SIZE AND TRENDS OF LEACH'S STORM-PETREL *OCEANODROMA LEUCORHOA* BREEDING POPULATIONS IN NEWFOUNDLAND

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Robertson, G.J., Russell, J., Bryant, R., Fifield, D.A. & Stenhouse, I.J. 2006. Size and trends of Leach's Storm-Petrel *Oceanodroma leucorhoa* breeding populations in Newfoundland. Atlantic Seabirds 8(1/2): 41-50. *The world's largest Leach's Storm-Petrel* Oceanodroma leucorhoa *colonies are in Newfoundland, Canada, with Baccalieu Island alone supporting over 3 million nesting pairs. Since 2001, an effort was made to re-census many of the larger colonies in Newfoundland and compare current population estimates with those from the 1970s and early 1980s. Surveys were undertaken by grubbing small plots, calculating occupied burrow densities and extrapolating these densities to the area occupied by petrels. Playback and burrow entrance monitoring proved to be less or equally effective as grubbing, but required much more time, possibly due to the high densities of occupied burrows. The larger colonies examined appeared to be stable between the 1970-80s and the early 2000s while the two smaller colonies examined, Middle Lawn Island and Small Island, showed declines. The establishment of large gull (both Great Black-backed Gull* Larus marinus *and Herring Gull* L. argentatus*) colonies close to these two islands in the 1970s may explain the population declines at these sites, although habitat quality differences among islands could not be ruled out. In contrast, massive predation (an estimated 49,000 adults killed/year) of Storm-Petrels on Great Island, Witless Bay by large gulls did not appear to have reduced the breeding Storm-Petrel population which remains around 270,000 breeding pairs. Although Leach's Storm-Petrel colonies in Newfoundland appear to be faring well in the last 2-3 decades, continued monitoring is warranted, given potential threats from large gull predation, contaminants, chronic oil pollution and offshore oil and gas production.*

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INTRODUCTION

The east coast of Newfoundland harbours some of the largest Leach's Storm-Petrel *Oceanodroma leucorhoa* colonies in the world (Sklepkovych & Montevecchi 1989). In spite of their global significance, by 2000 most major colonies had not been surveyed since the late 1970s or early 1980s (Cairns *et al.* 1989), so little data existed to assess current population trends in this species

(but see Stenhouse *et al.* 2000). This was largely due to the extensive and time-consuming field work needed to effectively monitor this nocturnal, burrow-nesting seabird. To begin to fill this information gap, surveys of breeding populations of several important Leach's Storm-Petrel colonies were begun in the summer of 2001 and have continued annually since then.

This paper updates population size estimates of Leach's Storm-Petrel colonies in Newfoundland, assesses trends where historical data were available and discusses possible factors influencing the population size and trend of this species.

METHODS

Information from older surveys (pre-2001) was extracted from Cairns *et al.* (1989) and the associated Atlantic Seabird Colony Register, a database of seabird colony surveys maintained by the Canadian Wildlife Service. In addition, all available survey documentation was consulted directly, e.g. Sklepkovych & Montevecchi (1989) and Stenhouse *et al.* (2000). The methods used in older surveys were variable, and in some cases not known. For trend analysis, we included surveys that were based on quantitative estimates of colony size. Surveys since 2001 were conducted in a standardized manner, and details are presented in Robertson *et al.* (2001) and Robertson & Elliot (2002). Islands with larger populations (so that more of the global population could be sampled) accessible islands and islands with previous population estimates were selected for re-census. The methods used in recent surveys are outlined below.

As previous surveys did not always document the area used by breeding Leach's Storm-Petrels, island-wide grids were established to, 1) determine the limits and area of Leach's Storm-Petrel breeding habitat, and then, 2) determine occupied burrow densities. On maps of each island, a georeferenced grid was laid out which included at least 100 intersection points. These grid lines ranged from 25-75m wide, depending on the size of the island. In the field, grid intersection points were located by a hand-held GPS, or with tape measures and compass. At the intersection of all grid lines, a 16 m^2 circular plot was established by placing a stake at the centre of the plot and marking a circle on the ground with a can of spray paint tied to a cord of appropriate length (2.26 m). All burrow entrances in the plot were counted, and the contents assessed. Burrow entrances were recorded as leading to either: a burrow too short to hold a pair of breeding petrels, an empty burrow, an occupied burrow (adult and/or egg present), a burrow for which the contents could not be assessed (unknown), or as an additional entrance to a burrow already recorded as falling into one of the above categories. Contents of each burrow were assessed by grubbing (reaching into the burrow by hand). In rare cases an access hatch was dug in the peat to assess the contents of longer burrows.

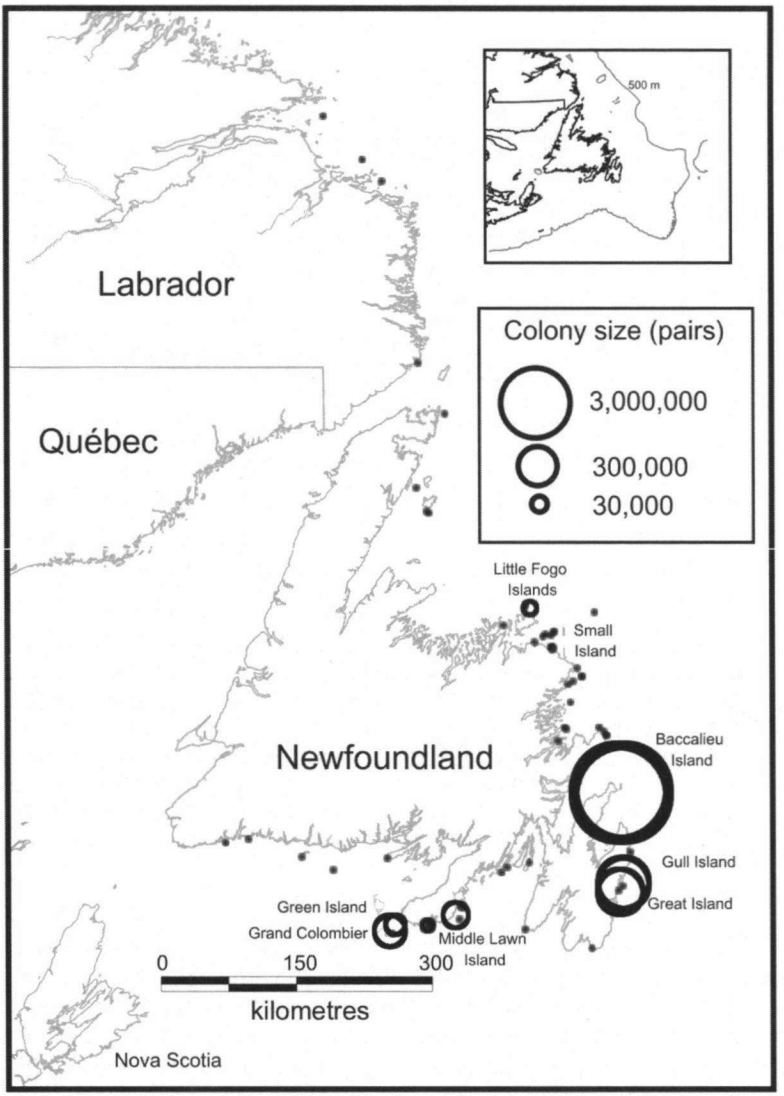

Figure 1. Distribution and size of Leach's Storm-Petrel colonies in Newfoundland and Labrador, Canada and St. Pierre and Miquelon, France. Inset map shows 500 m isobath.

Figuur 1. Verspreiding en grootte van kolonies van Vaal Stormvogeltje in Newfoundland en Labrador (Canada) en St. Pierre en Miquelon (Frankrijk). De inzet laat de 500 m isobath zien.

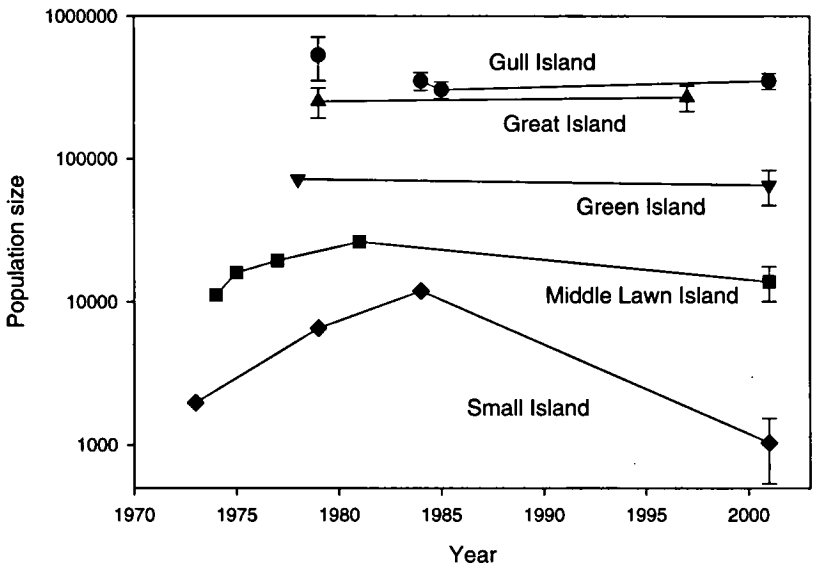

Figure 2. Population size (log 10) and trends of Leach's Storm-Petrel colonies monitored in Newfoundland, Canada. Data sources for older information can be found in Stenhouse et al. *(2000), Robertson* et al. *(2002) and Robertson & Elliot (2002) and 95% confidence are presented where available.*

Figuur 2. Populatiegrootte (log 10) en trends van gemonitorde kolonies van Vaal Stormvogeltje in Newfoundland (Canada). Bronnen van oudere data zijn te vinden in Stenhouse et al. *(2000), Robertson* et al. *(2002) en Robertson & Elliot (2002). Indien beschikbaar worden de 95%-betrouwbaarheidsintervallen gepresenteerd.*

For analysis, if a grid intersection had at least one burrow in the 16 m^2 plot then the surrounding area, specifically half the distance to the next grid line, was considered occupied habitat. Technically, plots without burrows could be included to calculate occupied burrow densities and then multiplied by total island area to obtain a population estimate. However, we chose not to include these unoccupied plots in the analysis, as it had the undesirable effect of skewing the distribution of occupied burrow densities due to the large number of 0s. Removing unoccupied habitat and 0 occupied burrow densities had two statistical advantages, firstly it allowed the standard error to be calculated on a distribution that approximated a normal distribution, and second, it effectively reduced the standard error of the estimate of population size. For islands with

steep topography, the occupied area was further corrected by the mean angle of all plots, measured with a clinometer. Occupied burrow densities for each plot were calculated by multiplying occupancy rates (excluding unknown burrows as the contents of these burrows was not known) by the burrow density in each plot (including unknown burrows). Mean occupied burrow densities were then calculated from all plots which had burrows. Finally, the total corrected occupied area was multiplied by the mean occupied burrow density to obtain a final population estimate. Standard errors and 95% confidence intervals are available in the original reports.

Table 1. Estimated population sizes, most recent census year, occupancy rates, burrow densities and occupied burrow densities for the largest known Leach's Storm-Petrel colonies in Newfoundland and Labrador, Canada and St. Pierre and Miquelon, France.

Tabel 1. Geschatte populatiegrootte, meest recente inventarisatiejaar, bezettingsgraad, holendichtheid en dichtheid bezette holen voor de grootste bekende kolonies in Newfoundland en Labrador (Canada) en St. Pierre en Miquelon (Frankrijk) van Vaal Stormvogeltje.

Colony	Year	Size (pairs)	Occupancy rate	Burrow density (m^{-2})	Occupied burrow density (m^{-2})	Source
Baccalieu Island	1984	3,360,000	0.680	0.046-4.166	0.017-2.495	1
Gull Island (Witless Bay)	2001	351,866	0.722	1.070	0.772	2
Great Island (Witless Bay)	1997	269,765	0.659	1.870	1.233	3
Grand Colombier, St Pierre	2004	142,783	0.617	0.670	0.451	4
Corbin Island	1974	100,000				5
Green Island (Fortune Bay)	2001	65,280	0.747	0.874	0.653	2
Little Fogo Islands	1975	38,000				5
Middle Lawn Island	2001	13,879	0.709	0.666	0.472	2
Iron Island	1974	10,000				5
Small Island	2001	1,038	0.338	0.223	0.076	6

[1] Sklepkovych & Montevecchi 1989; [2] Robertson *et al.* 2002; [3] Stenhouse *et al.* 2000; [4] CWS, Alder Institute and Service D'Agriculture et de la Faune, and Le Centre Culturel, St. Pierre et Miquelon; [5] Cairns *et al.* 1989; [6] Robertson & Elliot 2002.

RESULTS

The distribution of Leach's Storm-Petrel breeding colonies in Newfoundland and Labrador is shown in Figure 1, with details for the larger colonies in Table 1. In addition to the colonies in Table 1, another 7 have population sizes in the 1,000-10,000 range, 12 are in 100-1,000 range and 32 have between 1-100 breeding pairs. The information available on trends for Newfoundland shows that most larger colonies appear stable, while two smaller colonies showed declines since the early 1980s (Figure 2). As the estimate of 533,186 pairs available for Gull Island in 1979 (Cairns & Verspoor 1980) was based on a

single transect through habitat that had unrepresentatively high burrow densities, the apparent decline from 1979 to 1984 is a sampling artefact. Occupancy rates were relatively consistent among colonies, while burrow densities were much more variable (Table 1).

DISCUSSION

Newfoundland harbours some of the largest Leach's Storm-Petrel colonies in the world, totalling over 4 million breeding pairs. The distribution of colonies is highly skewed, with Baccalieu Island holding 3.36 million pairs (Sklepkovych & Montevecchi 1989), a few colonies harbouring 100s or 10s of thousands of pairs and a collection of smaller colonies of tens, hundreds or thousands of pairs. All large colonies have been surveyed at least once (although Corbin Island requires a thorough re-assessment) and are reasonably well known. On the other hand, most small colonies have only been visited once, have not had quantitative assessments of population size, and many more are likely to have gone unnoticed. The majority of the colonies occur in eastern Newfoundland, a distribution typical of most pelagic seabirds breeding in the province. This is likely a function of the proximity to appropriate foraging grounds near the continental shelf break. Labrador has a few known colonies, with numbers of pairs in the tens or hundreds, and represents the northern breeding limit of this species in the Northwest Atlantic. Québec has only a small population of Leach's Storm-Petrels, while Nova Scotia supports some larger colonies (tens of thousands) and may have over 100,000 breeding pairs (Huntingdon *et al.* 1996). New Brunswick and Maine support about 20,000 pairs, while Massachusetts represents the current southern breeding limit (Huntington *et al.* 1996).

Burrow occupancy rates did not vary greatly among colonies, ranging from 0.62-0.75, except for the sharply declining colony on Small Island (0.34). In contrast, excluding Baccalieu Island, burrow densities ranged from 0.22 to 1.87 burrows/m^2 across different islands; with Baccalieu Island itself showing an even greater range of 0.046-4.166 burrows/m^2. These ranges likely reflect habitat differences among islands, as burrow densities are related to habitat (Sklepkovych & Montevecchi 1989; Stenhouse & Montevecchi 2000). When used alone, the lack of range in occupancy rates, and the great range in burrow densities, make neither a suitable monitoring metric to assess population trends for this species in Newfoundland (except for crashing populations such as those on Small Island). Therefore, continued censuses to estimate island-wide breeding populations are recommended for future monitoring.

Both older and recent surveys used burrow grubbing to assess burrow contents. In other regions, the use of tape playbacks and/or video probes has been recommended (Ambagis 2004; Mitchell *et al.* 2004). These two methods

were attempted during recent surveys in Newfoundland, but reports from field workers suggested that they proved to be more difficult and less efficient than burrow grubbing. Playbacks proved difficult to interpret due to the high density of burrows. In Newfoundland, Leach's Storm-Petrel burrows tend to be relatively short and straight holes in peaty soils, making grubbing relatively easy (the contents could not be assessed for about 10% of burrows), especially in contrast to European Storm-Petrels *Hydrobates pelagicus* which nest in crevices and in scree. However, further work will be conducted to investigate the value of these less invasive methods in assessing burrow occupancy.

Although the data on population trends for colonies in Newfoundland is somewhat sparse, a few patterns emerge from the available information. Firstly, between the 1970s-early 1980s to the late 1990s-early 2000s, there has been little change in the population size of the large colonies that have been monitored. On the other hand, the two smaller colonies that have been monitored have shown significant, and in the case of Small Island, precipitous, declines. Both these colonies share one feature; hundreds of pairs of Herring *Larus argentatus* and Great Black-backed Gulls *L. marinus* began nesting in the vicinity of these colonies since the 1970s (Robertson & Elliot 2002; Robertson *et al.* 2002).

It is not clear why these small colonies have declined in the face of gull predation, while the larger colonies appear stable. In the case of Green Island, light keepers are still present on the island, which keeps the island free of nesting gulls. Baccalieu Island is similarly gull free, due to the presence of red foxes *Vulpes vulpes* (Sklepkovych & Montevecchi 1989); although trend data for this island are not available. The large islands in Witless Bay support over 600,000 pairs of Leach's Storm-Petrels and harbour significant gull colonies, with approximately 2,900 pairs of large gulls on Gull Island and 1,700 pairs on Great Island (Robertson *et al.* 2001). Stenhouse *et al.* (2000) estimated that 49,000 Leach's Storm-Petrels were killed by gulls annually on Great Island alone, while Robertson *et al.* (2001) postulated that habitat-specific changes in gull nesting locations could lead to increasing predation pressure on Leach's Storm-Petrel. However, Leach's Storm-Petrel populations on Gull and Great Island appear to have been stable over the last 25 years. In general, breeding success of Leach's Storm-Petrel in Newfoundland is high and does not appear to vary greatly in response to ecosystem changes, as seen in other seabirds (Stenhouse & Montevecchi 2000; Regehr & Rodway 1999). Consistently high chick production, and the subsequent abundance of young pre-breeding cohorts, could explain how these mortality levels are maintained. Clearly, more work is needed to understand the degree to which Leach's Storm-Petrel populations are impacted by predation pressure from large gulls.

Additional threats to Leach's Storm-Petrel could include contaminants, as there are indications that Mercury (Hg) levels in the eggs of this species have risen from 1972-2000 in the Northwest Atlantic (Burgess & Braune 2001). Recent offshore oil and gas exploration and production on the Grand Banks and Scotian Shelf has increased the risk of Leach's Storm-Petrel colliding with offshore installations and being incinerated in gas flare booms (Wiese *et al.* 2001). Newfoundland has one on of the largest chronic ship-source (bilge dumping) oil pollution problems in the world (Wiese & Ryan 2003). As surface feeders, Storm-Petrels consume hydrocarbons while foraging (Boersma 1986), which can impact chick survival and the reproduction of breeding adults (Trivelpiece *et al.* 1984). Unlike most major seabird colonies in the world, there is one significant threat that Leach's Storm-Petrel (and other seabirds) in Newfoundland are not currently facing, that is the introduction of predatory mammals or other invasive species (e.g. rats or rabbits). However, monitoring will be required to ensure that this remains the case.

Given the extent of the current potential threats, and uncertainties surrounding the impact of gull depredation, continued monitoring of Leach's Storm-Petrel in Newfoundland is clearly warranted. A survey of the large colony on Baccalieu Island is particularly critical for any future assessment of this population.

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OMVANG EN TRENDS VAN BROEDPOPULATIES VAN VAAL STORMVOGELTJE *OCEANODROMA LEUCORHOA* IN NEWFOUNDLAND

De grootste kolonies van Vaal Stormvogeltje Oceanodroma leucorhoa *ter wereld bevinden zich in Newfoundland, Canada, met alleen op Baccalieu Island al meer dan 3 miljoen paar. Sinds 2001 wordt inspanning verricht om de grotere kolonies in Newfoundland opnieuw te inventariseren teneinde huidige populatieschattingen te vergelijken met die van de jaren zeventig en begin jaren tachtig. Inventarisaties werden uitgevoerd door te 'graaien' in kleine plots (met de hand holen inspecteren), dichtheden van bezette holen te berekenen en deze dichtheden te extrapoleren naar het gebied dat door de stormvogeltjes wordt gebruikt. Playback van geluidsopnames en monitoring van ingangen van holen bleek minder of even efficiënt als graaien, maar vereiste veel meer tijd, mogelijk als gevolg van hogere dichtheden van bezette holen. De onderzochte grotere kolonies leken stabiel tussen de jaren zeventig/tachtig en begin 2000. De twee kleinere kolonies daarentegen Middle Lawn Island en Small Island vertoonden een afname. De vestiging in de jaren zeventig van grote meeuwenkolonies (bestaand uit Grote Mantelmeeuw* Larus marinus *en Zilvermeeuw* L. argentatus*)*

dichtbij deze twee eilanden kan de populatie-afname op deze eilanden verklaren. Verschillen in habitatkwaliteit tussen de eilanden kan echter niet uitgesloten worden. Aan de andere kant leek massale predatie (een geschatte 49000 adulte vogels per jaar) van stormvogeltjes op Great Island, Witless Bay door grote meeuwen de broedpopulatie, die nu nog bestaat uit 270000 broedpaar niet gereduceerd te hebben. Hoewel het kolonies van Vaal Stormvogeltje in Newfoundland de laatste twee à drie decades voor de wind gaat, is een voortgaande monitoring aanbevolen gezien de potentiële bedreigingen door predatie (door meeuwen), gifstoffen, chronische olievervuiling en offshore olie- en gasproductie.

REFERENCES

Ambagis J.A. 2004. A comparison of census and monitoring techniques for Leach's Storm-Petrel. Waterbirds 27: 211-215.

Boersma P.D. 1986. Ingestion of petroleum by seabirds can serve as a monitor of water quality. Science 231: 373-376.

Burgess N.M. & Braune B.M. 2001. Increasing trends in mercury concentrations in Atlantic and Arctic seabird eggs in Canada. In: Proceeding of SETAC Europe, 11th Annual Meeting, 11: 48-49. Madrid, Spain.

Cairns D.K. & Verspoor E. 1980. Surveys of Newfoundland seabird colonies in 1979. Unpublished Canadian Wildlife Service Report. Sackville, New Brunswick, Canada.

Cairns, D.K., Montevecchi W.A. & Threlfall W. 1989. Researcher's guide to Newfoundland seabird colonies: Second edition. Memorial University of Newfoundland, Occasional Papers in Biology No. 14. St. John's, Newfoundland.

Huntington C.E., Butler R.G. & Mauck R.A. 1996. Leach's Storm-Petrel *Oceanodroma leucorhoa*. In: A. Poole and F. Gill (eds). The Birds of North America No. 233. The Academy of Natural Sciences, Philadelphia PA, and the American Ornithologists' Union Washington, DC.

Mitchell P.I., Newton S., Ratcliffe N. & Dunn T.E. 2004. Seabirds populations of Britain and Ireland. T. & A. D. Poyser, London.

Regehr H.M. & Rodway M.S. 1999. Seabird breeding performance during two years of delayed capelin arrival in the northwest Atlantic: a multi-species comparison. Waterbirds 22: 60-67.

Robertson G.J. & Elliot R.D. 2002. Changes in seabird populations breeding on Small Island, Wadham Islands, Newfoundland. Canadian Wildlife Service Technical Report Series No. 381. St. John's, Newfoundland.

Robertson G.J., Fifield D., Massaro M. & Chardine J.W. 2001. Changes in nesting habitat use of large gulls breeding in Witless Bay, Newfoundland. Canadian Journal of Zoology 79: 2159-2168.

Robertson G.J., Russell J. & Fifield D. 2002. Breeding population estimates for three Leach's Storm-petrel colonies in southeastern Newfoundland, 2001. Canadian Wildlife Service Technical Report Series No. 380. St. John's, Newfoundland.

Sklepkovych B.O. & Montevecchi W.A. 1989. The world's largest known nesting colony of Leach's Storm-Petrel on Baccalieu Island, Newfoundland. American Birds 43: 38-42.

Stenhouse I.J. & Montevecchi W.A. 2000. Habitat utilization and breeding success in Leach's Storm-Petrel: the importance of sociality. Canadian Journal of Zoology 78: 1267-1274.

Stenhouse I.J., Robertson G.J. & Montevecchi W.A. 2000. Herring Gull *Larus argentatus* predation on Leach's Storm-Petrels *Oceanodroma leucorhoa* breeding on Great Island, Newfoundland. Atlantic Seabirds 2: 35-44.

Trivelpiece W.Z., Butler R.G., Miller D.S. & Peakall D.B. 1984. Reduced survival of chicks of oil-dosed adult Leach's Storm-Petrel. Condor 86: 81-82.

Wiese F.K. & Ryan P.C. 2003. Chronic oil pollution in Newfoundland assessed through beached bird surveys 1984-1999. Marine Pollution Bulletin 46: 1090-1101.

Wiese F.K., Montevecchi W.A., Davoren G.K., Huettmann F., Diamond A.W. & Linke J. 2001. Seabirds at risk around offshore oil platforms in the North-west Atlantic. Marine Pollution Bulletin 42: 1285-1290.