Monitoring the impacts of the Gordon C. Leitch oil spill on the breeding bird populations of the Mingan Archipelago National Park Reserve (QC), Canada

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MONITORING THE IMPACTS OF THE GORDON C. LEITCH OIL SPILL ON THE BREEDING BIRD POPULATIONS OF THE MINGAN ARCHIPELAGO NATIONAL PARK RESERVE (QC), CANADA

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ABSTRACT

A monitoring program has been undertaken by Parks Canada and the Canadian Wildlife Service to evaluate the impacts of the Gordon C. Leitch oil spill, in Havre-Saint-Pierre in 1999, on the breeding bird populations of the Mingan Archipelago National Park Reserve (Gulf of St. Lawrence (QC), Canada). The three breeding bird species studied are the Common Eider (*Somateria mollissima*), the Black Guillemot (*Cepphus grylle*), and the Bald Eagle (*Haliaeetus leucocephalus*). The surveys were completed to provide a means of comparing the status of these bird populations on islands located inside and outside the contaminated area, both before and after the oil spill. The Gordon C. Leitch oil spill does not seem to have brought on noticeable impacts on the reproductive potential of the breeding bird populations of Minganie. The breeding population of Common Eiders on the islands located within the contaminated area has decreased from 1861 pairs in 1998 to 1707 in 1999 following the oil spill. The differences in the number of Eider nests on the islands surveyed ("test" and control islands), both before and after the oil spill, are not significant. Common Eider productivity in the Mingan Archipelago did not significantly differ between 1998 and 1999. The slight variability observed between 1998 and 1999 may result from natural processes or variations in the sampling method. The breeding Black Guillemot population of the Mingan islands does not seem to be visibly affected by the oil spill. On the islands that were contaminated with hydrocarbons, the Guillemot population has increased by 60% that is, from 32 pairs in 1994 to 54 pairs in 1999. The Bald Eagle population in the Mingan Archipelago seems stable, with four (4) nesting pairs in both 1998 and 1999. In 1999, the mean productivity of Bald Eagles, with two (2) eaglets/nest, suggests a healthy population. All in all, the Gordon C. Leitch oil spill may have caused the death of an estimated 211 to 777 breeding birds or 0,4 to 1,6% of the total number of breeding seabirds in the Mingan area. Protective measures are recommended in order to mitigate the effects resulting from the oil spill and to prevent as well as limit the impacts of such incidents.

RÉSUMÉ

Un programme de suivi a été initié par Parcs Canada et le Service canadien de la faune pour évaluer les impacts du déversement de pétrole du Gordon C. Leitch à Havre-Saint-Pierre en 1999 sur les populations d'oiseaux nicheurs de la réserve de parc national de l'Archipel-de-Mingan (golfe Saint-Laurent (QC, Canada). Trois espèces d'oiseaux nicheurs en Minganie ont été étudiées soit : l'Eider à duvet (*Somateria mollissima*), le Guillemot à miroir (*Cepphus grylle*) et le Pygargue à tête blanche (*Haliaeetus leucocephalus*). Les inventaires réalisés visaient à comparer les niveaux de ces populations d'oiseaux sur des îles sélectionnées à l'intérieur et à l'extérieur de la zone de contamination avant et après ce déversement. Le déversement de pétrole du Gordon C. Leitch ne semble pas avoir entraîné d'impacts observables au niveau de la reproduction de ces populations d'oiseaux nicheurs dans l'archipel de Mingan. La population nicheuse d'Eiders à duvet en Minganie sur des îles situées dans la zone de contamination est passée de 1861 couples en 1998 à 1707 couples en 1999 suite au déversement. Les différences dans le nombre de nids d'Eiders pour les îles étudiées et témoins avant et après le déversement ne sont pas significatives. La productivité des Eiders dans l'archipel de Mingan ne diffère pas non plus significativement entre 1998 et 1999. Les légères variations entre 1998 et 1999 peuvent être associées à des facteurs naturels ou des fluctuations d'échantillonnage. La population de Guillemots à miroir qui niche sur les îles Mingan ne présente pas d'effets détectables suite au déversement. Dans les îles affectées par la contamination d'hydrocarbures, la population de guillemots affiche une augmentation de 60% soit de 32 couples en 1994 à 54 couples en 1999. La population de Pygargues à tête blanche dans l'archipel de Mingan semble stable avec quatre (4) couples nicheurs en 1998 et 1999. La productivité moyenne des pygargues en 1999, avec deux (2) aiglons/nid, indique à première vue une population en bon état de santé. Dans l'ensemble, le déversement du Gordon C. Leitch a pu occasionner une mortalité estimée entre 211 et 777 oiseaux nicheurs soit des impacts possibles représentant de 0,4% à 1,6% de l'effectif total des oiseaux marins nicheurs en Minganie. Des mesures de protection sont recommandées pour compenser les effets occasionnés par le déversement et pour prévenir et limiter les effets d'éventuels incidents maritimes.

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1. INTRODUCTION

On the night of March 23 1999, the bulk-ore carrier Gordon C. Leitch accidentally strikes the wharf of QIT-Fer et Titane inc., in Havre-Saint-Pierre, and releases 49 metric tonnes of bunker C oil in the waters of the Gulf of St. Lawrence (QC, Canada). Adverse conditions cause the crude oil to concentrate westward near the shores of Pointe-aux-Morts and Anse à Nadeau. Later, part of the oil drifts south and reaches close to a dozen islands of the Mingan Archipelago National Park Reserve (MANPR). On the days that follow, this discharge leads to the death of more than a thousand (1003) seabirds and becomes one of the important cases of bird mortality due to hydrocarbon-related bird mortality in Canada (D. Lehoux, pers. comm., Canadian Wildlife Service, 1999).

Three bird species wintering in the Mingan region; the Common Eider (*Somateria mollissima*), the Black Guillemot (*Cepphus grylle*), and the Bald Eagle (*Haliaeetus leucocephalus*) have been particularly affected by the oil spill and have raised much concern as to the conservation of the breeding bird populations in the Mingan Archipelago.

The Gordon C. Leitch oil spill in Havre-Saint-Pierre has essentially affected more than 947 Common Eiders (*Somateria mollissima borealis*) that winter in the Gulf of St. Lawrence (Lehoux and Bordage, 1999). This number represents a fraction of the total population, which is estimated at 100 000 individuals (Bordage and *al.*, 1998; Bourget and *al.*, 1986). However, the breeding population of Common Eiders (*Somateria mollissima dresseri*) in the Mingan region, which is estimated at more than 5 000 pairs (Paradis, 1993; Roberge, 1998a, in prep.), could have very well been affected by the oil spill. Parks Canada, the Canadian Wildlife Service, Havre-Saint-Pierre communities, and Mingan Montagnais have raised concerns regarding the status of this important Common Eider population in the Mingan region, a population that is part of local sport hunting and traditional activities. The Black Guillemot was the second species most affected by the oil spill with more than 50 oil-covered individuals (Lehoux and Bordage, 1999). This bird, which is especially vulnerable to pollution caused by oil spill (Cairns, 1995; Ewins, 1985; Ewins and Tasker, 1985), is not very abundant in the Mingan Archipelago with only 115 nesting pairs in 1994 (Vaudry, 1995). The Bald Eagle was also affected by the oil spill, three (3) oil-covered individuals have been observed. The Bald Eagle may soon be given the status of vulnerable or threatened species under provincial legislation (Beaulieu, 1993). Its scarcity in the Mingan Archipelago, six (6) potential active nests in 1998 (Roberge, 1998, in prep.) may foreshadow a potential loss of nesting pairs.

Following the Gordon C. Leitch oil spill, a monitoring program, funded by the company responsible for the oil spill (Upper Lakes Group), has been undertaken by Parks Canada and the Canadian Wildlife Service to evaluate the impacts on these three breeding bird populations of the Mingan Archipelago National Park Reserve (MANPR).

2. METHODS

2.1 Study Area

The Mingan Archipelago National Park Reserve (MANPR) is a protected natural area established and managed by Parks Canada since 1984. It stretches from the villages of Longue-Pointe-de-Mingan and Aguanish and extends to Moyenne-Côte-Nord (Mid-North Shore) of the Gulf of St. Lawrence (**Figure 1**). This territory covers an area of 106 km^2. To the west, some forty calcareous (limestone) islands (> 0,1 ha) characterize the archipelago. To the east, more than 800 granitic islands and islets make up the rest of the territory. Some of the most striking features of the MANPR are its temperate marine climate, unique geology, arctic-alpine vegetation, and abundant marine avifauna (Parks Canada and Roche et Associés Ltée, 1984; Environnement Canada, 1992). The seabird populations of MANPR are characterized by 12 species and more than 25 000 nesting pairs, including the most important populations of Common Eider (*Somateria mollissima dresseri*) as well as Common and Arctic Terns (*Sterna hirundo and S. paradisaea*) of the Gulf of St Lawrence (Roberge, 1998b). In spring and fall, more than 50 species of ducks and shorebirds gather in important numbers in the general area of Mingan (Parcs Canada and Roche et Associés Ltée, 1984). Each year, the MANPR is frequented by 2 000 residents of Minganie and more than 27 000 visitors (Environnement Canada, 1992).

The immediate area affected by the Gordon C. Leitch oil spill extends from Pointe-aux-Morts to Grande Pointe, in Havre-Saint-Pierre, and includes some 10 islands of the MANPR (**Figure 1**).

2.2 Monitoring the Breeding Bird Populations

This monitoring program is carried out in order to determine the effects of the oil spill on the Common Eider, Black Guillemot, and Bald Eagle populations nesting within the Mingan Archipelago by comparing the number of birds on the islands sampled in 1999 with the numbers from previous studies.

2.2.1 Common Eiders

A census of Common Eider nests was completed on the selected islands both inside and outside the oil spill zone and compared with the 1998 inventory findings. Eight islands within the immediate contaminated area were selected (i.e., "test" islands). Using the same techniques as those used in 1998, the islands were inventoried from May 26 to May 28 1999, a time frame that corresponds to the period when incubation is most intense for Common Eider. A complete systematic nest count was carried out for four (4) relatively small islands (Cayes à Meck, île de la Pointe aux Morts, île à Calculot, and île aux Goélands). Nest counts, using 100-m by 32-m transects (n) were effected on four (4) large islands—Petite Romaine (n=3), île du Fantôme (n=9), île à Firmin (n=5), and Petite île au Marteau (n=7). For each island, nest density per transect was extrapolated for the potential Eider nesting area (Paradis, 1993; Chapdelaine, 1995; Roberge, 1998a, in prep.). The islands île du Wreck nord and île du Wreck sud were used as control. We assumed that the Eiders of those islands were negligibly affected by the oil spill considering their distance from the contaminated area. These islands were also subjected to a systematic count. Eider productivity was assessed for all islands by recording the clutch size to evaluate the reproductive success following the oil spill.

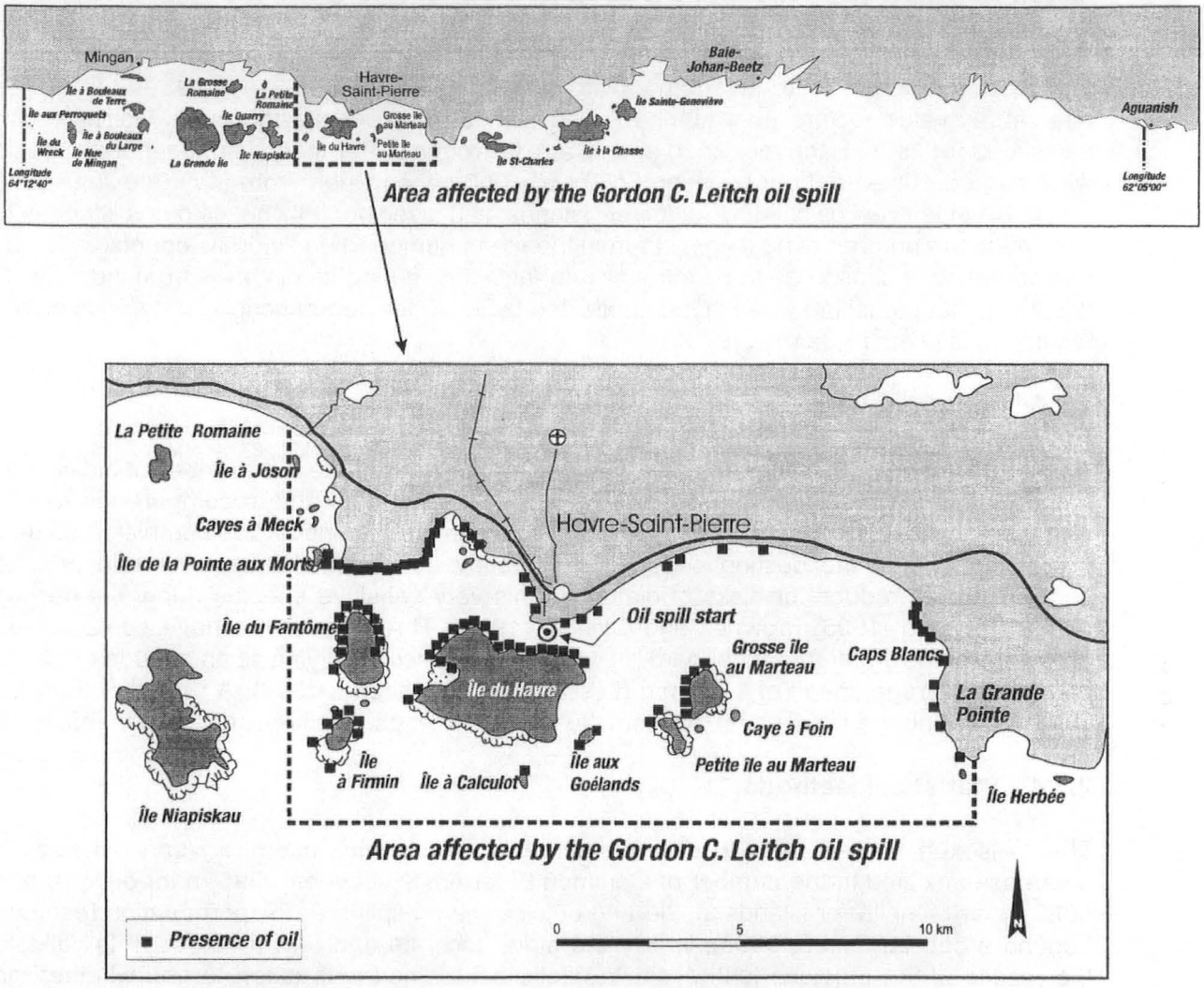

Figure 1 : The Mingan Archipelago National Park Reserve and the area affected by the Gordon C. Leitch oil spill at Havre-Saint-Pierre.

2.2.2 Black Guillemots

The Black Guillemot population was estimated by counting the number of birds in attendance (Cairns, 1979; Vaudry, 1995) at the colonies close to and away from the oil spill in order to compare them with the 1994 estimates. Three islands, which are hosts to a substantial number of Black Guillemots, were selected in the oil spill area—île du Fantôme, île du Havre, and Grosse île au Marteau. Two persons onboard a small boat, which would face the colonies, completed the census. Each week from May 9 to June 6, a series of three counts was carried out between 5h00 and 10h00 for a total of twelve (12) counts. According to Cairns (1979), a minimum of five (5) counts during the waiting period at the colonies for the Black Guillemot is required to obtain an estimated error of 19% (95% confidence interval). K value factors (K = number of nests/mean number of individuals waiting) were calculated for île du Fantôme (east) and île aux Perroquets. For these islands, hourly counts were carried out every hour between 5h00 and 10h00 each week, from May 9 to June 6. A mean K-value was calculated for these islands and used for all the colonies studied to determine the number of nesting pairs from the mean number of individuals counted. Île aux Perroquets was chosen as the control site. In fact, considering its distance from the oil spill, it is likely that the island was very little affected by it. A detailed description of the inventory technique is given in Cairns (1979).

2.2.3 Bald Eagles

An aerial census of Bald Eagle nests was carried out to estimate the number of individuals in the Mingan Archipelago, to assess the reproductive success, and to compare the results with those of 1998 (Roberge, 1998, in prep.). The one aerial census was completed on July 16, at the end of the nesting period, to accurately determine the success rate prior to fledging and to reduce the risks of disturbing this very sensitive species during its nesting period (Lessard, 1996; Brownell and Oldham, 1985). Three observers have surveyed the Mingan Archipelago territory onboard a Long Ranger helicopter flying at an altitude of 200 m and at an average speed of 110 km/h (Lessard, 1996; Fradette, 1998). A record of the data collected during the flight—nest location, the number of eggs, nestlings, etc.— was made.

2.2.4 Statistical Methods

The Wilcoxon signed rank test, a nonparametric test, was used to verify whether a differences existed in the number of Common Eider nests between 1998 (prior oil spill) and 1999 (after oil spill) for islands inside and outside the oil spill area. A permutation test (see Legendre and Legendre, 1998), which is a more accurate approach, was used to validate the results of the previous test. A similar statistical method was taken to see whether the variations in the number of Black Guillemot nests on the islands surveyed, before and after the oil spill (i.e., between 1994 and 1999), were comparable to those of the control islands. Clutch size comparison were carried out with a repeated-measures analysis of variance using the law of small numbers (Poisson distribution) as the theoretical distribution and taking into account the "test" and control islands in 1998 and in 1999 after the oil spill. Descriptive statistics were used for the Bald Eagles. The analyses were completed using the SAS software. The Mathematics and Statistics Department of Université Laval provided the statistical expertise.

3. RESULTS

3.1 Impacts on the Breeding Population of Common Eider

3.1.1 Number of Nests

The breeding population of Common Eiders in 1999 (after the oil spill) is compared with 1998 (before the oil spill) for the islands surveyed inside and outside the area contaminated by the Gordon C. Leitch in the Mingan Archipelago National Park Reserve (**Table I**).

For the islands inside the area directly affected, the Common Eider population dropped from 1861 in 1998 to 1707 pairs in 1999 (**Table I**). A high variation in the number of nest of Common Eider is observed among the islands and with respect to a given year. Some islands investigated experienced had an increase in the number of breeding Eider while others went through a decrease. Île à Firmin, island inside the contaminated area, showed the strongest decrease with a loss of 387 pairs. On the other hand, Petite île au Marteau saw its population increase by 183 pairs.

As for the control between islands located outside the oil spill area, the Eider population has remained stable in 1998 and 1999 (**Table I**). On île du Wreck nord, the population has remained constant. On île du Wreck sud, the number of breeding pairs is slightly lower in 1999 than in 1998. However, opportunistic observation suggested that gulls preyed Eider eggs on this island.

According to both the Wilcoxon (p=0,4320) and permutation (p=0,8889) tests, the differences in the number of Common Eider nests between 1998 and 1999 on the islands located within the contaminated area are not, on average, significantly different than those observed on the islands outside this zone. Consequently, the Gordon C. Leitch oil spill does not seem to have had impacts that led to a significant difference in the number of Common Eider.

3.1.2 Productivity

For Common Eider, the mean clutch size in 1999 was 4,23 eggs/nest in 1999 and was comparable to the 4,40 eggs/nest in 1998 for the islands surveyed inside the zone of the oil spill of the Mingan Archipelago (**Table II**). Similar clutch sizes (i.e., 4,26 eggs/nest) have previously been reported in the Mingan Archipelago, in 1988 (Paradis, 1993).

The 1999 mean clutch size (4,15 eggs/nest) of Common Eiders on the control islands located outside the area of the oil spill is similar to that of 1998 (4,11 eggs/nest) (**Table II**). On île du Wreck sud, the heavy predation on Eider eggs (23 nests in 1998, more than 25 nests and 160 eggs in 1999), probably by gulls, could have had an impact on the clutch size.

The differences in the mean clutch size observed between 1998 and 1999 in the islands inside the contaminated area are not significantly different, on average, than the ones surveyed outside this zone (p=0,1967). Furthermore, these differences between 1999 and 1998, on the whole, are not significant (p=0,4650), and that, for all islands surveyed (i.e., inside and outside the contaminated area). The oil spill does not seem to have had clear visible effects on the clutch size of Eider in Minganie. However, the assessment of the hatching success would have provided a better way to evaluate the reproductive success of Common Eiders following this marine incident.

Table I: Number of Cormon Eider (Somateria mollissima dresseri) nests in 1998 and 1999 on the islands located inside and outside the immediate area of the oil spill in the Mingan Archipelago National Park Reserve.

Islands	Pre-spill 1998 Number of nests	Post-spill 1999 Number of nests	Growth 1999 Number of nests
Islands inside the contaminated area			
Petite Romaine	90[1]	108[1]	18
Caye à Meck	19	11	-8
de la Pointe aux Morts	16	18	2
du Fantôme	563[1]	611[1]	48
à Firmin	859[1]	472[1]	-387
Petite île au Marteau	86[1]	269[1]	183
à Calculot	36	46	10
aux Goélands	192	172	-20
Total	**1 861**	**1 707**	**-154**
Islands outside the contaminated area			
du Wreck nord	84	85	1
du Wreck sud	270	250	-20
Total	**354**	**335**	**-19**

[1] Estimates obtained through the extrapolation of nest density in the transects.

Table II: Mean clutch size of Common Eider (*Somateria mollissima dresseri*) in 1998 and 1999 on the islands located inside and outside the immediate area of the oil spill in the Mingan Archipelago National Park Reserve.

Islands	Pre-spill 1998			Post-spill 1999		
	Number of nests (n)	Mean clutch size (eggs/nest)	SD	Number of nests (n)	Mean clutch size (eggs/nest)	SD
Islands inside the contaminated area						
Petite Romaine	5	4,6	0,89	6	4,33	0,52
Caye à Meck	15	3,4	1,76	9	4	1,22
de la Pointe aux Morts	16	4,81	1,38	18	4,06	1,11
du Fantôme	35	4,63	1,48	38	4,53	1,47
à Firmin	58	4,81	1,38	33	4,73	0,57
Petite île au Marteau	7	5,43	2,23	22	4,45	1,14
à Calculot	29	3,72	1,89	43	3,98	1,06
aux Goélands	176	4,32	1,28	172	4,14	1,38
Total	**341**	**4,40**	**1,45**	**341**	**4,23**	**1,26**
Islands outside the contaminated area						
du Wreck nord	84	4,39	1,05	85	4,32	1,14
du Wreck sud	247	4,01	1,16	222	4,09	1,09
Total	**331**	**4,11**	**1,15**	**307**	**4,15**	**1,11**

3.2 Impacts on the Breeding Population of Black Guillemots

3.2.1 Number of Nests

The population of Black Guillemots for all the islands surveyed (i.e., both inside and outside the contaminated area) in the Mingan Archipelago was estimated using the mean number of individuals in attendance at the colonies and the mean K value (number of nests/number of individuals) (**Table III**). The Black Guillemot population in 1999 is estimated at 54 breeding pairs. The mean K value (0,47) used the calculate the number of Black Guillemots in 1999 is the same as the one obtained in Vaudry's 1994 study (1995) on the Guillemots of the Mingan Archipelago.

The number of nests in 1999 and in the 1994 census are comparable to certain insular areas located inside or outside the zone contaminated by the spill (**Table IV**). Inside the immediate contaminated area, the Guillemot population has increased by more than 60%. The number of nests has gone from 32 to 54 between 1994 and 1999. Outside the oil spill area—on île aux Perroquets—the number of Black Guillemots has remained stable with 12 nests in both years.

According to the Wilcoxon (p=0,4364) and permutation (p=0,2857) tests, the effects of the oil spill on the Black Guillemot population are not visible since the differences observed in the number of nests between 1994 and 1999 on the islands inside the contaminated area are not, on average, significantly different from those noted on the islands outside this zone. Considering the difficulties to find the nest of this species, assessment of breeding performance is impracticable.

Table III: Mean number of Black Guillemots (*Cepphus grylle*) in attendance at each colony and the estimated number of nests, using a K value, in 1999 on the islands located inside and outside the immediate area of the oil spill in the Mingan Archipelago National Park Reserve.

Weeks of Surveys	Colonies							
	Outside the spill area		Inside the contaminated area					
	aux Perroquets		du Fantôme		du Havre	Grosse île au Marteau		
	Northwest	South	East	Southwest	Northeast	East	Northwest	Southwest
May 9	13	10	16	14	13	24	41	2
May 16	10	16	16	12	13	22	32	8
May 23	8	22	12	8	5	46	48	7
May 30	6	18	13	18	8	22	51	10
Mean	9,3	16,5	14,3	13,0	9,8	28,5	43,0	6,8
SD	3,0	5,0	2,1	4,2	3,9	11,7	8,4	3,4
K value	0,44	0,42	0,55	Mean K value = 0,47				
Estimated Number of Nests	4,4	7,8	6,7	6,1	4,6	13,4	20,2	3,2

[1] K value: Number of nests/mean number of individuals in attendance at the colony.

Table IV: Number of Black Guillemot (*Cepphus grylle*) nests in 1994 and 1999 on the islands located inside and outside the immediate area of the oil spill in the Mingan Archipelago National Park Reserve.

Colonies	Pre-spill 1994 Number of nests	Post-spill 1999 Number of nests	Growth 1999 Number of nests
Islands inside the contaminated area			
du Fantôme est	0	7	7
du Fantôme sud-ouest	6	6	0
du Havre nord-est	4	5	1
Grosse île au Marteau est	5	13	8
Grosse île au Marteau nord-ouest	14	20	6
Grosse île au Marteau sud-ouest	3	3	0
Total	**32**	**54**	**22**
Islands outside the contaminated area			
aux Perroquets nord-ouest and sud	12	12	0
Total	**12**	**12**	**0**

3.3 Impacts on the Breeding Population of Bald Eagles

3.3.1 Number of Nests

The number of active nests and adults sighted during the 1999 and 1998 Bald Eagle surveys in the Mingan Archipelago are presented in **Table V**.

The number of active Bald Eagle nests is similar in both years. The presence of two Bald Eagle nests observed in 1998 on île du Havre and Grande Île could not be ascertained in 1999. The difficulties associated with locating nests can, to some degree, provide explanations as to why some of them could not be spotted again (Fradette, 1998). Based on the work of Leighton and *al.* (1979) and Grier and *al.* (1981), the success rate of Bald Eagle nest surveys ranges between 76 and 85%, but the probabilities of detecting nests from an helicopter are certainly higher than 85%. The Bald Eagles nesting structures observed in 1998, on île du Havre (i.e., on the first census), could had been confused with Osprey nests. On Petite île Sainte-Geneviève confusion with Great Blue Heron nests, is also possible. It seems then reasonable to conclude that four (4) Bald Eagle nests were active in 1998. The higher number of adults and inactive nests that have been observed in 1999 is probably more indicative of the greater survey effort provided that year.

Table V: Number of active nests and adults observed during the 1998 and 1999 Bald Eagle (*Haliaeetus leucocephalus*) surveys in the Mingan Archipelago National Park Reserve.

Islands	Pre-spill 1998		Post-spill 1999	
	Number of adults sighted	Number of active nests	Number of adults sighted	Number of active nests
Bouleaux de Terre (pyt-01) [1]	1	1	2	1
Grande île (pyt-02)	0	0	2	(1 inactive)
Quarry	1	0	0	0
du Havre	2	(1)?	1	0
du Havre (pyt-03)	0	0	0	(1 inactive)
du Havre (pyt-04)	0	0	0	(1 inactive)
St-Charles (pyt-05)	0	1	1	1
à la Chasse (pyt-06)	2	1	2	1
à la Chasse	0	0	1	0
Petite île Ste-Geneviève	1	(1)?	0	0
Ste-Geneviève (pyt-07)	0	1	1	1
Total	**7**	**4**	**10**	**4**

?: Unconfirmed nidification

[1] pyt: Identification of the nests in 1999.

3.3.2 Productivity

The content of active Bald Eagle nests of the Mingan Archipelago in 1998 and 1999 is given in **Table VI**.

Bald Eagle productivity cannot be compared for the years 1998 and 1999. Clutch size was not evaluated in 1998 because the census, which was included in the waterfowl survey, was completed before the raptor's nesting season. However, the mean productivity of Bald Eagles in 1999 is two (2) eaglets/nest. The clutch size for this species is generally two (2) eggs per nest (Lessard, 1996; Brownell and Oldham, 1985). The Gordon C. Leitch oil spill does not seem to have had noticeable impacts on the productivity of Bald Eagles in the Mingan region, in 1999.

Table VI: The content of active Bald Eagles (*Haliaeetus leucocephalus*) nests in 1998 and 1999 in the Mingan Archipelago National Park Reserve.

Islands	Pre-spill 1998		Post-spill 1999	
	Number of active nests (n)	Content of active nests (young/nest)	Number of active nests (n)	Content of active nests (young/nest)
Bouleaux de Terre (pyt-01)	1	2	1	2
St-Charles (pyt-05)	1	nc	1	2
à la Chasse (pyt-06)	1	nc	1	2
Ste-Geneviève (pyt-07)	1	nc	1	2
Total	**4**	nc	**4**	**8**
Mean	**N/A**	**N/A**	**N/A**	**2**

[1] pyt: Identification of nests in 1999.

nc : Unconfirmed number of nestlings due to the early period at which the census was carried out.

4. DISCUSSION

4.1 Impacts on the Breeding Population fo Common Eiders

The Gordon C. Leitch oil spill in Havre-Saint-Pierre had limited impacts on MANPR's breeding population of Common Eiders. The breeding population of Common Eiders inside the affected area experienced a slight reduction in numbers, from 1861 pairs in 1998 to 1707 pairs in 1999. On the other hand, the other population located outside the contaminated area has remained stable over that same time period. Over the last few years, the number of Common Eiders had been increasing in the Mingan Archipelago (Paradis, 1993) as well as in the Gulf of St.Lawrence (Chapdelaine, 1995). The conservation and education efforts as well as the creation of the Mingan Archipelago National Park Reserve have contributed to the considerable increase in the Common Eider population observed over the years (Chapdelaine and Brousseau, 1991; Munro, 1995).

The overall consequences of this oil spill on the breeding population of Common Eiders in the Mingan Archipelago is difficult to determine clearly. This population seems to have experienced a loss of 150 pairs (i.e., 300 birds) between 1998 and 1999 in the immediate area of the oil spill. Based on a catchability coefficient of 40 %, Lehoux and Bordage (1999) estimate that approximately 255 individuals of the breeding population of Eiders (*S.m. dresseri*) have perished because of the oil spill (**Table VII**). According to the results of this monitoring program, the differences in the number of Common Eider nests are however not significant for both the contaminated and uncontaminated Mingan islands for the 1998-1999 period. In addition, Common Eider productivity in the Mingan Archipelago does not seem to have been affected by the Gordon C. Leitch incident since the mean clutch size for the 1998 and 1999 periods is not significantly different from one another and that, for all islands, surveyed, (i.e., inside and outside the contaminated area). Natural factors (movements, meteorological conditions, predation, competition, etc.) and occasional variations in the sampling method (estimations, observers, etc.) could account for some of the minor changes observed in the breeding population of Common Eider between 1998 and 1999. It is then reasonable to conclude that the Gordon C. Leitch oil spill had no observable impacts on the breeding population of Common Eiders (*S. m. dresseri*) in Minganie.

The wintering of northern eider population (*S. m. borealis*) of the Mingan Archipelago was certainly the most affected by the oil spill. Of the 947 Eiders found dead, 786 (83%) were of the *borealis* subspecies and 161 birds (17%) were of the *dresseri* subspecies, which breed on the Lower North Shore (Lehoux and Bordage, 1999). This proportion (83%; 17%) appears reasonable considering the lenght of the wintering period of *borealis* in the region and their phenological migratory calendar. The arrival of breeding Eiders (*S.m. dresseri*) in the MANPR is around mid-April, a period which coincides with the departure of the wintering subspecies (*S. m. borealis*) to its nesting grounds along the coasts of Labrador and Ungava Bay (M.Guillemette, pers. comm. *in* Paradis, 1993).

According to the present study, the impacts of the Gordon C. Leitch oil spill on Mingan's breeding population of Common Eiders, presented in **Table VII**, could range between 161 (minimum mortality observed) and 725 (maximum mortality observed) individuals, which represents between 1,6 to 7,3% of the 5 000 pairs surveyed in the MANPR (Paradis, 1993; Roberge, 1998, in prep.). In addition, the effects of the contaminated mussel beds on the eider population of Minganie following the oil spill (Génivar, 1999) are not documented. Although Common Eiders are often the victims of oil spill, the population has the ability to recover through recruitment and immigration (Seip and *al.*, 1991). If a small fraction of the Mingan Eider population was indeed impacted by the oil spill, it should recover fairly rapidly.

4.2 Impacts on the Breeding Population of Black Guillemots

The impacts on the breeding population of Black Guillemots are indiscernible. The breeding population of Black Guillemots in the immediate contaminated area increased from 32 to 54 pairs between 1994 and 1999.The Black Guillemot population of the Mingan Archipelago was on the rise between 1978 to 1994 (Vaudry, 1995). This increase may be associated with the better protection in this area since the creation of the park and the abundance of food resources, although their local diet is unknown (Vaudry, 1995; Chapdelaine, 1995). The evaluation of the current population trend should however be taken with caution since the available Black Guillemot demographics are fragmentary. Variations in the Black Guillemot populations of Mingan could have taken place between 1994 and 1998. The last census carried out by the Canadian Wildlife Service indicated a decrease in the Black Guillemots population in the North-Shore sanctuaries of the Gulf of St.Lawrence between 1988 and 1993 (Chapdelaine, 1995). However, the increase in the number of Black Guillemots in the immediate area of the spill is substantial when compared to the 1994 data and would suggest that the impacts of the spill on this breeding population is negligible or nill.

Black Guillemots affected by the oil spill had winter plumage and were more likely mainly using this zone as a wintering ground. The winter distribution of Black Guillemots is poorly known. For instance, it is not clear whether the population from the south of Quebec winters in the Estuary and the Gulf of St.Lawrence or whether it migrates to the Atlantic coast (Cairns, 1995). Considering the current state of knowledge and the increase in numbers of the Black Guillemots in the contaminated area, we conclude that the oil spill, mainly affected the Black Guillemot wintering in the Mingan Archipelago or those breeding elsewhere on the Lower North Shore, the Labrador coast, and the Low Arctic.

According the Canadian Wildlife Service, an estimated 50 to 200 Black Guillemots died. These numbers correspond to 22 and 87 % of the 115 pairs of Black Guillemots of the Mingan Archipelago in 1994 (Lehoux and Bordage, 1999). This study suggests that the proportion of the local Black Guillemot population affected by the oil spill is probably less important (<22%), considering the increase recorded since 1994 and by the possible deaths on non-breeding guillemots that overwinter in Minganie (**Table VII**).

4.3 Impacts on the Breeding Population of Bald Eagles

The effects of the oil spill on the Bald Eagles population of the Mingan Archipelago are hard to demonstrate. Mingan's Bald Eagle population is not very abundant and the direct consequences of the oil spill on this species are very limited and therefore complicates impact analysis. Many aspects of the biology and ecology of the Bald Eagles are still poorly known in Québec (Lessard, 1996). Parks Canada is just starting to acquire knowledge through studies on the breeding of Bald Eagles in the Mingan Archipelago National Park Reserve (Roberge, 1998, in prep.).

No changes were observed in the Bald Eagles population of the Mingan Archipelago following the Gordon C. Leitch oil spill in Havre-Saint-Pierre in 1999. The number of confirmed active nests and adults sighted during the aerial survey in 1998 and 1999 are comparable. The demographic trend of the breeding population of Bald Eagles in Québec is most likely stable or increasing (Fradette, 1998). The mean Bald Eagles productivity was high in 1999 with two (2) eaglets/nest. Bald Eagles must produce a minimum of 0,7 eaglet/nest each year to maintain a viable population (Brownell and Oldham, 1985). We conclude that the 1999 breeding population of Bald Eagles in the Mingan Archipelago - with its fledging success of two (2) eaglets/nest- appears healthy in spite of the Gordon C. Leitch

oil spill.

The monitoring program cannot be used to determine whether the Bald Eagles affected by the spill were indeed part of the breeding population or winter residents of the Anticosti-Minganie complex. In Québec, the breeding activities of Bald Eagles begin in early April (Aquin, 1997; Lessard, 1996). The timeline for these activities roughly coincides with that of the Gordon C. Leitch oil spill. Furthermore, Bald Eagles winter locally in southern Québec, especially on Anticosti island, on the North Shore, and in the southwest of the Laurentian Mountains (David 1980a *in* Bird and Henderson, 1995; Lessard, 1996).

While three oil-covered Bald Eagles -two (2) adults and a juvenile- have been sighted, no mortality has been reported. Some Bald Eagles have been seen feeding on oil-covered Common Eider carcasses (Pers. obs., 1999; Piatt and *al.*, 190; Rodway and *al.*, 1989). The ingestion of oil by birds could lead to certain toxic effects (Lee and *al.*, 1985; Peakall and *al.*, 1987; Cavanaugh and *al.*, 1983), but this has not been determined in the Bald Eagles of the Mingan Archipelago.

The impacts of the Gordon C. Leitch oil spill on the Bald Eagle population of the Mingan Archipelago appear minor. However, as minor as these repercussions may seem, they could have had a significant impact on this small and vulnerable bird population of Québec. The loss of one breeding pair in Mingan could potentially be 25% of the total number of Bald Eagles in the Mingan Archipelago and 3% of Québec minimum population, estimated at 34 active pairs in 1987 (Fradette, 1998).

The Bald Eagle population of the Mingan Archipelago, which currently represents close to 12% of the total population of this species in Québec, is highly vulnerable and could be seriously affected by an oil spill. The 1989 *Exxon Valdez* oil spill has resulted in the death of 247 Bald Eagles in Alaska's Prince William Sound, which significantly lowered this population, a population is estimated at 2 000 individuals (Bowman and *al.*, 1993 in Bowman and *al.*, 1997). The population recovered only after six years (Bowman and *al.*, 1995). Consequently, protective measures have to be considered to safeguard the Bald Eagle population of the Mingan Archipelago and to mitigate the impacts of various anthropogenic pressures such as those resulting from this marine incident.

4.4 Impacts on the Breeding Bird Populations of the MANPR

According to the Canadian Wildlife Service, 1 000 to 4 000 birds have died because of this oil spill. This represent 1 to 4% of the total wintering bird population of the Gulf of St.Lawrence (Lehoux and Bordage, 1999). Based on our study, among these birds it could be 161 Common Eiders, less than 50 Black Guillemots, and possibly no Bald Eagles, breeding in the MANPR (**Table VII**). The other migratory birds reported to have been impacted by the oil spill are : one Common Merganser and five King Eiders. Observed oil-covered birds - gulls, ducks, etc. - are not considered here. Most highly conservative mortality estimates make use of a correction factor of four to five times the number of dead birds reported (Burger, 1993). The proportion of oil-covered birds can be influenced by several factors : bird density on the water, winds, currents, distance of the oil spill from the shore, number of people involved in the recovery program, number of scavengers, number of sunken or lost carcasses (Ford and *al.*, 1987; Page and *al.*, 1990 *in* Burger, 1993). Consequently, the potential number of birds that have died as a result of the oil spill in Mingan could vary between 211 and 777. This represents 0,4 to 1,6% of the total breeding seabird population in that area, estimated at 50 000 individuals (see Roberge, 1998b).

Table VII: Impacts of the Gordon C. Leitch oil spill on the breeding bird populations of the Mingan Archipelago National Park Reserve in 1999.

Species	Number of dead birds found [1]	Estimated mortality of the breeding birds of the MANPR according to Lehoux and Bordage 1999 [2]	Estimated mortality of the breeding birds of the MANPR according to the present monitoring program [3]
Common Eider (*Somateria mollissima*)	947 (*S.m. dresseri* 161) [5] (*S.m. borealis* 786)	min. 175 (2%)[4] prob. 255 (2,6%) max. 612 (6%)	min. 161 (1,6%) prob.< 300 (<3%) max. 725 (7,3%)
Black Guillemot (*Cepphus grylle*)	50	min. 50 (22%) prob. 70 (35%) max. 200 (87%)	min. < 50 (<22%) prob.< 50 (<22%) max. 50 (22%)
Bald Eagle (*Haliaeetus leucocephalus*)	0 (3 oil-covered birds)	min. 0 (0%) max. 2 (25%)	min. 0 (0%) max. 2 (25%)
Others	6 (5 King Eiders) (1 Common Merganser)	0	0
Total	1003	min. 225 (0,5%) prob. 325 (0,7%) max. 814 (0,6%)	min. 211 (0,4%) prob.<350 (0,7%) max. 777 (1,6%)

1 Total number of breeding or overwintering birds in Minganie.

2 Lehoux and Bordage (1999) calculate the minimum number of deaths (min.) using the number of dead birds collected ; the probable death toll (prob.), by applying a catchability coefficient of 40% to the number of dead birds; and the maximum number of deaths (max.) by multiplying the number of dead birds by a correction factor of 4.

3 This monitoring program calculates the minimum number of deaths (min.) using the number of dead birds found; the probable death toll (prob.) taking into account the results of this study; and the maximum number of deaths (max.) by multiplying the number of dead birds by a correction factor of 4,5 (Burger, 1993).

4 The percentages in the table take into account the estimated number of dead breeding birds with respect to the total number of breeding birds for a particular species in the park; 5 000 pairs of Common Eiders (Paradis, 1993; Roberge, 1998a, in prep.), 115 pairs of Black Guillemots, 4 pairs of Bald Eagles (Roberge, 1998, in prep.). As for the total, the breeding seabird population in the MANPR is estimated at 25 000 pairs (Roberge, 1998b).

5 The death toll involving the different Common Eider subspecies may include certain biases considering the difficulties associated with their identification.

5. RECOMMENDATIONS

Protective measures have to be considered to mitigate the environmental impacts of the Gordon C. Leitch, to prevent and minimize the effects of other marine incidents and to protect the breeding bird populations of the Mingan Archipelago.

Impact Mitigation Measures

Certain mitigation measures, such as the manipulation of the nesting habitats, can be used to increase bird populations following oil spills. The restoration of natural nesting grounds has been proposed for Common Eiders and Guillemots (Lawrence and Davies, 1993). The use of artificial nesting structures constitutes a likely avenue for Common Eider (Clark and *al.*, 1975), Guillemots (Lawrence and Davies, 1993), and Bald Eagles (Hunter and *al.*, 1997).These interesting methods should not to be prioritized here because the effect of the oil spill on the breeding bird populations of Mingan was limited. We assume they will recover within the next few years.

Monitoring Activities

Monitoring activities on the Bald Eagle, a threatened species in Quebec, should be carried out in order to increase our understanding of this animal and to develop effective protective measures against future marine incidents such as accidental oil spills. A medium-term (5 years) monitoring program on the breeding population of Bald Eagles and a study on the use of the nesting grounds should lead to a greater understanding of its ecology and better protective measure.

We agree that a research project on the Eider populations could be completed to assess more precisely the time of arrival and departure of the subspecies (*S. m. dresseri* and *S. m. borealis*) in Minganie.

Protective Measures

Protective measures could be considered to prevent and mitigate the injurious environmental effects of oil spills in the Mingan Archipelago. The authorities responsible for environmental emergencies and industrial representatives should discuss the possibility of establishing seasonal scenarios to assess the potential ecological ramifications of such incidents on the birds of the MANPR, to develop intervention strategies, and to evaluate the consequences and effectiveness of the mitigation programs.

Outreach Activities

The company responsible for the oil spill, Upper Lakes Group, would benefit from developing public outreach programs in order to increase general awareness of the mitigation measures as well as the monitoring activities needed to maintain a long-lasting positive image to the Mingan communities.

6. CONCLUSION

The Gordon C. Leitch oil spill does not seem to have caused apparent impacts on the reproductive potential of the breeding bird population of the Mingan Archipelago National Park Reserve.

The Common Eider population on the islands inside the contaminated area dropped from 1861 pairs in 1998 to 1707 pairs in 1999 following the oil spill but this downward trend is not statistically significant. Clutch size of Eider was not different between 1998 and 1999, either inside or outside the immediate area of the oil spill. The slight variations observed may be associated to various natural factors (natural movements, meteorological conditions, predation) or random variations in the sampling method (estimation, observers).

The breeding population of Black Guillemots on the Mingan islands was not significantly affected by the 1999 oil spill. The Black Guillemot population inside the contaminated was made up of 54 pairs in 1999 comparatively to 32 in 1994.

Mingan's breeding population of Bald Eagles appears stable in 1999 when compared to 1998 with four (4) breeding pairs producing eggs. The mean productivity of two (2) eaglets/nest, in 1999, suggests a healthy population, even after this marine incident.

According to this study, the Gordon C. Leitch oil spill resulted in the death of approximately 211 to 777 breeding birds, representing between 0,4 to 1,6% of the total number of seabirds in the Mingan Archipelago National Park Reserve.

The breeding bird populations of Mingan slightly affected by the oil spill should recover over the next few years. Appropriate measures must be considered however to prevent and mitigate the potential repercussions of possible marine incidents and to protect the avifauna of the Mingan Archipelago.

The conditions encountered during the Gordon C. Leitch oil spill reminded us of the complexity involved in the cleaning process as well as the sensitivity of the insular ecosystem of the Mingan islands. This oil spill of national importance and of great socio-economical and ecological repercussions should provide the authorities the tools and experience needed to develop timely seasonal scenarios for ecological incidences and strategies to avoid natural catastrophes for the welfare of human communities.

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