Assessing and managing the ecological risk to leatherback sea turtles (*Dermochelys coriacea*) from marine oil pollution in Atlantic Canada

By

Brett Howard

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The undersigned hereby certify that they have read and recommend to the Marine Affairs Program the acceptance of the graduate project titled "Assessing and managing the ecological risk to leatherback sea turtles (*Dermochelys coriacea*) from marine oil pollution in Atlantic Canada" by Brett Howard in partial fulfillment of the requirements for the degree of Master of Marine Management.

Supervisor: Peter Wells

Signature: ______________________________ Dated: ____________________________

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Author: Brett Howard

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Abstract

The critically endangered leatherback sea turtle (*Dermochelys coriacea*) migrates annually into Canadian waters. The species has been listed under the Canadian *Species at Risk Act* (2002) since 2003. The act legally requires the federal government to protect leatherbacks from anthropogenic threats, including exposure to marine oil pollution. However, to what extent oil pollution puts leatherbacks in Atlantic Canada at risk is unknown. This study conducted a quantitative ecological risk assessment to address this question. It was determined that oil pollution from coastal refineries, ships, small engine vessels, and oil and gas exploration and production is a risk to leatherback survival, particularly if a catastrophic oil spill were to occur similar to the 2010 *Deepwater Horizon* disaster in the Gulf of Mexico. Exposure to oil through ingestion or dermal contact was predicted to be harmful and possibly fatal to leatherbacks. Following the risk assessment, an analysis of risk management strategies currently employed by the federal government was done. This analysis looked at the environmental assessment process for marine oil and gas development projects, the aerial observation program used to discourage illegal oil pollution by vessels, and current oil spill response procedures in relation to the risk of marine oil pollution to leatherbacks. The finding of greatest concern was the failure to effectively employ expert opinion and resources in the assessment and mitigation of the risk. Both the environmental assessments and the emergency response plans did not adequately address the risk of marine oil pollution to leatherbacks in Atlantic Canada.

Keywords: leatherback sea turtle; *Dermochelys coriacea*; oil pollution; oil spill; Atlantic Canada; species at risk; SARA; environmental assessment; CEAA; ecological risk assessment; risk management

List of Abbreviations

AIS	Automatic Identification System
ATSDR	Agency for Toxic Substances and Disease Registry
CCG	Canadian Coast Guard
CEAA	*Canadian Environmental Assessment Act* (1992)
CNSOPB	Canada-Nova Scotia Offshore Petroleum Board
CSA	*Canada Shipping Act* (2001)
CSR	comprehensive study report
CWS	Canadian Wildlife Service
DFO	Department of Fisheries and Oceans
EA	environmental assessment
ECRC	Eastern Canada Response Corporation
EEZ	Exclusive economic zone
GESAMP	Group of Experts on the Scientific Aspects of Marine Environmental Protection
IMO	International Maritime Organization
I-STOP	Integrated Satellite Tracking of Pollution
IUCN	International Union for Conservation of Nature
LMWH	light molecular weight hydrocarbon
LNG	liquefied natural gas
LRIT	Long Range Identification and Tracking

MARPOL	International Convention for the Prevention of Pollution from Ships
NASP	National Aerial Surveillance Program
NL	Newfoundland and Labrador
NRC	United States National Research Council
NS	Nova Scotia
QB	Quebec
REET	regional environmental emergencies team
SARA	*Species at Risk Act* (2002)
UN	United Nations
U.S. EPA	United States Environmental Protection Agency
VEC	valued ecosystem component

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Chapter 1: Introduction

Conservation management is defined as the process of developing and implementing practical approaches to protecting a species or system (Primack, 2006). Ideally, conservation managers operate with a complete understanding of how a management decision will increase or decrease risks to the species or system they are attempting to conserve, and are able to direct conservation efforts from a position of complete certainty. This, of course, is never the case in biological systems, which are stochastic, complex, and fraught with irreducible uncertainties. Therefore conservation managers require tools that allow them to make decisions in spite of unavoidable uncertainty. Two such tools are ecological risk assessment and the precautionary principle, which when used in combination can result in refined, defensible management decisions (Santillo et al., 1998). This study discusses the role of each of these tools in context of a highly uncertain system - managing the interaction between marine oil pollution and the critically endangered leatherback sea turtle population of Atlantic Canada.

1.1 Uncertainty in Ecological Risk Assessment

While often misidentified in the literature (e.g. hazards, threats, uncertainty), risk is the likelihood that a particular event or stressor will occur. Ecological risk assessment is a method of evaluating the potential adverse effects of human activity on the environment, based on the likelihood of the risk and the consequences if and when it occurs (US Environmental Protection Agency (EPA), 2003; Harwood, 2000). Uncertainty is intrinsic to risk assessment, because if the outcome of an event is certain (it is guaranteed to occur or not occur) there is no risk (Harwood, 2000; Hope, 2006). Therefore, risk assessment is used to inform management decisions when there is uncertainty (Hope, 2006). Once risk has been assessed, the results are analyzed and a risk management approach for reducing the likelihood or the consequences of that risk can be developed and implemented.

Risk assessment methodologies were originally developed for applications in the fields of economics, engineering and medicine (Hope, 2006; Burgman, 2005). This resulted in an emphasis on the use of controlled experiments to measure the consequences and probabilities of particular risks as a means of reducing epistemic uncertainty (Hall & Giddings, 2000). This quantitative emphasis was subsequently extended to risk assessments for ecological problems, particularly the effect of pollutants on organisms. The field of ecotoxicology adapted its experimental methods from human toxicology and medicine, and is similarly based on the use of controlled laboratory and field experiments to conduct ecological risk assessments (Burgman, 2005). However, there are many situations where the epistemic uncertainty inherent to natural systems is not easily resolved with quantitative methodologies. For example, a quantitative ecotoxicological risk assessment for an endangered or rare species will be prohibitively challenging. A rare species will almost certainly be difficult or impossible to keep in the lab or locate in the field and, in the case of endangered species, the ability to perform the experiments will be limited to the study of sub-lethal, fully reversible effects in most countries (Shigenaka, Milton, & Lutz, 2010).

To overcome these limitations of traditional, quantitative ecological risk assessment, qualitative methodologies have been developed so that assessments can be done with less specific knowledge of the species and stressors. Probably the most well known application of qualitative methods in ecological risk assessment is the determination of species extinction risk by the International Union for Conservation of Nature (IUCN) Red

List. The IUCN uses specialist groups, workshops, and task forces to compile and review the available literature on species and produce a simple qualitative ranking of extinction risk (e.g. vulnerable, endangered, etc.) (IUCN, 2010). The use of expert panels and comprehensive literature analysis has made the IUCN Red List the standard in international species conservation information, despite its qualitative methodology. This is because qualitative risk assessment methods are designed to handle situations where there is high epistemic uncertainty. While the susceptibility of qualitative risk assessment methods to researcher bias is a recognized weakness (Burgman, 2005), some biological problems cannot be feasibly subjected to quantitative, experimental studies, and management decisions have to be made regardless.

1.2 The Precautionary Principle

Perhaps more than any other environment, marine ecosystems demonstrate high levels of epistemic uncertainty. They are complex and highly variable, and even basic information about species assemblages, life histories or abundance may be incompletely understood or unknown (Norse, 1993). This is further complicated when the species of interest to managers is endangered or rare, such as in the case of many charismatic marine vertebrates, which tends to result in high levels of data deficiency (Thompson, Wilson, Grellier & Hammond, 2000; McClenachan et al., 2011). Conservation measures for marine species often reflect that deficiency by using 'insufficient information' as justification for limited or non-existent management plans (McClenachan et al., 2011). While this practice may prevent the unnecessary implementation of management measures that would have no impact on species survival, it presents the more damaging possibility of failing to consider rare or underreported risks that can seriously harm the species (Santillo et al., 1998). This is in contradiction to the precautionary principle which, in the face of uncertainty about the possible consequences of an event or activity, requires the responsible party to take action to mitigate potential environmental harm "in advance of, or without, a clear demonstration that such an action is necessary" (Cooney & Dickson, 2005 p.5). In the context of marine species this means that uncertainty about the species itself, or the possible threats to its survival, do not constitute sufficient reasons to ignore those threats.

As with environmental risk assessment, the precautionary principle was developed for a much broader purpose than marine species conservation decisions. It dates back at least to the 1970s where it was a tenet of German environmental law, and has since been incorporated into a wide variety of national and international laws, policies, and conventions ranging in topics from pollution, sustainability, economics and development (Tickner, Raffensperger, & Myers, n.d.). Probably the most cited version of the principle is in the Rio Declaration, from the 1992 United Nations Conference on Environment and Development (Tickner, Raffensperger, & Myers, n.d.; Cooney & Dickson, 2005):

> *"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." (Rio Declaration, Principle 15)*

Signatories to the Rio Declaration, including Canada, have since included versions of the precautionary principle (or approach) into their national environmental policies and legislation. In Canada, some form of the precautionary principle appears in several pieces of Canadian environmental legislation (Appendix I), including the *Species at Risk Act* (2002). Section 38 of SARA states that if a "threat of serious or irreversible damage to the listed wildlife species" is identified, "cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty."

As with risk assessment, the application of the precautionary principle in management is only relevant in situations where there is uncertainty (Moyle, 2005). The more uncertainty there is, the more heavily a manager will have to rely on the precautionary principle to make decisions. In its most extreme form, the precautionary principle would prohibit any actions that pose a risk to the environment (Tickner, Raffensperger, & Myers, n.d). However, this is rarely a feasible option, so managers must apply a more moderate form of precaution in their management decisions and wherever possible combine it with ecological risk assessment to generate a measure of risk. Ultimately, this study argues for the dual application of risk management and precautionary management (Santillio et al., 1998) in the conservation of leatherbacks in Atlantic Canada.

1.3 Protecting Leatherback Sea Turtles from Oil Pollution in Atlantic Canada

Sea turtles are recognized around the world as charismatic megafauna, often associated with traditional economic, social, and ecological value, particularly in tropical and subtropical coastal environments (Norse, 1993). Unfortunately, all seven extant species of sea turtle are at risk of extinction, making them a focus of ongoing conservation efforts worldwide. In a review of the global research priorities for the conservation management of sea turtles, Hamann et al. (2010) examines the need for more research on the impacts of marine pollution on sea turtle development, survival, health, reproduction, and habitat.

The kinds of pollution either implicated or known to negatively affect sea turtles include plastic debris, discarded fishing gear, chemical and nutrient runoff, and oil spills (Hamman et al., 2010).

The leatherback sea turtle (*Dermochelys coriacea*) occurs regularly in Atlantic Canada and is therefore potentially exposed to the above-mentioned pollution sources in Canadian waters. Leatherbacks occur in the Canadian waters of the northwest Atlantic throughout the summer months (James, Ottensmeyer & Myers, 2005), with their transient population numbering in the thousands (pers. comm. Mike James, May 16, 2012). However, leatherback populations have been declining rapidly since the 1980s worldwide and are currently listed as endangered under the Canadian *Species at Risk Act* (SARA, 2002; Atlantic Leatherback Turtle Recovery Team, 2006); this means the species is facing imminent extirpation or extinction. This listing grants leatherbacks in Canadian waters complete legal protection from harm, including monitoring and enforcement of harmful activities, and requires a federal recovery strategy be implemented (SARA, 2002, section 37). Risk assessment is incorporated as part of that strategy, as SARA (2002) requires the identification of potential hazards that might prevent species recovery.

Exposure to liquid petroleum products in the marine environment (i.e. oil pollution) is one the many potential anthropogenic threats that may contribute to leatherback mortality in Atlantic Canada and worldwide (Atlantic Leatherback Turtle Recovery Team, 2006). However, the severity of this threat in Atlantic Canada has yet to be thoroughly determined, indicating that there is a need to conduct an ecological risk assessment. The degree of risk that oil pollution poses to leatherbacks is dependant on both the likelihood of their exposure to oil in Atlantic Canada waters, the length of time they are exposed, and their toxicological response to oil. Recent major oil spill events, most notably the *Deepwater Horizon* blowout of 2010 in the Gulf of Mexico, have demonstrated that sea turtles are highly vulnerable to oil pollution in the marine environment (Shigenaka, Milton, & Lutz, 2010; Barron, 2011). To date it appears that no one has ever recovered an oiled leatherback sea turtle, however this should not be interpreted to mean that oil exposure does not occur.

In Atlantic Canada the most common anthropogenic sources of oil pollution are from coastal runoff and the small (less than 5,000 metric tonnes), but frequent operational and accidental oil discharges from ships, vessels and oil extraction activities (NRC, 2003; Transport Canada, 2007). There is also the ongoing risk of a large spill (greater than 5,000 metric tonnes) occurring from a shipping or oil platform accident (Transport Canada, 2007). What needs to be determined is if, either individually or cumulatively, these sources present a threat to leatherbacks severe enough to warrant restricting or monitoring projects and activities that might introduce oil to the marine environment.

This study is separated into two separate analyses. The first half of the study will focus on understanding of the risks of oil pollution to leatherback sea turtles in Atlantic Canada by conducting an independent, qualitative risk assessment. The risk assessment methodology used is adapted from the U.S. Environmental Protection Agency (US EPA) *Framework for Ecological Risk Assessment* (2003). The purpose of the methodology is to condense all the available information into two analyses: the possible exposure pathways that might allow leatherbacks to encounter oil pollution, and the subsequent effects of that exposure. While the absence of controlled field and lab studies of the behavioural and physiological effects of oil on leatherbacks prevents conducting a quantitative ecotoxicological risk assessment, this project will represent the most comprehensive assessment and analysis of the cumulative risk of oil pollution on leatherback sea turtles to date. The purpose of the risk assessment is to determine the significance of the risk to leatherbacks from oil pollution in Atlantic Canada.

The second half of the study analyses the state of current risk management in Canada by discussing the strengths and weaknesses of current legislation and policies in place to manage the risk of oil pollution. The first analysis looks at the role of the *Canadian Environmental Assessment Act* (CEAA, 1992) in preventing the development of projects, particularly in the oil and gas industry, from placing leatherbacks at risk from an oil spill. The study analyzes eight CEAA-mandated risk assessments to determine how effectively they assess and manage the risk of oil pollution to leatherbacks. The next analysis will looks at the legislation in place to prevent oil pollution, particularly from ships, shipping and small-engine vessels. The two most relevant pieces of federal legislation are the *Canada Shipping Act* (2001) and the *Fisheries Act* (1985). The federal detection and enforcement program for marine pollution, the National Aerial Surveillance Program (NASP) is also discussed. Finally, the federal marine oil spill response program is analyzed for its approach to managing oiled marine wildlife, particularly leatherbacks.

Chapter 2: Literature Review

2.1 Marine Oil Pollution: Worldwide Sources, Fates, and Effects

Oil has been formally recognized as a marine pollutant since 1954, with the introduction of the International Convention for the Prevention of Pollution of the Sea by Oil (Socioeconomic Data and Applications Center, n.d.). Since then, efforts to reduce and regulate marine oil pollution both internationally and nationally continue to be made (GESAMP, 2007). However, the relentless global demand for petroleum products means oil continues to enter the marine environment through oil exploration and extraction, operational and accidental discharge from shipping activities, and coastal sources (e.g. runoff, coastal refineries) (National Research Council, 2003). The amount and type of oil contributed by these sources is both spatially variable and difficult to estimate. Recent attempts by the US National Research Council (NRC) and the United Nation's Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) have estimated the total global petroleum inputs into the marine environment from anthropogenic sources at between 645,200-700,000 metric tonnes (mt) annually (Table 1) (NRC, 2003; GESAMP, 2007). Most anthropogenic sources contribute more oil to the marine environment in the form of minor, individual spills and chronic inputs of less than 5,000 mt. Large spills of more than 5,000 mt are uncommon, localized events, constituting around 146,000 mt annually, most of which originates from accidents involving tankers and barges transporting oil (GESAMP, 2007, p. 28). It is important to note that natural seeps introduce a nearly equivalent amount of oil into the marine environment as human-based sources, but at low rates, and in localized areas where there are large oil reserves (e.g. the Gulf of Mexico) (NRC, 2003; GESAMP, 2007).

Table 1: The estimated average annual inputs of oil into the marine environment (in metric tonnes per year), from all major sources, from 1988-1997. Large uncertainties of estimates are shown in brackets. Adapted from GESAMP (2007), Table 28, p.60.

Source of Oil into the Marine Environment	Ranges (mt/yr)	Estimate /Average (mt/yr)
1. Ships & Shipping		
Discharges		
Operational discharges		
Machinery space bilge oil		1,880
Fuel oil sludge		186,120
Oily ballast		907
Operational – cargo related		
Tank washing and oily ballast		19,250
Volatile organic compound emissions	250-68,000	68,000
Accidents		
Tankers and barges	46,000-256,000	157,900
Non-tankers		5,300
Sunken ships		(not possible to estimate)
Dry docking		2,900
Scrapping/recycling		14,830
2. Offshore Oil & Gas Exploration and Production		
Operational		16,350
Accidents		600
Pipelines		2,800
3. Coastal Facilities		
Coastal refineries	45,000-180,000	112,500
Accidents		2,400
4. Other Inputs		
Reception facilities		no data
Small craft activity	2.14-5.6 x 10^6	53,000-3.9 x 10^6
Natural seeps	0.02-2.0 x 10^6	600,000
Other sources		200
Totals		
Ships (1)		457,000
Ships (1) + Offshore (2)		477,000
Ships (1) + Offshore (2) + Coastal Facilities (3)		592,000
Small craft activity		53,000
Natural oil seeps		600,000
Grand total (minus oil seeps)		645,000 mt/yr
Grand total (all inputs)		1,245,000 mt/yr

Oil spilled in the marine environment undergoes some combination of eight generalized processes before completely dispersing or degrading. These processes are: evaporation, emulsification, dissolution, oxidation, horizontal transport, vertical transport, and tarball formation (NRC, 2003), and which of those occur is largely dependent on the type of oil and the environmental conditions to which the spilled oil is exposed. For example, more refined petroleum products, such as gasoline, evaporate within days, whereas heavier oils, like crude, diesel, or bunker fuel (shipping fuel) will persist in the environment for months, undergoing emulsification, transport and tarball formation (Table 2). This combination of environmental effects is generically referred to as ‘weathering’ (see NRC, 2003, Chapter 4 and NRC, 1985 for more information on the fate and behaviour of spilled oil).

Table 2: The general processes that move oil products spilled in the marine environment. **H** = high, **M** = moderate, **L** = low, **NR** = not relevant, **U** = unknown. Adapted from National Research Council, 2003, Table 2-1, p.22)

Input Type	Fate of Spilled Oil								
	Persistence	**Evaporation**	**Emulsification**	**Dissolution**	**Oxidation**	**Horizontal Transport**	**Vertical Transport**	**Sedimentation**	**Tarballs**
Spills	years	H	M	M	M	H	M	M	H
Gasoline	days	H	NR	M	L	L	L	NR	NR
Light Distillates	days	M	L	H	L	M	H	L	NR
Crudes	months	M	M	M	M	M	M	M	M
Heavy Distillates	years	L	M	L	L	H	L	H	H
Produced Water	days	M	NR	M	M	L	L	L	NR
Vessel Operational	months	M	L	M	L	M	L	L	M
Recreational Craft	days	H	NR	M	L	L	L	NR	NR
Land-based	U	M	L	L	L	M	M	M	U

Both the GESAMP and NRC studies acknowledge the significant data gaps in their estimates of annual, global marine oil pollution, largely due to a lack of records and data for many parts of the world, and some of the major input sources (e.g. small-engine vessel pollution, or illegal activities). The accuracy of the estimates is also affected by the rapid regulatory and technical improvements being implemented worldwide to reduce marine oil pollution. For example, the introduction of mandatory double-hull technology on all tanker ships, implemented by the International Maritime Organization (IMO) in 1993, has significantly reduced the amount of oil spilled in accidents involving tankers and barges carrying petrochemical products (Yip, Talley, & Jin, 2011). However, while the amount of oil entering the marine environment annually from human-related sources is declining, the amount of oil being transported and used in the marine environment annually is increasing (NRC, 2003). As long as the global appetite for oil continues to require the transport and use of petroleum products on or near the marine environment, there will be a need to continually assess the risks of those activities, including the possible impacts of oil pollution on the marine environment and species.

Relating anthropogenic oil pollution to ecological consequences is difficult, especially when estimates of global oil pollution volumes are used, as this limits analysis of ecological impacts in two ways. First, the type of oil that is spilled can have greater influence over how the oil pollution interacts with the environment than volume alone (NRC, 2003). The type of oil spilled affects the persistence and toxicity of the oil (Table 2). Second, global oil pollution trends do not apply uniformly throughout the world's oceans. For example, natural seeps in Canada are extremely rare, whereas the Gulf of Mexico has the largest concentration of natural seeps in the world (NRC, 2003). Similarly, differences in national pollution legislation and enforcement will alter the amount of localized oil pollution from country to country. Therefore, regional and national oil pollution assessments are more appropriate than global assessments for managing both the risk of pollution and the subsequent ecological consequences on a national or regional scale.

2.1.1 Marine Oil Pollution in Atlantic Canada

Both the NRC and GESAMP reports present a regional assessment of oil pollution along the Atlantic coast of North America alongside their global analyses, although Canada-specific information is limited. The GESAMP report demonstrates that since 1978 the amount of oil pollution entering the Atlantic coastal and offshore waters of North America has been less than 25,000 mt a year, with most years experiencing less than 5,000 mt annually (Figure 1). The NRC report gives both a regional estimate for the entire Atlantic Coast of North America (43,800 mt) and Atlantic Canada specifically (1,800 mt) (Table 3). In both estimates, the three catastrophic accidental spill events that have occurred in the region (the *Atlantic Empress* in 1979, and the *Odessesy* and *Athenian Adventure* in 1988) have been excluded from the average annual spill estimate.

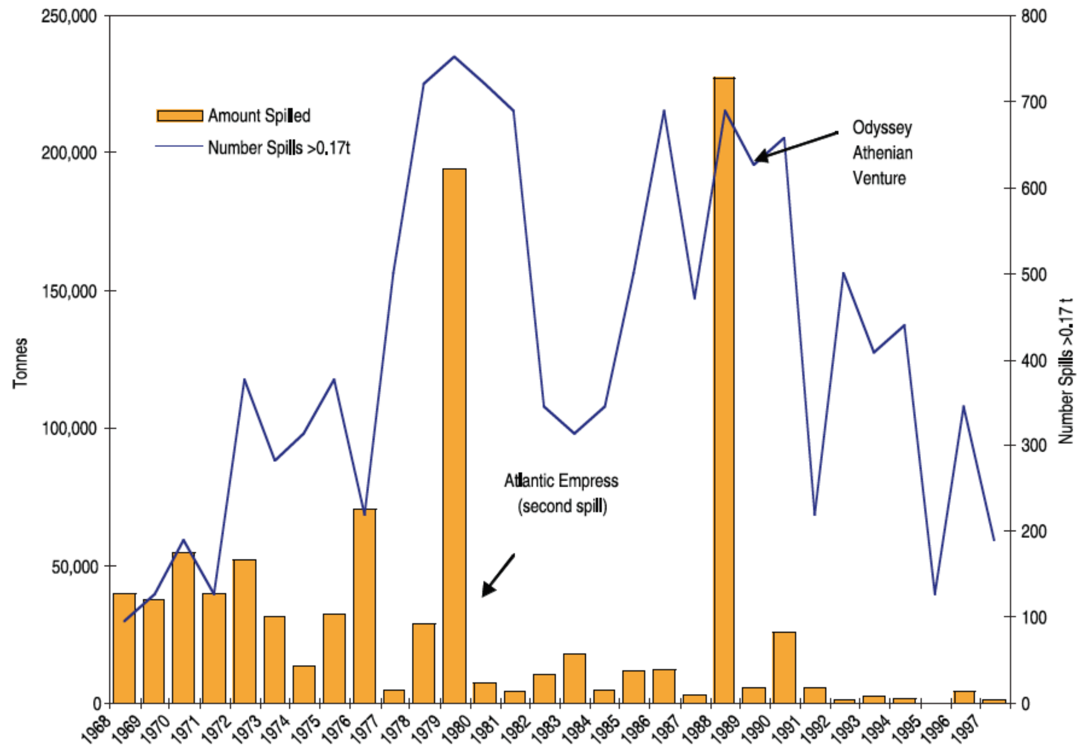

Figure 1: Estimated oil spilled in the North Atlantic Ocean between 1968-1997, both amount spilled and number of spills. From GESAMP, 2007 (Figure 21, p.33).

Table 3: Average annual input of marine oil pollution (in metric tonnes) for the Atlantic Seaboard of Canada (**nd**=no/insufficient data, **na**=not applicable) (1990-1999). Adapted from NRC, 2003, Table 2-6, p.53.

Source		Coastal	Offshore
Seeps (total)		**na**	**na**
	Platforms	nd	28
	Atmospheric	nd	trace
	Produced	nd	62
Extraction (total)		**nd**	**90**
	Pipelines	0	na
	Tank vessel	0	na
	Coastal facilities	trace	na
	Atmospheric	trace	trace
Transportation (total)		**11**	**trace**
	Land-based	500	na
	Recreational vessels*	nd*	nd*
	Vessels >100 gross tonnes (spills)	trace	trace
	Vessels >100 gross tonnes (operational discharge)	trace	trace
	Vessels <100 gross tonnes (operational discharge)	trace	trace
	Atmospheric	93	160
	Aircraft	na	120
Consumption (total)		**1400**	**290**
Grand Total		**1800 mt/year**	

*The data both on the number of small-engine craft operating in Canada, and their emission of oil pollution directly to the marine environment are too scarce to make confident estimates. In the NRC (2003) and GESAMP (2007) reports on global marine pollution, estimates of marine oil pollution from small-engine craft were made but neither report endorsed their estimate as particularly accurate. Depending on the calculations used, global small-engine pollution is between 53,000 and 5.6 million metric tonnes a year (see GESAMP, 2007, section 5.5). It is sufficient to assume that small-engine craft are a significant source of oil pollution in Atlantic Canada.

While these estimates are some of the best publicly available summaries of regional oil pollution, the spatial component is limited to broad categories of coastal and offshore pollution estimates and there are limited data on sources like coastal runoff and small-engine vessel pollution (GESAMP, 2007). One of the few studies that mapped oil pollution more explicitly in the North Atlantic found that the distribution of oil, particularly tarballs, was strongly associated with the dominant surface currents of the western North Atlantic (Levy & Walton, 1976). Specifically, the circular gyre that encircles the Sargasso Sea funnels oil pollution into the Gulf Stream, where it moves northward, until reaching the boundary between the Gulf Stream and the southerly moving Labrador current, where the resulting convergence zone traps the oil. The study was able to repeatedly demonstrate a marked increase in pollution starting at the Cabot Strait, moving southwards (Levy & Walton, 1976). At a regional scale, the horizontal transport of pollution is therefore defined by the interaction between the Gulf Stream and the Labrador Current. At finer scales (tens of metres), wind-driven horizontal movement becomes the predominate force determining where oil moves on the ocean surface, and can similarly cause convergence zones (NRC, 2003).

2.2 Sea Turtles: Life History, Conservation Status, and Threats

Globally, there are seven species of sea turtle, all of which are considered threatened with extinction to varying degrees. All of the threats to the survival of sea turtle species are anthropogenic: predominantly poaching, fisheries bycatch, habitat loss, and marine pollution (Hamann et al., 2010), including oil pollution. The most significant pollution source known to affect sea turtle survival is discarded plastic debris, which they consume, often with fatal effects (see Derraik, 2002 for review of the interaction between plastic pollution and sea turtles). Sea turtles are also threatened by coastal nutrient runoff, which alters coastal habitats contributing to habitat loss and physiological stress on resident sea turtles (Aguirre & Lutz, 2004). Coastal environments that have been degraded by nutrient pollution have been correlated with an increase in the rate of green turtle fibropapilloma infection, a debilitating and often lethal disease (Aguirre & Lutz, 2004).

Oil pollution is also considered to be a hazard to sea turtles. Despite their robust physical characteristics, the limited toxicological studies that have been performed on sea turtles demonstrate their sensitivity to oil pollution (Shigenaka, Milton, & Lutz, 2010). The lethality of oil pollution to juvenile/adult sea turtles has also been demonstrated in the wake of catastrophic accidental oil spills. In 1979 in the Gulf of Mexico the *Ixtoc I* oil well suffered a blowout and during the nine months it took to cap the flow of oil, an estimated 480,000 metric tonnes of oil entered into the Gulf of Mexico. The *Ixtoc I* spill is known to have exposed green and Kemp's ridley sea turtles to both acute and chronic oil pollution (Hall, Belisle & Sileo, 1983). The three sea turtles necropsied by the US Fish and Wildlife Service following the spill displayed evidence of acute (short-term) exposure to the spilled oil (external oil coating the body and oil in the mouth and esophagus indicating the possibility of ingestion), as well as chronic (long-term) exposure (incorporation of non-natural hydrocarbons into the animals' tissues) (Hall, Belisle &

Sileo, 1983). During the *Deepwater Horizon* oil spill in 2010 in the Gulf of Mexico, concerns about effected wildlife, including sea turtles, was a primary issue throughout the disaster. From April to October, the US Fish and Wildlife Service collected the reports of sea turtles recovered from the spill area. Of the 688 records collected, 608 were recorded as fatalities (National Oceanic and Atmospheric Administration, n.d.). While only 14 of the dead sea turtles were visibly oiled, ongoing necropsies of the remaining sea turtles are expected to reveal important information about the effects of oil pollution on sea turtle survival (Jones, 2010).

It is important to note that both the *Ixtoc I* and *Deepwater Horizon* oil spills were large environmental catastrophes where cleanup efforts would have likely resulted in an increased detection rate for dead or moribund sea turtles. Far less is known about how many or how often sea turtles are affected by exposure to oil pollution resulting from more frequent, smaller oil spills. It is arguably more important to address these types of exposure, as it far more common for oil to enter the environment though operational, accidental or land-based discharges of less than 5,000 mt (GESAMP, 2007, p. vi). Sea turtles can and do encounter these smaller sources of oil pollution. One study collected stomach contents of 160 post-hatchling loggerhead sea turtles found in the advection zones of dominant surface currents. The study found that 34% of the loggerheads had tar in their stomachs, mouths, or both (Witherington, 1994). The sea turtles had been collected throughout the summer of 1993, off the Atlantic coast of Florida, where there had been no major spills (>5000 mt) reported since the 1979 *Ixtoc I* catastrophe. This supports the conclusion that it does not require large volumes of oil for an interaction between oil pollution and sea turtles to occur, particularly if the species has an affinity for areas where surface or wind currents converge, funneling oil pollution into a smaller area (Levy & Walton, 1976; NRC, 2003).

Experimental studies clarifying what kinds of oil pollution and at what exposures cause severe or lethal consequences to sea turtles would be extremely useful in the development of management plans and decision-making. However, the lab-intensive ecotoxicological risk assessment methods that would normally be utilized are not feasible, due to the endangered status of all sea turtle species. Advances in this area of study are almost completely reliant on data collected in the process of rehabilitating rescued sea turtles, or necropsying those that succumb to oil-related effects. Unfortunately, this method of incidental data collection is slower than direct experimental methods.

As adults, all sea turtles migrate to their natal nesting beaches every few years to breed and lay eggs. Hatching success of sea turtle nests is determined by a number of natural and anthropogenic influences. Nest depredation by animals and egg collection by humans (for trade and consumption) are primary threats (Lutcavage et al., 1997). However, oil pollution is among the known anthropogenic stressors for sea turtle eggs and hatchlings. Under certain conditions, clutches of eggs that come into contact with fresh oil have higher rates of hatchling mortality and deformities (Fritts & McGehee, 1982). During the 2010 *Deepwater Horizon* oil spill in the Gulf of Mexico over 200 sea turtle nests were relocated from their original locations in the Northern Gulf region to incubators at Cape Canaveral, Florida to prevent them from being damaged by oil (Zepeda, 2010).

Following hatching, most sea turtle species spend a number of years offshore avoiding predators (Musick & Limpus, 1997). The length of time spent offshore is species dependent, and only some species then permanently recruit to coastal environments upon reaching a juvenile or sub-adult stage (Musick & Limpus, 1997). Species that spend most of their adult life in coastal environments will likely have greater exposure to oil pollution from coastal runoff, industrial pollution, recreational boating, shipping, ports and shallow water oil and gas production (NRC, 2003). Of the studies that exist on oil pollution and its effects on sea turtles, the majority concern incidents involving sea turtles common to the coastal environments of the Gulf of Mexico. However, oil pollution occurs in offshore environments as well, threatening sea turtles during their pelagic life history stages. In addition to point sources like shipping and offshore oil and gas, the horizontal transfer of oil pollution along the dominant surface currents (e.g. the Gulf Stream) provides a steady supply of oil pollution into the offshore environment (Levy & Walton, 1976). To begin to develop an understanding of the risk of oil pollution to leatherbacks in Atlantic Canada, it is necessary to relate the occurrence of pollution to the movements and behaviours of leatherbacks.

2.2.1 Life History and Conservation Status of the Leatherback Sea Turtle

While the critically endangered leatherback sea turtle is the largest of all sea turtle species, an adult leatherback averages 400 kilograms, they are obligate predators of gelatinous plankton (e.g. jellyfish) (Bjorndal, 1997; Ruckdeschel & Shoop, 2006; Heaslip et al., 2012). The low energetic value of these prey require leatherbacks to consume large quantities daily, perhaps as much or more than 73% of their body mass (Heaslip et al., 2012). Foraging for high densities of gelatinous plankton is considered to be the primary reason adult leatherbacks migrate annually to temperate waters, including Atlantic Canada, which demonstrate high concentrations of jellyfish during the summer months

(Doyle et al., 2007; James, Ottensmeyer, & Myers, 2005; Heaslip et al., 2012). Leatherbacks in Atlantic Canada arrive annually around June and remain in Atlantic Canada until October (James, Ottensmeyer, & Myers, 2005). When foraging, leatherbacks are capable of diving more than 200 m in search of prey, although such dives are uncommon in northern waters (James et al., 2006). This is attributed to the increase in prey abundance allowing the sea turtles to avoid costly deep dives by foraging readily near the surface (James et al., 2006). To maximize their foraging efficiency, it would appear that leatherbacks in Atlantic Canada target areas with increased primary productivity and convergence of surface currents, which acts to aggregate their jellyfish prey (Atlantic Leatherback Turtle Recovery Team, 2006)

Within Canadian waters, leatherbacks are protected under the Canadian *Species at Risk Act* (2002) as an endangered species, meaning the species is facing imminent extirpation or extinction. This listing grants leatherbacks complete legal protection from being killed, harmed, harassed, bought, sold or otherwise possessed (SARA, 2002, section 32.1 and 32.2). This listing also requires the relevant federal department, the DFO in the case of endangered marine species, to prepare a recovery strategy and a subsequent action plan for the implementation of conservation measures (SARA, 2002, sections 37 and 47). The purpose of these plans is to identify threats to survival, critical habitat, research priorities, conservation objectives and monitoring methods for the species of interest. Further, section 38 of SARA states that if a “threat of serious or irreversible damage to the listed wildlife species” is identified, then “cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty.” This process has been partially completed for leatherbacks in Canada, with Pacific and

Atlantic populations addressed under separate recovery strategies. The DFO published their recovery strategy for Atlantic leatherbacks in 2006, but has yet to produce an action plan for their recovery, despite a commitment to do so by 2009 (Atlantic Leatherback Turtle Recovery Team, 2006, p. 27). The recovery strategy is fairly comprehensive in its assessment of the threats to species survival faced by leatherbacks, both in Canada and internationally. The threats identified for adult leatherbacks in Canada are entanglement in fishing gear, collisions with ships, marine pollution and acoustic disturbances (e.g. seismic surveys). On the subject of marine pollution, the recovery strategy states:

> *The effect of marine pollution on sea turtles is not well quantified, and therefore the magnitude of pollution-related mortality is unknown. Leatherback sea turtles may be more susceptible to marine debris ingestion than other turtle species due to their pelagic existence and the tendency of floating debris to concentrate in convergence zones that adults and juveniles use for feeding areas and migration...*
>
> *Leatherbacks are known to ingest a variety of anthropogenic marine debris, including plastic bags, balloons, plastic and Styrofoam pieces, tar balls, plastic sheeting, and fishing gear... Ingestion of such materials may interfere with metabolism or gut function and lead to blockages in the digestive tract, which could result in starvation or in the absorption of toxic byproducts.* (Atlantic Leatherback Turtle Recovery Team, 2006, p. 13)

This statement does address the predominant pollution threats to leatherbacks, as it would be misleading to portray marine oil pollution as the most severe threat to the survival of the leatherback, either in Canada or internationally (Kaplan, 2005; Shigenaka, Milton &

Lutz, 2010). However, it is only necessary to look to the recent 2010 *Deepwater Horizon* disaster in the Gulf of Mexico for evidence of the severity of oil pollution to sea turtles (National Oceanic and Atmospheric Administration, n.d.; Jones, 2010). As Canada's Atlantic region increases its development, use and transportation of oil products in the marine environment, it becomes increasingly important that the risks this poses to Canada's vulnerable marine wildlife be assessed.

Chapter 3: Ecological Risk Assessment

Ecological risk assessment is the evaluation and communication of the ecological effects of human activities (EPA, 2003). Risk assessment is implicit in the *Canadian Environmental Assessment Act* (CEEA, 1992) section 16, under "factors to be considered" in any environmental assessment (EA) mandated under the Act. These factors include "the environmental effects of malfunctions or accidents that may occur in connection with the project and any cumulative environmental effects that are likely to result from the project in combination with other projects or activities that have been or will be carried out." (CEAA, 1992, section 16.1.a). In considering risks to endangered species from oil pollution, the emphasis on "cumulative environmental effects" is particularly important, as organisms do not experience oil from one source in isolation from all others. The risk assessment presented here assesses the consequences and likelihood of the risk to leatherbacks presented by both individual sources of oil pollution, as well as the cumulative risk of these sources, in accordance with section 16.1.a of the CEAA (1992).

3.1 Methodology

The risk assessment methodology used here is a qualitative adaptation of the US Environmental Protection Agency's *Framework for Ecological Risk Assessment* (EPA, 2003). The purpose of this methodology is to condense all the available information into two profiles: the likelihood of leatherbacks encountering oil pollution in Atlantic Canada, and the anticipated physical and behavioural consequences to a leatherback exposed to oil pollution. Once the two profiles are created, it is possible to make an assessment of the cumulative risk of oil pollution to leatherbacks in Atlantic Canada. In this chapter, two questions will be answered to generate the most comprehensive risk assessment possible with existing knowledge. The methodology used to answer each of these questions is described below.

1. *What pathways exist that expose leatherbacks in Atlantic Canada to marine oil pollution, and how often are these pathways available?*

To determine if it is possible for leatherbacks in Atlantic Canada to encounter marine oil pollution, either chronic or acute, it is necessary to examine the environmental pathways that could reasonably lead to the co-occurrence of the pollutant and the species of interest. This is done through an exposure pathways model. The methodology used here was adapted from the U.S. Center for Disease Control's Agency for Toxic Substances & Disease Registry (ATSDR) five-step methodology for building pathway models (Figure 2). Using available data from multiple sources on oil spill occurrence and behaviour of leatherbacks in Atlantic Canada, an exposure pathway model for leatherback sea turtles was generated.

2. *What are the anticipated toxic effects that result when a leatherback is exposed to oil pollution, relative to the duration of exposure?*

The methodology for this question is an analysis of the existing literature on the known chronic and acute effects of marine oil pollution on leatherbacks, sea turtles and in some cases, species analogs including marine birds and mammals. Very little quantitative information exists on this subject, as controlled ecotoxicological experiments are prohibitively complicated. Much of what is presented here is available in greater detail in Shigenaka, Milton and Lutz (2010), including a review of the only experimental study ever conducted on sea turtles and response to oil pollution. The study (Lutcavage et al., 1995) was conducted at the request of the U.S. Minerals Management Service (now the Bureau of Ocean Energy Management, Regulation and Enforcement) to determine if exposure to crude oil was detrimental to the health of sea turtles. Using these sources and others, it is possible to generate a plausible series of behavioural and physical effects for leatherbacks exposed to oil pollution.

3.2 Ecological Risk Assessment for Leatherbacks in Atlantic Canada

3.2.1 Exposure Pathways Model

To determine the consequences of oil exposure to leatherbacks in Atlantic Canada specifically, it is necessary to identify likely exposure situations where the species of interest and the pollutant will co-occur in both time and space. This is the purpose of an exposure pathway model. The ATSDR's five-step methodology was adapted to develop such a model for the exposure of leatherbacks in Atlantic Canada to marine oil pollution (Figure 2) (ATSDR, 2005).

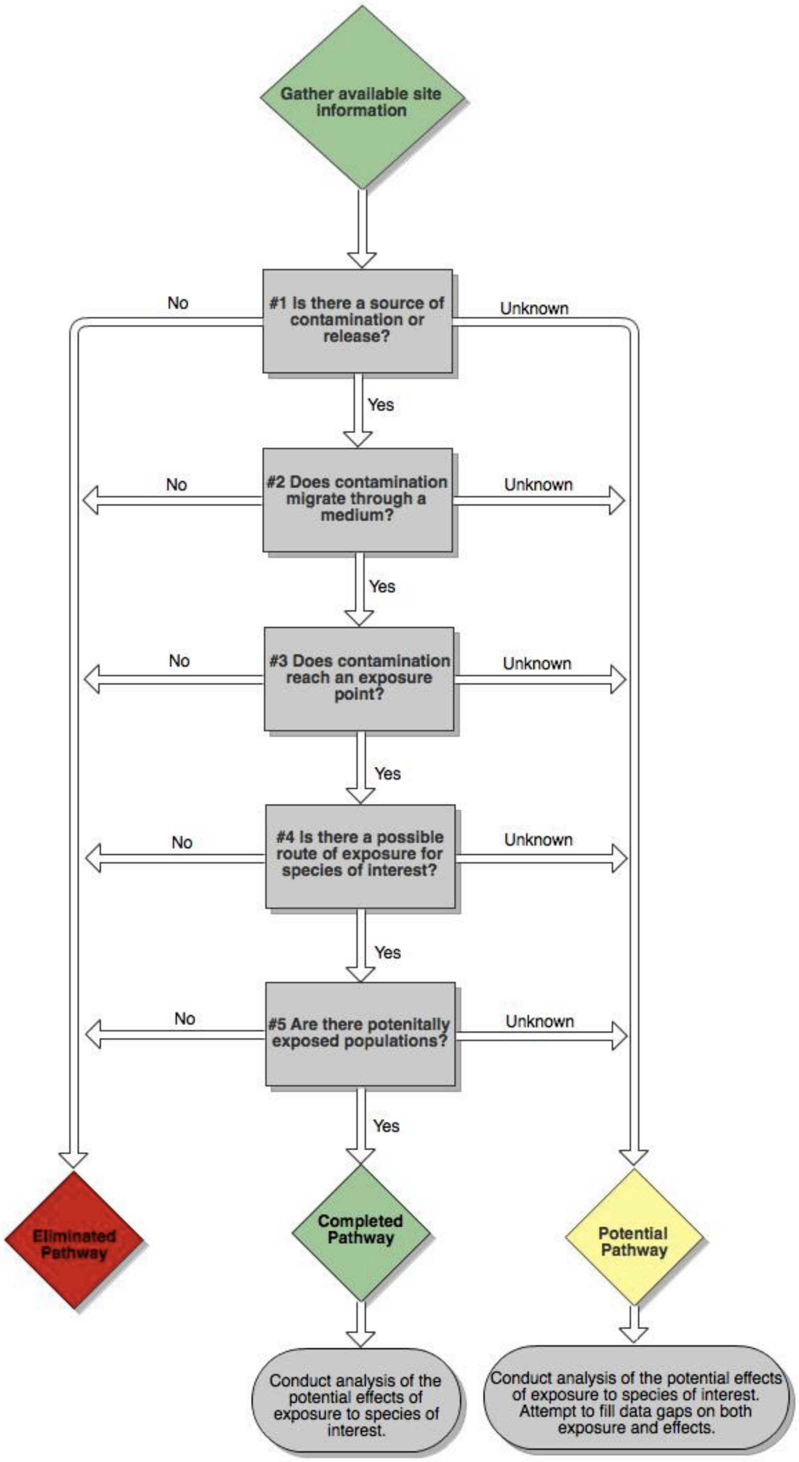

Figure 2: Adaptation of the U.S. Center for Disease Control's Agency for Toxic Substances & Disease Registry (ATSDR) five-step methodology for building pathway models (ATDSR, 2005).

The first step is to determine if there is a source of contamination or release. From the literature review (Chapter 2), the major sources of oil pollution in the marine environment have been identified as natural seeps, coastal runoff, coastal refineries, small-engine craft, shipping (both accidental and operational sources), and the offshore oil and gas industry (including pipelines). In Atlantic Canada, natural seeps are rare, occurring only off western Newfoundland, southern Labrador, and northeastern Baffin Island, and therefore not a primary source of oil pollution (NRC, 1985; Environment Canada, 2006). The remaining anthropogenic activities are all possible sources of oil contaminant release in Atlantic Canada and can therefore form the basis of the model.

Second, the potential media through which the contaminant might migrate away from the source need to be identified. The obvious medium is the marine environment, although where and how oil moves through the marine environment is unique for every oil spill (NRC, 2003). For the purposes of this study, the type of movement considered most relevant is the horizontal transport of oil via the dominant surface currents and wind, as this results in the presence and potential accumulation of oil in convergence zones (Levy & Walton, 1976; NRC, 2003). However, the marine environment is not the only available medium, as any low molecular weight hydrocarbons (LMWHs) present within spilled oil will volatilize into the air above the ocean surface creating a layer of polluted air above the surface of the ocean. This process happens very quickly, so LMWHs are a less persistent source of pollution than the slicks and tarballs that can form over time (NRC, 2003).

Third, it needs to be determined if the sources of contamination reach an exposure point; an exposure point is any location where leatherbacks are known to occur. While leatherbacks can be found throughout Atlantic Canada during their summer migration, there are areas where they appear to congregate preferentially (James, Ottensmeyer, & Myers, 2005). These high-use areas are the southern Gulf of St. Lawrence, the eastern coast of Cape Breton Island (NS), Placentia Bay (NL), and the Scotian Shelf (Figure 3a). For the purposes of this study, these four sites are considered to be exposure points.

From Levy and Walton (1976) it is known that dominant surface currents push oil pollution to convergence zones, particularly the one formed south of Nova Scotia where the Gulf Stream and Labrador Current collide. This corresponds spatially with the leatherback high-use area over the Scotian Shelf. Beyond this, it is unknown how surface currents and wind on a finer spatial scale would influence the transport of oil towards or away from the other exposure points; predicting these movements would require mathematical modeling well beyond the scope of this study. Therefore, this study focuses on the point sources of oil pollution: operational and accidental discharges from ships, fishing vessels, oil and gas exploration and production. While no single, comprehensive data set exists for Atlantic Canada documenting the volumes and locations of oil spills from these sources, the locations and density of the polluting activities is available. The Department of Fisheries and Oceans' (DFO) publications *The Scotian Shelf: An Atlas of Human Activities* (DFO, 2005) and *The Grand Banks of Newfoundland: An Atlas of Human Activities* (DFO, 2007) visually display the multitude of human uses that occur throughout Atlantic Canada, including those that are a potential source of oil pollution. Overlapping these maps with the exposure points (Figure 3a-d) it is apparent that vessel pollution and oil and gas activities in and near the southern Gulf of St. Lawrence and the eastern coast of Cape Breton Island (NS) display the greatest overlap between leatherback exposure points and point sources of marine oil pollution.

The potential bioaccumulation or bioconcentration of oil or its toxic compounds into the jellyfish that leatherbacks feed on is also a potential exposure point, but there is very little evidence in the literature for or against this. Because jellyfish are similarly pushed into convergence zones (Atlantic Leatherback Turtle Recovery Team, 2006), this may increase their likelihood of exposure to and contamination by oil. However, uptake of toxic compounds from oil into the tissues of jellyfish is not likely to occur (Shigenaka, Milton, & Lutz, 2010). Exposure to oil pollution through the food chain cannot be omitted as a possible route, but more data is needed.

Having identified the most likely exposure points (southern Gulf of St. Lawrence, the eastern coast of Cape Breton Island (NS), and the Scotian Shelf), the fourth step in the ATDSR methodology is to determine the possible exposure routes, which are the ways that leatherbacks can physically interact with oil. There are three primary exposure routes for adult leatherbacks: inhalation, ingestion, and dermal contact (Shigenaka, Milton & Lutz, 2010). Finally, the fifth step is identifying the existence of potential populations of leatherbacks that could be exposed, which exist throughout Atlantic Canada during the summer months (James, Ottensmeyer, & Myers, 2005).

In the final exposure pathways model, there are five viable pathways through which it can be assumed that there is a risk that leatherbacks and oil might co-occur. The key point sources are shipping (both operational and accidental pollution), small-engine craft, and oil and gas activities (both coastal and offshore). These sources also contribute to non-point pollution, through horizontal transport. While additional research and data for these sources would certainly refine the model, there is enough information to posit a reasonable sequence of events that could lead to the exposure of leatherbacks in Atlantic Canada to marine oil pollution though any of these pathways. Whether contamination of jellyfish prey by oil is a viable exposure route is unknown, with arguments both for and against its viability.

What is not immediately evident from the model-building process is how frequently these pathways are actively resulting in leatherbacks being exposed to oil. To determine this, it would be preferable to calculate the frequency of oil spilled by each source annually in Atlantic Canada. Unfortunately, this is not data that exists publicly. A more general measure of the likelihood of pollution was used in the final exposure pathways model - the total annual oil pollution produced by these sources (in metric tonnes), as represented by the thickness of the arrows (Figure 4, Table 3).

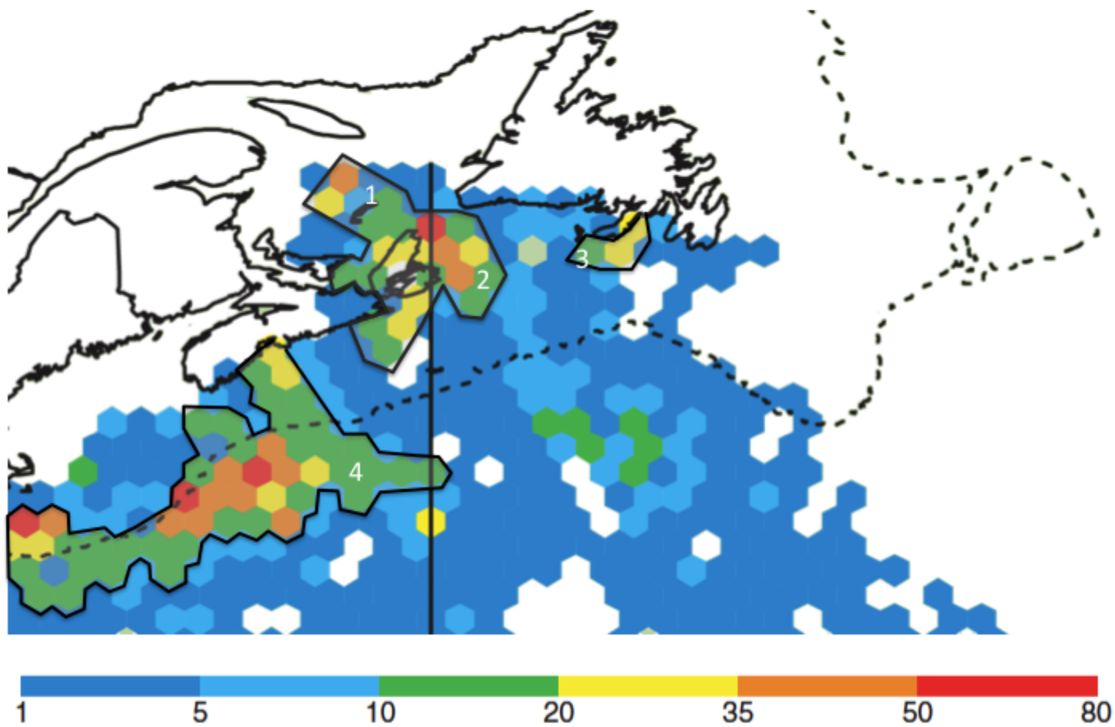

Figure 3a: Spatial use by 38 leatherback turtles equipped with satellite tags in Atlantic Canada. Colour identifies the number of days turtle(s) were observed in each hexagon, between one (dark blue) and 80 (red) total days. Black polygons represent the high-use areas for leatherbacks: (1) southern Gulf of St. Lawrence, (2) eastern coast of Cape Breton Island (NS), (3) Placentia Bay (NL), (4) the Scotian Shelf. Dashed line: 1000 m depth contour. Source of the spatial use map: James, Ottensmeyer, and Myers (2005).

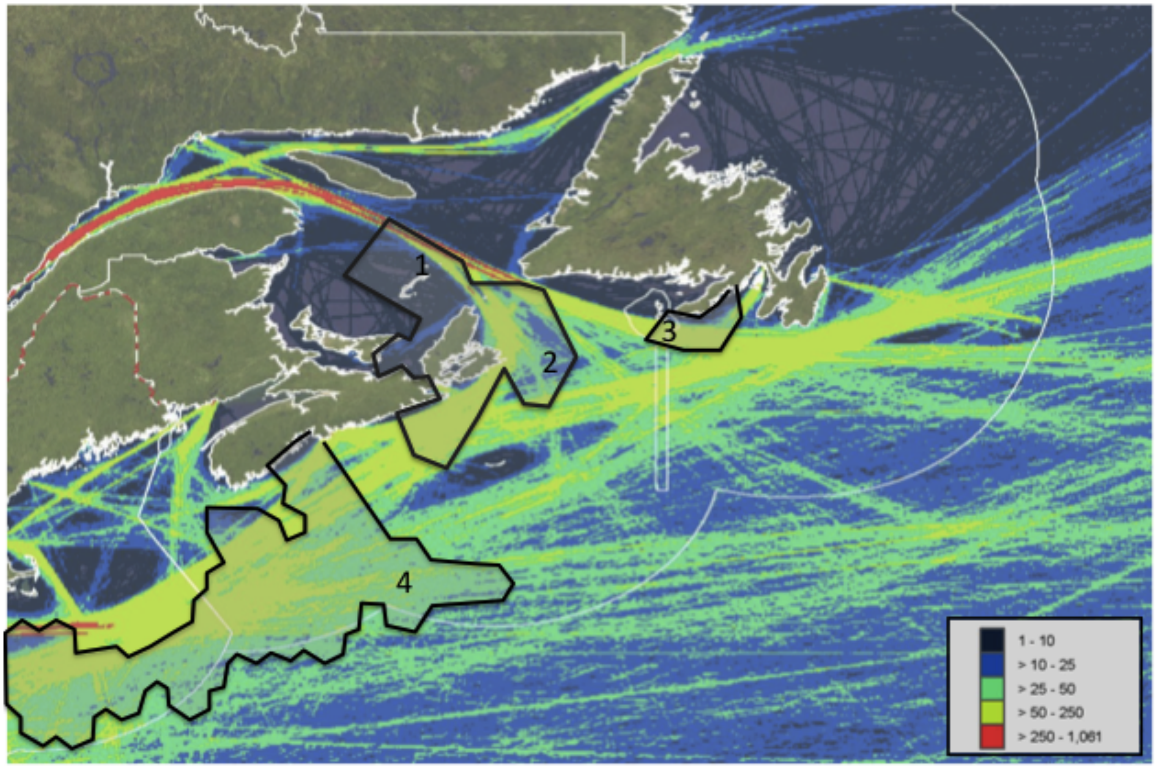

Figure 3b: Composite of vessel tracks from the Long Range Identification and Tracking (LRIT) dataset, recorded between March 2010 and February 2011. Representing the density of ships in Atlantic Canada, between one (dark blue) and 1,061 (red) ships. Black polygons represent the high-use areas for leatherbacks based on James, Ottensmeyer, and Myers (2005): (1) southern Gulf of St. Lawrence, (2) eastern coast of Cape Breton Island (NS), (3) Placentia Bay (NL), (4) the Scotian Shelf. Source of vessel track image: Koropatnick et al. (2012).

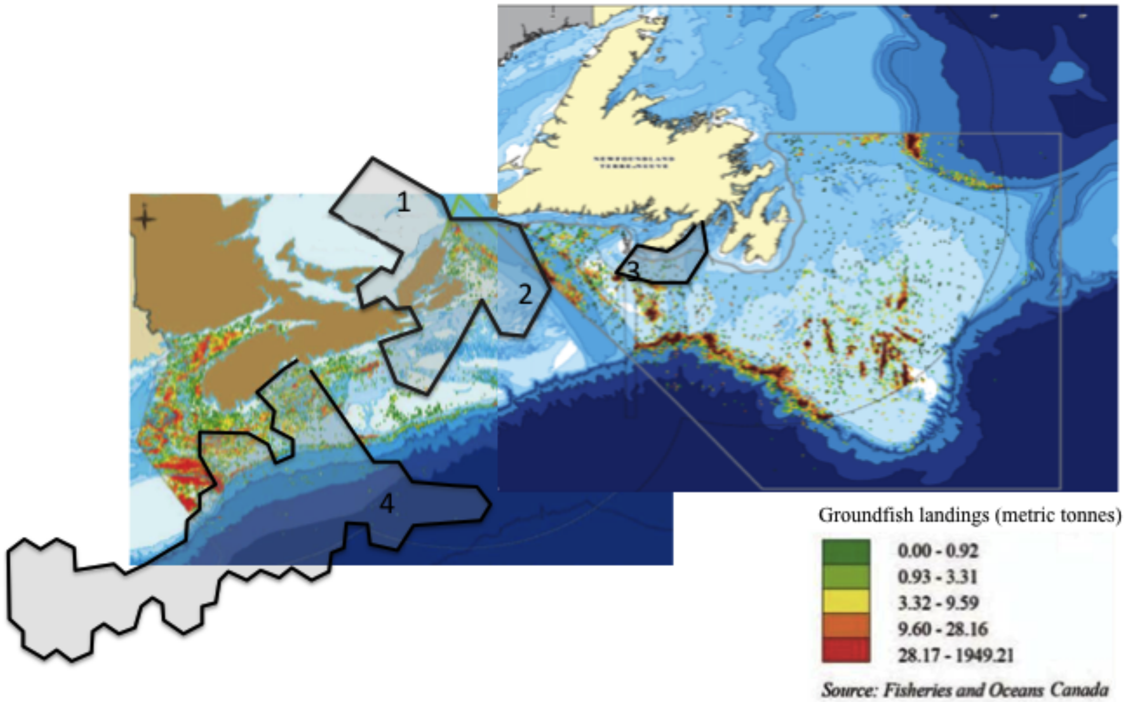

Figure 3c: Groundfish landings from 1999-2003, as a representation of fishing vessel presence in Atlantic Canada, from low (green) to high (red). Black polygons represent the high-use areas for leatherbacks based on James, Ottensmeyer, and Myers (2005): (1) southern Gulf of St. Lawrence, (2) eastern coast of Cape Breton Island (NS), (3) Placentia Bay (NL), (4) the Scotian Shelf. Source of groundfish landings map: Fisheries and Oceans Canada (2005); Fisheries and Oceans Canada (2007).

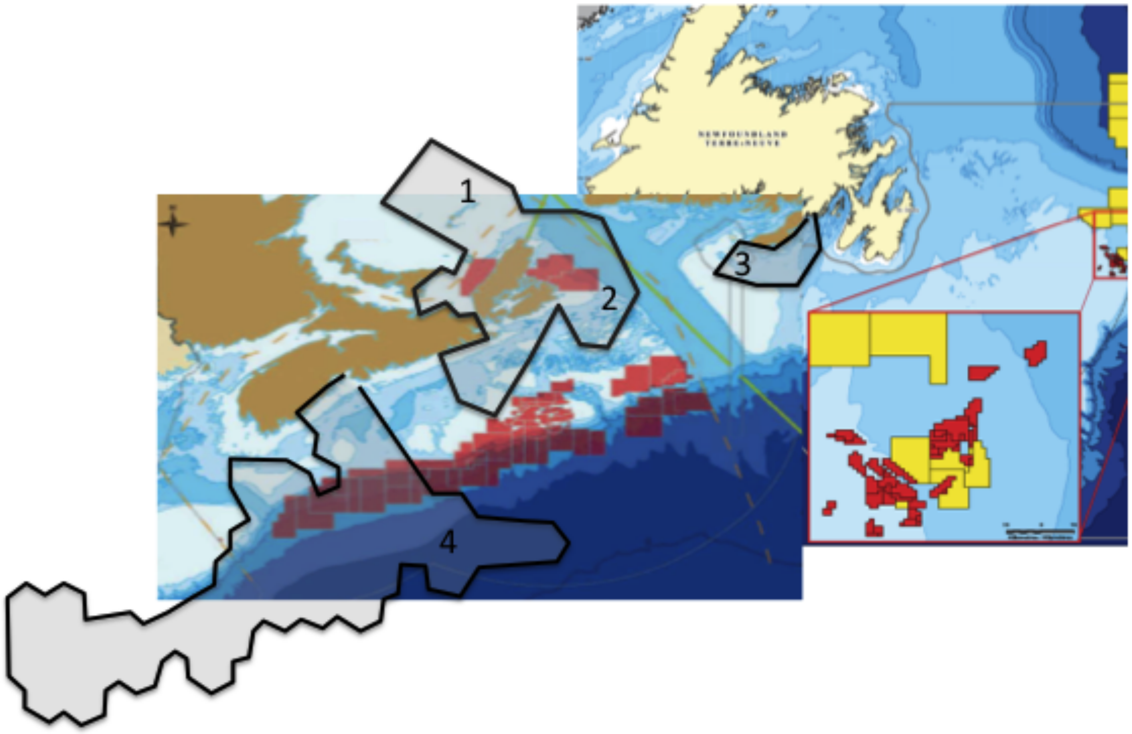

Figure 3d: Current production and significant discovery licenses for the oil and gas industry as of 2005 (for Nova Scotia) and 2007 (for Newfoundland and Labrador), representing current and potential future oil and gas production in Atlantic Canada. Black polygons represent the high-use areas for leatherbacks based on James, Ottensmeyer, and Myers (2005): (1) southern Gulf of St. Lawrence, (2) eastern coast of Cape Breton Island (NS), (3) Placentia Bay (NL), (4) the Scotian Shelf. Source of oil and gas licenses map: Fisheries and Oceans Canada (2005); Fisheries and Oceans Canada (2007).

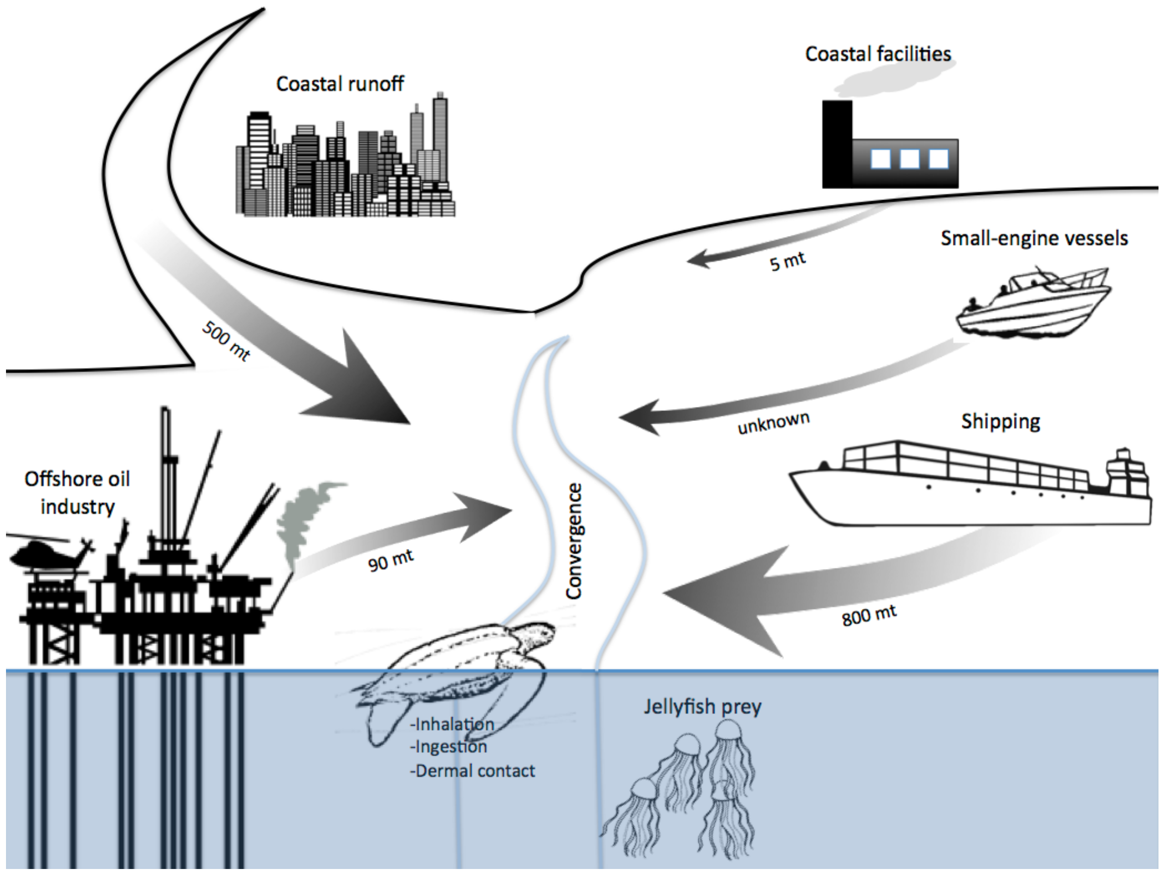

Figure 4: Diagram of exposure pathways model for leatherback sea turtles in Atlantic Canada and marine oil pollution. Thickness of arrows is representative of estimated volume of oil pollution generated by these sources in metric tonnes (mt) annually, corresponding with Table 3.

3.2.2 Analysis of Ecological Consequences

The physical and behavioural consequences that might result if a leatherback were to be exposed to oil pollution is an area of almost complete uncertainty. To date, it appears that no one has ever recorded or observed a visibly oiled leatherback sea turtle. There are two mutually exclusive explanations for this situation. First, it is possible that leatherbacks possess an ability to detect and avoid oil, but this has not been demonstrated by other sea turtle species (Odell & MacMurray, 1986). Second, leatherbacks are impacted by oil, but the challenges in detecting this effect are significant enough to have so far never resulted in a reported incidence of an oiled leatherback. Leatherback sea turtles are rare and largely pelagic animals, and even free-swimming, healthy adults are an uncommon sight (Godley et al., 2008). Additionally, most records of oiled sea turtles originate from the coastal cleanup efforts that follow catastrophic oil spill events, particularly in the Gulf of Mexico (e.g. *Ixtoc I* in 1979, *Deepwater Horizon* in 2010). Due to their affinity for pelagic habitats, leatherbacks are probably less likely to be detected during this cleanup process. This study assumes that this second explanation, the difficulty of detecting an oiled leatherback, is the primary reason that no publically accessible information exists about the interaction between leatherbacks and marine oil pollution.

However, by combining the existing knowledge about the effects of oil pollution on other sea turtle species, other marine vertebrates (particularly birds), and expert opinion, it is possible to generate a series of possible behavioural and physiological consequences for leatherbacks exposed to oil. The primary consideration is the route by which a leatherback encounters oil on the surface of the water. Excluding contamination on nesting beaches, and assuming surface contamination, there are three exposure routes for adult leatherbacks: inhalation, ingestion, and dermal contact (Shigenaka, Milton, & Lutz, 2010).

Ideally, for each of these routes the possible consequences resulting from acute (short term) exposure and chronic (long term) exposure would be described. Unfortunately, almost nothing is known about the effects of chronic oil pollution on sea turtles. For this study, the risk posed by chronic exposure to oil follows Shigenaka, Milton, and Lutz

(2010) in that “Chronic exposure may not be lethal by itself, but it may impair a turtle’s overall fitness so that it is less able to withstand other stressors.” (p. 35).

Exposure to acute oil pollution is considered through the lens of the three exposure routes. Exposure by inhalation refers to sea turtles breathing in the LMWHs that volatilize off of fresh oil spills (NRC, 2003). Both the persistence and amount of oil that evaporates is determined by the type of oil spilled, but even heavy oils will lose up to ten percent of their volume to evaporation (NRC, 2003, p.90). The risk to leatherbacks from air-borne LMWHs is exacerbated by their diving behaviour, as they rapidly inhale large volumes of air prior to diving (Shigenaka, Milton, & Lutz, 2010). The specific consequences of inhaling large volumes of LMWHs are speculative, but it has been studied. From their experimental study in which loggerhead sea turtles were exposed to surface oil pollution, Lutcavage et al. (1995) concluded that inhaled vapours were unlikely to reach levels causing critical respiratory damage. However, severe and fatal effects of inhaling petroleum vapours have been observed in marine mammals (Geraci & St. Aubin, 1988; Willams et al., 1990). Fortunately, LWMHs quickly disperse into the atmosphere, so the risk of a leatherback inhaling these toxic compounds only exists for a relatively short period following a spill, depending on the size of the spill and the type of oil (Table 2).

Exposure by ingestion of oil would most likely result when leatherbacks forage in an area where prey and oil pollution co-occur. In Atlantic Canada, the likelihood of this interaction would appear to be high, since leatherbacks preferentially forage in convergence zones (Heaslip et al., 2012) where surface currents trap both jellyfish prey and oil pollution (Levy & Walton, 1976; Atlantic Leatherback Turtle Recovery Team, 2006). Once oil is ingested the physiological consequences for leatherbacks may be quite severe, depending on the quantity ingested. Organ dysfunction, gut impaction and internal hemorrhaging are among the most severe effects observed in heavily oiled sea turtles (Shigenaka, Milton, & Lutz, 2010). Although the loggerhead turtles experimentally exposed to oil by Lutcavage et al. (1995) were not fed during the procedure, the observed decrease in the sea turtle's red blood cell count parallels changes observed in sea birds that have ingested oil (Leighton, 1986). Several studies, including the Atlantic Leatherback Turtle Recovery Team (2006) highlight the ingestion of tarballs as being of particular concern. Tarballs are a very persistent form of oil pollution (NRC, 2003) and are frequently consumed by sea turtles (Witham et al., 1986).

The final route of exposure is dermal contact. In their experimental study on loggerheads exposed to oil, Lutcavage et al. (1995) observed a significant decrease in white blood cell count, which was attributed to the physical effects of oil exposure on the loggerheads' epidermis. The soft skin of the flippers, neck and eyes rapidly became inflamed and began to necrotize, eventually sloughing off in layers. Although the animals were only exposed to oil for three days, the effects of dermal contact persisted up to 21 days after exposure had ceased and residual oil cleaned off. Similar effects were observed in the mucous membranes of the eyes, nose and mouth (Lutcavage, et al., 1995). The persistence of these open wounds raised the possibility of increased susceptibility to infection or disease (thus accounting for the increase in white blood cells) or cancerous transformation of the healed tissue (observed in some mammalian species) (Lutcavage, et al., 1995). The risks of dermal contact are potentially even greater in leatherbacks as, unlike the other sea turtle species which have a keratinized (hard) shell, leatherbacks' shell is covered in a soft, dermal layer (Pritchard, 1997). Therefore, the potential area of dermal irritation for leatherbacks includes the carapace, along with the head, neck, and flippers. Lutcavage et al. (1995) also incidentally observed that direct contact with oil caused the salt glands of the exposed loggerheads to stop functioning until after exposure ceased. Salt glands (also called lachrymal glands) are responsible for excreting the excess salt taken up by marine reptiles and are fundamental to water and salt homeostasis. These observations parallel the response of the nasal salt glands of marine birds that are orally exposed to oil (Shigenaka, Milton & Lutz, 2010).

3.2.3 Risk Characterization

Risk characterization is the final phase of a risk assessment. It is the integration of the exposure and ecological consequence analyses and a summary of the significance of the risk (EPA, 2003). The exposure pathways model demonstrated that the sources of oil pollution in Atlantic Canada do threaten marine wildlife. This is supported by the observed presence of oiled sea birds in the region (Wiese & Ryan, 2003). This effect may be exacerbated by the convergence of leatherbacks, their jellyfish prey, and oil in the marine environment due to wind and currents. The proposed behavioural and physiological consequences of oil exposure in leatherbacks found that ingestion of and dermal contact with oil were the most harmful. Acute exposure to large volumes of oil could lead to serious health problems and even death. It is harder to predict the effect of chronic exposure to small quantities of oil.

Unfortunately, the both the means of exposure to and consequences of exposure to oil remain qualitative and hypothetical, because they are necessarily based on observations and studies of sea turtle species other than leatherbacks. Despite this limitation, the risk to leatherbacks in Atlantic Canada from oil pollution can still be characterized as not only existing, but under the right conditions, posing a serious or irreversible risk to the migratory population. This characterization is supported by the literature. The authors of the only study that experimentally exposed sea turtles to oil determined that "sea turtles are among the endangered or threatened marine species that may be most at risk in the event of an oil spill." (Lutcavage et al., 1995, p.421). Similarly, Shigenaka, Milton, and Lutz concluded "the result of such a low-probability [oil pollution] event occurring at just the wrong time of year and at the wrong location could be catastrophic and unacceptable for a given population" (2010, p.7-8). The worst-case scenario in Atlantic Canada would be a crude or unrefined oil spill of several thousand metric tonnes occurring during the summer months and in a coastal region frequented by leatherbacks, primarily the Scotian Shelf, Cabot Strait or Placentia Bay (NL). Therefore, based on the findings of this assessment, under SARA "cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty." (section 38).

Table 4: Summary of possible behavioural and physiological consequences to leatherback sea turtles from exposure to marine oil pollution.

Route	Possible Effects	Significance
INHALATION	• Irritation of the airways and lungs • Aerobic scope decreased, altered dive capacity* • Altered diving behaviour** EFFECTS IN OTHER SPECIES • Sea otters - emphysema and petroleum hydrocarbon toxicity (Williams et al., 1990). • Cetaceans - serious health hazards (Geraci & St. Aubin, 1982).	No fatal or long-term effects of inhalation of petroleum vapours by sea turtles have been recorded.
INGESTION	• Organ dysfunction, reduced metabolic function** • Irritation of digestive system, accumulation of hydrocarbons in tissues, gut impaction* • Significant changes to blood chemistry, including an increase in white blood cells and decrease of red blood cells** • Accumulation of hydrocarbons in organs and tissues* EFFECTS IN OTHER SPECIES • Marine birds - intestinal bleeding, anemia, gut impaction, enteritis, organ damage and dysfunction*	Fatal effects are possible. Incidences of mildly and heavily oiled sea turtles with oil in their mouths and digestive tracts have been recorded, sometimes dead or moribund.*
DERMAL CONTACT	• Persistent inflammation and necrotizing of epidermis of the neck, head, flippers, and possibly carapace** • Increased vulnerability to infection through open wounds** • Increase in white blood cells** • Salt gland dysfunction** EFFECTS IN OTHER SPECIES • Marine birds - salt gland dysfunction*	Long-term effects, with possible secondary effects (e.g. infection) are possible, as post-exposure recovery appears to be lengthy in loggerhead study.** While not directly fatal, secondary effects could affect survivorship.

* Shigenaka, Milton & Lutz (2010) "Oil and Sea Turtles: Biology, Planning, and Response". A comprehensive review of the effects of oil pollution to sea turtles.
** Lutcavage, Lutz, Bossart, & Hudson (1995) "Physiologic and clinicopathologic effects of crude oil on loggerhead sea turtles". The only experimental study of the effect of oil on sea turtles, representing the best source of quantitative data available.

Chapter 4: Managing the Risk

Risk management takes the results and conclusions from the ecological risk assessment process and uses them to develop mitigation and response procedures for managing risk. This process of incorporating the assessment results into management solutions falls to risk managers and associated policy makers, who are responsible for deciding what risk mitigation strategies are affordable or reasonable, and how much risk is acceptable (Burgman, 2005). In Canada, the threat of oil pollution to the Atlantic population of leatherbacks has been recognized in the species' recovery strategy (Atlantic Leatherback Turtle Recovery Team, 2006). It is then up to other federal departments to subsequently assess and manage the risk, as per section 38 of SARA (2002). Federal departments like the Canadian Environmental Assessment Agency and Transport Canada have developed their own mechanisms of assessing and managing risk. The following reviews and evaluates what those mechanisms are and how well they perform in the protection of leatherbacks from marine oil pollution.

4.1 Methodology

The oil pollution sources most relevant in Atlantic Canada include those from coastal industry, the oil and gas industry, shipping, and small-engine vessels. Not all of the sources are subject to the same amount or type of legal regulation and enforcement. Some sources are predominantly regulated through proactive measures, such as conducting environmental risk assessments, and some are retroactively regulated though the enforcing of specific pollution restrictions set into law. These two processes require different analyses, and so this chapter is divided into two sections.

The first addresses sources of oil pollution regulated by environmental risk assessments, which are overseen by the Canadian Environmental Assessment Agency and mandated under the *Canadian Environmental Assessment Act.* (both the now-repealed 1992 act and the forthcoming 2012 act)[1]. To analyze the efficacy of CEAA environmental assessments in the protection of leatherbacks from marine oil pollution, relevant EAs were sourced from the CEAA Environmental Assessment Registry website. The registry is a pubic record of all the environmental assessments that have been required under CEAA (1992). Projects involving the oil and gas industry undergo an EA process that results in a comprehensive study report (CSR). From the CEAA Registry Archive Advanced Search webpage (http://www.ceaa.gc.ca/052/plus-eng.cfm), all the completed CSRs for the Maritime Provinces, and Newfoundland and Labrador were accessed. From those, any project that included the exploration, production, transportation or storage of large volumes of petroleum products was kept in the dataset. This resulted in a total of seven CSRs. Because one CSR included both a coastal construction phase and an offshore oil production phase, it was treated as two individual CSRs for a total of eight assessments (Table 5).

Analysis of the CSRs was conducted using a simple content review process whereby a series of questions targeting the effects of oil pollution on leatherbacks were considered for each of the assessments (Table 6). Most of the questions were derived from the legal requirements of EAs, as specified by CEAA (1992). The objective was to determine if the

[1]As of July 6, 2012 the *Canadian Environmental Assessment Act, 1992* was repealed under Bill C-38. This bill also put into place a new *Canadian Environmental Assessment Act, 2012* but as of the time of writing, the official text has not been made available (in either the Canada Gazette or on the Department of Justice website). The assessments reviewed in this study were all completed under the old CEAA, 1992 and so are critiqued in relation to that piece of legislation. What the new CEAA, 2012 might mean for marine oil pollution and leatherbacks is addressed in the final chapter of this report.

CSRs met the legal requirements for assessing the risk to leatherbacks from oil pollution. Two final questions were added to determine if important sources of expert opinion were being utilized in the development of the CSRs. The second section of this chapter addresses the regulations that prevent oil pollution through laws that restrict discharge of pollutants. Primarily these laws are directed at ships and small-engine vessels. The section also analyzes the spill mitigation and response procedures in place for oil spills in Canada.

Table 5: Summary information for the comprehensive study reports (CSRs) analyzed in this study. All the CSRs used were available on the Canadian Environmental Assessment Agency Registry archive (http://www.ceaa.gc.ca/052/index-eng.cfm). The Hebron CSR, having both a coastal and offshore section, was separated and the two sections analyzed separately.

Name	Location	CEAA Registry Reference #	Date Started/Date Completed	Coastal/ Offshore	Prepared by	Description of Project
Hebron 1	Bull Arm, NL	09-03-46144	03-2009/01-2011	coastal	Stantec Consulting Ltd.	ExxonMobil's Hebron project has two stages, the first is the construction of an offshore oil rig, which will take place in Bull Arm, Nl. The second part, production of oil, will occur after the rig is towed out and installed in the Jeanne d'Arc Bassin on the Grand Banks.
Hebron 2	Jeanne d'Arc Bassin	09-03-46144	03-2009/01-2011	offshore	Stantec Consulting Ltd.	
Eider Rock	Saint John, NB	07-03-28779	05-2007/09-2009	coastal	Jaques Whitford Stantec, Ltd.	The construction, operation and decommissioning of a marine terminal, including oil handling and transfer facilities for the receiving and loading/unloading of petroleum products.
Grassy Point	Placentia Bay, NL	07-03-26546	02-2007/04-2008	coastal	Jaques Whitford Ltd.	The construction, operation and eventual decommission of a liquefied natural gas (LNG) transshipment and storage marine terminal.

Name	Location	CEAA Registry Reference #	Date Started/Date Completed	Coastal/ Offshore	Prepared by	Description of Project
Southern Head	Placentia Bay, NL	07-03-24726	01-2007/12-2007	coastal	SNC-Lavalin Inc.	The construction, operation and eventual decommission of a new oil refinery and marine terminal.
Deep Panuke	Scotian Shelf	06-03-21748	08-2006/06-2007	offshore	various federal departments	An offshore gas production project, approximately 250 km southeast of Halifax in the Deep Panuke field.
Keltic	Goldboro, NS	05-03-10471	04-2005/10-2007	coastal	AMEC Earth & Environmental Ltd.	The construction, operation and eventual decommission of a liquefied natural gas (LNG) shipment and storage marine terminal.
EL2407	Scotian Shelf	04-03-2712	05-2004/02-2005	offshore	CNSOPB	An exploration drilling program carried out by BEPCo. Canada to confirm the presence of hydrocarbons on the Scotian Shelf.

Table 6: Summary of the comprehensive study report (CSR) analysis. Questions refer to legal requirements set out in CEAA (1992); **✓**= the question was addressed, **x** = the question was not addressed, **n/a** = the question was not addressed because there was no obligation to, **n/d** = no data becuase the necessary information was not available.

		Oil and Gas Development Projects in Atlantic Canada (2005-2011)							
	Environmental Assessment Analysis	**EL2407 (2005)**	**Southern Head (2007)**	**Keltic (2007)**	**Deep Panuke (2007)**	**Grassy Point (2008)**	**Eider Rock (2009)**	**Hebron 1 (2011)**	**Hebron 2 (2011)**
1	Are the possible effects to leatherbacks from exposure to oil described, and is the significance of those effects considered (section 16.1.a)?	✓	✓	x	✓	✓	x	✓	✓
2	Are the possible cumulative effects to leatherbacks from exposure to oil from the project in combination with other projects/activities (pursuant section 16.1.a)?	n/a	x	x	x	✓	x	✓	✓
3	Does the EA find the interaction between oil and leatherbacks to be a significant risk according to their definition (section 16.1.b)?	n/a	x	n/a	x	✓	n/a	x	x
4	If the EA found the risk to leatherbacks to be significant, were management or mitigation measures recommended (section 23.1.b)?	✓	n/a	n/a	n/a	x	n/a	n/a	n/a
5	If the EA found the risk to leatherbacks to be significant, was the precautionary principle in any form applied to the risk of leatherbacks' exposure to oil pollution (section 4.1)	n/a	n/a	n/a	n/a	x	n/a	n/a	n/a
6	In the final decision statement by the competent minister was the project approved (section 37)?	✓	✓	✓	✓	✓	✓	✓	✓
7	Was the Canadian Sea Turtle Network consulted?	✓	n/d	n/d	✓	x	n/d	x	x
8	Was the literature on the interaction between oil and sea turtles referenced (i.e. does Shigenaka, Milton & Lutz (2003 or 2010) or Lutcavage et al. (1995) appear in text or bibliography)?	x	x	x	x	✓	x	x	x

4.2 Preventing Marine Oil Pollution in Canada

4.2.1 Coastal and Offshore Petroleum Industries

Since the 2010 *Deepwater Horizon* offshore oil spill in the Gulf of Mexico, considerable attention has been paid to the question of whether the risk of these events is justified by the economic gain from activities related to the petroleum industry in the marine environment. A lot of faith is placed in the role of regulation, both within the industry and from government, in preventing a similar blowout event from occurring in Canadian waters (Crawford, 2010). While EAs are not the only form of regulation imposed on these industries, they are the proverbial 'first line of defense'. That is, if the project were considered to be too risky, then under CEAA (1992) the project would not receive ministerial approval. However, federal authorities are often criticized for failing to apply such precautionary measures in practice (Vanderzwaag, Fuller, & Myers, 2002). For this reason the content of CSRs, not the subsequent ministerial decision, was analyzed.

All of the CSRs analyzed applied variations of the same risk assessment methodology: valued ecosystem component (VEC) analysis. The VEC method of assessing risk is essentially a multi-factorial version of simple risk ranking, which is described by Burgman as an "assessment that relies on qualitative, usually subjective estimates of likelihood and consequences to rank hazards" (Burgman, 2005, p.450). Using the VEC method, the important or significant elements of the surrounding marine environment are identified and for each, it is determined what the possible effects of the project are, and if those effects are significant. Although all the CSRs identified leatherbacks as a VEC potentially affected by the project, in six of eight CSRs leatherbacks were not considered as a separate VEC, but were combined with other species at risk, most commonly cetaceans. Therefore, most assessments considered the "potential impacts from the project on marine turtle [sic] to be similar to those for marine mammals" (CNSOPB, 2005, p.33). The comparison is incorrect and invalid because cetaceans, being mammals, are simply not an appropriate toxicological species analog for leatherbacks or sea turtles in general (Selcer, 2006).

Under Sections 16.1.a and 16.1.b of CEAA (1992), CSRs are required to consider the environmental effects of the project, both on its own and in conjunction with any other activities in the area, as well as the significance of those effects to the VECs identified. Only six of eight CSRs considered the risk of oil pollution from their project affecting leatherbacks and only three of eight considered the cumulative effects of oil pollution on leatherbacks (Table 6). The two projects that failed to consider the interaction between leatherbacks and oil entirely are of most concern. The CSRs for the Keltic LNG facility and the Eider Rock petrochemical refinery both concede that there is a risk of a large oil spill occurring as a result of the projects, and that leatherbacks are a VEC in the area (Figure 5), however, they do not further qualify the interaction between the two or the consequences to the recovery of Atlantic leatherbacks. This is quite simply a violation of Section 16.1.a of CEAA (1992).

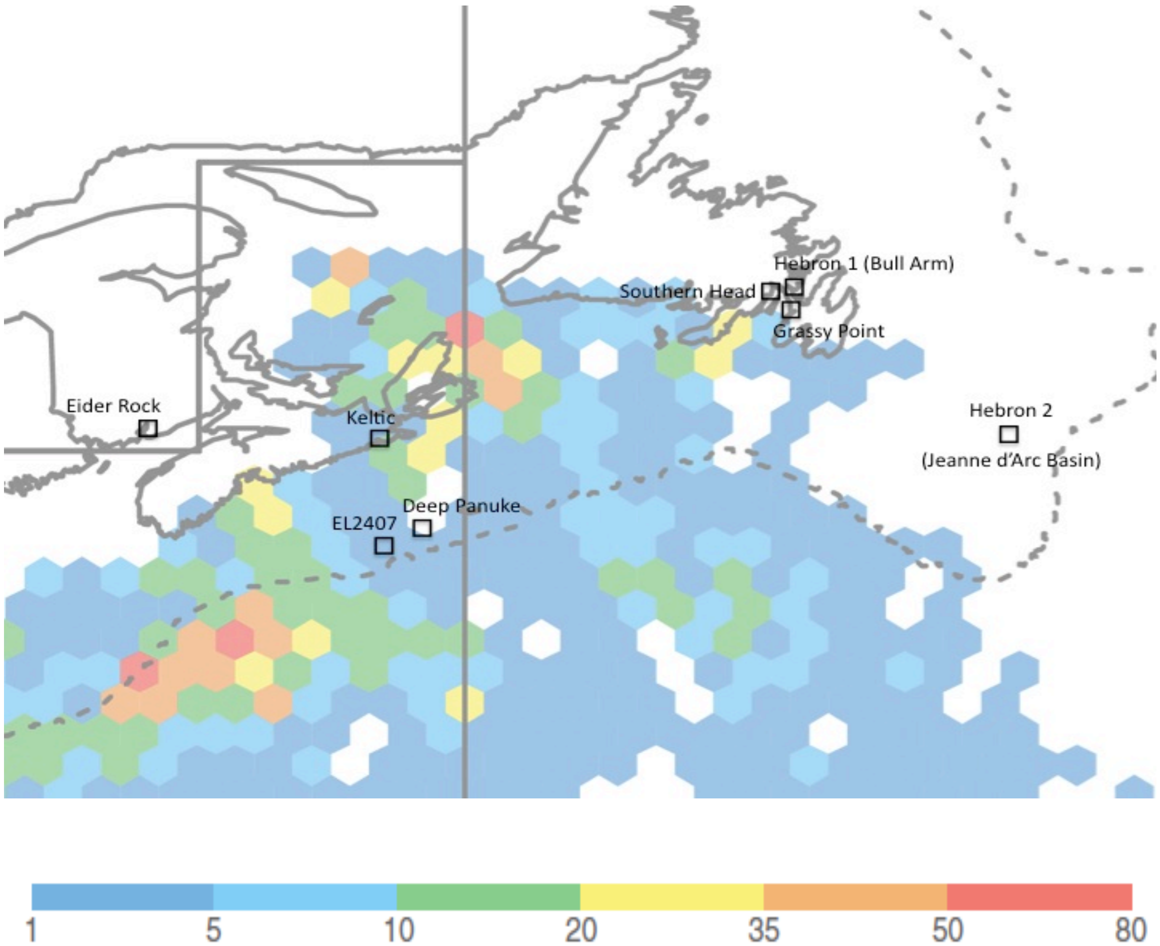

Figure 5: Approximate locations of the eight CSRs analyzed (black squares) and the spatial use of 38 leatherback sea turtles equipped with satellite tags. Colour identifies the number of days turtle(s) were observed in each hexagon, between one (dark blue) and 80 (red) total days. Dashed line: 1000 m depth contour. Source of the spatial use map: James, Ottensmeyer, and Myers (2005).

Section 16.1.b then requires that it be determined if the effects identified in 16.1.a are severe enough to cause a “significant effect”. While no single definition of significant effect was used, all the CSRs generally determined that in regard to species at risk, it could be defined as any adverse environmental effects to an individual sea turtle. This definition derives from the focus on harm to an individual animal found within the *Species at Risk Act* (2002). It is a reasonable definition, since a major oil spill event could seriously threaten the recovery of the species if even a small number of individuals were permanently or fatally affected. However, the CSRs were generally not clear on whether an event that causes significant harm needs to also be 'likely' to occur. Some CSRs did explicitly make the distinction that if the event were unlikely, then its effects were insignificant, while others were vague on the subject of likelihood. The *Deepwater Horizon* blowout of 2010 in the Gulf of Mexico was itself a highly improbable event (GESAMP, 2007), yet it had significant environmental impacts, particularly for species at risk (Campagna et al., 2011). It would seem reasonable then, that the significance of an event be defined separately from the likelihood of the event. However, CEAA (1992) fails to define 'significant effects' entirely, despite it being a central tenant of the act and the process of ecological risk assessment.

Of the six CSRs that considered the effects of oil on leatherbacks at all, only one determined those effects to be significant. The CSR for the Grassy Point LNG transshipment and storage facility, in Placentia Bay (NL), was also the only CSR to reference the work of Shigenaka, Milton and Lutz (either the 2003 or 2010 publication) or Lutcavage et al. (1995). These two literature sources are the foremost studies on the interaction between oil and sea turtles. The Grassy Point CSR reiterates the finding of both publications and concludes "Given their current population status (i.e. endangered) and the potential of a large spill to cause injury to one or more individuals, this worst case scenario has been assessed as significant." (Jaques Whitford Ltd., 2008, p.xi)

The rest of the CSRs overlook these critical publications and made assumptions about the interaction between leatherbacks and oil that are neither supported by the literature, nor precautionary. For example, the Deep Panuke CSR concluded that the effects of oil exposure to sea turtles were not significant because “sea turtles have the ability to avoid areas of a spill” (CNSOPB et al., 2007, p.179). Not only is there no evidence of this from observations during spill events, there is research evidence supporting the opposite (Lutcavage et al., 1995). In another example, the effects of oil to leatherbacks were “considered reversible” (SNC-Lavalin, 2007, p.175). Again, this conclusion is neither supported by the literature or direct observations of sea turtles exposed to accidentally spilled oil (Lutcavage et al., 1995; National Oceanic and Atmospheric Administration, n.d.). Both of these examples use data deficiency and insufficient literature review as an excuse to make unsupported assumptions that are favourable to the projects’ development. This is contrary to the precautionary principle; if these CSRs had been conducted in a precautionary manner (as is required under Section 4.1 of CEAA, 1992), they would have concluded that oil might have a significant, if unknown, negative effect on leatherbacks and proceeded to recommend a change to the projects’ status or the development of risk management measures.

Risk mitigation refers to the strategies put in place by managers to manage a perceived risk, and when risky projects are allowed to proceed then effective mitigation is becomes a necessary element of risk management. All major development projects carry some environmental risk and in the tradeoff with social and economic interests, many risky projects get approved. CEAA (1992) accommodates that reality by enforcing the development of mitigation measures for any significant risk (section 16.1.d) and gives the responsible minister the opportunity to require additional mitigation measures not outlined in the CSR (section 23.1.b). Since only one of the eight CSRs reviewed identified the risk of oil to leatherbacks to be significant, it was the only one legally required to identify mitigation measures to manage that risk. However, it did not do so. This is because the responsible federal authorities combined the leatherback VEC with Atlantic cod (*Gadus morhua*), a co-occurring species at risk, which the CSR considered renewable and not likely to be significantly affected by an oil spill. Therefore "the capacity of species at risk as a renewable resource to meet the needs of the present and the future, is considered not likely to be significant" (Jaques Whitford, 2008, p.416). This unorthodox method of circumventing the responsibility of responding to an identified significant risk is possible because within both SARA (2002) and CEAA (1992), there is a lot of room for ministerial discretion in the interpretation of EAs (Vanderzwaag & Hutchings, 2005).

The final decision statements issued by the minister for each of the projects following the CSR process were also reviewed. A decision statement can be one of three things: 1) the project and the risk management measures suggested by the EA are sufficient, the project is not likely to cause significant environmental harm, and it can therefore go ahead; 2) that more extensive risk management measures are required, but the project can go ahead; and 3) the project is too risky and cannot go ahead. In every CSR analyzed, the first option was chosen by the responsible minister, and no additional mitigation measures, either in general or specific to leatherbacks, were required by the minister. The responsible minister for all eight projects was the Minister of the Environment, and in every instance the project was deemed unlikely to cause significant environmental effects and was given development approval. The purpose of the CSR process is to give the responsible minister the most accurate, impartial, and comprehensive information available to make the most informed decision possible. However, as previously discussed, most of the CSRs analyzed in this study failed to include the best available research, made egregiously incorrect assumptions, and failed to find the risk of oil exposure to leatherbacks as significant. While there are many possible reasons for this, ultimately it is a failure of the consulting companies and government departments that these CSRs were outsourced to (Table 5), which has resulted in biased EAs.

The biggest oversight found in this analysis was the failure to adequately utilize expert opinion by referencing the existing primary and secondary literature on the effects of oil on sea turtles. As previously discussed, VEC analysis is a qualitative risk-ranking method. When using risk ranking a diversity of expert opinion is supposed to be utilized so that consensus can be reached over the rankings of risks, the consequences, and the likelihoods of events, to reduce bias and linguistic uncertainty (Burgman, 2005). If a wealth of expert opinion is not used, or only type of expert is used, the resulting assessment is subject to a wide variety of potential biases and errors. If decision-makers use a biased risk assessment, there could be serious consequences. In the case of the CSRs analyzed, the exclusion of key literature sources and local experts (particularly the Canadian Sea Turtle Network) obviously violates the core requirement of risk ranking, and by extension the VEC analysis methodology.

4.2.2 Shipping and Small-Engine Vessels

Accidental Oil Spills

Oil and associated petroleum products have long been identified as environmental pollutants (GESAMP, 1993; GESAMP, 2007) and their release into the marine environment is highly regulated. Possibly no marine industry has worked harder to reduce its contribution to marine oil pollution than the international shipping industry. The most important international regulation developed and adopted by the International Maritime Organization (IMO) of the United Nations, is the International Convention for the Prevention of Pollution From Ships (MARPOL 73/78). The MARPOL Convention was initially signed in 1973, but an additional Protocol, drafted in response to a series of tanker accidents in 1976-1977, was added in 1978 (IMO, 2011). It was in this form that it entered into force in 1983, and is now referred to as MARPOL Annex I/II. As of March 2012, there were 151 signatories to MARPOL 73/78 (Annex I/II), representing 98.9% of the world's shipping tonnage (IMO, 2011). It was Annex I (Regulations for the Prevention of Pollution by Oil) that required oil tankers to be double-hulled. Annex II (Regulations for the Control of Noxious Liquid Substances in Bulk) made significant contributions in regulating the discharge of over 250 types of liquid substances, and the prohibition of the dumping of residual noxious substances (e.g. oil-contaminated bilge water) within 12 nautical miles (nm) of the shoreline (IMO, 2011). Since these two Annexes entered into force, there has been a steady reduction in accidental spills of oil and other ship-based contaminants (IMO, 2012). As a member of the IMO and a signatory to the MARPOL convention, Canada is duly obligated to incorporate the regulations set out by MARPOL 73/78 into its federal law.

There are two primary pieces of legislation that deal with MARPOL and illegal dumping of pollutants into the marine environment. The first is Part 8 of the *Canada Shipping Act* (2001). The section regulates oil-handling procedures and requirements, spill prevention plans, spill response procedures, enforcement and prosecution. The second is section 36 of the *Fisheries Act* (1985). This section does suggest the precautionary principle, despite predating the principle's development at the Rio Declaration during the UN Conference on Environment and Development in 1992. There are strong, general prohibitions on the depositing of "deleterious substances" into the marine environment (*Fisheries Act*, 1985, section 36.3). However, the act also contains regulations that exempt some industries from this precautionary, zero-tolerance approach, including petroleum refineries (*Petroleum Refinery Liquid Effluent Regulations,* n.d.). Like the CEAA (1992), both the

CSA (2001) and the *Fisheries Act* (1985) include a lot of legal exemption allowances and ministerial discretion (Vanderzwaag, Fuller & Myers, 2002; Vanderzwaag & Hutchings, 2005).

In addition to introducing measures, such as double-hull construction for tankers, to reduce the likelihood of oil being spilled in an accident (Yip, Talley, & Jin, 2011), the IMO has also introduced measures to reduce the likelihood of accidents occurring. The ubiquity of geographical positioning technology has made it possible for the IMO to implement mandatory vessel tracking programs: the Automatic Identification System (AIS) and more recently, the Long Range Identification and Tracking (LRIT) system (Eide et al., 2007), which reduce the likelihood of vessel collisions. These IMO measures are relevant to the protection of leatherback sea turtles from oil pollution because large accidental oil spills from ships, especially oil tankers, can be catastrophic for the marine environment and species at risk. For example, the *Exxon Valdez* tanker spill in 1989 spilled over 37,000 mt into Alaska's Prince William Sound (Wells, et al. 1995) and was responsible for the deaths of more than 1,000 endangered sea otters (*Enhydra lutris*), with long-lasting ecological effects (Monson et al., 2000).

In the event of a major ship-sourced oil spill event in Canada response is guided by the National Oil Spill Preparedness and Response Regime, and the Canadian Coast Guard (CCG) is the lead federal response agency. However, under the *Canadian Shipping Act* (CSA, 2001), private oil spill response companies are tasked with being the primary responders to spills up to 10,000 mt in size. Both shipping companies and oil-handling facilities are legally required to have a response plan in place that engages a privately contracted response company (CSA, 2001, sections 167 and 168). Monitoring these arrangements is the responsibility of Transport Canada, while the activities of these companies during an oil spill is monitored and supported by the CCG (Fisheries and Oceans Canada, 2009). However, in the event that the polluter is unknown, does not have a private company in place to manage the response, or the spill is more than 10,000 mt in size, then the CCG takes the lead in responding to the spill.

To effectively carry out their mandate for oil spill response, which includes minimizing impacts to the environment, the CCG Emergency Response Division has both a national response plan and separate regional response plans (Fisheries and Oceans Canada, 2009). At the national level the *Marine Spills Contingency Plan* does not address specific ecosystem components or wildlife recovery procedures. This level of planning falls to the regional environmental emergencies teams (REETs). A REET is an “advisory body consisting of scientific and technical specialists from federal, provincial, and local governments assisted by representatives from industry and the public” (CCG, 2011, p.vii). Among other responsibilities, they are tasked with identifying environmentally sensitive areas, which may include at-risk marine species. Environment Canada’s *National Policy on Oiled Birds and Oiled Species at Risk* (Canada Wildlife Service, 2000) states that the Canadian Wildlife Service (CWS) will act as a REET specialist and will provide information and advice regarding migratory birds and species at risk to the emergency responders. Unfortunately, there is no species-specific information contained in the *National Policy on Oiled Birds and Oiled Species at Risk* and the CCG regional response plans are not publicly available, so it is unknown if the federal response to marine oil spills contains any information on the risk, recovery or rehabilitation of oiled leatherbacks or sea turtles. Additionally, spill response procedures for the private companies are proprietary and the publicly available information on their wildlife recovery and rehabilitation measures was also limited. For example, the Eastern Canada Response Corporation (http://www.ecrc.ca), a private spill response company serving Atlantic Canada, states only that:

> *There are also other operational activities involved in a marine oil spill response. However, they are not automatically a part of ECRC's contracted work… ECRC recognizes that the Responsible Party may request them to undertake these duties and has, therefore, identified and sourced the appropriate resources that could be activated. These concerns include: wildlife recovery and rehabilitation, recovered material transportation and disposal and final site restoration.* (ECRC, n.d.)

<u>Operational & Illegal Oil Discharges</u>

Accidental oil spills are not the only source of marine oil pollution resulting from the shipping industry; both legal (operational) discharges and illegal dumping from ships also contribute. MARPOL sets the international regulations on how much, where, and at what concentration oil pollution can legally be discharged. These operational discharge regulations have been incorporated into Canadian law under CSA (2001) in the *Vessel Pollution and Dangerous Chemicals Regulations*. Globally, compliance with MARPOL's operational discharge regulations is between 72% and 100% (GESAMP, 2007). While the environmental consequences of this legal chronic oil pollution is of concern, in Atlantic Canada the problem is exacerbated by illegal dumping of waste oil in the form of tank washings, oily ballast water, fuel oil sludge, and oily bilge water from fishing and merchant vessels (Wells, 2001). In a survey of dead marine birds recovered in Newfoundland between 1984 and 1999, up to 74% had oil in their feathers, despite there being no large oil spills reported in the area (Wiese & Ryan, 2003; GESAMP, 2007). To manage the risk of these illegal oil spills, most of what can be done is unfortunately retroactive. A combination of detection, enforcement, prosecution, and oil spill cleanup efforts are used in Atlantic Canada to limit the environmental impact of this illegally dumped oil.

Detection of illegal oil pollution is the primary difficulty faced in managing an environmental response. In Atlantic Canada, this problem is solved by the National Aerial Surveillance Program (NASP), which conducts regular flyovers of the marine environment gathering information about the location, size and sources of oil spills (Figures 6a-b). Transport Canada also works closely with Environment Canada's Integrated Satellite Tracking of Pollution (I-STOP) program, which uses satellite imagery to track oil spills in near-real time (Transport Canada, 2012a). In 2010-2011, NASP crews observed 84 pollution events nationally, for a total estimated volume of 30,987 litres (Transport Canada, 2012b). Information about the spills observed is then combined with the data from vessel tracking systems to determine the responsible party. Between 2000 and 2011 aerial surveillance data was used to successfully prosecute over a dozen cases, resulting in fines totaling over $1 million (Table 7). The NASP observations recorded between 2007-2012, demonstrate that most spills are small (50 litres or less) and occur along the coastline. Spills larger than 50 litres occur throughout the marine environment. The high density of shipping activity in Cabot Strait is probably responsible for the higher number of observed spills in the area. This is the region of greatest concern for leatherbacks, since both the southern Gulf of St. Lawrence and the eastern coast of Cape Breton Island (NS) are high use areas for leatherbacks (Figure 3a).

Table 7: Completed prosecutions of illegal oil pollution between 200-2011, in which aerial surveillance programs were pivotal in gathering evidence. Adapted from: Transport Canada (2012), Successful Prosecutions: Marine Pollution Prosecutions (2000-2011). Retrieved from http://www.tc.gc.ca/eng/atlantic/page-1385.htm.

Prosecution Date	Incident Date	Ship Name	Incident Location	Amount/Type Discharged	Penalty
15-Dec-08	22-Jun-07	Alida Gorthon**	65 NM SE of Cape Sable, NS	22 L, illegal pollutant	$80,000
18-May-07	16-Dec-05	Nobel Fortuna**	37 NM east of Sydney, NS	5.5 L, illegal pollutant	$45,000
24-0ct-05	22-Jun-04	Front Fighter / Nordic Fighter**	85 miles SW of Cape St.Mary's, NL	64 L, illegal pollutant	$70,000
26-Aug-05	22-Aug-03	Project Europa**	62 miles SE of St. John's, NL	40 L, illegal pollutant	$70,000
10-May-04	26-Feb-02	Olga (F/V)**	134 km SE off Cape Race, NL	20 L, oil pollution	$170,000
02-Apr-04	5-Apr-01	Olga (F/V)**	120NM off NL	40,000 L, contaminated ballast water	$113,000
23-Mar-04	25-Feb-02	DSV West Navion**	Halifax, NS	277 L, oil pollution	$60,000
25-Nov-02	6-Mar-02	CSL Atlas**	80 NM south of Halifax, NS	92 L, oil pollution	$125,000
12-Apr-02	19-Apr-01	MV Scarab**	64 NM SSE of St. John's, NL	380 L, oil pollution	$45,000
25-Feb-02	22-Dec-99	MV Baltic Confidence**	85 NM SE of Halifax, NS	850 L, oil pollution	$125,000
25-Oct-01	27-Sep-01	Olympic Melody*	38 NM NE of Cape North, NS	290 L, oil pollution	$25,000
06-Jun-01	28-Nov-00	Endurance*	50 NM off Canso, NS	1,200 L, oil pollution	$35,000
23-Apr-01	10-Oct-00	Sandviken*	37 NM off Yarmouth, NS	2,400 L, oil pollution	$40,000
21-Mar-01	22-Feb-00	Donau Ore**	40NM off Cape Saint Mary's, NL	Undetermined, oil pollution	$30,500
11-Apr-00	7-Jan-00	Med Taipei*	195 NM SE off Sable Island, NS	778 L, oil pollution	$30,000
14-Feb-00	8-Feb-99	Nordholt*	186 NM off NS	15 L, oil pollution	$35,000
31-Jan-00	13-Mar-99	Polar Duke*	135 NM off NS	2.6 L, oil pollution	$20,000
10-Jan-00	25-Sep-99	Sauniere**	17 NM South off NL	37 L, oil pollution	$10,000

*Department of National Defence Aerial Surveillance, ** Transport Canada Aerial Surveillance Program (NASP)

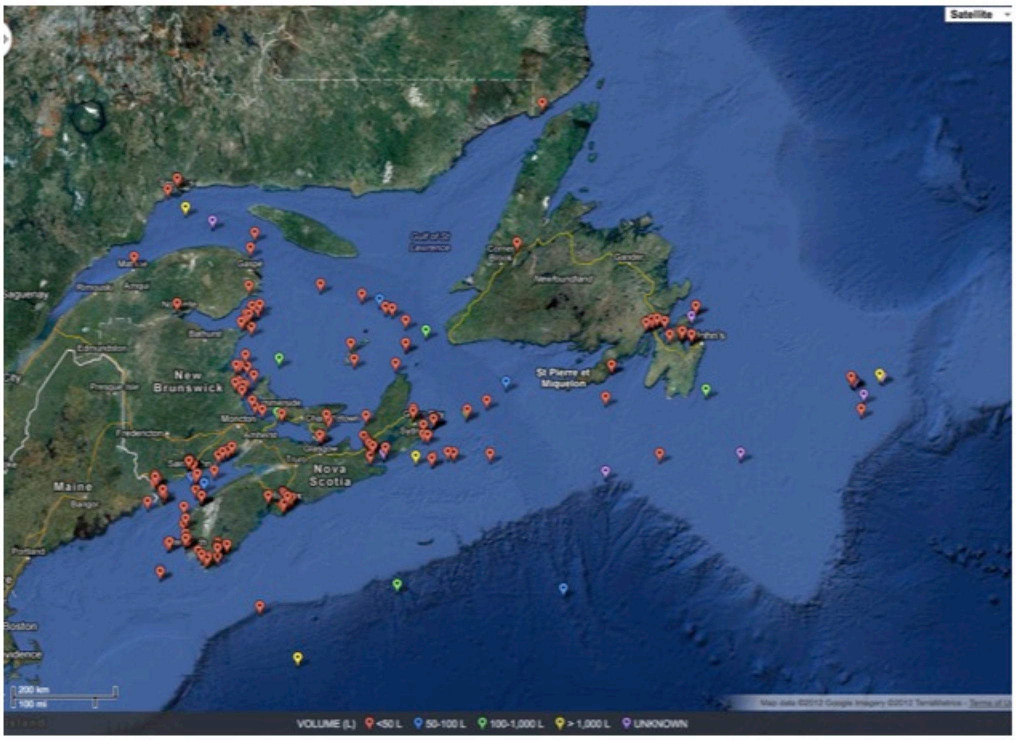

Figure 6a: Oil spill locations observed in Atlantic Canada through the National Aerial Surveillance Program (NASP), separated by spill volume (litres), from 2007-2012. NASP data supplied by the Marine Aerial Reconnaissance Team of Environment Canada.

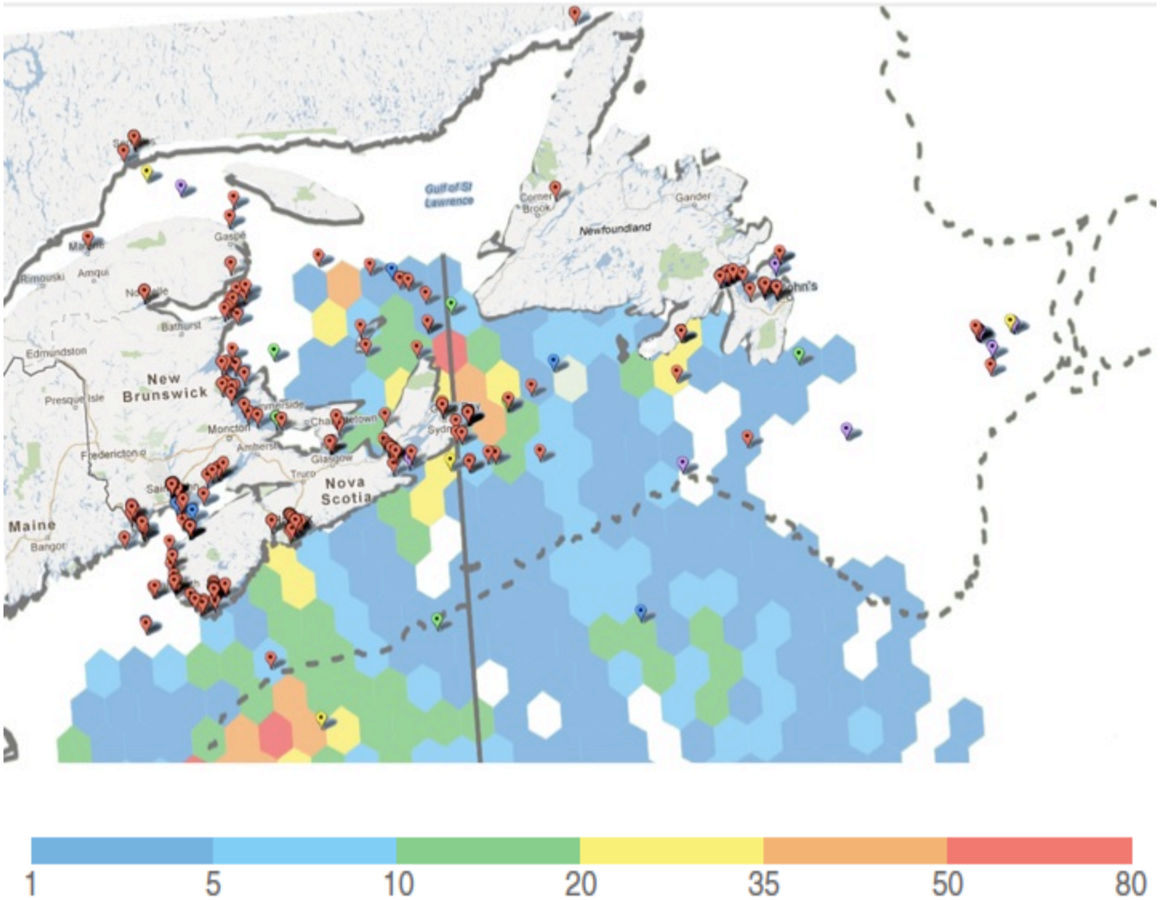

Figure 6b: Oil spill locations observed in Atlantic Canada through the National Aerial Surveillance Program, and the spatial use of 38 leatherback sea turtles equipped with satellite tags. Colour identifies the number of days turtle(s) were observed in each hexagon, between one (dark blue) and 80 (red) total days. Colour of the spill location indicates the estimated volume of the spill in litres (red=<50 L; blue=50-100 L, green=100-1,000 L; yellow=>1,000 L; purple = unknown). Dashed line: 1000 m depth contour. Source of the spatial use map James, Ottensmeyer, and Myers (2005). NASP data supplied by the Marine Aerial Reconnaissance Team of Environment Canada.

NASP does not only aid in the prosecution of vessels involved in the shipping industry. The *Vessel Pollution and Dangerous Chemicals Regulations* apply to all vessels in Canadian waters, and Canadian vessels everywhere (section 3), regardless of their size or whether they are engaged in recreational or commercial activities. Operators of Canadian fishing vessels and pleasure craft have been observed illegally discharging oil and oily water by NASP and other enforcement agencies. In 2004, the fishing vessel *Olga* was fined a precedent-setting $170,000 fine for illegally discharging approximately 20 litres of oil in its ballast water and failing to report the incident. The purpose of the enormous fine was to “act as a general deterrent for any would-be polluter” (Transport Canada, 2004). The success of detection and enforcement through NASP is encouraging and Transport Canada asserts that the program now effectively acts as a disincentive against marine pollution (Transport Canada, 2012a).

This deterrent effect is relevant to the protection of the marine environment and leatherback sea turtles. It is not economical to deploy the CCG or other oil spill responders to the typically small volumes of oil pollution discharged illegally, especially if the spills are located offshore where it might disperse before it could be reached. Therefore, this oil remains in the marine environment having unknown and possibly severe long-term effects (e.g. Monson et al., 2000; Wiese & Ryan, 2003). As identified in Chapter 3, the chronic effects of exposure to oil pollution in leatherbacks, and sea turtles in general, are not known at this time. Therefore, the best risk management option for both operational and illegal oil discharges from ships is prevention through regulation, education, enforcement, and prosecution.

Chapter 5: Conclusions & Recommendations

5.1 Conclusions

Increasingly, the tracking and monitoring efforts of marine conservation biologists are producing compelling evidence that sea turtles are more frequent visitors to Canadian waters than previously known. In particular, the leatherback sea turtle is a seasonal migrant to Atlantic Canada, coming to feed on the high densities of jellyfish prey available in the summer months (James, Ottensmeyer, & Myers, 2005; Heaslip et al. 2012). With this information comes new conservation management challenges for the federal government, especially given the leatherbacks critically endangered status. These challenges were formally recognized when the Atlantic leatherback was listed as endangered under the Canadian *Species at Risk Act* (2002) in 2003. This listing set in motion of a series of regulatory requirements meant to protect the leatherback from anthropogenic harm in Canada, which cascaded through to other federal departments and agencies.

The purpose of this study was to focus on those regulations and how well they functioned to protect leatherbacks from a specific threat - marine oil pollution. Exposure to marine oil pollution is one the many anthropogenic threats that contributes to sea turtle mortality worldwide. It is only necessary to look to the 2010 *Deepwater Horizon* disaster in the Gulf of Mexico, which killed thousands of sea turtles (Campagna, 2011) to gain insight on just how serious an oil spill might be for the leatherbacks in Atlantic Canada. However, to date no one has ever recorded an observation of an oiled leatherback turtle either in Canadian waters or elsewhere. While this should not be misinterpreted to mean that it does not occur, or that leatherbacks have some unknown immunity to oil pollution, the lack of data specific to the interaction between leatherbacks and oil makes assessing and managing the potential risk very difficult. Therefore, this study began with an overview of how, when trying to balance marine species conservation against the myriad of human uses in the marine environment, marine conservation managers need to apply both the precautionary principle and risk management strategies to develop and implement effective legislation. The less certainty there is about the probability of a risk event occurring and its potential consequences, the harder it becomes to implement effective risk management strategies. In the case of protecting leatherbacks from marine oil pollution, there is a significant amount of uncertainty. To demonstrate how leatherbacks might be protected from the risk of oil pollution despite this uncertainty, an independent risk assessment was conducted, followed by an analysis of risk assessment and mitigation strategies currently employed by the federal government to manage this risk.

Risk management is the process of using the conclusions of risk assessment to development mitigation measures that reduce the likelihood and/or consequences of a threat. There is not enough experimental or observational data about the interaction between leatherbacks (or sea turtles in general) and oil pollution to assess consequences quantitatively. Similarly, data on how frequently and how much oil is spilled in Atlantic Canada is also limited and often difficult to access publicly. Assessing the risk to leatherbacks from oil pollution is, for now, a necessarily qualitative process. Using the available literature as a foundation, an exposure pathway model was generated. This model described the path of oil spilled in Atlantic Canada, from its primary sources, through transportation routes and eventually exposure points on leatherbacks. From this characterization of oil pollution in Atlantic Canada, industrial sources, both coastal and offshore, and vessels accounted for the major sources of both chronic and acute oil pollution. Regardless of source, one of the findings of greatest concern was the possibility of oil pollution and jellyfish co-occurring at convergence zones. Fronts and convergence zones have been identified as preferred habitat for foraging leatherbacks, due to the high densities of jellyfish (Heaslip et al., 2012), and might therefore increase their likelihood of exposure to oil pollution. The exposure model also identified the methods by which a leatherback might interact with oil: inhalation, ingestion and dermal contact.

The risk assessment then used existing studies, especially Shigenaka, Milton, and Lutz (2010) and Lutcavage et al. (1995), to posit the likely consequences of exposure to leatherbacks, via these three exposure points. While the results are not definitive, the risk assessment concluded that interaction of sea turtles with oil from inhalation, ingestion, or dermal contact could have short-term health and behavioural effects. Ingestion and dermal contact could have chronic, long-term effects, and in sufficient quantities, ingestion could be fatal. The observed accidental and experimental oiling of other sea turtle species supported these conclusions. While it can be assumed that there are differences in species-specific toxicology, other sea turtle species are the best analogs available for leatherbacks. The risk assessment concluded that under the right conditions, an oil spill in Atlantic Canada could lead to significant effects for the leatherback population, including fatalities from oil exposure. The worst-case scenario would be a crude or unrefined oil spill of several thousand metric tonnes occurring during the summer months and in a coastal region frequented by leatherbacks, primarily the Scotian

Shelf, Cabot Strait or Placentia Bay (NL). At the very least, the likelihood of this sort of major event should be receiving attention from federal marine mangers and emergency responders.

In the second half of the study this expectation was measured against current risk management for the interaction between leatherbacks and oil pollution. In the analysis of the comprehensive study reports (CSRs) generated during the environmental assessment process for eight projects related to the oil and gas industry in Atlantic Canada, only six assessed the risk of oil to leatherbacks at all, and only one found the risk to be significant. Subsequently, no specific mitigation measures were proposed in any CSR to reduce the risk of oil spills to leatherbacks, or sea turtles in general. These trends were of concern because they effectively violated the requirements of the environmental assessment process, as laid out by the *Canadian Environmental Assessment Act* (1992). Furthermore, the reason that the conclusions of the majority of the CSRs ran contrary to the risk assessment conducted in this study was because they failed to utilize the literature or other expert opinion available on the subject. Many unsupported assumptions were used in the place of research evidence, for example the behavioural and toxicological responses of leatherbacks to oil were repeatedly assumed to be the same as those of cetaceans. The lack of expert opinion in the assessments introduced a bias in the CSRs that was favourable to the development of the project and when these reports were reviewed by the Environment Minister, all the projects were approved without additional comments on the risks of the project, or the mitigation measures in place to protect species at risk.

The processes in place for managing the risk of oil exposure to leatherbacks from the oil pollution that results from vessels was also analyzed. There were two categories of management: proactive measures and retroactive measures. Proactive measures primarily dealt with the laws and regulations in place to prevent or discourage large, accidental oil spills. The International Convention for the Prevention of Pollution From Ships (MARPOL 73/78) has been codified into Canadian law under the *Canada Shipping Act* (2001). This act requires both ships and small-engine craft to meet specific requirements in their design and operation to reduce not just the probability of oil being spilled if an accident occurs, but also the probability of an accident occurring at all. However, these measures are not specific to leatherbacks, or even species at risk. Therefore this study looked specifically at the emergency response measures in place for wildlife affected by marine oil spills. Although there are both private and government response agencies responsible for oil spill mitigation, all of them presented limited information on their strategies for dealing with oiled or at-risk wildlife. It seems that the primary source of advice on how to manage the risk of oil to leatherbacks in an emergency would come from the Canadian Wildlife Service, in their participation in the regional environmental emergencies teams (REETs).

Finally, the role of retroactive enforcement and prosecution of polluters as a deterrent against future oil pollution was analyzed. The National Aerial Surveillance Program (NASP) appears to be successful in discouraging illegal oil pollution.

5.2 Recommendations

Ultimately, the goal of this study was to provide managers working in both leatherback conservation and marine oil spill response with four inferences: 1) an understanding of the likelihood and consequences of a leatherback in Atlantic Canada interacting with marine oil pollution, 2) an example of an ecological risk assessment that would help them to make risk management decisions, despite high uncertainty and data deficiency, 3) an overview of the current management of the risk of oil pollution to leatherbacks at the federal level, and 4) recommendations for how to improve both the assessment and management of that risk. However, at the time of writing (July 2012), Canada underwent significant changes to the federal approach to the environmental management issues.

Foremost among these changes is the repeal of the *Canadian Environmental Assessment Act* (1992) by the federal budget bill C-38 on July 6, 2012. The act will soon be officially replaced by the *Canadian Environmental Assessment Act* (2012). Currently, the only existing version of this new act is contained within Bill C-38, and this document has been subject to extensive scrutiny by government representatives, the public, and non-governmental organizations. The widely held opinion is that the new act favours development and shortens the environmental assessment process. It was observed in this report that the old *CEAA* (1992) process was already so condensed that necessary information about the risk to listed species was overlooked and mitigation measures were given limited attention. Further condensation of the environmental assessment process is going to be detrimental to both the assessment and management of the risk of oil pollution to leatherbacks. The other relevant effect of Bill C-38 is widespread cuts to federal environmental programs, including REETs. The $4 million annual cuts to Environment Canada's environmental emergencies program has resulted in the closure of six REET offices leaving only two in place, in Montreal and Gatineau (QB) (de Souza, 2012). These REETs are the advisory bodies for oil spill response companies and Canadian Coast Guard. Through them, the CWS and other specialists can direct responders on how to deal with specific emergency response challenges, such as an oiled leatherback. While the CWS will hopefully be able to maintain an effective presence in the remaining two REET offices, the capacity for the REETs to recognize and utilize local expertise, for example the Canadian Sea Turtle Network based in Halifax, is threatened.

The most favourable recommendation this study could make would be policy changes that shift the focus towards a more honest and through assessment of environmental risk and identification of mitigation measures that balance species conservation with industrial development of the marine environment. However, the above-mentioned cuts to the federal funding of and focus on environmental assessment and management are even more extensive than what is presented here; they certainly suggest that federal concern about the risk to leatherbacks from oil pollution is not likely to increase. It therefore falls to individual managers, whether in government, private industry, or non-governmental positions, to take personal initiative to close the gaps in risk assessment and management. Wherever possible the following initiatives could help improve risk management for leatherback sea turtles:

1) Defining significance separately from probability: In the CSRs analyzed there was a tendency to only call an environmental effect 'significant' if the causal event was likely to happen. The most disastrous oil spills are extremely rare, and can have extensive and long-term environmental consequences. These rare events do not necessarily even require massive volumes of oil, as both the type of oil spilled and the surrounding environmental conditions are extremely influential in determining the

behaviour of a spill. That an oil spill event must be either common or of a particular volume in order to require mitigation measures is failure of risk management.

2) Data deficiency should invoke precautionary management: There was a demonstrated tendency in the analyzed CSRs to fill in data gaps about leatherbacks with favourable assumptions. Data deficiency is a common problem in the management of rare, endangered, and migratory species such as leatherbacks. However, management decisions often have to be made in spite of uncertainty, and in this case the precautionary approach should be taken. For example, it is not known if leatherbacks have the capacity to avoid an oil spill, instead of assuming they can (as some CSRs did), precautionary management would assume that they cannot and mitigation would proceed from there.

3) Consider chronic and long-term effects: While to date there are no published studies on the effects of chronic oil exposure to sea turtles, that does not mean that there are none. Not only are there chronic effects to individuals, but populations demonstrate long-term effects as well. For example, more than a decade after the *Exxon Valdez* oil spill Monson et al. (2000) finally quantified the difficult-to-detect long-term impacts of the spill on sea otter populations. Limiting risk assessment and conservation management to acute, immediate effects will result in decisions that are biased towards the short-term.

4) Utilize expert opinion: Whether it is found through the literature or local experts, these sources are going to have invaluable species-specific insight that can greatly improve the quality of ecological risk assessment and risk management. This is especially true

when dealing with a species like the leatherback sea turtle, about which very little is quantitatively known.

5) Improve data collection and risk modeling: Quantitative ecological risk assessments are always preferable to qualitative, as statistics can be utilized and bias significantly reduced. This requires access to through, long-term data sets. The more information that can be gathered and made available on the volumes, types and locations of oil spills in Canadian waters, the better the likelihood of a leatherback, or other marine species, coming into contact with even small volumes of oil can be calculated. While there are federal pollution databases, they are difficult or impossible for managers to access.

Finally, while leatherbacks were specifically addressed in this study, very little is known about the behavioural and physical effects of oil pollution on many marine species in Canada and there is likely insufficient risk management for them as well. The recent federal cuts to environmental programs will affect more that just the leatherback sea turtles. Managers should, in general, be aware that from the perspective of ecological risk assessment and the management of leatherback sea turtles, Canada is not prepared to respond to a major marine oil spill like the one suffered in the Gulf of Mexico in 2010.

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Appendix I: Table of federal legislation that contains the precautionary principle or approach in some form, as defined by the Rio Declaration, from the 1992 United Nations Conference on Environment and Development.

Title of Legislation	Year	Official Text
Canadian Environmental Assessment Act	1992	**4(1)** The purposes of this Act are **(a)** to ensure that projects are considered in a careful and precautionary manner before federal authorities take action in connection with them, in order to ensure that such projects do not cause significant adverse environmental effects. **4(2)** In the administration of this Act, the Government of Canada, the Minister, the Agency and all bodies subject to the provisions of this Act, including federal authorities and responsible authorities, shall exercise their powers in a manner that protects the environment and human health and applies the precautionary principle.
Canadian Environmental Protection Act	1999	**2(1)(a)** exercise its powers in a manner that protects the environment and human health, applies the precautionary principle that, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation, and promotes and reinforces enforceable pollution prevention approaches;
Fisheries Act	1985	**36(1)** No one shall **(a)** throw overboard ballast, coal ashes, stones or other prejudicial or deleterious substances in any river, harbour or roadstead, or in any water where fishing is carried on; **36(3)** Subject to subsection (4), no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any other deleterious substance that results from the deposit of the deleterious substance may enter any such water.
Oceans Act	1996	**30** The national strategy will be based on the principles of **(c)** the precautionary approach, that is erring on the side of caution.
Species at Risk Act	2002	**38** In preparing a recovery strategy, action plan or management plan, the competent minister must consider the commitment of the Government of Canada to conserving biological diversity and to the principle that, if there are threats of serious or irreversible damage to the listed wildlife species, cost-effective measures to prevent the reduction or loss of the species should not be postponed for a lack of full scientific certainty.