Marine Pollution Bulletin 107 (2016) 36–45

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

An evaluation of oil spill responses for offshore oil production projects in Newfoundland and Labrador, Canada: Implications for seabird conservation

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ARTICLE INFO

Article history:
Received 18 October 2015
Received in revised form 3 March 2016
Accepted 14 April 2016
Available online 28 April 2016

Keywords:
Chronic oil pollution
Marine birds
Post-spill monitoring
Independent observers
C-NLOPB

ABSTRACT

Seabirds are vulnerable to oil pollution, particularly in cold-water regions. We investigated the response of small spills (<7.95m^3) at offshore production platforms in Newfoundland, a region recognized for seabird diversity and abundance. In three environmental assessments for oil production operations Environment Canada requested monitoring and mitigation of small spills potentially impacting seabird populations; suggestions supported by two independent reviews. An industry spill response plan states that operators would collect systematic observations on spills and deploy countermeasures where possible. Operators' spill reports were obtained under an Access to Information request. There were 220 daytime spills with sheens (out of 381 spills; 1997–2010). Of these, six reported time to oil dispersion and eleven the presence or absence of seabirds. Industry self-reporting has not permitted an evaluation of the impact of chronic oil spills on seabirds. We recommend that independent observers be placed on platforms to systematically collect data on spills and seabirds.

1. Introduction

Environmental assessments for offshore oil production projects predict that small spills (defined as <7.95 m^3) will occur with higher frequency than larger spills (>7.95 m^3; e.g., Mineral Management Services 2007; ExxonMobil Canada Properties, 2011). Yet our understanding of small spills at offshore hydrocarbon platforms and their association to seabird mortality remains weak (Dicks et al., 1982; Mosbech, 2000; Wiese et al., 2001; McCrary et al., 2003; Fraser and Ellis, 2008a; Ellis et al., 2013; Ronconi et al., 2015). Monitoring of small spills could provide information on (Kirby and Law, 2010): 1) short and long term impacts to the marine environment; 2) distinguishing spill impacts from other types of impacts (e.g., oil sheens from legal discharges from produced water, see Fraser et al., 2006); and 3) a comparison of spill response efforts.

In areas with high concentrations of seabirds, researchers have suggested that chronic pollution may have greater population-level impacts than a single large spill (e.g., Exxon Valdez, 42,000 m^3; Hunt, 1987; Piatt et al., 1991; Wiese and Robertson, 2004; O'Hara and Morgan, 2006; Renner and Kuletz, 2015; Ronconi et al., 2015). In cold-water environments, diving seabirds in particular have a high risk of mortality from very small amounts of oil pollution due to loss of insulation and resulting hypothermia (Jenssen et al., 1985; Jenessen, 1994; Lock et al., 1994; Wiese and Ryan, 2003; O'Hara and Morandin, 2010). Due to their life-history strategies (low reproductive rates, delayed maturity, high adult survivorship), seabird populations are also sensitive to small changes in adult mortality (Wooller et al., 1992). In many parts of the world there are, or will be, offshore oil extraction projects in cold waters with high concentrations of seabirds (e.g., North Sea [Tasker et al., 1986; Ollason et al., 1997; Fraser et al., 2008], Falkland Islands [Pakhomov and McQuaid, 1996; White et al., 2002], Tasmania [Bretagnolle and Thomas, 1990; Bernecker and Totterdell, 2012], Newfoundland and Labrador [Burke et al., 2012] and Canadian arctic [Wong et al., 2014]). As most seabird populations are declining (International Union for Conservation of Nature, 2012), many species using these regions are also of conservation concern (e.g., rock hopper penguin, *Eudyptes chrysocome* [Cuthbert and Sommer, 2004]; erect crested penguin, *Eudyptes sclateri* [Taylor, 2000]); and thick-billed murre, *Uria lomvia* [Kålås et al., 2010]). Offshore oil platforms attract seabirds (Tasker et al., 1986; Baird, 1990; Wiese et al. 2001; Montevecchi, 2006; Burke et al., 2012; Ronconi et al., 2015), thus increasing the likelihood of exposure to localized oil pollution. In the absence of on-platform monitoring (see Montevecchi et al., 1999; Ronconi et al., 2015) the main approach to assess oil production spills is through beached bird surveys (e.g., Camphuysen and Heubeck, 2001). However, the move towards extraction activities further offshore means that seabirds oiled from platform spills are less likely to be detected or will be under-represented in such surveys (Robertson et al., 2012). Collecting standardized observations on seabirds from offshore platforms could help evaluate the risk small spills pose to various seabird populations (Montevecchi et al., 1999; Ronconi et al., 2015).

In this context, we first surveyed environmental impact statements for three oil production projects in Newfoundland and Labrador (NL) for their consideration of chronic oil pollution and impacts on seabirds. We then evaluated the subsequent reporting of and response to small spills from

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http://dx.doi.org/10.1016/j.marpolbul.2016.04.026
0025-326X/

the oil production projects. The Grand Banks off NL supports an estimated 40 million seabirds annually (Montevecchi and Tuck, 1987) and as of 2016, there are four offshore oil production projects all over 300 km offshore (Fig. 1). While regional beached bird surveys provide oil-related mortality estimates (Wiese and Ryan, 2003; Wiese and Robertson, 2004; Wilhelm et al., 2009), it is unlikely that they detect seabirds oiled by spills from platforms so far offshore (Wilhelm et al., 2007; Robertson et al., 2012).

2. Regulatory framework

The offshore oil and gas regulatory agency, the Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB, formerly C-NOPB), is an independent joint federal-provincial board (Government of Canada, 1987). The C-NLOPB issues authorizations for offshore oil activities, is the lead responsible authority in environmental assessment processes and ensures compliance to environmental protection plans (see Van Driel and MacDonald, 2002; Erlandson Consulting Inc., Petroleum Research Atlantic Canada, 2004; C-NLOPB, NDa). Environment Canada is the regulatory agency responsible for the Migratory Bird Convention Act (Government of Canada, 1994), an international treaty designed to protect migratory birds in general and from oil pollution specifically (Section 5.1(1)). As a federal agency with relevant expertise, Environment Canada participates as a responsible authority in environmental assessment review processes for oil and gas activities and is consulted for the duration of a project (Van Driel and MacDonald, 2002). The C-NLOPB has a Memorandum of Understanding with Environment Canada that outlines their respective roles for offshore oil development (C-NOPB, 1988; C-NLOPB and Environment

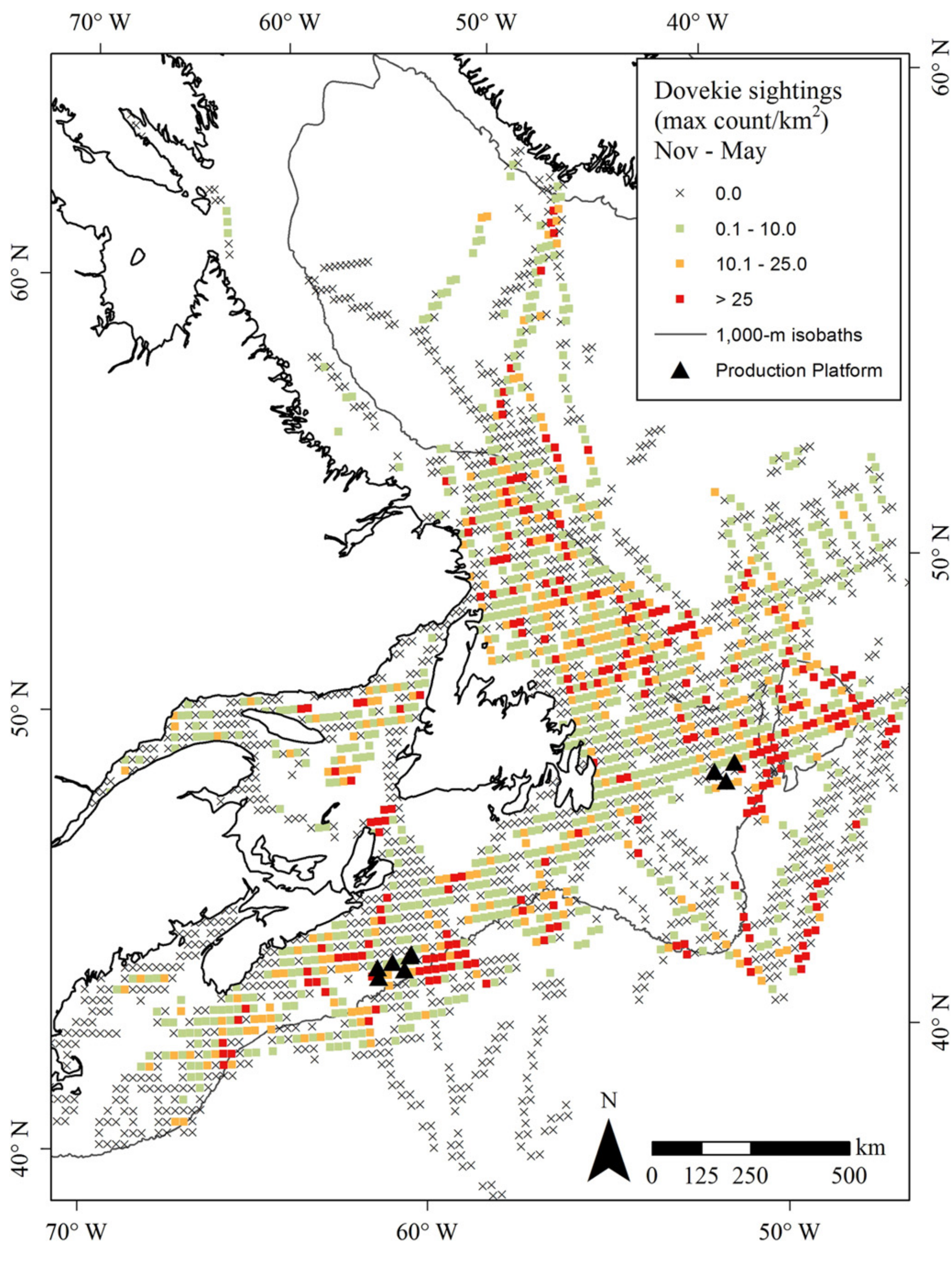

Fig. 1. Eastern Canada Seabirds at Sea (ECSAS) survey data showing Dovekie (*Alle alle*) distribution and abundance from May to November (maximum counts/km^2 per 15° grid). Data are from Canadian Wildlife Service — Environment Canada (Carina Gjerdrum) collected according to the Eastern Canada Seabirds at Sea survey protocol and area based on sightings while the ship was moving, within transect, and not following the ship (see Gjerdrum et al., 2012). The map shows relative densities and are not corrected for differences in detectability (i.e., not all birds are detected within the 300 m transect) and the data are therefore underestimates.

Canada, 2015). While the Canadian Wildlife Service (Environment Canada) has worked with industry to develop seabird sampling protocols (see Baillie et al., 2005; Gjerdrum et al., 2012), the C-NLOPB is identified as the lead agency that investigates spills from offshore operations (Canadian Wildlife Service, 2012). Due to the regulatory complexity of these relationships, we sought to evaluate how Environment Canada's comments on chronic oil pollution articulated in the environmental assessment processes (see Section 5) were operationalized with respect to oil spill reporting and response.

3. Spill reporting and response plans

In the event of an oil spill, Canadian Wildlife Service (2012) advises: 1) hazing or release of scare devices to prevent birds contacting oil; 2) mechanical dispersing of small oil spills; 3) monitoring using ship-based survey approaches; and 4) releasing drift blocks to estimate bird mortality (see Wiese and Jones, 2001). Ship-based surveys, developed by Environment Canada, are standardized observations of seabirds using scanning techniques and include recording of weather, visibility and sea state (Gjerdrum et al., 2012). Gjerdrum et al. (2012) specifically note that negative observations are important.

Operators must have an Environmental Protection Plan which includes an Oil Spill Response Plan, as part of the permitting process (Erlandson Consulting Inc.,Petroleum Research Atlantic Canada, 2004; National Energy Board et al., 2011) which includes "contingency plans, including emergency response procedures, to mitigate the effects of any reasonably foreseeable event that might compromise safety or environmental protection…" (Government of Canada, 2010:9). Operators are required to report spills (The Canada-Newfoundland and Labrador Atlantic Accord Implementation Act s161 (2); Government of Canada, 1987). The C-NLOPB has Incident Reporting and Investigation Guidelines, identified as non-statutory or mandatory (C-NLOPB, 2012). The C-NLOPB (2012: forward) notes "The onus is on the operator to comply with the Act and the regulations and be able to demonstrate to the appropriate Board the adequacy and effectiveness of the methods employed to achieve compliance." Written notification of location, date, time, description of "operations and relevant environmental conditions at the time of incident", immediate and planned responses; substance, volume "and information/observations of environmental impact" is requested for hydrocarbon releases (C-NLOPB, 2012:11).

While we requested and received spill response plans for each operator, and would like to compare individual plans with the realized responses, their public status remains unclear[1] (see also Office of the Auditor General, 2012). However, the Canadian Association of Petroleum Producers (CAPP, 2009) provided a generic spill response plan for the C-NLOPB which we briefly summarize for small spills.

Responses to spills are tiered according to type and size. Discrete spills which occur during production operations (batch spills) typically fall under a "Tier 1" category, where operators use resources on site (i.e., on platforms; Armsworthy et al., 2003; CAPP, 2009; Turner et al., 2010). A Tier 1 response could include: "natural dispersion, mechanical dispersion and containment and recovery" CAPP (2009). Natural dispersion is self-evident. Mechanical dispersion uses a boat propeller to break up oil. Containment and recovery (also called a mechanical response) would use one or more booms and skimmers available on site (Mobil Oil, 1985; Petro Canada, 1997; Husky Oil Operations Ltd., 2000; Turner et al., 2010). An independent review of spill response capability for this region identifies the environmental conditions for a containment-recovery response as wave height ≤2 m and visibility ≥0.5 nm (Turner et al., 2010).

In all cases, surveillance and monitoring were identified as "Always necessary" and "…the only response in poor conditions" (CAPP, 2009:19; see also Husky Oil Operations Ltd., 2000). Specific to seabirds, CAPP (2009:6.1, 19, 23) states that "Surveillance [is] necessary to determine distribution of wildlife and potential for impact by floating oil…" and "Supply vessel crews or offshore personnel may be tasked with initial seabird surveys before seabird specialists can be dispatched to the scene of an offshore oil spill." Husky Oil Operations Ltd. (2000: 522) identifies "Surveillance to determine distribution of wildlife and potential for effects" as a "Potential response option". The deployment of drift blocks is also noted as a possible action (CAPP, 2009; see also Table 1).

4. Materials and methods

4.1. Study area

Three ongoing oil production projects, all 300 km or more offshore, were the focus of this study, Hibernia (Mobil Oil, 1985), Terra Nova (Petro Canada, 1997) and White Rose (Husky Oil Operations Ltd., 2000; Fig. 1). Hibernia is a 224 m high gravity-based platform which started producing oil in 1997. The project was approved for expansion and is expected to continue to 2036 (Hibernia Management and Development Company, 2009). Terra Nova and White Rose are Floating, Production, Storage and Offloading (FPSOs) platforms. Terra Nova began producing oil in 2002 and is expected to last 18 years. White Rose started production in 2005 and with a recent extension it will continue an additional 25 years to 2040 (C-NLOPB, 2015). In addition to the platforms and drilling rigs, tankers are used to transport oil.

Seabirds most vulnerable to oil pollution are those that spend the majority of their time on the water (Montevecchi et al., 1999; Mosbech, 2000; Lock et al., 1992). Wilhelm et al. (2009) identify 14 seabird species commonly found oiled in NL beached bird surveys: auks (thick-billed murre, common murre *U. aalge*, dovekie *Alle alle*, Atlantic puffin *Fratercula arctica*, black guillemots *Cepphus grylle*); gulls (herring *Larus argentatus*, great-black backed *Larus marinus*, black-legged kittiwakes *Rissa tridactyla*, ring-billed *Larus delawarensis*), northern gannets (*Morus bassanus*), northern fulmars (*Fulmarus glacialis*), long-tailed ducks (*Clangula hyemalis*), common eiders (*Somateria mollissima*) and greater shearwaters (*Puffinus gravis*). From ship-based surveys on the Grand Banks, Burke et al. (2012) report greater shearwater, common murre, northern fulmar and great black-backed gull as the most common species offshore. In both summer and fall, high auk densities were found near the Hibernia platform and a drilling rig, respectively (Burke et al., 2012).

4.2. Environmental impact statements

Three sequential environmental impact statements, Hibernia (Mobil Oil, 1985), Terra Nova (Petro Canada, 1997) and White Rose (Husky Oil Operations Ltd., 2000) were used for this analysis. We compiled comments from Environment Canada, panel reviews (Hibernia and Terra Nova) or a Commissioner's review (White Rose) and the C-NOPB on small hydrocarbon spills from the environmental assessment process, as well as provide the predictions for batch spills from each impact statement.

4.3. Analyses of spill reports

Through the Access to Information and Privacy Act (Government of Canada, 1985), we received raw data in the form of original reports submitted by operators to the C-NLOPB for spills that occurred between 1997 and 2010 from production projects (i.e., projects with a production license; spills were from submersibles, drilling rigs and production

[1] ExxonMobil response plan states "ExxonMobil Canada use only, Property of HMDC". Husky Oil response plan states "CONFIDENTIALITY NOTE: All rights reserved. No part of this document may be reproduced or transmitted in any form or by any means without the written permission of Husky Energy." Suncor (2008; Terra Nova) appears to have no such restrictions. See also http://www.cnlopb.ca/news/nr20100722.shtml.

Table 1
Environmental impact statement predictions and comments from Environment Canada, review panels and regulator during the environmental assessment process for three offshore oil and gas projects with respect to small oil spills and seabirds in Newfoundland and Labrador 1985–2001 (emphases on chronic oil pollution and monitoring is ours).

Project	Batch spill environmental impact statement predictions, mitigations for seabirds & response commitments	Environment Canada's comments on draft EIS[a]	Panel or Commissioner's review recommendations or	Regulator's (& responsible authority's) response
Hibernia (1985)	"Summary of worst-case potential impacts prior to mitigation — large crude oil transfer spill" [800 m^3] for seabirds — negligible to minor. "Mitigation measures — operational safety and accident prevention; oil spill response plan." (No impact predictions for smaller spills; see Mobil Oil 1985:81,194). "As per the contingency plan, oil spill response teams are activated immediately, and oil spill countermeasures suitable for the occasion are implemented as soon as spill control operations and environmental conditions permit. A number of considerations establish best type and level of countermeasures. Real-time surveillance (visual and remote sensing) is invaluable in this task. It can identify behavior and fate of the slick, as well as establish the distribution of many of the biological resources that may interact with oil." (Mobil Oil 1985:101) "The analysis of residual impacts resulting from 'important' accidental events does reveal one potentially major concern: seabirds and oil spills….Mobil's chief mitigation measure is its commitment to clean, safe operations, and to awareness, training, and planning in the countermeasure areas. However, even with the best operation and training, oil spills can still occur. In many instances, no mitigation may be possible once oil is spilled…" (Mobil Oil 1985:108).	"2.2 Marine Birds….Since seabird mortality following an oil spill bears no predictable relationship to the amount of oil spilled, **Environment Canada is as concerned with the incidence of small chronic oil releases** as with the occurrence of a large accidental oil spill. The proponent should be required to more fully evaluate the risk to seabird populations and propose mitigative measures to reduce or eliminate the loss of even small quantities of oil." (bold ours; Environment Canada 1985: 4) "3.7.2 Limits of Detection….Any reduction in seabird populations and/or fish stocks must be very large before it can be detected in such a monitoring program. However substantial, and possibly irreversible, ecological (and economic) impacts can occur with very little prior indication. The inability to detect an impact should not be interpreted as 'no impact'. Accordingly, **the Hibernia Development Monitoring Program should carefully examine methods and techniques for monitoring low level impacts in order to facilitate the introduction of mitigative measures as required before such impacts become critical**…." (Environment Canada 1985: 53).	"The Panel concludes that large numbers of seabirds could be killed in the event of an oil spill and prevention is the best option to deal with this possibility" "The Panel recommends that a monitoring plan should be developed taking into account the viewpoints of the responsible government agencies and allowing for publication of results. The government agencies should consult with interested public groups concerning the monitoring program." (Hibernia Development Project, Report of the Environmental Assessment Panel 1985:33, 40)	"…effects monitoring will occur both during routine operations and in response to an oil spill or blowout….The Proponent's effects monitoring program should be developed taking into consideration the recommendations of appropriate government agencies made at the Panel hearings. The Board intends to request the advice of other government agencies during the development with the proponent of the requirements of an acceptable effects monitoring program. The responsibility for developing the program to meet government requirements resides with the Proponent." (C-NOPB 1986:80)
Terra Nova (1997)	"Summary of worst-case potential impacts of accidental spills" batch spill of 800 m^3 — negligible to minor for seabirds. "Small spills — Marine biota" predicted mortality, with negligible to minor magnitude. Mitigation — preventing spills and "minimizing environmental damage once a spill has taken place" and the Environmental Protection Plan. (Petro Canada 1997: Tables 5.7-23, 5.8-1, pp. 5-130,)	"Environment Canada would like to emphasize that **all spills of all sizes are a threat to birds** and that on the Grand Banks, which is one of the richest areas of the NW Atlantic at any time of the year, any spill is likely to have a major impact." (Environment Canada 1997: 19) Recommendation 27: "In the development of oil spill contingency plans, spills of all sizes should be included (from chronic discharges to very large spills (e.g., blowouts))." (Environment Canada 1997: 21)	5.10 Oil spills "The possibility of a major oil spill is clearly the prospect most feared by the public. Not only are such events dramatic, but the impacts are immediately visible. Further, given the nature of the environment, the possibility of effective mitigation is quite remote. Therefore, a concern for long-term repercussions must remain...**lesser spills, which may have disproportionately large consequences**…may result from failure in normal production activities… the possibility of a spill, however minimal, occurring	"The Board acknowledges **the risk of small batch spills occurring during the life of the project**…and commends the proponent for its stated 'zero tolerance' policy toward these spills. The Board notes that the Accord Act takes a 'zero tolerance' approach to oil spillage, forbidding the spillage of any oil and by declining to define any 'minimal acceptance' amount in this context. The Board believes that thorough advance planning for monitoring effects of an oil spill is a necessary precaution and will ensure that this is addressed in the Proponent's contingency

(continued on next page)

Table 1 (*continued*)

Project	Batch spill environmental impact statement predictions, mitigations for seabirds & response commitments	Environment Canada's comments on draft EIS[a]	Panel or Commissioner's review recommendations or	Regulator's (& responsible authority's) response
	"Although prevention of oil spills will be a primary focus, Petro-Canada will…ensure that the appropriate spill response capability is in place for all phases of the Terra Nova Development." (Petro Canada 1997:6-5) "An offshore spill is likely to spread quickly and break up in rough weather conditions. Countermeasure operations away from the spill source will be successful only if accurate and up-to-date information on the oil's properties and behaviour slick sizes, and projected movement are known. Updated slick information for a Terra Nova oil spill will be obtained through continuing surveillance activities." (Petro Canada 1997: 6–7)	Recommendation 31: "The proponent should have at its disposal, and readily available, bird scaring devices or other countermeasure equipment, specifically intended to minimize impacts on seabirds." (Environment Canada 1997: 23) Recommendation 32: "The proponent should describe other methods that would be used to reduce the risk of marine birds contracting oil, if an oil release were to occur in the area." (Environment Canada 1997: 23)	at some point in the life of the project is real. The Proponents state that they are committed to a zero-tolerance for release predicated upon the best design and the highest standards of safety…. Recommendation 57: The Panel recommends that the Board require the Proponents to adopt a zero-tolerance policy for oil spills." (Terra Nova Development Project Environmental Assessment Panel 1997: 55) "**A contingency plan specifically designed to measure the impact of an oil spill on seabirds is necessary**. Oiled birds recovered at sea and onshore must be counted. The release of a known number of drifters at the time of any spill, and their subsequent recovery along with affected birds, will provide a measure of recovery effectiveness in the conditions prevalent at the time and by extrapolation will provide an estimation of the spill's total impact. Recommendation 74: The Panel recommends that the **Board ensures that preparations to evaluate the effects of oil spills be done in advance of actual events**….In the event of a spill, evaluation of the impact must begin with the dispersal of drifters and the careful collection of all oiled seabirds and drifters in the area of the spill and on beaches." (Terra Nova Development Project Environmental Assessment Panel 1997:62)	plans…. The Board also notes that oil spill contingency plans typically provide for the deployment of drifting buoys following a spill. These are designed to move with the spilled material and to be remotely tracked to give an indication of the spill location. The deployment of a larger number of 'drifters' to simulate the movement of dead oiled birds…may be feasible in most cases; however, their recovery may not be possible…and therefore less useful in estimating seabird mortalities…. Nevertheless, the Board will ensure that the Proponent's spill response plan provides for the provision of a stockpile of 'drifters'…and for their deployment when conditions permit…(C-NOPB 1997:53).
Husky Oil Operations Ltd., 2000	Batch spills [800 m^3] were predicted to be significant, with a magnitude between low and high. Regulative mitigation – "Contingency Plan" and Project specific mitigation – "Training, preparedness, prevention, cleanup, inventory" (no environmental effects predictions for small spills; Husky Oil Operations Ltd., 2000:Table 5.9-4). Extensive information on oil spill response is present in the impact statement (see Table 6.10–2 provides a list of response options). Under "Strategies" Husky notes that "if there are birds nearby, the use of physical or chemical dispersion should be considered to remove the oil from the sea surface…" (522). "In the unlikely event of an accidental oil spill, Husky Oil will implement a dedicated oil spill monitoring program that focuses on marine birds in particular." (Husky Oil Operations Ltd., 2000: 534).	"Section 5.8 clearly shows that the waxy nature of White Rose crude, if that were the product to be spilled, is persistent, stays on the surface and can have disastrous effects on marine birds which frequent the area of the White Rose project. It is strongly recommended that this issue be readdressed to ensure that small spills are treated with the level of effort and importance that they deserve. **Given the higher frequency expected with smaller spills, and the variety of products that can be spilled...the issue must not be viewed as a trivial matter**." (Husky Oil Operations Limited 2001: 240) "…Environment Canada strongly recommends that the proponent commit to a monitoring program for marine birds during development and production stages of the White Rose project….This information would be especially useful in the event of an accidental release, minor or major, to determine impacts associated with the release of product." (Husky Oil Operations Limited 2001:240)	"There are two main sources of environmental impacts on birds according to participants who addressed this issue. They are…contact with oil sheens from small spills….A constant theme during the public sessions was the insufficient level of monitoring to determine the impact on seabirds of offshore operations. Recommendation 5.13: The Commissioner recommends that the Board requires the proponent to conduct a program of research to establish the **effects from its operations on marine birds in general and specifically with respect to…oil spills**." (Clarke 2001:88, 91)	"The Board generally concurs with the Proponent's statements respecting offshore oil spills. A contingency plan for oil spill response is a required component of the Environmental Protection Plan and the adequacy of these contingency plans is reviewed by the Board prior to authorizing the corresponding activities." (C-NOPB 2001:129)

[a] Environment Canada was recognized as a regulatory authority in the Terra Nova (see C-NOPB, 1996; Environment Canada, 1997; Erlandson Consulting Inc., Petroleum Research Atlantic Canada, 2004) and White Rose projects (Husky Oil Operations, Ltd., 2000; see also van Driel and MacDonald, 2002). The federal agency also submitted substantial technical comments for the Hibernia project (see also Sec. 46 Canada-Newfoundland and Labrador Atlantic Accord Implementation Act; Government of Canada, 1987).

platforms)[2]. In this analysis, we focused on "small" spills (defined by Petro Canada [1997] and Husky Oil Operations Ltd. [2000] as spills <7.95 m^3). We crosschecked the data received from the Access to Information request with data posted on the regulator's website (http://www.cnlopb.ca/information/statistics.php#environment) and queried the C-NLOPB who provided clarification where necessary. A cross-check was not possible for spills <0.001 m^3 as no details were provided on the C-NLOPB's website for these spills. Therefore, for spills <0.001 m^3 where the operator did not estimate volume, we used 0.00099 m^3 as the spill volume to include those spills in the summary statistics. If wave height or visibility was provided as a range, we used the maximum and minimum values, respectively. If a measure of visibility was not provided, but was noted as "good" or "clear" we recorded it as greater than 0.5 nm; "very poor" was rated as less than 0.5 nm. If units were "miles" or visibility recorded in fractions with no units we assumed both were nautical miles. We coded each release time to local daylight or night-time hours based on the time of year using timeanddate.com.

Using the operators' reports we asked:

1) What was spilled and how much?
2) When did the releases occur (time the spill occurred, when it was discovered or reported) and in what weather conditions? Specifically, how many releases occurred during the day and with weather conditions which may have permitted: a) observations on the spill and on seabirds in the vicinity (see CAPP, 2009); and b) countermeasures (i.e., containment-recovery or mechanical dispersion)? Observations on a spill and seabirds can occur in a wide range of conditions during daylight hours (see CAPP, 2009; Gjerdrum et al., 2012). Countermeasures require conditions where wave height <2 m and visibility >0.5 nm (hereinafter a "countermeasures window"; Turner et al., 2010).
3) What actions were taken by the operators following a release?
4) What was the average time to dispersion for daytime spills? Sheen dispersion data are necessary to estimate possible interactions with seabirds (Fraser et al. 2006; see also Montevecchi et al., 1999).
5) The number of synthetic based fluids or mud spills resulting in sheens (Fraser and Ellis, 2008c; O'Hara and Morandin, 2010; see also House of Assembly NL, 2010; C-NLOPB, 2011).
6) How many spill reports included information on seabirds and what details were included?

4.3.1. Evaluation of operators' forms

We evaluated the spill report forms for the standardization of formatting, for seabird information and time to spill dispersion.

[2] The request: Information on all spills from oil production activities within the Canada-Newfoundland and Labrador's jurisdiction between 1997 and 2010: a) The number of spills which had a response team on site to clean or contain the spill; b) details for each spill which had a response team, specifically: name of operator; date and time of spill; volume of spill; substance of spill; estimated date and time of arrival of response team at the spill site; description of the response team (number of responders and their spill response qualifications) spill recovery technology and the practices/strategies employed; estimated volumes of spilled material recovered; and disposal practices of recovered spill material (how transported; where disposed).
Of the oil production spills which had a response team, information is requested on: a) the number of spills which had a *dedicated, trained* person collecting data on seabirds and marine mammals observed within the vicinity of the spill. Here "dedicated" means the person was fully focused on collecting data and was conducting no other task; b) details for each of these spills which had seabird and marine mammal data collected: name of operator; date and time of spill; estimated date and time of arrival of the dedicated, trained person at the spill site; training and qualifications of the person collecting data; location(s) of data collection; data collection methods and technology used; the dates and times of data collection, and the process for reporting data (who received the data and when).

5. Results

5.1. Environmental assessments

All three environmental impact statements reviewed provided spill environmental effects predictions for a relatively large batch spill (800 m^3), but effects predictions for small spills were present only for second of the series of three (Terra Nova; Table 1). For all three environmental impact statements Environment Canada expressed concern and requested monitoring of chronic oil pollution (Table 1). The Terra Nova Review Panel and the White Rose review Commissioner both provided clear recommendations on monitoring small spills with respect to increasing the understanding of the impacts on seabirds (Table 1). The C-NLOPB had varying responses for each project around monitoring the impacts of, or responding to oil spills (Table 1).

5.2. Spill data

From 1997 to 2010, there were 381 spills <7.95m^3 with an average (±SD) spill volume of 0.12 ± 0.54 m^3 from production platforms (Table 2). As a wide variety of events caused releases we categorized each spill: 1) "crude", "mixed oil", "oil", "residual oil", "hydrocarbon", "oily water" (n = 126); 2) "hydraulic oil", "seal oil", "lubricating oil", "deck wash", "diesel oil", "diesel fuel", "helicopter fuel", "brine diesel" (n = 149); 3) "produced water"(n = 14); 4) "synthetic based fluids", "synthetic based muds" (n = 38); 5) "condensate"(n = 11); and 6) "unknown", "unidentified" (source of sheening not identified; n = 43). In instances where multiple substances were spilled, the first category was used if crude was involved.

Out of 381 spills, 352 reported time of day: 306 (86.9%) occurred during daylight hours and 46 (13.1%) at night (Table 2). Two hundred and sixty two (68.8%) reports had a complete description of the weather at the time of the spill (i.e., wave height and visibility); 131 had a wave height of ≤2 m and 214 had a visibility of ≥0.5 nm.

Out of 381 spills, 241 created sheens and 220 of those occurred during daylight hours. The size and coloring of sheens were often used to estimate spill volume (using the "Thickness Appearance Rating", Canadian Coast Guard Tar Code; CAPP, 2009). Where no sheening occurred, spill volume was sometimes estimated through pressure and volume loss. In some cases the problem causing the sheen was ongoing and so it was difficult to measure the amount of time the sheen was present and in some cases phrases like "a few hours" were used to describe time to sheen dispersion. Six reports provided the actual time (3.2% out of 220 daytime spills with sheens) to dispersion (average ± SD, 82 ± 61 min). Fourteen out of 28 synthetic based spills (including both fluid and muds) in daylight hours reported sheens.

Overall, 17 reports (4.5%, out of 381) provided some observation on seabirds (12 negative, i.e., no birds observed and five positive i.e., birds present). There was no apparent temporal trend of these 17 reports (2—1997, 3—1998, 2—1999, 1—2000, 1—2003, 3—2007, 4—2008, and 1—2009). Eleven reports (5%, out of 220) provided information seabirds for daytime spills with sheens. Information on seabirds was typically provided beside a question on the form specifically asking for wildlife observations (e.g., "Are there hazards to persons/property/wildlife, marine bird?"; see below).

One-hundred and sixty one (61.5%) spills occurred outside the countermeasure window; 47 (12.3%) spills with visible sheens occurred inside the countermeasure window (Table 2). Overall, 21 (5.5% out of 381) report some action beyond observing the spills: mechanical dispersion, boom deployment, scaring birds and/or deploying a tracking buoy. Three responses within the countermeasure window used mechanical dispersion via a boat propeller (n = 2, average volume = 0.01 ± 0.00 m^3) or deployed a boom (n = 1, volume = 0.00045 m^3). Eleven responses (average volume = 0.61 ± 1.23 m^3) occurred outside the weather limits and one outside countermeasure window (n = 1,

Table 2
A summary of spill data from three oil production projects in NL from 1997 to 2010.

Total number of production spills from reports and average ± SD volume	381; 0.12 ± 0.54 m^3
Number of spills with complete [i.e., wave height & visibility reported] weather description, out of total amount of spills (%)	262/381 (68.8%)
Number of spills occurring during the day, out of total number of spills with time provided	306/352 (86.9%)
Number of spills occurring at night, out of total number of spills with time provided	46/352 (13.1%)
Number of spills reported causing a sheen	241/381 (63.3%)
Number of spills reported causing a sheen during the day, out of total number of spills with time of spills provided	220/352 (62.5%)
Number of spills reported causing a sheen at night, out of total number of spills with time of spills provided	11/352 (3.1%)
Number of spills causing a sheen during daytime with good visibility, out of total number of daytime spills with time provided	109/306 (35.6%)
Number of spill reports providing time to dispersion (in minutes[a]) of a sheen, out of total number of spills where sheens were observed	6/241 (2.3%)
Number of spill reports with information[b] on seabirds, out of the total number of spills reported	17/381 (4.5%)
Number of spill reports with information[b] on seabirds, out of the total number of spills reported causing a sheen on the water during the day	11/220 (5.0%)
Number of spills that could have had a counter-measure[c] (i.e., spills during the day, with wave height ≤ 2 m, visibility ≥0.5 nm and visible sheen) and average ± SD volume	47/381 (12.3%); 0.005 ± 0.016 m^3
Number of spills that had a counter-measure[c] out of total number of spills that were potentially recoverable[d]	3/47 (6.4%)

[a] In two additional reports a qualitative statement was provided on sheen persistence.
[b] Either negative (i.e., seabirds not present in area) or positive observations.
[c] Counter-measure refers to the use of mechanical dispersion, boom deployment, and/or scaring birds (CAPP 2009).
[d] Overall, there were 21 occurrences where operators responded to spills, but, only three fell in the counter-measures window to allow a possible response.

volume = 4 m^3). The remaining six were missing weather or time of day information.

5.3. Spill form format and seabirds

There were different modes of communication (notes from phone calls, emails, faxes, pollution incident reports from Environment Canada etc.) and types of spill report forms (n = 33) from the operators and their contractors. Documents had different titles (e.g., "Flash Report", "Environmental Incident Report", "Incident Information Summary", "Environmental Incident and Number", "Hazardous Event Notifications", "LOC [Letter of Compliance] Event report"). The most frequently used form was the "Oil or Chemical Spill Notification Form" (n = 172). In total, three forms included a question on seabirds. Two forms (i.e., "Pollution Incident Report" and "Initial Incident Report") included the following questions: a) "Environmental Impact/ Consequences/ Number of Oiled Birds/ Number of Dead" (submitted form November 9, 2008); b) "Are there hazards to persons/property/wildlife, marine bird?" (submitted forms between December 1, 1999 to December 10, 1999); or c) "Figure for slick location, drift direction and presence of seabirds" (submitted forms between August 2, 2006 to January 5, 2007). Three additional forms had more general questions about environmental impact but did not reference seabirds specifically (i.e., "Probable coastal site and habitat at site impact?", "Information/observations of environmental impacts" or "Release or damage to the environment?"). In the last year of our dataset (2009–2010), the most commonly used forms were the "C-NLOPB — Incident Notification" form (n = 13) and the "Oil of Chemical Spill Notification Form" (n = 13), neither form asked for observations on seabirds.

6. Discussion

For three environmental assessments over a 15 year period, a regulatory authority, Environment Canada, repeatedly requested monitoring and mitigation for the possible impact of chronic oil spills on seabird populations. For two of the environmental assessments, the review panel/review Commissioner recommended plans to measure impacts of small spills on seabirds. However, based on the forms obtained evidence that these recommendations were implemented was lacking. Operators had three possible ways of responding, the first two must co-occur in order to have data on seabird and spill interactions (see Mosbech, 2000): 1) observe and record spill dispersion time (or time sheen drifts out of sight); 2) observe and record seabird presence or absence in the area while spill was present; and/or 3) deployment of boom or mechanical dispersion of oil. Of six reports that provided spill dispersion time, only one also provided information on seabirds. Hence, there were few data available to evaluate interactions even though most spills occurred, or were detected, during the daylight hours.

For this analysis, we used a conservative approach to assess the number of spills which could have had seabird observations or attempted a counter-measure: the visibility and wave height criteria were those identified by an independent review (Turner et al., 2010); and we assumed spill and seabird observations could only occur during the day. The spill data were crosschecked with the C-NLOPB. While potentially relevant data were redacted in the response/remedial action section in 14 reports, the missing information is unlikely to change the overall conclusions. The data used were the original reports submitted by the operators and would be the basis of any final reports submitted to the C-NLOPB. The C-NLOPB, in response to our request for information on spills that had trained observers (see Section 4 Materials and Methods) referred us to the spill reports, but noted that operators are not required to submit information on observer qualifications (see Section 3 Spill reporting and response).

The information in the reports was variable and inconsistent. Weather was not always included perhaps due to variation of reporting format (e.g., photocopying may not have included the page on weather for some reports; see also Baillie et al., 2005). However, consistent and standardized formatting is important for logistics, post-spill analyses and improving offshore operations (Christou and Konstantinidou, 2012). Since 2010, the C-NLOPB asked operators to use a standardized form, but the request still falls under guidelines (C-NLOPB, 2012). For spills less than 0.025 m^3, operators are asked to submit written notification via the form. The form allows operators to determine which factors are environmentally "relevant", and it does not specifically ask for observations on seabirds (or wildlife) or time of spill dispersion ("Description of site operations and relevant environmental factors at the time of the incident"; C-NLOPB, 2013). Thus, the lack of data is likely an ongoing issue. Missing data from reports probably resulted in an underestimate of the number of spills where countermeasures may have been deployed. At a minimum, 47 spills were within the countermeasure window. While the response plan identifies a number of variables which would be considered in deciding on a countermeasure (see Husky Oil Operations Ltd., 2000; CAPP, 2009), an effort to contain even a small spill provides an ongoing opportunity to evaluate the effectiveness of emergency plans (see Christou and Konstantinidou, 2012).

The industry's oil spill response plan clearly articulates the use of surveillance and monitoring for Tier 1 spills (CAPP, 2009), as well as following Canadian Wildlife Service's seabird survey protocol. There were few reports (Table 2) that included any information on seabird presence or absence during a daytime spill, and none provided evidence of following the seabird protocol. As individual operators' spill response plans appear to be protected under Sec. 119 of the Atlantic Accord Act (see Fraser and Ellis, 2008b), any further analysis at the operator level is not possible at this time. Without data on seabird presence or absence and sheen dispersion time, we are unable to make any conclusions on these interactions or estimate the cumulative impact upon seabirds from production operations (Kirby and Law, 2010; Krausman, 2011). Lack of estimated oiling rates also prevents Environment Canada from seeking compensation for seabird mortality (see Wiese, 2002; Canadian Wildlife Service, 2004; Robertson et al., 2012).

Spills from offshore oil platforms are perhaps proportionately a lower source of seabird mortality compared to other sources, though a regional comparison for all sources of oil pollution is lacking (Committee on Oil in the sea, 2003). For example, illegal ship-sourced discharges are a significant source of seabird mortality in NL with a mean annual estimate of 315,200 ± 45,600 (Wiese and Robertson, 2004; see also Wilhelm et al., 2009). Nonetheless, researchers have stressed the need for a better understanding of seabird mortality associated with small spills from oil and gas activities (Dicks et al., 1982; Burger, 1993; Montevecchi et al., 1999; Wiese et al., 2001; Fraser and Ellis, 2008a; Ellis et al., 2013; Ronconi et al., 2015); an issue clearly highlighted in the environmental assessment processes (Table 1). In cold water systems seabird mortality from hypothermia is linked to exposure to relatively small amounts of oil. For example, Jenessen and Ekker (1991) found a significant effect for eiders on water when exposed to 70 ml of oil (see also Jenessen, 1994 for review). O'Hara and Morandin (2010) found Hibernia crude and synthetic based drilling fluids (from Terra Nova) changed auk feather structure with a sheen thickness (>0.1 μm) and suggested mortality may result from these changes. The vulnerability to low concentrations of oil means even very small spills spread out over an area could cause seabird mortality. To assess the possible cumulative impact of 220 daytime small spills with sheens requires species-specific information on the frequency of exposure to those spills.

The environmental assessment processes for these projects allow other regulatory authorities to provide their expertise (van Driel and MacDonald, 2002; Erlandson Consulting Inc. and Petroleum Research Atlantic Canada, 2004). The concerns Environment Canada raised were reflected in the recommendations by two of the independent reviews (Table 1). From the recommendations compiled, several issues can be identified. First, the main emphasis of the spill predictions for all three projects was focused on large spills, despite Environment Canada's comments on small spills. Second, a clear response to the recommendations to address the issue of small spills was not always evident in the regulator's decision reports. Third, because approval for Oil Spill Response Plans occurred after the environmental impact statement phase, there was no public opportunity to understand how or if these plans met the recommendations and no associated level of acceptable risk was articulated (see Mosbech, 2000). As a result of the lack of data, future production environmental impact statement predictions will not be informed by previous experience (see ExxonMobil Properties Canada, 2012) and a weak environmental assessment process is perpetuated (Fraser et al., 2006; Fraser and Russell, in press).

Baillie et al. (2005; Environment Canada, plus one representative from industry) describe industry's participation in collecting bird abundance data from drilling rigs (from spring 2000 to end of 2002; Terra Nova), exploration activities (White Rose) and the Hibernia platform (1997–1998). The latter was "required" by the C-NOPB as part of the environmental assessment process (Baillie et al., 2005). The summary data provided seabird abundance (fall abundance ranging from 81 to 190 birds per day) and included observations of oiled birds (see also Burke et al., 2005), but none were linked with oil spills, thus we were unable to cross-reference spill reports. The authors evaluated the quality of the data collected by the operators and some recommendations were to: 1) collect oil spill "disturbances" with the seabird surveys; 2) ensure that dedicated observers be highly qualified and standardized; 3) standardize data collection; and 4) collect data that contributes towards measuring seabird densities (see also Montevecchi et al., 1999). Seabird densities using ship-based surveys (Gjerdrum et al., 2012) may be used to model population level impacts of small spills, but at minimum quality information on the spill behavior must also be collected (Mosbech, 2000).

Industry self-reporting has not contributed to understanding how small spills from production operations impact seabird populations (see also Burke et al., 2012). It is possible that the C-NLOPB has these data and is aware of these issues, but is constrained by the Atlantic Accord Act (i.e., Sec. 119, see Fraser and Ellis, 2008b and below) from divulging it. However, if this were the case, we would expect the new spill reporting form to address this issue (see above; C-NLOPB Incident Notification Form 2013). Unfortunately, there were so few reports of the presence or absence of seabirds that we could not analyze trends in reporting. To improve reporting standards, spill reports could be cross referenced with remote sensing or aerial surveillance efforts (Transport Canada, 2015); the latter could also be used for daytime seabird observations with qualified personnel using high quality imaging cameras (Duron et al., 2015). Ronconi et al. (2015) recommend the use of instrument based approaches (such as radar and thermal imaging which allow for night-time observations on seabirds) and independent observers to counteract the weakness of industry's self-reporting and positively impact the quality of reporting and the response system overall.

The independent reviews of the Terra Nova and White Rose production projects both recommended independent observers on platforms (Terra Nova Development Project Environmental Assessment Panel, 1997; Clarke, 2001; see also Natural History Society of Newfoundland and Labrador, 1997; Montevecchi et al., 1999; Burke et al., 2012). In the fishing industry observers provide standardized, unbiased data (e.g., Brooke, 2012). The oil and gas industry, supported by the regulator, has resisted calls for independent observers on production platforms (C-NOPB, 1997). However, the C-NOPB (1997:3) acknowledged that "in all of its decisions respecting the approval of activities in the Newfoundland Offshore Area, it has adopted an approach which is consistent with the definition of the precautionary principle…". With respect to third-party observers "The Board wishes to emphasize, however, that should such circumstances arise, it is fully prepared to adopt a different regulatory approach, including consideration of full-time on-site oversight of the operations concerned." (C-NOPB, 2001:139). We would argue that the analyses in this paper provide such a circumstance: trained independent observers, supported by instrument-based technologies (Ronconi et al., 2015) are the only and immediate way forward (see also Office of the Auditor General of Canada, 2012).

Placing independent observers on platforms would likely not result in data being publicly available because there are significant legislative obstacles that constrain the C-NLOPB from releasing such information (Sec.119 of the Atlantic Accord Act; see Fraser and Ellis, 2008b). After 2008, some data have been released (e.g., the data used in this paper). However, details of important documents cannot be discussed in public forums (e.g., spill response plans) and thus the Atlantic Accord Act remains a significant challenge in understanding the interactions and impacts of this industry on seabird populations.

The world-wide decline of many seabird populations requires a concerted effort to minimize all sources of adult mortality (see International Union for Conservation of Nature, 2012). Current and future offshore oil operations in regions with high seabird densities should use independent observers to collect data (Ronconi et al., 2015) on seabird density estimates, seabird behavior, seabird mortality associated with light attraction (Wiese et al., 2001; Montevecchi, 2006; Burke et al., 2012; Fraser, 2014; Fraser and Russell, in press) and oil spill behavior (Montevecchi et al., 1999). The data could be housed centrally (e.g., Seabird Information Network; World Seabird Union, ND) and aid our understanding of the proportional contribution of mortality that results from this industry.

Acknowledgements

This research was funded by a Social Science and Humanities Research Council Strategic Research Grant of Canada (#865-2008-0062).

This paper has benefitted from various conversations with: Angela Carter, Joanne Ellis, Bill Montevecchi, Laurence Packer, Janet Russell (Alder Institute) and Martin Renner, as well as comments provided from three reviewers. We thank C. Gjerdrum, Environment Canada, for the figure.

References

Armsworthy, S.L., Muecke, A., Cranford, P.J., 2003. Bedford Institute of Oceanography, Dartmouth, NS, May 26–30. Environmental research funds, report No. 160. Dartmouth, NS. Workshop on Offshore Oil and Gas Environmental Effects Monitoring.

Baillie, S.M., Robertson, G.J., Wiese, F.K., Williams, U.P., 2005. Seabird Data Collected by the Grand Banks Offshore Hydrocarbon Industry 1999–2002: Results, Limitations and Suggestions for Improvement. Canadian Wildlife Service Technical Report Series No. 434. Atlantic Region.

Baird, P.H., 1990. Concentrations of seabirds at oil-drilling rigs. Condor 92, 768–771.

Bernecker, T., Totterdell J., 2012. New petroleum opportunities for offshore petroleum exploration, 2012 Acreage release areas include Australia's southern margin. Australian Government, AUSGEO News Issue 106 June 2012. <http://www.ga.gov.au/webtemp/image_cache/GA20838.pdf> (11.09.2015).

Bretagnolle, V., Thomas, T., 1990. Seabird distribution between Tasmania and Adélie Land (Antarctica), and comparison with nearby Antarctic sectors. Emu 90 (2), 97–107.

Brooke, S.G., 2012. Federal fisheries observer programs in the United States: over 40 years of independent data collection. Mar. Fish. Rev. 76, 1–38.

Burger, A., 1993. Estimating the mortality of seabirds following oil spills: effects of spill volume. Mar. Pollut. Bull. 26 (3), 140–143.

Burke, C.M., Davoren, G.K., Montevecchi, W.A., Wiese, F.K., 2005. Offshore oil and gas environmental effects monitoring. In: Armsworthy, S.L., Cranford, P., Lee, K. (Eds.), Seasonal and Spatial Trends Along Support Vessel Transects and at Oil Platforms on the Grand Banks. Battelle, Columbus, Ohio USA, pp. 587–614.

Burke, C.M., Montevecchi, W.A., Wiese, F.K., 2012. Inadequate environmental monitoring around offshore oil and gas platforms on the Grand Bank of Eastern Canada: are risks to marine birds known? J. Environ. Manag. 104, 121–126.

Camphuysen, C.J., Heubeck, M., 2001. Marine oil pollution and beached bird surveys: the development of a sensitive monitoring instrument. Environ. Pollut. 112, 443–461.

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), 2011. C-NLOPB responding to SBM spill by Husky Energy, September 20, 2011, <http://www.cnlopb.ca/incidents/ib_sep202011.php> (12.09.2015).

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), 2015(. Decision 2015.07, White Rose extension project development application. C-NLOPB; St. John's, NL, Canada.

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), 2012. Incident reporting and investigation guidelines, Nov. 30, 2012. C-NLOPB; St. John's, NL, Canada. <http://www.cnlopb.ca/pdfs/guidelines/incrptgl.pdf > (03.02.2016).

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), 2016. Mandate and objectives. C-NLOPB; St. John's, NL, Canada. <http://www.cnlopb.ca/about/mandate.php> (1.31.2016) (NDa).

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), 2016. Incident notification form. C-NLOPB; St. John's, NL, Canada. <http:www.cnlopb.ca/pdfs/forms/incident_notification.doc> (25.08.2015) (2013).

Canada-Newfoundland and Labrador Offshore Petroleum Board (C-NLOPB), Environment Canada, 2015. Memorandum of understanding between Canada-Newfoundland and Labrador Offshore Petroleum Board and Environment Canada. C-NLOPB; St. John's, NL, Canada <http://www.cnlopb.ca/pdfs/mous/mouec.pdf> (25.08.2015).

Canada-Newfoundland Offshore Petroleum Board (C-NOPB), 1988. Memorandum of understanding. Among CNOPB, Environment Canada, Department of Energy, Mines and Resources, the Newfoundland and Labrador Department of Environment and Lands, the Newfoundland and Labrador Department of Energy, the Newfoundland and Labrador Intergovernmental Affairs Secretariat concerning the provision of environmental services in the Newfoundland Offshore Area, 1988. St. John's, NL 19 pp.

Canada-Newfoundland Offshore Petroleum Board (C-NOPB), 1996. Memorandum of understanding concerning the environmental assessment of the Terra Nova development. Among the C-NOPB, the Minister of the Environment, the Minister of Natural Resources, the Minister of Environment and Labour, the Minister of Mines and Energy (NL) and the Premier as Minister responsible for Intergovernmental Affairs (NL). June 17, 1996.

Canada-Newfoundland Offshore Petroleum Board (C-NOPB), 1986. Decision 86.01, application for approval Hibernia development plan. June, 1986. C-NOPB; St. John's, NL, Canada.

Canada-Newfoundland Offshore Petroleum Board (C-NOPB), 1997. Decision 97.02, application for approval, Terra Nova development plan. December 1997. C-NOPB; St. John's, NL, Canada. <http://www.cnlopb.ca/news/pdfs/d97_02e.pdf> (11.09.2015).

Canada-Newfoundland Offshore Petroleum Board (C-NOPB), 2001. Decision 2001.01, application for approval White Rose development plan. Nov, 2001. C-NOPB; St. John's, NL, Canada. ISBN: 0-921569-35-1. < http://www.cnlopb.ca/news/nr20011219eng.php> (02.26.2016).

Canadian Association of Petroleum Producers (CAPP), 2009. Marine hydrocarbon spill response capability assessment. Jeanne d'Arc production operation, <http://www.cnlopb.ca/pdfs/sr/oilassrep.pdf> (13.08.2015).

Canadian Wildlife Service, 2004. Environmental Assessment Best Practice Guide for Wildlife at Risk in Canada, First edition. Environment Canada. <http://www.sararegistry.gc.ca/virtual_sara/files/policies/EA%20Best%20Practices%202004.pdf> (02.08.2016).

Canadian Wildlife Service, 2012. Canadian Wildlife Service response plan guidance. Draft June 2012. <http://www.cnlopb.ca/pdfs/mkias/cwsresponseplan.pdf> (01.31.2016).

Christou, M., Konstantinidou, M., 2012. Safety of Offshore Oil and Gas Operations: Lessons from Past Accident Analysis. Ensuring EU Hydrocarbon Supply Through Better Control of Major Hazards. Joint research centre of the European Commission. Publications Office of the European Union; Luxembourg. DOI:http://dx.doi.org/10.2790/73321 <http://publications.jrc.ec.europa.eu/repository/bitstream/JRC77767/offshore-accident-analysis-draft-final-report-dec-2012-rev6-online.pdf> (02.06.2016).

Clarke, H.M., September 2001. Report of the Public Review Commissioner for the White Rose Development Application. Submitted to Minister of Natural Resources Government of Canada. Minister of Mines and Energy Government of Newfoundland and Labrador, Chairman Canada-Newfoundland Offshore Petroleum Board.

Committee on Oil in the Sea, 2003. Oil at Sea III: Inputs, Fates and Effects. Committee on Oil in the Sea: Inputs, Fates, and Effects; Ocean Studies Board; Marine Board; Transportation Research Board; Division on Earth and Life Studies. National Research Council, Washington, D.C., USA http://dx.doi.org/10.17226/10388.

Cuthbert, R.J., Sommer, E.S., 2004. Population size and trends of four globally threatened seabirds at Gough Island, South Atlantic Ocean. Mar. Ornithol. 32, 97–103.

Dicks, B., Hartley, J.P., Straughan, D., Clark, R.B., 1982. The effects of repeated small oil spillages and chronic discharges [and discussion]. Philos. Trans. R. Soc. B Biol. Sci. 297, 285–306.

Duron, C., Connelly, E., Stenhouse, I., Williams, K., 2015. High resolution digital video aerial survey data protocols. Chapter 4 in. Final Report to the Department of Energy and Wind and Water Power Technologies Office 2015. Biodiversity Research Institute Report (BRI ID # 2015-11) submitted to: Department of Energy, Washington DC, USA. <http://www.briloon.org/uploads/Library/item/427/file/MABS%20Project%20Chapter%204%20-%20Duron%20et%20al%202015.pdf> (02.29.2016).

Ellis, J.I., Wilhelm, S.I., Hedd, A., Fraser, G.S., Robertson, G.J., Rail, J.F., Fowler, M., Morgan, K.H., 2013. Mortality of migratory birds from marine commercial fisheries and offshore oil and gas production in Canada. Avian Cons. Ecol. 8 (2), 4. http://dx.doi.org/10.5751/ACE-00589-080204.

Environment Canada, 1985. Environment Canada review of the Hibernia development project as presented to the Hibernia Environmental Assessment Panel July 1985, Scientific and Technical Comments. St. John's, NL, Canada.

Environment Canada, 1997. Environment Canada's panel submission to the Terra Nova project environmental assessment Panel April 14, 1997 File # 4194-22-70/T3. St. John's, NL, Canada.

Erlandson Consulting Inc.,Petroleum Research Atlantic Canada, 2004d. A regulatory roadmaps project. Offshore Oil and Gas Approvals in Atlantic Canada: a Guide to Regulatory Approval.

ExxonMobil Canada Properties, 2011. Hebron Project, Comprehensive Study Report, September 2011. St. John's, NL, <http://www.cnlopb.ca/assessments/hebron.php> (11.09.2015).

ExxonMobil Canada Properties, September 2012. Hebron Project Final Comprehensive Study Report.

Fraser, G.S., 2014. Offshore oil and gas development impacts on marine wildlife resources. In: Gates, J.E., Trauger, D.L., Czech, B. (Eds.), Peak Oil, Eonomic Growth, and Wildlife Conservation. Springer, New York, NY, USA, pp. 191–217.

Fraser, G.S., Ellis, J., 2008a. Offshore hydrocarbon and synthetic hydrocarbon spills in Eastern Canada: the issue of follow-up and experience. J. Environ. Assess. Policy Manage. 10, 173–187.

Fraser, G.S., Ellis, J., 2008b. The Canada-Newfoundland Atlantic accord implementation act: transparency of the environmental management of the offshore oil and gas industry. Mar. Policy 33 (2), 312–316.

Fraser, G.S., Ellis, J., 2008c. Reply from Gail Fraser and Joanne Ellis to a letter from C-NLOPB. J. Environ. Assess. Policy Manage. 10, 475–481.

Fraser, G.S., Ellis, J., Hussain, L., 2008. An international comparison of governmental disclosure of hydrocarbon spills from offshore oil and gas installations. Mar. Pollut. Bull. 56, 9–13.

Fraser, G.S., Russel, J., 2016. Following up on uncertain environmental assessment predictions: the case of offshore oil projects and seabirds off Newfoundland and Labrador. J. Environ. Assess. Policy Manage. 18 (1) (in press).

Fraser, G.S., Russell, J., von Zharen, W.M., 2006. Produced water from offshore oil and gas installations on the Grand Banks, Newfoundland and Labrador: are the potential effects to seabirds sufficiently known? Mar. Ornithol. 34, 147–156.

Gjerdrum, C., Fiefield, D.A., Wilhelm, S.I., 2012. Eastern Canada at Sea (ECSAS) Standardized Protocol for Pelagic Seabird Surveys from Moving and Stationary Platforms. Canadian Wildlife Service Technical Report Series No. 515. Atlantic Region.

Government of Canada, 1987. Canada Newfoundland and Labrador Atlantic Accord Implementation Act, <http://laws-lois.justice.gc.ca/eng/acts/c-7.5/> (24.08.2015).

Government of Canada, 1985. Access to Information Act, <http://laws.justice.gc.ca/en/A-1/> (02.03. 2016).

Government of Canada, 1994. Migratory Bird Convention Act, <http://laws-lois.justice.gc.ca/eng/acts/M-7.01/> (02.03. 2016).

Government of Canada, 2010. Newfoundland Offshore Petroleum Drilling and Production Regulations (consolidation), SOR/2009-316. Minister of Justice. <http://www.cnlopb.ca/pdfs/regulations/drillprodregs.pdf> (02.03.2016).

Hibernia Development Project, 1985. Report of the Environmental Assessment Panel St. John's, NL, Canada.

Hibernia Management and Development Company, 2009. Hibernia Drill Centres Construction and Operations Program, Screening Report. 24 July 2009: St. John's. http://www.cnlopb.ca/pdfs/hibdrill/hibeareportfinal.pdf (02.03.2016).

House of Assembly NL, 2010. House of Assembly Proceedings, June 1, 2010, Vol XLVI, No. 30. http://www.assembly.nl.ca/business/hansard/ga46session3/10-06-01.htm (02.03.2016).

Hunt Jr., G.L., 1987. Offshore oil development and seabirds: the present status of knowledge and long-term research needs. In: Boesch, D.F., Rabalais, N.N. (Eds.), Long-Term Environmental Effects of Offshore Oil and Gas Development. Elsevier Applied Science, New York, NY, USA, pp. 539–586.
Husky Oil Operations Limited, 2000. White Rose Development Environmental Complete Comprehensive Study, Part I. St. John's, NL. http://www.cnlopb.ca/pdfs/wrda_vol3_vol4.pdf (11.09.2015).
Husky Oil Operations Limited, 2001. Responses to comments from Canada-Newfoundland Offshore Petroleum Board, Department of Fisheries and Oceans, Environment Canada, Natural Resources Canada and Canadian Environmental Assessment Agency. April 2001. St. John's, NL, CAN. White Rose Oilfield Comprehensive Study Supplemental Report.
International Union for Conservation of Nature, 2012. Worrying declines for world's seabirds. <http://www.iucn.org/?9359/Worrying-declines-for-worlds-seabirds> (02.03.2016).
Jenessen, B.M., 1994. Review article: effects of oil pollution, chemically treated oil, and cleaning on the thermal balance of birds. Environ. Pollut. 86, 207–215.
Jenessen, B.M., Ekker, M., 1991. Dose dependent effect of plumage oiling on thermoregulation of common eiders *Somateria mollissima* residing in water. Polar Res. 10, 579–584.
Jenssen, B.M., Ekker, M., Bech, C., 1985. Thermoregulation in a naturally oil-contaminated black-billed murre *Uria aalge*. Bull. Environ. Contam. Toxicol. 35, 9–14.
Kålås, J.A., Viken, Å., Henriksen, S., Skjelseth, S., 2010. The 2010 Norwegian Red List for Species.
Krausman, P.R., 2011. Quantifying cumulative effects. In: Krausman, P.R., Harris, L.K. (Eds.), Cumulative Effects in Wildlife Management. CRC Press, New York, N.Y., USA, pp. 47–64.
Kirby, M.F., Law, R.J., 2010. Accidental spills at sea—risk, impact, mitigation and the need for co-ordinated post-incident monitoring. Mar. Pollut. Bull. 60, 797–803.
Lock, A.R., Brown, R.G.B., Gerriets, S.H., 1992. Gazetteer of the marine birds in Atlantic Canada. Canadian Wildlife Service 137.
Lock, A.R., Brown, R.G.B., Gerriets, S.H., 1994. Gazetteer of Marine Birds in Atlantic Canada: an Atlas of Seabird Vulnerability to Oil Pollution. Canadian Wildlife Service. Environmental Conservation Branch, Environment Canada Atlantic Region.
McCrary, M.D., Panzer, D.E., Pierson, M.O., 2003. Oil and gas operations offshore California: status, risks, and safety. Marine Ornithol. 31, 43–49.
Mineral Management Services, 2007. Gulf of Mexico OCS oil and gas lease sales: 2007–2012. Western Planning Area Sales 204, 207, 210, 215, and 218; Central Planning Area Sales 205, 206, 208, 213, 216, and 222. Final Environmental Impact Statement, Volume II: Figures and Tables. OCS EIS/EA MMS 2007-018.
Mosbech, A., 2000. Predicting Impacts of Oil Spills—can Ecological Science Cope? A Case Study Concerning Birds in Environmental Impact Assessments. National Environmental Research Institute, Denmark 126 pp.
Mobil Oil, 1985. Hibernia Development Project Environmental Impact Statement. Mobil Oil, St. Johns, NL, CAN.
Montevecchi, W.A., 2006. Influences of artificial light on marine birds. In: Rich, C., Longcore, T. (Eds.), Ecological Consequences of Artificial Night Lighting. Island Press, Washington, DC, USA, pp. 94–113.
Montevecchi, W.A., Tuck, L.M., 1987. Newfoundland Birds: Exploitation, Study, Conservation, Publication of the Nuttall Ornithological Club, 21 Nuttall Ornithological Club.
Montevecchi, W., Wiese, F., Davoren, G., Diamond, A., Huettmann, F., Linke, J., 1999. Seabird Attraction to Offshore Platforms and Seabird Monitoring from Offshore. Support Vessels and Other Ships: Literature Review and Monitoring Designs Environmental Studies Research Funds, No. 138. Canadian Association of Petroleum Producers; Calgary, AB, Canada.
National Energy Board, Canada-Newfoundland, Labrador Offshore Petroleum Board, Canada-Nova Scotia Offshore Petroleum Board, 2011. Environmental Protection Plan Guidelines. March 31, 2011. <http://www.cnlopb.ca/pdfs/guidelines/env_pp_guide.pdf> (02.03.2016).
Natural History Society of Newfoundland and Labrador, 1997. Comments Submitted to the Terra Nova Environmental Assessment Panel. St. John's, NL, Canada.
Office of the Auditor General of Canada, 2012. Report of the Commissioner of the Environment and Sustainable Development. CHAPTER 1 Atlantic Offshore Oil and Gas Activities <http://www.oag-bvg.gc.ca/internet/docs/parl_cesd_201212_01_e.pdf> (02.03.2016).
O'Hara, P.D., Morgan, K.H., 2006. Do low rates of oiled carcass recovery in beached bird surveys indicate low rates of ship-source oil spills? Mar. Ornith. 34, 133–140.
O'Hara, P.D., Morandin, L.A., 2010. Effects of sheens associated with offshore oil and gas development on the feather microstructure of pelagic seabirds. Mar. Pollut. Bull. 60, 672–678.
Ollason, J.G., Bryant, A.D., Davis, P.M., Scott, B.E., Tasker, M.L., 1997. Predicted seabird distributions in the North Sea: the consequences of being hungry. ICES J. Mar. Sci. 54, 507–517.
Pakhomov, E.A., McQuaid, C.D., 1996. Distribution of surface zooplankton and seabirds across the Southern Ocean. Polar Biol. 16 (4), 271–286.
Petro Canada, 1997. Terra Nova Development: offshore Petroleum Project, Environmental Impact Statement Petro-Canada, St. John's, NL, Canada.
Piatt, J.F., Carter, H.R., Nettleship, D.N., 1991. The effects of oil on wildlife. Proceedings from: The Oil Symposium Oct 16–18, 1990; Herndon, VR, USA. Effects of Oil Pollution on Marine Bird Populations.
Renner, M., Kuletz, K.J., 2015. A spatial-seasonal analysis of the oiling risk from shipping traffic to seabirds in the Aleutian archipelago. Mar. Pollut. Bull. 101, 127–136.
Robertson, G.J., Fifield, D.A., Montevecchi, W.A., Gaston, A.J., Burke, C.M., Byrne, R., Elliott, K.H., Gjerdrum, C., Gilchrist, H.G., Hedd, A., Mallory, M.L., McFarlane Tranquilla, L., Regular, P.M., Ryan, P.C., Smith, P.A., Wilhelm, S.I., 2012. Miniaturized data loggers and computer programming improve seabird risk and damage assessments for marine oil spills in Atlantic Canada. J. Ocean Technol. 7, 42–58.
Ronconi, R.A., Allard, K.A., Taylor, P.D., 2015. Bird interactions with offshore oil and gas platforms: review of impacts and monitoring techniques. J. Environ. Manag. 147, 34–45. http://dx.doi.org/10.1016/j.jenvman.2014.07.031.
Tasker, M.L., Jones, P.H., Blake, B.F., Dixon, T.J., Wallis, A.W., 1986. Seabirds associated with oil production platforms in the North Sea. Ringing Migr. 7, 7–14.
Taylor, G.A., 2000. Action Plan for Seabird Conservation in New Zealand. Part A: Threatened Seabirds, Department of Conservation, Wellington, <http://www.doc.govt.nz/documents/science-and-technical/TSOP16.pdf> (11.09.2015).
Terra Nova Development Project Environmental Assessment Panel, 1997n. Minister of public works and Government Services Canada, August 1997. Report of the Terra Nova Project Environmental Assessment Panel ISBN 0-662-25908-4. Cat. No.: En105-55/1997E.
Transport Canada, 2015. Spill Prevention: National Aerial Surveillance Program. <https://www.tc.gc.ca/eng/marinesafety/oep-ers-nasp-2195.htm> (02.29.2016).
Turner, M., Skinner, J., Roberts, J., Harvey, R., S.L. Ross Environmental Research Ltd., 2010. Review of offshore oil-spill prevention and remediation requirements and practices in Newfoundland and Labrador. St John's, NL Government of Newfoundland and Labrador, <http://www.cnlopb.ca/pdfs/sr/turnerrep.pdf> (11.09.2015).
Van Driel, G., MacDonald, A., 2002. Environmental regime for development of an oil and gas project in the Newfoundland offshore. Alberta Law Review 40, 131–164.
White, R.W., Gillon, K.W., Black, A.D., Reid, J.B., 2002. The Distribution of Seabirds and Marine Mammals in Falkland Islands Waters. Joint Nature Conservation Committee, <http://jncc.defra.gov.uk/pdf/pubs02_Falklands_Print.pdf> (11.09.2015).
Wilhelm, S.I., Robertson, G.J., Ryan, P.C., Tobin, S.F., Elliot, R.D., 2009. Re-evaluating the use of beached bird oiling rates to assess long-term trends in chronic oil pollution. Mar. Pollut. Bull. 58, 249–255.
Wilhelm, S.I., Robertson, G.J., Ryan, P.C., Schneider, D.C., 2007. Comparing an estimate of seabirds at risk to a mortality estimate from the November 2004 Terra Nova FPSO oil spill. Mar. Pollut. Bull. 54, 537–544.
Wiese, F.K., 2002. Report for World Wildlife Fund. WWF; Toronto, ON, Canada. Seabirds and Oil Pollution: Impacts, Trends, and Solutions.
Wiese, F.K., Montevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W., Linke, J., 2001. Seabirds at risk around offshore oil platforms in the north-west Atlantic. Mar. Pollut. Bull. 42, 1285–1290.
Wiese, F.K., Jones, I.L., 2001. Experimental support for a new drift-block design to assess seabird mortality from oil pollution. Auk 118, 1062–1068. DOI: http://dx.doi.org/10.1642/0004-8038(2001)118[1062:ESFAND]2.0.CO;2
Wiese, F.K., Robertson, G.J., 2004. Assessing seabird mortality from chronic oil discharges at sea. J. Wildl. Manag. 68, 627–638.
Wiese, F.K., Ryan, P.C., 2003. The extent of chronic marine oil pollution in southeastern Newfoundland waters assessed through beached bird surveys 1984-1999. Mar. Pollut. Bull. 46, 1090–1101.
Wooller, R.D., Bradley, J.S., Croxall, J.P., 1992. Long-term population studies of seabirds. Trends Ecol. Evol. 7, 111–114. http://dx.doi.org/10.1016/0169-5347(92)90143-Y
Wong, S.N.P., Gjerdrum, C., Morgan, K.H., Mallory, M.L., 2014. Hotspots in cold seas: the composition, distribution, and abundance of marine birds in the north American Arctic. J. Geophys. Res. Oceans 119 (3), 1691–1705.
World Seabird Union, 2016. Seabird Information Network. http://www.seabirds.net/seabirdinfonetwork.html (01.03.2016). (ND).