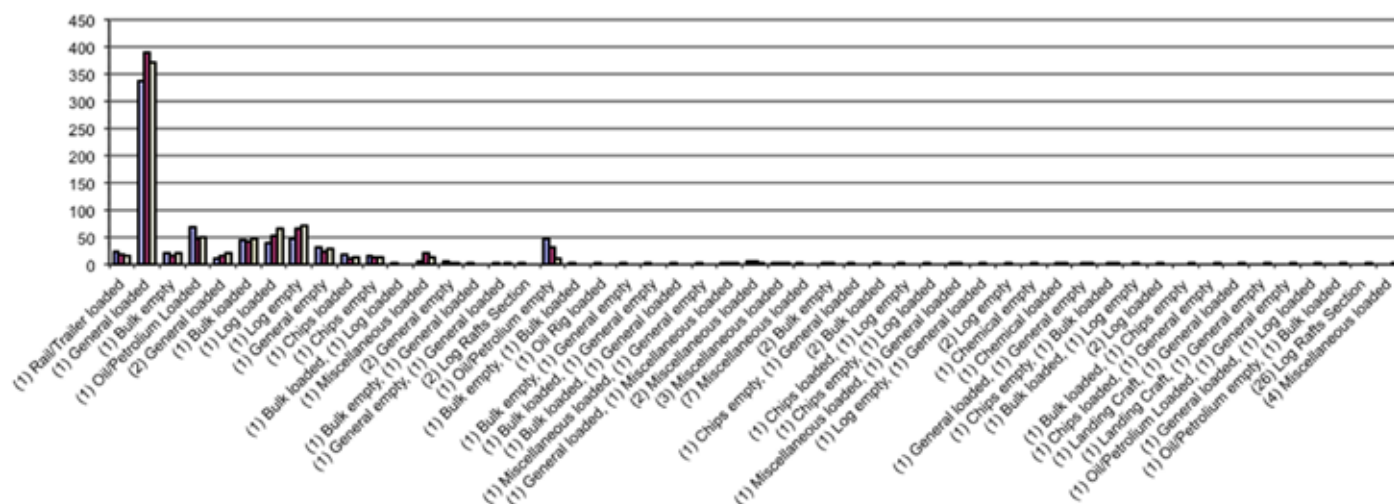


Figure A26. Transits by Vessel Length

■ 2014 ■ 2015 ■ 2016



A review of the vessel type, length and type of tow for Lama Pass reveals that the predominate type of vessel transits consist of Tug (30 m in length excluding tow), Merchant Ferry (175 m in length), and Fishing Vessel (30 m in length) followed by landing craft.

## A.3 ACCIDENT/INCIDENT TYPE: VANCOUVER ISLAND TO ALASKAN BORDER

This section provides an overview of incident data based on the TSB report *Statistical Summary - Marine Occurrences* for shipping accidents by ship type and the number of incidents by vessel type for 2015 and the period between 2006-2014 based on averages.

This section also provides a summary of “groundings and near grounding” on the BC coast obtained via a PowerPoint presentation by the Pacific Pilotage Authority (PPA) and Greenwood Maritime Solutions Ltd., prepared for the HTC specific to managing navigational safety on the BC coast in relation to waivers. Information on the major type of marine incidents as presented in the PPA presentation focused on “groundings” and “near groundings” within the study area of the north coast. The spatial context of “groundings” and “near groundings” as presented provided the team with insight into potential navigational hazard areas based on historical records.

As part of this review, the TSB of Transport Canada (TC) was contacted to obtain data on the types of marine occurrences along the west coast, specific to the area from Vancouver Island to the Alaskan border.

### A.3.1 CANADIAN PERSPECTIVE ON MARINE OCCURRENCES

The TSB report *Statistical Summary - Marine Occurrences* provides an overview of the most frequent types of shipping accidents in 2015 compared to the average between 2006 - 2014. In 2015, nationwide, the most frequent types of shipping accidents were groundings (28%), collisions (26%), sustained damage rendering a vessel unseaworthy/unfit for purpose (17%) and fire explosion accidents (16%). Shipping incidents by accident type are illustrated below: AIS transponders were aggregated based on specific navigational passages that essentially frame the BC coast.

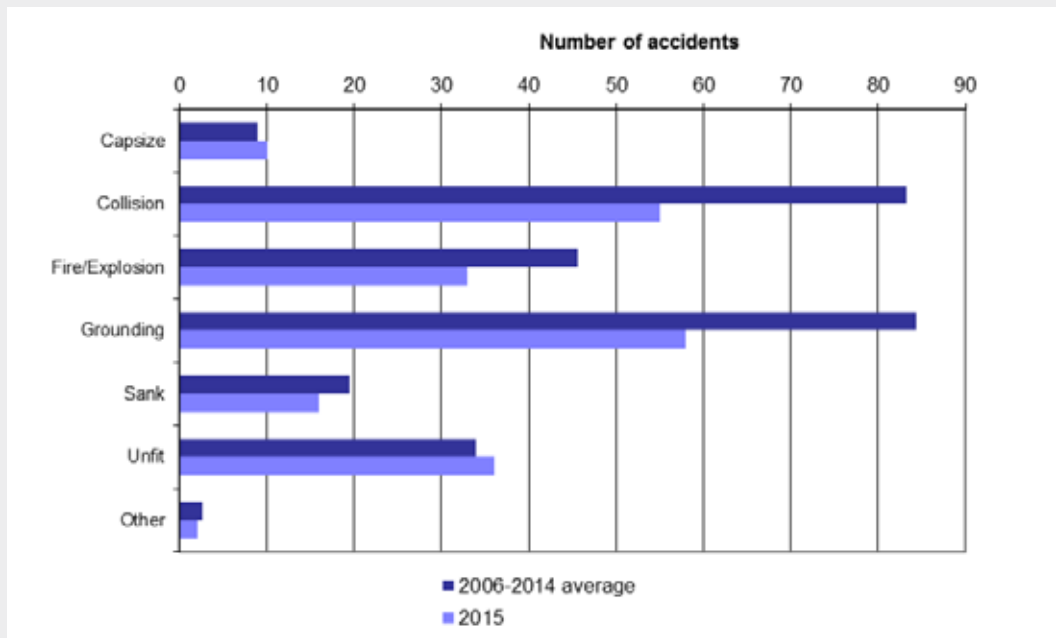
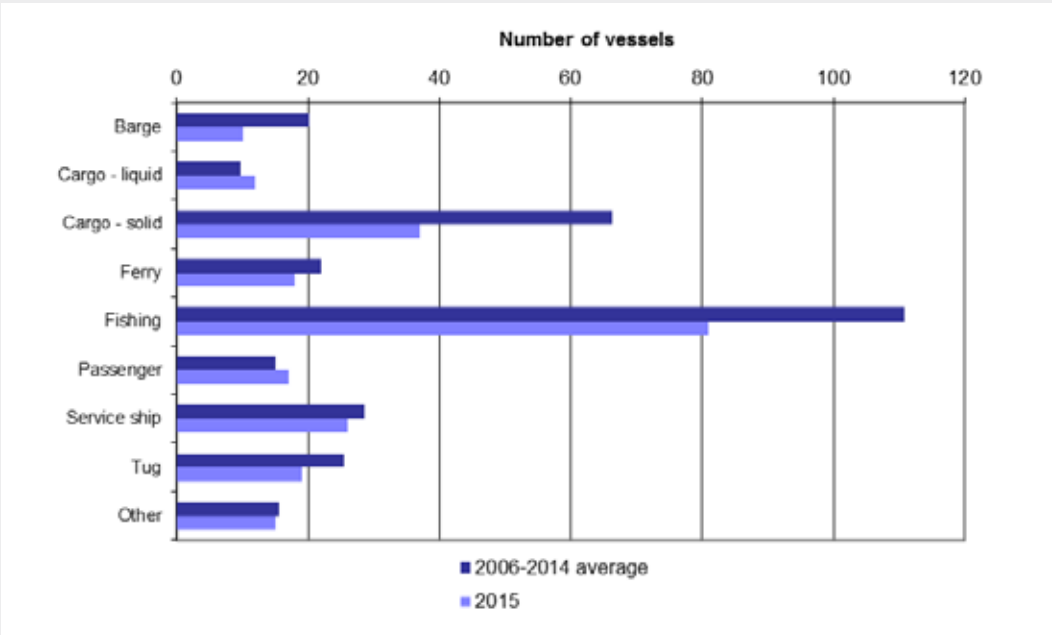


Figure A28. Shipping Accidents by Accident Type

Source: Transportation Safety Board of Canada Statistical Summary-Marine Occurrences 2006-2014, 2015 (April 2016)

Based on the type of vessel involved in an accident, Figure A29 below illustrates that fishing vessels were the predominant type of vessel most involved in accidents (34%), followed by cargo-solid vessels (16%), service ships (11%) and tugs.



**Figure A29. Number of Vessels Involved in Accidents by Type of Vessel**  
Source: Transportation Safety Board of Canada Statistical Summary-Marine Occurrences 2006-2014, 2015 (April 2016)



### A.3.2 SPATIAL CONTEXT TO GROUNDINGS AND NEAR GROUNDINGS, VANCOUVER ISLAND TO ALASKAN BORDER

The TSB data, as in Table A1, shows that groundings were the predominant type of incident between 2011-2015. To help facilitate an understanding of the spatial context to where such incidents occurred, the PPA figures with the identified IMRC response area are shown in Figure A30. The incidents are noted as fishing vessel, barge or tug from 1997-2017. Within the more regionalized study area around Bella Bella, the total number of groundings and near groundings over the 1997-2017 period is presented in Figure A31.

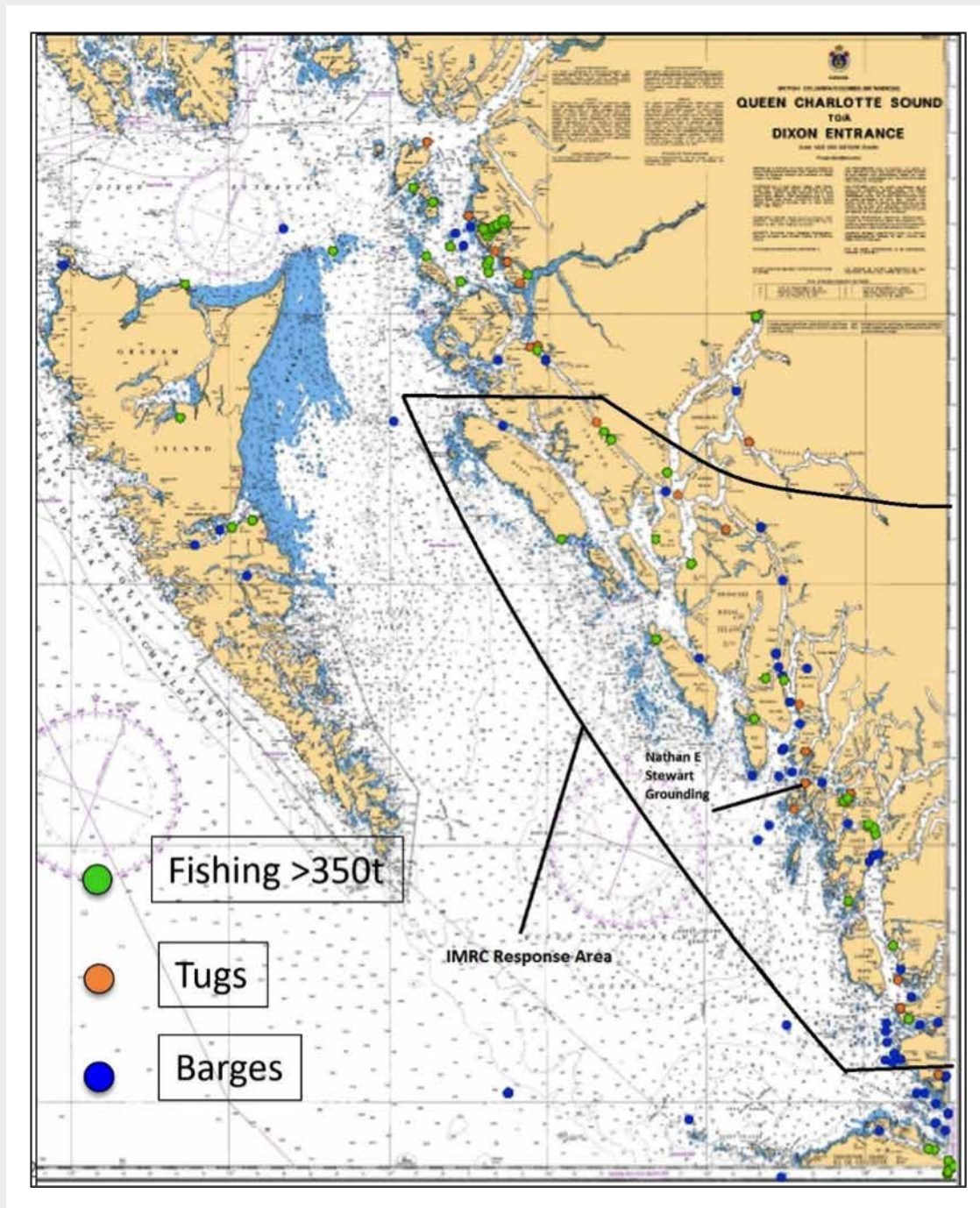


Figure A30. PPA Groundings by Type of Vessel from the North End of Vancouver Island to the Alaska Border

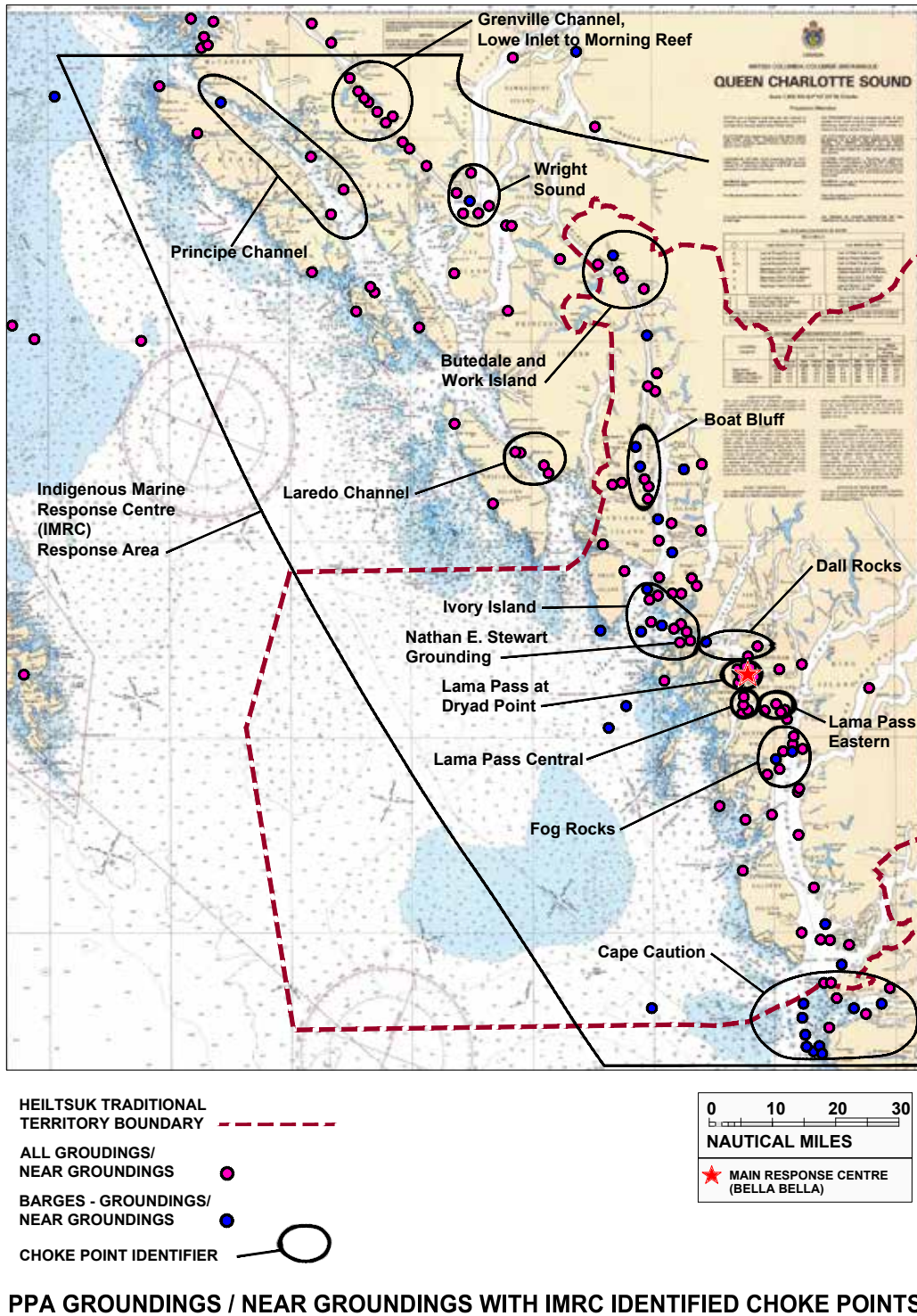


Figure A31. PPA Groundings and Near Groundings in the IMRC Response Area

As illustrated in Figure A31, there are a number of areas where the greatest incidents occur, and these are designated as “choke points”. The number of incidents at the choke points are extracted for the risk analysis performed in Appendix B.

### A.3.3 HISTORICAL TRENDS FOR INCIDENTS (2011 – 2016, INCLUSIVE)

The TSB provided the study team with an analysis of incidents and type of incidents to illustrate trends over a six year time period. The data obtained is for the west coast from the north end of Vancouver Island to the Alaskan border. TSB reports provided summaries of the type of incident based on the following categories:

- Total failures of any machinery or technical system
- Sank vessels
- Groundings
- Strikings
- Collision
- Bottom contact
- Risk of collision

The various types of incidents have been compiled for input into the probabilistic analysis provided in Appendix B to the report.

**Table A1. Number of Accidents/Incidents by Type (2011- 2016)**

TYPE OF INCIDENT	TOTAL
Fire	34
Total Failure of Any Machinery or Technical System	357
Person Seriously Injured or Killed	49
Sank	22
Grounding	106
Striking	26
Risk of Grounding	20
Collision	28
Person/Crew Member Physical Incapacitation	3
Risk Of Striking	13
Person Overboard	7
Cargo Shift/Cargo Loss	6
Sustains Damage Render Unseaworthy/Unfit for Purpose	16
Risk of Sinking	14
Abandoned	1
Bottom Contact	14
Intentional Beaching/Grounding/Anchoring to Avoid Occurrence	2
Risk of Collision (Near Collision)	12
Fouls Underwater Object	1
Capsizes	1
Risk of Capsizing	1
Dangerous Goods Released	1
<b>Total</b>	<b>734</b>



A.3.3.1 Total Failures of any Machinery or Technical System

Total failures of any machinery or technical system are presented below. As shown, there has been an increase in incidents over the six-year period.

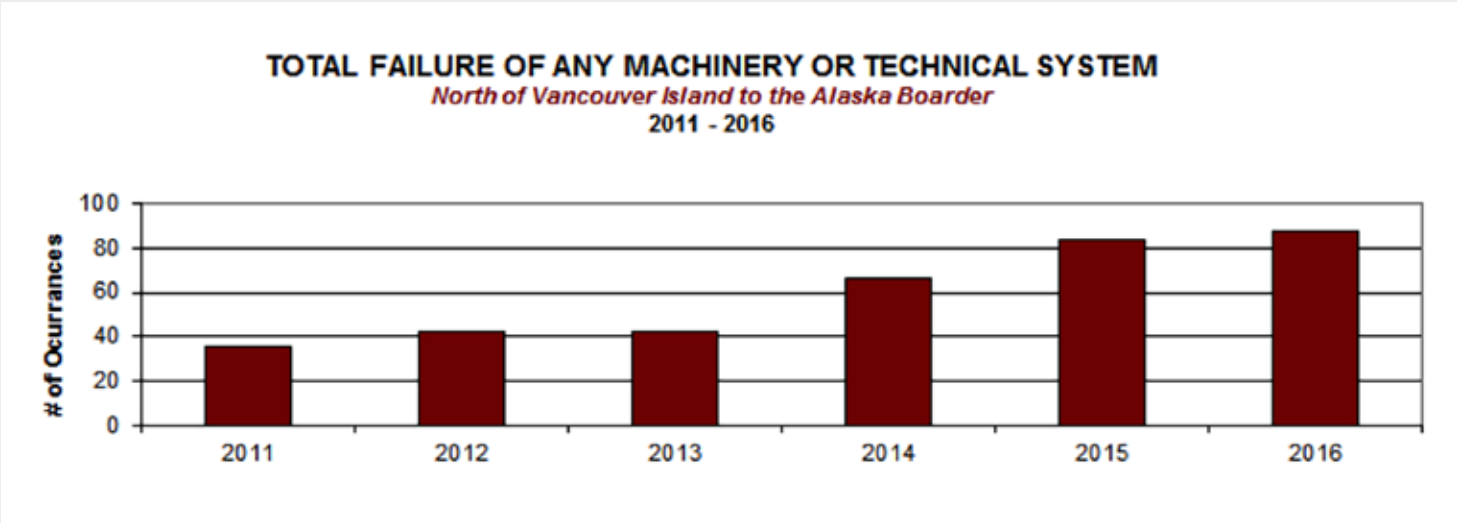


Figure A32. Total Failures of any Machinery of Technical System (2011 – 2016)

The analysis shows that, between the period of 2011 through 2016, the total failures of any machinery or technical system have increased by almost 300% .

A.3.3.2 Sank Vessels

The number of sank vessels is presented below. This type of incident ranges annually from a low of one in 2013 to eight in 2014 and 2016.

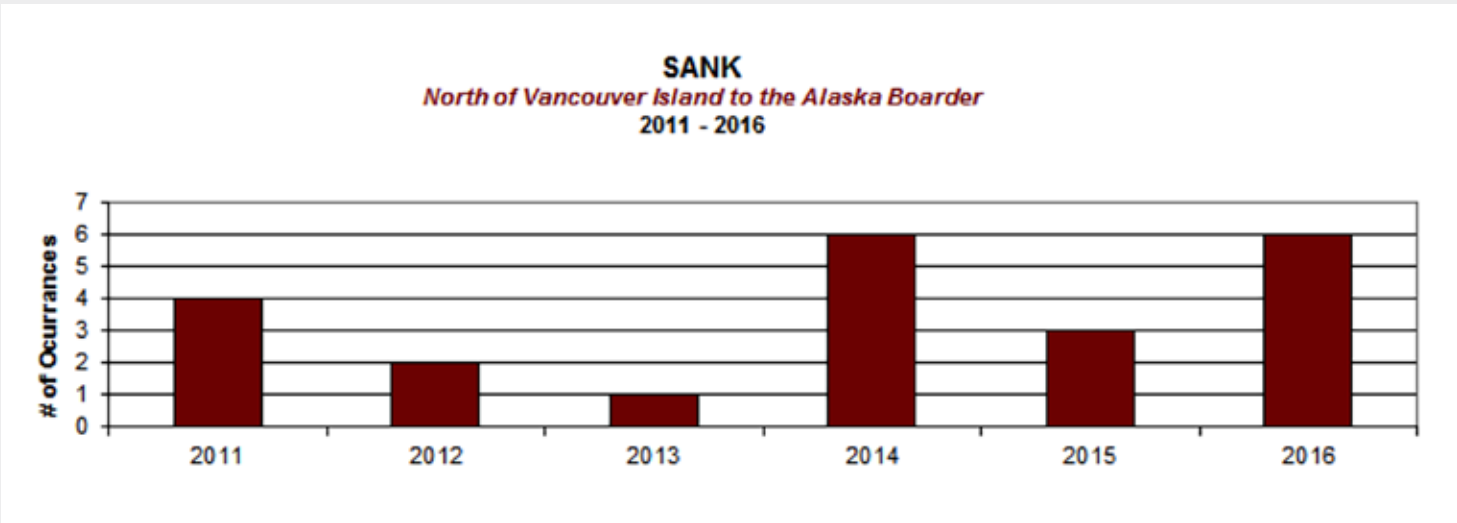


Figure A33. Sank Vessels (2011 – 2016)

A.3.3.3 Groundings

The number of groundings is illustrated below. The average number of groundings per year is around 15, and the number of groundings has increased annually since 2014, to 24 groundings in 2016.

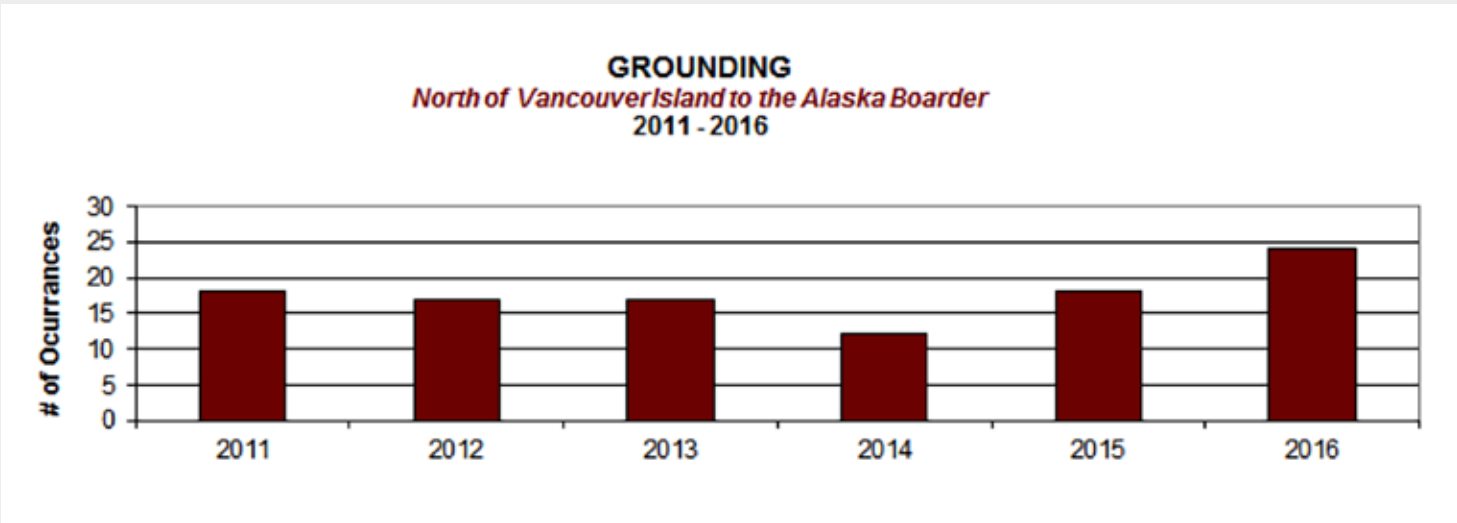


Figure A34. Groundings (2011 – 2016)

A.3.3.4 Strikings

The number of strikings has been declining overall since 2013, although striking increased to three in 2016 from one in 2015.



Figure A35. Strikings (2011 – 2016)



A.3.3.5 Collision

The number of collisions is presented below. There is a trend of increasing number of collisions, from one in 2011 to nine in 2016.

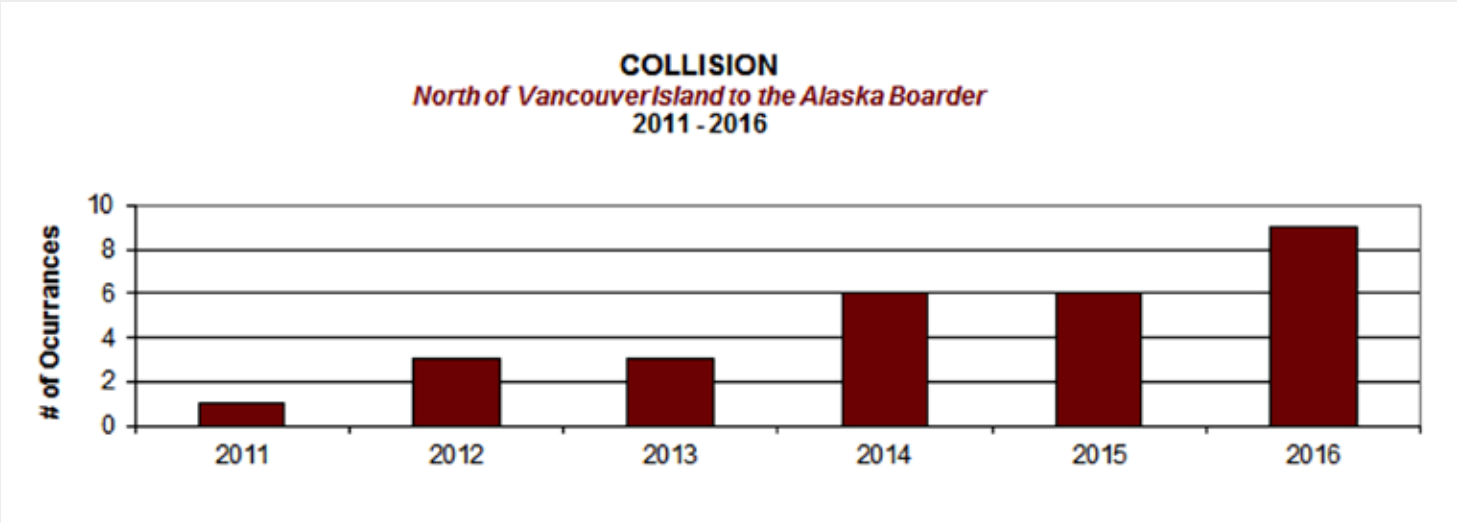


Figure A36. Collisions (2011 – 2016)

A.3.3.6 Sustain Damage Render Unseaworthy/Unfit for Purpose

There appears to be a steady increase between 2011-2016 in the number of incidents in which vessels sustain damage and become unseaworthy and are unfit for purpose.

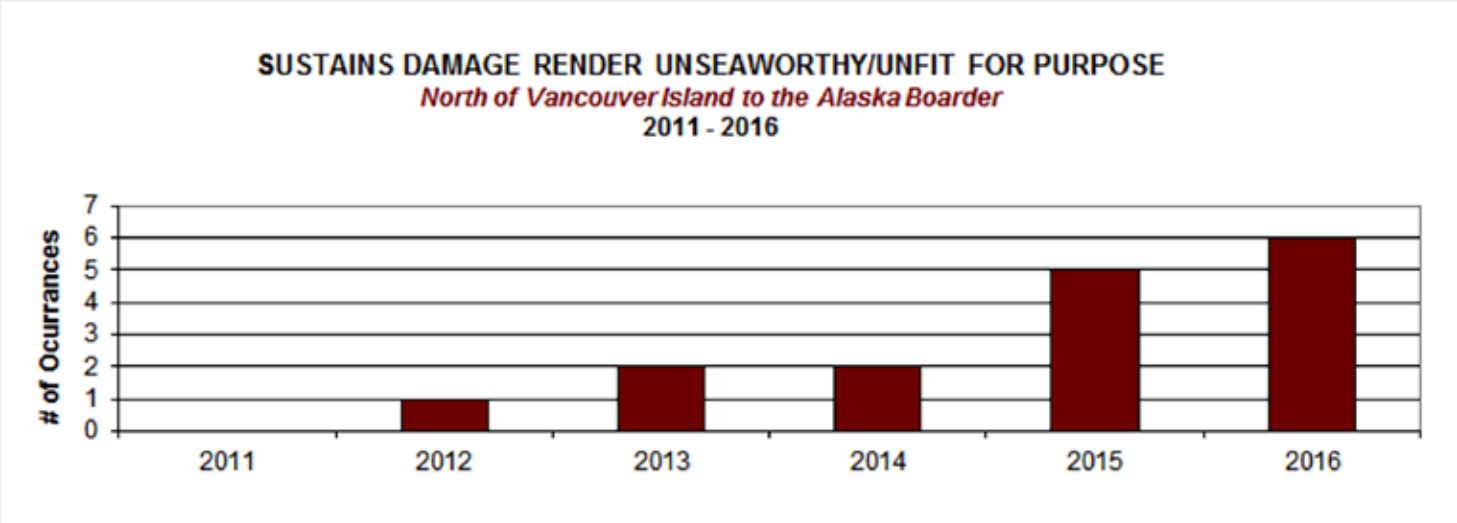


Figure A37. Sustain Damage Render Unseaworthy/Unfit for Purpose

A.3.3.7 Bottom Contact

In terms of bottom contact, there appears to be a trend of increasing occurrences between 2011 -2016.

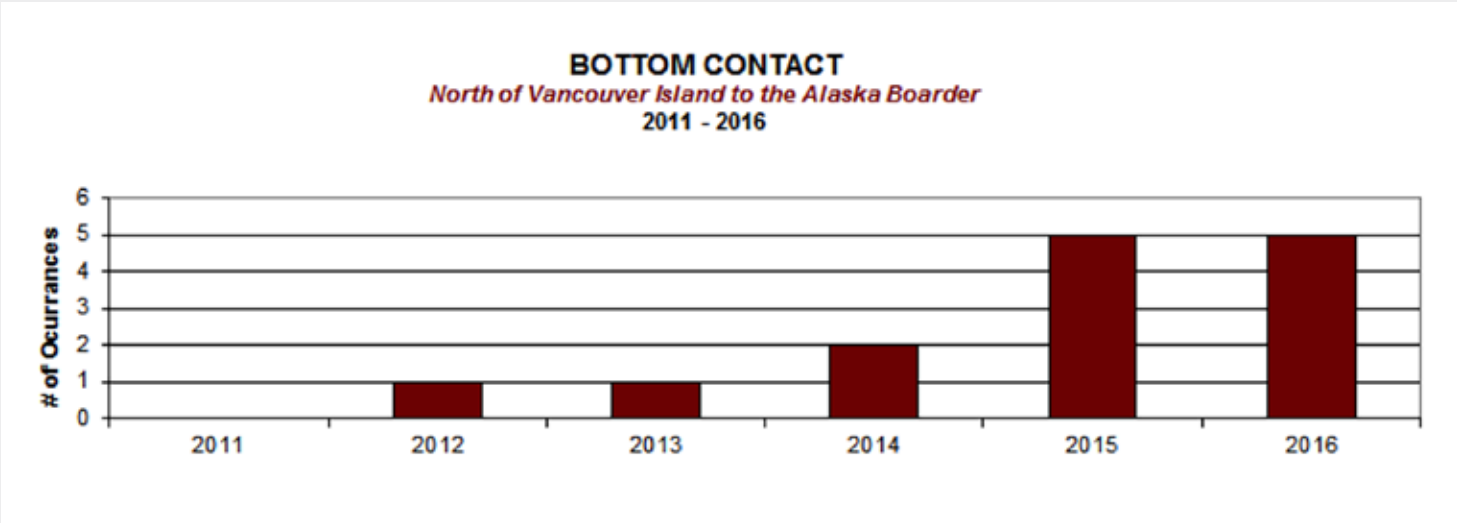


Figure A38. Bottom Contact

A.3.3.8 Risk of Collision

The TSB data show that there is a trend of increasing risk of collision between the years of 2011-2014.

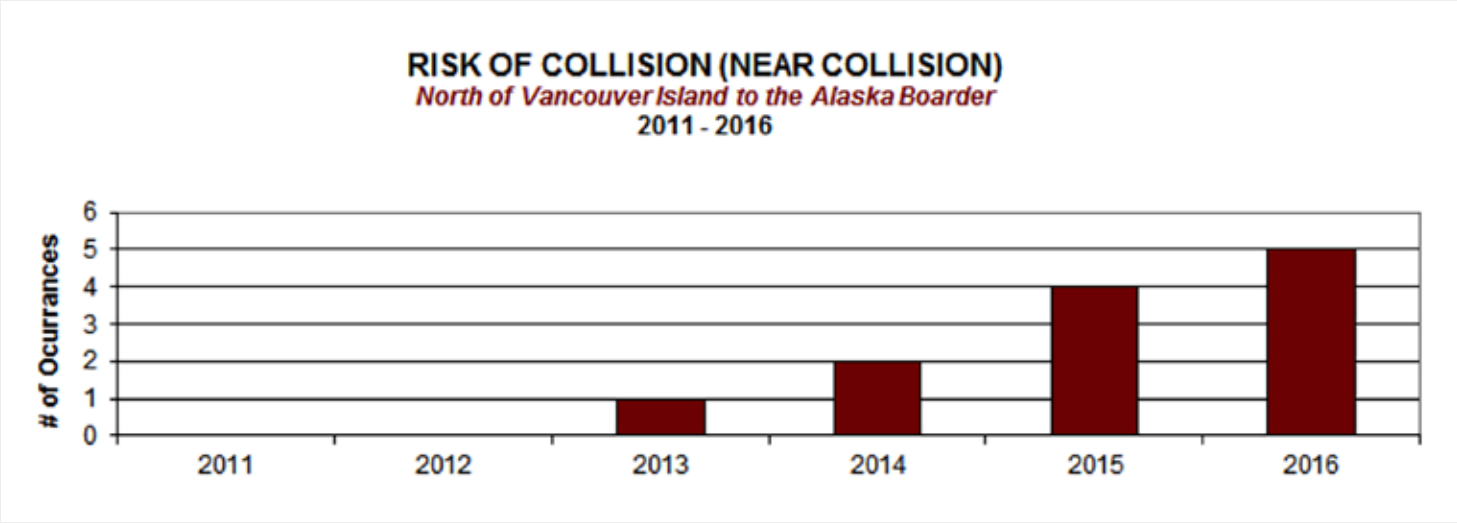


Figure A39. Risk of Collision

A.3.3.9 All Accidents/Incidents

The TSB data show that there is about a 100% increase in all accidents/incidents over the six year period of 2011 to 2016, inclusive, as shown in the following figure:

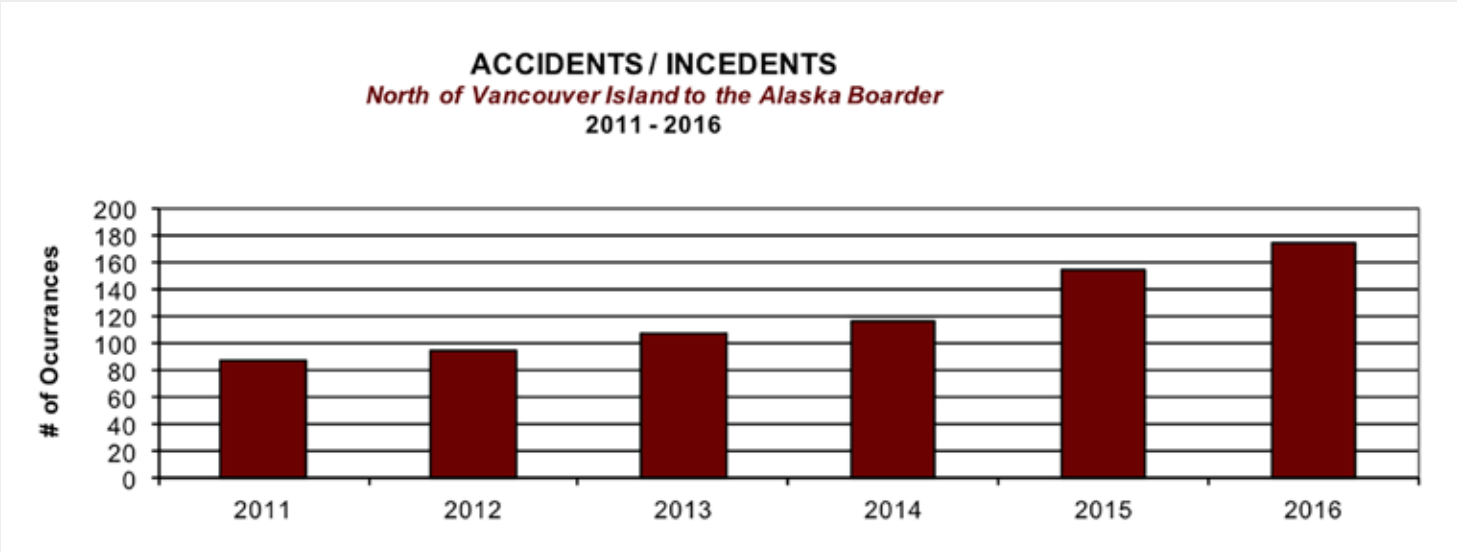


Figure A40. All Accidents/Incidents

Assuming that the rate of increase in all accidents/incidents does not change, then the number of accidents/incidents from the mean period of this data set (January 1, 2014), will double by the year 2020, and that there will be a further 100% increase by the year 2026. Therefore, by the year 2026, there will be in the order of 367 accidents/incidents per year, or roughly one per day. This is calculated by dividing the total number of accidents/incidents of 734 as provided in Table A1, dividing by six to get the number of accidents/incidents per year, and multiplying by three to get the projected number of accidents/incidents in the year 2026, i.e.  $(734/6)*3=367$  accidents/incidents per year in 2026.

## A.4 CONCLUSIONS

### Introduction and Purpose

The HTC is pursuing the development and implementation of an IMRC to address safety, incident prevention and environmental protection associated with marine traffic on the Pacific coast.

The study area of interest is spatially defined as from the north end of Vancouver Island to the north end of Principe Channel and to Morning Reef in Grenville Channel.

Emergency response planning along the Pacific coast is becoming increasingly important to local stakeholders and First Nations due to potential incidents, and in particular the recent *Nathan E. Stewart* sinking and oil spill that impacted environmentally sensitive areas, culturally important areas, resource harvesting and subsistence lifestyle of the Heiltsuk people.

The vessel data (from CCG MCTS), based on CIPs, when correlated to intercoastal waterways, provide an indication of vessel incident occurrences at the various waterways and choke points and provide the data for the risk analysis of vessel incidents conducted in Appendix B of this report.

### Navigational Passages and Vessel Traffic and Characteristics

Navigating the Pacific coast includes ocean going routes and intercoastal waterways. The types of vessels transiting such waterways vary substantially. As part of this study six navigational routes have been identified and through data provided by the CCG MCTS and the TSB (for incidents), we have characterized each navigational route by type of vessel, frequency and length. Also included is the number and type of tow, as the data revealed the most predominant form of transport along the coast is via tug and tow. The findings by navigational route are presented below:

- A review of vessels transiting Cape Caution covers all vessels transiting the north coast which can either transit Hecate Strait or Lama Pass. The data reveal that tug traffic, Merchant Passengers, Merchant Ferry, and fishing boats are the most predominant type of vessels transiting this waterway. In terms of tugs, the predominant forms of tow include general, oil/petroleum, rail, bulk and logs.
- A review of Hecate Strait reveals different characteristics of vessels transiting the Strait and is reflective of the ocean oriented types of transits such as Merchant Passenger, Merchant Container and Merchant Bulk ships being the most predominant type of vessel transiting this waterway. In terms of tugs, the predominant tow is general, logs and oil/petroleum.
- A review of the Grenville Channel reveals that the predominant type of vessel transits consists of Tugs, Merchant Ferry, and fishing vessels followed by Merchant Passenger Vessels. It is noted that in 2015, both merchant crude and merchant chemical vessels transited the passage. As noted, tugs were the predominant type of transit, and mostly towed general cargo, as well as both loaded and unloaded petroleum barges.
- A review of the Douglas Channel confirms that the predominant type of transits is represented by Merchant Ferry, Tug, and Merchant Bulk, followed by Merchant General vessels. It is noted that larger merchant tankers and merchant chemical vessels have transited this passage and are between 140-180 m in length. As tug transits are one of the key types of vessel using this passage, most transits are for general cargo but also include oil and petroleum products.

- A review of Principe and Laredo Channel reveals that the predominant type of vessel transits consist of Tug, Merchant Passenger, and Merchant Bulk followed by Coast Guard Patrol. While not frequent, Merchant Crude, Merchant Tankers and Merchant Chemical transits have been noted in these waters. Tug transit is the most predominant transit type, and most tug and tows are defined as general cargo, rail, oil/petroleum and logs.
- A review of Lama Pass reveals that the predominate type of vessel transits consists of Tug (30 m in length excluding tow), Merchant Ferry (175 m in length), and Fishing Vessel (30m in length) followed by landing craft. The predominant form of tug and tow is for general cargo, logs and oil/petroleum products loaded and empty.

## Occurrences

For the area from Cape Caption to the Alaskan Border the following comments summarize the type of incident and the trends between 2011-2106, as provided by TSB:

- Total failures of any machinery or technical system have been increasing in incidents over the five-year period.
- No trend is evident for sank vessel, but the number ranges from a low of one in 2013 to eight in 2014 and 2016.
- The number of groundings per year is around 15, and the number of groundings has increased annually since 2014 to 24 groundings in 2016.
- The number of strikings has been declining overall since 2013 although striking increased to three in 2016.
- There is a trend of increasing collisions, from one in 2011 to nine in 2016.
- In terms of bottom contact, there appears to be a trend of increasing occurrences between 2011 - 2016.
- There is a steady increase between 2011 and 2016 in the number of incidents in which vessels sustain damage and become unfit for purpose.
- According to the TSB data, there appears to be a trend of increasing risk of collision between the years of 2011 and 2014.
- The TSB data show that there was a 100% increase in all accidents in the six year period from 2011 through 2016.

## Observations

The vessel inventory data presented in this Appendix provided a breakdown of the Pacific coast into various navigational passages and provided information on vessel transit frequency by type of vessel, length of vessel and type of tow needed to support the probabilistic analysis provided in Appendix B of this report.

The table below provides a summary of the top three types of vessel transits by navigational route, the number of annual transits by type, average length of vessel, speed of vessel and the length of tow to support the probabilistic analysis.



Table A2. Summary Vessel Traffic in Choke Points

NAVIGATIONAL ROUTE /PASSAGE	TOP THREE VESSEL TYPES TRANSIT NAVIGATIONAL ROUTE/PASSAGE (2016)	NUMBER OF TRANSITS PER TOP THREE TYPE OF TRANSITS (2016)	AVERAGE LENGTH OF VESSEL (2016 IN m)	AVERAGE SPEED BY VESSEL CLASS (knots)	REDUCED SPEED TO MAINTAIN SAFE STEERAGE	MAXIMUM TOW DEPLOYED (m)	SAFE MINIMUM TOW DEPLOYED (m)
Cape Caution	Tug Merchant Passenger Merchant Ferry	1419 397 281	27 253 134	8	4	457	61
Hecate Strait	Merchant Passenger Merchant Container Merchant Bulk	502 192 163	269 308 196	14	8		
Grenville Channel	Tug (general loaded) Merchant Ferry Fishing Vessel	707 426 184	27 95 30	8	4	457	61
Douglas Channel	Tug Merchant Ferry Merchant Bulk	121 102 65	17 21 188	8	4	365	61
Principe and Laredo Channel	Tug Merchant Passenger Merchant Coastal	328 76 39	34 267 69	8	4	600	61
Lama Pass	Tug Merchant Ferry Fishing Vessel	862 285 207	24 129 31	8 10	4 5	457	61

## A.5 REFERENCES

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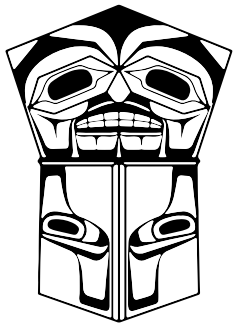
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## **HEILTSUK TRIBAL COUNCIL**

### APPENDIX B

#### Collision With An Obstacle And The Expected Number Of Incidents

## B.1 INTRODUCTION

This Appendix details the approach taken to estimate the probability of a grounding-related incident between an out-of-control-vessel with a specific obstacle. Such incidents could lead to a spill of cargo, with associated environmental consequences. In general terms, the methodology follows the approach specified both in the American Association of State Highway and Transportation Officials (AASHTO) Code (2016) as well as in the Canadian Standards Association Canadian Highway Bridge Design Code (CSA-S6-14 (2014)), for estimating the probability of vessel collisions with bridge piers and the resulting collision forces. This Section, however, only uses the approach in those Codes insofar as the estimation of collision or grounding probability, since here the resulting collision forces are not addressed.

The approach detailed here is also used to determine the expected number of assistance calls likely to occur per year, depending on the traffic and the implemented incident mitigation policies.

Obstacles are defined here in association with **choke points** (or challenging locations along the navigation route). A total of 13 choke points are considered here, as shown in Figures B1 and B2. Most choke points, like Grenville Channel or Lama Pass Dryad Point, offer obstacles on either side of the line. In all these cases, or when there is a bend in the line, there could be more than one possibility of collision with the obstacles. All such possibilities are considered in the probability estimation, and a successful (no collision) passage is considered to imply no collision with any of the different obstacles.

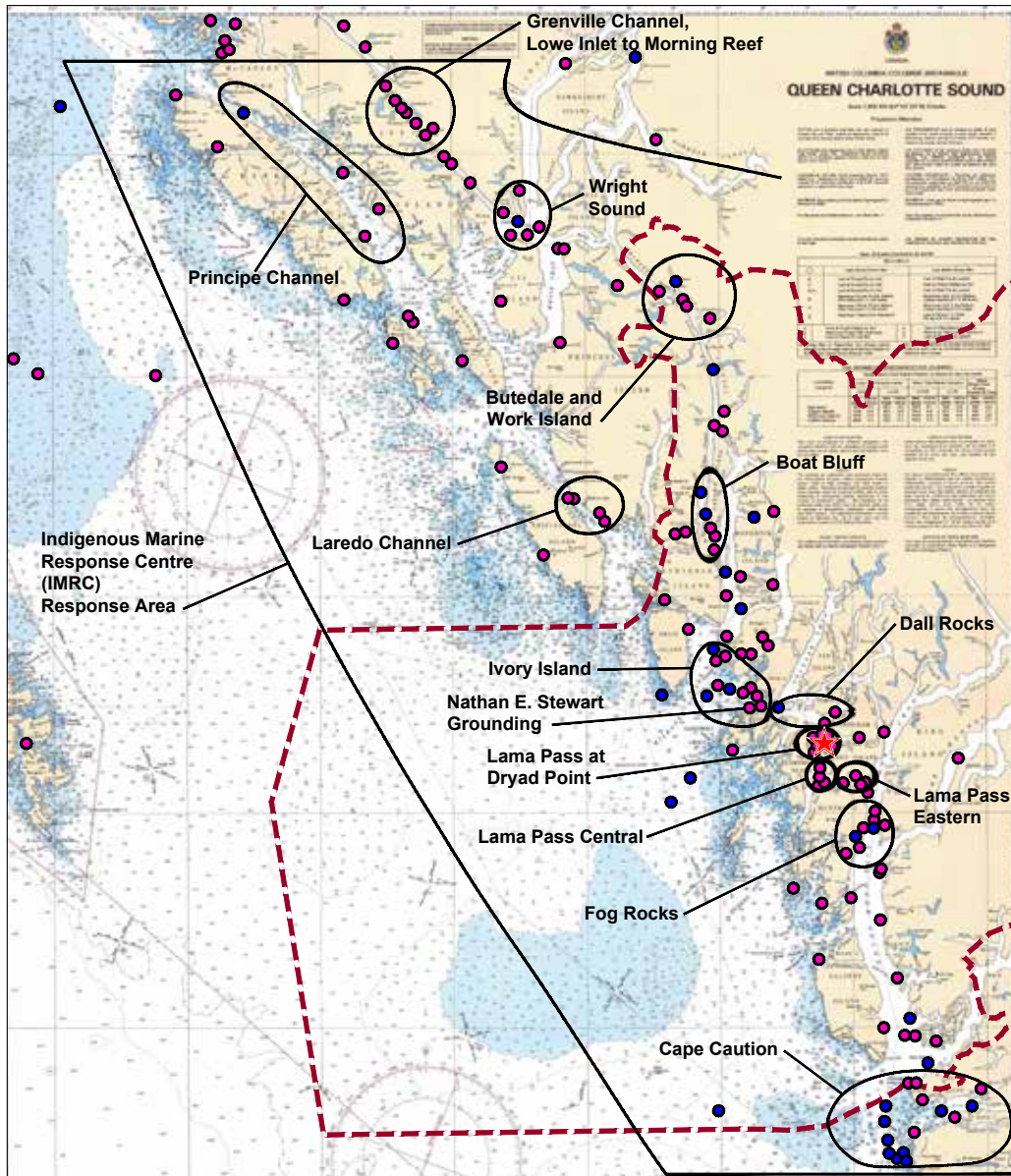
The vessels could be out-of-control because of either mechanical or navigational issues, which can be affected by a combination of human errors and environmental conditions (wind, currents or fog). A multi-year study by the American Bureau of Shipping (ABS) reported that human errors are the dominant factor in maritime accidents. Human errors can be attributed to the vessel master, crew, or the local pilot onboard the ship. Among all the human error types classified in the numerous databases and libraries of accident reports evaluated in the ABS study, human failures in situational awareness and situational assessment are overwhelmingly predominate. According to accident data from the Canadian Transportation Safety Board (TSB) evaluated in the ABS study, 84% of maritime accidents are directly associated with the occurrence of human error. This is consistent with the findings in other countries; 85% in Australia; 82% in United Kingdom; and 75%-96% by various studies in the U.S.

The probability that a vessel will be out-of-control is called the **Aberrancy Rate (R)**. This is normally estimated on the basis of data from past incidents. Codes, however, specify aberrancy rates which should be generally conservative in order to apply to different situations. Thus, AASHTO (2016) and CSA-S6 (2014) specify

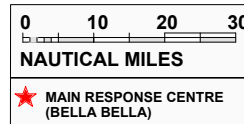
$$R = 0.6 \times 10^{-4} \quad \text{for ships (vessels other than barges)}$$

$$R = 1.2 \times 10^{-4} \quad \text{for barges}$$

Other **R** values can be found in the literature:  $R = 3.6 \times 10^{-4}$ , for example, was used in the vessel collision study for the Alex Fraser Bridge in Vancouver, a situation involving heavy river traffic. For this report, none of the above aberrancy rates were used. Rather, **R** was estimated by matching the data for all grounding and near grounding-related incidents observed from 1997 to 2017 (20 years) from the Pacific Pilotage Authority (PPA) in the area shown in Figure B1, from Cape Caution to the north end of Grenville Channel, an area that includes all 13 identified choke points.



- HEILTSUK TRADITIONAL  
TERRITORY BOUNDARY - - - - -
- ALL GROUDINGS/  
NEAR GROUNDINGS ●
- BARGES - GROUNDINGS/  
NEAR GROUNDINGS ●
- CHOKE POINT IDENTIFIER ○



### PPA GROUNDINGS / NEAR GROUNDINGS WITH IMRC IDENTIFIED CHOKE POINTS

Figure B1. Coastal Zone of Interest and Definition of Choke Points, Showing PPA Groundings and Near Grounding Incidents from 1997-2016 (20 years, inclusive)



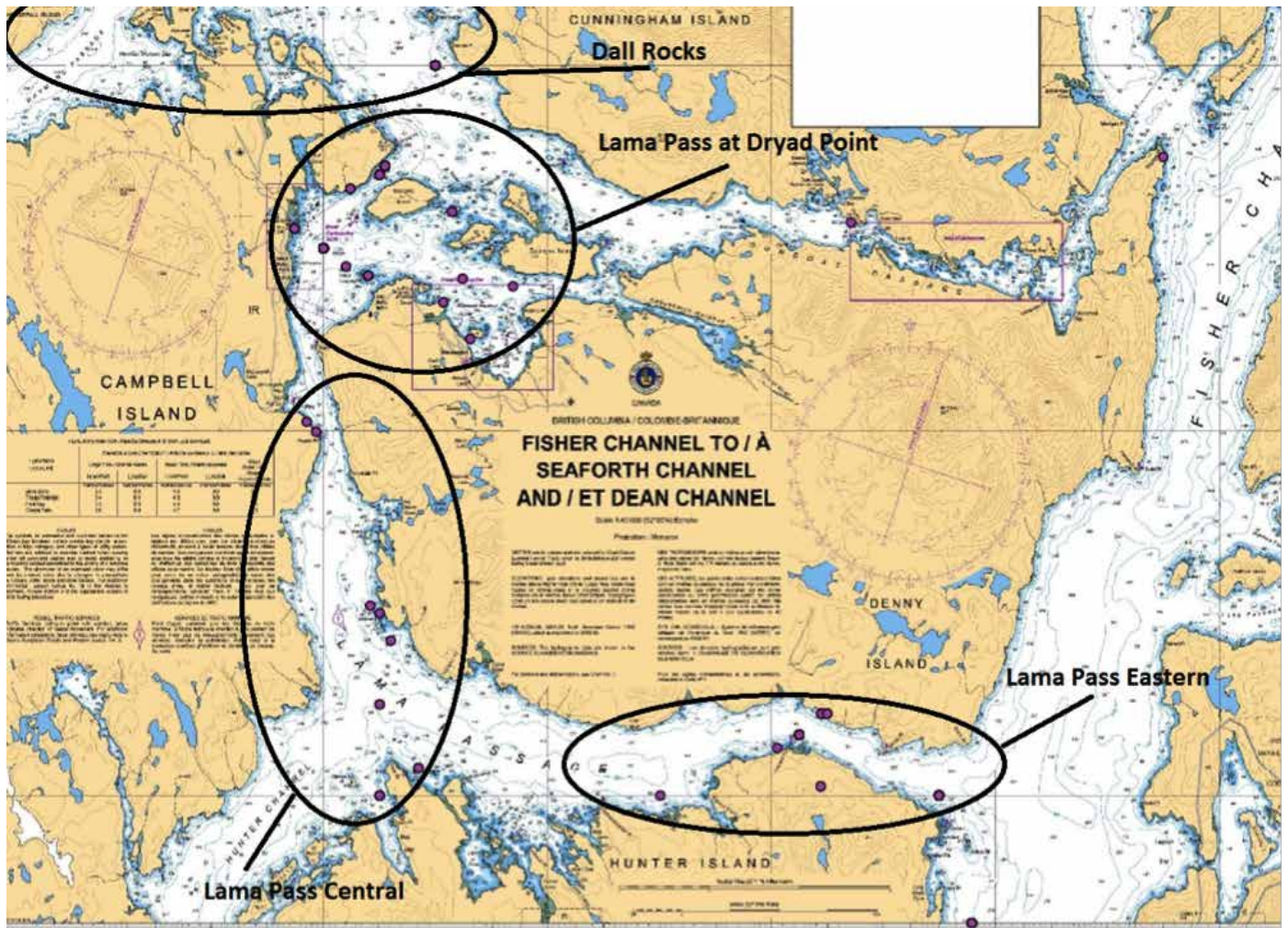


Figure B2. Zone around Bella Bella and Surrounding Choke Points, Showing PPA Groundings and Near Grounding Incidents from 1997-2016(20 years, inclusive)  
Source: Pacific Pilotage Authority



## B.2 PROBABILITY OF GROUNDING OR COLLISION WITH AN OBJECT

Following the approach similar to that detailed in either the American Code AASHTO (2016) or the Canadian Code S6 (2014), the probability of an event related to grounding or collision with an obstacle,  $P_e$ , is expressed as follows:

$$P_e = P_e|_R \cdot R \quad [B.1]$$

In which  $P_e|_R$  is the conditional probability of grounding given that the vessel is out-of-control and  $R$  is the **aberrancy rate**.

The conditional probability  $P_e|_R$  is obtained from

$$P_e|_R = P_G \cdot R_C \cdot R_{XC} \cdot R_D \quad [B.2]$$

In which

$P_G$  = geometric probability that the vessel will collide with the obstacle, given that it is out of control or likely to be involved in a collision;

$R_C$  = adjusting coefficient for the effect of currents parallel to the vessel transit path. Following AASHTO,  
 $R_C = 1.0 + V_C / 10.0$   
 $V_C$  being the current velocity parallel to the vessel transit path, in knots;

$R_{XC}$  = adjusting coefficient for the effect of cross-currents, perpendicular to the vessel transit path.  
Following AASHTO,  
 $R_{XC} = 1.0 + V_{XC}$ ,  
 $V_{XC}$  being the cross-current velocity in knots;

$R_D$  = adjusting coefficient to reflect traffic density and the implementation of navigational aids for hazard mitigation. Following the guidelines in the CSA-S6 (2014) Code, values for  $R_D$  are assigned as follows:

$R_D = 1.0$ , corresponding to *low density traffic*, when vessels rarely meet, pass or overtake each other in the immediate vicinity of the obstacle, or for *average or high traffic density when mitigations are in place*;

$R_D = 1.3$ , for *average density traffic*, when vessels occasionally meet, pass or overtake each other in the immediate vicinity of the obstacle;

$R_D = 1.6$ , for *high density traffic*, when vessels routinely meet, pass or overtake each other in the immediate vicinity of the obstacle and *no mitigations are in place*.

In this report,  $R_D$  is given the value 1.3 for the current level of traffic, with no mitigation measures or navigational aids in place. This value is used in matching the observed incident data for estimating the aberrancy rates. Should mitigation measures be implemented with the current traffic volume, the value of  $R_D$  is reduced to 1.0.

This report also studies the impact of either a 10%, or 25% or a 100% increase in annual traffic volume. In these cases, with no mitigations, the value of  $R_D$  is taken (respectively) as 1.4, 1.5 or 1.6. The influence of mitigation measures, even at these higher levels of traffic, is always expressed by taking  $R_D = 1.0$ .

Figure B3 illustrates the approach used in the Codes for estimating the geometric probability  $P_G$ . This Figure shows a vessel at point O approaching an obstacle at point P. The normal navigation path follows the direction  $\mathbf{n}$  which makes an angle  $\phi$  with the North direction N. Being out-of-control, the vessel could take, randomly, any direction other than the intended  $\mathbf{n}$ .

The length of the vessel is  $L$  and, if continuing along the navigation line  $\mathbf{n}$ , a point  $P'$  would be reached at which the vessel will be closest to (or at a minimum distance from) the obstacle, point P. The line direction  $P'P$  is thus perpendicular to the direction  $\mathbf{n}$ , and the distance from the closest point  $P'$  to P is shown as  $X$ .

Should the vessel become out of control and take a direction randomly different from  $\mathbf{n}$ , it would cross  $P'P$  at a point  $P''$ , which is at a random distance  $x$  from  $P'$ . Should  $x$  be less than  $X$ , then there would be no collision. If, on the other hand, the direction taken results in  $x$  being greater than or equal to  $X$ , then there would be a collision. The probability of such an event is defined as  $P_G$  and equals the probability  $\text{Prob}(x \geq X)$ .

In order to calculate the minimum distance  $X$  between the direction  $\mathbf{n}$  and the obstacle at P, the following data are required:

- The location of the obstacle at P, given by its coordinates in a  $(n_x, n_y)$  coordinate system as shown in Figure B3;
- The location of the vessel at O, given by its corresponding coordinates;
- Either the angle  $\alpha$  (the orientation of the normal navigation line with respect to the North N), or the coordinates of any other point along  $\mathbf{n}$ .

The distance  $x$ , from  $P'$  to the intersection  $P''$  in Figure B3, is then a random variable. The variability in  $x$  corresponds to the randomness in the out-of-control orientation taken by the vessel. This distance  $x$  is represented by a Normal probability distribution, with a mean of zero and a standard deviation equal to the length of the vessel,  $L$ . This assumption is adopted here and is as specified in either the current Canadian Code S6 or in the American Code AASHTO for studies of vessel collision with bridges or piers.

The length  $L$  for *barges* includes the length of the tug, the length of the tow line and the length of the barge itself. These lengths vary with the type of tug and the challenge posed by the choke point, as follows (information provided by Peter Brown).

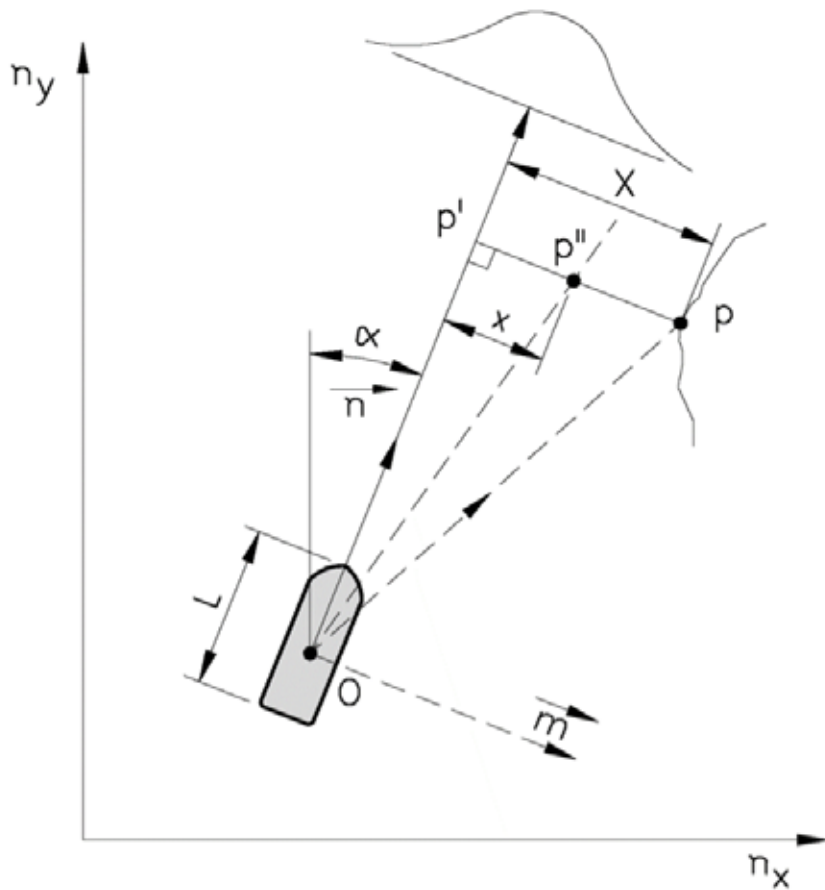


Figure B3. Geometry for Collision of a Vessel at O with an Obstacle P

Tug lengths vary according to the tug size: 60 ft (18.3m) for small tugs, 90 ft. (27.4m) for medium size tugs, to 130 ft. (39.6m) for large tugs.

Barge lengths vary from small (200 ft. or 60.9m), to medium (300 ft. or 91.4m) to large (400 ft. or 121.9m). A small tug tows a small barge, a medium tug tows a medium barge and a large tug is required to tow a large barge. The tow line lengths for the barge vary according to the difficulties offered by the choke point. For tight situations, such as Lama Pass and Dall Rocks, the tow lines do not exceed 200 ft. (60.9m). For open areas, tow lines vary with the tug: 1200 ft. (365.8m) for small tugs; 1500 ft. (457.2m) for medium tugs; or 1800 ft. (548.6m) for large tugs. For intermediate situations, including Boat Bluff and Grenville Channel from Lowe Inlet to Morning Reef, tow line lengths range from 500 ft. to 600 ft. (152.4m to 182.9m).

The probability  $P_G$ , or  $\text{Prob}(x \geq X)$ , can then be obtained using appropriate software. In this case, the program **RELAN** (developed at the University of British Columbia) was used. This probability  $P_G$  was calculated for all vessels, for each of the choke points, with results shown in Table B1. This table shows, for each choke point, the total length  $L$  for the transiting barges (and the details of the individual lengths in the tug-tow-barge combination), along with the data for current velocities along either the navigational path or normal to that path. The vessel information used in Table B1 is from Appendix A. The current velocities are given in knots, in order to calculate the adjustment coefficients  $R_c$  and  $R_{xc}$ . The velocities used here were provided by Peter Brown.

Table B1. Geometric Probabilities of Incidents, per Choke Point and Vessel Type

CHOKE POINT	VESSEL	L (m)	D (Km)	VC (kn)	VXC (kn)	RC	RXC	N (annual)	PG
Cape Caution	Tug (*) (27+457+91)	575	3.17	2	4	1.2	5	1419	0.00864
	Merchant Passenger	253						397	-
	Merchant Ferry	134						281	-
Grenville Channel	Tug (27+183+91)	301	0.40	2	4	1.2	5	707	0.44218
	Merchant Ferry	95						426	0.03490
	Fishing	30						184	-
Wright Sound (Sainty Point)	Tug (27+183+91)	301	1.20	2	2	1.2	3	707	0.00605
	Merchant Ferry	95						426	-
	Fishing	30						184	-
Boat Bluff	Tug (18+183+60)	261	0.50	3	4	1.3	5	121	0.28080
	Merchant Ferry	21						102	-
	Merchant Bulk	188						65	0.15956
Butedale	Tug (18+183+60)	261	1.10	2	2	1.2	3	121	0.07025
	Merchant Ferry	21						102	-
	Merchant Bulk	188						65	0.01943
Laredo Channel	Tug (40+548+122)	710	1.20	2	2	1.2	3	328	0.40232
	Merchant Passenger	267						76	0.01099
	Merchant Coastal	69						39	-
Principe Channel	Tug (40+548+122)	710	1.70	2	4	1.2	5	328	0.11006
	Merchant Passenger	267						76	0.278x10 <sup>-4</sup>
	Merchant Coastal	69						39	-
Ivory Island	Tug (27+60+91)	178	1.50	2	2	1.2	3	862	0.167x10 <sup>-1</sup>
	Merchant Ferry	129						285	0.151x10 <sup>-7</sup>
	Fishing	31						207	-
Lama Pass Central	Tug (27+60+91)	178	0.3	3	0	1.3	1	862	0.30999
	Merchant Ferry	129						285	0.17819
	Fishing	31						207	-
Lama Pass Eastern	Tug (27+60+91)	178	0.6	2	0	1.2	1	862	0.03068
	Merchant Ferry	129						285	0.00358
	Fishing	31						207	-
Lama Pass Dryad Point	Tug (27+60+91)	178	0.2	3	4	1.3	5	862	0.47003
	Merchant Ferry	129						285	0.36197
	Fishing	31						207	0.494x10 <sup>-3</sup>

Table B1. Geometric Probabilities of Incidents, per Choke Point and Vessel Type (cont'd)

CHOKE POINT	VESSEL	L (m)	D (km)	VC (kn)	VXC (kn)	RC	RXC	N (annual)	PG
Dall Rocks	Tug (27+60+91)	178	0.7	2	2	1.2	3	862	0.04995
	Merchant Ferry	129						285	0.00701
	Fishing	31						207	-
Fog Rocks	Tug (27+60+91)	178	1.8	1.5	2	1.15	3	862	0.307x10 <sup>-2</sup>
	Merchant Ferry	129						285	-
	Fishing	31						207	-

For Table B1:

- Tug total dimensions: (Tug itself + Tow + Barge) (all in m)  
L = Total vessel length (m)  
D = Choke point opening width (km)  
V<sub>C</sub> , V<sub>XC</sub> = Current velocities (kn), respectively, parallel and perpendicular to navigation line  
R<sub>C</sub> , R<sub>XC</sub> = Modification factors to account for current effects, AASHTO (2016)  
N = Annual number of trips at the choke point  
P<sub>G</sub> = Geometric probability of grounding or collision



## B.3 PROBABILITY OF NUMBER OF GROUNDINGS OCCURRING IN TIME INTERVAL, T

If  $P_e$  is the probability of a grounding event, the probability  $P_s$  of **no** such events occurring over a time  $T$  (in years) is given by (according to a Poisson's distribution for event arrivals):

$$P_s = e^{-NTP_e} \quad [B.3]$$

in which  $N$  is the number of vessels transiting per year. Therefore, the probability  $P_T$  of **at least one** grounding event occurring over a time  $T$  (in years) is given by

$$P_T = 1.0 - e^{-NTP_e} \quad [B.4]$$

Equation B.4 gives, for  $T = 1$  year, the *annual probability*  $P_a$  of at least one event occurring:

$$P_a = 1.0 - e^{-NP_e} \quad [B.5]$$

Rather than at least one event occurring in  $T$ , we are interested here on the probability of a number  $n$  events occurring in  $T$ . For this one has to consider first the probability  $P(m)$  of  $m$  trips occurring in  $T$ , assuming that these trips occur at number  $N$  times per year.  $P(m)$  is given by the Poisson arrival of events,

$$P(m) = \frac{(NT)^m}{m!} e^{-NT} \quad [B.6]$$

In our case, the probability of exactly  $n$  grounding events in  $m$  trips, when the probability of grounding in one event is  $P_e$ , is given by the binomial distribution

$$P(n/m) = \left( \frac{m!}{(m-n)!n!} \right) P_e^n (1 - P_e)^{m-n} \quad [B.7]$$

The product of Equations B.6 and B.7 gives the probability of  $n$  events given  $m$ . Considering all possible  $m$  in  $T$ , one can obtain the final probability of  $n$  events in  $T$ , which results:

$$P(n \text{ in } T) = \frac{(NT P_e)^n}{n!} e^{-NTP_e} \quad [B.8]$$

Equation B.8 can now be used to obtain the expected or mean value of  $n$  in  $T$ ,  $\bar{n}$ , as follows:

$$\bar{n} = \sum_1^{\infty} n \frac{(NT P_e)^n}{n!} e^{-NTP_e} \quad [B.9]$$

For the results obtained here, the average value  $\bar{n}$  in Equation B.9 was obtained with  $n$  ranging from 1 to 150, a sufficiently large number to give convergent results for the average.

B.3.1 ESTIMATION OF THE ABERRANCY RATES, R

Equation B.9 can be used to estimate the expected number of trips with incidents over  $T = 20$  years. For this, Equations B.1 and B.2 are used first in Equation B.4 to express  $P_e$ . For the  $i^{th}$ -choke point,

$$P_e = P_{Gi} R_{Ci} R_{XCi} R_{Di} R_i$$

[B.10]

It is assumed here that different environmental characteristics at each choke point will result in a different, local aberrancy rate  $R_i$ .

Using the barge data for each choke point, as shown in Table B1, Equation B.9 was applied to calculate  $\bar{n}$  at each choke point and to compare it to the data for observed incidents, over  $T = 20$  years, for the same choke point. This allows the adjusting of the aberrancy rate parameter  $R_i$  until agreement is reached. Data provided by the PPA, covering the 20-year period 1997-2016, show the total number of observed groundings and near grounding incidents per choke point. This data is shown in Table B2.

Table B2. PPA Incident Data: for Cape Caution to the North End of Grenville Channel

CHOKE POINT	PPA GROUNDINGS/NEAR GROUNDINGS, 20 YEARS <sup>(1)</sup>
Cape Caution	16
Grenville Channel	8
Wright Sound (Sainty Point)	5
Boat Bluff	5
Butedale and Work Island	5
Laredo Channel	4
Principe Channel	4
Ivory Island	13
Lama Pass Central	8
Lama Pass Eastern	7
Lama Pass at Dryad Point	12
Dall Rocks	3
Fog Rocks	8
Total	98
Rest of the Coast <sup>(2)</sup>	59

(1) PPA data were extracted from maps shown in the PPA Waivers Risk Assessment presentation to the Heiltsuk Tribal Council on March 21, 2017, shown here in Figures B1 and B2.  
(2) Rest of the Coast is defined as the coast from the north end of Vancouver Island to the north end of Principe Channel and to Morning Reef in Grenville Channel.

Table B2 shows those incidents occurring at the choke points. In addition, the PPA database shows a total of 59 incidents occurring, over 20 years, outside the choke points but still within the area described by Figure B1.

The results for aberrancy rates are shown in the following Table B3, which, in the last column, indicates the corresponding estimated number of grounding incidents over 20 years. Good matching is shown between observed and estimated results.

**Table B3. Estimated Aberrancy Rates**

CHOKE POINT	PPA GROUNDINGS/ NEAR GROUNDINGS, 20 YEARS	ABERRANCY RATE	ADJUSTED NUMBER OF GROUNDINGS, 20 YEARS
Cape Caution	16	$0.8500 \times 10^{-2}$	16
Grenville Channel	8	$0.1650 \times 10^{-3}$	8
Wright Sound (Sainty Point)	5	$0.1250 \times 10^{-1}$	5
Boat Bluff	5	$0.9000 \times 10^{-3}$	5
Butedale and Work Island	5	$0.6500 \times 10^{-2}$	5
Laredo Channel	4	$0.3300 \times 10^{-3}$	4
Principe Channel	4	$0.7600 \times 10^{-3}$	4
Ivory Island	13	$0.9870 \times 10^{-2}$	13
Lama Pass Central	8	$0.9000 \times 10^{-3}$	8
Lama Pass Eastern	7	$0.8800 \times 10^{-2}$	7
Lama Pass at Dryad Point	12	$0.3800 \times 10^{-3}$	12
Dall Rocks	3	$0.8500 \times 10^{-3}$	3
Fog Rocks	8	$0.3400 \times 10^{-1}$	8

## B.4 NUMBER OF INCIDENTS PER CHOKE POINT, THEIR RANKING AND THE EFFECT OF 1) HAZARD MITIGATION OR 2) EITHER 10%, 25% OR 100% INCREASE IN ANNUAL TRAFFIC

Using Equations B.9 and B.10, the estimated aberrancy rates from Table B3 can be used to calculate the expected number of grounding-related incidents at each choke point. The results appear in Table B4.

**Table B4. Calculated Expected Number of Trips with Grounding Related Incidents, per Choke Point, over 20 Years**

CHOKE POINT	N <sub>20</sub>	N <sub>20m</sub>	N <sub>20,10</sub>	N <sub>20,10m</sub>	N <sub>20,25</sub>	N <sub>20,25m</sub>	N <sub>20,100</sub>	N <sub>20,100m</sub>
Cape Caution	16	13	19	14	23	16	40	25
Grenville Channel	8	6	10	7	12	8	20	12
Wright Sound (Sainty Point)	5	4	6	4	7	5	12	8
Boat Bluff	5	4	6	4	7	5	13	8
Butedale and Work Island	5	4	6	4	7	5	13	8
Laredo Channel	4	3	5	3	6	4	10	6
Principe Channel	4	3	5	4	6	4	11	7
Ivory Island	13	10	16	11	19	13	33	20
Lama Pass Central	8	6	10	7	12	8	20	13
Lama Pass Eastern	7	6	9	6	10	7	18	11
Lama Pass at Dryad Point	12	9	14	10	17	12	30	18
Dall Rocks	3	3	4	3	5	3	8	5
Fog Rocks	8	6	10	7	12	8	20	12
<b>Sum for all choke points</b>	<b>98</b>	<b>77</b>	<b>120</b>	<b>84</b>	<b>143</b>	<b>98</b>	<b>248</b>	<b>153</b>

Table B4 Notes:

N<sub>20</sub> values used for calibration of aberrancy rates.

All a values are rounded to the closest integer value,

N<sub>20</sub> applies if the current annual traffic is maintained over 20 years, with no mitigations;

N<sub>20m</sub> applies if the current annual traffic is maintained over 20 years, with mitigations;

N<sub>20,10</sub> applies if the current annual traffic is increased 10% over 20 years, with no mitigations;

N<sub>20,10m</sub> applies if the current annual traffic is increased 10% over 20 years, with mitigations;

N<sub>20,25</sub> applies if the current annual traffic is increased 25% over 20 years, with no mitigations;

N<sub>20,25m</sub> applies if the current annual traffic is increased 25% over 20 years, with mitigations;

N<sub>20,100</sub> applies if the current annual traffic is increased 100% over 20 years, with no mitigations;

N<sub>20,100m</sub> applies if the current annual traffic is increased 100% over 20 years, with mitigations.

Table B4 shows that Cape Caution, Ivory Island and Lama Pass Dryad, in that order, dominate the expected number of grounding incidents.

Similarly, Table B5 shows the *expected number of trips with grounding incidents over a 6-year period*, per choke point. As provided in the next section, the TSB has provided 6 years of incident data from 2011 to 2016 inclusive, for the coast from the north end of Vancouver Island to the Alaska border, and Table B5 provides the number of incidents at the choke points for the same length of time. The TSB data is provided in Appendix A to this report.

**Table B5. Calculated Expected Number of Trips with Grounding Incidents per Choke Point, over 6 Years**

CHOKE POINT	N <sub>6</sub>	N <sub>6m</sub>	N <sub>6,10</sub>	N <sub>6,10m</sub>	N <sub>6,25</sub>	N <sub>6,25m</sub>	N <sub>6,100</sub>	N <sub>6,100m</sub>
Cape Caution	5	4	6	4	7	5	12	8
Grenville Channel	2	2	3	2	3	2	6	4
Wright Sound (Sainty Point)	2	1	2	1	2	1	4	2
Boat Bluff	2	1	2	1	2	1	4	2
Butedale and Work Island	2	1	2	1	2	1	4	2
Laredo Channel	1	1	1	1	2	1	3	2
Principe Channel	1	1	2	1	2	1	3	2
Ivory Island	4	3	5	3	6	4	10	6
Lama Pass Central	2	2	3	2	4	2	6	4
Lama Pass Eastern	2	2	3	2	3	2	5	3
Lama Pass at Dryad Point	4	3	4	3	5	3	9	6
Dall Rocks	1	1	1	1	1	1	3	2
Fog Rocks	2	2	3	2	3	2	6	4
<b>Sum for all choke points</b>	<b>30</b>	<b>24</b>	<b>37</b>	<b>24</b>	<b>42</b>	<b>26</b>	<b>75</b>	<b>47</b>

In either Table B4 or B5, the sensitivity of the expected number of grounding incidents has been investigated with respect to the annual traffic. There is no projection on how much the traffic would increase in the future, but there are TSB data on how much the total number of incidents (including groundings) increased during a 6-year period from 2011 to 2016. As discussed in Appendix A, Fig. A39, a total incident increase of approximately 100% has been recorded during that period (a factor of 2). Assuming that the same increase corresponded to groundings, Table B5 shows that an approximately doubling of the grounding incidents corresponds to an approximately doubling of the traffic (a 100% increase). Thus, since N<sub>6</sub> and N<sub>6m</sub> in Table B5 correspond to current traffic levels (2014), N<sub>6,100</sub> and N<sub>6,100m</sub> would be the expected number of groundings in 2020, with an equal expected increase to follow between 2020 and 2026.



## B.5 NUMBER OF INCIDENTS TO RESPOND TO PER YEAR

It is assumed that the PPA and TSB data bases have the same number of groundings and near groundings in the overlapping data sets. The PPA data set was used to identify, over 20 years, the number of groundings and near groundings that occurred on the central coast from Cape Caution to the north end of Grenville Channel by choke point. The TSB data provide the number of incidents, and the type of incidents that occurred over 6 years (2011 to 2016, inclusive) from the north end of Vancouver Island to the Alaska border. Based on the above assumption, the following methodology was used to estimate the total number of incidents per year, not just groundings or near groundings, that the IMRC would respond to at each choke point. The presumed types of incidents that the IMRC will respond to are: Fire, Total Failure of Any Machinery or Technical System, Sinking, Grounding, Collision, Person Overboard, Sustained Damage Render Unseaworthy/Unfit for Purpose, Risk of Sinking, Abandoned, Bottom Contact, Intentional Beaching/Grounding/Anchoring to avoid Occurrence, Capsizes, and Dangerous Goods Released.

**Table B6. TSB Data over 6 Years, Response to Incidents**

TYPE OF INCIDENT	TOTAL	RESPONDING TO (Y/N)	TOTAL REQUIRING IMRC RESPONSE
Fire	34	Y	34
Total Failure of Any Machinery or Technical System	357	Y	357
Person Seriously Injured or Killed <sup>(1)</sup>	49	?	0
Sank	22	Y	22
Grounding	106	Y	106
Striking <sup>(2)</sup>	26	N	0
Risk of Grounding	20	N	0
Collision	28	Y	28
Person/Crew Member physical incapacitation <sup>(1)</sup>	3	?	0
Risk Of Striking	13	N	0
Person Overboard	7	Y	7
Cargo Shift/Cargo Loss	6	N	0
Sustains Damage Render Unseaworthy/Unfit for Purpose	16	Y	16
Risk of Sinking	14	Y	14
Abandoned	1	Y	1
Bottom Contact	14	Y	14
Intentional Beaching/Grounding/Anchoring to avoid occurrence	2	Y	2
Risk of Collision (Near Collision)	12	N	0
Fouls Underwater Object	1	N	0
Capsizes	1	Y	1
Risk of Capsizing	1	N	0
Dangerous Goods Released <sup>(3)</sup>	1	Y	1
<b>Total</b>	<b>734</b>		<b>603</b>

Notes for Table B6

(1) It is assumed that the vessel will attend to the injured person using on-board First-Aid

(2) It is assumed that this is a glancing blow to some object and that it does not require response by the IMRC

(3) This is assumed to be the *Nathan E. Stewart* grounding that occurred on October 13, 2016

The TSB data were used to estimate the number of assistance trips required, per year, in response to an incident at any of the choke points. As shown in Table B6, assistance is normally provided for situations beyond grounding or near grounding. Over a period of 6 years, between 2011 and 2017, 603 assistance trips were needed for all calls, while the number of groundings and near groundings only accounted for 126 calls. These data were used to obtain a conversion factor to be applied to the number of groundings over a 6-year period (Table B5), in order to obtain the number of assistance calls for all situations, per year. This factor is, then:

$$F = \frac{603}{126 \times 6} = 0.7976$$

When the factor F is applied to the entries of Table B5, the number of assistance calls, per year, for all calls, is obtained. The results are shown in Table B7, indicating the effect of traffic increases and the implementation of mitigation measures. In all cases, the results have been rounded to the closest integer.

**Table B7. Expected Number of Assistance Trips, per Choke Point, per Year**

<b>CHOKE POINT</b>	<b>N<sub>a</sub></b>	<b>N<sub>am</sub></b>	<b>N<sub>a,10</sub></b>	<b>N<sub>a,10m</sub></b>	<b>N<sub>a,25</sub></b>	<b>N<sub>A,25m</sub></b>	<b>N<sub>a,100</sub></b>	<b>N<sub>a,100m</sub></b>
Cape Caution	4	3	5	3	6	4	10	6
Grenville Channel	2	1	2	2	3	2	5	3
Wright Sound (Sainty Point)	1	1	1	1	2	1	3	2
Boat Bluff	1	1	1	1	2	1	3	2
Butedale and Work Island	1	1	1	1	2	1	3	2
Laredo Channel	1	1	1	1	1	1	2	2
Principe Channel	1	1	1	1	1	1	3	2
Ivory Island	3	2	4	3	5	3	8	5
Lama Pass Central	2	1	2	2	3	2	5	3
Lama Pass Eastern	2	1	2	1	3	2	4	3
Lama Pass at Dryad Point	3	2	3	2	4	3	7	4
Dall Rocks	1	1	1	1	1	1	2	1
Fog Rocks	2	1	2	2	3	2	5	3
<b>Sum for all choke points</b>	<b>24</b>	<b>17</b>	<b>26</b>	<b>21</b>	<b>36</b>	<b>24</b>	<b>60</b>	<b>38</b>
<b>Yearly calls, including incidents outside the choke points</b>	<b>38</b>	<b>27</b>	<b>41</b>	<b>33</b>	<b>57</b>	<b>38</b>	<b>95</b>	<b>60</b>
<b>Monthly calls, including incidents outside the choke points</b>	<b>3</b>	<b>2</b>	<b>3</b>	<b>3</b>	<b>5</b>	<b>3</b>	<b>8</b>	<b>5</b>

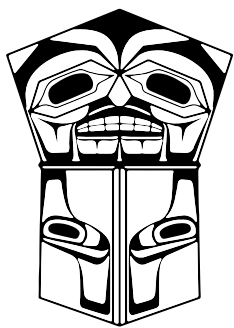
Table B7 applies only to those assistance trips originating from incidents at the choke points. The PPA data show a total of 59 incidents occurring over 20 years outside the choke points but still within the area described by Figure B1. This corresponds to 18 incidents over 6 years and, accordingly, to an additional  $18 \times 0.7976 = 14$  yearly assistance calls. These 14 additional calls must be added to the 24 shown in Table B7 for the current situation, for a total of 38. The last rows of Table B7 show the number of calls per year or per month, including the additional trips corresponding to the locations outside the choke points, and includes the factor RD as provided in Section B.2. Again, the numbers have been rounded to the closest integer. Following the same reasoning as on page 127, the columns  $N_{a,100}$  and  $N_{a,100m}$ , corresponding to a 100% increase in traffic, provide an estimate of the 2020 situation, with an equal increase expected from 2020 to 2026.

## B.6 REFERENCES

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**HEILTSUK TRIBAL COUNCIL**

APPENDIX C

World-Class Preparedness And Response:  
A Benchmark Review

# C.1 INTRODUCTION

## C.1.1 GENERAL

In order to establish the basic requirements of a world-class oil spill response system, an initial review of equipment, response vessels and facilities in jurisdictions with similar coastlines to the BC central coast is presented herein. The definition of “world-class” can be quite subjective and should always take into account the local needs. If taken from the BC Ministry of Environment point of view, a report commissioned by the Ministry recommends the following initiatives to reach world-class standard in terms of preparedness and response (Ref 19):

- Geographic areas are prioritized for protection from oil spills.
- Contingency planning is comprehensive, integrated, and well understood by all relevant parties.
- Sufficient equipment can be deployed quickly to respond to a worst-case spill.
- Sufficient personnel are available to respond to a worst-case spill.
- A process is in place to restore damaged resources and to promote ecosystem recovery after a spill.

For the BC central coast, Transport Canada is the main federal regulatory agency responsible for the preparedness and response to marine oil spills in Canada. To meet this obligation, Transport Canada has partnerships with private organizations that have large inventories of oil spill response equipment. In British Columbia, Western Canada Marine Response Corporation (WCMRC) responds to oil spills on behalf of its members and receives certification from Transport Canada following a review of their response plan. WCMRC must comply with the Canada Shipping Act (2001) and demonstrate to Transport Canada that it is prepared to respond to spills on the BC coast with response capabilities outlined in Table C1.

Table C1. Tiered Response Capability Requirements for Canadian Waters

TIER	OIL SPILL VOLUME [TONNES]	MIN. RESPONSE TIME REQUIRED [HOURS]
1	150	6
2	1,000	12
3	2,500	18
4	10,000	72



## C.2 OVERVIEW OF OIL SPILL RESPONSE EQUIPMENT AND VESSELS

### C.2.1 GENERAL

The appropriate response to an oil spill will depend on its location, size and oil characteristics, as well as environmental factors such as wind, waves and current. For oil spills at sea, the preferred method is to use a containment and recovery system with the following components:

- Oil boom or barrier used for containment;
- Mechanical recovery device used to remove oil;
- Pump used to transfer the oil-water mixture;
- Temporary oil storage.

Floating booms are typically used to gather the spilled oil into a suitable thickness prior to mechanical removal. A containment boom typically consists of an air- or foam-filled flotation chamber and a skirt with ballast weight to keep boom vertical during towing.

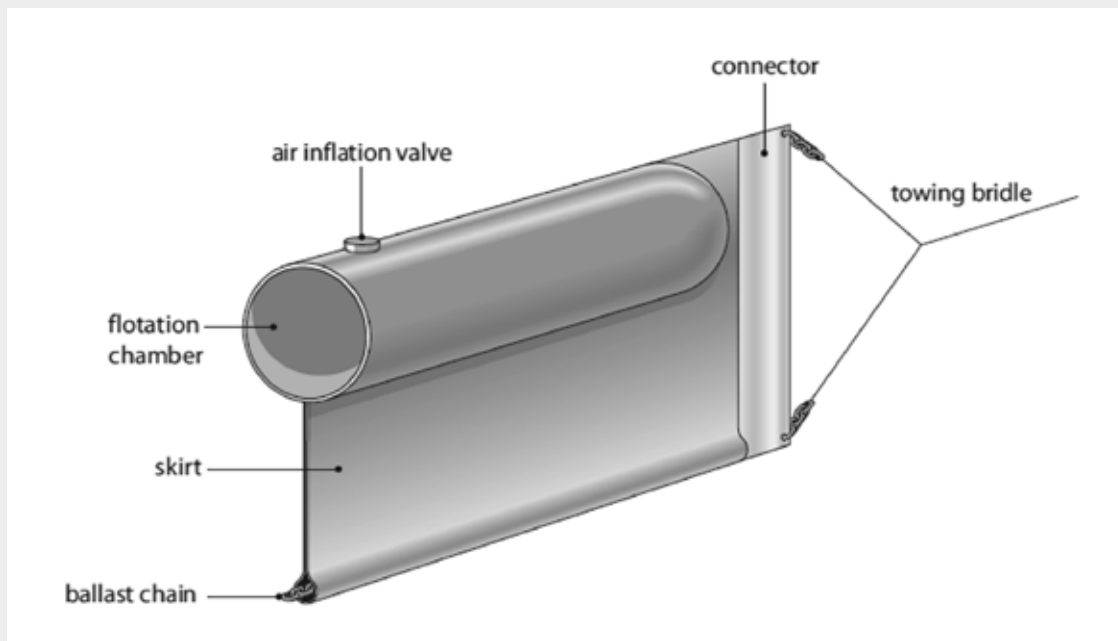


Figure C1. Floating containment boom

Removal of the oil is typically in the form of skimmers that pump the oil from the water surface into temporary storage facilities. The selection of skimmer type depends on the characteristics of oil, environmental conditions and available vessel resources. In addition, the selection of skimmer equipment may have to be re-evaluated as the oil weathers and its properties change.

Skimmers are generally grouped into the following main categories:

- Weir skimmers: A weir is placed at edge of the oil-water interface;
- Oleophilic skimmers: Oil sticks to rotating equipment and is subsequently removed;
- Mechanical skimmers: Oil is removed from surface using belts, paddles, etc.



Weir



Oleophilic



Mechanical

**Figure C2. Floating skimmer types**

In addition to the conventional boom and skimmer systems described above, newer systems are available that combine the containment boom with an integrated skimmer. High speed towing systems with temporary storage facilities have also been developed. Although these newer systems have fewer components, they rely on larger response vessels for deployment and operations.

The containment and recovery response system should not be restricted by the amount of oil that can be stored during the at-sea recovery operations. Hence, adequate storage facilities must be part of the overall response strategy. Typical storage options for oil recovery consist of smaller floating inflatables, plastic containers and large storage tanks onboard response vessels or barges.

When choosing the response equipment, it is important to consider the suitability of equipment and the logistical constraints associated with deployment and operations. Light-weight equipment may be suitable for quick response in sheltered waters and harbours, but have limited effect in open waters. An oil spill preparedness plan will therefore have to rely on a mix of oil booms and skimmers for their marine response centres and satellite locations.

The following sections include a brief overview of typical equipment used in British Columbia, Washington State, Alaska, Norway, and New Zealand. The skimmer capacities have been given in their De-Rate form, which is 0.2x the name plate capacity given by the manufacturer.

## C.2.2 OVERVIEW OF RESPONSE EQUIPMENT USED IN BRITISH COLUMBIA

A large proportion of the oil spill response equipment along the BC coast is owned by the WCMRC and the Canadian Coast Guard. The main depots are located in the Lower Mainland, Vancouver Island, and Prince Rupert. Limited equipment is available on the central coast between Vancouver Island and Prince Rupert.

The WCMRC operates a total of 28 response vessels and 50 response trailers. Typical equipment available on the BC south coast is listed below:

### *Oil booms*

- General purpose boom (Calm waters)
- Shore-seal boom (Intertidal)
- Zoom Boom (Open waters)
- NOFI “V” sweep system (Open waters)
- Kepner Boom (Open waters)
- Ro Boom (Open waters)
- NOFI Current Buster (Open waters)



**Figure C3. Kepner boom**

Source: WCMRC

Oil skimmers

Table C2. WCMRC oil skimmers

SKIMMER MODEL	DE-RATE CAPACITY [m <sup>3</sup> /h]
Crucial-Fuzzy Disk Skimmer	3-6
Multi-Head (RBS) Skimmer	2-3
GT-185 w/ Helix Brush	9
Disk Skimmer T12/T18	3-9
Rope Mop	1-2

Source: WCMRC



Figure C4. GT-185 w/ Helix Brush  
Source: WCMRC

### *Response vessels*

- Burrard Cleaner No. 4 (LOA = 9.1m; Speed = 40 knots)
- Burrard Cleaner No. 5 (LOA = 7.9m; Speed = 25 knots)
- Burrard Cleaner No. 8 (LOA = 14.3m; Speed = 18 knots)
- Burrard Cleaner No. 11 (LOA = 14.7m; Speed = 18 knots)
- M.J. Green (LOA = 13.7m; Speed = 25 knots)
- Eagle Bay



**Figure C5. Burrard Cleaner No. 5**

Source: WCMRC

### *Response boom boat*

- Burrard Cleaner No. 6 (LOA = 10.6m; Speed = 30 knots)
- Burrard Cleaner No. 7 (LOA = 11.8m; Speed = 30 knots)



**Figure C5. Burrard Cleaner No. 5**

Source: WCMRC



### C.2.3 OVERVIEW OF EQUIPMENT USED IN WASHINGTON STATE

Similar to the BC coast, a large proportion of the oil spill equipment is owned by private organizations. Typical equipment used by the Marine Spill Response Corporation (MSRC) depots in Washington State are listed below:

#### *Oil booms*

- 10" to 43" Curtain Internal Foam Boom
- 27" to 67" Curtain Pressure-Inflatable Boom
- 26" to 43" Curtain Self-Inflatable Boom
- 16" to 60" Fence Boom
- 26" Tidal Seal Boom



**Figure C7. 60" Fence Boom**

Source: MSRC

## Oil skimmers

Table C3. MSRC Oil Skimmers

SKIMMER MODEL	DE-RATE CAPACITY [m <sup>3</sup> /h]
AardVac	25.4
Aqua Guard RBS	2.4
Crucial Disc 56/30	37.6
Desmi Ocean	20.0
Destroil 150	5.0
Destroil 250	19.3
DOP-250	60.0
GT-185 Skimmer (with Adapter)	9.1
JBF Belt 5001	39.7
JBF Belt 6001	79.5
Lori Brush Module	48.5
Lori Brush	32.4
Lori LBC Brush	17.2
Marco 1ft Belt	23.8
Morris Disc	1.4
OMI Rope	0.3
Queensboro	6.0
Slickbar Slurp	0.7
Stress I	104.9
Transrec 350	70.0
WP-1	20.0

Source: MSRC



Figure C8. GT-185 Skimmer

Source: MSRC



Figure C9. Transrec 350

Source: MSRC

## C.2.4 OVERVIEW OF EQUIPMENT USED IN ALASKA

Typical equipment operated by Southeast Alaska Petroleum Response Organization (SEAPRO) on the Alaskan southeast coast is listed below, Ref. [18]:

### *Oil booms*

- ACME Optimax II foam boom (Calm waters)
- Ro-Boom 1000 pressure inflatable curtain boom (Calm waters)
- Ro-Boom Beach 800 tidal seal boom (Intertidal)
- AirMax II offshore boom (Open waters) 18" FB, 25" draft
- Vikoma Harbor Pak inflatable boom (Calm waters)



**Figure C10. Ro-Boom 800 tidal seal boom**

Source: SEAPRO

Table C4. SEAPRO Oil Skimmers (Ref. [5])

SKIMMER MODEL	DE-RATE CAPACITY [m <sup>3</sup> /h]
AP Multi 24	3
Aquaguard RBS	5
Aquaguard Triton 35	8
Crucial Disc C-13/24	4
Crucial Rope Mop	1
Foilex TDS-250	26
LORI Brush	16-25
Marco Sidewinder	7
Vikoma 12K Komara	4



Figure C11. Aquaguard RBS Triton 35 Drum/Brush Skimmer

## C.2.5 OVERVIEW OF EQUIPMENT USED IN NORWAY

The Norwegian oil containment booms are categorised into light-weight (L), medium (M) and heavy (H) systems, where the limiting sea states are  $H_s=0.5\text{m}$ ,  $1.5\text{m}$  and  $3.5\text{m}$ , respectively, Ref. [5]. Examples of typical systems are illustrated in Figure C12 and Figure C13.

Sorbent booms are also used, and would be categorised as a light-weight system, but are not included in the summary tables in this report.



Figure C12. NOFI 250/350 EP Oil Containment Boom (Light) (Ref. [5])



Figure C13. Expandi 3500 Oil Containment Boom (Medium) (Ref. [5])



Main data for the various systems are shown in Table C5 and Table C6 (N/A is given when data are not available).

**Table C5. Norwegian Coastal Administration Approved Oil Booms – Light-Weight Systems (Ref. [5])**

OIL BOOM SYSTEM	FREEBOARD [m]	DRAUGHT [m]	SECTION LENGTH [m]	UNIT WEIGHT [kg/m]
NOFI 250 EP	0.25	0.35	25	2.7
NOFI 350 EP	0.35	0.5	25	4.7

**Table C6. Norwegian Coastal Administration Approved Oil Booms – Medium to Heavy Systems (Ref. [5])**

OIL BOOM SYSTEM	FREEBOARD [m]	DRAUGHT [m]	SECTION LENGTH [m]	UNIT WEIGHT [kg/m]
Expandi 4300	0.45	0.65	15	5.3
NOFI 500 EP	0.5	0.8	25	11.6
NO 450S	0.45	0.65	100	7.1
NO 600S	0.6	0.8	100	8.0
NO 800R	0.8	1.0	100	17.0
Current Buster 2	0.6 (at tank)	1.5	27	122.2
Current Buster 4	0.8 (at tank)	2.0	34	111.8
Current Buster 6	1.0 (at tank)	2.6	63	N/A
Uniboom A-1300HD	0.5	0.8	25	9.3
NO-T-1000-S	1.0	HOLD	37	N/A

Main data for the various systems are shown in Table C5 and Table C6 (N/A is given when data are not available).



**Figure C14. FoxTail 1-6 Oil Skimmer (Small)**



Figure C15. DESMI Terminator Drum Skimmer

Figure C16. Lamor Bow Collector LBC-6B

Table C7. Norwegian Coastal Administration Approved Oil Skimmers (Ref. [5])

OIL SKIMMER SYSTEM	DE-RATE CAPACITY [m <sup>3</sup> /h]	TOTAL WEIGHT [kg]
Desmi Terminator, Belt	16	162
Desmi Termite	6	95
Foilex TDS200	12	170
FoxTail 1-6	0.6	130
FoxTail 2-6	1.8	454
FoxTail 4-9	7	1360
FoxTail 8-14	16	2400
KLK 402/Foxdrum	6	95
KLK 602/Foxdrum	10	410
Lamor Bow Collector	10	310
Lamor LWS 500	14	100
NorMar 30	6	256
Sandvik Band	9	1500
Uniskim Multiskimmer 30	3	175

*Norwegian Coastal Administration oil spill response vessels*

As part of the rapid oil spill response system, the Norwegian Coastal Administration (NCA) has 18 pilot stations along the coast with light-weight oil spill equipment. Each boat is equipped with a 200m or 300m NOFI 350 EP oil boom system, Ref. [2].

The heavier equipment are placed onboard the larger NCA vessels as shown in Table C8. In addition, most of the Norwegian Coast Guard vessels have oil spill equipment, see Figure C18 and Table C9.



Figure C17. NCA Oil Spill Response Vessels, Ref. [1]

Table C6. NCA Approved Oil Booms – Medium to Heavy Systems (Ref. [5])

VESSEL	VESSEL LOA [m]	OIL BOOM SYSTEMS			OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m³]
		ABS [m]	L [ea]	M/H [ea]		
KYV Oljevern 01	33	-	-	2	1	90
KYV Oljevern 02	33	-	-	2	1	90
KYV Oljevern 03	33	100	-	2	1	90
KYV Utvær	44	-	-	2	2	160
KYV Skomvær	44	-	-	4	3	160

Notes:  
1. ABS = Sorbent; L = Light-weight; M/H = Medium/Heavy (see Section 7.2.4)  
2. A new NCA vessel, the KYV Bøkfjord, has recently been added to the fleet.

Additional support for oil spill response is provided from the smaller NCA vessels specified in Ref. [2].



Figure C18. KV Nornen with NCA Oil Boom System

Table C9. Summary of Equipment Onboard Coast Guard Vessels (Ref. [3])

VESSEL	VESSEL LOA [m]	OIL BOOM SYSTEMS			OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m³]
		ABS [m]	L [ea]	M/H [ea]		
KV Nornen	47	125	-	1	1	155
KV Tor	47	-	-	2	1	155
KV Njord	47	-	-	1	1	155
KV Heimdal	47	-	-	2	1	155
KV Farm	47	100	-	2	1	155
KV Bergen	93	-	-	3	2	1075
KV Barentshav	93	-	-	3	2	1075
KV Sortland	93	-	-	3	2	1075
KV Harstad	83	-	-	3	2	1116+25
KV Svalbard	104	-	-	2	1	50

Notes:  
 1. ABS = Sorbent; L = Light-weight; M/H = Medium/Heavy (see Section 7.2.4)  
 2. The Magnus Lagabøte has recently been added to the fleet.

C.2.6 OVERVIEW OF EQUIPMENT USED IN NEW ZEALAND

Typical booms used by Maritime New Zealand (MNZ) and the Regional Councils are as follows:

- Harbour Buster
- Ro-Boom
- Structurflex air curtain boom
- Structurflex 350mm rapid deployment curtain boom

For comparison, the main characteristics of light-weight and heavy boom systems are provided in Table C10 and Table C11.

Table C10. MNZ Approved oil Booms – Light-Weight Systems (Ref. [13])

OIL BOOM SYSTEM	FREEBOARD [m]	DRAUGHT [m]	SECTION LENGTH [m]	UNIT WEIGHT [kg/m]	LIMITING WAVE HEIGHT [m]	LIMITING CURRENT [knots]	MAX TOWING SPEED [knots]
Ro-Boom 600	0.2	0.3	15/25/50	4.5	2	3	10
Ro-Boom 1000	0.36	0.38	25/50/100	6.4	2	3	10
Ro-Boom 1100	0.37	0.54	50-300	8	2	3	10

Table C11. MNZ Oil Booms – Medium to Heavy Systems (Ref. [13])

OIL BOOM SYSTEM	FREEBOARD [m]	DRAUGHT [m]	SECTION LENGTH [m]	UNIT WEIGHT [kg/m]	LIMITING WAVE HEIGHT [m]	LIMITING CURRENT [knots]	MAX TOWING SPEED [knots]
Ro-Boom 2000	0.59	1.1	50-300	15	4	3	10
Ro-Boom 2200	0.83	0.95	50-300	15.5	4.5	3	10
Ro-Boom 3200	1.2	1.4	200	38	6	3	10



The oil recovery skimmers are categorised into light-weight, easily deployed skimmers and larger skimmers that require deployment using cranes and forklifts. The smaller skimmers have theoretical oil recovery rates of 10 tonnes/h (11 m³/h) or less. The larger skimmers have recovery rates that can reach up to 100 tonnes/h (111 m³/h). Examples of skimmers used in New Zealand are listed below and shown in Figure C19 to Figure C21:

Table C12. MNZ Approved Oil Skimmers (Ref. [13])

OIL SKIMMER SYSTEM	SKIMMER TYPE	DE-RATE CAPACITY [m³/h]	TOTAL WEIGHT [kg]
Aquaguard brush skimmer	Oleophilic		
Aquaguard multi-head skimmer	Oleophilic		
Lamor DIP 420 on OR vessel or 3rd party vessels	Inclined plane (mechanical)	7.2	1818
Foilex weir skimmer	Weir	7.4-28	75-190
Global rope mop skimmer	Rope/Mop		
Global weir skimmer	Weir		
Lamor Slickbar Multi Skimmer LMS/S	Oleophilic		
Lamor Mini-max (12W/25/50)	Oleophilic	5.4-10.8	23-55
Ro-Disc	Oleophilic		
Terminator	Weir		
Vikoma Komara 12K disc skimmer	Oleophilic	3.6	



Figure C19. Foilex Mini Weir Light-Weight Skimmer

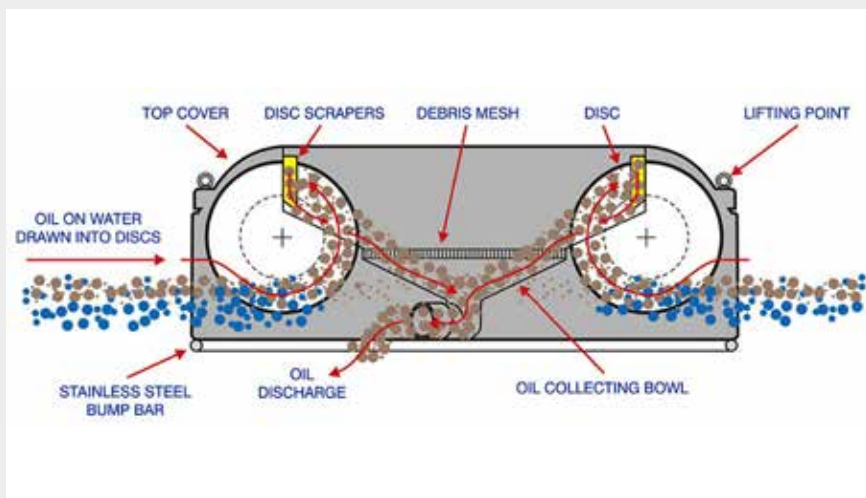


Figure C20. Vikoma Komara Oleophilic Disc Skimmer

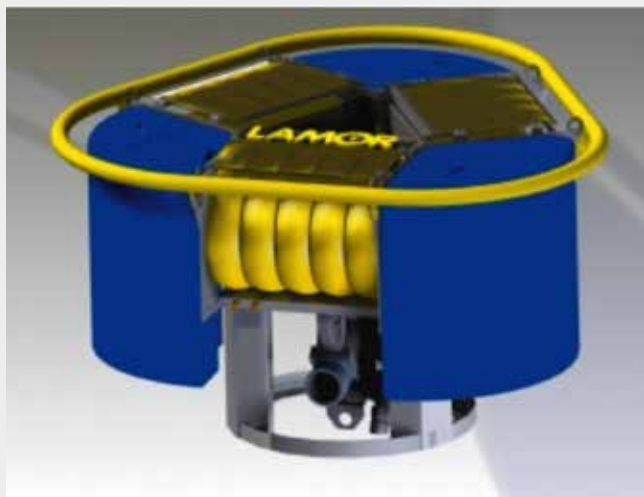


Figure C21. Lamor Multi Skimmer

## C.2.7 OIL BOOM SYSTEMS FOR THE OFFSHORE ENVIRONMENT

There is a wide selection of oil boom systems that perform well for rivers, lakes and coastal waters. However, in open water with sea states above  $H_s=1.5\text{m}$ , further research and development is required. The main design challenges for oil boom containment systems in open waters include the following:

- **Wind & waves**  
During high sea states, there is potential for sea spray and for oil to splash over the oil boom, see Figure C22. This can be improved by increasing the freeboard of the boom and by adding ballast to the skirt.
- **Current & towing speed**  
The current or towing speed may cause the skirt to deflect and allow oil to escape underneath. The relative speed of the boom may also create vortices within the water column that pass under the boom skirt.
- **Retention capacity**  
When the maximum containment volume of the boom system is reached, additional oil escapes under the skirt. Temporary oil storage is required to avoid loss of oil due to drainage.
- **Handling**  
The containment systems that can operate in open waters are typically heavier than conventional oil booms. New methods to ease the mobilisation of equipment will allow smaller vessels to operate these systems.

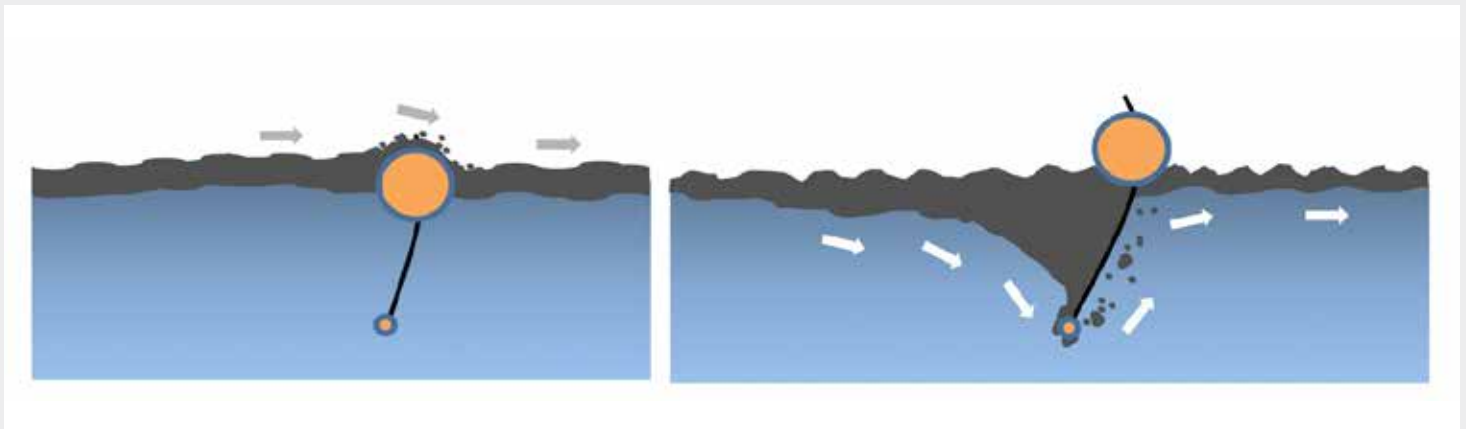


Figure C22. Oil Boom Design Challenges: Overtopping and Drainage

As described in Section 2.5, medium to heavy oil containment booms can typically operate in sea states between  $H_s=1.5\text{m}$  and  $3.5\text{m}$ . These open water containment systems will have to have sufficient freeboard to minimise sea spray and overtopping. To prevent oil from escaping underneath the skirt, ballast weight is required to keep the boom system in a vertical position.

A selection of booms systems that can operate in stormy seas is provided below:

Table C10. MNZ Approved Oil Booms – Light-Weight Systems (Ref. [13])

OIL BOOM SYSTEM	SUPPLIER	FREEBOARD [m]	DRAFT [m]	UNIT WEIGHT [kg/m]	COMMENTS
NO 1200R	NorLense	1.2	1.5	24.0	
NO 1370R	NorLense	1.37	1.5	27.5	
Current Buster 6/ Current Buster 8	NOFI	0.8 to 1.0	2.6	8700kg/20ft	Limiting current speed is 5 knots in calm seas. Reduced to 2-3 knots in waves.
NO-T-1000-S	NOFI	1.0	N/A	N/A	Limiting current speed is 1.2 knots.
Ro-Boom 2200	Desmi	0.83	0.95	15.5	Limiting current speed is 3 knots. Can operate in wave heights up to 4.5m.
Ro-Boom 3200	Desmi	1.2	1.4	38	Limiting current speed is 3 knots. Can operate in wave heights up to 6m.
HI Sprint	Vikoma	0.9	1.1	11.2	
AirMax Deep Sea	Elastec	0.61	1.01	7.3	
Heavy Duty Boom	Lamor	0.56	1.16	17.1	
Uniboom X	Lamor	1.4	1.6	29.5	

An example of an oil response system for offshore conditions, currently marketed by AllMaritim, includes the following components:

- NOFI Current Buster 6
- Boom Vane, replacing the second towing vessel
- NorMar High Capacity Discharge System/Skimmer
- Dispersant spray arms
- MIROS Oil Spill Detection System including IR camera and Radar Detection system allowing for efficient recovery operations 24/7

This offshore single-vessel sweep system is a self-contained system allowing the vessel to operate single-handed without any backup from other parties. It is a cost-efficient system that gives the operator great flexibility and substantial increase in performance, see Figure C23. A similar set-up with two response vessels is shown in Figure C24.



**Figure C23. Single-Sweep High Speed Recovery System for Offshore Environment**  
Source: AllMaritim



**Figure C24. Two Vessel High Speed Recovery for Offshore Environment**  
Source: AllMaritim



## C.3 COMPARISON OF OIL SPILL PREPAREDNESS AND RESPONSE PLANS

### C.3.1 GENERAL

In order to evaluate the type of equipment and vessels best suited for the central BC coast, a general overview of existing oil spill response systems is presented herein. To establish a benchmark for establishing a world-class response capability, a selection of jurisdictions having similar coastlines to British Columbia is chosen. These include Washington State, Alaska, Norway and New Zealand.

Since the latest technology developments are driven by the private industry, most of the information related to equipment can be found with these organisations. The Global Response Network (GRN) is a group of non-profit organizations that provide oil spill response services and technology development. The network shares information related to oil spill performance and acts as a centre of expertise in spill preparedness, response and recovery techniques. The group consists of the following organizations:

- **Western Canada Marine Response Corporation (WCMRC)** [www.wcmrc.com](http://www.wcmrc.com)  
WCMRC is a Transport Canada certified response organization that operates response vessels and has multiple equipment stockpiles along the BC coast.
- **Eastern Canada Response Corporation (ECRC - SIMEC)** [www.ecrc.ca](http://www.ecrc.ca)  
ECRC is a Transport Canada certified response organization and provides oil spill response services in Canadian waters east of the Rockies.
- **Marine Spill Response Corporation (MSRC)** [www.msrmc.org](http://www.msrmc.org)  
MSRC is an organization that owns and operates a fleet of oil spill response vessels, ocean-going barges and oil spill equipment throughout the US.
- **Oil Spill Response Limited (OSRL)** [www.oilspillresponse.com](http://www.oilspillresponse.com)  
OSRL is the largest global industry-owned response organization operating from locations in Europe, Africa, the Middle East, Asia Pacific and the Americas. An emergency response can be activated from bases in Fort Lauderdale, Southampton and Singapore.
- **Norwegian Clean Seas Association for Operating Companies (NOFO)** [www.nofo.no](http://www.nofo.no)  
NOFO is an organization for oil spill preparedness on behalf of the operating oil companies on the Norwegian Continental Shelf.
- **Australian Marine Oil Spill Centre (AMOSOC)** [www.amosoc.com.au](http://www.amosoc.com.au)  
AMOSOC is financed by nine participating oil companies and other subscribers that carry out oil and gas production and transportation on the Australian coast.

## C.3.2 APPROACH TO OIL SPILL PREPAREDNESS IN WASHINGTON STATE

### C.3.2.1 General

Washington State requires large oil handling facilities and commercial vessels to have state-approved oil spill contingency plans. To meet these requirements, Washington State Maritime Cooperative (WSMC) provides coverage for members that transit Washington waters. In addition, all covered vessels are required to provide an emergency response towing vessel stationed at Neah Bay, Washington if they transit to a port through the Strait of Juan de Fuca. WSMC utilises the services of the following entities:

- Marine Spill Response Corporation
- Global Diving & Salvage
- Island Oil Spill Association
- Western Canada Marine Response Corporation (reciprocal agreement)

### C.3.2.2 Marine Spill Response Corporation (MSRC)

MSRC is a non-profit organization that provides oil spill and emergency response services across the United States. Their equipment stockpiles located close to BC waters are shown in Figure C25 and summarised in Table C14.

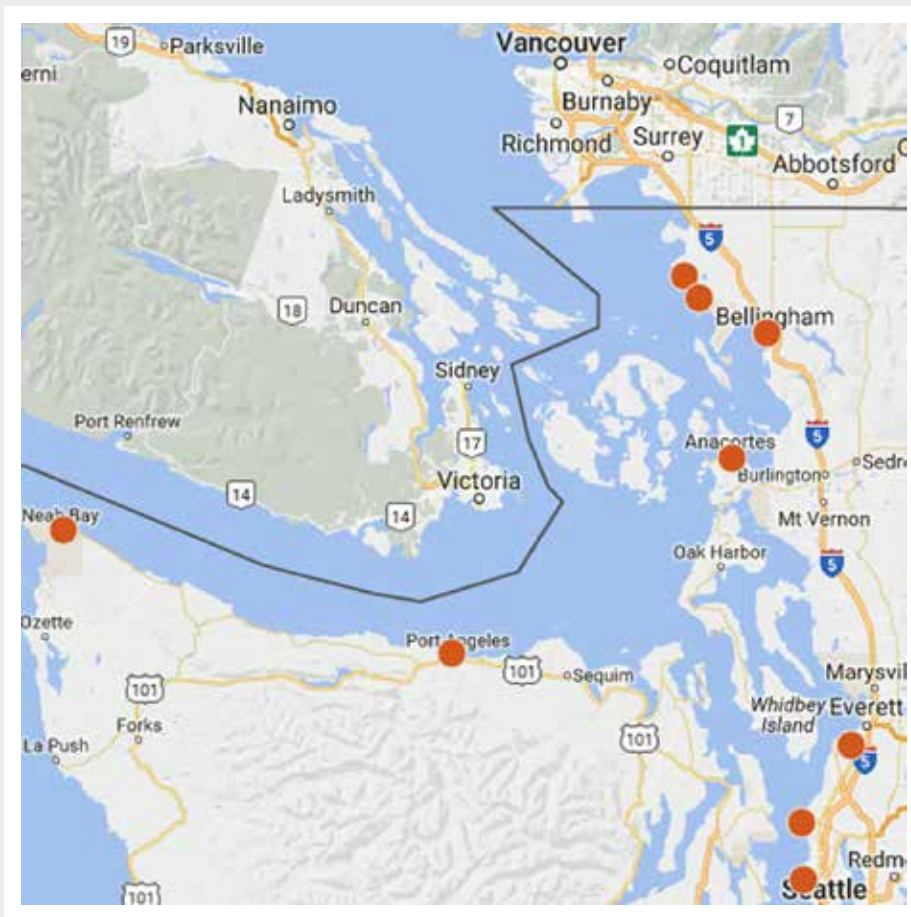


Figure C25. MSRC oil spill equipment locations

Table C14. Summary of Major MSRC Equipment in Washington State (Ref. [16])

PORT ID	DEPOT	WORKBOATS (>20ft) [ea]	OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m <sup>3</sup> ]
1	Blaine	-	2	-	-
2	Ferndale	-	2	-	-
3	Bellingham	4	3	3	110
4	Anacortes	4	5	4	150
5	Everett	4	6	17	420
6	Point Wells	-	2	-	-
7	Seattle	3	4	3	20
8	Tacoma	4	6	3	1980
9	Port Angeles	8	10	10	6960
10	Neah Bay	2	4	2	40
<b>Typical MSRC depot in WA</b>		<b>4</b>	<b>4</b>	<b>6</b>	<b>1380</b>

Based on information provided from the MSRC, a typical depot consists of the following response equipment:

- 4-off workboats
- 4-off containment booms
- 6-off oil skimmer systems
- 1,380 m<sup>3</sup> temporary oil storage facilities

The average distance between depots along the coast is 15 nautical miles. Based on a one hour mobilisation, a minimum transit speed of 14 knots as specified in Ref. [9] and one hour for full deployment of equipment, the maximum response time from a depot is, therefore, three hours.

C.3.3 APPROACH TO OIL SPILL PREPAREDNESS IN ALASKA

C.3.3.1 General

Due to the oil and gas activities along the Alaskan coast, the oil spill preparedness consists of a number of non-profit organizations that have a mandate to respond to oil spills on behalf of its members. The Alaska Chadux Corporation is classified as an oil spill removal organization by the US Coast Guard and maintains 17 hubs throughout the state.

C.3.3.2 Southeast Alaska Petroleum Response Organization (SEAPRO)

From the BC border to Yakutat, the Southeast Alaska Petroleum Response Organization (SEAPRO) acts on behalf of its 52 member companies. SEAPRO has its equipment distributed to nine different zones along the coast as shown in Figure C26 and Table C15. The average distance between the depots is 100nm, Ref. [17].



Figure C26. SEAPRO Oil Spill Equipment Zones

**Table C15. Summary of Equipment at SEAPRO Oil Response Depots (Ref. [18])**

ZONE	DEPOT	WORKBOATS (20FT± ) [ea]	OIL BOOM SYSTEMS			OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m³]
			ABS [m]	L [m]	M/H [m]		
1	Ketchikan <sup>2</sup>	2	300	150	2700	16	2380
2	Craig <sup>3</sup>	-	60	-	600	2	20
3	Petersburg/Wrangell <sup>3</sup>	-	60	-	600	1	30
4	Kake <sup>3</sup>	-	60	-	600	1	20
5	Sitka <sup>2</sup>	-	300	-	2800	6	1160
6	Gustavus/ Pelican <sup>3</sup>	1	90	-	2000	2	60
7	Juneau <sup>2</sup>	2	320	150	2600	7	80
8	Haines/ Skagway <sup>3</sup>	1	60	-	900	4	100
9	Yakutat <sup>3</sup>	1	60	-	1200	3	110
<b>Typical SEAPRO marine centre</b>		<b>2</b>	<b>300</b>	<b>150</b>	<b>2700</b>	<b>10</b>	<b>1200</b>
<b>Typical SEAPRO satellite depot</b>		<b>1</b>	<b>65</b>	<b>0</b>	<b>1000</b>	<b>2</b>	

Notes:

1. ABS = Sorbent; L = Light-weight; M/H = Medium/Heavy (see Section 7.2.4)

2. Large marine response centre

3. Satellite depot

Based on information provided from SEAPRO, a typical marine centre consists of the following response equipment:

- 2-off workboats
- 300m of sorbent booms
- 150m of light-weight containment booms
- 2,700m of medium to heavy containment booms
- 10-off oil skimmer systems
- 1,200 m³ temporary oil storage facilities

A typical SEAPRO satellite depot would have the following response equipment:

- 1-off workboat
- 65m of sorbent booms
- 1,000m of medium to heavy containment booms
- 2-off oil skimmer systems
- 55 m³ temporary oil storage facilities

The average distance between depots along the south Alaskan coast is 25 nautical miles. Based on a one hour mobilisation, a minimum transit speed of 14 knots as specified in Ref. [9], and one hour for full deployment of equipment, the maximum response times from a depot is, therefore, four hours.



## C.3.4 APPROACH TO OIL SPILL PREPAREDNESS IN NORWAY

### C.3.4.1 General

The overall responsibility for oil spill response preparedness in Norway lies with the Norwegian Coastal Administration (NCA). The major contributors to the emergency response are as follows:

- Norwegian Coastal Administration (NCA)
- Inter-municipal Committee for Oil Spill Response (IUA)
- Norwegian Clean Seas Association for Operating Companies (NOFO)
- Coast Guard

Due to the large-scale oil & gas industry off the Norwegian coast, detailed oil spill preparedness plans are defined prior to any field development approvals from the Norwegian Petroleum Directorate. Naturally, the responsibility for any clean-up operations for events that cause harm to the environment lies with the polluter. Hence, the operating companies have formed a private organization, NOFO, which has the largest inventory of vessels and equipment for response to oil spills in Norway. Although the NOFO oil spill systems are located at various locations along the coast and on offshore vessels, the NCA cannot assume unrestricted use of their equipment. NOFO and NCA therefore rely on independent oil spill preparedness plans.

### C.3.4.2 Norwegian Coastal Administration (NCA)

The NCA works together with the Department of Defence, the Directorate for National Security and Preparedness, and the Department of Fisheries and Oceans. Local preparedness is organized at the municipal level through the IUA. In the event of major accidents or oil spills, Norway will require assistance from other countries, or vice versa. Examples of international collaboration are the Copenhagen, NORBRIT and Bonn agreements.

A summary of the oil spill response resources available to the NCA is given below, Ref. [1]:

- 16 oil response depots with personnel (typically 10 people at each location)
- 29 IUA depots with NCA equipment
- 6 NCA oil spill response vessels
- 11 Coast Guard vessels with oil response equipment
- 5 tug boats under NCA contracts
- 34 vessels for coastal oil spill response
- 17 rapid response vessels
- Surveillance aircraft and satellite agreements
- International agreements

The locations of the 16 oil response depots are shown in Figure C27, Ref. [2].



Figure C27. Norwegian Coastal Administration (NCA) Oil Spill Response Depots

The depot locations and the type of equipment stored at each location are based on risk assessments that take into account the probabilities of oil spills and the resulting environmental impacts at various locations along the coast. A detailed list of vessels and equipment available at the main NCA depots is given in Table C6, Ref. [2].

Table C16. Summary of Equipment at NCA Oil Response Depots

ID	DEPOT	WORKBOATS (20FT± ) [ea]	OIL BOOM SYSTEMS <sup>1</sup>			OIL SKIMMER SYSTEMS [ea]	SHORELINE CLEAN-UP SYSTEMS [ea]	PORTABLE OIL STORAGE [m <sup>3</sup> ]	DISTANCE TO NEAREST DEPOT [nm]
			ABS [m]	L [m]	M/H [ea]				
1	Horten	5	1000	4	20	23	13	60	123
2	Kristiansand	2	941	2	8	7	7	45	123
3	Stavanger	2	1050	3	11	8	9	45	99
4	Bergen	2	1025	3	16	7	8	45	30
5	Fedje	1	1400	7	11	6	8	10	24
6	Solund	1	1200	3	6	4	8	45	24
7	Florø	2	1600	3	12	6	8	45	50
8	Ålesund	2	1250	2	11	7	9	45	82
9	Ørland	1	1012	2	6	7	9	70	120
10	Sandnessjøen	2	1000	3	7	8	9	45	93
11	Bodø	1	1100	4	8	6	8	45	84
12	Lødingen	2	1200	3	5	6	9	45	84
13	Tromsø	2	2450	3	11	11	9	45	100
14	Hammerfest	2	1175	3	4	11	8	37	119
15	Vadsø	1	3050	3	7	6	8	45	221
16	Svalbard	0	1650	19	6	7	8	55	470
<b>Typical NCA depot<sup>2</sup>:</b>		<b>2</b>	<b>1360</b>	<b>3</b>	<b>10</b>	<b>8</b>	<b>9</b>	<b>45</b>	<b>92</b>

Notes:

1. ABS = Sorbent; L = Light-weight; M/H = Medium/Heavy (see Section 2.5)  
2. Based on average values for mainland Norway (excluding Svalbard).

Based on the information gathered from the Norwegian Coastal Administration, a typical depot consists of the following response equipment:

- 2-off 20ft+ workboats
- 1360m sorbent oil booms
- 3-off light-weight conventional containment booms
- 10-off medium to heavy duty oil boom systems
- 8-off oil skimmers
- 9 shoreline clean-up systems
- 45 m<sup>3</sup> temporary oil storage facilities

The average distance between depots along the mainland coast is 90 nautical miles. Based on a one hour mobilisation, a minimum transit speed of 14 knots as specified in Ref. [9] and one hour for full deployment of equipment, the maximum response time from a depot is, therefore, eight hours.

### C.3.4.3 Inter-Municipal Committees for Oil Spill Response (IUA)

In terms of oil spill response, the municipalities in Norway are divided into 29 IUA regions. Each municipality is responsible for preparedness and clean-up of smaller oil spills within its boundary. If required, they may call on help from other municipalities through the IUA.

The locations of the IUA oil spill response depots are shown in Figure C28. An extract from the NCA equipment database, Ref. [2], is shown in Table C17.



Figure C28. Norwegian Coastal Administration (NCA) IUA Depot (Ref. [3])

Table C17. Summary of Equipment at IUA Depots (Extracts from Ref. [2])

DEPOT	IUA REGION	WORKBOATS (20FT± ) [ea]	OIL BOOM SYSTEMS L [ea]	OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m <sup>3</sup> ]	DISTANCE TO NEAREST DEPOT [nm]
Tananger	Sør Rogaland	1	3	1	-	33
Haugesund	Haugesund	1	7	1	10	33
Bergen	Bergen	1	1	1	-	64
Florø	Sogn og Sundfjord	1	3	1	10	79
Stryn	Nordfjord	1	4	1	10	79
Ålesund	Sunnmøre	1	1	2	10	34
Molde	Romsdal	1	1	1	10	34
Kristiansund	Nordmøre	1	3	1	-	48
Trondheim	Sør Trøndelag	1	3	1	10	48
Steinkjer	Inntrøndelag	1	1	1	10	48
Rørvik	Namdal	1	3	1	10	44
Brønnøy	Helgeland	1	1	1	-	44
<b>Typical IUA depot</b>		<b>1</b>	<b>3</b>	<b>1</b>	<b>10</b>	<b>58</b>

Based on information provided in table above, a typical IUA depot consists of the following response system:

- 1-off small workboat
- 300m light-weight oil boom (freeboard 0.35m)
- 500m light-weight oil boom (freeboard 0.25m)
- 500m sorbent boom
- 1-off oil skimmer system (min 10m<sup>3</sup>/h)
- Temporary oil storage (10m<sup>3</sup>)

The distance between each depot along the mainland coast is typically 58 nautical miles. Based on a one hour mobilisation, 14 knot transit and one hour for deployment of equipment, the response time from an IUA depot should, therefore, be maximum six hours.



C.3.4.4 Norwegian Clean Seas Association for Operating Companies (NOFO)

Each operating company on the Norwegian continental shelf shall ensure that they have sufficient oil response equipment available in the event of an oil spill from their operations. Hence, more than 31 operating companies have formed the organization NOFO to administer and maintain the preparedness through combined personnel, equipment and vessels. NOFO is also involved in research & development of new oil spill equipment and improvement of existing systems through lessons learned from previous oil spills.

A summary of the NOFO equipment is listed below, Ref. [8]:

- Approx. 30 full time employees
- 60 people on-call with additional personnel available at operating companies
- 31 Oil Response (OR) vessels and 34 vessels for towing in open waters
- 5 marine response centres with 80 equipment operators (see Table 7.5)
- Storage areas for dispersion liquid
- Satellite, aircraft, helicopters and vessels used for surveillance operations
- 63 vessels for coastal operations
- 25 oil spill response systems for coastal operations
- 10 dispersion systems
- Response groups for shoreline oil spill preparedness

A typical equipment list for a NOFO depot is given in Table C18. The Krisitansund depot is located on the central Norwegian coast and is mainly meant for responding to oil spills related to the offshore oil and gas activities. The distance to the nearest NOFO depot is 200nm.

Table C18. Summary of Equipment at NCA Oil Response Depots

OIL BOOM SYSTEMS			OIL SKIMMER SYSTEMS					PORTABLE OIL STORAGE	DISPERSION LIQUIDS [litres]
NO-1200-R [m]	NOFI-350 EP [m]	OCEAN BUSTER 4 [ea]	TRANSREC 150 [ea]	FOXTAIL [ea]	HI VISC [ea]	HI-WAX [ea]	NORMAR 15-30 [ea]	COVERTEX 10M³ TOW TANK [ea]	
1600	300	3	4	1	2	2	1	1	98000

Notes:  
1. Includes storage on standby vessels.

### C.3.4.5 Response times

In terms of emergency response times, the NCA expects the IUA to respond to local oil spills within six hours. Equipment used during this phase should include oil booms, skimmers and temporary storage systems. Full assistance from the NCA resources shall be in place within 24 hours.

For beach clean-up operations, NCA shall be fully mobilised within 48 hours of an incident. For this phase, the main challenge may be the logistics of getting people to the site. Shoreline clean-up kits are located at the NCA and IUA depots.

NCA spill control equipment categories are defined according to expected response times in the event of an incident, Ref. [3]:

- **Category 1: Open water oil spills**

Response time: < 9 hours

Equipment in this category, designed to operate in open water under challenging sea states, includes a large response vessel (e.g. Coast Guard vessel) with oil boom, skimmer and oil storage capacity. Assistance is provided from a tug boat and an oil spill detection system.

- **Category 2: Coastal oil spills**

Response times: IUA < 6 hours/ NCA < 24 hours

Equipment in this category, designed to prevent spreading of spill to other regions, includes two distinct systems – a Coastal system and a Fjord system.

The Coastal system consists of a medium-sized NCA response vessel (e.g. OV Utvær) with oil boom, skimmer and oil storage capacity, see Figure C29. Assistance is provided from a tug boat. If the response vessel does not have equipment onboard, the oil boom and skimmer have to be mobilised from IUA/NCA depot (2-off 10ft containers).

The Fjord system consists of two or three rapid response vessels certified for oil recovery operations (approx. 50ft vessels on contract with NCA or NOFO). It is assumed that the oil booms, skimmers and temporary storage facilities are from an IUA/NCA depot.

Equipment required from IUA/NCA depot can be transported in 3-off 10ft containers.



Figure C29. Norwegian Coastal Administration (NCA) Category 2 Oil Spill Response

- **Category 3: Shoreline clean-up**

Response times: NCA < 48 hours

The NCA shall be able to mobilise a full beach clean-up operation within 48 hours of an incident. For this phase, the main challenge is the logistics of getting a sufficient number of people to the site. Shoreline clean-up kits are located at the NCA and IUA depots.

Historic coastal oil spills illustrate how the above-referenced target response times are generally maintained. For three incidents close to the Marine Response Centre in Horten, the first responders were shown to be within the target of six hours and full NCA mobilisation was achieved within 24 hours, see Figure C30.

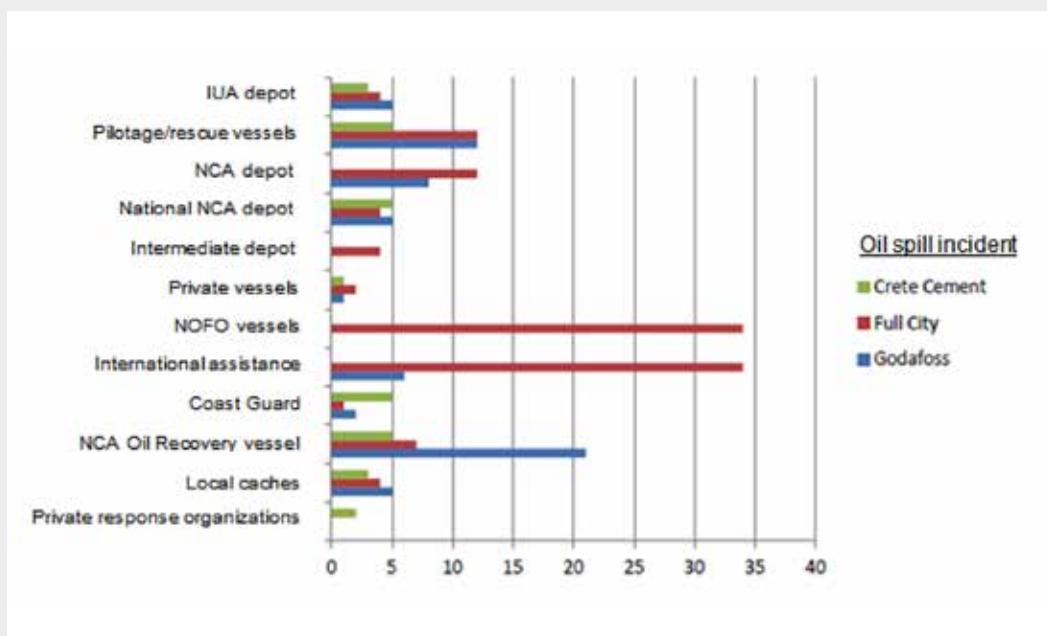


Figure C30. Response Times for Oil Spill Incidents

Table C19. Oil Spill Incident Data (Ref.[3])

DESCRIPTION	CRETE CEMENT	FULL CITY	GODAFOSS
DATE OF INCIDENT	NOV 19, 2008	JUL 31, 2009	FEB 17, 2011
Distance to nearest NCA depot [nm]	19	45	26
Potential oil spill [ tonnes]	157	1154	555
Oil recovered from ocean [tonnes]	20	27	55
Oil recovered from beach clean-up [tonnes]	-	74	35
Oil recovered directly from vessel [tonnes]	78	860	443

C.3.5 APPROACH TO OIL SPILL PREPAREDNESS IN NEW ZEALAND

C.3.5.1 General

Maritime New Zealand (MNZ), previously known as New Zealand Safety Authority, has the overall responsibility for protecting the marine environment. However, the oil spill response preparedness in New Zealand is based on a three-tiered approach, where the responsibilities are defined as follows:

- Tier 1: Industry (e.g. ships and onshore/offshore oil transfer sites)
- Tier 2: Regional councils (16 regional councils and territorial authorities)
- Tier 3: Maritime New Zealand

For larger oil spills, New Zealand has international agreements with Australia, Singapore and the UK.

C.3.5.2 Maritime New Zealand (MNZ)

The main equipment for oil spill response is stored at the MNZ’s Marine Pollution Response Service (MPRS) warehouse in Te Atatu, Auckland. In addition, there are smaller equipment depots distributed along the coast as described in Section 3.5.3. The Auckland location has eight permanent staff members and is supported by a National Response Team with 120 trained responders. Regional responders account for another 400 trained personnel. The MPRS is in possession of the equipment listed in Table C20.

Table C20. Summary of National Response Equipment Operated by MPRS (Ref. [12])

WORKBOATS [ea]		OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	DISPERSANTS [litres]	PORTABLE OIL STORAGE [tonnes]	PUMP SYSTEMS [ea]
(<20FT)	(>20FT)					
8	1	101	22	114840	350	15

C.3.5.3 Regional councils

The regional MNZ stockpiles of oil spill response equipment are located as shown in Figure C31 and Figure C32, Ref. [11]. The average distance between regional depots is 120nm on the North Island and 100nm on the South Island (excluding West Coast and Chatham Island). From risk analyses, the probabilities of oil spills are found to be highest at the following regional councils: Northland, Taranaki, Auckland, Canterbury, Southland and Te Atatu (Auckland), Ref. [14]. Due to limited vessel traffic, the lowest risks for oil spills are on the South Island West Coast.



Figure C31. Regional Council MNZ Equipment Stockpiles – North Island (Ref. [11] )

Table C21. Summary of Equipment at Regional Councils – North Island (Ref. [12])

ID	DEPOT	OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	DISPERSANTS [litres]	PORTABLE OIL STORAGE [tonnes]
N1	Opus-Marsden Pt	32	8	4060	145
N2	Auckland	19	5	3200	40
N3	Tauranga	16	4	6900	40
N4	Gordonton	8	2	3200	40
N5	Gisborne	6	3	3200	40
N6	Napier2	14	5	3200	40
N7	New Plymouth	17	7	19200	65
N8	Palmerston North	3	2	-	40
N9	Wellington	9	4	10900	40
Typical MNZ North Depot		12	4	7,000	40 (45m <sup>3</sup> )



Figure C32. Regional Council MNZ Equipment Stockpiles – South Island (Ref. [11] )

Table C22. Summary of Equipment at Regional Councils – South Island (Ref. [12])

ID	DEPOT	OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	DISPERSANTS [litres]	PORTABLE OIL STORAGE [tonnes]
S1	Nelson	13	3	3300	40
S2	Picton	15	4	3300	55
S3	Westport	8	2	1600	40
S4	Greymouth	4	1	800	15
S5	Lyttleton	8	4	23600	50
S6	Timaru	8	4	2000	50
S7	Dunedin	11	3	3200	50
S8	Bluff	9	4	3400	60
S9	Chatham Islands	9	2	5600	50
Typical MNZ South depot		9	3	5,000	45



Based on information provided from the MNZ, a typical depot on the North Island, excluding the National Response Centre at Marsden Point, consists of the following response equipment:

- 12-off containment booms
- 4-off oil skimmer systems
- 7,000 litres of dispersants
- 45 m<sup>3</sup> of temporary oil storage facilities

On the South Island, a typical depot consists of the following response equipment:

- 9-off containment booms
- 3-off oil skimmer systems
- 5,000 litres of dispersants
- 50 m<sup>3</sup> of temporary oil storage facilities

The average distance between depots along the coast is approximately 100 to 120 nautical miles. Based on a one hour mobilisation, a minimum transit speed of 14 knots as specified in Ref. [9] and one hour for full deployment of equipment, the maximum response times from a depot is, therefore, nine to 11 hours. The response times will be much faster, however, if quick deployment of dispersant systems are included in the response plan.

## C.4 SUMMARY & CONCLUSIONS

### C.4.1 SUMMARY

From the benchmark survey carried out herein, an initial measure of a “world class response plan” has been established. Comparison of response times, facilities and equipment has been assessed in the following jurisdictions:

- State of Alaska
- State of Washington
- Norway
- New Zealand

When it comes to response times to an oil spill incident, it should be distinguished between an initial rapid response and the response required to get the spill under control. The initial response relies on having a sufficient number of response depots along the coast – the smaller the distances between depots, the faster the response.

A response plan also needs to consider the suitability of equipment and the logistical constraints associated with deployment and operations. Light-weight equipment may be suitable for quick response in sheltered waters and harbours, but have limited effect in open waters. An oil spill preparedness plan will therefore have to rely on a mix of oil booms and skimmers for their marine response centres and satellite locations.

Based on the summary provided in Table C23, the requirements for an oil spill response facility on the BC central coast should as a minimum include the following equipment:

- 2-off rapid response vessels
- 300m sorbent booms
- 2-off light-weight containment booms
- 4-off medium to heavy containment booms
- 4-off oil skimmer systems
- 45 m<sup>3</sup> temporary oil storage facilities
- Shoreline clean-up systems
- Wildlife rescue equipment
- Specific equipment and procedures for handling environmentally sensitive areas

Table C23. Benchmark Review of Marine Emergency Response Facilities

AUTHORITY REVIEWED	RESPONSE COVERAGE		FACILITY EQUIPMENT			
	RESPONSE TIME [hrs]	SPATIAL COVERAGE [nm]	WORK BOATS [ea]	OIL BOOM SYSTEMS [ea]	OIL SKIMMER SYSTEMS [ea]	PORTABLE OIL STORAGE [m <sup>3</sup> ]
State of Washington (MSRC)	3	15	4	4	6	1,380 <sup>1</sup>
State of Alaska (SEAPRO, Main)	4	25	2	8 <sup>2</sup>	10	1,200
State of Alaska (SEAPRO, Satellite)				4 <sup>2</sup>	2	55
Norway (NCA, Main)	8	90	2	13	8	45 <sup>3</sup>
Norway (IUA, Satellite)	6	58	1	3 <sup>4</sup>	1	10 <sup>3</sup>
New Zealand (North Island)	11 <sup>5</sup>	120	-	12	4	45 <sup>6</sup>
New Zealand (South Island)	9 <sup>5</sup>	100	-	9	3	50 <sup>6</sup>

## Notes:

1. Volumes do not include oil spill response barges at Tacoma (1,890 m<sup>3</sup>) and Port Angeles (6,040 m<sup>3</sup>) and storage onboard response vessels.
2. Estimated number based on total boom lengths of 3,150m and 1,700m for main and satellite depots, respectively.
3. Additional storage from response vessels not included, e.g. 90 – 160 m<sup>3</sup> for NCA vessels and up to 1,100 m<sup>3</sup> for Coast Guard vessels.
4. Based on a total of 1,300 m light-weight oil booms.
5. Response times do not include use of dispersant systems - 7,000 and 5,000 litres of dispersants are typically stored for North and South Island depots, respectively.
6. Storage capability of response vessels not included.

## C.4.2 CONCLUSIONS

Based on the review of existing marine response centres and satellite depots, the following conclusions are made:

- Typical distances between oil spill response depots are approximately 15 nm for Washington State, 25 nm for South East Alaska, 58 nm for Norway and 100 nm for New Zealand.
- In Washington State, based on information provided from the MSRC, a typical response depot consists of the following response equipment:
  - 4-off workboats
  - 4-off containment booms
  - 6-off oil skimmer systems
  - 1,380 m<sup>3</sup> temporary oil storage facilities
- The average distance between the MSRC depots is 15 nautical miles. Hence, maximum response times from a depot should therefore be 3 hours.
- In Alaska, based on current SEAPRO equipment distribution, a typical marine response centre will have the following equipment:
  - 2-off workboats
  - 300m of sorbent booms
  - 150m of light-weight containment booms
  - 2,700m of medium to heavy containment booms
  - 10-off oil skimmer systems
  - 1,200 m<sup>3</sup> temporary oil storage facilities

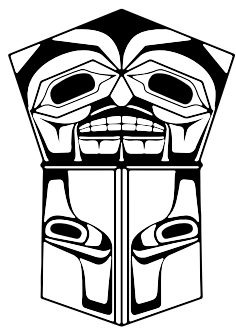
- A typical SEAPRO satellite depot would have the following response equipment:
  - 1-off workboats
  - 65m of sorbent booms
  - 1,700m of medium to heavy containment booms
  - 2-off oil skimmer systems
  - 55 m<sup>3</sup> temporary oil storage facilities
- The average distance between depots along the south Alaskan coast is 25 nautical miles. This gives an estimated response time from a depot of four hours.
- Based on the information gathered from the Norwegian Coastal Administration, a typical depot consists of the following response equipment:
  - 2-off workboats
  - 1360m sorbent oil booms
  - 3-off light-weight conventional containment booms
  - 10-off medium to heavy duty oil boom systems
  - 8-off oil skimmers
  - 9 shoreline clean-up systems
  - 45 m<sup>3</sup> temporary oil storage facilities
- The average distance between NCA depots along the Norwegian coast is 90 nautical miles. This gives an estimated response time from a depot of eight hours.
- A typical Norwegian IUA depot consists of the following response system:
  - 1-off small workboat
  - 300m light-weight oil boom (freeboard 0.35m)
  - 500m light-weight oil boom (freeboard 0.25m)
  - 500m sorbent boom
  - 1-off oil skimmer system (min 10m<sup>3</sup>/h)
  - 10 m<sup>3</sup> temporary oil storage
- The average distance between IUA depots is 58 nautical miles, resulting in a response time of six hours.
- Based on information provided from Maritime New Zealand, a typical depot on the North Island, excluding the equipment at the National Response Centre, consists of the following response equipment:
  - 12-off containment booms
  - 4-off oil skimmer systems
  - 7,000 litres of dispersants
  - 45 m<sup>3</sup> of temporary oil storage facilities

- On the South Island, a typical MNZ depot consists of the following response equipment:
  - 9-off containment booms
  - 3-off oil skimmer systems
  - 5,000 litres of dispersants
  - 50 m<sup>3</sup> of temporary oil storage facilities
- Based on average distances of 100-120 nm between MNZ depots, the response times assuming vessels travelling at 14 knots would be between nine and 11 hours. The response times will be much faster, however, if quick deployment of dispersant systems is included in the response plan.

## C.5 REFERENCES

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**HEILTSUK TRIBAL COUNCIL**

APPENDIX D

Summary of Equipment Testing  
and Standards

## D.1 PURPOSE

For the Indigenous Marine Response Centre (IMRC) to be a world-leading facility, it is important to have trained responders and vessels, facilities and equipment that are suited to the environment and the types of possible incidents and oil spills.

This Appendix provides information on tests performed on containment booms and oil skimmers.

Most of the published test results on oil booms obtained for this study were performed before the most recent testing standards were developed. Thus, they are of limited value for selecting booms for the IMRC, but they indicate the difficulty in containing light petroleum product such as diesel fuel oil.

The test procedures and data for oil skimmers, on the other hand, comply with American Society for Testing and Materials (ASTM) standards and are very useful in providing information on the selection of this equipment.

## D.2 BOOM REVIEWS AND FIELD TESTS

The US Bureau of Safety and Environmental Enforcement (BSEE) has performed recent boom testing between Jan 30 – Feb 17, 2017 at the National Oil Spill Response Test Facility (Ohmsett) testing station in New Jersey, and MAR Inc. completed boom testing for the BSEE on June 19-June 23, 2017 also at Ohmsett. The project(s) for which these tests were performed is currently not listed on the BSEE Oil Spill Response Research page, therefore the project completion and publication dates are not known. From the Ohmsett webpage: “The scope of [the BSEE boom testing] effort [was] to conduct boom testing in advancing mode. Tests included data collection of relative water velocities at various points within the boom apex area as the boom was towed at various tow speeds, and ASTM F2084 testing of booms of varying lengths to determine first loss and gross loss speeds.”

Most current boom testing is being done using ASTM standards. It is recommended that the next phase of the development of the IMRC utilize the ASTM Standard Guide for the selection of booms in accordance with water body classification (ASTM F1523-94) and the ASTM Standard Guide for the selection of booms for oil spill response (ASTM F2683-11).

Physical model tests were performed by the Canadian Coast Guard (CCG) in 1991 at the Institute of Fisheries and Marine Technology (IFMT) in St. John's, Newfoundland and Labrador, and were reported on by Robert Schultz in “Oil Spill Response Performance, Review of Booms” 2001. The following points were extracted from that study:

- The tests performed by the CCG in 1991 were performed in the recirculating flume tank (8 m x 22.5 m x 4 m) at the IFMT in St. John's, Newfoundland in November 1991. These tests were done in calm water.

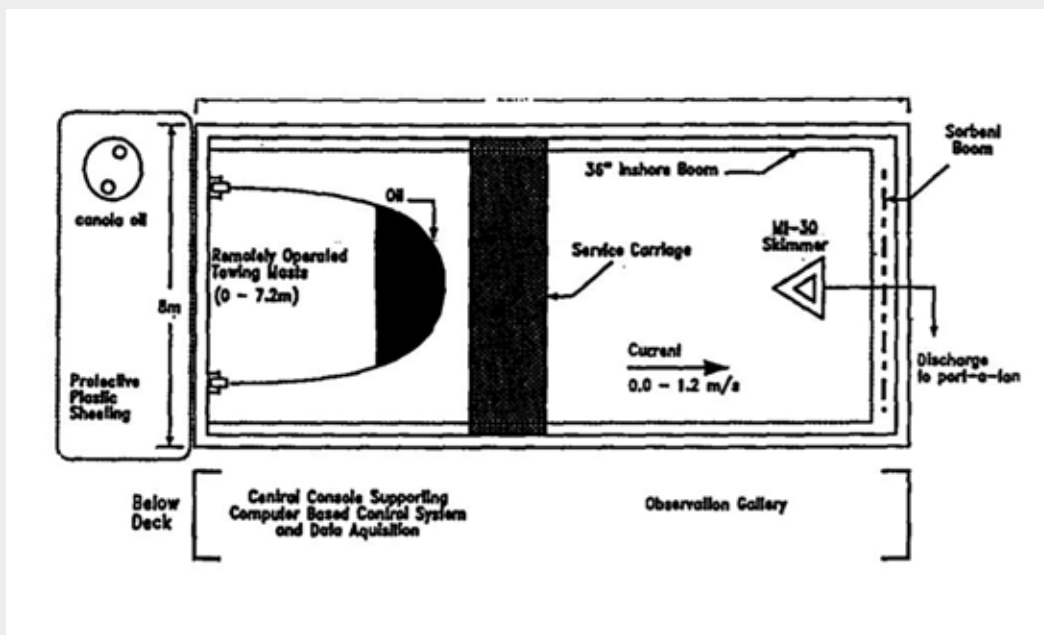


Figure D1. IMFT Tank Diagram (Shultz, 2001), with a Catenary Type of Boom Deployment

- The reserve buoyancy (Buoyancy-Weight) to weight (RB/W) ratio is unitless, and a higher RB/W ratio tends to make booms sustain higher tow speeds or currents better than those of lower ratios. The increased ratio allows for the boom to follow the wave without lifting off of the water or submerging.
- For the *Nathan E. Stewart* (NES) Spill the majority of the oil that was released into the environment was diesel. Diesel has a viscosity of  $\sim 10 \text{ mm}^2/\text{s}$  (centistokes, cSt) and a density of  $\sim 835 \text{ kg/m}^3$ . The tendency of the boom to submerge at a given velocity is greatly affected by the reserve buoyancy of the boom; splash over is largely dependent on the free board height; entrainment is largely affected by the angle between the boom and the current and the draft of the boom.
- From this report, it was also found that the difference between the current speed at which the first loss occurs (when the first oil flows under or over the boom) and the current speed at which gross loss occurs (when the oil flows freely over or under the boom) is typically in the order of 0.3 kn.
- As oil viscosity decreases, the current/towing speed at which first failure occurs also decreases.
- These tests have not all been done to ASTM standards, as some were performed prior to the current boom testing standards.
- The results are those for varying oil viscosities and wave heights.
- Note that the convention used in this section is to denote a wave height of H ft. with a wave length of L ft. as H x L'.
- All figures were taken from the Oil Spill Response Performance Review of Booms (Schultz, 2001).

## D.2.1 BOOM FORMATION TEST RESULTS (TESTED AT OHMSETT WITH A B.F. GOODRICH SEA BOOM IN APRIL AND SEPTEMBER, 1977):

The following figure shows a number of boom deployment formations:

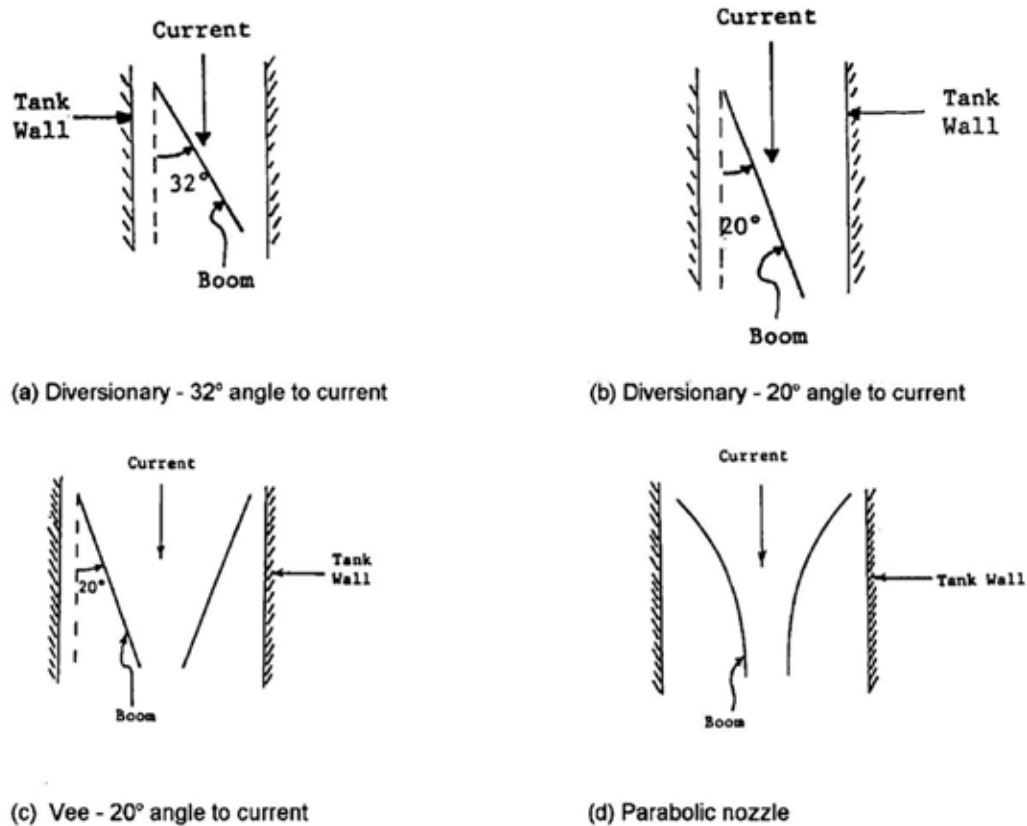


Figure D2. Boom Formation Diagram

1. Diversionary, 32° from current
  - Good for low current/tow speeds
2. Diversionary, 20° from current
  - Holds a higher percentage of oil behind the boom than the 32° diversionary configuration
3. Vee, 20° from current
  - The amount of oil retained by the boom is similar to the Diversionary 20°, however a higher percentage of oil is retained in the boom compared to behind it
4. Parabolic Nozzle with a boom extender
  - Performs similarly to, but not quite as well as, the Vee 20° formation with respect to oil being retained in the boom and not behind it

- B.F. Goodrich Seaboom with a 0.15m freeboard and a 0.3m draft. The reserve buoyancy is 10.4kg/m (reserve buoyancy is defined for the purpose of this document to be the value of the buoyancy with the weight subtracted)
- The slick was approximately 1 to 2 mm thick for the tests at Ohmsett in April and September of 1977 and was composed of Circo medium oil with a viscosity of 190 cSt and a density of 921 kg/m<sup>3</sup>

## D.2.2 BOOM MODELS

### a. Fence Booms:

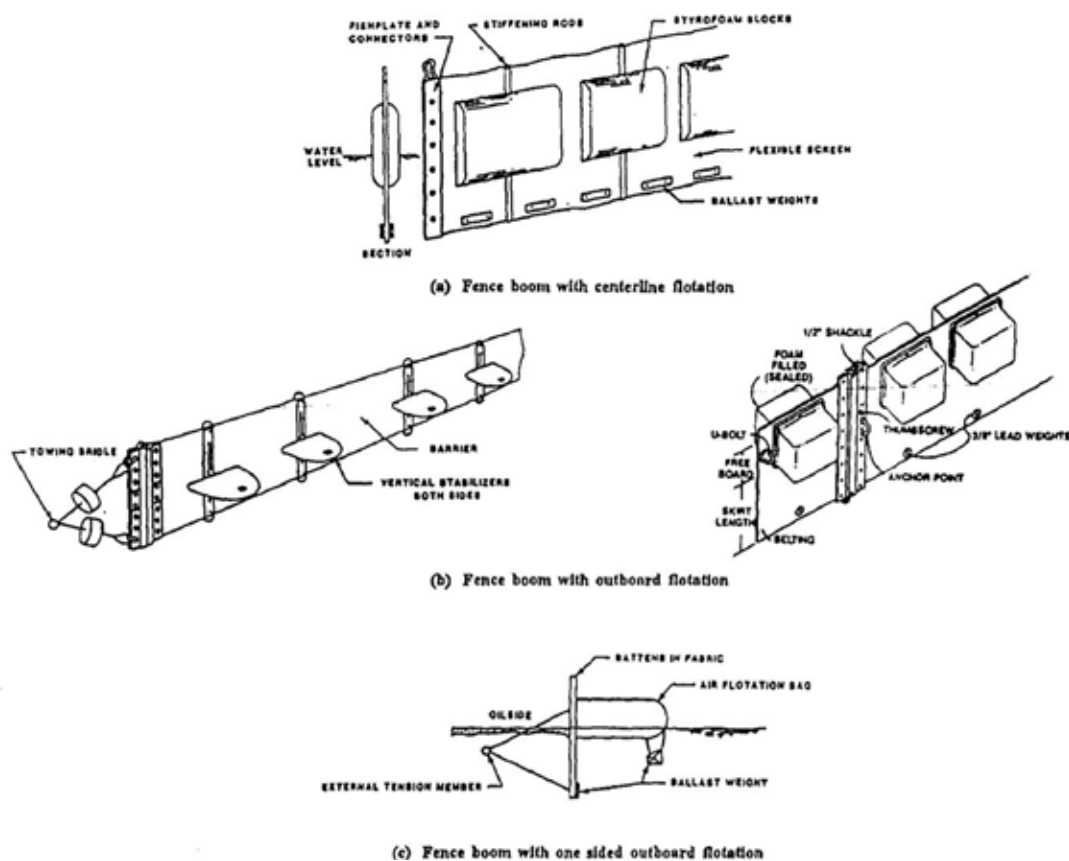


Figure D3. Fence Boom Diagrams

- Generally mediocre buoyancy (generally lower buoyancy than inflatable booms).
- Often used for permanent installations in harbours so that strength and durability often increased with an attendant increase in weight without proportional increase in float volume, and can be used for an immediate response.
- Easy to deploy as there is no need for pumps to inflate them.
- Resistant to damage because if there is a puncture in the boom, the flotation is not compromised as an inflatable boom might be.

- Bulky for storage because the flotation is generally quite space intensive.
- DESMI- Globe Boom 36 ED (0.3 m (12") freeboard, 0.61 m (24") draft, and the RB/W ratio is 4.2) (note that this model has changed slightly to presently be heavier and have a higher tensile strength). The test results are summarized as follows:
  - Test oil: canola oil- viscosity of 64 cSt, and density of 935 kg/m<sup>3</sup>, with a 5 mm slick
  - Test configuration: catenary
  - Test agency and year: CCG 1991
    - 1<sup>st</sup> loss at 1.2 kn
    - Loss rate at 1.4 kn is 7.0 m<sup>3</sup>/hr
    - Boom is stable at higher velocities
    - The researchers state that most of the loss is from "vortices", and some from entrainment in the water flowing under the boom
- Overall fence boom comments:
  - Fence booms can contain oil successfully in a catenary mode under 1 kn (either towing or with current)
  - Fence booms can be used in a diversionary method in a steep V up until ~3 kn (with either towing or with current)

b. Curtain Booms with Internal Foam Floatation:

- The following figure provides examples of curtain booms with internal floatation:

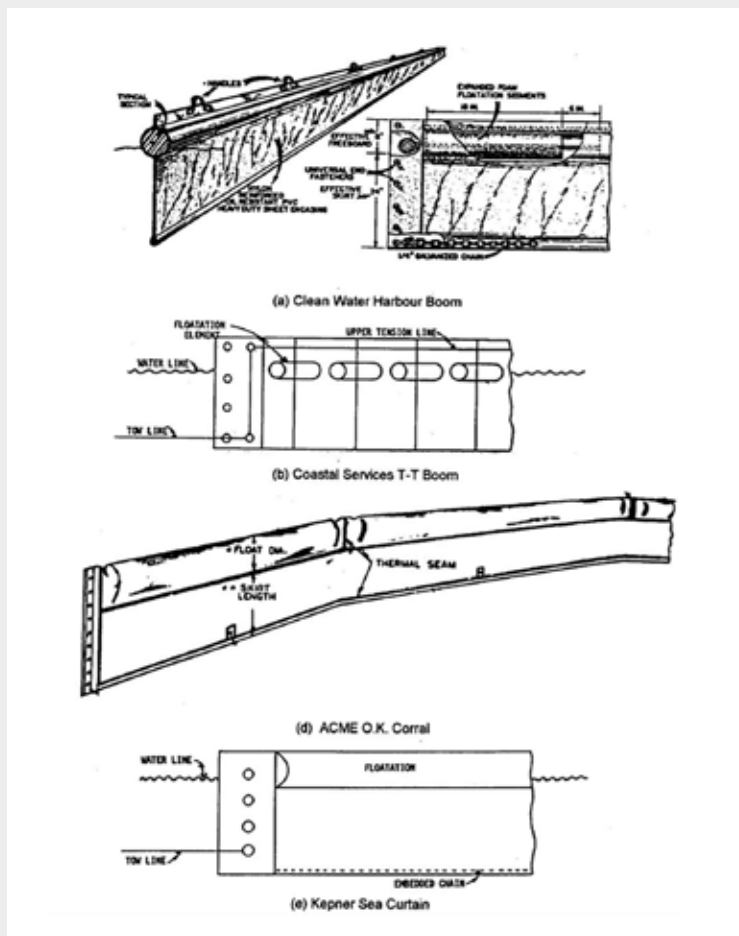


Figure D4. Curtain Booms With Internal Foam Floatation



- Curtain booms with internal foam flotation have moderate buoyancy, usually in the range of 2 to 8 Buoyancy/Weight ratio.
- These higher ranges of buoyancy are adequate for most conditions, with the exception of severe offshore conditions.
- They tend to follow the wave shape.
- Commonly used as spill response booms
- Moderately expensive.
- Fairly easy to store, either on reels for fast deployment or on pallets in storage.
- May be vulnerable to damage by chaffing or cutting by sharp objects.
- An example of a test performed on this type of boom: Kepner-Sea Curtain (0.3 m (12") draft, 0.2 m (8") freeboard, RB/W is 6.5-7.8) (closest to the Harbor Foam Filled Model, BHD81208RF)
  - Test oil: lube oil with a viscosity of 97 cSt
  - Test configuration: catenary
  - Test facility and year: Ohmsett 1975
    - Failure at 0.9 kn from entrainment in calm water and in waves with dimensions 1 x 45', and 2 x 30'.
    - "Submarines" in calm water at 2.1 kn, 1.8 kn in waves 1 x 75' (no tests were performed with 1 x 75' waves with oil)
    - Splash over occurs at 1.1 kn for waves 1 x 45' and waves 2 x 30'. Splash over occurs at 0.5 kn with waves 1 x 9'
  - Test oil: Lube oil with a viscosity of 235 cSt
  - Test configuration: diversionary (23-44°)
  - Test facility and year: Ohmsett 1975
    - Submarining occurred at 1.8 kn in calm water and with waves of either 1 x 45' or 1 x 75', where the boom is submerged and cannot retain oil.
    - Submarining occurred at 1.5 kn in waves 2 x 30'
    - Splash over occurred at 0 kn in 2 x 75' waves
    - Entrainment occurred at 1.4 kn in calm water, and in waves 2' x 30'

#### c. Curtain Booms with External Foam Flotation

- Buoyancy to weight ratio is generally 2 or more
- Usually used as industrial, or permanent harbour boom, but is used in some spill response situations
- Generally durable and easy to store and deploy
- Typically more expensive than curtain booms with internal flotation
- Fairly low failure speeds (0.7 kn in catenary formation, and 0.9 kn in diversionary configuration)

d. Self-Inflatable Curtain Booms:

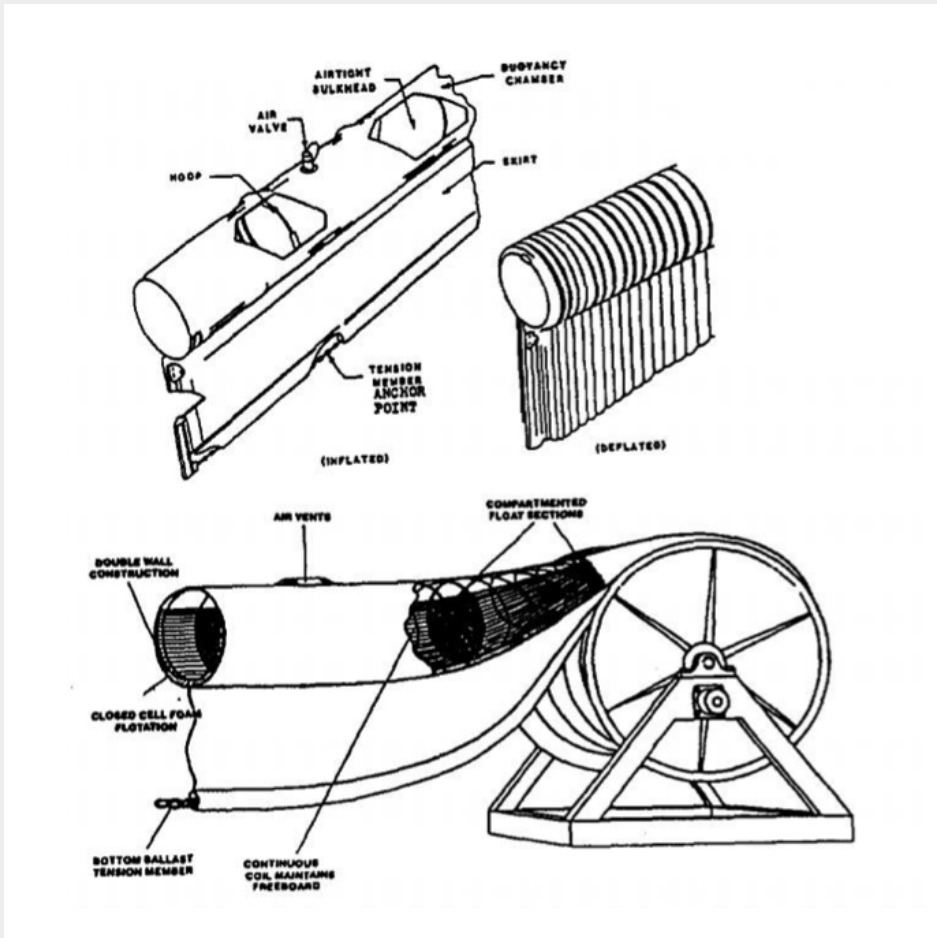


Figure D5. Self-Inflatable Curtain Boom Diagrams

- Generally a very high buoyancy to weight ratio (often in the range of 20-50), but buoyancy may be lost as a result of a puncture or leaking air valve
- Follow waves well
- Generally not used for long-term deployment at a spill site (good for initial response).

- Example of tests performed on this type of boom: Expandi Boom, 0.28 m (12.5") freeboard, 0.5 m (19.5") draft, RB/W is 22 (similar dimensions to M3000 model):

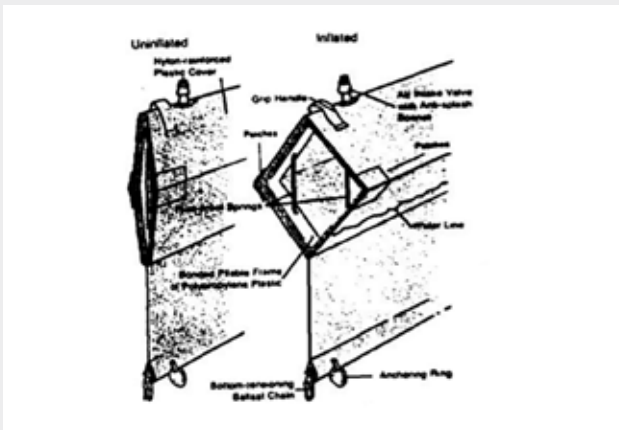


Figure D6. Expandi Boom Diagram

- Test oil: lube oil with a viscosity of 177 cSt
- Test configuration: catenary
- Test facility and year: Ohmsett 1975
  - Planing occurs at 2.5 kn in calm water
  - Planing occurs at 2.0 kn in waves 1 x 45', 1 x 75' and 2 x 30'
  - Splashover occurs at 0 kn with 1 x 9' waves
  - Entrainment occurs at 0.5 kn in calm water, 0.6 kn in 1 x 45' waves, 0.8 Kn in 2 x 30' waves
- Test oil: diesel with a viscosity of 10 cSt
- Test configuration: catenary
- Test facility and year: Ohmsett 1975
  - Entrainment occurs at 0.4 kn in calm water and in 1 x 45' waves
  - Entrainment occurs at 0.7 kn in 2 x 20' waves
- Test oil: viscous lube oil with a viscosity of 238 cSt, 2 mm thick
- Test configuration: diversionary (23-44°)
- Test facility and year: Ohmsett 1975
  - Splashover occurs in 1 x 9' waves at 0.4 kn
  - Entrainment occurs in calm water between 1.4 kn and 1.6 kn , at 1.0 kn in 1 x 45' waves, and between 1.2 kn and 1.6 kn in 2 x 30' waves

- Example of tests performed on this type of boom: Versatech Zoom Boom (0.45 m (18") freeboard, 0.45 m (18") draft, RB/W ratio is 24) (Zoom Boom is used by the WCMRC with the same draft)
  - Test oil: Circo X heavy oil with a viscosity of 3,000 cSt
  - Test configuration: catenary
  - Test facility and year: Ohmsett 1980
    - Failed in entrainment with the 1<sup>st</sup> loss at:
      - 0.78 kn in calm water
      - 0.5 kn in 0.6 x 9' waves
      - 0.9 kn in 0.6 x 27' waves
      - 0.8 kn in 0.6 x 63' waves
      - 0.8 kn in 1.3 x 63' waves
  - The Ohmsett report states in "Booms Offshore" (part of the proceedings of the Third Arctic and Marine Oil Spill Program Technical Seminar (AMOP), that occurred in June 1980) that it is concluded from these tests that the Zoom Boom is too small to be seriously considered for offshore use.
  - Ohmsett also reported in "Booms Offshore" that small waves were reflected back from the air chambers, causing the wave to roll back in an outward and downward direction, which was speculated to create a mixing action that would produce emulsification and a downward velocity that would carry oil under the boom quite quickly.
  - Zoom Booms now have a max of 0.61 m (2 ft.) diameter floatation. No other dimensions are available on their website, and so it is not known if they are manufactured with a larger draft and freeboard than the ones tested.
- Example of tests performed on this type of boom: Kepner Sea Curtain (self inflating single chamber + closed cell foam) (0.41 m (15") freeboard, 0.64 m (25") draft, RB/W is 25.1); most similar to the current offshore model, BPHD1823RP) (WCMRC uses this boom series - they have this model as well as the Ocean Harbor and the Hi-Seas 600 models).
  - Test oil: canola oil with a viscosity of 64 cSt
  - Test configuration: catenary
  - Test agency and year: CCG 1991
    - 1<sup>st</sup> loss occurs at 1 kn
    - Loss rate at 1.2 kn is 0.70 m<sup>3</sup>/hr
    - The loss was caused by entrainment, although the boom remained stable throughout the testing process

e. Pressure Inflatable Curtain Booms:

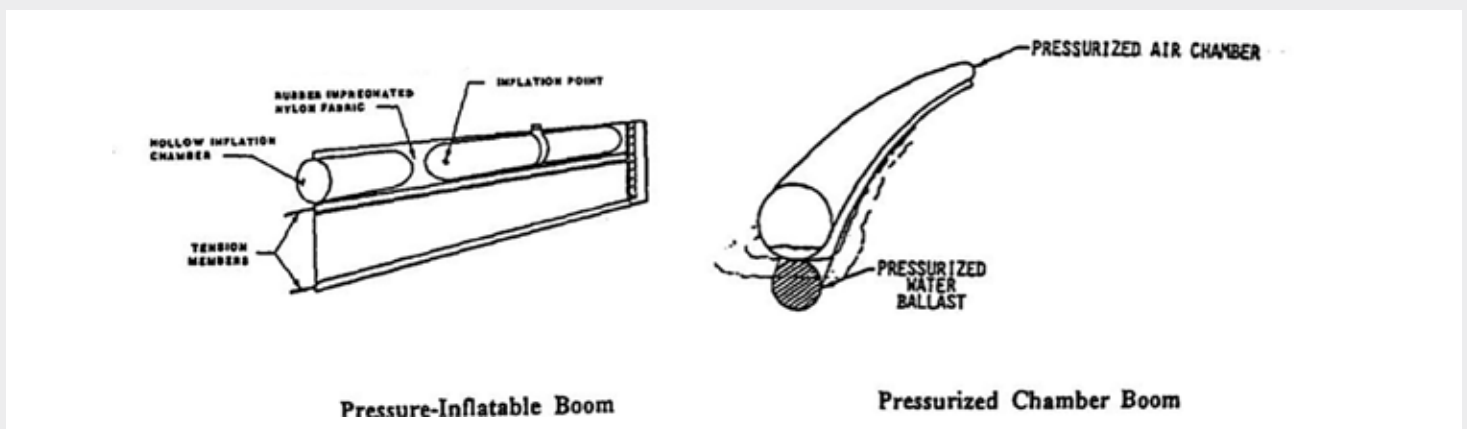


Figure D7. Pressure Inflatable Curtain Boom Diagrams

- Generally high buoyancy to weight ratio (ranges between 2 to 70, with most being greater than 10).
- Buoyancy may be lost because of a puncture or a leaking valve.
- They have a good wave response.
- These may be used for first deployment, or for long term. Some models are used in industrial applications.
- Example of tests performed on this type of boom: NOFI Vee-Sweep 600 Boom (0.6 m (24") freeboard, 0.7 m (27.6") draft, RB/W is 25) (WCMRC uses this model with the full draft depth of 1.0 m).
  - Test facility and year: Ohmsett 1992
  - Test oils: Sundex 8600 and Hydrocal 300. The viscosity of the oil for each test is described in the following table:

Table D1. NOFI Vee-Sweep Results (Schultz, 2001)

BOOM	NOFI VEE-SWEEP Freeboard 24 inches Draft 27.6 inches B/W 25:1 (Bitting [A-3] shows B/W 15:1)				
	WAVE HT. feet (m)	AV. WAVE PERIOD (sec)	1st LOSS SPEED (kts)	GROSS LOSS SPEED (kts)	OIL PRELOAD/ VISCOSITY (gallons/cSt)
<u>DIVERSIONARY (Vee)</u>					
CALM WATER	0	0	1.0-1.1	1.3-1.4	100/370
	0	0	1.4	1.8	100/9,300 & 16,500
REGULAR WAVE	0.74 (0.2)	4.6	1.3-1.4	1.6-1.7	100/9,900
	0.4-0.5 (0.12-0.15)	2.5	1.5	1.7	100/9,900
	0.36 (0.11)	1.6	1.3	1.65	100/9,700
CALM WATER	0	0	1.2-1.3	1.6	900/7,500 & 8,300
REGULAR WAVE	0.68 (0.2)	1.6	1.0	1.35	900/9,700 & 13,700

- With low viscosity oil, the 1<sup>st</sup> loss speed was approximately 1 kn, and the gross loss speed was approximately 1.35 kn in calm water.
- With high viscosity oil, the first loss speed was approximately 1.4 kn, and the gross loss speed was approximately 1.8 kn in calm water.
- With "regular waves" the 1<sup>st</sup> loss speeds varied between 1.3 to 1.5 kn for the high viscosity oil.
- Example of tests performed on this type of boom: NOFI 600S (the characterises of this boom were not provided for the test, and so they are assumed to be the same as those published in 1999-2000), 0.6 m (24") freeboard, and 0.7 m (27.6") draft.
  - Test oil: viscosity of 870 cSt
  - Test configuration: vee configuration, with a 16.8 m (55ft) gap
  - Test facility and year: Ohmsett 1992
    - In calm water, the 1<sup>st</sup> loss occurred at 1.25 kn, and the gross loss speed occurred at 1.4 kn
    - In a wave with a height of 0.7 m and a period of 4 s, the 1<sup>st</sup> loss occurred at 1.3 kn, and the gross loss speed occurred at 1.6 kn
    - In a wave with a height of 1.2 m and a period of 2 s, the 1<sup>st</sup> loss occurred at 1.25 kn, and the gross loss speed occurred at 1.5 kn

- Example of tests performed on this type of boom: RO-BOOM (0.66 m (26") freeboard, 1.10 m (43") draft; closest to the RO-BOOM 2000 dimensions as of July 2017) (WCMRC uses this boom series, but they have a model with a slightly larger overall height).
  - Test oil: canola oil with a viscosity of 64 cSt
  - Test configuration: Catenary
  - Test agency and year: CCG 1991
    - 1<sup>st</sup> loss occurred at 1.2 kn due to the boom rising out of water at higher velocities
    - At 1.4 kn, the loss rate was 1.45 m<sup>3</sup>/hr
    - Most oil loss was due to vortices
    - This boom was damaged prior to the testing (the ballast/tension chain was longer than the design length, a shorter chain would have pursed the boom at the bottom, thereby possibly resulting in a better performance)
- Example of tests performed on this type of boom: RO-BOOM (0.60 m (24") freeboard, 1.30 m (51") draft, RB/W is 7.4; no current model with similar dimensions) (WCMRC uses a model similar to this, but with a smaller draft and larger freeboard), and test details are as follows:
  - Test oil: 67.7 m<sup>3</sup> of oil was pumped from the stern of one of the towing vessels, all of the oil entered the mouth of the boom. The viscosity of the oil used was 24 cSt
  - Test configuration: catenary
  - Test agency, year and location: Ross Tests Performed for the CCG 1987, 25 nm NE of St John's, Newfoundland
    - Deployment took approximately 100 minutes for two 200 m long sections.
    - The Desmi website now claims that on average 200 m long RO-BOOM can be deployed in 15 minutes using their high capacity air blowers.
    - The loss of a single flotation unit does not affect the overall integrity of the boom.
    - Failure occurred because of splash over at the joints between the flotation sections, and a rate varying between 0.006 to 0.06 m<sup>3</sup>/hr was discharged from the boom, while it traveled at about 0.6 kn with respect to the surface of the water.
  - Approximately 89% of the oil discharged directly into the boom was contained.
- Example of tests performed on this type of boom: RO-BOOM 3500 (1.30 m (51") freeboard, 1.53 m (60") draft, RB/W ratio is 23.3; no longer available on the Desmi website) Tested by the Norwegian Clean Seas Association for Operating Companies (NOFO):
  - Test method: Towed in a catenary configuration by two vessels, in significant wave height of 1.6 m (5 ft.), with a maximum wave height of 3 m (10 ft.), tested with 50 m<sup>3</sup> of a water in oil emulsion of 30% water, that had a viscosity of 320 cSt, discharged directly into the boom (NOFO Test 1992).
    - Oil leakage was observed only after the tow speed was at 1.3 kn
  - Test method: Towed in a catenary configuration by two vessels, in the sea with a maximum wave height of 1.6 m (5 ft.), tested with 96 m<sup>3</sup> of a water in oil emulsion of 68% water, that had a viscosity of 1200 cSt, discharged directly into the boom (NOFO Test 1993).
    - The slick thickness was an average of 1 mm when the boom was being towed at 0.5 to 0.7 kn.
    - The oil was held effectively until the towing speed was increased to 1.2 kn; the estimated loss rate was 0.4 m<sup>3</sup>/hr, and part of the loss was due to evaporation.



## D.2.3 SUMMARY TABLES

Table D2. Catenary Formation in Calm Water

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
DESMI	Globe Boom 36ED	64	0.61	0.3	4.2	1.2
Kepner	Foam Sea Boom	97	0.3	0.2	6.5 - 7.8	0.8
Expandi	unknown	10	0.5	0.3	22	0.4
Expandi	unknown	177	0.5	0.3	22	0.5
Versatech	Zoom-Boom	2763	0.41	0.45	24	0.78
Kepner	self inflating Sea Boom	64	0.64	0.4	25	1
Desmi	RO-BOOM	64	1.1	0.66	7.4	1.2

Table D3. Catenary Formation in Regular Waves (wave height x length is approximately 1ft x 45 ft)

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
Kepner	Foam Sea Boom	97	0.3	0.2	6.5 - 7.8	0.9
Expandi	unknown	10	0.5	0.3	22	0.4
Expandi	unknown	177	0.5	0.3	22	0.6
Versatech	Zoom-Boom	2763	0.41	0.45	24	0.8
Desmi	Ro-Boom 3500	320 (30% water emulsion mix)	1.53	1.29	23.3	1.3
Desmi	Ro-Boom 3500	1200 (68% water emulsion mix)	1.53	1.29	23.3	1.2

Table D4. Catenary Formation in Harbour Chop (wave height x length is approximately 2ft x 35ft)

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
Kepner	Foam Sea Boom	97	0.3	0.2	6.5 - 7.8	0.9
Expandi	unknown	10	0.5	0.3	22	0.7
Expandi	unknown	177	0.5	0.3	22	0.8
Versatech	Zoom-Boom	2763	0.41	0.45	24	0.5

Table D5. Diversionary (23-44 degrees) Formation in Calm Water

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
Kepner	Foam Sea Boom	235	0.3	0.2	6.5 - 7.8	1.4
Expandi	unknown	238	0.5	0.3	22	1.4 - 1.6
NOFI	Vee Sweep 600	270	0.7	0.61	25	1.0 - 1.1
NOFI	Vee Sweep 600	9300	0.7	0.61	25	1.4
NOFI	600S boom	870	0.7	0.6	24	1.25

Table D6. Diversionary (23-44) Formation in Regular waves

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
Expandi	unknown	238	0.5	0.3	22	1
NOFI	Vee Sweep 600	9900	0.7	0.61	25	1.6 - 1.7
NOFI	600S boom	870	0.7	0.6	24	1.3

Table D7. Diversionary (23-44) Formation in Harbour Chop

MAKE	MODEL	TEST OIL KINEMATIC VISCOSITY (cSt)	DRAFT (m)	FREEBOARD (m)	RESERVE BUOYANCY/ WEIGHT	CURRENT AT FIRST FAILURE (kn)
Kepner	Foam Sea Boom	235	0.3	0.2	6.5 - 7.8	1.4
Expandi	unknown	238	0.5	0.3	22	1.2-1.6
NOFI	600S boom	870	0.7	0.6	24	1.25

From the above tables, it can be noted that the current at first failure is dependent on the test oil viscosity, and that with a higher viscosity, the first loss occurs at a faster current. With a low viscosity oil, such as diesel, a successful containment will depend largely on the environmental factors such as the waves, winds, currents and the formation that the booms are deployed in.

## D.3 CONTAINMENT BOOMS FOR VARYING CONDITIONS

### D.3.1 CONTAINMENT BOOM STANDARDS IN THE UNITED STATES

The Code of Federal Regulations in the United States contains an appendix to a sub section that contains the range of boom heights appropriate for varying wave heights. The information used to create the tables below was sourced from the US Office of the Federal Register.

Table D8. Definition of Operating Environments

OPERATING ENVIRONMENT	SIGNIFICANT WAVE HEIGHT (ft)	SIGNIFICANT WAVE HEIGHT (m)	SEA STATE
Rivers and Canals	≤ 1	≤ 0.31	1
Inland	≤ 3	≤ 0.91	2
Great Lakes	≤ 4	≤ 1.22	2-3
Ocean	≤ 6	≤ 1.83	3-4

Table D9. Boom Properties for Operating Environments

PROPERTY	RIVERS AND CANALS	INLAND	GREAT LAKES	OCEAN
Boom Height (in)	6-18	18-42	18-42	≥ 42
Boom Height (m)	0.16-0.46	0.46-1.07	0.46-1.07	≥ 1.07
Minimum Reserve Buoyancy to Weight Ratio	2:1	2:1	2:1	3:1 to 4:1
Total Tensile Strength (lbs)	4500	15,000-20,000	15,000-20,000	> 20,000
Total Tensile Strength (kN)	20.0	66.7 - 89	66.7 - 89	> 89.0

From Table D8 and Table D9, it can be noted that for waves larger than 1.83 m, a 1.07 m boom is the minimum total height that should be used. During the Seaforth Channel Incident, the wave height during the early days of the response reached 3 m in Hecate Strait, and the largest boom that was used was a 1.03 m (42") boom. The majority of the booms deployed at the beginning of the incident were 0.61 m (24") in total height (Resource Summary for the Seaforth Channel Incident, 2016).

D.3.2 BOOM SIZE AND WAVE EFFECTS ON LIMITING CURRENT

From the data in Tables D2 to D7, we selected the data presented in Table D10, and Figure D8 and Figure D9 below were created for a visual representation of how the boom size relates to the current speed at the first failure. This plot is approximate, and is only for the purpose for understanding the general relationship.

Table D10. Plotted Containment Boom Data

GRAPH NUMBER	MAKE	MODEL	TEST VISCOSITY (cSt)	DRAFT (m)	WAVE HEIGHT (ft) [WAVE LENGTH]	CURRENT AT FIRST LOSS (knots) [CURRENT AT GROSS LOSS]
1	Desmi	Globe Boom 36ED	64	0.61	0	1.2
2	Kepner	Self Inflating Sea Boom	64	0.64	0	1.0
3	Desmi	Ro-Boom	64	1.1	0	1.2
4a	Expandi		10	0.5	1	0.4
4b	Expandi		177	0.5	1	0.5
4c	Expandi		10	0.5	2	0.4
4d	Expandi		177	0.5	2	0.6
5a	Versatech	Zoom-Boom	2763	0.41	0	0.78 [1.13]
5b	Versatech	Zoom-Boom	2763	0.41	0.6 [63]	0.8 [1.2]
5c	Versatech	Zoom-Boom	2763	0.41	0.6 [9]	0.5 [0.68]
5d	Versatech	Zoom-Boom	2763	0.41	0.6 [27]	0.9 [0.9]
6a	NOFI	600S Boom	870	0.7	0	1.25
6b	NOFI	600S Boom	870	0.7	1	1.3
6c	NOFI	600S Boom	870	0.7	2	1.25

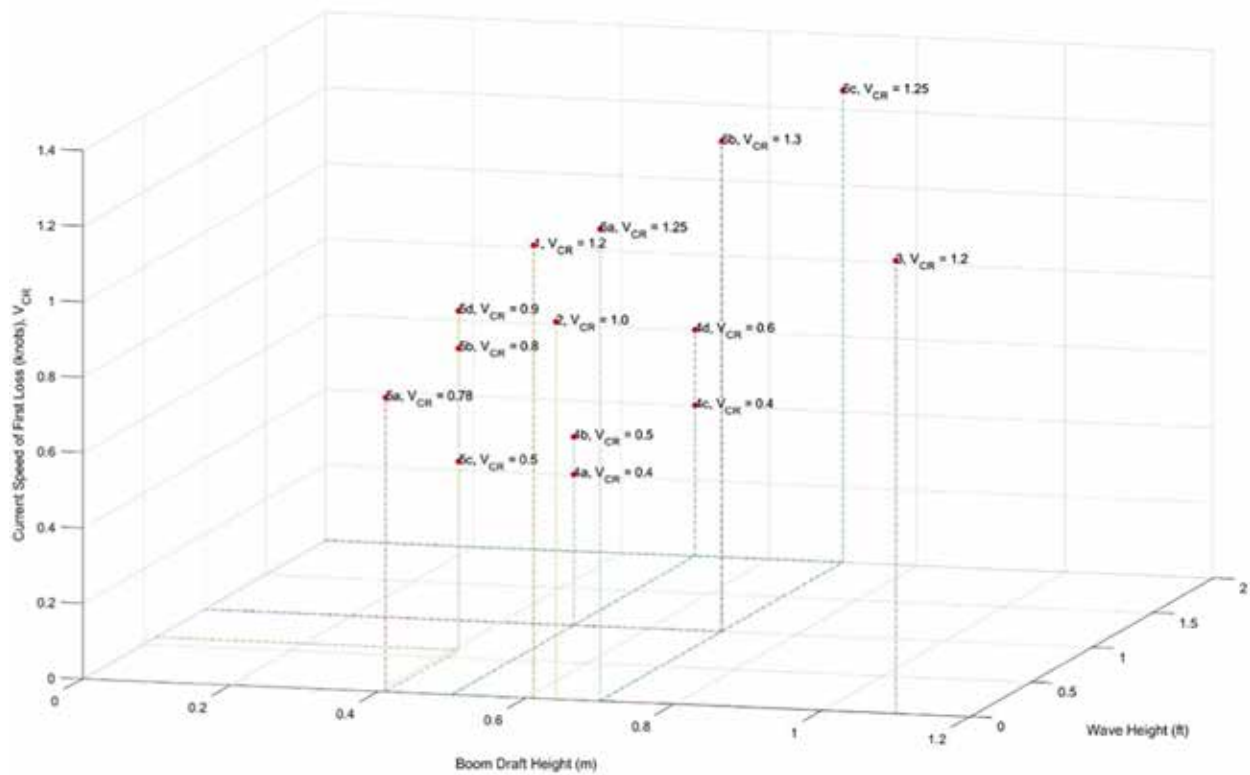


Figure D8. Boom Specification 3-D Plot View 1

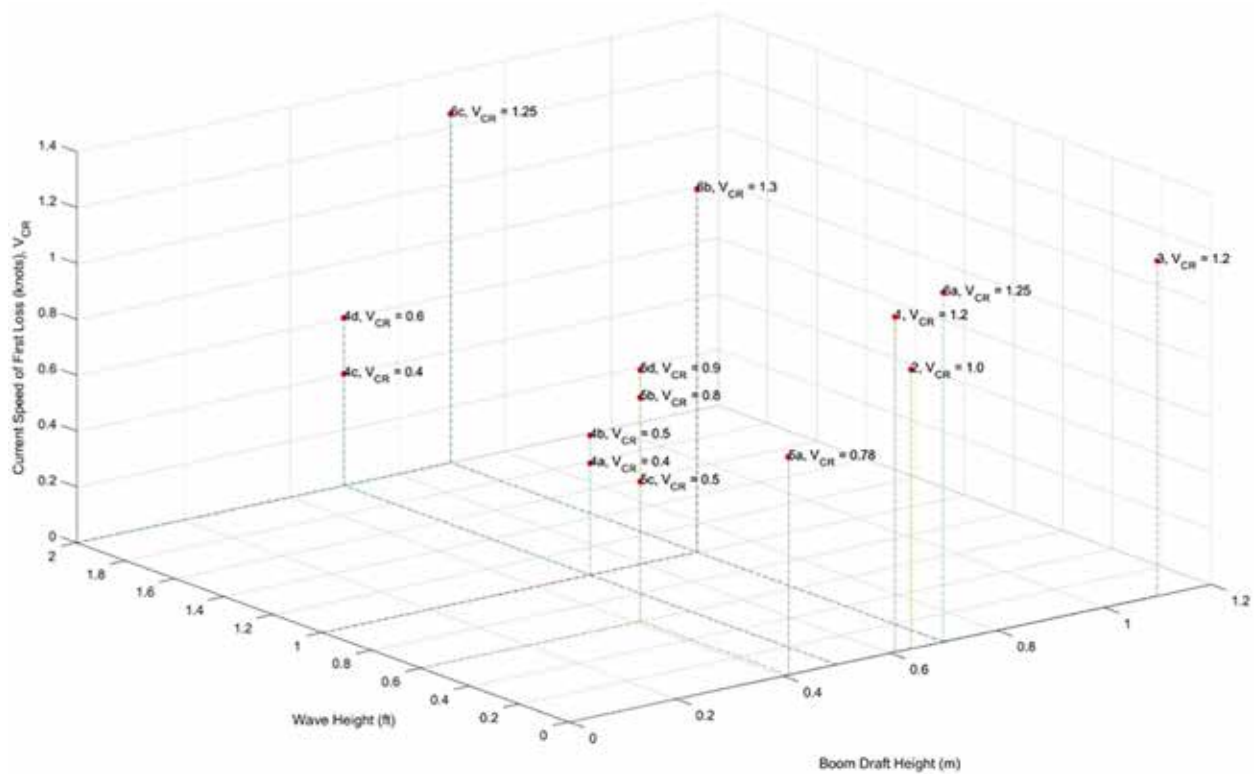


Figure D9. Boom Specifications 3-D Plot View 2

## D.4 SKIMMER TESTING PERFORMED BY BSEE AT OHMSETT

Tests were completed to ASTM F2709-08 standard, the “Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems”.

- All equipment was tested with the auxiliary equipment specified by the manufacturer.
- ORR- Oil Recovery Rate (Litres per Minute, Lpm) =  $\frac{\text{Volume of Oil Collected}}{\text{Time}}$
- RE- Recovery Efficiency (%) =  $\frac{\text{Volume of Oil Collected}}{\text{Volume of Total Fluid Collected}} \times 100$
- Tables 1, 2, and 3 were taken directly from the BSEE report (McKinney & DeVitis, 2015)
- The oil viscosities presented in this section are the dynamic viscosities measured in kg/m/s (cP). The kinematic viscosity, as used in section D.2 can be found by dividing the dynamic viscosity by the density.
- The figures and tables in this section are all sourced from ASTM F2709-08 Testing of Skimmer Systems at the Ohmsett Facility (McKinney & DeVitis, 2015).

Elastec TDS 118G – Drum skimmer; Elastec recommends it for lakes, rivers, and creeks.



Figure D10. Elastec TDS 118G Drum Skimmer



Crucial C14-d Mop Ringer System – From the Crucial website: for emergency spill response or permanent installation on pits, API separators, storage tanks or holding ponds.



Figure D11. Crucial C-14d Mop Ringer System

Lamor LWS 500 (with GTA 50 pump) – Weir Skimmer. From the Lamor website: Self-adjusting to wave flow, portable and small size, quick assembly/disassembly for cleaning/maintenance (no tools required), skimmer equipped with single point lifting.



Figure D12. Lamor LWS 500\GTA 50 Weir Skimmer and Pump

Desmi AFTI MI-2HD – Disc Skimmer. No longer available on Desmi website.



Figure D13. Desmi AFTI MI-2HD Disc Skimmer

Desmi Terminator – Weir Skimmer. From Desmi website: there is a cutting knife on the inlet of the pump that can handle a lot of debris normally found at a spill site, and it has an integrated Dop-Dual 250 pump.



Figure D14. Desmi Terminator Weir Skimmer

Crucial C-13/24 Coated Disc – Disk Skimmer. No background information provided by Crucial website. WCMRC has a Crucial Fuzzy Disk Skimmer with a capacity of 3-6 tonnes/hr, which is unlisted on the Crucial website and is most likely now listed as the Coated Discs (no capacities are listed on the Crucial website for their skimmers).



Figure D15. Crucial C-13/24 Coated Disc Skimmer

Desmi Terminator with the Helix 1000 adaptor– Weir with a Brush Skimmer Adaptor. The Desmi website claims that the circular design of the brush skimmer allows a higher efficiency for the oil retrieval compared to other brush skimmers. WCMRC uses this same brush adaptor, however they use it on a Lamor GT-185 model weir skimmer (no longer available on the Lamor website).



Figure D16. Desmi Dop-Dual Terminator with Helix Circular Brush Skimmer

Table D11. Test Oil Specifications

Oil	Density, (g/mL @ 20→C)	Viscosity, (cP @ 20→C)
Hydrocal 300	0.91	300
Calsol 8240	0.94	1900

Table D12. Average Temperature and Viscosity for Test Oils During Testing

Skimmer	Avg Water Temp (→C) Hydrocal/ Calsol	Water Salinity (ppt)	Avg Temp Hydrocal (→C)	Viscosity, Hydrocal (cP)	Avg Temp Calsol (→C)	Viscosity, Calsol (cP)
Elastec TDS 118G	25/24	30	22	180	24	1770
Crucial C-14d Mop	27/25	30	26	150	26	1180
Lamor LWS 500\GTA50	24/27	29	29	120	34	670
Desmi AFTI MI- 2HD	26/N/A	27	32	130	N/A	N/A
Desmi Terminator	24/6	27/24	24	160	2	22,600
Crucial C-13/24	19/19	26	24	170	23	1850
Desmi Dop-Dual Helix	10/10	25	9	620	11	5750



Table D13. Summary of Test Results (Mfg is manufacturer)

Skimmer	Mfg nameplate capacity Lpm[gpm]	ORR (Hydrocal) Lpm[gpm]	RE (Hydrocal) (%)	ORR (Calsol) Lpm[gpm]	RE (Calsol) (%)
Elastec TDS 118G	341[90]	388[103]	91	366[97]	85
Crucial C- 14d Mop Wringer System	83[22]	37[10]	100	37[10]	100
Lamor LWS 500\GTA50	833[220]	982[260]	89	1017[269]	95
Desmi AFTI MI- 2HD	23[6]	34[9]	96	N/A	N/A
Desmi Terminator	2082[550]	1275[337]	94	1529[404]	81
Crucial C- 13/24 Coated Disc	321[85]	458[121]	90	189[50]	86
Desmi Dop-Dual Helix	2082[550]	902[238]	93	862[227]	96

#### From the Elastec Website:

The Elastec X150 Skimmer was tested at the Ohmsett facility according to ASTM F2709. From this test, the X150 has an ORR of 150 m<sup>3</sup>/hr.

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