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Seasonal and Spatial Trends of Marine Birds Along Support Vessel Transects and at Oil Platforms on the Grand Banks

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ABSTRACT: Our primary goal is to ensure the well-being of seabirds and mammals on the Grand Banks through improved ecological understanding and environmental protection. Our major objective is to conduct year-round, scientifically robust surveys to document seabird and mammal diversity, distribution, and abundance in relation to hydrocarbon activity and oceanography. Surveys along a fixed support vessel route between St. John's, NL and offshore platforms are limited by narrow spatial coverage yet have wide temporal coverage and repeatability. Twenty-one surveys, including the first winter surveys to platforms, were conducted from 1999 through 2003. Oiled murres and dovekies, the species most susceptible to oil pollution, were recorded at the Hibernia platform during February and November when the risk of mortality due to thermal stress is greatest. Roosting gulls were recorded feeding at night on fish, apparently attracted by platform illumination. Marine mammals were observed at offshore platforms. Humpback and minke whales

were the most common mammals and were seen within 5–10 meters of the Hibernia platform. The abundance of storm-petrels and shearwaters near Hibernia was highest during fall and spring migratory periods, when millions of these species move onto the shelf. These are critical periods for potential mortality from flaring, oiling, and collisions. It is environmentally and ethically essential to continue independent, scientifically rigorous surveys of seabirds in relation to ongoing hydrocarbon activities. Assessments could be greatly enhanced with independent, year-round scientifically valid observation procedures on platforms. Without such surveys, it is impossible to document seabird mortality associated with marine hydrocarbon activity in eastern Canada, and hence not possible to effectively mitigate negative environmental effects.

INTRODUCTION

Pelagic surveys of seabirds are recognised worldwide as a useful tool for examining the ecological effects of natural and anthropogenic influences on marine ecosystems (e.g. Veit et al., 1996; 1997; Veit and Montevecchi, 2003). However, the level of research directed at pelagic surveys in eastern Canadian waters is insufficient to provide the information necessary to detect changes in the pelagic diversity, distribution and abundance of marine birds and mammals.

The unique Low Arctic oceanographic regime of the Northwest Atlantic supports more than 40 million marine birds of regional and global significance including long-distance migrants from the High Arctic (dovekies, thick-billed murres; note the common and taxonomic names of all species mentioned in the text are given in Table 1) and from high latitudes in the South Atlantic (greater and sooty shearwaters) and millions of locally breeding seabirds (Leach's storm-petrels, common murres, gulls) (Montevecchi and Tuck, 1987; Montevecchi, 2000; Fig. 1). This oceanographic region also supports globally significant populations of marine mammals including humpback whales (Barlow and Clapham, 1997), fin whales (Hay, 1982), sperm whales (Braham, 1984), sei whales (Mitchell and Chapman, 1977), pilot whales (Nelson and Lien, 1996),

TABLE 1. Avian and mammalian species observed during offshore support vessel surveys along the survey route and at offshore platforms.

Seabird Species Common Name	Seabird Species Scientific Name	Transect	Platform
Northern fulmar	*Fulmarus glacialis*	yes	yes
Greater shearwater	*Puffinus gravis*	yes	yes
Sooty shearwater	*Puffinus griseus*	yes	no
Leach's storm-petrel	*Oceanodroma leucorhoa*	yes	yes
Northern gannet	*Morus bassanus*	yes	no
White-winged scoter	*Melanitta fusca*	no	yes
Merlin	*Falco columbarius*	yes	no
Red-necked phalarope	*Phalaropus lobatus*	no	no
Red phalarope	*Phalaropus fulicaria*	yes	no
Pomarine jaeger	*Sterocorarius pomarinus*	no	yes
Great skua	*Sterocorarius skua*	yes	no
Glaucous gull	*Larus hyperboreus*	yes	yes
Iceland gull	*Larus glaucoides*	yes	yes
Great black-backed gull	*Larus marinus*	yes	yes
Herring gull	*Larus argentatus*	yes	yes
Ring-billed gull	*Larus delawarensis*	yes	yes
Black-legged kittiwake	*Rissa tridactyla*	yes	yes
Common murre	*Uria aalge*	yes	yes
Common murre juvenile	*Uria aalge*	yes	no
Thick-billed murre	*Uria lomvia*	yes	yes
Dovekie	*Alle alle*	yes	yes
Black guillemot	*Cepphus grylle*	yes	yes
Atlantic Puffin	*Fratercula arctica*	yes	no
Fox Sparrow	*Passerella iliaca*	no	no

Mammal Species Common Name	Mammal Species Scientific Name	Transect	Platform
Humpback whale	*Megaptera novalanglia*	yes	yes
Minke whale	*Balaenoptera acutorostrat*	yes	yes
Harp seal	*Pagophilus groenlandicus*	yes	yes
Harbour seal	*Phoca vitulina*	yes	yes
Common dolphin	*Delphinus delphis*	yes	yes

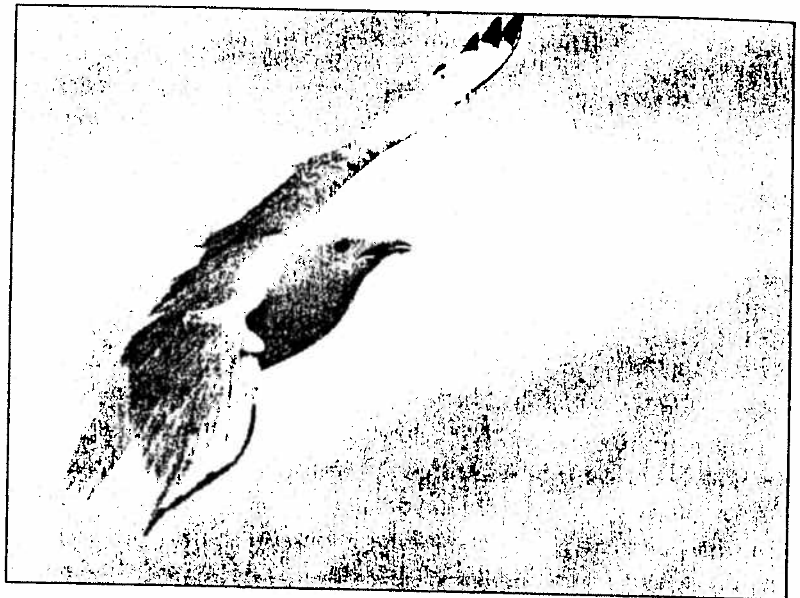

FIGURE 1. Black-legged kittiwake flying in the Northwest Atlantic (photo: W.A. Montevecchi).

harbour porpoises (Gaskin, 1992), and harp, hooded, gray, and harbour seals (Bundy et al., 2000). Chronic oil pollution (Montevecchi and Tuck, 1987; Wiese and Ryan, 1999; 2003; Wiese, 2002) and increasing offshore hydrocarbon development (Wiese et al., 2001) in this region is encroaching on traditional seabird and mammal habitat. These events and their cumulative effects create disturbances not previously experienced by marine animals on the Grand Banks of eastern Canada.

Offshore platforms create artificial reefs that promote algal growth, attract crustaceans and fishes, and their avian and mammalian predators (Shinn, 1974; Duffy, 1975; Sonnier et al., 1976; Ortego, 1978; Weise et al., 2001). The vegetative growth and biologically attractive properties of these reefs are enhanced by direct discharges of human waste water directly below the platforms. The thermal and structural (barrier) properties of platforms are known to attract fishes, birds, and mammals (Klima and Wickham, 1971). The intense artificial lighting associated with platforms and flares also are highly

attractive to seabirds, especially planktivorous and nocturnal species, such as Leach's storm-petrels (Wood, 1999). Once in platform vicinities, marine animals are exposed to mortality threats from spilled oil, incineration by flaring, and collision with the large illuminated structures. For these reasons, we investigated variability in the diversity, distributional, and abundance patterns of seabirds and marine mammals within and among seasons along a vessel-based, fixed transect route from St. John's to oil platforms on the Grand Banks from 1999 through 2003.

Seabirds are highly mobile, wide-ranging predators. Owing to the high energetic demands of endothermy in cold ocean regimes, avian and mammalian predators spend much of their time foraging. Therefore, the distributional patterns of marine birds are primarily influenced by the distributional patterns of their prey and by proximity to breeding sites (Davoren et al., 2002; 2003a) and generally reflect how individuals meet their energetic requirements for survival (Horne and Schneider, 1994). To meet these high energetic requirements, a high proportion of animals are found associated with a few large, dense prey aggregations (Heinemann et al., 1989; Hunt et al., 1991; Veit et al., 1993). Marine endotherms also tend to concentrate their foraging efforts in areas where prey aggregations are spatially and temporally persistent, thereby avoiding energetically costly search activities (Schneider et al., 1987; Cairns and Schneider, 1990; Hunt and Harrison, 1990; Coyle et al., 1992; Horne and Schneider, 1994, Decker and Hunt, 1996; Davoren et al., 2002; 2003b). Physical features of the pelagic environment, such as hydrographic regimes, combined with prey behaviour influence the distribution and density of prey (Mehlum et al., 1996; Ostrand et al., 1998) and the spatial and temporal persistence of prey patches (Cairns and Schneider, 1990, Hunt and Harrison, 1990; Coyle et al., 1992; Decker and Hunt, 1996; Irons, 1998). Oceanic structures, both natural (e.g. high bathymetric relief) and anthropogenic (e.g. offshore hydrocarbon platforms) concentrate prey in a persistent and predictable manner. These circumstances, combined with the energetic constraints of seabirds, suggest that these predators will concentrate at offshore platforms.

Energetic requirements and, thus, distributional patterns of marine birds vary among species due to dissimilar mobility constraints and flight efficiencies (Birt-Friesen et al., 1989). Auks are pursuit-diving birds and their wing design compromises aerial (high surface area) and underwater flight (low surface area; Livezey, 1988; Thompson et al., 1998) and results in high wing-loading (i.e. body mass to wing area ratio; Guillemette, 1994). Therefore, energy expenditure is elevated during flight compared to most other seabirds (Birt-Friesen et al., 1989). One strategy for auks to minimise energy expenditure is to reduce time spent flying. This results in more time spent sitting at sea, a behaviour that increases these birds' risk of mortality during winter when water temperatures are near or at freezing and birds are thermally stressed. Prolonged periods spent sitting on water also increases their chances of coming in contact with oil pollution making them more vulnerable than other avian species. In contrast, the wing design of surface-feeding birds, such as gulls, petrels, and shearwaters, optimises the efficiency of aerial flight and, thus, these birds have lower energetic requirements (metabolic rates) than pursuit-diving birds (Birt-Friesen et al., 1989; Croll and McLaren, 1993). These birds also tend to minimise thermal stress during the winter by roosting on land or other substrates at sea (e.g. offshore platforms). Therefore, not only are seabirds likely attracted to offshore platforms by elevated prey densities but they will also remain there due to flight constraints or accessibility to roosting sites. Overall, we predict that seabirds will aggregate at offshore hydrocarbon platforms on the Grand Banks throughout the year.

MATERIALS AND METHODS

Study Area

Research was carried out on the eastern Newfoundland Shelf, where globally and regionally significant seabird breeding sites occur (Montevecchi and Tuck, 1987). These include the world's largest colonies of Leach's storm-petrels (Sklepkovych and Montevecchi, 1989) and common murres (Nettleship and Evans, 1985), the only North American colonies of Manx

shearwaters (Storey and Lien, 1985; Robertson, 2002) and common black-headed gulls (Montevecchi et al., 1987), three of North America's six northern gannet colonies including the world's southernmost colony at Cape St. Mary's (Montevecchi and Tuck, 1987; Nettleship and Chapdelaine, 1988), North America's largest colonies of Atlantic puffins (Rodway et al., 1996), the largest colonies of northern fulmars and Caspian terns in eastern Canada, and the world's southernmost breeding sites for thick-billed murres (Cairns et al., 1989; Lock et al., 1994). As well, tens of millions of birds that breed in the Arctic (dovekies, thick-billed murres) and at high latitudes in the South Atlantic (greater and sooty shearwaters), inhabit the region during their non-breeding seasons. Globally significant populations of marine mammals and fishes also inhabit the Grand Banks (Bundy et al., 2000).

Survey Design

The distribution and density of marine birds, as well as mammals, were quantified during monthly, fixed-line transect surveys from offshore support vessels traveling from St. John's to offshore oil exploration (Glomar Grand Banks, Bill Shoemaker) and production (Hibernia, Terra Nova) platforms on the Grand Banks (Fig. 2).

Surveys were carried out by dedicated, independent observers using scientifically standardised methods (method Ib, Tasker et al., 1984). While not free from biases (e.g. overestimation of densities of flying birds; Tasker et al., 1984), these methods have errors considered to be consistent among surveys. Observers underwent extensive training, which began by studying species identification with seabird and marine mammal guides, and then by accompanying experienced observers during at-sea surveys for up to two weeks prior to conducting surveys on their own. All marine birds and mammals were recorded by a single observer within a 300 m 90°-viewing arc from the bow to either the port or starboard side of the vessel. A single observer was determined to be sufficient due to low densities of seabirds encountered over the Newfoundland Shelf (Davoren et al., 2002). Species names, counts,

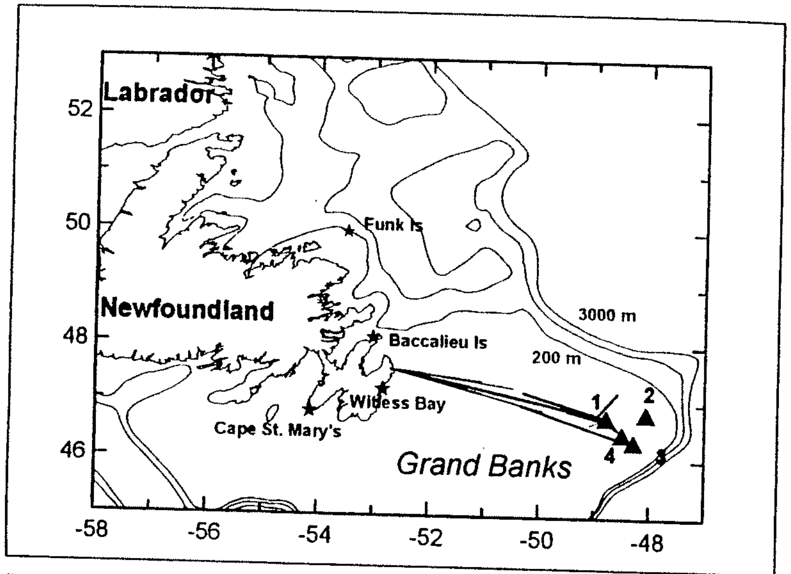

FIGURE 2. Monthly fixed transect surveys conducted from offshore support vessels to hydrocarbon platforms on the Grand Banks (total distance = 350 km). Seabird ecological reserves (*) and offshore platforms indicated: Hibernia (1), Bill Shoemaker drill rig (2), Terra Nova (3), Glomar Grand Banks drill rig (4).

and behavioural descriptions (on water, feeding, flying, and flight direction) were entered directly into a laptop computer. This laptop was interfaced with a hand-held Global Positioning System (Garmin III Plus) and counting software (D. Senciall, Birds and Beasty Counter, 1998, Fisheries and Oceans Canada, version 1.0) to append the GMT, latitude and longitude to each entry. Continuous observations were recorded while the vessel was moving between stations during daylight hours. Weather conditions (wind speed and direction, precipitation, sea state) and visibility were recorded at the onset of transects and every 30 min thereafter or whenever a change in ambient conditions impacted the detectability of seabirds and mammals. The 300 m survey width was maintained following Heinemann (1981) and counting was discontinued if visibility was < 300 m (e.g. during fog, high wind, and sea spray).

Stationary Vessels at Hydrocarbon Platforms

To detect fluctuations in the species composition and abundance within seabird aggregations near offshore platforms, systematic hourly scans were conducted throughout the day and night when vessels were stationed alongside platforms. Continuous 360° scans within a 500 m range of the support vessel were carried out for 15 min at 1 h intervals. Species, counts, and behavioural descriptions, as well as weather conditions, visibility, vessel distance from platform, and flare size were recorded on data sheets. Birds flying through the survey area were recorded separately to differentiate birds associated with offshore installations and those obviously flying rapidly through the study area. Protocols for systematic scans at offshore platforms were developed in 2001 subsequent to offshore vessel surveys in 1999 and 2000. Consequently, results from stationary scans at hydrocarbon platforms do not include those surveys conducted in 1999 and 2000. Data were collected at Hibernia during 11 out of 12 surveys and at Terra Nova during 4 surveys.

Physical Oceanographic Measurements

Sea surface temperature (SST) at 5 m depths were recorded every 5 min along the transect line using an Acoustic Current Doppler Profiler (ACDP) on support vessels. SST data were collected simultaneously with seabird observations whenever possible. When ACDP data were unavailable on survey vessels, SSTs were obtained from an alternate support vessel that had covered the transect within days of the survey. The data for the summer profile along the survey route was obtained from Fisheries and Oceans Canada (DFO) website (www.meds-sdmm.dfo-mpo.gc.ca/zmp/hydro_data-e.html). These data were related to seasonal species diversity, distribution, and abundance. These physical oceanographic variables are important to understanding the factors that influence distributions of seabirds at sea.

Mapping and Analysis

Seabirds and mammals were partitioned into six guilds. Birds were separated into: auks (common murre and thick-billed murres, dovekie, Atlantic puffin, black guillemot), gulls (herring, great black-backed, Iceland, and glaucous gulls), kittiwake (black-legged kittiwake; Fig. 1), fulmar (northern fulmar), storm-petrels (Leach's and Wilson's storm-petrels), and shearwaters (greater and sooty shearwaters). Marine mammal species were lumped into a single category, which included humpback and minke whales, harp and harbour seal and porpoise and dolphins.

The mean densities of birds on the water and flying and marine mammals observed along the survey route were calculated by averaging the number of individuals in each category per 5 km along the survey route using Matlab© routines provided by R. O'Driscoll (see O'Driscoll, 1998). Mean densities per 5 km were mapped using GIS software (Surfer 8.0, Golden Software) to examine distributional patterns relative to offshore platforms as well as shifting distributional patterns among seasons. SST data were also binned by 5 km means using Matlab© routines and were mapped. Raw count data along surveys and at offshore platforms were used to examine seasonal trends in species composition and abundance of birds and mammals. Species composition, mean abundance and distribution patterns were compared among years.

RESULTS

Seasonal Patterns

Striking seasonal fluxes were observed in seabird species diversity and abundance on the Grand Banks during surveys to offshore platforms. The numbers of seabirds recorded were highly variable between seasons, and mean numbers were highest during summer (Table 2). This pattern can be explained by dense summer concentrations of migrant shearwaters offshore, and breeding auks (common murres and Atlantic puffins) near coastal colonies in July and August. Sooty and greater shearwaters comprised nearly half (48%) of all birds recorded during summer surveys (Table 3; Fig. 3). These long-distance, southern hemisphere migrants were present from May through to October when warm SST ranged from 7 to 13.2°C. Leach's storm-petrels were also present from May to October and were most abundant offshore during fall.

TABLE 2. Seasonal mean ± standard deviation (sd) and range of seabird abundance per 5 km² blocks along transect route. All surveys pooled by season (1999–2003). N = total number of binned 5 km counts from all pooled surveys.

Summary Statistics	Winter (2 surveys)	Spring (4 surveys)	Summer (8 surveys)	Fall (7 surveys)
Mean ± sd	1.8 ± 3.5	1.83 ± 1.7	3.8 ± 22.7	1.7 ± 1.20
Range	(1 - 31)	(1 - 18)	(1 - 500)	(1 - 12.5)
N	85	232	569	409

TABLE 3. Mean ± standard deviation of seabirds (partitioned by guilds) and mammals per 5 km segments along the survey route during 12 surveys from October 2001 to June 2003.

Survey Dates	Auks	Fulmars	Gulls	Kittiwakes	Petrels	Shearwaters	Mammals
2001							
1 - 3 Oct	1.5 ± 0.8	1.1 ± 0.3	1.2 ± 0.3	3.2 ± 3.8	1.1 ± 0.3	1.0 ± 0.0	0.0
23 - 25 Oct	1.6 ± 0.7	1.3 ± 0.5	1.1 ± 0.2	4.0 ± 3.5	1.3 ± 0.6	1.8 ± 1.8	0.0
2002							
Feb	1.9 ± 2.2	1.1 ± 0.3	1.0 ± 0.0	1.1 ± 0.3	0.0	0.0	0.0
Apr	1.3 ± 0.5	1.6 ± 1.6	1.0 ± 0.0	1.4 ± 0.5	0.0	2.0 ± 0.0	1.3 ± 0.4
May	2.9 ± 4.5	1.1 ± 0.4	1.0 ± 0.0	1.2 ± 0.4	1.8 ± 2.2	0.0	1.2 ± 0.4
Sep	1.4 ± 1	1.0 ± 0.0	1.8 ± 1	1.0 ± 0.0	1.2 ± 0.3	1.3 ± 0.8	3.7 ± 2.2
Oct	1.8 ± 1.0	1.3 ± 0.6	2.2 ± 1.2	2.1 ± 1.6	1.1 ± 0.2	1.3 ± 0.6	1.3 ± 0.7
Nov	1.9 ± 1.0	2.0 ± 4.5	1.3 ± 0.7	1.6 ± 1.5	0.0	0.0	1.0 ± 0.0
2003							
Feb	2.4 ± 1.8	3 ± 7.5	1.0 ± 0.0	1.0 ± 0.0	0.0	0.0	1.0 ± 0.0
Apr	1.4 ± 0.7	2.4 ± 2.2	1.2 ± 0.4	1.9 ± 2.1	0.0	0.0	1.1 ± 0.2
May	1.8 ± 1.1	1.1 ± 0.4	1.2 ± 0.3	1.4 ± 0.5	1.1 ± 0.3	1.0 ± 0.0	1.0 ± 0.1
Jun	5.8 ± 9.2	1.1 ± 0.3	1.0 ± 0.1	1.3 ± 0.7	1.1 ± 0.2	1.3 ± 0.5	1.0 ± 0.0

During winter surveys when SSTs ranged between -1 to 0.5°C, auks (primarily dovekies and thick-billed murres) were the most abundant species.

Seasonal patterns in seabird species diversity and abundance were also obvious from observations at offshore platforms, and reflected trends along the survey route. Large aggregations of greater shearwaters were recorded at offshore platforms on the Grand Banks during late July/early August (Fig. 4). During October, black-legged kittiwakes formed large rafts in the water near the Hibernia platform (Table 4). Kittiwakes were also the most abundant seabirds along the

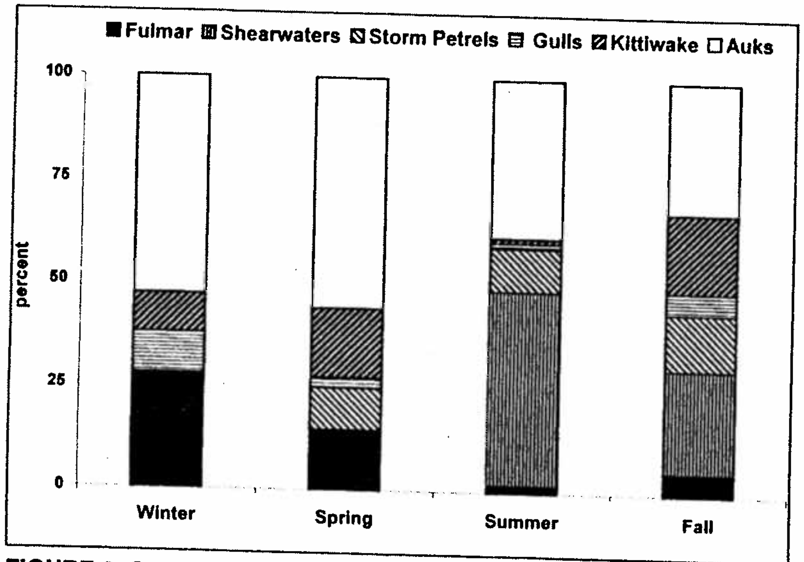

FIGURE 3. Seasonal diversity of seabird species grouped by guild during offshore support vessels surveys from 1999–2003.

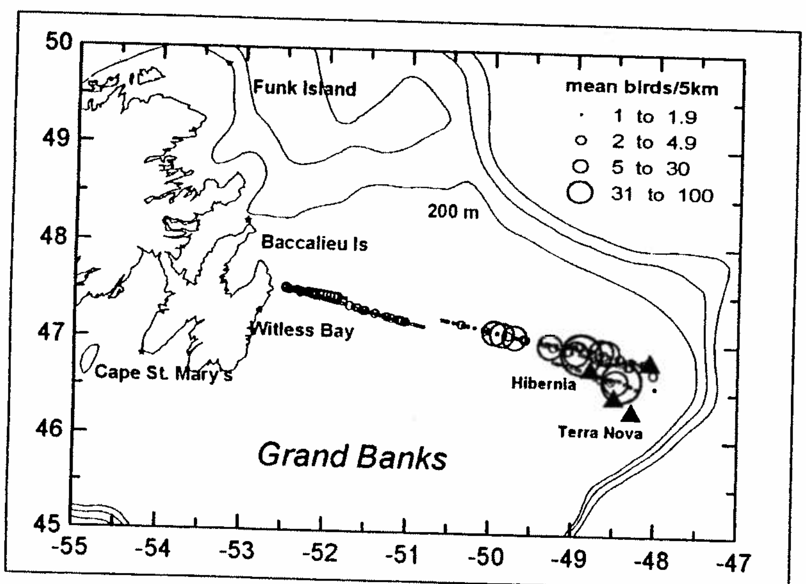

FIGURE 4. Distribution of all seabirds binned into 5 km segments from three surveys during July and August 2000.

TABLE 4. Mean ± standard deviation (range) of seabirds (partitioned by guilds) recorded during scans from support vessels positioned alongside offshore platforms. N = total number of scans completed during each survey.

Survey Dates	N	Fulmars	Shearwaters	Petrels	Gulls	Kittiwakes	Auks	Total Birds
2001								
1 - 3 Oct	7	0.0	0.0	2.1 ± 5.7 (0 - 15)	92.1 ± 84.8 (0 - 250)	2.9 ± 7.6 (0 - 20)	0.0	680
23 - 25 Oct	7	2.9 ± 5.9 (0 - 16)	0.0	0.0	31.7± 26.9 (0 - 61)	83.4 ± 148.5 (0 - 400)	1.1 ± 2.6 (0 - 7)	834
2002								
Feb	14	0.5 ± 1.3 (0-5)	0.0	0.0	0.7 ± 0.7 (0 - 2)	0.7 ± 1.3 (0 - 4)	4.1 ± 3.8 (0 - 12)	84
Apr	4	0.0	0.0	0.0	0.0	0.0	3 ± 1.4 (2-5)	12
May	10	0.0	0.0	0.0	0.5 ± 0.6 (0 - 5)	0.0	0.0	3
Sept	3	0.0	0.0	0.0	46.7 ± 5.8 (40 - 50)	0.0	0.0	140
Oct	18	0.5 ± 0.1 (0 - 3)	0.0	0.0	71.1 ± 67.1 (0 - 190)	4.4 ± 6.8 (0 - 20)	0.0	1369
Nov	8	0.9 ± 0.8 (0 - 2)	0.0	0.0	3.7 ± 6.1 (0 - 18)	40 ± 42 (0 - 115)	7.9 ± 6.9 (0 - 23)	415
2003								
Feb	11	0.5 ± 1 (0 - 3)	0.0	0.0	0.7 ± 1.3 (0 - 3)	0.8 ± 1.3 (0 - 4)	0.8 ± 0.1 (0 - 2)	32
Apr	9	2.2 ± 3.3 (0 - 15)	2.2 ± 3.3 (0 - 15)	0.0	0.6 ± 0.9 (0 - 2)	0.0	0.8 ± 0.1 (0 - 6)	40
May	7	0.0	0.0	0.0	0.3 ± 0.5 (0 - 1)	0.6 ± 1.5 (0 - 4)	1 ± 0.8 (0 - 2)	13
Jun	4	0.0	0.2 ± 0.5 (0 - 1)	0.0	0.6 ± 0.6 (0 - 1)	0.0	0.0	4

survey route during this period, with mean numbers ranging between 2.1 and 4 birds per 5 km segments. During September and October, large groups of great black-backed gulls roosting at the Hibernia platform during the day were observed foraging at night on fish attracted to the illuminated surface water under the structure. A total of 11 oiled birds including thick-billed and common murres, dovekies, great black-backed gulls, and kittiwakes were observed during 4 surveys over 41 scans at the Hibernia platform. Anecdotal information from support vessel personnel on several occasions provided further evidence of oiled birds near offshore platforms with increased incidents during winter (Fig. 5). A total of 18 marine mammals were observed over 8 days of observations in the immediate vicinity of Hibernia. Avian and mammalian occurrences at platforms were episodic in nature,

FIGURE 5. Oiled common murre retrieved by support vessel personnel near Hibernia during January 2003 (photo: crew of Maersk Nascopie).

and long-term dedicated observations will be required to adequately capture these events (Montevecchi et al., 1999).

Oceanographic Distributional Patterns

Seabirds were patchily distributed along the survey route, often forming considerable aggregations. Thick-billed and common murres were observed at densities that ranged from 1–50 birds per 5 km intervals (Fig. 6 f). These aggregations were closely associated with a branch of the Labrador Current. Densities of marine birds and mammals also were considerably higher in the vicinity of offshore platforms than along the transect routes leading to it (Figs. 6 a–f). This pattern of aggregation was previously documented by Wiese et al. (2001). The association of seabirds with offshore installations is readily observable and vessel and platform personnel have commented on this attraction. Seabird concentrations were more evident at Hibernia gravity-based platform than at the Terra Nova floating platform with an average of 71 birds per scan at Hibernia (3576 birds during 50 scans) and 6.8 birds at Terra

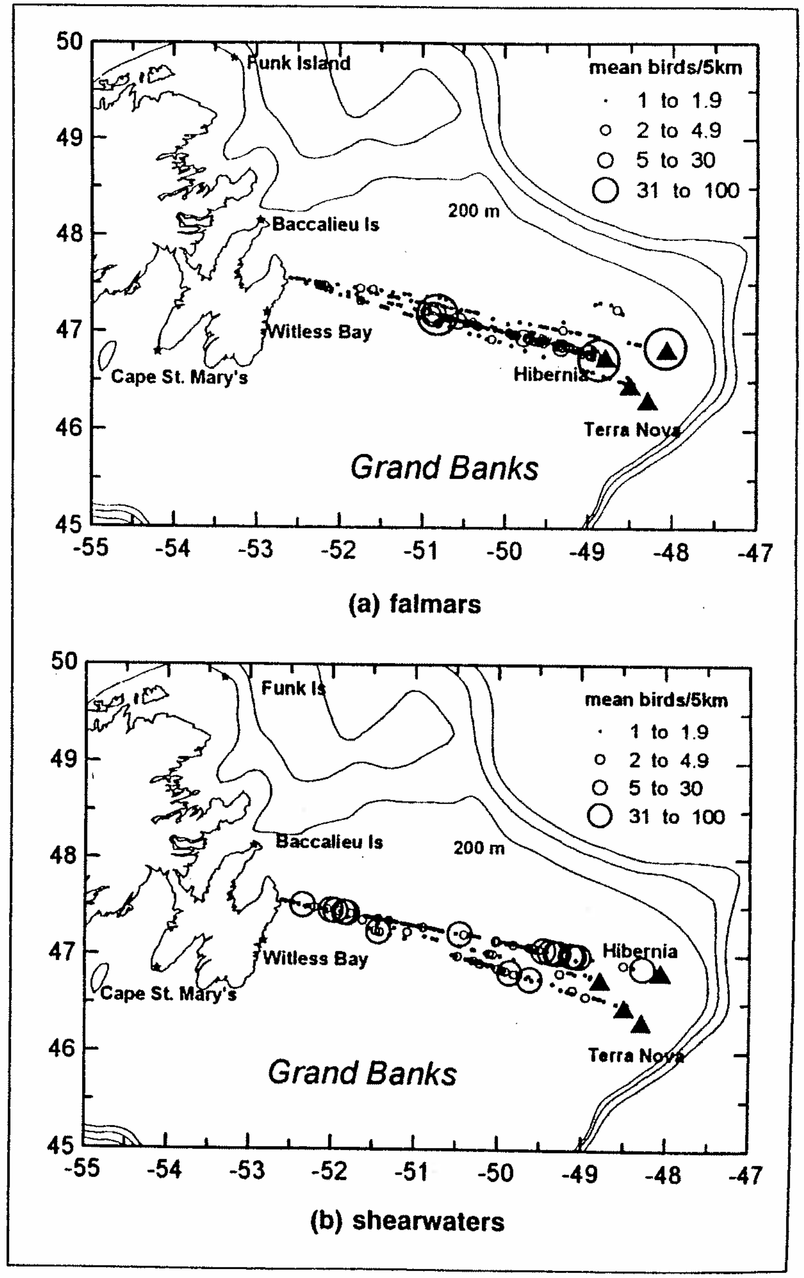

FIGURE 6. Distribution of seabirds: **(a)** fulmars, **(b)** shearwaters, **(c)** storm-petrels, **(d)** gulls, **(e)** kittiwakes, **(f)** auks binned into 5 km segments during surveys in 1999 and 2001–2003.

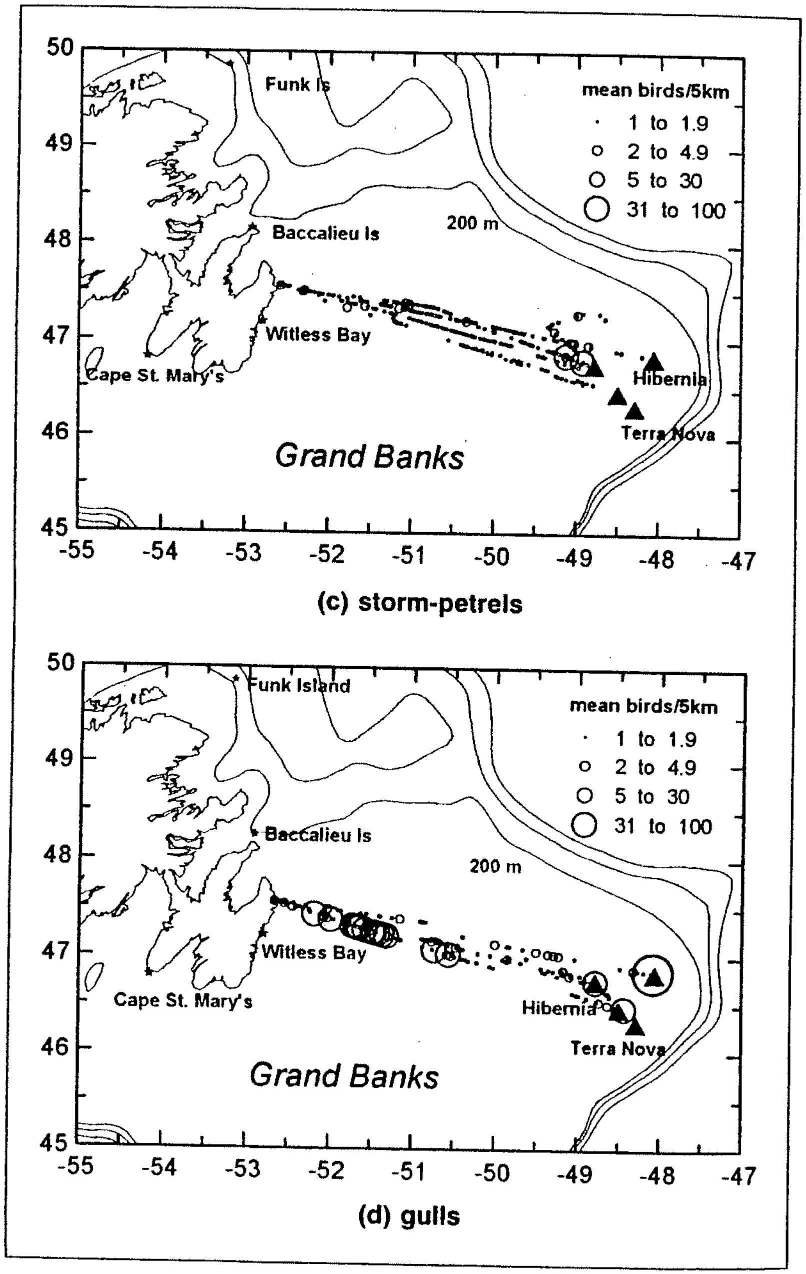

FIGURE 6. *(continued)*

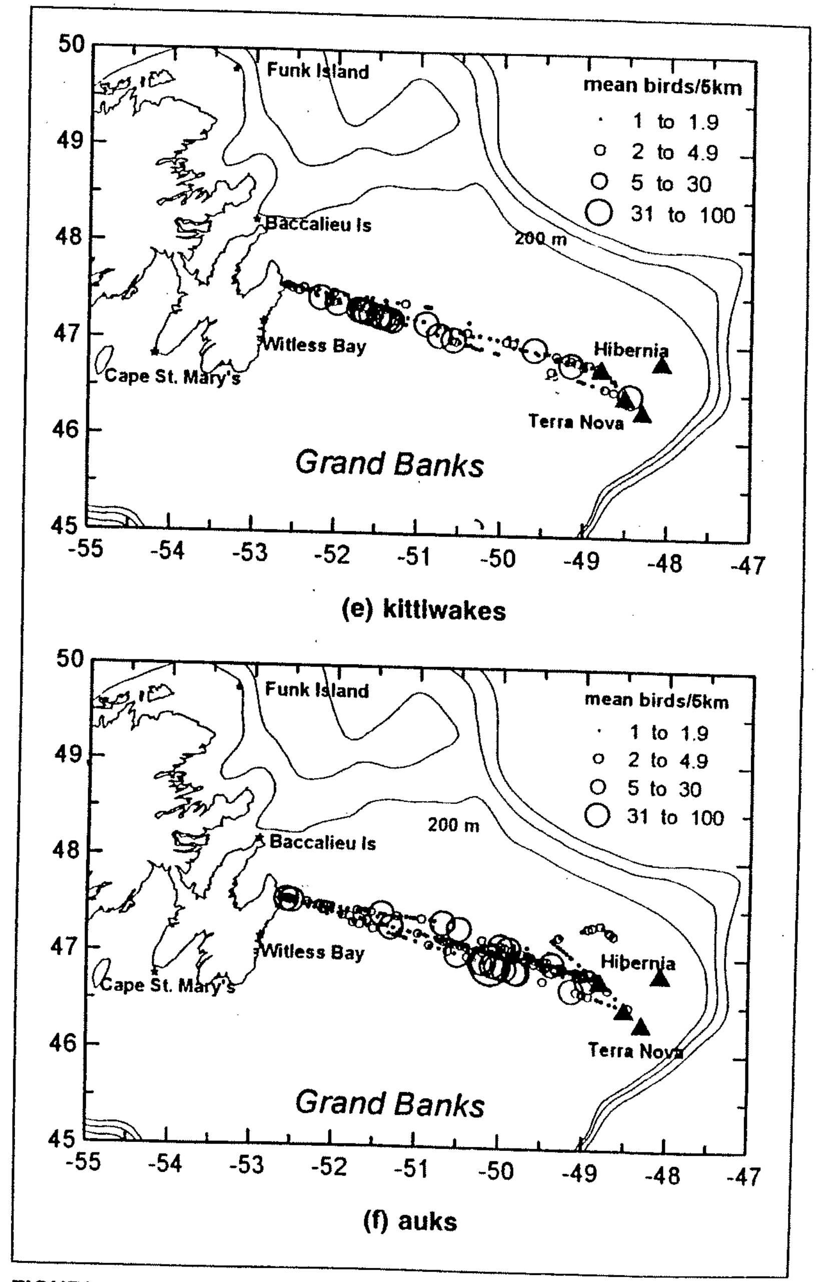

FIGURE 6. *(continued)*

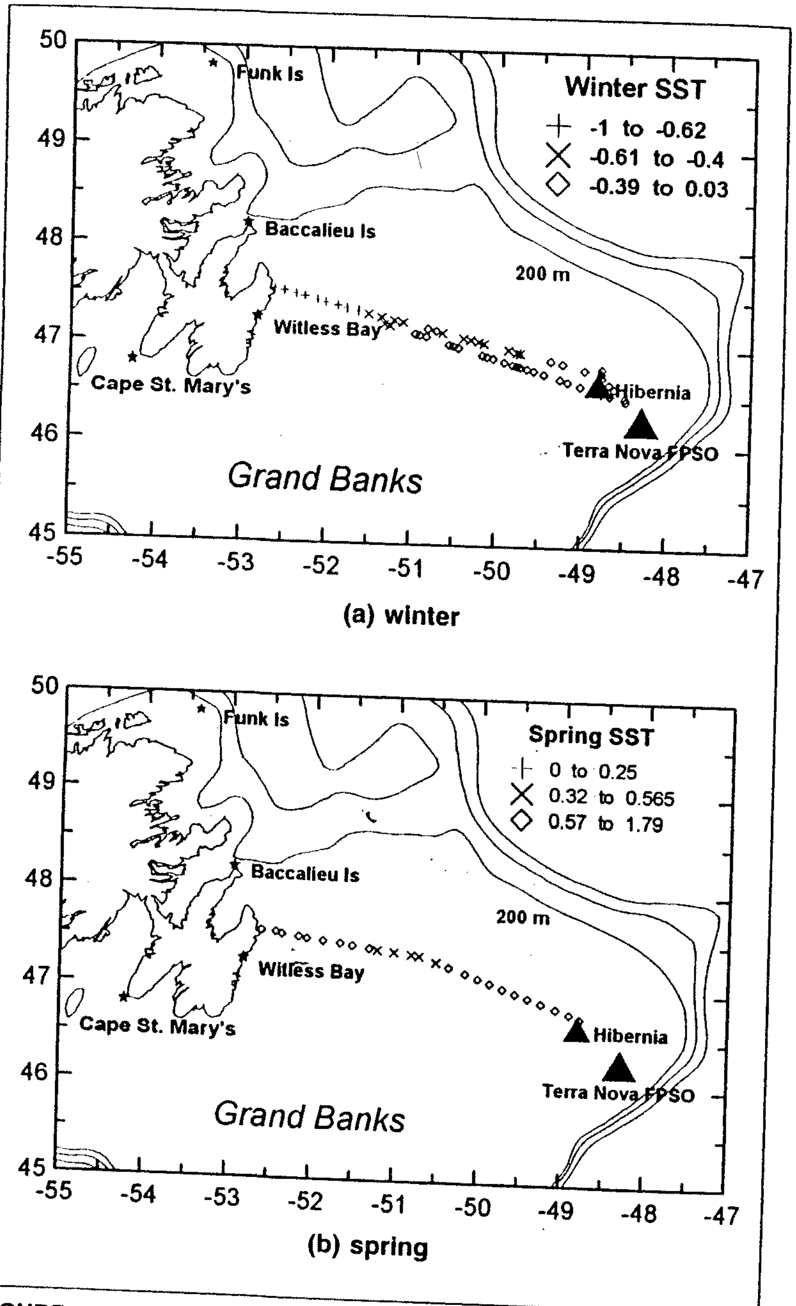

FIGURE 7. Mean sea surface temperature (°C) along 5 km segments during **(a)** winter, **(b)** spring, **(c)** summer (DFO data) and **(d)** fall.

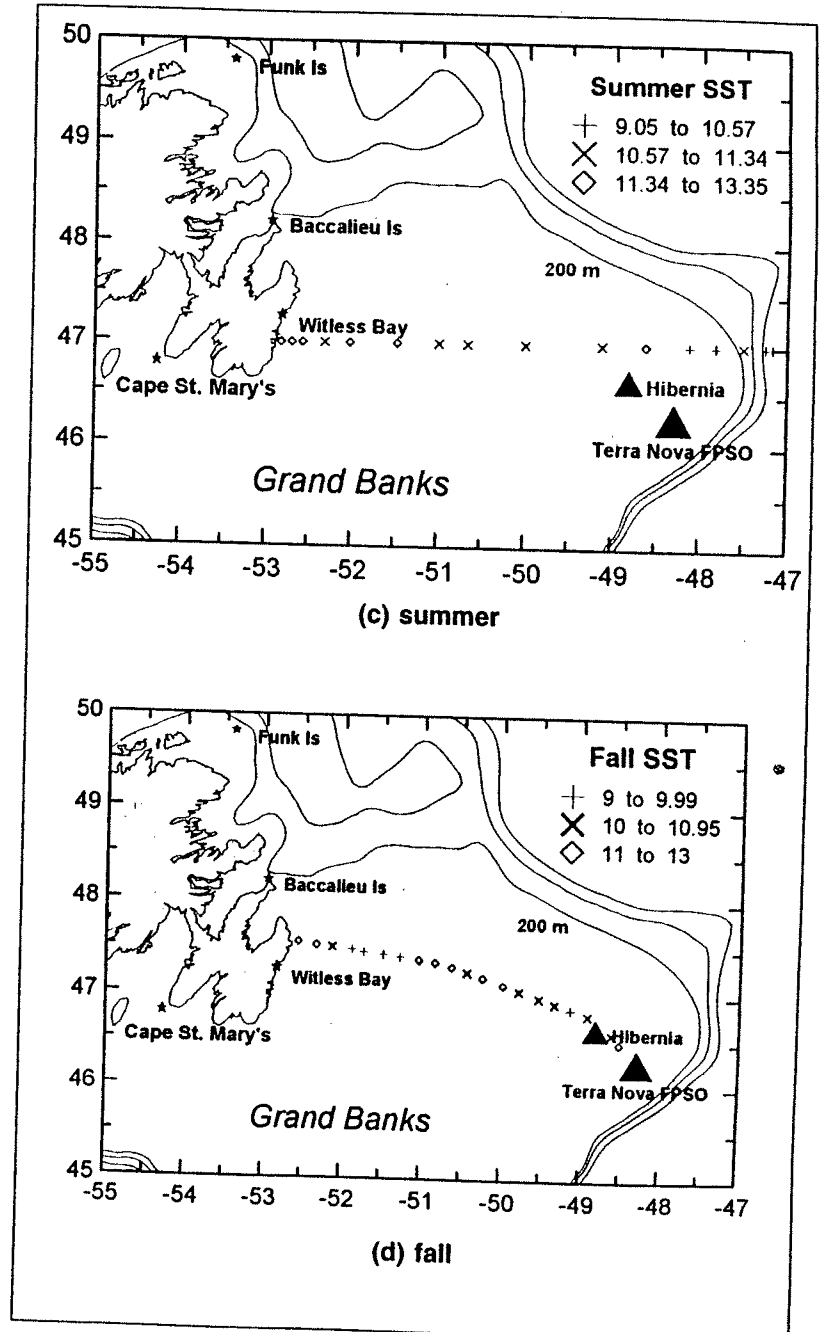

FIGURE 7. *(continued)*

Nova (89 birds during 13 scans). The physical features of the Hibernia platform (i.e. a fixed structure in place over years) present ideal conditions for artificial reef development, and the concrete icewall at the base of the platform (7 m above water) is an attractive roosting refuge for large numbers of gulls and kittiwakes.

DISCUSSION

Year-round surveys were carried out by well-trained, arm's length observers along offshore support vessel routes. Surveys, including the first winter observations along the support vessel route, and at the Hibernia platform, showed striking seasonal patterns in species occurrences and abundances. Thick-billed murres and dovekies, the species most vulnerable to oil pollution (Wiese and Ryan, 1999; 2003; Wiese, 2002), were most abundant during winter when thermal stresses, and hence risk of mortality associated with oil pollution are greatest. Oiled dovekies and thick-billed and common murres were documented at the Hibernia platform. Storm-petrels and shearwaters, species naturally attracted to light (e.g. Reed et al., 1985), were common during summer and fall. These periods represent vulnerable stages to mortality in flares in these species' annual cycles (Wood, 1999; Wiese et al., 2001). Fishes attracted to surface waters by lighting from the Hibernia platform were preyed on at night by flocks of great black-backed gulls that roosted at the platform.

It is no surprise that oiled murres and dovekies were documented at the Hibernia platform during our surveys, that large numbers of storm-petrels have been observed to die in the flare (Wood, 1999) or that they are easy prey for gulls when they fall in the water after impact with the platform. Marine mammals may also be influenced by hydrocarbon and produced waters in platform vicinities. Because there are no independent, dedicated observers on platforms (see Montevecchi et al., 1999; Wiese et al., 2001), it impossible to quantify mortality and cumulative effects on these species at offshore hydrocarbon platforms. Surveys at offshore platforms during fall when storm-petrels migrate offshore, are key times to quantify

mortality rates associated with flaring. The timing of surveys is particularly crucial given the episodic nature of flaring mortalities.

Features of offshore platforms that attract marine animals can be modified and mitigated. For example, 1) waste water could be recycled rather than discharged directly below platforms, 2) lights on the platform could be reduced and shielded without causing safety concerns (Reed et al., 1985), 3) maintenance and refit (i.e. down time) of flare equipment could be carried out during periods of greatest risks to seabirds (e.g. September, October). Before and after comparisons could be made to attempt to assess influences of any manipulations that are carried out. There have been no known mitigation efforts for marine birds and mammals at the Hibernia platform in eastern Canada.

The year-round support vessel surveys conducted through Memorial University of Newfoundland were the only arm's length surveys for marine birds and mammals related to offshore hydrocarbon activities that have been carried out in eastern Canadian waters. These surveys have generated new and important information about the seasonal occurrences of marine birds and mammals along the support vessel route and in the vicinity of offshore hydrocarbon platforms on the Grand Banks. Funding for these surveys by the Environmental Studies Research Fund of the Energy Board of Canada was terminated in August 2003, with no anticipation of reinstatement. To not conduct independent scientific surveys for marine birds and mammals throughout and beyond the duration of hydrocarbon extraction on the Grand Banks is environmentally and ethically irresponsible.

Beyond the limited duration of these monthly support vessel surveys for seabirds and marine mammals, it has been impossible to station independent, dedicated, trained observers on offshore hydrocarbon platforms in eastern Canada. This environmental monitoring inadequacy is occurring despite a report prepared in 1999 for the Canadian Association of Petroleum Producers (CAPP) on monitoring marine birds and mammals in relation to offshore hydrocarbon activities that recommended a scientifically robust observation program on offshore platforms (Montevecchi et al., 1999). This report and recommendations were reviewed and supported by international scientific experts. Owing to the absence of dedicated, independent observers on platforms, the mortality of marine birds and disturbance of marine mammals that have occurred due to lighting, flaring, collisions and oiling at offshore hydrocarbon platforms in Canada's eastern ocean have not been documented.

CONCLUSIONS

Monthly transect surveys to offshore platforms were generating the only scientifically reliable indices of seabirds and mammals with respect to hydrocarbon developments in eastern Canada. The threat of seabird mortality due to flaring and collisions with offshore platforms is likely greatest during fall when tens of millions of small planktivorous and nocturnal seabirds (dovekies, Leach's storm-petrels) are moving in the Northwest Atlantic. The threat of oil pollution is highest during the winter when marine bird populations are dominated by mainly diving species (auks), water temperatures are lowest, and their populations expand into oil development and shipping areas (Lock et al., 1994). An estimated 300,000 seabirds die due to oiling off the coast of eastern Canada every year, which is equivalent to the mortality of the Exxon Valdez disaster on an annual basis (Wiese, 2002; Wiese and Robertson, 2003). Mortality associated with hydrocarbon developments cumulates with other sources of mortality from hunting and entrapment in fishing gear (Piatt et al 1984; Montevecchi and Tuck, 1987; Montevecchi, 2001; Wiese and Robertson, 2003).

Current levels of scientific effort directed at marine birds and mammals in relation to hydrocarbon developments in eastern Canadian waters are inadequate to document the dynamic distributional patterns of these animals and ongoing mortality. Yet even modest independent research efforts were curtailed due to lack of support from responsible government agencies. Whether or not these environmental and ethical challenges will be met depends on the commitments of individuals, both within and outside of government. The needs and circumstances are self-evident.

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