Halifax Harbour Integrated Response Plan (HHIRP) for Marine Oil Spills

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Abstract

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Shipping has played a vital role in the globalization of trade, allowing goods to be transported between continents efficiently and cost-effectively. While safety standards have improved dramatically, the increasing scale of the industry still poses threats to the marine environment. Canada's approach to oil spill response has relied on National planning standards across the country despite certain regions transporting a disproportionate amount of oil. Area Response Planning is a new endeavor of the federal government, and led by Transport Canada (TC) and the Canadian Coast Guard (CCG), that considers the risks and conditions specific to a geographic area. This project continues that trend and has been developed for CCG's Environmental Response program to help organize and coordinate a response to an emergency marine oil pollution event in the Halifax Harbour. To provide tangible examples of response operations, five oil spill scenarios have been created based on vessel traffic and density, past spill events in the study area, and proximity to local sensitivities. These scenarios reveal how spills under a variety of circumstances lead to different roles and responsibilities for CCG and other agencies involved in response. They also highlight the sensitivities throughout the study area that may be affected and the needed response efforts to mitigate impacts. By focusing on the unique characteristics that define a region, this project allows response planning to be specific to its geographic region and can help inform the creation of further response plans in areas of a similar geographic scale.

Abbreviations

AIS	Automatic Identification System
ALERT	Atlantic Emergency Response Team
ARA	Area Risk Assessment
ARP	Area Response Plan
CCG	Canadian Coast Guard
CCH	Communities Culture and Heritage
CSA	Canadian Shipping Act
DFO	Fisheries and Oceans Canada
DWT	Deadweight Tonnage
ECRC	Eastern Canada Response Corporation
ECCC	Environment and Climate Change Canada
EEMAP	Environmental Emergency Mapping System
EPA	Environmental Protection Agency
ER	Environmental Response
GRT	Gross Register Tonnage
HHIRP	Halifax Harbour Integrated Response Plan
HPA	Halifax Port Authority
IC	Incident Commander
ICP	Incident Command Post
ICS	Incident Command Structure
IOGP	International Association of Oil & Gas Producers
IPIECA	International Petroleum Industry Environmental Conservation Association
ITOPF	International Tanker Owners Pollution Federation Limited

MCTS	Marine Communications and Traffic Services
MPCF	Maritime Pollution Claims Fund
MPIRS	Marine Pollution Incident Reporting System
NSE	Nova Scotia Environment
OHF	Oil Handling Facility
OPP	Oceans Protection Plan
PTMS	Point Tupper Marine Services
RO	Response Organization
RRP	Regional Response Plan
SCAT	Shoreline Cleanup and Assessment Technique
SOPEP	Shipboard Oil Pollution Emergency Plan
SOPF	Ship-source Oil Pollution Fund
TC	Transport Canada
TIP	Technical Information Paper
WCMRC	Western Canada Marine Response Corporation

SECTION 1

1.1 Introduction

Maritime shipping is a critical component of the world's economy. Through a network of shipping lanes and ports, the industry provides a link between nations and has played a leading role in globalization. (Corbett & Winebrake, 2008). Worldwide oil production continues to increase, and 90% of all oil is transported via tankers across the world's oceans (Zhang, Ji, & Fan, 2015). While spills have become less common due to improvements in shipping safety standards, the increase in maritime trade necessitates the continued improvement of response plans in at-risk areas. Oil spills not only impact the marine environment, but seriously threaten marine industries such as fishing, aquaculture, and tourism, and can incur significant financial costs (Chen et al., 2018).

At over 243,000 kilometers in length, Canada has the longest coastline of any country in the world (Transport Canada, n.d.). Protecting this coastline and the valuable resources the ocean provides is vital considering tankers export 80 million tonnes of oil from Canada's coasts annually (Transport Canada, n.d.). To respond to the threat of oil spills, the Canadian federal government has recently been focusing on the development of Regional Response Plans (RRPs). They are a geographically-focused risk-based initiative, led by the Canadian Coast Guard (CCG) and Transport Canada (TC), to enhance Canada's preparedness and response regime for ship-source oil spills (CCG, 2017) (See Section 4.1). In congruence with this new endeavour, this project aims to assist regional response planning by creating an integrated oil spill response plan for Atlantic Canada's busiest port: the Halifax Harbour.

The Halifax Harbour Integrated Response Plan (HHIRP) for Marine Oil Spills has been developed for CCG's Environmental Response (ER) program as a guide to help organize and coordinate a response to an emergency marine pollution event in the harbour. It provides a detailed and localized geographic focus to inform relevant government agencies and local authorities the needed steps to mitigate impacts of an oil spill to environmental and socio-economic sensitivities. An oil spill in the Halifax Harbour would involve multiple stakeholders. Clearly defining the roles and responsibilities of all involved parties under varying spill circumstances is critical in ensuring an effective response. This will be a key outcome of the plan.

To provide tangible examples of response operations, five oil spill scenarios have been created to highlight how responses are carried out. These scenarios were selected based on vessel traffic, past spill events in the study area, and proximity to sensitive resources (hereby referred to as sensitivities). For example, considering the main shipping routes into the harbour, as well as the number and type of ships, helps identify where a spill is most likely to occur. Identifying local sensitivities enables mitigation measures to be put in place and reveals who needs to be contacted and consulted following a spill. There are several outcomes of the HHIRP: highlight how CCG may respond under varying spill circumstances and how response efforts are coordinated; identify where the main sensitivities are located in the study area to plan mitigation measures; and to continue the development of CCG's Area Response Planning (ARP) initiative (See Section 4.1).

1.2 Objectives

1. Establish a template for marine pollution events to inform the development of response plans by CCG in other regions of a similar scale.
2. Outline the roles and responsibilities of relevant agencies, stakeholders, and legal authorities during a response.
3. Identify key environmental and socio-economic sensitivities of the study area to help plan mitigation measures.
4. Create specific oil spill scenarios within the study area to reveal how CCG's roles and responsibilities vary under changing spill circumstances and describe how a response is carried out following a spill event.

1.3 Scope

1. Geographic scope: For the purpose of this project, the Halifax Harbour consists of all waters stretching from the southern edge of Herring Cove northeast past the southern tip of McNabs Island to Hartlen Point, delineated by the blue line in Figure 1.
2. The HHIRP applies to any oil pollution event that impacts the marine environment in the Halifax Harbour.
3. Temporal Scope: The project looks at spill data from 2008-2017 for the study area, and for the broader Atlantic Region, looks at data from 01/01/2017 to 04/29/2018.

1.4 Assumptions

1. The responsible party for a spill will take immediate action to stop the source of the spill and contain it.
2. Proper notification procedures are followed allowing for an effective and timely response.

3. Communication and information sharing between government agencies, industry, stakeholders, and Indigenous groups continues throughout the response process (CCG, 2017).
4. Not all spills require a response (CCG, 2017). Should CCG determine that natural weathering processes will effectively remove a spill from the environment, and the spill poses little to no threats to the environment, then a spill response may be deemed not necessary.

Figure 1. The study area, the Halifax Harbour, spilt into five sections: the Bedford Basin, The Narrows, and the Inner, Middle, and Outer Harbours.

SECTION 2

2.1 Growth in Shipping and Risk of Ship-Source Spills

Shipping has played a vital role in the globalization of trade, allowing goods to be transported between continents efficiently and cost-effectively. As a result, ships currently transport 80% of all global trade and freight transport volumes are expected to double by 2030 (Canada Transport Act Review, 2015). The last half century has seen the largest vessel sizes exceed 300,000 deadweight tonnage (dwt) (compared to the 1960 average of 20,000 dwt), average vessel speed increase from 15 to 25 knots, and the volume of oil transported via tankers see a tenfold increase (Hodgson, 2010). As of 2016, there are currently 13,222 oil and chemical tankers worldwide, representing almost 15% of the global total fleet and 30% of total gross tonnage (Equasis, 2018). Not only are these ships a risk to the marine environment due to the products they carry, but the use of oil-powered engines requires ships to carry additional supplies of fuel in bunkers, increasing the risk of an oil spill throughout the world's fleet. Therefore, in the event of a grounding, collision, fire, or some other disaster, the risk of oil pollution has increased with the expansion and industrialization of shipping (Hodgson, 2010).

Compared to other modes of transport, shipping has a smaller ecological footprint in most respects; specifically, improved safety regulations, safer ship designs, and better response systems have resulted in a steady decrease in ship-source spills since the 1970s (Hodgson, 2010). In Canada, 67% of ship-source spills between 2003-2012 were less than 1000 litres (an average hot tub holds approximately 1,600 litres); and for larger spills over 10,000 litres, close to 80% derive from fuel oil rather than oil carried as cargo (Clear Seas, n.d.). However, Canadians rely on fossil fuels for 85% of all energy needs, and tanker traffic provides close to a million barrels of oil daily on the east coast alone (McCardle & MacPhail, 2018). The scale at which the industry is increasing means the threat of a spill still exists, and as a result, comprehensive response plans must be developed for the areas at greatest risk.

2.2 Site Description

The Halifax Harbour is located at 44° 39' 15.5" N and 63° 33' 56.7" W in Nova Scotia, Canada. It is an ancient river valley—an extension of the Sackville River—that eventually drowned due to rising sea levels following glaciation (Fader & Buckley, 1995). It acts as an estuary with incoming saltier water flowing in from the ocean and fresh water outflowing from the Sackville River overtop the colder and denser salt water (Fournier, 1990). Stretching 24 kilometers in length, the long, narrow harbour can be divided into several distinct sections.

The Bedford Basin, the largest and deepest portion, is a sheltered bay at the harbour's northern end with an approximate area of 17 square kilometers and a maximum depth of 71 meters (Fournier, 1990). The Sackville River flows into the basin from its northernmost point bringing fresh water into the harbour. This portion of the harbour also experiences the weakest currents and results in relatively poor mixing and flushing capabilities (Fournier, 1990). The Narrows is the next section, comprising the area between the MacKay and Macdonald bridges and connecting the basin to the rest of the harbour. It is a constricted passage of three kilometers with an average depth of 20 meters and channels water from the Inner harbour into the basin, creating stronger currents in this area (Fournier, 1990). The Inner Harbour, beginning at the Macdonald Bridge and extending to the northern end of McNabs Island, is wider than the Narrows and contains the downtown waterfronts of Halifax and Dartmouth, the historic Georges Island, and the Northwest arm: a narrow, shallow channel 5 kilometers long used primarily by pleasure craft. The Middle Harbour contains McNabs and Lawlor Islands and the narrow Eastern Passage, and the Outer Harbour contains the main shipping routes leading in and out of the harbour.

2.3 History of the Halifax Harbour

Archaeological evidence suggests that the area surrounding the Halifax Harbour has been inhabited for approximately 12,000 years (Halifax Harbour, 2008). Its first inhabitants, the Mi'kmaq, named it Chebucto (Kjipuktuk) or “Great Harbour” and chose it for its sheltered bay and year-round access to food (McDonald, 2017). Although explorers visited the harbour as early as the 1500s, Mi'kmaq hostility prevented permanent European settlement until 1749 when the British established a fortified town on the banks of the harbour under the leadership of Colonel Edward Cornwallis (McDonald, 2017; Fournier, 1990).

The harbour played an important role as a British naval port sheltering ships and housing prisoners of war during Britain's involvement in the American Revolutionary War and Napoleonic Wars. These conflicts also saw a sharp increase in Halifax's population and the city quickly became an important base for trade and commerce (Forward, 1982). It was during the two World Wars, however, that the Halifax Harbour truly rose to prominence. Its depth, size, and proximity to Europe allowed Allied forces to stage convoys in the harbour during both wars—a vital lifeline in supplying Europe with troops and provisions. The completion of the Ocean Terminals project in the early 1920s provided large docking facilities in Halifax's South end, expanding the city's capacity for trade (Forward, 1982).

With the containerization revolution following the Second World War and further development of Halifax port facilities, the city saw continued growth in domestic and international trade. It is now Canada's fourth largest port in terms of container volume behind Vancouver, Montreal, and Prince Rupert. This growth can be attributed to several unique characteristics: year-round absence of sea ice, small tidal range, great depth, hard substrate, wide berths, and close proximity to major international shipping routes (Gao, 2015; NRCAN, n.d.).

Despite the Dartmouth oil refinery closing in 2013, the Port of Halifax has experienced a steady increase in total cargo volume (Halifax Port Authority, n.d.). It is home to four shipping facilities managed by the Halifax Port Authority (HPA), several non HPA-managed facilities, and five oil-handling facilities (OHFs) (two of which are further from shore). Cruise ships, containerized and non-containerized cargo ships, government and military vessels, ferries, tour boats, fishing vessels, and pleasure craft all compete for space. As a result, the Halifax Harbour is now the busiest port in Atlantic Canada—a gateway to international ports—connecting the city to over 150 countries while providing over 12,400 jobs and contributing $1.7billion to the economy. The city has become a popular tourist destination with 292,722 visitors arriving via cruise ship in 2017, almost 20% more than the previous year (Halifax Port Authority, n.d.).

The HPA is a leader in marine safety and is the first port in Canada to achieve ISO 14001 certification, demonstrating its commitment to reducing its environmental footprint (HPA, n.d.). Despite this, no official CCG response plan currently exists for the Halifax Harbour; a large spill in the Halifax Harbour could pose a serious threat to the area's ecological and socio-economic sensitivities while creating logistical issues surrounding the roles and responsibilities of each government agency and local authorities. The high vessel traffic and presence of OHFs increases the risk for marine oil spills and necessitates the development of an integrated response plan.

SECTION 3

3.1 Properties of Oil

Crude oils are composed of a variety of hydrocarbons as well as traces of other compounds and elements (IPIECE-IOGP, 2015). Once released into the marine environment, oil undergoes several behavioral changes that affect its chemical and physical properties. The degree to which these changes occur are determined primarily by the oil type, size of spill, and local environmental conditions, which subsequently influence the physical movement of the oil and how it should be cleaned. The key physical properties of oil to be considered are density (the mass of a given amount of oil), viscosity (an oil's resistance to flow), pour point (the temperature below which an oil no longer flows), and solubility (the amount of oil that dissolves in the water column) (Fingas, 2013; ITOPF-TIP 2, 2014). The oil's fate is further influenced through the weathering processes of spreading, evaporation, dispersion, emulsification, dissolution, photo-oxidation, sedimentation, and biodegradation (See Figure 2) (ITOPF-TIP 2, 2014) which work together to alter its properties and its physical movement in the ocean. If the oil type and its physical properties are known, it may be possible to predict its trajectory in the ocean, which helps determine whether sensitive resources will be impacted, thus helping to improve response planning.

3.2 Fate of Marine Oil Spills

Oils with a low molecular weight have a higher proportion of volatile components, are less viscous, and evaporate more quickly than those with a high molecular weight (Azwell, 2013). The longer oil persists in the marine environment, the more prone it is to weathering processes which reduce the oil's volatile components (See Figure 2). As a result, oils with a low molecular weight typically have a lower environmental impact despite their higher toxicity (ITOPF-TIP 2, 2014). Oils with a high molecular weight are less volatile, less prone to evaporation, and much more persistent (IPIECA-IOGP, 2015). If left in the environment, they mix with water to form viscous emulsions which reduce in toxicity over time, are less prone to weathering changes, and more difficult to recover (Azwell, 2013).

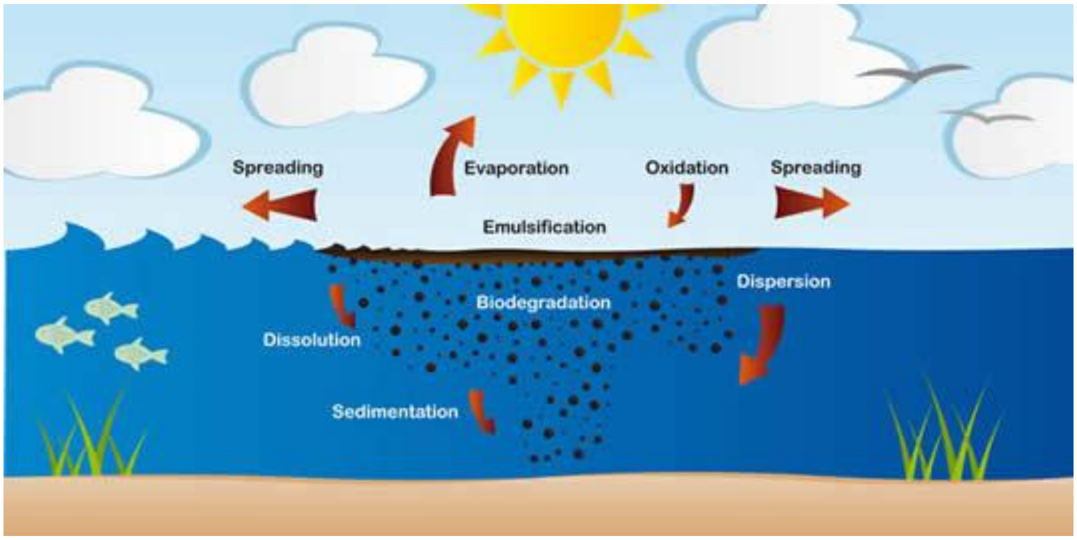


Figure 2. The weathering processes that affect oil once in the marine environment (ITOPF-TIP 2, 2014).

How each weathering process impacts oil depends on the local environmental conditions where the spill occurred. Local conditions also dictate the physical movement of oil in the ocean: the horizontal transport on the water surface, and the vertical and horizontal subsurface movement (Azwell, 2013).

Weathering Processes

The following points describe in general the key weathering processes affecting oil spills. They play a key role on where the oil ends up and the degree to which it may impact various sensitive resources.

i. Spreading: the movement, or spreading, of oil over the sea surface. The rate of spreading is dependent on an oil's pour point, viscosity, and the volume spilled (IPIECA-IOGP, 2015). Low viscous oils spread faster than those with high viscosity. Winds, currents, and tides also impact the speed of spreading (ITOPF-TIP 2, 2014)
ii. Evaporation: the vaporization of liquid oil into the gas phase. Oils with a lower molecular weight contain more volatile components and hydrocarbons with a low boiling point which will begin to evaporate into the atmosphere once a spill occurs (IPIECA-IOGP, 2015). As evaporation continues, the oil's viscosity increases while reducing its toxicity. For oils with a lower molecular weight, the entire spill can evaporate completely while heavy fuel oil may only lose 15-20% of its total volume over the course of several days (IPIECA-IOGP, 2015).
iii. Dispersion: wave action causes oil to break up into smaller droplets which mix throughout the water column (SpillPrevention, n.d.). Heavy wave action can cause lighter oils to be completely dispersed. Heavier droplets will resurface while lighter, less buoyant droplets remain in the water column and can impact benthic and subsurface marine life (IPIECA-IOGP, 2015).
iv. Emulsification: the mixing of water with oil to form oil-in-water emulsions that increase the oil's total volume (ITOPF-TIP 2, 2014; SpillPrevention, n.d.). More turbulent conditions increase the mixing effect and can result in the emulsion volume being up to five times greater than the volume of oil originally spilled (IPIECA-IOGP, 2015). Emulsification can reduce the effects of other weathering processes, leaving the oil more persistent (ITOPF-TIP 2, 2014).
v. Dissolution: the rate and extent at which oil dissolves. While most hydrocarbons have a low solubility, rendering them effectively insoluble, some aromatic hydrocarbons are somewhat soluble and partially dissolve in seawater. However, the soluble compounds evaporate faster than dissolution can occur and, as a result, dissolution contributes little to an oil's natural removal from the marine environment (ITOPF-TIP 2, 2014).
vi. Photo-Oxidation: the exposure of hydrocarbons to ultra-violet light makes them react with oxygen to form soluble compounds or persistent tars (ITOPF-TIP 2, 2014; IPIECA-IOGP, 2015). However, even intense sunlight is slow to break down oil, and its overall effect is minimal compared to that of other weathering processes (ITOPF-TIP 2, 2014).

vii. Sedimentation: the physical change of dispersed oil after binding with suspended solids in the water column (IPIECA-IOGP, 2015). Once oil and sediments bind together, their density increases and they are more likely to sink to the sea floor, impacting benthic communities. Sedimentation is more likely to occur in coastal areas and river estuaries where there are high levels of suspended materials (ITOPF-TIP 2, 2014).

viii. Biodegradation: the metabolization of oil compounds from marine micro-organisms such as bacteria and fungi (ITOPF-TIP 2, 2014). These organisms utilize the carbon in oil as a source of energy. The availability of oxygen and nutrients are limiting factors in biodegradation, but if present, a community of micro-organisms will quickly develop and the process will continue as long as the oil remains in the environment. Dispersed oil will biodegrade more rapidly as it increases the surface area of the oil (ITOPF-TIP 2, 2014).

3.3 Impacts on Marine Ecology

Oil spills can have serious adverse effects on the marine environment and wildlife. The severity of impacts generally depends on the type of oil, amount spilled, local conditions, and the sensitivity of affected marine life (ITOPF-TIP 13, 2014). When discussing the toxic impacts of oil, the terms *acute* and *chronic* are used, which refer to short- and long-term effects, respectively (Fingas, 2013). There are several ways in which oil can impact marine organisms: physical smothering, which coats an organism in a layer of oil, affecting its physiological functions; chemical toxicity, with lethal or sub-lethal effects; shifts in ecosystem diversity, as one or more species become displaced leading to opportunistic species taking over; and loss of habitat and the species that live there (ITOPF-TIP 13, 2014). Wildlife hazing is a preventative technique used to deter animals away from polluted areas. The techniques can be reactive—the use of auditory or visual devices to scare an animal away—or proactive—the use of bait to lure an animal away (CCG, 2015). Wildlife hazing is most often employed for waterfowl, but can also be effective in deterring reptiles and marine mammals (CCG, 2015). This section will focus on the effects of oil in the marine environment as it pertains to plankton, invertebrates, marine plants, fish, marine mammals, and seabirds.

Plankton: Plankton are microscopic plants and organisms that include microbes (bacteria), phytoplankton, and zooplankton (Fingas, 2013; ITOPF-TIP 13, 2014). They comprise the lowest trophic level upon which all marine life directly or indirectly depends and, as a result, any oil ingested by plankton subsequently works its way to higher trophic levels such as fish and marine mammals (Fingas, 2013). Plankton are sensitive to rapid changes in the environment and tend to experience high levels of mortality if exposed. However, their short generation times mean they are quick to recover, and those killed from oil are soon replaced (Fingas, 2013; IPIECA-IOGP, 2015). For example, following the spill of 1,000 tonnes of fuel from the oil tanker, Tsesis, in the Baltic Sea, zooplankton biomass was able to recover after five days despite high initial mortality (IPIECA-IOGP, 2015).

Invertebrates: Invertebrates make up the majority of species in the ocean (Mah, 2010). Many invertebrates will be narcotized by oil pollution, often leading to an inability to ingest food; if this persists, it can lead to death or predation (IPIECA-IOGP, 2015). Sessile invertebrates such as clams, oysters, and mussels are unable to avoid oil pollution. Many of these species rely on filter-feeding from the water column, thus ingesting oil particles. Species such as mussels, sponges, and sea-squirts typically survive even high concentrations of oil as they are resistant to its toxic effects under short time spans (IPIECA-IOGP, 2015).

Marine Plants: Marine plants most affected by oil pollution include algae, macroalgae (particularly rockweeds and kelp), and seagrass. Algae are highly susceptible to oil spills and experience high mortality even by small spills. They are also susceptible to onshore cleanup techniques—such as high pressure washing—which often kill more algae than the spill itself. Like plankton, algae are able to recover quickly due to their short lifecycle (Fingas, 2013).

Macroalgae, such as rockweeds and kelp, are less susceptible to oil. Rockweeds are coated in a mucus which prevents oil adhesion in moderate amounts while kelps are typically found at depths below which an oil spill's impacts are felt (IPIECA-IOGP, 2015). Both rockweeds and kelps absorb hydrocarbons in the water column, and its effects depend on the volume of oil, length of exposure, and water depth. Oil slicks rarely affect the water column below ten meters meaning communities below this depth experience fewer negative impacts. However, because macroalgae provide habitat for a multitude of species, lethal doses in shallower waters can have cascading effects on the entire ecosystem, the recovery of which can take years (Fingas, 2013).

Seagrasses, like macroalgae, absorb hydrocarbons in the water column but are more sensitive to oiling and can experience lethal doses should a moderate volume of oil persist in the water column for several hours. It is rare though for oil slicks to remain in one area for long periods of time as wind and ocean currents transport the oil and disperse it throughout the water column, decreasing its overall toxicity (IPIECA-IOGP, 2015).

Fish: While juvenile fish are vulnerable to even low volumes of oil pollution, adults are far more resilient and are thought to actively avoid water contaminated with oil (ITOPF-TIP 13, 2014;

IPIECA-IOGP, 2015). This is especially true in deep water where free-swimming fish are mobile enough to avoid oil concentrations. The juvenile stages of fish tend to concentrate in shallow, coastal waters where seagrass and kelp forests help protect them from predators. In addition to being more sensitive to hydrocarbons than adults, they are also more exposed as eggs, larvae, and juveniles are less mobile and cannot avoid oil concentrations like adults can. Therefore, coastal spills of persistent oil increase the risk of toxic exposure to fish more than a spill offshore in deep water would (IPIECA-IOGP, 2015).

Marine Mammals: The effects of oil on marine mammals varies with species. For cetaceans, the greatest risk comes from floating oil; evidence suggests they are unable to detect oil on the water's surface and are vulnerable to inhaling or ingesting oil when surfacing to breathe (Matkin, Saulitis, Ellis, Olesiuk, & Rice, 2008). The buildup of toxic chemicals in cetaceans' fat tissue can have long-term effects; it impacts their ability to reproduce and weakens their immune system, making them more susceptible to disease (Larson & Ferrell, 2007). However, little information exists on the impacts of ingested oil on cetaceans (Fingas, 2013), and whether mortalities are directly related to oil is unknown: necropsies suggest mortalities are from causes other than oil, and cetaceans have been observed to actively avoid polluted waters (ITOPF-TIP 13, 2014).

Marine mammals that live on shorelines, such as seals, sea lions, otters and walruses, are more vulnerable when oil contaminates the shore (IPIECA-IOGP, 2015; Fingas, 2013). Should these species become smothered in oil, their fur loses its insulation abilities and the animal becomes susceptible to hypothermia (Fingas, 2013). Juveniles are especially at risk as their coats are not fully developed, and mortalities have been observed in juveniles as a result (IPIECA-IOGP, 2015).

Seabirds: Compared to other marine species, seabirds are the most vulnerable biota to oil spills (IPIECA-IOGP, 2015; ITOPF-TIP 13, 2014). They are affected in three ways: physical oiling of their feathers, ingestion, and transferring oil to their eggs or young (IPIECA-IOGP, 2015). Smothering of oil reduces a bird's buoyancy and insulating abilities, causing seawater to come in direct contact with the bird's skin, increasing the risk of hypothermia (Fingas, 2013). Even a small spot of oil can be enough to cause mortality (ITOPF-TIP, 13, 2014). The risk is compounded when birds attempt to preen themselves free of oil, causing it to be ingested. This may result in direct mortality or sublethal effects such as liver or kidney damage, intestinal or lung haemorrhages, pneumonia, or behavioral disorders (ITOPF-TIP 13, 2014; Fingas, 2013). Birds may also transfer oil contamination to their eggs or young, reducing embryo survival and the hatchability of eggs (IPIECA-IOGP, 2015). Due to the high vulnerability of exposure, confirmed bird casualties have surpassed the tens of thousands (IPIECA-IOGP, 2015).

3.4 Impacts on Socio-Economic Sensitivities

The socio-economic sectors impacted by an oil spill can be numerous, sometimes resulting in serious financial loss. In particular, the greatest economic effects are experienced in tourism, commercial fisheries, and other sectors that rely on clean seawater and coastlines such as power plants, shipping, salt production, or desalination plants. Many coastal areas rely on tourism as a driving economic force, and an oil spill that disrupts coastal activities such as boating, beach-going, angling, or diving can subsequently impact local restaurants, tourist shops, hotels, and other companies that rely on these activities. Coastal areas affected by a spill may also gain a negative reputation, causing tourists to holiday somewhere else. For example, following the 2010 BP Deepwater Horizon oil disaster in the Gulf of Mexico, tourism declined heavily, even in adjacent states where the impacts were felt less (Oceana, n.d.). In Louisiana, leisure spending declined by $247 million, approximately 35% of surveyed hotels experienced cancellations, and more than a quarter of people planning a trip to Louisiana postponed or cancelled (Oceana, n.d.). The ripple effects of decreased tourism can be far-reaching with financial losses to bus, ferry, and rail transport companies, restaurants that can no longer serve local seafood, and car parks relying on tourists for business (ITOPF-TIP 12, 2014).

Marine oil spills may also cause negative impacts to commercial fisheries and aquaculture. If commercial species are exposed to oil contamination, these industries may be forced to close down operations to avoid human consumption of contaminated, or ‘tainted’ seafood. Sedentary species such as shellfish, cultivated marine plants, and animals in aquaculture pens, are particularly vulnerable as they are unable to avoid oil should they come into contact with it (ITOPF-TIP 11, 2014). Should consumers detect tainted seafood, it will likely be taken off the market leading to less confidence among consumers. This can subsequently cause negative media portrayal, and a decrease in market price. Furthermore, oil can impact boats, fishing gear, and aquaculture equipment, which can be transferred to the catch if not effectively cleaned before further use. This costs time and money to those affected. Aquaculture facilities can sometimes be protected in calmer waters through the use of booms or plastic sheeting wrapped around the cages (ITOPF-TIP 11, 2014).

Although ports offer optimal response conditions due to their sheltered nature and proximity to response equipment, there are difficulties that present themselves should a spill occur. Busy ports will have to coordinate their response around ship movements in attempts to avoid regular port activities. Oil can also become trapped under wharves and must be flushed out in order to clean (ITOPF-TIP 12, 2014). Ports rely on clean seawater for a range of industries, including seafood processing plants, power plants, and numerous other uses. These water intakes will have to be shut down if a spill occurs to avoid contamination, or in the case of power plants, the entire shutdown of the plant which can have severe financial repercussions.

Another concern of oil spilled in coastal areas is its potential impact on cultural and heritage sites, through either direct contact or via cleanup operations. Special care is required when removing oil from cultural/heritage sites as they are often old and susceptible to irreparable damage (For response approaches in the Halifax Harbour pertaining to cultural and heritage areas, see Section 4.2).

3.5 Response Techniques

Once spilled into the marine environment, oil immediately spreads out over the sea surface and undergoes natural dispersal due to oceanographic conditions and weather. The amount spilled and the oil's physical and chemical characteristics also influence how the oil interacts with the marine environment (ITOPF-TIP 2, 2014). Understanding and predicting how oil will react once spilled is critical in organizing response efforts.

For smaller spills, natural remediation is sometimes possible—not all spills require a response (CCG, 2017). Natural remediation refers to natural weathering processes breaking down and removing oil from the environment (ITOPF-TIP 2, 2014). These processes change the viscosity and density of oil in seawater. Typically, the longer oil is exposed to weathering processes, the harder it will be to mechanically remove as it spreads over a greater surface area and mixes with seawater (ITOPF-TIP 2, 2014). Evaporation removes lighter substances from oil, making the remaining slick heavier and susceptible to sinking (Dave & Ghaly, 2011). All oil spills undergo weathering processes to some degree, but for spills too large for natural remediation to be effective, a coordinated response must occur to limit the negative impacts of oil. There are three broad categories for oil spill response at sea: containment and recovery, in-situ burning, and dispersants.

Booms are floating barriers used to contain oil from spreading and come in a variety of sizes and designs to suit different situations and conditions. Containment booms are used to surround a spill into a confined space for mechanical recovery, while exclusion and diversion booms are strategically placed and used to prevent oil from contaminating sensitive resources and redirect spills to suitable locations for removal (ITOPF-TIP 3, 2014). Some, smaller booms are inexpensive and meant for single use only while others are large and robust, requiring the use of cranes on board vessels for deployment (ITOPF-TIP 3, 2014). Two key features of booms include a freeboard to limit splash-over and a sub-surface skirt to prevent oil moving under the boom (ITOPF-TIP 3, 2014). A drawback is that strong wave action or currents can render them ineffective (ITOPF-TIP 3, 2014). Booms are typically used in tandem with skimmers: a boom will surround and concentrate the oil into a confined area while skimmers mechanically remove oil from the surface and pump it to storage areas (ITOPF-TIP 5, 2014). Deciding on the specific type of boom to be deployed is dependant on several factors: prioritizing sensitivities to be protected, noting local weather and ocean conditions, and the ease and speed with which different booms can be deployed (ITOPF-TIP 3, 2014).

Skimmers are stationary or mobile devices specifically designed to recover oil instead of water by taking advantage of the different adhesive properties and densities of oil and water (Prendergast & Gschwend, 2014). Like booms, skimmers have different designs and uses depending on the oil types, environmental conditions, and location. They can be sorted into two main categories: oleophilic and non-oleophilic skimmers. Oleophilic skimmers use belts, drums, discs, or rope-mop to attract oil to the oleophilic material; they lift oil out and away from the water which can then be scraped or squeezed into a recovery tank (ITOPF-TIP 5, 2014). Non-oleophilic skimmers are differentiated from oleophilic skimmers as they typically use a metal disc, belt, or drum which operate at the surface tension of oil and water to attract oil while rejecting water (ITOPF-TIP 5, 2014).

As discussed in Section 3.2, spilled oil undergoes natural dispersal to some degree, particularly for oils with a lower viscosity such as crude oils (ITPOF TIP 4). Dispersants are another response option that use surfactants in a solvent to thin out the slick at the oil-water interface so the oil breaks up into smaller droplets (ITOPF-TIP 4, 2014). By increasing the surface area of the oil slick, a greater area is available for dissolution and biodegradation by micro-organisms such as bacteria and fungi (Prendergast & Gschwend, 2014). Wave action helps mix the dispersant with oil to speed up the dissolution process. Dispersants are typically applied directly from a vessel or via aircraft and help minimize impacts to important sensitivities.

The use of dispersants is often controversial as it involves adding a chemical to the marine environment. An oil slick’s proximity to sensitive regions must be considered as dispersants can be toxic to marine flora and fauna. They must also be used quickly following a spill as the longer oil is exposed, the more viscous it becomes through weathering processes, and dispersants are most effective for oils with low viscosities (ITOPF-TIP 4, 2014). Therefore, the opportunity to use dispersants varies depending on oil type and ocean conditions and should typically be used within 48 hours of the initial spill to be most effective (King et al., 2017). For oils with a higher viscosity that still qualify for dispersant use, the window of opportunity may be as short as several hours (ITOPF-TIP 4, 2014). Due to their potential impact on environmental sensitivities and short window for use, applying dispersants must be taken into careful consideration and is highly dependent on the type of oil spilt and its location.

In-situ burning, or controlled burning, is another method of at-sea oil removal in which floating oil is ignited to burn away the oil slick. Specialized, high temperature booms help concentrate the oil into a defined area to be ignited (Prendergast & Gschwend, 2014). In-situ burning is especially effective for viscous oils with a high molecular weight, before weathering processes begin to degrade and break down the oil. Removal efficiencies can exceed 95% (Mullin & Champ, 2003). In-situ burning is comparatively inexpensive and safe to undertake if done in a controlled setting and, due to its ability to quickly remove oil from the environment, offers an effective method for reducing the negative environmental impacts of oil spills (Buist, 2003). However, like dispersants, in-situ burning is controversial and has a limited time window. It must commence before weathering processes remove the volatile components and before oil emulsifies with seawater: if water content exceeds 25%, the oil is usually unignitable (Mullin & Champ, 2003). Furthermore, the soot and respirable particles that result from the burn present a health hazard to humans and wildlife, threaten property and resources, and emit greenhouse gases—specifically carbon dioxide—into the atmosphere (Mullin & Champ, 2003). As a result, this method of spill response must be undertaken offshore where prevailing winds cannot carry harmful gases to sensitive areas or areas with human populations.

Because the Halifax Harbour is a densely populated urban area, with a variety of physical, ecological, and socio-economic sensitivities, dispersants and in-situ burning are not viable options for oil spill response. These two treatment methods create additional risks to human health and sensitivities and are typically saved for stable weather conditions offshore where sensitive resources are less likely to be impacted (Mullin & Champ, 2003). Mechanical recovery continues to be the favoured response option despite being labour intensive, costly, and dependent on local conditions (Mullin & Champ, 2003). Skimmers and pumps also produce a mixture of oil, water, and debris, creating issues surrounding waste disposal (ITOPF-TIP 9, 2014).

Thus, considering which response method constitutes the best option for any given oil spill, a variety of factors come into play: cost, time, weather, oil type, and proximity to wildlife, sensitivities, and human population all need to be considered (Dave & Ghaly, 2011). Each spill response method has an environmental impact to some degree; deciding which method to employ requires a trade-off between the effects of the spill itself versus the impacts and cost of the response method (Dave & Ghaly, 2011).

If a spill reaches the shoreline, Shoreline Cleanup Assessment Teams (SCAT) survey the affected area to provide an accurate profile of the shoreline's oiling conditions (Owens & Sergy, 2000). This information is used by planners and decision-makers to evaluate operational and logistical options and ultimately propose the most effective and efficient cleanup methods (ECCC, 2016). While every situation is unique, SCAT provides a systematic approach to ensure consistent surveys and data collection across all shoreline assessments (Owens & Sergy, 2000). The goal is to return the shoreline to pre-spill conditions and recovery options are highly dependent on shoreline type (CCG, 2015).

Manual cleanup of shorelines is often the best method for areas experiencing light oiling. Where oiling is heavier, steam cleaning or high-pressure water washing offer effective cleanup methods (DFO, n.d.). On shorelines of mixed sediment, sand, or pebble/gravel affected by heavy oiling, low pressure flushing of oil into booms is often the preferred method, while flooding and sediment washing may also be employed. However, many shoreline cleanup methods are difficult, time-consuming, and have a high potential impact on historic, cultural, and archaeological sensitivities. If affected, special treatment plans are required (ECCC, 2016). Oftentimes, natural remediation is the least damaging option (Fingas, 2013). A cultural or archaeological specialist should be notified who can inform the SCAT survey on the location of these sensitivities and precautions to be taken (Owens & Sergy, 2000; ECCC, 2016).

SECTION 4

4.1 Oil Spill Response in Canada

This section provides a brief history of marine spill response in Canada and outlines CCG's new Regional Response Plan (RRP) initiative, providing context for the purpose of the HHIRP. The roles and responsibilities of CCG and other government agencies will be described before introducing scenario-based oil spills in the Halifax Harbour to provide tangible examples of how a response is orchestrated following different spill events.

Prior to 1970, pursuing compensation for the cost of recovery and expenses from marine oil spills was difficult (Macinnis, 2005). Proving liability typically required proving negligence or human error (SOPF, n.d.). Such proof was often difficult to determine and it became clear that new approaches were required. In 1970, the Arrow oil tanker struck Cerberus Rock in Chedabucto Bay, Nova Scotia spilling 8000 tonnes of oil into the marine environment. The environmental and economic damage that resulted became a catalyst in reforming the Canada Shipping Act (CSA). CCG Environmental Response (ER) was created following the incident with the purpose to "minimize the environmental, economic and public safety impacts of marine pollution incidents occurring in Canadian waters" when responding to marine pollution events (CCG, 2011, p. 1-2). Amendments were then made to the CSA in 1971 which turned new oil spill legislation into law (SOPF, n.d.). As stated on the "Ship-source Oil Pollution Fund's (SOPF) website, the principle elements are:

- Establishing the strict liability of shipowners to be responsible for costs and damages for a discharge of oil.
- Allowing the shipowner, in certain circumstances, to limit his liability.
- Creating a new fund, the Maritime Pollution Claims Fund (MPCF), to be available for claims in excess of the shipowner's limit of liability.
- Giving the Minister of Transport the power to move or to dispose of any ship and cargo discharging or likely to discharge oil." (SOPF, n.d.)

The next significant change in CCG's oil spill response regime came following the Exxon Valdez disaster in 1989. The Exxon Valdez oil tanker ran aground on a reef off the coast of Alaska, spilling 40,000 tonnes of crude oil into Prince William Sound (Boufadel, Geng, & Short, 2016). The SOPF was established in response to the disaster and serves as Canada's national fund for ship-source oil spills (SOPF, n.d.). Government and industry collaborated in the early 1990s to improve Canada's oil spill preparedness and response, and in 1995, the Ship-source Oil Spill Preparedness and Response Regime was created. It has since governed Canada's oil spill response (Tanker Safety Expert Panel, 2013).

Because industry engenders the risk of spills, they are held liable for a spill and bear operational responsibility for preparedness and response (Tanker Safety Expert Panel, 2013). Four industry-funded, government-certified Response Organizations (RO's) were established in Canada for this purpose (See Section 4.2). Conversely, government oversees industry's response in the event of a spill and provides the legislative and regulatory framework (Tanker

Safety Expert Panel, 2013). Transport Canada (TC) is the lead federal agency responsible for the regime and ensures Canada's level of preparedness up to 10,000 tonnes of oil while CCG overseas the response itself (Transport Canada, n.d.). A hierarchy of Marine Spill Contingency Plans was created under the new regime (See Figure 3).

Figure 3. The hierarchy of response plans with the National and Regional chapters containing general response procedures and national standards and the RRPs and site-specific plans containing response strategies as they pertain to the unique characteristics that define the location.

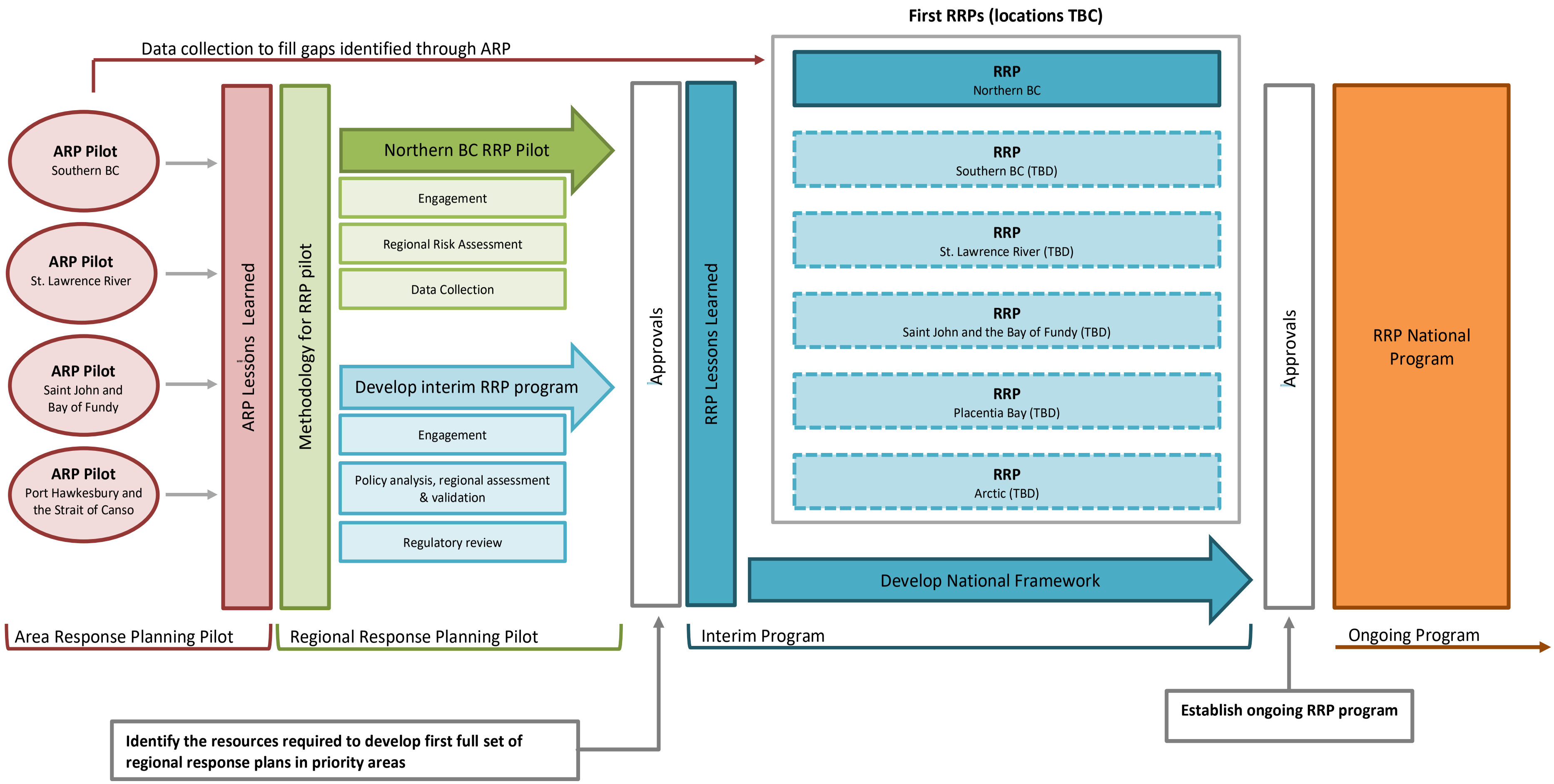
At the top of this hierarchy is the National Chapter which provides the overarching details on CCG ER's operational role following marine oil spills as well as CCG's national level of preparedness, its national stockpile of response equipment, and post-response activities to be carried out (CCG ER National Chapter, 2011). Regional Chapters are a step below the National Chapter, dividing the country into separate regions for environmental response: Pacific, Central & Arctic, Quebec, Maritimes, and Newfoundland & Labrador. The latter two have subsequently been combined into one Atlantic Region, for which the contingency plan is currently under revision. The four Regional Chapters aim to support the National Chapter and "detail the procedures, resources and strategies used to prepare for and conduct a response to a marine pollution incident within a Region's geographic area" (CCG ER National Chapter, p. 1-6).

The likelihood of a worst-case spill scenario occurring in Canadian waters is relatively low (Tanker Safety Expert Panel, 2013). To prepare for large-scale spills, the National and Regional chapters set national planning standards across all regions. However, national standards do not consider unique socio-economic sensitivities of different regions nor the fact that certain regions transport a disproportionate amount of oil. The one-size-fits-all approach was seen as outdated, and in 2013, the government-appointed Tanker Safety Expert Panel was tasked with conducting the first major review of Canada's spill response regime in twenty years (Tanker Safety Expert Panel, 2013). While the foundational principles of the 1995 Regime still hold true today, The Panel identified several aspects that could be improved upon and made 45 recommendations to enhance Canada's oil spill preparedness and response (Tanker Safety Expert Panel, 2013). In particular, the Panel recognized the need to consider higher risks of a spill within certain regions; Area Response Plans (ARPs) are the intended solution.

Through funding received from 2016's Oceans Protection Plan (OPP), ARPs are a new endeavour by the federal government, led by Transport Canada (TC) and CCG, to strengthen Canada's ship-source oil spill preparedness and response. They subdivide Canada's marine waterways into smaller zones and, in doing so, consider the site-specific geographic characteristics of the area as well. They also focus on the unique environmental and socio-economic sensitivities, and shipping activity patterns to develop a risk-based approach for oil spill response. By considering differences in regional geography, ARPs allow for greater flexibility in each region. Four pilot areas were chosen based on higher levels of vessel traffic and the location of Canada's four ROs. The pilot areas are:

- The Southern portion of British Columbia including lower Vancouver Island
- Saint John and the Bay of Fundy, New Brunswick
- Port Hawkesbury and the Strait of Canso, Nova Scotia
- St. Lawrence River (Montreal to Anticosti Island)

Drafts of the ARPs were completed to create nationally consistent methodologies for each region and inform the transition to Regional Response Plans (RRPs) which have a larger scope. Unlike the ARPs, RRPs (not to be confused with the Regional Chapters), will not be limited to mystery spills and ship-source spills only, and will ultimately include spills of hazardous and noxious substances (HNS) as well as oil. The ARP drafts and the Lessons Learned Report from the ARPs were used to inform the creation of the first RRP in the North Pacific Integrated Management Area. This first RRP is currently under development. Once completed, it will serve as a basis for a national framework for RRPs that will be used to upgrade the original ARPs to the same, broader scope (See Figure 4). There will then be five RRPs consisting of the original four as well as the new RRP in the north Pacific, and the term Area Response Plan will no longer be used. RRPs will then be created for other regions along Canada's coasts. The HHIRP, as described in Section 1, is a step below the RRPs with a site-specific, localized geographic scope. Just as CCG will be able to use the methodologies of RRPs to develop additional RRPs, they will similarly be able to use the HHIRP to inform the creation of further, site-specific response plans in other regions.



Data collection to fill gaps identified through ARP
First RRPs (locations TBC)
ARP Pilot
Southern BC
ARP Pilot
St. Lawrence River
ARP Pilot
Saint John and Bay of Fundy
ARP Pilot
Port Hawkesbury and the Strait of Canso
ARP Lessons Learned
Methodology for RRP pilot
Northern BC RRP Pilot
Engagement
Regional Risk Assessment
Data Collection
Develop interim RRP program
Engagement
Policy analysis, regional assessment & validation
Regulatory review
Approvals
RRP Lessons Learned
RRP
Northern BC
RRP
Southern BC (TBD)
RRP
St. Lawrence River (TBD)
RRP
Saint John and the Bay of Fundy (TBD)
RRP
Placentia Bay (TBD)
RRP
Arctic (TBD)
Develop National Framework
Approvals
RRP National Program
Area Response Planning Pilot
Regional Response Planning Pilot
Interim Program
Ongoing Program
Identify the resources required to develop first full set of regional response plans in priority areas
Establish ongoing RRP program

Figure 4. The proposed incremental approach for the development of a national program for RRP. Source: (Canadian Coast Guard, communication, April 3, 2018).

4.2 Roles & Responsibilities: Responding to Marine Pollution Incidents

The following section describes the roles and responsibilities of primary and secondary organizations and federal agencies in the event of an oil spill in the marine environment. This list does not include stakeholders that need to be notified under particular circumstances depending on where a spill occurs; rather, it provides a brief summary of the roles and responsibilities of all organizations and agencies that play some sort of role in the response to a spill regardless of where it occurs in the study area.

Responsible Party

Canada follows the polluter pays principle: in the event that the polluter is known, willing, and able to respond, they are responsible for incurring the cost of cleaning up the spill and taking immediate action to control the source and limit impacts. In order to have spill coverage, vessels are required under the Canada Shipping Act (CSA) 2001 to "have an arrangement with a response organization [RO] in respect of a quantity of oil that is at least equal to the total amount of oil that the vessel carries, both as cargo and as fuel, to a prescribed maximum quantity, and in respect of waters where the vessel navigates or engages in a marine activity" (CSA 2001, Part 8). Under the polluter pays principle, those ships which have arrangements with a RO must have on board a Shipboard Oil Pollution Emergency Plan (SOPEP). The SOPEP "shall advise the Master how to react in case of an oil spill to prevent or at least mitigate negative effects on the environment" (SOPEP procedure manual, p. 2). Similarly, oil handling facilities (OHFs) must have an arrangement with a RO as well to cover all oil being loaded and unloaded between a vessel and the facility. Directly surrounding the Halifax Harbour, there are three OHFs.

Response Organization (RO):

The government-certified, industry-funded ROs were established to meet Canada's obligations for marine safety and oil spill preparedness and response under the Canada Shipping Act 2001. Their function is to provide equipment and resources in the event of a spill, and in doing so, carry out industry's operational role. Their presence will be requested by either the responsible party, CCG, or any other Government Lead Agency and they will act under the direction of the Incident Commander.TC set the regulatory framework for ROs, and determined they must have a level of preparedness to respond to spills of up to 10,000 tonnes of oil within prescribed times depending on where the spill occurs (Tanker Safety Panel, 2013). The four government-certified, industry-funded ROs cover all waters in Canadian jurisdiction south of the 60th parallel: Western Canada Marine Response Corporation (WCMRC) covers Canada's west coast in British Columbia; Atlantic Emergency Response Team (ALERT) operates out of Saint John, New Brunswick and covers the Bay of Fundy region; Point Tupper Marine Services (PTMS) operates out of Point Tupper, Nova Scotia and covers the Strait of Canso/Chedabucto Bay region; and Eastern Canada Response Corporation (ECRC) which covers all navigable waters east of the Rocky Mountains (and south of the 60th parallel) except where the two aforementioned local ROs operate in Saint John and Point Tupper (See Figure 5). The relevant RO for the Halifax Harbour is ECRC.

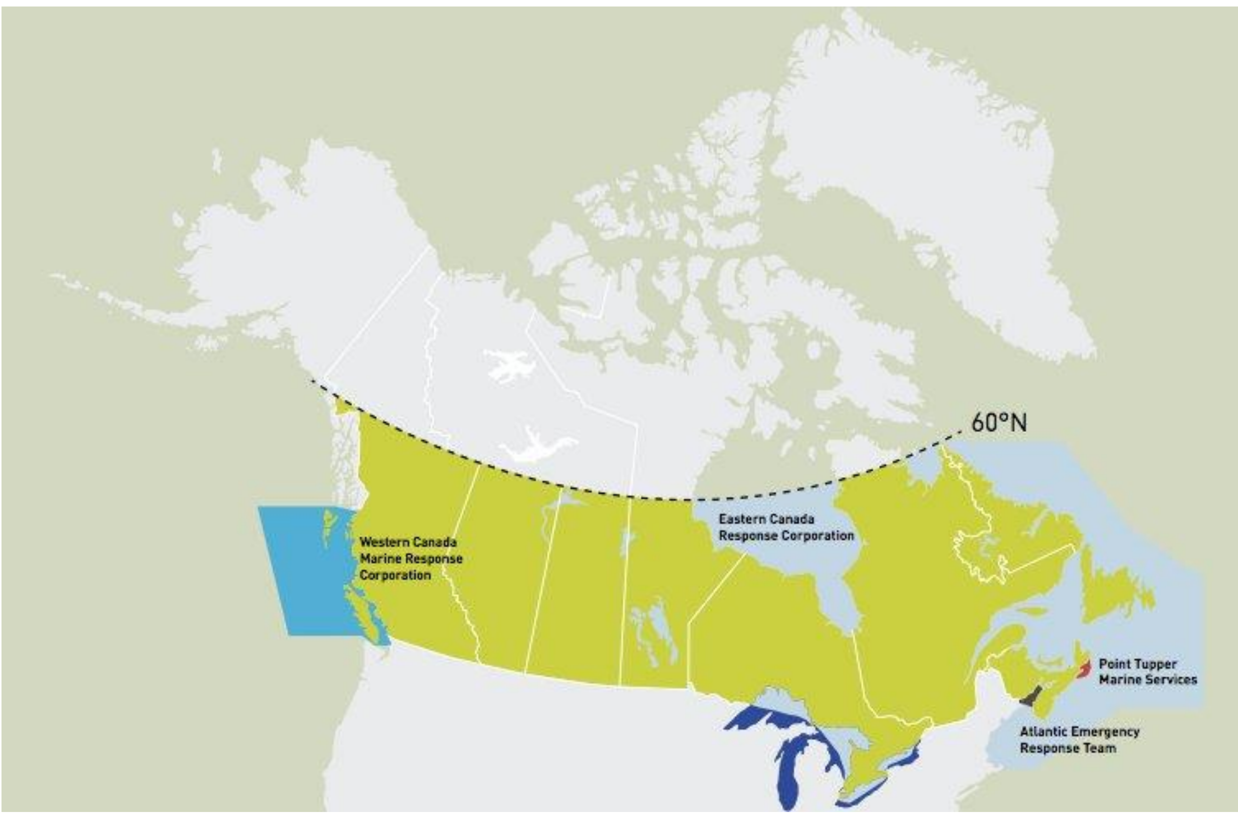


Figure 5. Canada's four government-certified, industry-funded Response Organizations and their geographic areas of response (Tanker Safety Expert Panel, 2013).

ECRC's regional base in Dartmouth NS provides coverage for the Halifax Harbour with eight full time staff, 90 trained responders (from contractors), and 20 advisor personnel (specialized consultants). In the event of a spill, ECRC houses 9100m of boom, 31 skimmers of various size, and 17 vessels to provide an effective and timely response (A. Vickerd, ECRC, personal communication, July 31, 2018).

Canadian Coast Guard (CCG)

CCG is responsible for ensuring the cleanup of all mystery and ship-sourced oil spills and can take on one of two roles. If the responsible polluting party is known and willing and able to respond, CCG assumes the role of Lead Federal Agency. They will establish an incident command structure and provide federal oversight, expertise, and experience while the Responsible Party takes actions to prevent, minimize, or cleanup pollution, according to the Polluter Pays Principle. However, when the polluter is unknown, unwilling, or unable to respond, CCG becomes the Incident Commander and initiates response activities (CCG is the only environmental operational arm in the Canadian Government with spill response capabilities). They will contract out certain tasks to the local Response Organization if needed. In this case, CCG is taking responsibility for the spill clean-up and will submit a claim to the SOPF for cost recovery. The SOPF was established “to pay for claims for oil pollution damage or anticipated damage caused by the discharge of oil from all classes of ships on inland or coastal waters, including the exclusive economic zone of Canada” (Mission, n.d.). If a polluter is identified, the SOPF will recover costs from them if possible.

Transport Canada (TC)

TC is the lead federal regulatory agency responsible for the National Oil Spill Preparedness and Response Regime. TC ensures that the appropriate level of preparedness is available to respond to marine oil pollution incidents in Canada up to 10,000 tonnes. TC is the lead agency for oil spills when the response involves navigational hazards or wreck removals. However, while CCG is involved with responding to the spill, TC works as a partner on the prevention of spills.

Department of Fisheries and Oceans (DFO)

In the event of an oil spill, DFO coordinates fishery closures, ensures compliance with provisions for the protection of marine species, and the protection of Marine Protected Areas (MPAs). DFO also participates at the Science Table and provides information on environmental sensitivities that may be impacted, and thus, need protection.

Environment and Climate Change Canada (ECCC)

ECCC provides shoreline and sensitivities information, trajectory modelling, GIS services and maps, on-site conditions and forecasts, and wildlife treatment. ECCC assumes the role of lead federal agency for land-source spills originating on Federal land and Federal vessels (e.g. warships or research vessels). ECCC can also take the role as lead federal agency when the situation is a grey area and uncertainties exist on who the lead agency should be.

Halifax Port Authority (HPA)

Should a spill occur in the Halifax Harbour and HPA is notified first, either through the responsible party or whoever discovers the spill, they will immediately notify CCG ER who will then assess the spill site to determine whether a response is required. CCG ER will provide HPA and other relevant stakeholders with a Marine Pollution Report. HPA's main priority is stopping the source of the spill; however, HPA has no operational capacity and acts under the guidance of the Lead Agency. They will provide backup and assistance, ensuring the spill is cleaned in a timely manner. Should a large spill occur, HPA will work closely with CCG ER, Marine Communications and Traffic Services (MCTS), TC, the Atlantic Pilotage Authority, and other relevant stakeholders to decide whether shipping operations within the harbour need to be shut down. Ultimately, it is HPA's authority to make this decision (A. Parsons, HPA, personal communication, November 13, 2018).

Nova Scotia Environment (NSE)

NSE is the lead agency in the province for land-source spills that do not occur on Federal land, including those spills that extend into the harbour. NSE will investigate land-based spills and are responsible for overseeing cleanup operations and designating disposal sites (CCG, 2007).

Nova Scotia Special Places Program

In the event of a spill, heritage sites and sites of cultural significance to the Mi'kmaq First Nations must be protected. To avoid looting and vandalism, information on these sites is sensitive and not publicly shared; however, in the case of an emergency such as an oil spill, Nova Scotia Special Places will be contacted and they can provide information on where these sites are located so mitigation measures can be put in place. One strategy for mitigating onshore impacts includes beach excavations prior to oil reaching shore to clear the beach of anything that may encounter oil (this reduces the amount of oily waste); however, shoreline excavation poses the main threat to heritage and cultural sites. Communities Culture & Heritage

(CCH) and the Nova Scotia Museum also possesses cultural and traditional information and would liaise with Nova Scotia Special Places and CCG to ensure their protection (S. Weseloh-McKeane, Nova Scotia Special Places Program, personal communication, July 4, 2018).

Royal Canadian Mounted Police (RCMP)

The RCMP are responsible for organizing evacuations, crowd, and traffic control when necessary (CCG, 2007).

4.4 General Response Procedures

A formal procedure to follow is in place to ensure that the right parties are notified once a spill is discovered. Following the discovery, the vessel, citizen, or aircraft who made the discovery should call the 24-hour toll free public spill reporting hotline. For the Atlantic Region, the number is 1-800-565-1633. As previously stated, vessels over 400 GRT—or over 150 GRT for oil tankers—are required under Canadian Law to have an agreement with an RO, and for the Halifax Harbour, the RO is ECRC. If one of these vessels is the polluter, they will contact ECRC directly as well as calling the spill reporting hotline. The Marine Communications and Traffic Services (MCTS) Center of CCG receives these calls and then notifies three agencies: The Duty Officer of CCG ER, the On Duty Emergency Officer of ECCC, and the Joint Rescue Coordination Center (DND and CCG). Once MCTS has contacted the duty officer, a Marine Pollution Report is filed providing details on both the vessel and the incident which is then sent out to all relevant external agencies. As described in *The Marine Spills Contingency Plan – The Atlantic Chapter,* the CCG ER Duty Officer will take the following actions:

- Assess a pollution or pollution hazard report involving a vessel, oil handling facility (OHF), or an unknown source if it falls within the CCG mandate.
- Report on pollution affecting fauna or flora
- Request for humanitarian assistance
- Request for assistance made to the department by the federal authority responsible for coordinating federal resources

If a response is deemed necessary, the ER Duty Officer alerts the ER team. The Senior Response Officer then provides mobilization and travel instructions for the other response officers. For more information on notification and activation procedures, see Figure 6.

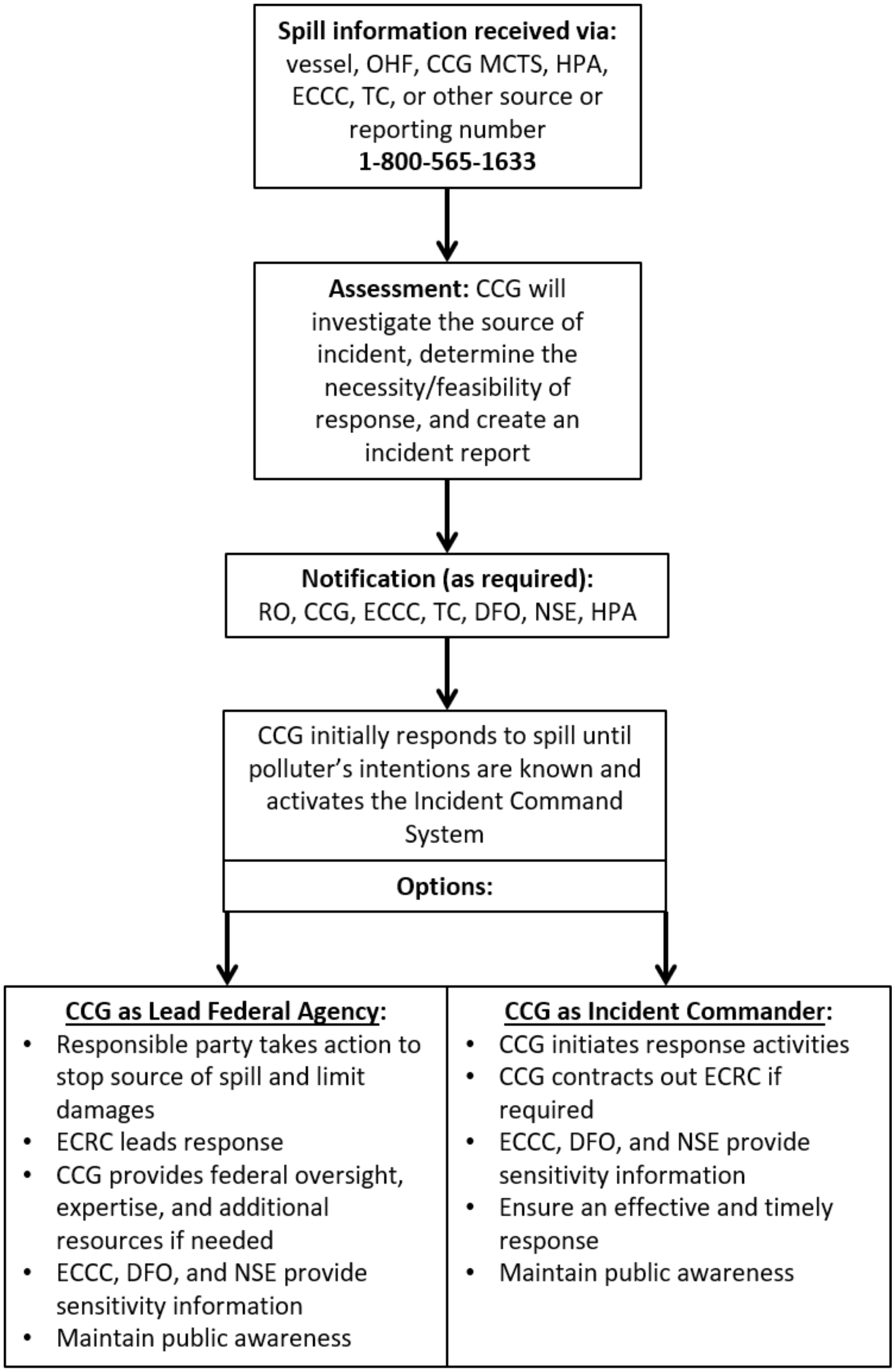


Figure 6. The general process for the HHIRP's activation from the detection of a spill to CCG's two primary roles in spill response (CCG, 2017).

SECTION 5 – CASE STUDIES

5.1 Methods & Risk Assessment

While the RRPs do focus on local risks and environmental sensitivities, they operate on a much larger geographic scale. The HHIRP focuses on a smaller study area and uses five tangible scenarios to demonstrate potential spill events, roles and responsibilities, and mitigation strategies. Oil spill incidents were analyzed in the study area between 2008-2017 as described in the Marine Pollution Incident Reporting System (MPIRS) to determine locations with the highest density of spills. These incidents are shown in Figure 7 with the five scenarios overlaid on the study area. A report of incidents in Atlantic Canada between 01/01/2017 to 04/29/2018 was additionally analyzed to increase the sample size of how spills can occur in the region. Due to the high volume of reported incidents during this time period, Level 3 incidents were used only as spills below this level can be handled with reduced resources and personnel (CCG, n.d.). Level three incidents refer to spills that exceed local capabilities (CCG, n.d.).

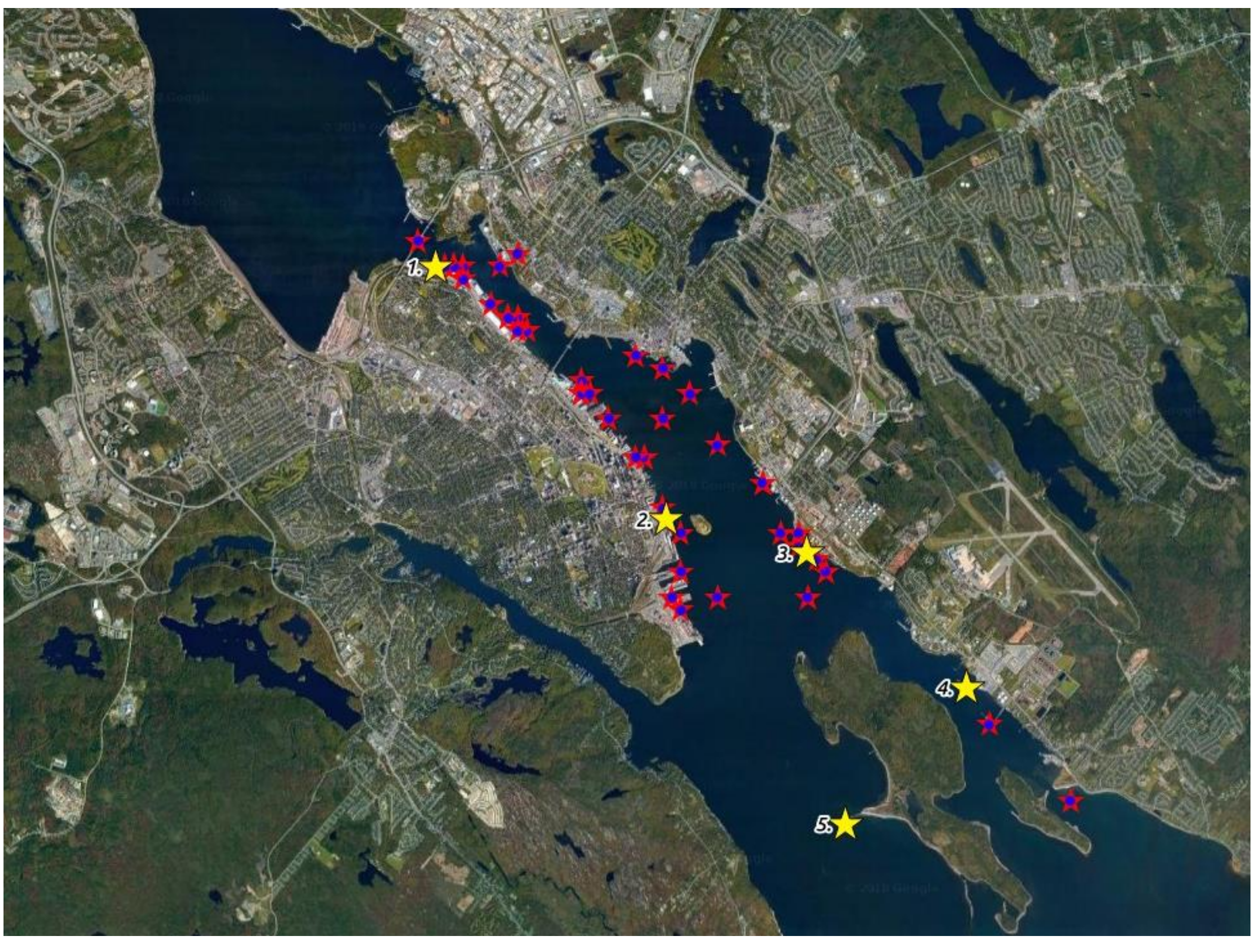


Figure 7. Past spill events in the Halifax Harbour as magenta stars with the HHIRP scenarios overlaid as the numbered yellow stars

There were 121 reported spill incidents in the Halifax Harbour in the ten-year period between 2008-2017, the majority of which were small, requiring little to no response. There were, however, four spills over 100 litres: a 1200 litre spill of jet fuel in 2008 due to refueling/bunkering; a 150 litre spill of diesel oil in 2012 due to ship mechanical failure; a 1000 litre spill of diesel oil in 2013 due to negligence/human error; and an 800 litre spill of diesel oil in 2016 due to operational discharge. More recently, a spill occurred from Tufts Cove power plant on August 2nd, 2018 in which approximately 24,000 litres of oil leaked from a pipe on land into the harbour. Because this spill occurred after the ten-year period, it is not included in Figure 7.

Aside from unknown/mystery spills, which accounted for 88 of the 121 spills in the harbour, mechanical failures represented the next highest proportion of suspected causes with 17. The report of level three spills in Atlantic Canada provide a more comprehensive view of how spills can occur (See Table 1). Mechanical failures represented the highest spill cause with 84 of the 348 spills, followed by unknown/mystery spills (60), sinking/foundering (43), negligence/human error (28), and groundings and operational discharges both at 25. For the five scenarios, a variety of spill causes were selected to highlight how a spill may occur in the study area, invoking different CCG roles. Because mechanical failures represent the highest known cause of spills, this spill cause was chosen for two of the HHIRP scenarios: a land-source spill due to mechanical failure at Pier 9 (scenario 1) and a vessel source mechanical failure at the Autoport (scenario 4). The other three spill causes include an oily bilge discharge at the downtown waterfront (scenario 2), an overflow while refueling at Imperial Oil Wharf (scenario 3), and a vessel grounding at McNabs Island (scenario 5). Spill amounts are largely arbitrary as the purpose is to reveal how CCG may respond under different circumstances and the sensitivities that can be affected across the study area. While a large spill requires additional resources (booms and skimmers) to contain it, the operational procedures would be the same for a smaller spill that is still requiring a response.

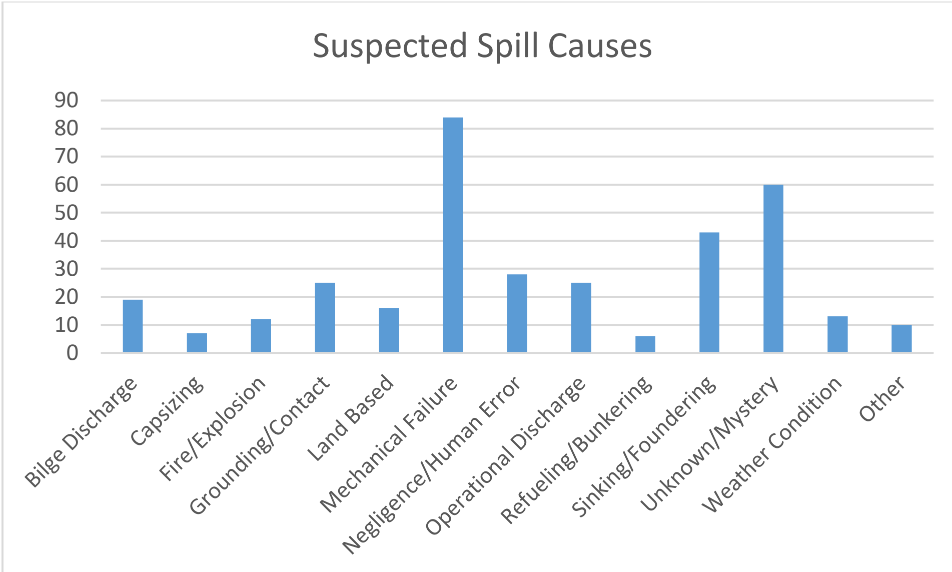


Table 1. Suspected Spill Causes for Level 3 incidents in Atlantic Canada from 01/01/2017 to 04/29/2018. Mechanical failures represent the highest suspected causes with 84 and unknown/mystery the second highest with 60. Total spills = 348.

Automatic Identification System (AIS) data, a common data source for monitoring vessel movements from shore, was used to track vessel traffic in the harbour; the frequency with which tankers use an area for transit, arrival/departure, refueling, or transfer of fuel increase the likelihood of a spill (See Figure 8). Tanker vessels in particular were focused on as they carry the most oil and could have the highest consequences should a spill occur. Different locations in the study area were chosen to highlight the sensitivities that may be impacted near each spill site and consequently the various stakeholders that need to be notified.

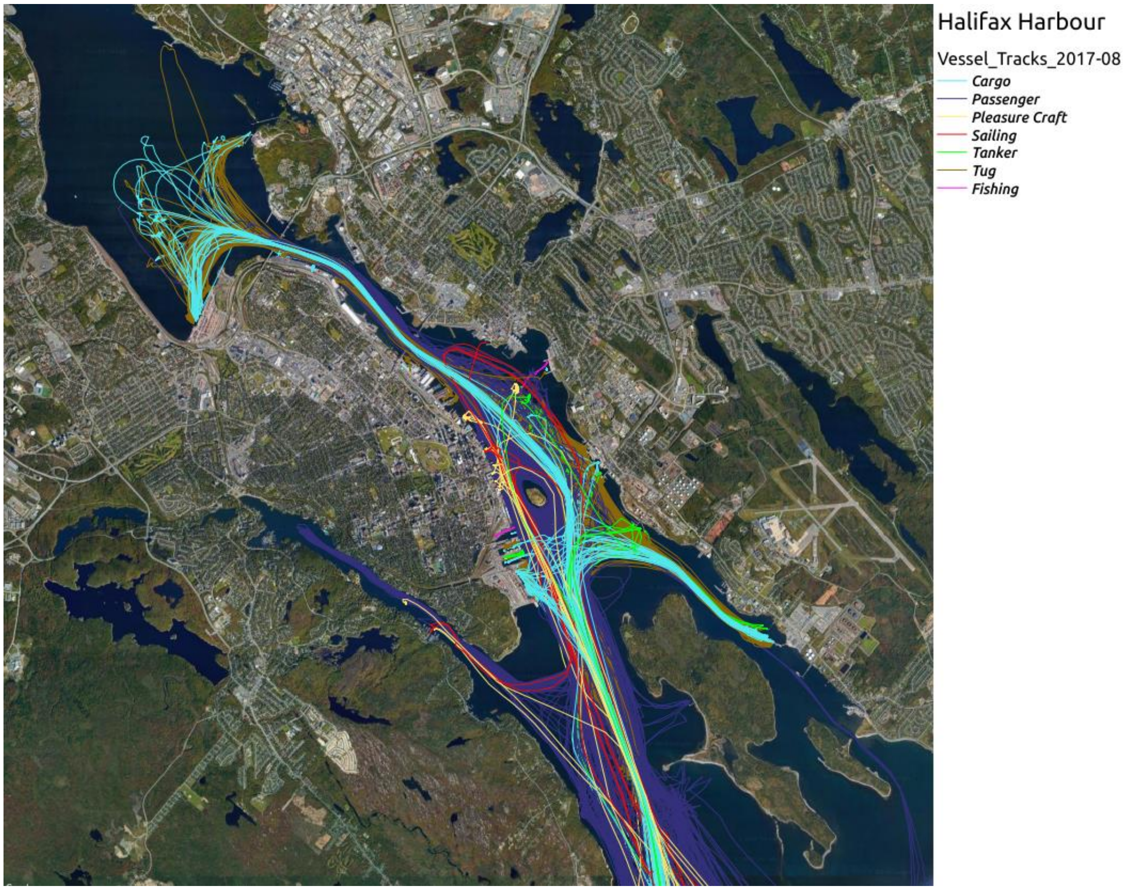


Figure 8. Vessel traffic for a single month (August, 2017) to highlight typical traffic routes for different vessel types. Only one month of data was selected to show the extent of vessel movements without appearing too cluttered.

Stochastic modelling was done to predict the trajectory of oil in the harbour for two of the five scenarios in the HHIRP: the spill at Imperial Oil Wharf (scenario 3 in Figure 7) and the fishing vessel grounding at McNabs Island (scenario 5 in Figure 7). The modelling was provided by Haibo Niu from Dalhousie University's Department of Engineering. Only two of the five scenarios were chosen for detailed drift modelling, due to time constraints and the fact that two of the five fuel types were based on hydraulic oil, which is not easily amenable to modelling. In order to model hydraulic oil, its chemical and physical properties must be known; without this data, simulations could not be run. It was determined that focusing on two scenarios and running effective simulations would be sufficient to reveal how oil generally reacts once in the marine environment of the Halifax Harbour. One of the benefits in modelling a spill's trajectory is that it reveals what shorelines and sensitivities are at the highest risk of contamination, and thus, what mitigation strategies would best be utilized.

The two oil spill trajectories considered here are based on 2006 wind and ocean current data. This year was selected because ocean current data were available for 2006 and already in the system. Wind data were obtained from ECCC's online historical data portal from the McNabs Island station. Within the twelve-month period, both spills were run 160 times starting at midnight on January 1, 2006. The model tracks the spill for five days which considers a myriad of possibilities. The trajectories are then merged together to provide an overall picture of where a spill at that location is most likely to go given the amount of oil and the environmental conditions.

5.2 Sensitivity Mapping

Access to sensitivity mapping through ECCC's Environmental Emergency Mapping System (EEMAP) provides an inventory of physical, biological, and socio-economic sensitivities relevant to the Halifax Harbour and where they are located. It helps prioritize what sensitivities must be protected and, subsequently, which stakeholders need to be contacted depending on where a spill occurs. The sensitivities and shorelines relevant to the HHIRP are shown in Figures 9 and 10, respectively. In particular, the HHIRP is concerned with any sensitivities that may be directly or indirectly impacted by the effects of an oil spill. Sensitivities have been divided into three categories: physical (shorelines), biological, and socio-economic.

It should be noted that EEMAP does not include every sensitivity in the study area that may be affected by an oil spill. Sensitivities not shown, but that should be considered, include wharves, ferry services, and salt water intakes: wharves because they are often difficult and time-consuming to clean; ferry services because they may be disrupted, resulting in economic loss; and salt water intakes because they rely on clean saltwater for various operations including power plants and seafood processing plants. Why these sensitivities are omitted is unknown. Additionally, the EEMAP category 'Coastal Tourism' was omitted from the map as its layer encompassed the entire study site. Including this layer would have distracted from other sensitivities, rendering the map convoluted and unreadable. Coastal Tourism includes boat tours and charters, diving tours (distinct from recreational dive sites), kayaking tours, and sailing charters. These coastal tourism layers are included in the sensitivity table.

Furthermore, while the location of archaeological sites is shown, no data is available on what the sites consists of. As mentioned in Section 4.2, this information is sensitive and not publicly shared to avoid looting and vandalism (S. Weseloh-McKeane, personal communication, July 4, 2018). Nova Scotia Special Places Program, Communities Culture & Heritage (CCH), and the Nova Scotia Museum maintain this information and are able to notify the Lead Agency as to their exact location when needed to ensure they are not damaged.

Appendix 1 has been created to highlight the physical, biological, and socio-economic sensitivities that may be affected by the five scenarios with general mitigation strategies to be undertaken. The Appendix provides additional data on the specific types of sensitivities shown on the map. For example, the 'Shellfish' layer around McNabs Island refers to American lobster. EEMAP does not provide details for every layer shown, and in these cases, the cell is left blank. The sensitivities are prioritized into three levels based on their degree of sensitivity to oil contamination, with green indicating the least sensitive, yellow the mid-level, and red the most sensitive. This methodology is consistent with that of the ARP pilot projects. The Task Force in charge of developing the pilot ARPs also used ECCC's EEMAP system and prioritized the sensitivities using a Delphi approach to solicit expert opinion, "identify and confirm presence, likelihood and severity of impacts for the identified sensitivities" (ARP Atlantic Pilot, Saint John and Bay of Fundy).

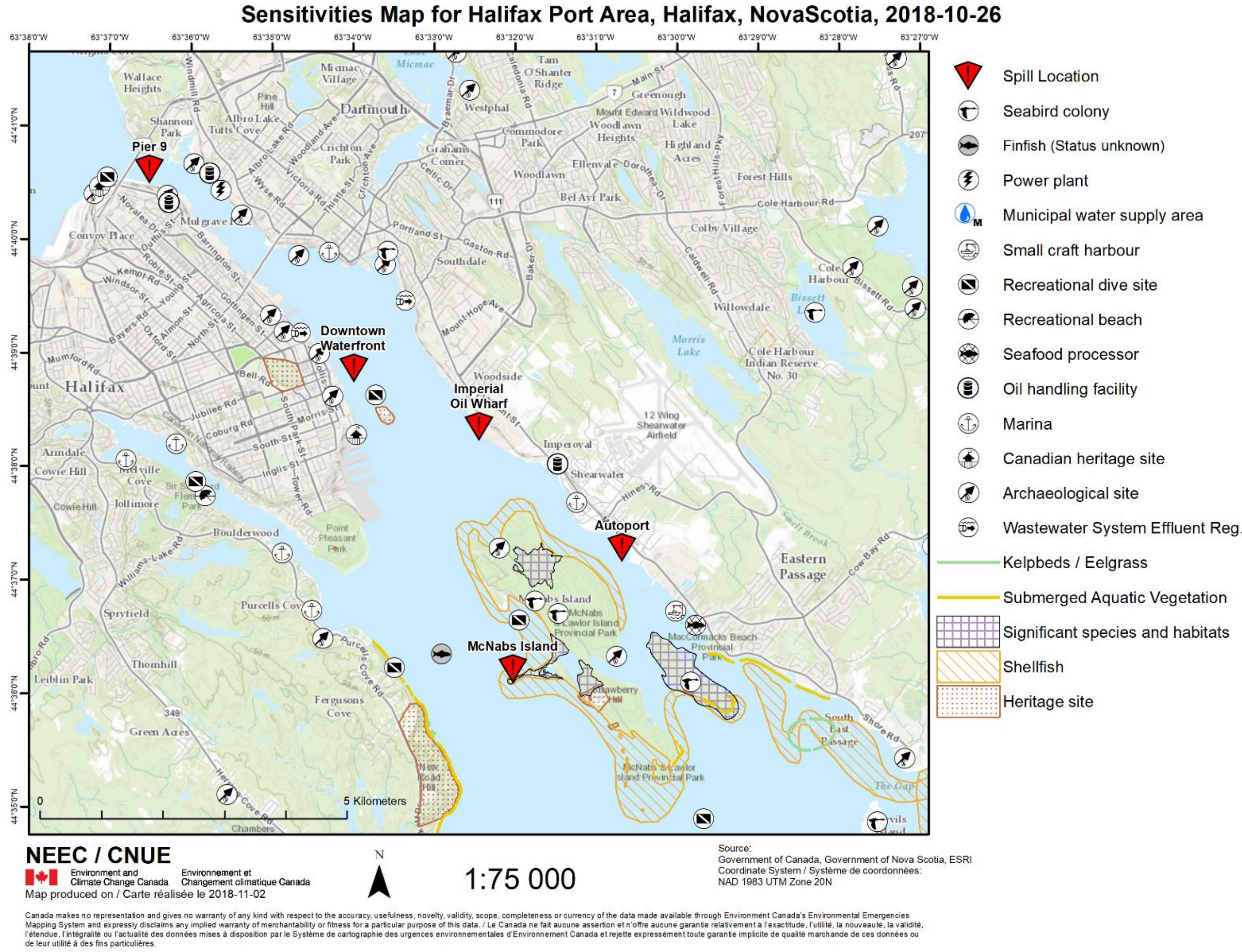


Figure 9. The key biological and socio-economic sensitivities to be considered in the Halifax Harbour. This map was produced by ECCC through their EEMAP system.

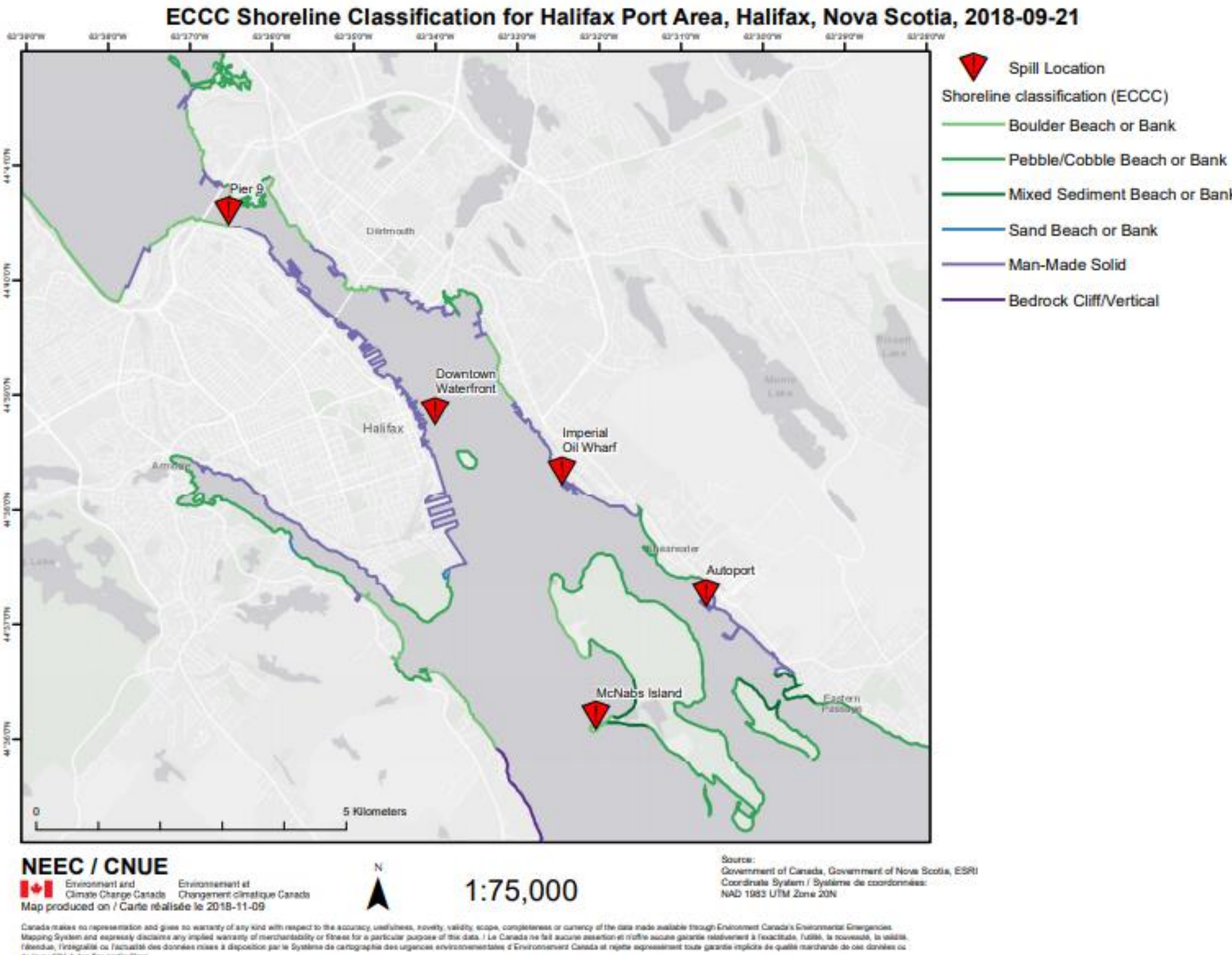


Figure 10. The shoreline classification of the Halifax Harbour as it relates to this project. The shoreline classification system was developed by ECCC who provided this map.

5.3 Case Studies

Scenario 1: Mechanical failure (land source) at Pier 9

While containers were being loaded onto a cargo vessel at Pier 9, a crane's hydraulic oil pump began to leak oil. The majority was contained on shore, however 100 litres of hydraulic oil leaked into the marine environment. Unlike the other scenarios, this one is unique in that it originated on land, meaning CCG is not the lead agency. For land-based spills on federally-owned land, ECCC is the lead federal agency, while for land-source spills that do not occur on federal land in Nova Scotia, such as this scenario, the role of lead agency goes to NSE. Because all oil handling facilities (OHFs) are required to have an arrangement with an RO under the CSA 2001, ECRC would be contracted to lead the response to this spill. In fact, it is likely that CCG would play no role at all. This scenario is important as it shows that not all spills into the marine environment require CCG to play a role. This spill is relatively small; however, a larger spill under these circumstances may require additional resources that ECRC cannot provide. Should ECRC decide that further assistance is needed to adequately respond to the spill, they would contact the OHF (in this case Pier 9 at Richmond facilities) with which they have an arrangement, and the OHF would contact CCG to act as a Resource Agency. As a resource agency, CCG would support NSE and ECRC in the response, provide expertise and the equipment and personnel needed to effectively respond to the spill. As with all spills, information on the resources/sensitivities at risk is provided by DFO, ECCC's National Environmental Emergency Center, and NSE.

A recent spill in the Halifax Harbour from Tufts Cove power plant provides a good case study for the operational response to a spill of this nature. A pipe leaked approximately 24,000 litres of oil into the harbour on August 2, 2018. NSE was the lead agency for this spill as well; however, because NSE has no operational capacity, they did not physically respond to the spill, and would not have responded to the spill at Pier 9 either. Nova Scotia (NS) Power—the owner of the power plant—contracted ECRC to provide equipment and clean up the spill at Tufts Cove. CCG was not needed as a Resource Agency and played no role in this spill's response. The spill of hydraulic oil at Pier 9 would follow the same procedures. ECRC would lead the response efforts after being contracted by NS Power with NSE overseeing the response.

Response efforts should focus on diverting oil away from sensitive areas such as the salt water intakes of the Bedford Institute of Oceanography and the Tufts Cove Power Station, as well as the Canadian heritage site at Africville. Strong currents in the Narrows necessitate a swift response but should not disrupt shipping activity moving in and out of Bedford Basin. Containment booms could be effective in preventing oil from spreading into the Bedford Basin or reaching sensitive areas. Onshore cleanup should focus on preventing further oil from entering the harbour while steam cleaning and/or high-pressure washing would be effective in removing oil from man-made structures. Ultimately, 100 litres is a relatively small volume of oil and, if discovered quickly, the use of booms can prevent the spill at Pier 9 from contaminating sensitive areas. Natural remediation or the use of skimmers will effectively remove this spill from the harbour.

Scenario 2: Unknown/Mystery source at Pier 20.

Emulsified oil is discovered at Pier 20. Its source is unknown but is suspected to be a bilge discharge from a cruise ship. It is determined that 500 litres of emulsified fuel have been spilt. Although the spill is suspected to have originated from a bilge discharge, its source is ultimately unknown; therefore, the polluter is unable to respond. When the polluter is unknown, unable, or unwilling to respond, CCG will assume the role of Incident Commander (IC) and lead the response. If required, CCG may contract ECRC to assist or undertake the actions of cleaning up the spill; however, CCG is the only arm of the federal government with operational capacity and may clean up the spill itself. CCG will also maintain public awareness while ensuring the response is effective and efficient (CCG, 2017).

The primary aim of this response should be to protect the downtown waterfront and Georges Island heritage site from oil contamination as well as private vessels moored along the waterfront. As discussed in Section 3.2, emulsified oil persists longer in the environment and is less prone to other weathering processes (ITOPF-TIP 2, 2014). Containing this spill quickly will be a high priority. The Halifax-Dartmouth ferry line may have to be interrupted to effectively respond to the spill.

The shoreline of the downtown waterfront consists primarily of man-made structures. Booms should be deployed to contain and concentrate the spill, and skimmers can remove the oil. Should oil impact waterfront wharves, steam cleaning or high-pressure water washing offer effective methods for removing oil. If light oiling occurs on the rocky shoreline of Georges Island, manual cleanup is the recommended action; if oiling is more severe, low pressure flushing can transfer oil from rocks into booms in the water where natural remediation or skimmers can remove the oil depending on the amount and location of historical/cultural/archaeological sensitivities.

Scenario 3: Overflow while refueling at Imperial Oil Wharf

While refueling at Imperial Oil Wharf, a merchant chemical-oil tanker spilled 5000 litres of crude oil directly into the harbour. The responsible party—in this case the tanker owner—would take immediate action to stop the source of the spill and contain it as much as possible. Because in this case the polluter is known, CCG assumes the position of Lead Federal Agency and provides federal oversight and monitors industry's response (Tanker Safety Expert Panel, 2013). ECRC initiates the response as industry's RO for the region; both the vessel (responsible party) and Imperial Oil are required to have contracts with ECRC.

As lead federal agency, CCG establishes an Incident Command Post (ICP) from which it oversees and coordinates response operations (CCG, 2017). For spills in rural coastal areas, CCG will typically set up its ICP from the closest community; however, because all spills in this project are within the Halifax Harbour, the ICP would be based out of CCG's base in Dartmouth (K. Laidlaw, CCG ER, personal communication, September 27, 2018). The ICP serves as the tactical headquarters where incident planning is conducted (CCG, 2017). A Unified Command may be organized consisting of representatives from various agencies such as DFO, ECCC, TC, and in the case of the Halifax Harbour, NSE and HPA. Should CCG determine that the responsible party is incapable of adequately responding to the spill, the ICP provides a structure for the transition of CCG's role to Incident Commander and CCG will then undertake response activities (CCG, 2017). The ICP structure is used for all marine oil spills regardless of complexity or size (CCG, 2017).

As seen in the stochastic modelling maps for this oil spill's trajectory (See Figures 11 & 12), the areas at the greatest risk of contamination are the shorelines along the Dartmouth side of the harbour on either side of the spill, and the north and northeastern shorelines of McNabs Island. Mitigation strategies should immediately focus on preventing oil from entering the salt water intake at Imperial Oil as the spill's proximity puts this area of shoreline at the highest risk. As with the other man-made shorelines, steam cleaning and high-pressure water washing can be used to remove oil along affected shorelines while sand blasting can remove oil weathered on wharves. Oil should also be directed away from the sensitive shorelines of McNabs Island and the waters around McNabs as it is an important lobster fishing area. Atlantic mackerel is found throughout the harbour and recreational angling is common along the shorelines of Point Pleasant Park and the Northwest Arm (L. Delaney, DFO, personal communication, July 23, 2018). This recreational fishery is open year-round, and may have to be temporarily closed should DFO determine that oil is having a negative impact on the species. Preventing oil from spreading too far from the spill site will limit impacts to recreational and commercial fisheries in the area.

Although the probability of oil affecting the shorelines across the harbour is only between 0-5%, the shorelines of Point Pleasant Park, the Northwest Arm, and Purcell's Cove are highly sensitive. The only sand beach shorelines in the study area are found at Point Pleasant Park and the Northwest Arm—popular spots for recreation. Deflection or containment booms should be deployed to prevent oil from reaching these sensitive shorelines or entering the Northwest Arm at all. Should oil reach the sand beach segment of the shoreline, manual cleanup is recommended. Preventing oil from spreading across the harbour also ensures shipping activity will not be disrupted, particularly at Ocean and Halterm Terminals. Once boomed, skimmers can be effective in removing oil from the surface, depending on wave height and wind speed.

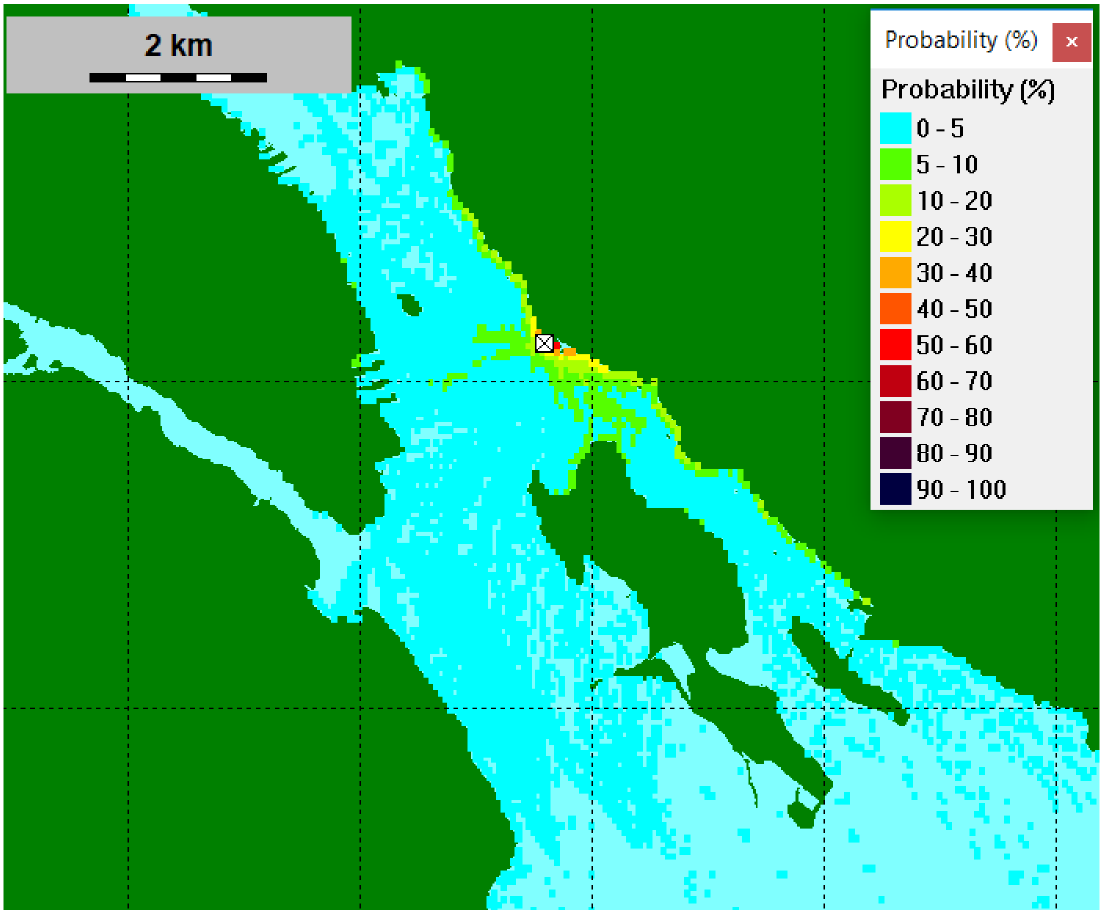


Figure 11. A statistical map showing surface probability of contamination for Scenario 3.

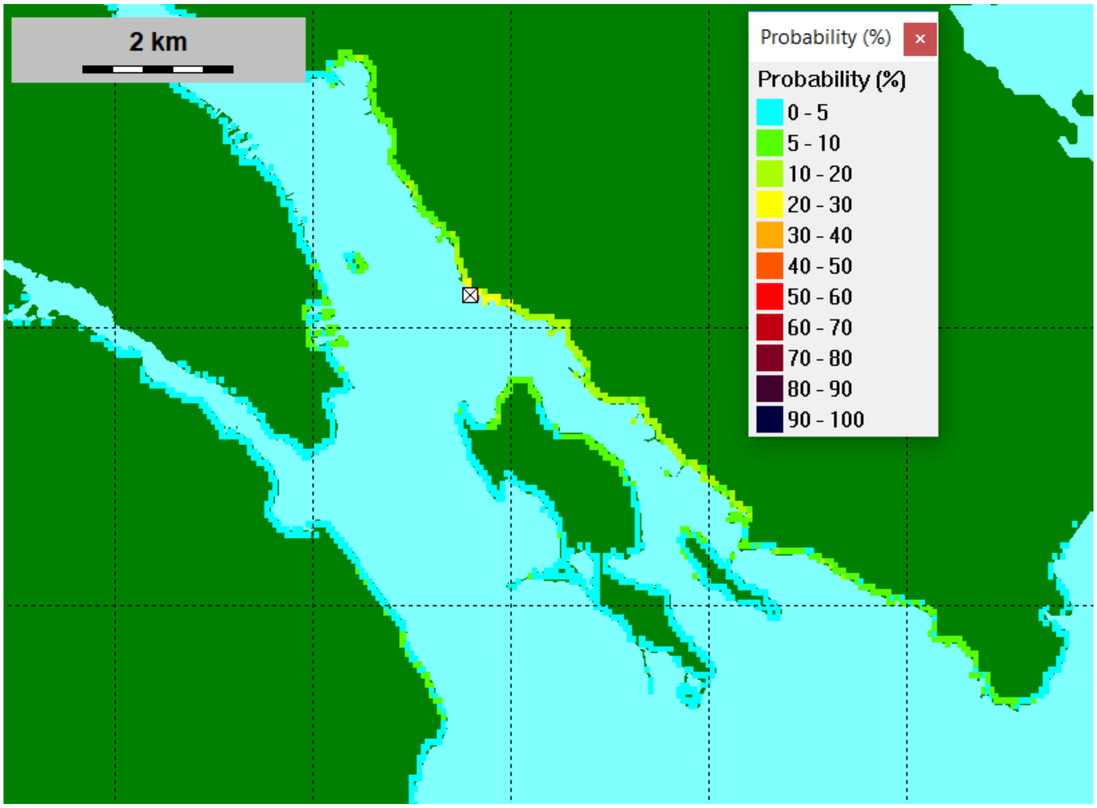


Figure 12. A statistical map showing the probability of contamination for shorelines following Scenario 3.

Scenario 4: Mechanical failure (vessel source) from ruptured hose at the Autoport

A tanker ship departing from the Autoport ruptures a hose on board, spilling 1000 litres of hydraulic oil. Like the previous scenario, the polluter is known and able to respond and, as a result, CCG assumes the role of Lead Agency. The response to this scenario will follow the same protocol as the last: the responsible party (the vessel) will take action to control the pollution source, an ICP will be established at CCG's base in Dartmouth, and ECRC will lead the response with CCG oversight.

Vessels typically now use environmentally acceptable hydraulic fluids as equipment leaks are common (Sundin, 2013; Nash, 2014). Biodegradable hydraulic oils are lighter than heavier crude oils and undergo natural weathering processes, such as evaporation and biodegradation, at a faster rate (ITOPF-TIP 2, 2014). As a result, remediation costs of such spills are typically lower than spills of heavier oils (Sundin, 2013).

Response efforts should focus oil away from the sensitive pebble/cobble beach shorelines of McNabs Island and the mixed sediment beaches of northeast Lawlor Island and MacCormacks Beach Provincial Park. Although environmentally acceptable fluids have less of an impact on aquatic life such as fish and marine plants, it still poses a threat to seabirds. As discussed in Section 3.3, physical smothering of birds' feathers impairs their ability to regulate body temperature which can lead to hypothermia (Fingas, 2013). The east side of McNabs contains osprey nests, and the island in general is important habitat for Great blue heron and tern as well. Wildlife hazing may be necessary for preventing birds from becoming oiled. Containment, exclusion, and diversion booms should be used to protect these areas. Depending on the type of hydraulic oil, natural remediation may biodegrade up to 60% of the spill within 28 days (Sundin, 2013). Skimmers will also be effective in removing the oil from the water's surface.

Scenario 5: Grounding at McNabs Island

A 600 gross register tonnage (GRT) fishing vessel returning to port to offload its products experiences a mechanical failure, causing the captain to lose control of the vessel. As a result, the vessel runs aground on McNabs Island southeast of the Maugher Beach Lighthouse. Both fuel tanks are punctured and 20,000 litres of diesel oil spills into the marine environment. Because it is a Canadian fishing vessel under 1,500 GRT, it is not subject to compulsory pilotage and was under the control of the vessel's regular captain (Atlantic Pilotage Authority, n.d.). Additionally, the vessel is over 400 GRT requiring it to have a contract with ECRC who is notified upon the discovery of oil pollution (ECRC, n.d.). The responsible party (i.e. the fishing vessel) takes immediate action to respond and contain the source of the spill and CCG assumes the role of Lead Federal Agency. However, it becomes apparent to CCG that the responsible party's attempt to respond to the spill is inadequate and the situation is not improving. Under the Incident Command System (ICS) structure, CCG then transitions from Lead Federal Agency to IC (note: no other federal agency takes over the Lead Federal Agency role, and CCG continues to provide oversight while simultaneously initiating response activities). Although CCG has operational capacity, they will contract ECRC to undertake the majority of the spill response while providing additional resources when needed (CCG, 2017). The ICP will be located at CCG's base in Dartmouth.

Stochastic modelling was done for this scenario as well to predict the trajectory of the spill based on a year's average of running the spill scenario 160 times (Section 5.1). The models, shown in Figures 13 and 14, reveal that the spill will spread throughout much of the

Middle Harbour with the shorelines between Purcell's Cove and Sandwich Point and the western side of McNabs Island at the highest risk of contamination. Response should focus on protecting these sensitive shorelines as they include York Redoubt National Historic Park, Fort McNab and Strawberry Battery historic sites, as well as finger kelp and rockweed communities along the shorelines across from the island. Maughers Beach and McNabs Cove are important recreational sites for swimmers and divers respectively, while the waters surrounding McNabs Island are important lobster fishing areas. Deployment of containment or deflection booms can help limit contamination in these sensitive areas; however, these fishing areas may have to be closed by DFO temporarily if the fishery is impacted.

This is the largest spill of the five scenarios and the stochastic modelling suggests it will impact a good portion of the middle harbour. This is a critical line of transportation in and out of the harbour, and if response operations are unable to effectively contain the spill, shipping lanes may have to be temporarily closed. This would have serious financial repercussions. As discussed in Section 4.2, HPA has the final authority to make this decision. As with other spills affecting the waters around McNabs and Lawlor Islands, efforts should focus on preventing contamination of seabirds with oil. These islands are important habitats for tern, great blue heron, and nesting osprey; therefore, wildlife hazing will be important in preventing oil contamination of seabirds.

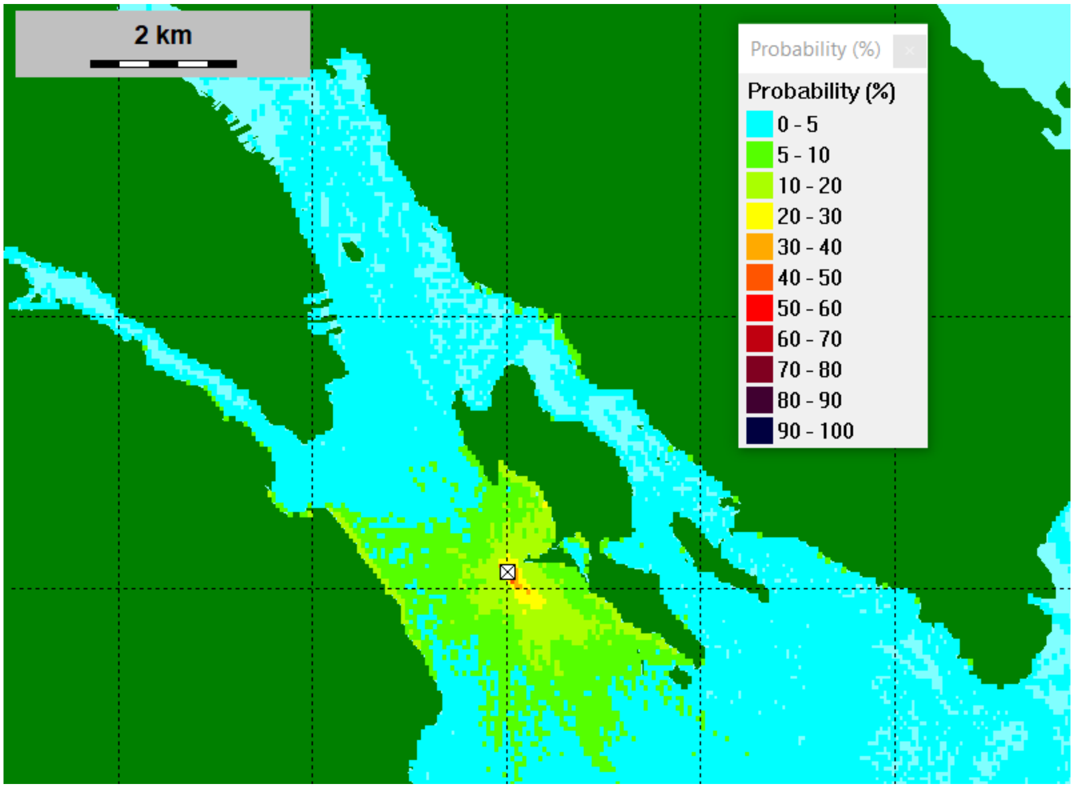


Figure 13. A statistical map showing surface probability of contamination for Scenario 5

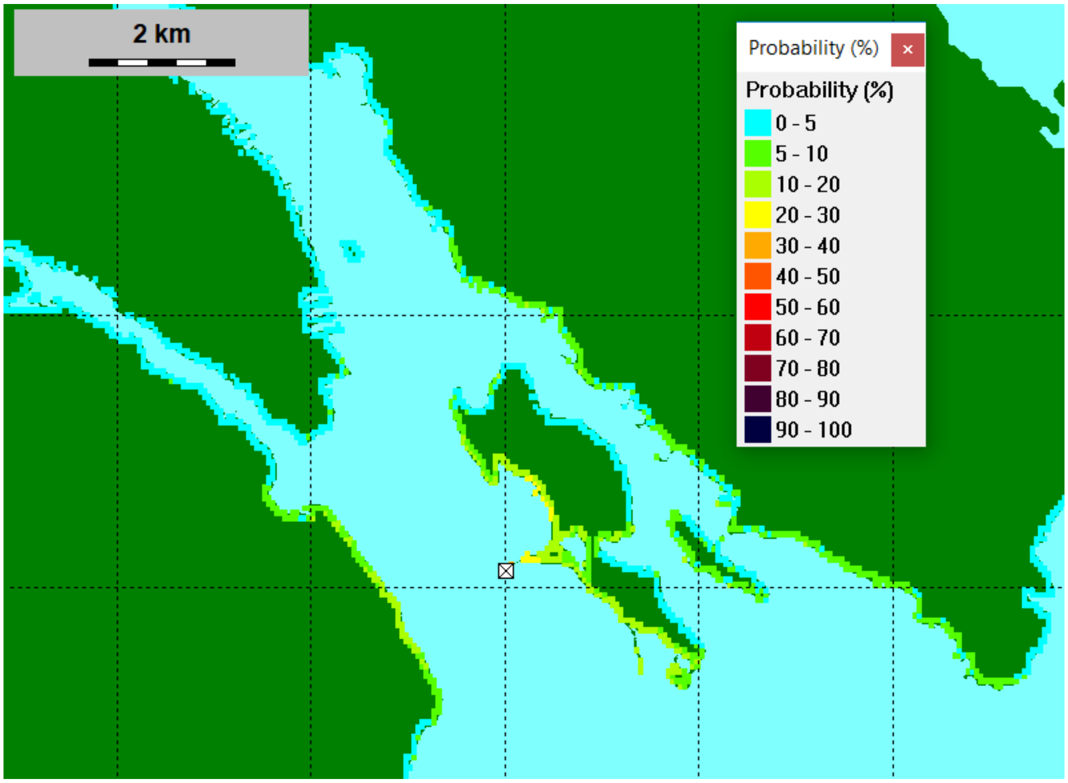


Figure 14. A statistical map showing the probability of contamination for shorelines following Scenario 5.

SECTION 6

6.1 Discussion

Canada's marine oil spill response regime is a complex endeavour involving multiple government agencies, organizations, and industry-funded response organizations. One of the primary accomplishments of the ARP/RRP process has been greater collaboration between government agencies involved in preparedness and response to marine oil pollution. TC led the development of the Area Risk Assessment (ARA) methodology; CCG led the development of the ARPs; and DFO and ECCC provided the scientific information related to environmental sensitivities, socio-economic sensitivities, and geological features (CCG, 2017). The HHIRP continues this trend as collaboration with these branches of government assisted in the development of this project.

Before the development of RRPs, confusion existed on the precise roles and responsibilities surrounding oil spill response, exemplified in a 2016 Evaluation Report on CCG ER's Services Program. It suggested CCG ER "needs to articulate more clearly, to its internal and external stakeholders, its role as the lead federal agency when it comes to responding to ship-source spills in Canadian waters" (DFO, 2016). Engaging a broad range of stakeholders, including local communities, Indigenous groups, and industry, has been another key outcome of the RRP process as they are able to enhance the development of response planning through their unique knowledge (CCG, 2017).

As the scenarios in the HHIRP highlight, the roles and responsibilities of CCG and other federal and provincial agencies is a complex affair and is highly dependent on the precise circumstances under which a spill occurs. Despite being the only operational arm of the federal government, it is rare that CCG will actually respond to a spill as in most cases, the responsible party will have a contract with ECRC who will lead response operations. Therefore, CCG typically assumes the role of Lead Federal Agency and provides federal oversight, expertise, and additional resources if needed while ECRC works with the responsible party to clean the spill. However, as the scenarios revealed, the situation becomes more complex when the spill is land-based or the polluter is unknown, unwilling, or unable to respond. For situations involving the former, CCG may play no role at all despite oil pollution impacting the marine environment;

for situations involving the latter, CCG will likely contract ECRC to lead the response despite CCG being operationally capable of leading a response themselves. Whether or not this is the best system for the federal government and industry can use is not for this paper to discuss; rather, it is important to highlight that complexities exist. Continuing to clarify the exact roles and responsibilities of relevant federal and provincial agencies and organizations is an important aspect of response plans such as the HHIRP.

What sets the HHIRP apart from other RRPs is its geographic focus. By focusing on a smaller area, this plan is able to provide a level of detail that RRPs cannot. It is a valuable asset to CCG as it reveals the exact location of various sensitivities in the Halifax Harbour: information that had not yet been compiled by CCG. Through sensitivity mapping, responders are able to see where sensitivities are located and plan response efforts accordingly to mitigate negative impacts. As a result, the HHIRP can help in decision-making. While sensitivity mapping is a strong component of this report, several challenges arose with the program.

The project could be improved through more detailed and up-to-date sensitivity mapping. ECCC's EEMAP System remains a work-in-progress and, therefore, does not provide an exhaustive list of all sensitivities in the study area. It lacks important ecological data, particularly for marine fauna. No marine mammals are listed despite a variety of species visiting or living within the harbour. While the presence of cetaceans is rare, fin, humpback, right, and sei whales have all been sighted in the outer harbour and sightings of minke whale are fairly common (Simard, Lawlor, and Gowans, 2006). Harbour seals, harbour porpoises, and common and white-sided dolphins are regularly seen throughout the harbour with harbour seals found as far as the Bedford Basin (Fournier, 1990). Their omission in EEMAP is likely because their regular habitat and spawning grounds are located elsewhere; however, this prevents this report from providing a complete overview of all sensitivities relevant to the area.

Information on sensitivities occasionally lacks detail. For example, parts of McNabs Island and all of Lawlor Island are identified as areas with significant species and habitats, yet no further information is available on what the species or habitats are. Knowing the location of these areas is useful in mitigating impacts, but preparedness and response planning would be improved if accurate details were provided. Socio-economic data is also incomplete. Salt water intakes are particularly sensitive and are not shown on the EEMAP program. Should they be negatively impacted, entire operations such as power plants and seafood processing plants may need to be shut down. Overall, EEMAP is a valuable tool in identifying and locating sensitivities and resources at risk, and this project could not have been completed without it. It is important to note that gaps exist and improvements could be made through frequent updates that add new sensitivities while omitting outdated layers. In doing so, it could lead to more accurate response planning.

The results from this report differ from those produced by risk assessments that determine overall probability of an oil spill occurring. While both that approach and the one employed in this report use traffic density and historic spill records, one determines an aggregate spill probability for a given area while this project uses the data to inform the creation of risk-based scenarios. The former approach often splits a region up into different sub-sectors and weights them based on the probability of a spill occurring in that sub-sector (Marty & Nicoll, 2016). This method is particularly valuable for large geographic regions such as the Canadian Arctic or the Great Lakes as it showcases differences in probability between sub-sectors, differences in vulnerability to oil, and where response planning should be focused (Marty & Nicoll, 2016). It also uses historic data to assign probabilities to spills of different sizes (eg. <10, 100, 1000, or >10,000m^3) and the likely frequency with which they would occur in each sub-sector. This approach is useful in knowing what to be prepared for in a given area but does not provide real life examples of how spills occur or how response operations are carried out.

Given the relatively small area of the Halifax Harbour, this project uses a scenario-based approach to reveal different ways in which a spill can occur, thus leading to different roles and responsibilities for CCG. Dividing the Halifax Harbour into sub-sectors would be less useful for this project as traffic density remains high throughout all parts of the harbour, save the Bedford Basin, which is still used by tanker and container ships (See Figure 9). Instead, the HHIRP uses historic spill data and vessel traffic density to reveal the most at-risk areas, but rather than focusing the scenarios solely in areas that experience the most spills (which would concentrate them in The Narrows and inner harbour), they are spread throughout the study area. This is done to show how different sensitivities and shorelines may be affected by each scenario.

The scenarios in the HHIRP are valuable for response planning, highlighting the legislative framework that dictates the roles and responsibilities of different government agencies, and ultimately response strategies. Modelling spill trajectories—based on ocean currents and wind data—also reveals the general direction in which oil will flow from two of the scenarios. Because the modelling in this report is averaged over a year's worth of simulations, a spill occurring under these scenarios may act differently due to temporal variations in weather, currents, and tides. However, trajectory modelling is valuable as it enhances knowledge on potential impacted sensitivities and can lead to a more effective response.

The HHIRP does not consider the effects of weather in oil spill response. As the recent November 2018 Husky Energy SeaRose FPSO spill in offshore Newfoundland shows, weather can delay response operations. Waves between five and seven meters prevented workers from containing and recovering a spill in which an estimated 250,000 litres of oil leaked from a flowline on an offloading vessel 350km southeast of St. John’s (McKenzie-Sutter, 2018). Including weather in this response plan would introduce a new set of variables in oil spill response. The purpose of the HHIRP is to reveal how spills under a variety of circumstances lead to different roles and responsibilities for CCG and other agencies involved in response. It also highlights the sensitivities throughout the study area that may be impacted by the scenarios and the needed response efforts to mitigate impacts. While weather may increase the severity of impacts to sensitivities, the purpose is to show where they are and how they may be impacted as opposed to the degree of impact.

SECTION 7

7.1 Conclusion

The HHIRP comes at a critical time as international shipping experiences steady growth and Halifax becomes an increasingly vital line in Canada’s international trade. Although safety standards have lowered the risk of ship-source oil spills, busy ports such as the Halifax Harbour must continue to be prepared. CCG ER is the federal agency that oversees industry’s response to marine oil spills; however, no official CCG ER response plan exists for the Halifax Harbour. Area and Regional Response Plans have been a primary focus of the federal government (led by TC and CCG ER) over the past several years and the HHIRP continues this trend. Different regions face different risks and Canada’s preparedness and response regime for marine oil spills is finally acknowledging that national standards cannot apply everywhere along its coastline (Tanker Safety Expert Panel, 2013). This is a promising step forward. By focusing on the unique characteristics that define a region, the HHIRP allows response planning to be specific to its geographic region.

SECTION 8

8.1 Acknowledgements

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Appendix 1

This Appendix highlights the physical, biological, and socio-economic sensitivities that may be affected by the five scenarios with general mitigation strategies to be undertaken. The sensitivities are prioritized into three levels based on their degree of sensitivity to oil contamination, with green indicating the least sensitive, yellow the mid-level, and red the most sensitive.

Halifax Harbour Sensitivities			
Category	**Layer**	**Specific (if provided)**	**Mitigation Measures**
Physical			
Shoreline	Sand beach or bank		1. Shoreline protection through containment, deflection, and diversion booms 2. Shoreline Cleanup Assessment Team (SCAT) survey to make decisions on best shoreline cleanup methods
	Mixed sediment beach or bank		
	Pebble/cobble beach or bank		
	Boulder beach or bank		
	Bedrock cliff/Vertical		
	Man-made solid		
Biological			
Fauna	Seabirds	Great Blue Heron	1. Wildlife hazing 2. Wildlife rescue and rehabilitation if needed
		Tern	
		Osprey	
	Shellfish	American lobster	
		Green sea urchin	
	Finfish	Atlantic mackerel	
		American Smelt	
		Brook Trout	
		Gaspereau	
		Bluefin tuna	

		Redfish	
Flora	Marine Vegetation	Finger Kelp	
		Rockweed	
Habitat	Significant species and habitats		
Socio-Economic			
Cultural	Archaeological sites		1. Notify stakeholders on potential contamination 2. Containment and mechanical recovery 3. Determine possible actions to be taken: evacuations, partial or full closures
	Heritage site	Georges Island	
		Fort McNab National Historic Site	
		York Redoubt National Historic Park	
	Canadian heritage site	Africville	
		Pier 21	
Industry	Oil handling facilities	Nova Scotia Power Inc.	
		Wilson Fuel Company	
		Valero Energy Inc	
	Seafood processor	Atlantic Canada Connection Inc	
Tourism	Recreational beach		
	Recreational dive site		
	Boat tours & charters		
	Kayaking tours		
	Sailing charters		
Infrastructure	Salt water intake	Tufts Cove Power Station	
		Bedford Institute of Oceanagraphy	
		Imperial Oil Ltd	

	Wharves	
	Marina	Shearwater yacht club
	Ferry services	
	Wastewater System Effluent Reg.	