

HERRING GULL *LARUS ARGENTATUS* PREDATION  
ON LEACH'S STORM-PETRELS *OCEANODROMA*  
*LEUCORHOA* BREEDING ON GREAT ISLAND,  
NEWFOUNDLAND

*PREDATIE VAN ZILVERMEEUWEN OP VALE*  
*STORMVOGELTJES VAN GREAT ISLAND, NEWFOUNDLAND*

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*The east coast of Newfoundland, Canada, harbours some of the largest Leach's Storm-Petrel Oceanodroma leucorhoa colonies in the world. In 1997, we estimated the breeding population of Leach's Storm-Petrels on Great Island, Witless Bay, Newfoundland at 269 765 ± 27 769 (213 866 - 325 664) pairs. This is similar to a previous estimate from 1979 of 252 910. A shift in distribution has occurred with more petrels nesting in forested habitat and fewer in grass-shrub meadows in 1997. Gull predation on seabirds has increased in Newfoundland in the 1990s as a response to a variety of changes in the marine ecosystem. We estimated that gulls killed 49 189 Leach's Storm-Petrels in 1997. However, in the face of this large kill, the breeding populations does not appear to have substantially declined. Recruitment from other large colonies may be maintaining the breeding population on Great Island.*

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## INTRODUCTION

Leach's Storm-Petrels *Oceanodroma leucorhoa* are small Procellariiforms that breed throughout temperate and boreal waters of the northern Hemisphere (Huntington *et al.* 1996). The east coast of Newfoundland, Canada, harbours some of the largest breeding colonies in the world, with numbers estimated in the millions (Sklepkovych & Montevecchi 1989). Leach's Storm-Petrels are nocturnal at the breeding colonies, presumably an adaptation to avoid predation by large gulls, to which they are vulnerable (Watanuki 1986; Huntington *et al.* 1996).

Recent changes to marine ecosystems in the northwest Atlantic have resulted in a change in foraging habits of Herring Gulls *Larus argentatus* and

Great Black-backed Gulls *L. marinus*. Traditionally, gulls consumed mussels *Mytilus edulis*, storm-petrels, refuse and fisheries offal, and capelin *Mallotus villosus* once their chicks hatched (Pierotti 1982; Pierotti & Annett 1987). In the 1990s a moratorium on most ground fisheries has reduced the availability of fisheries offal, and improvements in waste management has reduced the amount of refuse available (e.g. Howes & Montevecchi 1993). Additionally, capelin have been arriving inshore up to one month later (Carscadden & Nakashima 1997), well beyond the time when gull chicks hatch. Gulls have responded to these changes by focusing much of their foraging efforts on other seabirds, their chicks and eggs (Russell & Montevecchi 1996; Regehr & Montevecchi 1997). Recently, Stenhouse & Montevecchi (1999) showed that gulls prey heavily on Leach's Storm-Petrels until capelin arrives, after which predation declines substantially. Furthermore, some individual gulls specialise in preying upon Leach's Storm-Petrels and continue to pursue them throughout the breeding season (Pierotti & Annett 1987). With this increased predatory effort by gulls on Leach's Storm-Petrels and the high numbers of breeding gulls (Cairns *et al.* 1989), gull predation could be impacting the Leach's Storm-Petrel breeding population.

The objectives of this paper were to estimate the breeding population of Leach's Storm-Petrel on Great Island, Newfoundland, and to estimate the number of adult Leach's Storm-Petrels killed by Herring Gulls that nest on the island. We also compared this recent population size estimate with earlier estimates to see if any evidence exists that the breeding population of Leach's Storm-Petrel has changed on Great Island.

## METHODS

This study was carried out in the summer of 1997 on Great Island (47°11'N, 52°49'W), in the Witless Bay Seabird Ecological Reserve, Newfoundland (Figure 1). The island and its nesting seabirds are described in Nettleship (1972) and Rodway *et al.* (1996). Leach's Storm-Petrels breed in two different habitats on Great Island, grass-shrub meadows and coniferous forest (Stenhouse & Montevecchi 1999). To estimate burrow density and burrow occupancy rates in these two habitat types, 50 2 x 2 m plots were randomly placed in each habitat. Plots were located along one of eight east-west transects running across the island that were established for a survey of Atlantic Puffins *Fratercula arctica* in 1994 (Rodway *et al.* 1996). For each plot, the transect, the distance and direction along each transect and distance away from the transect were randomly assigned. Only plots which fell in forest or meadow habitat were established. The number of burrows in each plot were counted and burrows were checked three times during the breeding season to assess occupancy.

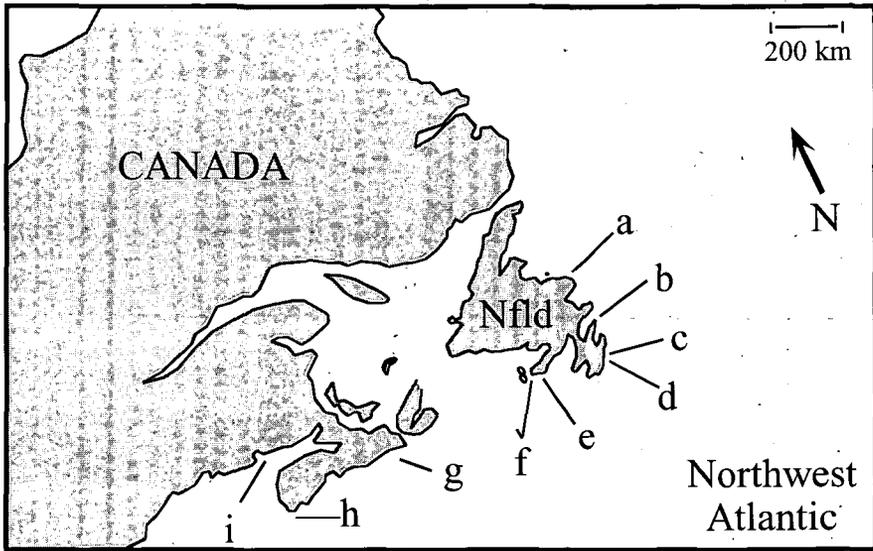


Figure 1. Locations of major Leach's Storm-Petrel colonies in eastern North America. (a) Wadham Islands c. 20 000 breeding pairs (Cairns et al. 1989); (b) Baccalieu Island c. 3 360 000 (Sklepkovych & Montevecchi 1989); (c) Gull Island c. 530 000 (Cairns & Verspoor 1980), (d) Great Island c. 270 000 (this study); (e) Middle Lawn Island c. 27 000 (Cairns et al. 1989); (f) Green Island c. 72 000 (Cairns et al. 1989); (g) Big White Island c. 30 000 (Paterson & Snyder 1999); (h) Bon Portage Island c. 54 000 (MacKinnon 1988); and (i) Kent Island c. 2500 (Huntington et al. 1996).

Figuur 1. Belangrijke kolonies Vale Stormvogeltjes in oostelijk Noord-Amerika. (a) Wadham Islands ca. 20 000 broedparen (Cairns et al. 1989); (b) Baccalieu Island ca. 3 360 000 (Sklepkovych & Montevecchi 1989); (c) Gull Island ca. 530 000 (Cairns & Verspoor 1980), (d) Great Island ca. 270 000 (dit onderzoek); (e) Middle Lawn Island ca. 27 000 (Cairns et al. 1989); (f) Green Island ca. 72 000 (Cairns et al. 1989); (g) Big White Island ca. 30 000 (Paterson & Snyder 1999); (h) Bon Portage Island ca. 54 000 (MacKinnon 1988); en (i) Kent Island ca. 2500 (Huntington et al. 1996).

Burrows were checked by grubbing (reaching in to the burrow by hand) and were considered occupied if they met one of the following conditions: two adults present on at least one occasion, a single adult on more than one occasion, or an egg was found (Stenhouse 1998).

To assess the number of Leach's Storm-Petrels killed by gulls a 360 m long x 2 m wide transect was established that ran through the two habitat types (135 m in grass-shrub habitat and 225 m in forested habitat). This transect did not run along an established pathway. Approximately each week from early

May to late August the number of Leach's Storm-Petrel kills were counted along the transect. Storm-petrel kills were identified as a carcass, wings or collection of loose feathers lying on the ground. All evidence of each kill was removed after counting. Total area of the two habitat types were extrapolated from the habitat map provided in Rodway *et al.* (1996). A 1 x 1 mm square grid overlay was placed over the map and the number of squares falling into each habitat were counted and the area of each habitat type was corrected by the mean slope (12° in forest, 16° in grass-shrub) of each habitat (Stenhouse 1998).

The total breeding population of Leach's Storm-Petrels was calculated as the product of total habitat area and occupied burrow density. 95% CI were based on the standard errors of occupied burrow densities. Total number of Leach's Storm-Petrels killed each week (occasionally biweekly) were calculated as the product of the density of kills/week and the area of habitat. Total number killed over the breeding season (conservatively from early May to late August) was calculated as the sum of these (bi)weekly kill numbers. Where available, all means are presented  $\pm 1$  standard error and 95% confidence limits are presented in parentheses.

## RESULTS

**Breeding population size** In 1997, there was 72 696 m<sup>2</sup> of grass-shrub meadow and 128 460 m<sup>2</sup> of forest available on Great Island. We estimate the number of breeding pairs of Leach's Storm-Petrels was 63 972  $\pm$  7778 (48 315 - 79 629; 95% CL) in grass-shrub meadow habitats and 205 793  $\pm$  19 991 (165 551 - 246 035) in forest habitat for a total of 269 765  $\pm$  27 769 (213 866 - 325 664) pairs of Leach's Storm-Petrels breeding on Great Island in 1997 (Table 1). In 1979, Cairns & Verspoor (1980) estimated that 252 910 (190 000 - 320 000, estimated 95% CL) pairs of Leach's Storm-Petrels were breeding on Great Island. Although the area of available grass-shrub and forest habitat has declined since 1979 (Table 1), occupied burrow density appears to have increased in forest and remained the same in grass-shrub habitat (Table 1).

**Number of adult Leach's Storm-Petrels killed** From 18 May 1999 to 21 Aug 1999, we estimate that 12 653 Leach's Storm-Petrels were killed in grass-shrub habitat and 36 536 were killed in forest habitat, for a total of 49 189 storm-petrels killed (or 9% of the estimated breeding population). We believe that this is a conservative estimate because only kills made in these habitats were recorded (if entire petrels were brought to the nests to be killed, our method would not detect them) and if the evidence of a kill disappeared before the next transect (such as after a storm) then we would not have recorded it.

Table 1. Habitat available and sampled ( $m^2$ ), occupied burrow density ( $n$  per  $m^2$ ) and estimated Leach's Storm-Petrel breeding population on Great Island, 1979 and 1997. All values for 1979 are from Cairns & Verspoor 1980.

Tabel 1. Beschikbaar en onderzocht broedgebied ( $m^2$ ), dichtheid aan bezette nestholten ( $n$  per  $m^2$ ) en geschatte aantallen Vale Stormvogeltjes op Great Island in 1979 en 1997. Alle gegevens van 1979 zijn gebaseerd op Cairns & Verspoor 1980.

|             | habitat ( $m^2$ ) |             | $n$ per $m^2$     | burrows                |                          | population       |
|-------------|-------------------|-------------|-------------------|------------------------|--------------------------|------------------|
|             | available         | sampled     |                   | occup./total           | occupied per $m^2$       | estimated (p)    |
| Grass-shrub |                   |             |                   |                        |                          |                  |
| 1979        | 117 780           | 384 (0.33%) | 1.26 <sup>1</sup> | 146 / 236 <sup>1</sup> | 0.88 ± 0.09 <sup>1</sup> | 104 000          |
| 1997        | 72 696            | 200 (0.28%) | 1.53              | 141 / 245              | 0.88 ± 0.11              | 63 972 ± 7778    |
| Forest      |                   |             |                   |                        |                          |                  |
| 1979        | 168 641           | 220 (0.13%) | 1.60 <sup>1</sup> | 91 / 135 <sup>1</sup>  | 0.88 ± 0.09 <sup>1</sup> | 148 910          |
| 1997        | 128 460           | 200 (0.16%) | 2.21              | 227 / 313              | 1.60 ± 0.16              | 205 793 ± 19 991 |

<sup>1</sup>No differences found between grass-shrub and forest habitat, so pooled values (1.38 burrows/ $m^2$  and 63.9% occupancy rate) were used to calculate occupied burrows/ $m^2$  (Cairns & Verspoor 1980).

Table 2. Number of Leach's Storm-Petrels carcasses found and estimates of island-wide mortality over the 1997 breeding season on Great Island, Newfoundland. Transect covered 270  $m^2$  of grass-shrub habitat (0.37% of available habitat) and 450  $m^2$  of forest habitat (0.35% of available habitat).

Tabel 2. Aantal dood gevonden Vale Stormvogeltjes en schattingen van de totale sterfte in het broedseizoen van 1997 op Great Island, Newfoundland. Het onderzoek betrof 270  $m^2$  grasland met struikjes (0.37% van het aanwezige terrein) en 450  $m^2$  bosgebied (0.35% van het terrein).

| Date           | Grass shrub habitat |                  | Forest habitat |                  |
|----------------|---------------------|------------------|----------------|------------------|
|                | kills found         | estimated killed | kills found    | estimated killed |
| 18 May 1997    | 5                   | 1346             | 4              | 1141             |
| 23 May 1997    | 7                   | 1885             | 16             | 4567             |
| 29 May 1997    | 6                   | 1615             | 11             | 3140             |
| 5 June 1997    | 5                   | 1346             | 18             | 5138             |
| 12 June 1997   | 2                   | 538              | 12             | 3425             |
| 26 June 1997   | 8                   | 2154             | 29             | 8279             |
| 4 July 1997    | 5                   | 1346             | 18             | 5138             |
| 10 July 1997   | 0                   | 0                | 2              | 571              |
| 18 July 1997   | 1                   | 269              | 3              | 856              |
| 24 July 1997   | 4                   | 1077             | 0              | 0                |
| 1 August 1997  | 0                   | 0                | 5              | 1427             |
| 7 August 1997  | 1                   | 269              | 1              | 285              |
| 21 August 1997 | 2                   | 808              | 9              | 2569             |
| Totals         | 46                  | 12653            | 128            | 36536            |

## DISCUSSION

We estimated that 269 765 pairs of Leach's Storm-Petrel were breeding on Great Island in 1997. This is very similar to an estimate of 252 910 (190 000 - 320 000; 95% CI) breeding pairs from 1979 (Cairns & Verspoor 1980). However, Rodway *et al.* (1996) suggested that the 1979 occupancy rate may be low because occupancy rates were assessed in late August. They provided a revised estimate of 340 000 for 1979, based on the same burrow density but using an occupancy rate of 0.87 (as opposed to 0.639, Cairns & Verspoor 1980) obtained during incubation. However, burrow occupancy rates between 0.6-0.7 appear the norm for other colonies (Huntington *et al.* 1996, Stenhouse 1998). Therefore, the estimate provided by Cairns & Verspoor (1980) is possibly low, but the magnitude of any bias is difficult to assess. When compared with the revised estimate of 340 000 pairs in 1979, the population may have declined by 1997.

In 1997, we estimated that Herring Gulls killed close to 49 000 adult Leach's Storm-Petrels during the breeding season. Because this estimate was so high, we attempted to validate at least the magnitude of the estimate from another approach. Pierotti (1982) provided data on the foraging habits of gulls on Great Island, and with his data on gull diet and foraging frequency we calculated a rough estimate of *c.* 50 000 Leach's Storm-Petrels consumed by gulls in 1976. This number was obtained by using only the most conservative of estimates in Pierotti (1982) (of 2144 breeding pairs of gulls, 11.6% specialised on eating Leach's Storm-Petrels for a period of 35 days (i.e. until capelin arrived), each pair ate 5.8 meals of petrels per day and 1 petrel constituted a meal). Our estimate based on kills found on the ground and Pierotti's data based on gull diet are at least in the same order of magnitude, so we believe that our estimate is reasonable. Further, Watanuki (1986) estimated that Slaty-backed Gulls *Larus schistisagus* killed between 15 000 and 50 000 Leach's Storm-Petrel's each month through the breeding season on a Japanese colony. So mortality estimates in the 10 000s are not unprecedented. Given these large numbers, it is surprising that the Leach's Storm-Petrel population on Great Island has not declined precipitously in the face of predation by Herring Gulls. For long-lived species, such as storm-petrels, populations are most sensitive to reductions in adult survival (Danchin *et al.* 1995).

Our occupied burrow density for grass-shrub habitat is very similar to the 1979 overall estimate (Cairns & Verspoor 1980), but our estimate for the forest is almost double that of 1979 (Table 1). Consequently, the number of breeding storm-petrels has increased in the forest and declined in the grass-shrub meadows compared to 1979. Leach's Storm-Petrels appear to be

occupying the forest in greater densities, possibly in response to gull predation. However, predation rates on adult Storm-Petrels were not different between the two habitats, but, breeding success was higher in forested habitats (Stenhouse 1998).

Foraging conditions and breeding success during the 1990s have changed dramatically for most seabirds breeding in Newfoundland (Regehr & Rodway 1999), largely due to their dependence on capelin as a primary prey. However, Leach's Storm-Petrel productivity has remained high (Regehr & Rodway 1999) as they are pelagic feeders dependent on plankton and nekton and not capelin (Montevecchi *et al.* 1992). Gull predation on storm-petrels is assumed to involve mostly non-breeding storm-petrels (Morse & Buchheister 1977, Huntington *et al.* 1996). If this is the case, then population level impacts would be reduced as the survival rate of breeding adults would be minimised. However, since the bulk of the predation occurs in May and June, before non-breeders arrive in numbers, it is highly likely that some portion of the adults killed were breeders (see Stenhouse & Montevecchi 1999 for details).

Little is known about recruitment of breeders in Leach's Storm-Petrels. Large scale-banding efforts on Kent Island, New Brunswick, have shown that recruitment of fledging birds to their natal colony is very low (Huntington *et al.* 1996). This could be caused by high post-fledging mortality and/or natal dispersal of young to other breeding colonies. Genetic analyses suggest that there is gene migration between colonies and natal dispersal was suggested as the source of this mixing (Paterson & Snyder 1999). It is possible that the colony on Great Island is not able to sustain itself and recruitment from other colonies is maintaining the population. The huge colony at nearby Baccalieu Island, which does not have a breeding population of gulls (Sklepkovych & Montevecchi 1989) would be a likely candidate to supply recruits (Figure 1). If this were the case, Great Island would be a sink colony for Leach's Storm-Petrels (Pulliam 1988). Storm-Petrel populations appear able to sustain losses to gulls at other colonies as well (Ainley *et al.* 1975; Watanuki 1988), so the situation in Witless Bay is not unique.

North American seabird communities and ocean ecosystems have not been in equilibrium since European colonisation, so it is impossible to predict what influence gull predation may have on Leach's Storm-Petrel populations in the future. Populations of large gulls are probably inflated due to increased access to human refuse, so Leach's Storm-Petrels may be facing unprecedented levels of adult mortality. Currently, however, Herring Gull populations are declining in eastern North America (Howes & Montevecchi 1993; Chapdelaine 1995; Chapdelaine & Rail 1997), and the population on Great Island, has decreased from 2771 to 1640 pairs (40.8% reduction) from 1979 to 2000 (Cairns & Verspoor 1980; D. Fifield & G. J. Robertson, unpubl. data). With reductions

in gull numbers, predation on Leach's Storm-Petrels will decrease. Capelin arrival is beginning to return to traditional times (mid-June; Massaro *et al.* in press). These changes may have two effects, 1) gull productivity should increase and the population reduction in gulls may halt, but 2) gull predation on Leach's Storm-Petrels is substantially reduced when capelin arrives, so earlier capelin arrival will result in a reduced period of intense gull predation. Given the uncertainties, careful monitoring of gull and Leach's Storm-Petrel populations are clearly warranted to understand present and future impacts of gull predation on breeding Leach's Storm-Petrels.

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#### SAMENVATTING

*Langs de oostkust van Newfoundland (Canada) bevinden zich enkele van de grootste kolonies van het Vaal Stormvogeltje *Oceanodroma leucorhoa* ter wereld. In 1997 werd het aantal broedvogels op Great Island (Witless Bay, Newfoundland) geschat op  $269\,765 \pm 27\,769$  (213 866 - 325 664) paren. Deze schatting is goed vergelijkbaar met die uit 1979: 252 910 paren. Toch is er in dit tijdsbestek een opvallende verandering opgetreden in de verspreiding van de stormvogeltjes op Great Island. Tegenwoordig broedt een veel groter percentage in de beboste delen van het eiland, terwijl de populatie in het open grasland of in struikgewas terugloopt. Deze verandering zou veroorzaakt kunnen zijn door een toegenomen predatie van stormvogeltjes door Zilvermeeuwen *Larus argentatus*. De Zilvermeeuwen in dit deel van de wereld hebben door tal van veranderingen in het mariene ecosysteem (inclusief een moratorium bij de kabeljauwvisserij) tegenwoordig te maken met beperkte voedselvoorraden. Veel meeuwen hebben hun heil gezocht in het vangen en doden van zeevogels. Op Great Island werden in 1997, op grond van de aantallen dood gevonden exemplaren, naar schatting bijna 50 000 Vale Stormvogeltjes door Zilvermeeuwen gedood. Omdat dit zo'n enorm getal was werd de schatting herhaald met behulp van een andere methode (consumptiemodel van de op Great Island broedende meeuwen), maar dit gaf hetzelfde resultaat, zodat de schattingen vermoedelijk een juiste orde van grootte aangeven. Ondanks deze omvangrijke predatie, en afgezien van de veranderende habitatkeuze van de Vale Stormvogeltjes, lijkt de populatie op Great Island niet onder druk te staan. Het is mogelijk dat de kolonie gevoed wordt door immigranten van omliggende kolonies (respectievelijk 3,4 miljoen paren en 530 000 paren op de nabijgelegen Baccalieu Island en Gull Island). Op Baccalieu broeden geen meeuwen en de productiviteit van het Vaal Stormvogeltje is hoog. Het is niet gemakkelijk te voorspellen hoe de predatie van Vale Stormvogeltjes zich verder zal ontwikkelen. De populatie Zilvermeeuwen is onnatuurlijk groot, doordat deze meeuwen geprofiteerd hebben van voedselaanbod op vuilnisbelten en in de commerciële visserij. Nu dat deze voedselbronnen sterk in betekenis zijn afgenomen, terwijl tegelijkertijd een geweldige afname in het bestand van de Lodde *Mallotus villosus* (een spieringachtig visje) voor veel zeevogelsoorten waaronder de Zilvermeeuw een belangrijke vermindering van het voedselaanbod heeft veroorzaakt, hebben veel meeuwen zich gespecialiseerd in de jacht op andere zeevogels. Aanhoudend voedselgebrek zou dan tot aanhoudend hoge predatie van Vale Stormvogeltjes aanleiding kunnen geven. Net als op veel andere plaatsen in het Noord-Atlantische gebied neemt het aantal Zilvermeeuwen ook in Canada tegenwoordig echter snel af.*

## REFERENCES

- Ainley D.G., S. Morrell & T.J. Lewis 1975. Patterns of the life histories of storm petrels on the Farallon Islands. *Living Bird* 13: 295-311.
- Cairns D.K. & E. Verspoor 1980. Surveys of Newfoundland seabird colonies in 1979. Unpublished Canadian Wildlife Service Report. Sackville, New Brunswick, Canada.
- Cairns D.K., W.A. Montevecchi & W. Threlfall 1989. Researcher's guide to Newfoundland seabird colonies. Memorial Univ. Newfoundland Occasional Papers in Biology No 14, St. John's, Newfoundland.
- Carscadden J.E. & B.S. Nakashima 1997. Abundance and changes in distribution, biology, and behavior of capelin in response to cooler waters of 1990s. Forage Fishes in Marine Ecosystems. Proc. Internat. Symp. Role of Forage Fishes in Alaska. Sea Grant Program Rep. No. 97-01: 457-468.
- Chapdelaine G. 1995. Fourteenth census of seabird populations in the sanctuaries of the north shore of the Gulf of St. Lawrence, 1993. *Can. Field-Nat.* 109: 220-226.
- Chapdelaine G. & J.-F. Rail 1997. Relationship between cod fishery activity and the population of herring gulls on the North Shore of the Gulf of St. Lawrence, Québec, Canada. *ICES J. Mar. Sci.* 54: 708-713.
- Danchin E., G. González-Dávila & J.-D. Lebreton 1995. Estimating bird fitness correctly by using demographic models. *J. Avian Biol.* 26: 67-75.
- Howes L.A. & W.A. Montevecchi 1993. Population trends of gulls and terns in Gros Morne National Park, Newfoundland. *Can. J. Zool.* 71: 1516-1520.
- Huntington C.E., R.G. Butler & R.A. Mauck 1996. Leach's Storm-Petrel, *Oceanodroma leucorhoa*. In Poole A. & F. Gill (eds) *Birds of North America*, No. 233, BNA Inc., Philadelphia, PA.
- MacKinnon C.M. 1988. Population size, habitat preference and breeding ecology of the Leach's Storm-Petrel *Oceanodroma leucorhoa* (Viellot) on Bon Portage Island, Nova Scotia. MSc-thesis, Acadia University, Wolfville, Nova Scotia.
- Massaro M., J.W. Chardine, I.L. Jones & G.J. Robertson *in press*. Delayed capelin (*Mallotus villosus*) availability influences large gull predatory behaviour on black-legged kittiwakes (*Rissa tridactyla*), causing a reduction in breeding success. *Can. J. Zool.*
- Montevecchi W.A., V.L. Birt-Friesen & D.K. Cairns 1992. Reproductive energetics and prey harvest of Leach's Storm-Petrel in the Northwest Atlantic. *Auk* 73: 823-832.
- Morse D.H. & C.W. Buchheister 1977. Age and survival of breeding Leach's Storm-Petrels in Maine. *Bird-Banding* 48: 341-349.
- Nettleship D.N. 1972. Breeding success of the common puffin (*Fratercula arctica* L.) on different habitats at Great Island, Newfoundland. *Ecol. Monogr.* 42: 239-268.
- Paterson I.G. & M. Snyder 1999. Molecular genetic (RAPD) analysis of Leach's Storm-Petrels. *Auk* 116: 338-344.
- Pierotti R.J. 1982. Habitat selection and its effect on reproductive output in the Herring Gull in Newfoundland. *Ecology* 63: 854-868.
- Pierotti R.J. & C.A. Annett 1987. Reproductive consequences of dietary specialization and switching in an ecological generalist predator. In: Kamil A.C., Krebs J. & Pulliam R. (eds) *Foraging behaviour*: 417-422. Plenum Press, New York.
- Pulliam H.R. 1988. Sources, sinks and population regulation. *Am. Nat.* 132:652-661.
- Regehr H.M. & W.A. Montevecchi 1997. Interactive effects of food shortage and predation on breeding failure of black-legged kittiwakes: indirect effects of fisheries activities and implications for indicator species. *Mar. Ecol. Prog. Ser.* 155: 249-260.
- Regehr H.M. & M.S. Rodway 1999. Seabird breeding performance during two years of delayed capelin arrival in the Northwest Atlantic: a multi-species comparison. *Waterbirds* 22: 60-67.
- Rodway M.S., H.M. Regehr & J.W. Chardine 1996. Population census of breeding Atlantic Puffins at Great Island, Newfoundland in 1993-94. Canadian Wildlife Service Technical Report Series No. 263, Atlantic Region, Sackville, New Brunswick.

- Russell J.O. & W.A. Montevecchi 1996. Predation on adult puffins *Fratercula arctica* by Great Black-backed Gulls at a Newfoundland colony. *Ibis* 138: 791-794.
- Sklepkovych B.O. & W.A. Montevecchi 1989. The world's largest known nesting colony of Leach's Storm-Petrel on Baccalieu Island, Newfoundland. *Amer. Birds* 43: 38-42.
- Stenhouse I.J. 1998. Habitat utilization and breeding success of Leach's Storm-Petrel, *Oceanodroma leucorhoa*. M.Sc.-thesis, Memorial Univ. Newfoundland, St. John's, Newfoundland.
- Stenhouse I.J. & W.A. Montevecchi 1999. Indirect effects of the availability of capelin and fishery discards: gull predation on breeding storm-petrels. *Mar. Ecol. Prog. Ser.* 184: 303-307.
- Watanuki Y. 1986. Moonlight avoidance behaviour in Leach's Storm-Petrels as a defence against Slaty-backed Gulls. *Auk* 103: 14-22.
- Watanuki Y. 1988. Regional differences in the diet of Slaty-backed Gulls breeding around Hokkaido. *J. Yamashina Inst. Ornithol.* 20: 71-81.



Leach's Petrel *Vaal Stormvogeltje* (C.J. Camphuysen)