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Inadequate environmental monitoring around offshore oil and gas platforms on the Grand Bank of Eastern Canada: Are risks to marine birds known?

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ABSTRACT

Petroleum exploration and production on the Grand Bank of eastern Canada overlaps with productive marine habitat that supports over 40 million marine birds annually. Environmental assessments for oil and gas projects in the region predict insignificant adverse effects on marine birds from oil spills, incineration in platform flares and collisions. Limited baseline data on seasonal occupancies and a failure to quantify the nature and extent of marine bird attraction to platforms and related mortality undermines these assessments. We conducted 22 surveys to offshore platforms on the Grand Bank during 1999–2003 to measure avian associations with platforms and to determine the level of monitoring needed to assess the risks to marine birds. We document seasonal shifts in marine bird occurrences and higher densities of auks (fall) and shearwaters (summer) around platforms relative to surrounding areas. The limited temporal and spatial coverage of our surveys is more robust than existing industry monitoring efforts, yet it is still inadequate to quantify the scale of marine bird associations with platforms or their associated mortality risks. Systematic observations by independent biologists on vessels and platforms are needed to generate reliable assessments of risks to marine birds. Instead, the regulatory body for offshore oil and gas in eastern Canada (Canada – Newfoundland and Labrador Offshore Petroleum Board; C-NLOPB) supports industry self-reporting as the accepted form of environmental monitoring. Conflicting responsibilities of oil and gas regulatory agencies for both energy development and environmental monitoring are major barriers to transparency, unbiased scientific inquiry and adequate environmental protection. Similar conflicts with the oil and gas regulatory body in the United States, the former Minerals and Management Service (MMS) were identified by the U.S. President as a major contributor to the Deepwater Horizon disaster in the Gulf of Mexico. The MMS has since been restructured into the Bureau of Ocean Energy Management, (BOEM) with separate departments responsible for drilling leases and the regulation of drilling activities. Similar restructuring of the oil and gas regulatory bodies in Canada is needed for better public information, scientific investigation and environmental protection in the offshore.

1. Introduction

The Grand Bank of eastern Canada is one of the most productive marine ecosystems in the North Atlantic Ocean. The unique Low Arctic oceanographic regime supports globally and regionally significant populations of marine birds (Cairns et al., 1987; Locke et al., 1994) including long-distance migrants from high latitudes in the North and South Atlantic (Nettleship and Birkhead, 1985; Brown, 1986; Montevecchi and Tuck, 1987). The Grand Bank has also emerged as an important region for hydrocarbon reserves, containing 4 of the 11 most significant oil discoveries in North America (>16 million cubic meters of recoverable reserves; CNOPB 2002). Three fields are currently in operation (Hibernia, Terra Nova, White Rose) producing a combined 500,000 barrels of oil per day (LGL Limited, 2005). The deepest subsurface well in Canadian history (2.6 km below the surface) was drilled in April 2010 on the Orphan Basin on the northeastern edge of the continental shelf (Appendix 1; Fig S1) and more exploratory deep-water drilling is planned for the area.

Environmental assessments (EAs) of offshore oil and gas projects on the Grand Bank predict nonsignificant adverse effects

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on seabirds from oil spills < 1000 barrels, incineration in platform flares and collisions with lighted structures (Mobil Oil, 1985; Petro-Canada, 1997; LGL, 2005; Husky Oil, 2007). The validity of these predictions (and the measure of comfort they provide) are confounded by reliance on inadequate baseline data on seasonal fluctuations in the seabird densities and species compositions around offshore platforms (Montevecchi et al., 1999; Burke et al. 2005), in addition to a lack of systematic assessments of marine bird attraction to platforms (Harris, 1997).

Marine birds are attracted to offshore platforms due to enhanced foraging opportunities (Ortego, 1978; Burke et al., 2005), oceanographic processes (Fedoryako, 1982) and artificial light (Bourne, 1979; Russell, 2005; Montevecchi, 2006). Patterns of attraction across species and seasons are rarely quantified and reports of mortality due to oil pollution, flaring and collisions with lighted structures remain largely anecdotal. By exception a multi-year, highly standardized survey conducted by observers on oil and gas platforms in the Gulf of Mexico documented nocturnal collisions of migratory birds and found this to be a significant source of mortality during fall migration (Russell, 2005). There are anecdotal reports of birds dying after flying into flares on the Grand Bank (storm-petrels and Dovekies; Wood, 1999) but the episodic nature of these events makes them extremely difficult to document without robust monitoring programs that target sensitive periods (e.g., migration).

Oil on the water around platforms also poses a significant risk for marine birds as it destroys the insulative properties of feathers (O'Hara and Morandin, 2010) and even small spills can potentially kill large numbers of birds (Burger and Fry, 1993). Diving auks (Thick-billed Murres *Uria lomovia*, Common Murres *Uria aalge*, Dovekies *Alle alle*) that forage from the surface are the most vulnerable seabirds to oil pollution (Montevecchi and Tuck, 1987; Wiese and Ryan, 1999). Massive concentrations of auks occupy the Grand Bank (Brown, 1986; Locke et al., 1994), and new information from tracking studies show a strong overlap between murre winter habitat and hydrocarbon fields on the Grand Bank (Hedd et al., 2011). The importance of the Grand Bank as non-breeding winter habitat for murres has not been adequately highlighted in existing EAs and misconceives potential adverse effects of oil spills on these vulnerable seabirds.

The research reported here is the only independent assessment of the associations of marine birds with offshore platforms on the Grand Bank of eastern Canada since the hydrocarbon production began in 1997 up until 2005 when Environment Canada initiated a pelagic seabird-monitoring program (Eastern Canadian Seabirds at Sea; ECSAS). Our objectives are to 1) define seasonal patterns in the species composition and densities of marine birds in the offshore region of the Grand Bank, 2) investigate the nature and extent of marine birds associations with offshore platforms, and 3) address why monitoring protocols need to be restructured to effectively detect and mitigate marine bird mortality.

2. Methods

2.1. Study area and design

Vessel surveys were conducted over 5 years (1999–2003) along transects between St. John's, Newfoundland and platforms on the Grand Bank (Fig 2). The Hibernia platform (46.75° N, 48.80° W; 315 km east of St. John's) is a 224 m high gravity-based platform situated in 80 m of water. During the 5 years of surveys, Hibernia was the most frequently visited platform (13 of 21 surveys; Appendix 1; Table S1). Three semi-submersible, exploratory drill platforms (Bill Shoemaker 46.83°N, 48.06° W; Glomar Grand Banks 46.46°N, 48.49°W; Sedco 46.63°N, 48.41°W; Fig. 1) were visited less frequently with most surveys occurring during 1999–2000 (Appendix 1; Table S1).

All surveys were conducted from Maersk support vessels (82.5 m length, ~35 m height) that traveled a mean (±SD) speed of 18.4 ± 4.3 km h^{-1}. While the vessel was in transit, all birds within a 300 m, 90° viewing arc from the bow to either the port or starboard side was recorded (Tasker et al., 1984; Heinemann, 1981). Experienced observers counted seabirds by naked eye and binoculars and identified seabirds to species whenever possible. Birds were recorded as flying or on the water. Data were entered into a GPS-interfaced computer (D. Senciall, Birds and Beasty Counter, 1998, Fisheries and Oceans Canada, version 1.0) that appended GMT, latitude and longitude to each observation. Observations were grouped into a series of continuous 5 min observation periods (termed watches), the total number of which reflect effort across surveys (Appendix 1; Table S1). Within trips, survey coverage along the vessel route varied according to the available hours of daylight and changes in visibility due to weather (fog, precipitation and wave height).

2.2. Seasonal and spatial patterns

We present seasonal seabird densities collected in the offshore region of the survey area (defined as east of 50°W longitude) where baseline data on the seasonal composition and abundance of marine birds is very limited. Seasons are defined as: summer (1 July–15 September), fall (16 September–31 October), winter (1 November–31 March) and spring (1 April–31 June). More common species are categorized by groups: large tubenoses (shearwaters/fulmars), auks (murres, dovekies, puffins) and gulls (gulls, kittiwakes).

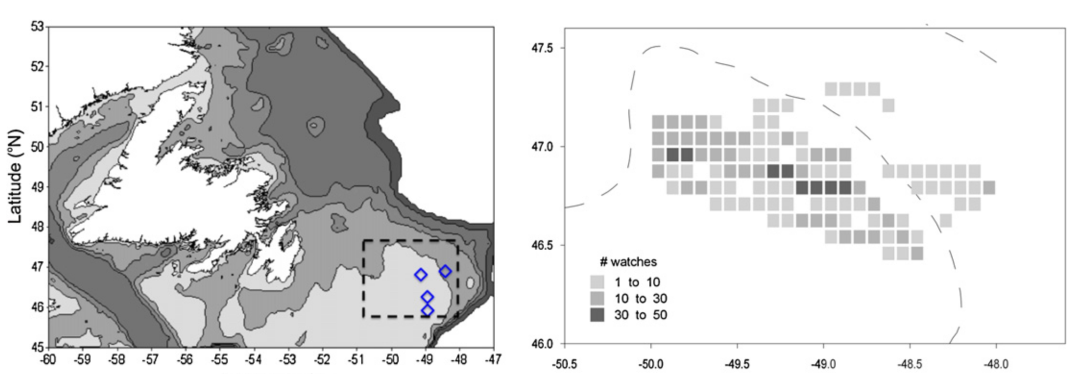

Fig. 1. Chart of the study area on the Grand Bank. The major (>100,000 bp) seabird colonies (red stars) and depth contours (m) are indicated. The insert shows the survey coverage in the offshore area and survey effort (# of continuous 5 min watches) per bin size. Blue symbols show the location of the platforms visited (1 = Hibernia, 2 = Bill Shoemaker, 3 = Sedco-714 and 4 = Glomar Grand Banks). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

For each season, spatiotemporal patterns are assessed using mean bird densities (birds/km^2) within 5 min lat × 5 min long bins, corrected for survey effort (i.e. number of watches per 5 min lat × 5 min long bin; Fig. 1). Density estimates are given for birds on the water only (flying birds excluded), as these have been shown to be most useful in assessing birds at risk of oiling (Fifield et al., submitted for publication). Mean densities of species groups are reported as mean ± SE (95% CI), and differences across seasons were tested using ANOVA (Minitab), alpha level < 0.05.

To investigate the attraction of marine birds to offshore platforms we assessed bird densities as a function of distance from platforms using a regression analysis for each species group (large tubenoses, auks, gulls). High variances and the frequency of zeros (typical of bird count data) required a negative binomial distribution (with a logit link) executed in R software. Because different platforms were visited across years and seasons (Appendix 1; Table S1), analyses were run separately for each platform.

2.3. Stationary surveys at offshore platforms

To characterize more detailed associations between birds and the Hibernia platform, we conducted stationary scans during daylight hours when vessels were within 500 m of the platform. Systematic scans at platforms were conducted during fall, winter and spring only. On the hour, a 360° scan range around the vessel was carried out for 15 min during which all seabirds within 500 m were recorded. Flying birds were recorded separately to differentiate from birds directly associated with installations. Seabirds observed around the platform were grouped according to species groups and foraging guilds (surface-feeders, divers) and roosting behavior was quantified by separating birds observed “on the platform” or “on water”. Counts were sorted by season and described as the mean number (±SE) and range (min–max) of species groups observed over all scans.

3. Results

During 1999–2003, 22 surveys were conducted, covering 2810 km of offshore transect (Appendix 1; Table S1). Survey effort was variable among seasons with the highest number of surveys in summer (1510 km; $n = 686$ watches) and the lowest during winter due to inclement weather (356.8 km; $n = 128$ watches).

3.1. Marine bird abundance

We observed a total of 9548 marine birds, 9511 identified to 16 species (Table 1). Great Shearwaters *Puffinus gravis* were the most abundant species (39.4% by number) followed by Common Murres *Uria aalge* (16.6%). Northern Fulmars *Fulmarus glacialis* and Great Black-backed Gulls *Larus marinus* had the highest occurrences (present during 19 and 20 surveys respectively). Fourteen species accounted for <10% of all birds and 10 of these were rare, comprising < 1% of birds recorded (Table 1).

3.2. Seasonal and spatial patterns of marine birds offshore

Seasonal densities of birds on the water according to species groups are shown in Fig. 2. Densities of large tubenoses (dominated by Greater Shearwaters) were highest during summer (3.8 ± 2.9 birds/km^2) with no significant seasonal effect ($F_{1, 220} = 1.72$; $p = 0.19$; Fig. 2). Auk densities were significantly higher during winter (7.6 ± 2.1 birds/km^2; $F_{1,220} = 7.9$; $p = 0.005$), accounting for the highest densities of birds on the water in any season. Gull densities peaked during fall (1.10 ± 0.66 birds/km^2) with no significant seasonal differences ($F_{1, 220} = 0.79$; $p = 0.37$). There were no records of small tubenoses on the water. The highest numbers of Leach’s Storm-Petrels (flying only) were observed during fall surveys (0.04 ± 0.04 birds/km^2).

Large tubenoses were patchily distributed and concentrated primarily west of shelf edge (denoted by the 100 m contour line; Fig. 3A). High densities (10–100 birds/km^2), made up mostly by Great Shearwaters were observed near the Hibernia (49.8 birds/km^2) and SEDCO platforms (27.7 birds/km^2). There was a significant positive relationship between shearwater density and proximity to the SEDCO platform during summer ($p = 0.04$; Table 2).

The highest concentrations of auks were distributed west of the continental shelf edge (Fig. 3B), and significantly higher densities of auks were found in proximity to Hibernia during fall ($p = 0.03$) and to the Glomar Grand Banks during summer ($p = 0.04$).

Table 1
Relative occurrence (no. cruises) and abundance of marine birds recorded offshore during 22 cruises in the offshore region of the Grand Bank, 1999–2003.

Family	Species	Taxonomic name	No. cruises	No. birds	% Number
Procellariidae Large Tubenoses	Northern Fulmar	*Fulmarus glacialis*	20	479	5
	Great Shearwater	*Puffinus gravis*	15	3759	39.4
	Sooty Shearwater	*Puffinus griseus*	16	298	3.1
	Manx Shearwater	*Puffinus puffinus*	4	10	0.1
Hydrobatidae Small Tubenoses	Wilson’s Storm-Petrel	*Oceanites oceanicus*	2	20	0.2
	Leach’s Storm-Petrel	*Oceanodroma leucorhoa*	17	1135	11.9
Alcidae Auks	Dovekie	*Alle alle*	9	184	1.9
	Common Murre	*Uria aalge*	7	1588	16.6
	Common Murre Fledgling		4	51	0.5
	Thick-billed Murre	*Uria lomvia*	9	830	8.7
	Black Guillemot	*Cepphus grylle*	2	3	0
	Atlantic Puffin	*Fratercula arctica*	15	298	3.1
Laridae Gulls	Black-legged Kittiwake	*Rissa tridactyla*	17	649	6.8
	Ring-billed Gull	*Larus delawarensis*	1	1	0
	Herring Gull	*Larus argentatus*	16	20	0.2
	Glaucous Gull	*Larus hyperboreus*	3	8	0.1
	Great Black-backed Gull	*Larus marinus*	19	178	1.9
		Total Identified Birds		***9511***	
Unidentified	*Storm-Petrels*		*1*	11	0.1
	Gulls		*6*	*8*	*0.1*
	Murres		*6*	*18*	*0.2*
		Total Unidentified Birds		***37***	
		Total Birds	***22***	***9548***	

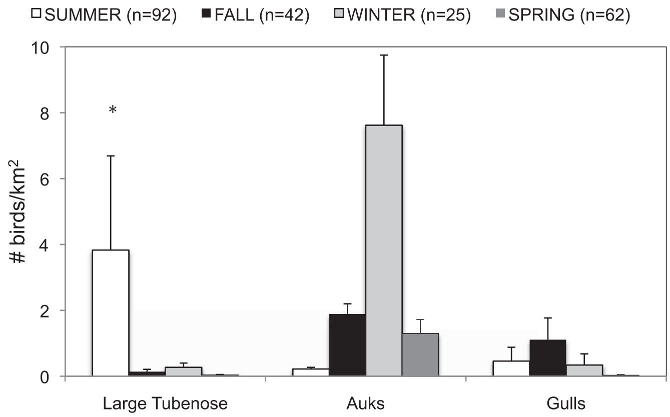

Fig. 2. Mean density of birds on water (#birds/km^2) by species groups according to season. Data are the mean ± SE of birds across all 5 min latitude × 5 min longitude bins. *N* refers to number of bins per season. Significant seasonal difference indicated by *.

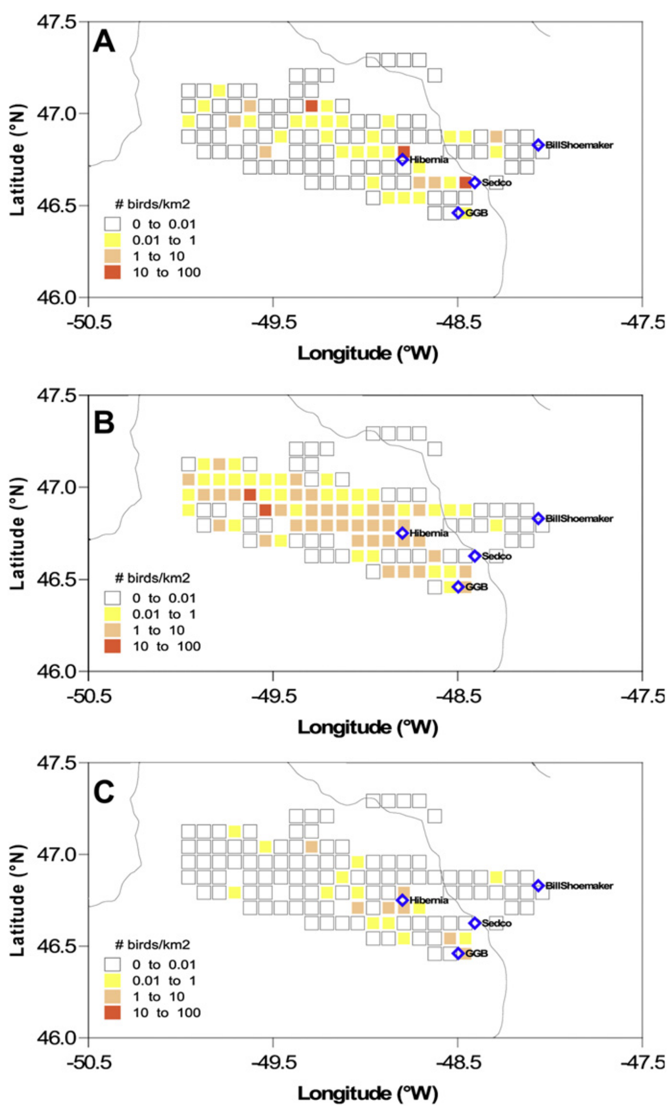

Fig. 3. Densities (#birds/km^2) of large tubenoses (A), auks (B) and gulls (C) on water (seasons combined) in relation to platform locations. Data are mean densities in 5 min lat × 5 min long bins. Contour line denotes 100 m depth.

Table 2
Analyses of associations between marine bird densities and distance from platforms. Significant effects are identified as the species group in which an effect was identified at a given platform in a given season.

Platform	Summer	Fall	Winter	Spring
Hibernia	ns	Auks ($p = 0.03$)	ns	ns
Bill Shoemaker	ns	No data	No data	No data
Sedco	Tubenoses ($p = 0.04$)	No data	No data	No data
Glomar Grand Banks	Auks ($p = 0.04$)	No data	No data	No data
	Gulls ($p = 0.02$)			

Gulls distribution was patchy with a high frequency of empty bins (0–0.01). Significantly higher densities of gulls were found in proximity to the Glomar Grand Bank drill rig during summer (Table 2). Gull densities were slightly higher around Hibernia (Fig. 3C), but there was no significant relationship during any season (Table 2).

3.3. *Seabird abundance and composition during stationary scans at platforms*

During systematic stationary scans at Hibernia (2001–2003), surface–feeding gulls (Black-legged Kittiwakes, Great Black-backed Gulls, Glaucous Gulls, Herring Gulls) were present during all three seasons (fall, winter and spring) and were the most abundant species overall (Table 3). Large concentrations of Great Black-backed Gulls and kittiwakes were consistently present during fall (Table 3). Gulls typically concentrated in large rafts on the water directly below the platform with numbers increasing throughout the day but were also observed resting on the concrete base of Hibernia during fall (28.7 ± 6.8; range 0–140). Small numbers of auks (Thick-billed Murres, Dovekies, Common Murres) were recorded at Hibernia during fall, winter and spring (range: 0–12).

3.4. *Oiled seabirds*

Twelve oiled birds were observed during four surveys (Table 4). Two of which were dead (dovekies). Oiled auks were on the water next to Hibernia and oiled gulls were standing on the concrete base of the platform.

4. Discussion

We provide a compilation of seasonal seabird occupancies near oil and gas platforms on the Grand Bank and show species-specific seasonal risks that concentrate seabirds at offshore platforms. Densities of large tubenoses (shearwaters and fulmars) peaked during summer and were significantly higher around the Shoemaker rig, located on the shelf edge. The association of birds with

Table 3
Mean (±SE) number and range of seabirds according to surface-feeders (large tubenoses and gulls) and divers (auks) observed within 500 m of Hibernia during systematic scans (2001–2003). *N* refers the total number of 15 min scans.

	Fall $n = 24$	Winter $n = 15$	Spring $n = 15$
Surface-feeders			
Large Tubenoses on water	0.68 ± 0.60 (0–15)	0	0
Large Tubenoses on platform	0	0	0
Gulls on water	42.7 ± 10.7 (0–300)	9.07 ± 4.88 (0–55)	0.46 ± 0.31 (0–4)
Gulls on platform	28.7 ± 6.8 (0–140)	0.27 ± 0.15 (0–2)	0
Divers			
Auks on water	0.04 ± 0.04 (0–1)	4.53 ± 0.9 (0–12)	1 ± 0.08 (0–2)
Auks on platform	0	0.13 ± 0.09 (0–1)	0

Table 4
Species, numbers and dates of oiled birds recorded within 500 m of the Hibernia platform during systematic scans (2001–2003).

Species	Date	Number
Dovekie	10-Feb-02	5
	08-Apr-03	1
Thick-billed Murre	18-Feb-03	1
	19-Feb-03	2
Great Black-backed Gull	27-Nov-03	2
Black-legged Kittiwake	26-Nov-03	1
Total		12

shelf edges is very well documented (Brown, 1986; Locke et al., 1994; Hedd et al., 2011), but the close proximity of the shearwaters to the platform (10s of meters) suggests a prey enhancement effect likely resulting from human waste discharge that fertilizes waters adjacent to the platform and facilitates the attraction of marine life (Wiese et al., 2001; Burke et al., 2005). Similarly, kittiwakes that are common on the Grand Bank throughout the year (Brown, 1986), aggregated in large rafts near the Hibernia platform during fall, likely taking advantage of augmented prey concentrations. Observations of gulls foraging on fish at night beneath the Hibernia platform on the well-lit waters below also suggests that lights may attract fish to the surface waters where they become easy prey for gulls. Black-backed Gulls move onto the Grand Bank during winter (Brown, 1986) and use the Hibernia platform as a roosting site (primarily immature birds), possibly allowing them to minimize thermal stress.

The highest auk densities occurred during winter when ice-associated Arctic breeding species, including Thick-billed Murres and Dovekies, migrate in the tens of millions to Newfoundland waters (Donaldson et al., 1997; Montevecchi and Stenhouse, 2003). The 9 oiled auks at Hibernia detected during three separate winter surveys suggests a threat of mortality from oiling that needs to be assessed as it may represent a significant source of cumulative mortality to seabirds not previously captured (Wiese and Robertson, 2004; Fraser et al., 2006). Oiled birds documented during this study at the Hibernia platform are the only known reports of oiled birds at this platform since production started in 1997, though we have had a number of anonymous communications about seabird occurrences and oiled birds from offshore crews and platform workers. Reports of oiled birds at oil and gas platforms in other regions are rare, a comprehensive study of marine bird associations at platforms in the Gulf of Mexico found oiling to be a minor source of mortality, collisions with platforms during accounted for the greatest mortality (Russell, 2005). This difference however on the Grand Bank may is the dominance of auks throughout the year that are among the species most vulnerable to oiling.

5. Inadequate environmental monitoring

Marine birds are killed at offshore platforms on the Grand Bank but the extent and nature of the mortality is rarely quantified (Wiese et al., 2001; Burke et al., 2005). Our observations of oiled birds at the Hibernia platform are the only known reports of oiled wildlife, except those occurring after large accidental spills (Wilhelm et al., 2007). This highlights the inadequacy of industry self-reporting as the primary tool for environmental monitoring and the lack of transparency and scientific rigor in the current regulatory system for offshore oil and gas development in Canada. The absence of comprehensive studies by independent observers on platforms despite recommendations to do so by Environmental Assessment review panels and reports (Harris, 1997; Montevecchi et al., 1999) is a failure of the regulatory regime.

Following the Gulf of Mexico disaster, the U.S. President criticized the federal regulatory agency's "scandalously close relationship" with the oil industry that allowed companies to drill offshore without properly assessing potential threats to marine life. This led to a restructuring of the oil and gas regulatory body, the Minerals Management Service into the Bureau of Ocean Energy Management (BOEM) with separate departments being responsible for drilling leases and the regulation of drilling activity. The regulatory body for offshore oil and gas in eastern Canada (Canada – Newfoundland and Labrador Offshore Petroleum Board; C-NLOPB) faced similar criticisms following the Deep Water Horizon disaster, during a time when the deepest oil well in Canadian history (2.5 km depth) was being drilled in the Orphan Basin. Industry self-regulation and a lack of transparency of environmental information have been identified as significant weaknesses in the current regulatory system (Fraser and Ellis, 2009; Wells, 2010). This compromises the C-NLOPB's ability to ensure adequate environmental protection, particularly given the high risk associated with oil and gas extraction in harsh conditions on the Grand Bank.

6. Conclusions

Our research highlights current regulatory deficiencies. These focus on two major weaknesses: 1) lack of comprehensive scientific research needed to generate sufficient statistical power to detect adverse effects (Type II statistical error) and 2) reliance on industry self-reporting to detect and report environmental effects. We conclude that the true level of adverse effects on seabirds around platforms on the Grand Bank is unknown and recommend that changes to the industry-biased structure of the Canada - Newfoundland Labrador Offshore Petroleum (C-NLOPB) are needed to ensure industry accountability and transparency, scientific rigor and adequate environmental protection.

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Appendix A. Supplementary material

Supplementary data related to this article can be found online at doi:10.1016/j.jenvman.2012.02.012.

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