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BREEDING SUCCESS OF COMMON GULLS *LARUS CANUS* IN WEST SCOTLAND II. COMPARISONS BETWEEN COLONIES

BROEDSUCCES VAN STORMMEEUWEN IN WEST-SCHOTLAND II. VERGELIJKINGEN TUSSEN KOLONIES

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In a study of Common Gull Larus canus *breeding success in west Scotland from 1991-1997, the number of colonies of five or more pairs monitored each year varied between 13 in 1991 and 27 in 1995. Observed mean clutch size varied greatly between colonies, from zero at colonies severely affected by predation by American Mink* Mustela vison, *to 3.0 at a colony where no predation was detected. Excluding mink-affected colonies, mean clutch for all colonies combined varied between 2.47 in 1993 (n = 663 clutches at 12 colonies) and 2.69 in 1995 (n = 843 at 14 colonies). Productivity (young fledged/pair nesting) varied significantly between colonies. In 98 observations of colonies during 1994-1997, there were 41 records of colonies producing no young, and mink predation of eggs or chicks occurred at most of these (between 25 and 38, 61%-93%). The highest productivity of a colony was 1.6 at a site where predation was not detected. Productivity for all colonies combined varied significantly between years, from 0.1 in 1993 to 0.4-0.6 in 1996 and 1997 when mink were removed from some of the colonies. For the years 1994-1997 combined, colonies apparently unaffected by predation fledged a mean of 0.7-0.9 young/pair (n = 23); colonies affected by raptors, usually or always Peregrine Falcons* Falco peregrinus, *fledged 0.4 (n = 11); colonies close to colonies of the larger gulls fledged 0.4 (n = 7); one colony affected by otter* Lutra lutra *predation fledged 0.76; and colonies affected by mink fledged 0.04-0.06 (n = 36). Predation by native species was rarely associated with whole-colony breeding failure (2 out of 19 colony observations), whereas predation by mink was commonly associated with whole-colony breeding failure (25 out of 36 colony observations). Between 1989 and 1997, at 32 colonies in 15 sealochs and sounds, total numbers of breeding pairs of Common Gulls decreased by 41% from 1248 to 734. Breeding Common Gulls disappeared from six of these 15 areas and decreased at six; at two sealochs where they increased, mink had been removed each spring to protect breeding seabirds; and, at one sealoch, breeding Common Gulls persisted only by nesting on a factory roof. These declines and disappearances are ascribed to the widespread annual breeding failures of Common Gulls caused by mink predation: too few young are reared each year to replace adults that die from all causes.*

Craik J.C.A. 2000. Breeding success of Common Gulls *Larus canus* in west Scotland. II. Comparisons between colonies. Atlantic Seabirds 2(1): 1-12.

INTRODUCTION

Most of the Common Gulls *Larus canus* in western Scotland breed in colonies of 10-100 pairs on small marine islands close to the mainland, almost always in sealochs, sounds and firths. Study of one such colony showed low productivity in 1988-1990 associated with predation by Peregrine *Falco peregrinus* and Herring Gull *L. argentatus*, followed by zero productivity in 1991-1992 after American Mink *Mustela vison* ('mink') took up residence on the island. The colony site was then abandoned by Common Gulls in 1993-1997 (Craik 1999).

A high density of easily available prey stimulates surplus killing behaviour by many carnivore species (Kruuk 1972). In the relatively small but high-density seabird colonies of the sealochs and sounds of western Scotland, such behaviour by mink can lead to widespread whole-colony breeding failures.

Predation by mink at seabird colonies in this area was first observed in 1983 and became widespread from 1989 onwards, seriously affecting the breeding success and breeding distribution of island-nesting colonial seabirds. The seabird species most affected by mink are those with smaller eggs and chicks, particularly terns *Sterna* spp., small gulls such as Common Gull and Black-headed Gull *L. ridibundus,* and Black Guillemot *Cepphus grylle* (Craik 1995, 1997 and unpublished results 1989-1997).

The purpose of the work described here was to record the numbers and productivity of Common Gulls at many colonies over several years, with particular reference to the effects of predators.

METHODS

The study area lay along the mainland of west Scotland between Fort William (56°50' N) and West Loch Tarbert (55°50' N). Most of the coasts of the large islands of Mull and Gigha were excluded since they were not regularly accessible. Clutch sizes and productivity were measured at Common Gull colonies on small islands during the years 1991-1997. The number of colonies visited each year varied between 13 (in 1991) and 27 (in 1995). In 1994-1997, almost all known Common Gull colonies in the area were visited. Colonies with fewer than five pairs are excluded from the analysis below. These, many with only single pairs, held a small minority of the total breeding population; for example, in 1997 they represented 1.5% of all known pairs but seven of 30 colonies.

During 20-30 May, a single visit was made to each colony to count clutches. Pilot work had shown this to be the optimum period (unpublished results 1988-1990). Eggs were marked to prevent double-counting. The number of clutches and well-formed empty nests defined the number of pairs breeding. A second visit was made in mid to late June when the number of large chicks was counted or estimated. At smaller colonies (<100 pairs) the whole colony could be counted and most chicks were found; at larger colonies (100-300 pairs) chicks were ringed and estimates of the total present were obtained by mark-recapture or by proportion of area covered (Walsh *et al.* 1995). Estimates were sometimes expressed as ranges and, at densely vegetated colonies, figures were rounded up to the nearest ten in order to account for concealed chicks. Productivity at each colony was calculated as the number of large young on the second visit/number of pairs (defined above) on the first visit. In 1989 clutches were counted at some of these colonies, but productivity was not measured.

In 1991-93 it was clear that many Common Gull colonies were failing to fledge any young because of mink predation of eggs and chicks. In 1994-1997 respectively, one, two five and eight of the study colonies were included in a mink control programme; mink were trapped within 1 km of these colonies (and humanely killed) in Feb-Apr, before any eggs had been laid.

During 1994-1997, predator species were inferred from prey remains (Craik 1995, 1999). Predation of small young by gulls was rarely detectable, since such prey is eaten or carried off whole. Common Gull colonies within 100 m of larger colonies of large gulls (Herring Gull, Great Black-backed Gull *L. marinus* and/or Lesser Black-backed Gull *L. fuscus*) have been classified under 'Large gulls'.

Chi-square tests, using Yates' correction where appropriate, were applied to the data (Fowler & Cohen 1986).

RESULTS

Clutch size The highest mean clutch recorded for any colony was 3.0 (all 22 nests held three eggs each). Corresponding figures for lowest mean clutch have little meaning because of egg predation. Egg collection by humans is known to occur in some areas. Egg removal by mink was severe at some colonies, leading to mean clutch sizes that were abnormally low or zero. For example, at one mink-affected colony there were no nests with more than one egg, four nests with a single egg each, and 19 empty nests; at another there were no eggs and 37 empty nests.

In order to minimise the difficulty in assessing true clutch size only colonies where 20 or more clutches were found were considered. Ignoring empty nests, mean clutch size over all such colonies for each of the years 1990-1997 varied from 2.47 (n = 663 clutches at 12 colonies in 1993) to 2.69 (n = 843 at 14 colonies in 1995). This between-year variation was significant ($\chi^2_{14} = 69.4$, $P < 0.001$; analysis performed on numbers of nests with 1, 2, 3+ eggs). It is not possible to say how much of this variation may have been caused by low levels of predation. Data from these colonies were combined for 1990-1997 (Table 1). Clutches with more than three eggs were found occasionally in seven of the eight years; this may have resulted from two females laying in one nest.

Table 1. Clutch size (number of eggs per clutch) of Common Gull, 1990-97; 83 colony records.
Tabel 1. Legselgrootte (aantal eieren) bij Stormmeeuwen, 1990-97; 83 kolonie studies.

	1 egg	2 eggs	3 eggs	4 eggs	5 eggs	Total no. clutches	Mean clutch size
No. of clutches	610	1267	4023	15	2	5917	2.58
% of clutches	10.3	21.4	68.0	0.3	0.0		

Table 2. Productivity of Common Gulls (all colonies combined). In "Pairs" column, total number of pairs studied each year is followed in brackets by range of colony size in pairs. In "Fledged" column, the total number fledged is followed in brackets by the number of colonies which fledged no young:total number of pairs at those colonies.
Tabel 2. Productiviteit van Stormmeeuwen (all kolonies gecombineerd). Onder paren ('pairs') wordt de variatie in koloniegrootte tussen haakjes weergegeven. Onder de uitgevlogen jongen ('fledged') wordt tussen haakjes het aantal jongen/aantal broedparen op deze kolonies gegeven.

Year	Colonies	Pairs	Fledged	Fledged/pair
1991	13	883 (9-246)	224-356 (4:250)	0.25-0.40
1992	17	1236 (5-309)	205-254 (7:213)	0.17-0.21
1993	17	978 (8-280)	85-152 (10:423)	0.09-0.16
1994	25	1211 (6-281)	294-433 (14:380)	0.24-0.36
1995	27	1175 (6-306)	412-536 (11:251)	0.35-0.46
1996	23	913 (5-293)	399-519 (11:196)	0.44-0.57
1997	23	1107 (5-344)	540-667 (5:199)	0.49-0.60

Productivity The numbers of Common Gull colonies visited, numbers of pairs counted and numbers of young fledged each year are given in Table 2.

Every year there were colonies at which no young fledged, leading to great variation in productivity between colonies. Within each year, the null hypothesis that productivity did not vary between colonies was tested by chi-square tests. This null hypothesis was rejected for each year: for 1991-1997 respectively: $\chi^2_{12} = 259$, $\chi^2_{16} = 229$, $\chi^2_{16} = 182$, $\chi^2_{24} = 525$, $\chi^2_{26} = 463$, $\chi^2_{22} = 234$, and $\chi^2_{22} = 352$; $P < 0.001$ in all cases.

The variation between years in overall productivity (Table 2) was not analysed because (a) the number of colonies monitored varied between years; (b) productivity was affected by mink predation, often leading to whole-colony breeding failure; and (c) mink control increased over the years, allowing the gulls to rear more young. Overall productivity ranged from about 0.1-0.2 young/pair in 1992 and 1993 to about 0.4-0.6 in 1996 and 1997. Both the increase in productivity

Table 3. Effect of predators and other factors on productivity of Common Gulls.
Tabel 3. Effecten van predatoren en andere factoren op de productiviteit van Stormmeeuwen.

	No. pairs	No. colonies	No. fledged	Colonies fledging none
1994				
No predators	323	3	228-340	0
Raptors	94	2	30	0
Mink confirmed	679	15	36-57	11
Mink suspected	115	5	0-6	3
1995				
No predators	360	4	245-349	0
Raptors	101	2	73	0
Large gulls	59	2	28-30	0
Otter	66	1	50	0
Terns	13	1	0-2	0
Mink confirmed	506	10	16-31	5
Mink suspected	70	7	0-1	6
1996				
No predators	506	6	330-445	0
Raptors	123	4	33	0
Large gulls	88	2	36-41	0
High tide	7	1	0	1
Mink confirmed	151	6	0	6
Mink suspected	38	4	0	4
1997				
No predators	651	10	481-594	0
Raptors	151	3	44-55	1
Large gulls	44	3	10-12	1
Mink definite	213	5	2-3	3
Mink suspected	48	2	3	0
Total	4406	98	1645-2155	41

towards the end of this period and the decrease in the number of failed colonies in 1997 (Table 2) accompanied increased levels of mink control (Table 3 and below).

Factors affecting productivity In 1994-1997, there was a total of 98 records from colonies (a colony that was observed in two, three or four years gave two, three or four records). These records were classified according to various influences, such as types of predator, as shown in Table 3. There were 36 records of confirmed mink predation at colonies (15, 10, 6 and 5 for 1994-97 respectively) and a further 18 (5, 7, 4 and 2) records of suspected mink predation at colonies. In addition, mink were removed from colonies on 16 occasions (1, 2, 5 and 8) and of these, mink predation did not occur at 14 (1, 2, 5 and 6 from 1994-97 respectively). Thus mink were present at 50-68 of 98 colony records (51%-69%).

Whole-colony breeding failure was recorded in 41 of the 98 colony observations. Of these, mink were confirmed as predators at 25 (11, 5, 6 and 3 from 1994-97 respectively) and suspected at a further 13 (3, 6, 4 and 0). Thus a high proportion of whole-colony failures were associated with predation of eggs and chicks by mink (25-38 of 41, or 61%-93%). The yearly increase in mink control accounts for the decrease in number of mink-affected colonies in 1997. For a comparison of productivity between colonies which were and which were not protected in this way, see Craik (1998).

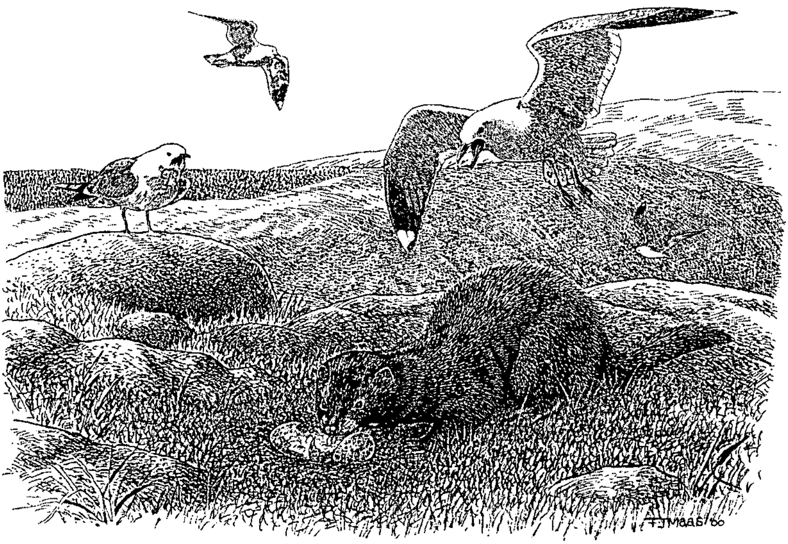
Other factors which affected breeding success were Peregrine Falcons, European Otters *Lutra lutra*, nearby colonies of large gulls, tern colonies on the same small island (where persistent aggression by adult terns deterred adult Common Gulls from approaching their own eggs or young), and high tides washing out clutches.

The effects of these various influences are summarised in Table 4; productivity of colonies where predation was not detected was 0.7-0.9; where predation by raptors was evident, it was about 0.4; near colonies of large gulls, it was about 0.4; and where there was chick predation by otters, it was 0.75 (although this figure is based on only one colony and is therefore provisional). Colonies affected by mink had very low mean productivity (0.04-0.06). Aggression by terns, recorded in one instance only, was also associated with low productivity of Common Gulls.

Predation by native predators was rarely associated with whole-colony breeding failure (a total of 2 out of 11, 7 and 1 instances involving raptors, gulls or otters respectively; Table 4), whereas predation by mink commonly led to whole-colony breeding failure (25 out of 36 instances when mink predation was definitely recorded; Table 4). This difference is highly significant ($\chi^2_1 = 15.0$, $P < 0.001$).

Productivity in the absence of predation At colonies where there was no evidence of predation, mean productivity for 1994-1997 combined was about 0.7-0.9 (Table 4). It was remarkably constant from year to year (0.71-1.1, 0.68-0.97, 0.65-0.88, and 0.74-0.91 in each of the years 1994-1997; Table 3). This range probably represents the maximum that this population, comprising a number of colonies, is capable of achieving when free of predation. The highest productivity recorded at a single colony was 1.57 young/pair.

In 1991-1996, colony productivity exceeded 1.0 only four times and never at more than one site each year. In 1997, it exceeded 1.0 at five sites; mink were killed locally at four of these, a higher proportion than in earlier years, which suggests that mink control contributed to this enhanced breeding success.



Mink plundering Common Gulls nest *Amerikaanse Nerts plundert Stormmeeuwnest* (F.J. Maas)

Effects of repeated breeding failure: local extinctions Three distinct effects of annually recurring, mink-related whole-colony breeding failures of seabirds have been described in this area (Craik 1995, 1997): (1) terns and small gulls abandon breeding sites and nest elsewhere; (2) overall breeding numbers decline; and (3) discrete areas of the habitat, such as sealochs, sounds and archipelagos, lose all or most of their breeding seabirds. In these circumstances, Common Gulls are often the last species to move their breeding site and they tend to move as short a distance as possible, frequently to the nearest island or the nearest mainland.

Counts of Common Gulls at 32 colonies in both 1989 and 1997 indicated a 41% decrease in total numbers breeding in 15 areas, i.e. sealochs and sounds (Table 5). Mink predation of adults, eggs or young was recorded at Common Gull colonies in all 15 areas at some time during 1989-1997. Breeding Common Gulls

Table 4. Mean estimated productivity of Common Gulls in colonies subject to various influences, 1994-97. Data are those in Table 3, excluding the "mink suspected" data. A colony studied each year may be represented four times here.
Tabel 4. Gemiddelde jongenproductie van Stormmeeuwen in kolonies die blootstaan aan een verscheidenheid aan verstoringen, 1994-97. De basisgegevens zijn in Tabel 3 samengevat (uitgezonderd de 'vermoedelijk' door Amerikaanse Nertsen verstoorde nesten). Een kolonie die jaarlijks werd onderzocht kan 4x in deze tabel voorkomen.

	Pairs	Colonies	Fledged	Colonies fledging no young	Fledged /pair
No predators	1840	23	1284-1728	0	0.70-0.94
Raptors	469	11	180-191	1	0.38-0.41
Gulls	191	7	74-83	1	0.39-0.43
Mink	1549	36	54-91	25	0.04-0.06
Otter	66	1	50	0	0.76
Terns	13	1	0-2		0.0-0.15
High tide	7	1	0	1	0

Table 5. Changes in numbers of pairs of Common Gulls 1989-97. The number of colonies is given in brackets. These figures represent an overall decrease of 41%.
Tabel 5. Veranderingen in aantallen broedparen Stormmeeuwen, 1989-97. Het aantal kolonies is tussen haakjes aangegeven. Deze gegevens representeren een totale afname van 41%.

Sealoch or Sound	1989	1997
L Teacuis/Sunart (2)	30	0
L Linnhe (5)	77	41
Coruanan (1991-1997)(1)	138	31
L Leven (3)	94	24
L Creran (2)	15	*c.* 20*
L Etive (4)	471	492
L Feochan (1)	36	23
L Melfort (3)	123	13
L Craignish (2)	63	84
L Crinan (1)	50	0
Sound of Luing (2)	26	0
L Sween: Danna (1)	50	0
L Fyne: Whitehouse Bay (1)	35	0
L Caolisport (1987) (2)	10	6
L Sween (2)	30	0
Total (32 colonies)	1248	734

* No ground- or island-nesters remained in Loch Creran in 1997 and these 20 pairs bred on an inaccessible roof (see text); this count is based on adults since clutches could not be counted.

were extirpated from six of the areas and decreased in another six; they increased in three sealochs - Lochs Etive, Craignish and Creran. Most of the mink control (see above) in 1994-1997 took place in Loch Etive, Loch Craignish and Loch Feochan. At Loch Creran all island-nesting Common Gulls left after well-recorded mink predation of eggs and young in successive years from 1989. By 1995-97 the only breeding Common Gulls were in a new colony on the roof of a shoreside factory, where they were presumably inaccessible to mink and where they fledged young in each of those three years.

DISCUSSION

Whether or not American Mink have affected the native fauna of the countries to which they have been introduced has been the subject of much debate. In particular, Birks (1986) and Dunstone (1993) have argued that the impact of mink has been slight or undetectable. This may be true for non-colonially breeding aquatic bird species, although strictly comparable "before-and-after" comparisons of such species appear not to have been made. It is certainly not true for ground-nesting seabird species that breed in dense colonies on islands. The work described here shows that the effect of mink on Common Gulls in west Scotland has been severe. Mink were present at a surprisingly high proportion of Common Gull colonies and responsible for most of the whole-colony breeding failures. This led to local declines in breeding numbers and to the abandonment by Common Gulls of many traditional breeding sites (Table 5 and Craik 1997, 1998).

This work attempts to quantify the extent to which breeding by Common Gulls is affected by and adapted to different predators. The figures in Table 4, although intended only as an approximate estimate of predator impact, show that Common Gulls are able to fledge reasonable numbers of young in the presence of native predator species, but that they are unable to do so in the presence of an introduced predator. This suggests that a fine adaptive balance exists between predator and prey species that have co-evolved and co-adapted to a habitat, and shows how easily this equilibrium can be disrupted by an introduced species.

Possible reasons for the severity of this disruption of seabird breeding patterns by introduced mink include: (1) their swimming ability allows them to reach islands up to 2 or 3 km offshore that were formerly safe from most mammalian predators; (2) both seabirds and mink utilise the shoreline habitat so that predator easily encounters prey; (3) mink readily travel to exploit a newly encountered source of abundant prey and so take up permanent residence in the colony (otters appear not to do this); and (4) mink often kill more than they eat. Much remains unknown of the details of the subsequent whole-colony breeding failures; it may be that the disruption of the colony by the permanent presence of a newly arrived mink is so extreme that other predators are able to exploit the unprotected eggs and chicks.

Adverse effects of American Mink and Herring Gulls on the breeding success of Common Gull colonies in the Baltic have been reported (Bergman 1986; Kilpi 1995). American Mink have also been considered responsible for the decline and disappearance of the water vole *Arvicola terrestris* from parts of Britain (Woodroffe & Lawton 1990; Lawton & Woodroffe 1991; Strachan 1997; Lambin 1998). There are many reports (some anecdotal) from Scandinavia and Iceland on the decline and disappearance of Black Guillemots, Razorbills *Alca torda* and other bird species following the arrival of American Mink (Andersson 1992; Asbirk 1978; Errington 1961; Folkestad 1982; Gerell 1968; Johansen 1978; Niemimaa & Pokki 1990; Olsson 1974; Bergman 1971 and *pers. comm.* 1990). However, there are comparatively few quantitative data that relate the primary effects of introduced mink on seabirds (widespread whole-colony breeding failures) to their consequent secondary effects (population decline).

In the absence of an adequate population model, it is difficult to say whether the higher values of overall productivity, 0.4-0.6, seen in 1996-1997 when mink were controlled at five to eight of the colonies (Table 2), will be high enough to reverse the present decline in population numbers. It seems likely, however, that lower mean productivity, such as the 0.1-0.2 recorded in 1992-1993 when there was little or no selective control of mink, are unsustainable. It is difficult to avoid the conclusion that Common Gulls in west Scotland are now unable to maintain their numbers, and that they will continue to decrease in numbers unless mink are controlled at selected colonies every year.

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SAMENVATTING

In deel twee van het onderzoek naar broedsucces van Stormmeeuwen in de buurt van Oban (West Schotland) worden de verschillen tussen kolonies beschreven op basis van onderzoek in de periode 1991-97. Het aantal onderzochte kolonies varieerde van 13 in 1991 tot maximaal 27 in 1995. De legselgrootte varieerde van 0 in kolonies waar Amerikaanse Nertsen hadden huisgehouden tot 3.0 op een plaats waar geen sporen van predatie konden worden aangetoond. In gebieden waar de effecten van predatie door Amerikaanse Nertsen te verwaarlozen waren, varieerde de legselgrootte van 2.47 in 1993 (n= 663 legsels in 12 kolonies) tot 2.69 in 1995 (n= 843 legsels in 14 kolonies). Ook het uitvliegsucces (uitgevlogen jongen per broedpaar) verschilde sterk tussen de onderzochte kolonies. In 41 gevallen (n= 98 onderzochte kolonies) vloog geen enkel jong uit en in veel gevallen werden sporen van Amerikaanse Nertsen aangetroffen die eieren of jongen hadden gepredeerd (25-38 gevallen; 61-93% van de niet producerende kolonies). De hoogst gemeten productie bedroeg 1.6 jongen per paar in een kolonie waar geen Amerikaanse Nertsen voorkwamen.

De productiviteit voor alle kolonies tezamen varieerde van 0.1 in 1993 tot 0.4-0.6 in 1996 en 1997, toen Amerikaanse Nertsen succesvol waren bestreden in een deel van de broedgebieden. In de periode 1994-97, vlogen 0.7-0.9 jongen per paar uit in 23 kolonies die blijkbaar weinig last hadden van predatie; 11 kolonies die last hadden van predatie door roofvogels (meestal Slechtvalken Falco peregrinus*) kenden een productie van 0.4 jongen per paar; 7 kolonies in de onmiddellijke omgeving van*

broedkolonies van grote meeuwen hadden eveneens een uitvliegsucces van 0.4 jongen per paar; één kolonie waar sporen van predatie door Otters Lutra lutra *werden aangetroffen kende een uitvliegsucces van 0.76 jongen per paar; de resterende 36 kolonies, alle met vraatsporen van Amerikaanse Nertsen, brachten 0.04-0.06 jongen per paar groot. Uit dit materiaal blijkt, dat in kolonies waar inheemse predatoren eieren of jongen pakten zelden of nooit een totaal verlies van jongenproductie werd waargenomen (2 van de 19 kolonies). In schril contrast daarmee staat het effect van de (geïntroduceerde/ ontsnapte) Amerikaanse Nerts: 25 van 36 koloniewaarnemingen met een totaal mislukt broedseizoen.*

Tussen 1989 en 1997 nam de populatie Stormmeeuwen in 32 kolonies in 15 zee-armen en -engtes met 41% af van 1248 naar 734 broedparen. Broedende Stormmeeuwen verdwenen uit zes van de 15 kustgebieden, namen af in zes andere en in twee gebieden waar een toename kon worden geconstateerd waren Amerikaanse Nertsen elk voorjaar intensief bestreden. In het 15e kustgebied, tenslotte, konden broedende Stormmeeuwen zich slechts handhaven door op het dak van een fabriek te nestelen. De geconstateerde afname in het broedsucces en het broedvoorkomen van Stormmeeuwen in dit deel van Schotland wordt geheel toegeschreven aan de predatie van eieren en jongen door Amerikaanse Nertsen: de kolonies produceren eenvoudig te weinig jongen om de populatie in stand te houden.

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ERRATUM

In: Breeding success of Common Gulls I: *Atlantic Seabirds* 1(4) page 176. the second sentence of the Legend to Figure 4 should begin: "Solid circles, open circles, open squares and solid squares are..."

Common Gulls *Stormmeeuwen* (C.J. Camphuysen)

NOTES ON THE DISTRIBUTION OF THE SPECTACLED PETREL *PROCELLARIA CONSPICILLATA* IN THE SOUTH ATLANTIC OCEAN

DE VERSPREIDING VAN DE GEBRILDE STORMVOGEL IN HET ZUID-ATLANTISCHE GEBIED

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At least 30 Spectacled Petrels Procellaria conspicillata *were observed during systematic seabird surveys between Walvisbaai (Namibia) and Cape Town (South Africa) in February 2000. Because the pelagic distribution of this rare seabird species is only poorly understood, a description is provided of all sightings. Contrary to most Spectacled Petrels seen away from the breeding grounds elsewhere in the South Atlantic, there were no indications that these (non-breeding) birds heavily relied on commercial fisheries, but these birds are potentially at risk for substantial tuna longline fisheries in this area.*

Camphuysen C.J. & J. van der Meer 2000. Notes on the distribution of the Spectacled Petrel *Procellaria conspicillata* in the South Atlantic. Atlantic Seabirds 2(1): 13-18.

INTRODUCTION

The Spectacled Petrel *Procellaria conspicillata* only breeds at Inaccessible Island in the Tristan da Cunha group (37°18'S, 12°41'W; central South Atlantic). It was considered a subspecies of the White-chinned Petrel *P. aequinoctialis* until recent research has shown that it is a valid species (Ryan 1998; Ryan 1999). Spectacled Petrels, until recently regarded as 'Endangered' because of their small population size (estimated at *ca.* 1000 pairs in the early 1980s), its restricted range and known mortality from long-line fishing, was found to breed with 3-4000 pairs on Inaccessible Island in 1999/2000 (Ryan & Moloney *in press*). In the light of this new census, its status will now be re-evaluated, and while the status still qualifies as 'Critical' (criteria B1 and 2e), it is only 'Vulnerable' in terms of other criteria (Ryan *pers. comm.*). Enticott & O'Connell (1985) have summarised the information on the distribution of the Spectacled Petrel at sea from five sources (Table 1). All records (n = 79) were either in April-July (28) or in September-November (51). Away from the breeding island, Spectacled Petrels disperse throughout the South Atlantic between 25°S

Table 1. Sources of information and total numbers of Spectacled Petrels used by Enticott & O'Connell 1985 for their description of the distribution of Spectacled Petrels at sea.
Tabel 1. Bronnen van informatie en het aantal Gebrilde Stormvogels dat door Enticott & O'Connell werd gebruikt voor hun overzicht van de verspreiding van deze soort op zee.

source	number of birds	observer effort (10-minute periods)
+ published records	9	unknown
+ BIOMASS , eight voyages to the Tristan da Cunha group	40	14000
+ British Antarctic Survey (voyages South Georgia - South America) during the breeding season	10	4000
+ commercial fishing trawlers in the Benguela region (SW Africa)	5	unknown
+ winter cruise (Jun-Jul) of MS *Agulhas*, Cape Town-Cough Island-South America and back via Inaccessible Island	16	751

Table 2. Sightings of White-chinned Petrels and Spectacled Petrels, February 2000, RV Pelagia. Shown are: date, ten-minute counts (effort), noon positions, area surveyed and numbers of petrels.
Tabel 2. Waarnemingen van Witkinstormvogels en Gebrilde Stormvogels, februari 2000, RV Pelagia. Gegeven worden: datum, aantal 10-minuten perioden (effort), middenposities, onderzoeksgebied en het aantal stormvogels.

date			observer effort	°S	°E	study area	White-chinned Petrel	Spectacled Petrel
15	2	2000	60	23	14	shelf Walvisbaai	934	
16	2	2000	77	24	13	shelf edge Namibia	25	
17	2	2000	77	26	11	ocean		
18	2	2000	76	27	7	ocean		
19	2	2000	24	27	4	ocean		
20	2	2000	28	30	3	ocean	2	4
21	2	2000	54	29	6	ocean	1	1
22	2	2000	28	30	8	ocean	2	
23	2	2000	60	31	9	ocean	30	16
24	2	2000	76	33	13	ocean	31	9
25	2	2000	65	33	16	shelf edge South Africa	15	
26	2	2000	4	34	18	shelf Cape Town	11	
			629				1051	30

and 40°S. Many birds visit the waters off southern Brazil, where interactions with long-line fisheries are frequent (Neves & Olmos 1998; Ryan 1999). For a rare seabird like the Spectacled Petrel, it is of considerable interest to assemble what is known of its distribution at sea (*cf.* Enticott & O'Connell 1985), particularly so, because the species is threatened by long-line fishing.

MATERIAL AND METHODS

This paper reports on sightings of Spectacled Petrels and White-chinned Petrels during a cruise on board RV *Pelagia* between Walvisbaai (Namibia) and Cape Town (South Africa) in February 2000 (629 10-minute periods, Table 2). Methods of observation were similar to those used in NW Europe (*cf.* Tasker *et al.* 1984), but with extra attention to foraging behaviour and interactions between species (*cf.* Camphuysen & Webb 1999).

RESULTS

The Namibian shelf and shelf-edge waters were rich in seabirds, marine mammals and commercial fisheries. White-chinned Petrels were among the most abundant seabirds following trawlers in these waters, but Spectacled Petrels were not seen. Further to the west, over deep oceanic waters between the Namibian shelf and Walvis Ridge, very low densities of seabirds were recorded, with Cory's or Scopoli's Shearwaters *Calonectris* spp., Great-winged Petrels *Pterodroma macroptera* and Leach's Petrels *Oceanodroma leucorhoa* numerically dominating.

On 20 February, two Spectacled Petrels joined the ship when it was stationary at 29°50'S, 02°25'E, soon followed by a third individual when the surveys were resumed. Later that day, a fourth Spectacled Petrel was following the steaming vessel for a while at 29°43'S, 02°47'E. On 21 February, one Spectacled Petrel was found in a mass feeding over some moribund squid, together with Scopoli's Shearwater *Calonectris diomedea**, Leach's Petrel, Great-winged Petrel and Atlantic Yellow-nosed Albatross *Thalassarche chlororhynchus*. Spectacled Petrels were frequently observed on 23 February and the use of individually characteristic head patterns and wing-moult stages was important to avoid double counts. Of at least 16 different individuals observed during the surveys, eight individuals followed the ship for some time, three of which subsequently joined a nearby mass-feeding with Great-winged Petrels and Leach's Petrels over unidentified prey. Of four further individuals, which alighted near the ship on a station at 31°27'S, 09°18'E, it was not clear whether or not they had been seen before and these have been excluded from the present analysis. On 24 February, surveys spanned the entire daylight period,

Spectacled Petrels *Procellaria conspicillata* Gebrilde Stormvogels (C.J. Camphuysen) but nine Spectacled Petrels were seen between 07:40 GMT-08:00 GMT (approx. position 32°24'S, 12°20'E). Up to five individuals at a time were seen in association with the ship, one was seen in a resting group together with (2) Leach's Petrels and (5) Great-winged Petrels. Again, double counts were avoided by carefully recording individual head patterns and moult stages.

Most Spectacled Petrels observed were actively moulting flight feathers. The observations did not allow time to carefully record the precise stage of wing moult, but most showed progressed primary moult, although not quite so dramatically as in the White-chinned Petrels observed in these waters. Either fewer feathers were shed simultaneously in Spectacled Petrels than in White-chinned Petrels, or the moult had not progressed quite so far in the former species. Head patterns ranged from narrow rings around the eye, difficult to detect at over 500m from the observers, to broad rings, suggesting to almost completely whitish heads.

DISCUSSION

Enticott & O'Connell (1985) report no Spectacled Petrels for December-March and Rowlands (1992) recorded none on cruises between Ascension, St Helena, Tristan da Cunha and Cape Town between December and May. Our records, indicating the presence of (moulting) birds in February at over 1100 nautical miles from the breeding grounds, are indicative for a non-breeding population over deep oceanic waters. The Spectacled Petrels were heavily attracted to the survey vessel (despite non-fishing operations onboard), so that densities of birds (n per km^2) cannot reliably be calculated. Sightings of at least 30 individuals are substantial, however, in comparison with a breeding population of a few thousands of pairs only.

Spectacled Petrels were seen together with White-chinned Petrels while following the ship and readily joined feeding assemblages with smaller species such as Great-winged Petrels and Leach's Petrels. Commercial trawler fisheries are rather rare away from the SW African shelf, and these non-breeding Spectacled Petrels perhaps mainly relied on natural sources of prey. The birds showed 'interest' in discarded kitchen scraps by the research vessel on stations, but were not seen to feed on it (in contrast to Leach's Petrels).

Enticott & O'Connell (1985) concluded that 8.4% of 190 White-chinned Petrels seen on their winter cruise between Cape Town and South America were *'conspicillata'*. Our results indicate that the (summer) at sea distribution of both species is highly dissimilar, with White-chinned Petrels largely being confined to shelf and shelf-edge waters (93.7%, n = 1051) and with Spectacled Petrels being found over deep ocean waters, so that such a comparison is not particularly meaningful. Recent sightings indicate that

Spectacled Petrels are regular visitors over the shelf off the Cape in summer, attending trawlers with vastly larger numbers of White-chinned Petrels (Peter Ryan *pers. comm.*).

ACKNOWLEDGEMENTS

We thank Richard White for information on Spectacled Petrels around the Falkland Islands and for helping to find some of the literature used for this note. Peter Ryan and Bill Bourne kindly reviewed an earlier version of this publication and shared their expert knowledge with us. We are indebted to to expedition leader Gert-Jan Brummer and to captain John Ellen and his crew of RV *Pelagia.*

SAMENVATTING

Tijdens zeevogeltellingen vanaf het onderzoeksschip Pelagia *in februari 2000 werden tenminste 30 verschillende Gebrilde Stormvogels* Procellaria conspicillata *waargenomen. Deze zeldzame stormvogel wordt nog maar sinds kort als een aparte soort beschouwd en heeft een totale wereldpopulatie van ongeveer 3-4000 broedparen (Inaccessible Island, Tristan da Cunha;* 37°18'S, 12°41'W*). Vooral voor de Braziliaanse kust komen jaarlijks veel Gebrilde Stormvogels om het leven als bijvangst in de* 'long-line' *visserij. Van de verspreiding op zee is nog maar weinig bekend en daarom worden de waarnemingen hier individueel besproken. Het voorkomen in het nu beschreven gebied (1100 nm ten noordoosten van de broedplaats) tijdens de broedtijd was nog niet gepubliceerd en het betreft vermoedelijk vooral niet-broedende vogels. Het voorkomen van de Gebrilde Stormvogels bleef tijdens deze surveys beperkt tot de open zee, terwijl de nauw verwante Witkinstormvogel* Procellaria aequinoctialis *hoofdzakelijk op de Contintale Shelf te vinden was. Trawlervisserij is op de open oceaan nauwelijks te vinden en mogelijk leven de Gebrilde Stormvogels hier vooral van natuurlijke prooien.*

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*Scopoli's Shearwater *Calonectris diomedea* known as Cory's Shearwater *C. d. diomedea* on the British list.

DIET OF HERRING GULL *LARUS ARGENTATUS* CHICKS IN THE GULF AND ESTUARY OF THE ST. LAWRENCE RIVER, QUÉBEC, CANADA

HET VOEDSEL VAN KUIKENS VAN ZILVERMEEUWEN IN DE GOLF EN HET ESTUARIUM VAN ST LAWRENCE RIVER, QUÉBEC, CANADA

JEAN-FRANÇOIS RAIL AND GILLES CHAPDELAINE

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Food availability is often an important regulating factor of seabird populations. In the Estuary and Gulf of the St. Lawrence River, most colonies of Herring Gulls are actually decreasing while diet information is lacking. Collection of 635 regurgitations in three areas (Estuary, Corossol Island and Carleton colonies) revealed that the overall diet of Herring Gull chicks was extremely varied and variable over time and space, which is typical of an opportunist species. Nevertheless, capelin, a key species in the food chain in the St. Lawrence Estuary and Gulf, constituted the bulk of gulls' diet. At Carleton, located in the southern Gulf, capelin was less abundant, and more human waste completed the chicks' diet, in comparison with the other sites. This study provides baseline data for future investigation of the relationship between trends in Herring Gull populations and food availability in the Estuary and Gulf of the St. Lawrence River.

Rail J-F. & G. Chapdelaine 2000. Diet of Herring Gull *Larus argentatus* chicks in the Gulf and Estuary of the St Lawrence River, Quebec, Canada. Atlantic Seabirds 2(1): 19-34.

INTRODUCTION

Biologists recognised that the tremendous increase of gull populations during the present century was closely related to their opportunistic ability to obtain extra food supplied indirectly by man through the intensification of commercial fishery, resulting in more discarded fish and offal (Furness *et al.* 1992; Oro *et al.* 1995, 1996), and utilisation of refuse dumps and other sources of human waste (Spaans 1971; Hunt 1972; Nisbet 1978; Cavanagh 1992; Brousseau *et al.* 1996). The Herring Gull *Larus argentatus* is an important component of the larids group in the Estuary and Gulf of St Lawrence as the total breeding population had been estimated at 35 000 pairs (Brousseau 1996). Populations on the North Shore (Chapdelaine & Rail 1997) and Gaspé Peninsula (Chapdelaine & Brousseau 1992) indicate a general downward trend during the last 15 years while some specific colonies continued to increase or stabilised. Similar declines are also reported in the Estuary (Brousseau 1996; J. Bédard pers. comm.).

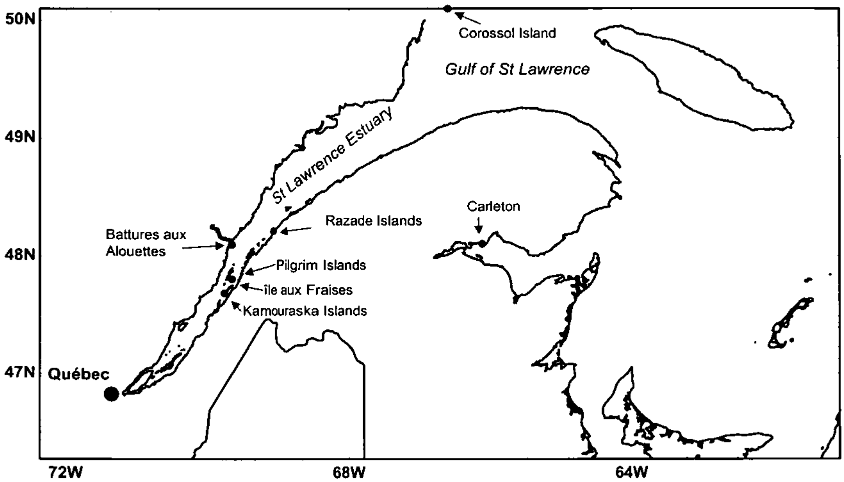


Figure 1. Study area, St Lawrence estuary and Gulf of St Lawrence in eastern Canada.
Figuur 1. Onderzoeksgebied, monding van de St Lawrence rivier en de Golf van St Lawrence in oostelijk Canada.

Chapdelaine & Rail (1997) attributed the decline of some colonies on the North Shore to the decrease in commercial fishing activities in the region but had no data on the diet of Herring Gull to demonstrate conclusively the relative importance of fish offal before and after the fishery collapse. Surprisingly, diet of Herring Gull during the breeding season is not very well known in marine waters of eastern Canada (Threlfall 1968; Haycock & Threlfall 1975; Pierotti 1983) and very few quantitative data exist for birds nesting in the Estuary and Gulf of St Lawrence (Guillemette 1997).

Gulls, unlike many other seabird species, are characterised by their lack of specialisation to the marine environment, and a high diversity of food items is expected in their diet. They would also exploit resources which are abundant both spatially and temporally to keep up breeding success. Within the context of using the Herring Gull as a marine bio-indicator (Rail *et al.* 1996), there was a strong need to have a current and closer look at the diet of this species. The present study aims to provide new data on the Herring Gull's diet in the Estuary and Gulf.

METHODS

Herring Gull regurgitations (n = 635) were collected between 1994-97 in five colonies in the St. Lawrence Estuary, and in two colonies in the Gulf of St. Lawrence (Fig. 1, Table 1). All sampling was done between 8 June and 1

Table 1. Number of regurgitations (n=) of Herring Gull chicks and number of visits (v) to each of the colonies in the St Lawrence Estuary and Gulf, summers of 1994-97.

Tabel 1. Aantal braaksels (n=) van Zilvermeeuwenkuikens and het aantal kolonie-bezoeken (v) in het St Lawrence estuarium en de Golf van St Lawrence, 1994-97.

	1994		1995		1996		1997		Total 1994-97	
	n =	(v)	*n* =	(v)	*n* =	(v)	*n* =	(v)	*n* =	(v)
-Ile aux Fraises	18	(3)							18	(3)
-Battures aux Alouettes	19	(1)							19	(1)
-Kamouraska Islands	17	(1)	24	(1)					41	(2)
-Pilgrim Islands	11	(2)	238	(14)					249	(16)
-Razade Islands	21	(1)							21	(1)
Total Estuary	86	(8)	262	(15)					348	(23)
Corossol Island					53	(5)	142	(28)	195	(33)
Carleton	92	(22)							92	(22)
Total	178	(30)	262	(15)	53	(5)	142	(28)	635	(78)

August, during the chick rearing period of each colony. All material comes from young gulls that regurgitated their stomach content when the colony was disturbed or when they were manipulated.

Regurgitations were either preserved individually (in 70% alcohol, 70% formaldehyde, or kept frozen) or analysed in the field. Each prey item was identified to the lowest taxon possible after Scott & Scott (1988) and a reference collection of specimen that we gradually developed. Plants, non-edible waste (e.g. plastic, paper), and parasite worms (Nematoda) were excluded from the results, since the presence of such material in the regurgitations is believed to be incidental, and moreover its nutritional value appears negligible.

The relative importance of each prey category is expressed by frequency of occurrence (the proportion of regurgitations containing a prey category), and percent mass or volume (the total volumetric or weight percentage of a prey category within a sample). Samples from the five Estuary colonies were regrouped. For samples from the Estuary and Carleton, volumes were measured by water displacement in a graduated cylinder at the nearest 0.1 ml. At Corossol Island, samples were weighed in the field at the nearest 0.5 g. Items too small to be measured were attributed 0.1 ml or 0.5 g, respectively.

Statistical analyses Data from regurgitations were regrouped by area and year. For each prey category, logistic regression was used to test the null hypotheses of no difference in frequency of occurrence between areas. Two-by-two comparisons of prey frequency of occurrence were also made between the five data subgroups (area-year). The distribution of the response variable was

Table 2. Composition of 635 Herring Gull chick regurgitations collected in colonies in the Estuary and Gulf of the St Lawrence River, 8 June-1 August in 1994-97.
Tabel 2. Samenstelling van 635 braaksels van Zilvermeeuwenkuikens in het St Lawrence estuarium en de Golf van St Lawrence, 8 juni-1 augustus, 1994-97.

Taxon	frequency (%)		volume or mass (%)	
Capelin *Mallotus villosus*	392	(61.7)	7189.6	(62.5)
gunnels *Pholis* spp.	7	(1.1)	58.3	(0.5)
Rainbow Smelt *Osmerus mordax*	7	(1.1)	103.1	(0.9)
clupeids *Clupea* spp.	7	(1.1)	166.0	(1.4)
sandeel *Ammodytes* spp.	24	(3.8)	502.5	(4.4)
other fish	5	(0.8)	80.0	(0.7)
unidentified fish	132	(20.8)	1705.2	(14.8)
crustaceans	41	(6.5)	565.6	(4.9)
annelids	20	(3.1)	181.4	(1.6)
human waste	20	(3.1)	564.0	(4.9)
other food	53	(8.3)	387.9	(3.4)
Total			11503.6	(100.0)

approximated by the binomial distribution in the model. In cases of overdispersion of the model, we fitted the generalised linear model by using the quasi-likelihood method to approximate the response distribution, and by estimating the scale parameter of the response distribution using the mean Pearson chi-square (instead of the maximum-likelihood estimate).

RESULTS

Diet composition The diet of Herring Gull chicks in the Estuary and Gulf was extremely varied. However, fish were most important as they represented 85.2% (in mass/volume) of the 635 regurgitations collected (Table 2). Capelin *Mallotus villosus* was by far the dominant prey, in frequency of occurrence (61.7%) as well as in mass/volume (62.5%). With the exception of the 'unidentified fish' category (14.8% in mass/volume), every other prey category amounted for less than 5% of the volume of regurgitations (Table 2). Moreover, capelin too degraded for identification may have represented a large fraction of the volume of 'unidentified fish'.

Regional variations Tables 3 and 4 compare the composition of Herring Gull regurgitations by area (Estuary, Corossol Island and Carleton) and by area-year, respectively. Fish was the main food of young Herring Gulls at all locations, representing between 59% (at Carleton in 1994) and 96% (Corossol Island in 1997) of the total volume of regurgitations. Also depending on locality and year,

Table 3. Composition of 635 Herring Gull regurgitations collected in the Estuary and Gulf of the St Lawrence River, by area (frq = frequency of occurrence; vol = percent volume).

Tabel 3. Samenstelling van 635 braaksels van Zilvermeeuwenkuikens in het St Lawrence estuarium en de Golf van St Lawrence, per deelgebied. (frq = frequentie; vol = volumepercentage).

	Estuary 1994-95 (*n* = 348)		Corossol 1996-97 (*n* = 195)		Carleton 1994 (*n* = 92)	
Taxon	frq (%)	vol (%)	frq (%)	vol (%)	frq (%)	vol (%)
Capelin *Mallotus villosus*	75.6	68.5	55.9	69.6	21.7	20.0
gunnels *Pholis* spp.	2.0	1.2	0.0	0.0	0.0	0.0
Rainbow Smelt *Osm. mordax*	1.7	1.9	0.0	0.0	1.1	0.6
clupeids *Clupea* spp.	1.4	1.9	0.5	0.7	1.1	2.5
sandeel *Ammodytes* spp.	0.0	0.0	12.3	10.0	0.0	0.0
other fish	0.3	0.1	0.5	0.7	3.3	2.5
unidentified fish	7.5	9.7	27.2	14.2	57.6	33.6
crustaceans	7.8	7.4	3.1	2.1	8.7	6.2
annelids	5.2	3.6	0.0	0.0	2.2	0.2
human waste	1.1	1.8	3.1	2.2	10.9	23.6
other food	7.8	4.0	3.1	0.5	21.7	10.9
Total		100.0		100.0		100.0

80% to 97% of the volume of fishes that were identified to species was capelin. Noteworthy is the lower proportions (in frequency of occurrence as well as in percent mass/volume) of capelin in regurgitations from Carleton (Table 3 and 4). However, a large proportion of fishes were unidentified, and capelin could account for most of it. But even then, capelin would represent a smaller volumetric proportion of gulls' regurgitations at Carleton.

Apparently compensating for the low abundance of capelin is a large proportion of food other than fish in chicks' diet at Carleton. The collection of 10 regurgitations containing large volumes of human refuse (such as sausages, ham, animal fat, chicken wings, etc.) resulted in human waste being the most important food category in volume (23.6%) at the Carleton colony in 1994. The prey category 'other food' was also better represented in regurgitations from Carleton (in 21.7% of regurgitations; 10.9% of total volume), in comparison with the other sampling sites (Estuary and Corossol Island, Table 3-4). At Carleton, this food category was composed of bird eggs (presumably of *Sterna* sp.), molluscs, and insects (4.7%, 3.4% and 2.8% of total volume, respectively). The 'unidentified fish' and 'other food' categories were the only ones present in regurgitations from all three areas for which the 'area' variable had a statistical significant effect on their frequency of occurrence (Table 4). Unidentified fishes

Table 4. Logistic regressions analyses on the frequency of occurrence (frq, %) of each prey category; different letters express significant differences (P < 0.05) of two-by-two comparisons between data subgroups (area-year). For prey categories present at more than one site, we also tested for an area effect.

Tabel 4. Resultaten van logistieke regressieanalyse van de frequentie van voorkomen (frq, %) van de verschillende prooisoorten; verschillende letters drukken significante verschillen uit (P < 0.05) van paarsgewijze vergelijkingen tussen de verschillende datasets (gebied-jaar). Voor alle prooisoorten die op meer dan één kolonie werden gevonden werd een test voor de gebieden uitgevoerd.

	Carleton		Corossol Island				Estuary Islands				test for an area effect	
	1994		1996		1997		1994		1995			
Prey category	frq (%)		frq (%)		frq (%)		frq (%)		frq (%)		*F*	*P* =
Capelin *Mallotus villosus*	21.7	d*	64.2	b	52.8	bc	40.7	c	87.0	a	2.03	0.36
gunnels *Pholis* spp.	-	-	-	-	-	-	5.8	a	0.8	b	-	-
Rainb. Smelt *Osm. mordax*	1.1	a	-	-	-	-	1.2	a	1.9	a	0.19	0.67
clupeids *Clupea* spp.	1.1	a	-	-	0.7	a	-	-	1.9	a	0.89	0.64
sandeel *Ammodytes* spp.	-	-	3.8	b	15.5	a	-	-	-	-	-	-
other fish	3.3	a	1.9	a	-	-	1.2	a	-	-	1.99	0.37
unidentified fish	57.6	a	28.3	b	26.8	b	11.6	c	6.1	c	64.24	<0.01
crustaceans	8.7	b	-	-	4.2	b	29.1	a	0.8	c	0.13	0.93
annelids	2.2	b	-	-	-	-	18.6	a	0.8	b	0.03	0.85
human waste	10.9	a	5.7	ab	2.1	b	4.7	ab	-	-	2.39	0.30
other food	21.7	a	7.5	b	1.4	c	8.1	b	7.6	b	9.88	<0.01

occurred more often at Carleton than at Corossol Island, and less frequently in the Estuary than in the two other areas; however, rather than being of any biological significance, this likely reflects the differences in experience and laboratory facilities of the person(s) that performed the identification of samples. The 'other food' category also occurred significantly more frequently at the Carleton colony than anywhere else.

Among other regional variations in the composition of gulls' regurgitations, blennies or gunnels *Pholis* sp. were present only in the Estuary, and sandeel *Ammodytes* sp. only at Corossol Island. Also, smelt *Osmerus mordax* and annelid worms were absent at Corossol Island.

Inter-annual variation Tables 5-7 show the annual composition of Herring Gull regurgitations from the Estuary, Corossol Island and Carleton respectively. At Estuary colonies, the proportion of capelin in 1995 was more than twice that of 1994 (Table 4-5). Surprisingly large quantities of annelids and crustaceans completed the gulls' diet in 1994 (together representing 34.6% of total volume in 1994, versus 0.1% in 1995). However, careful examination of the data revealed

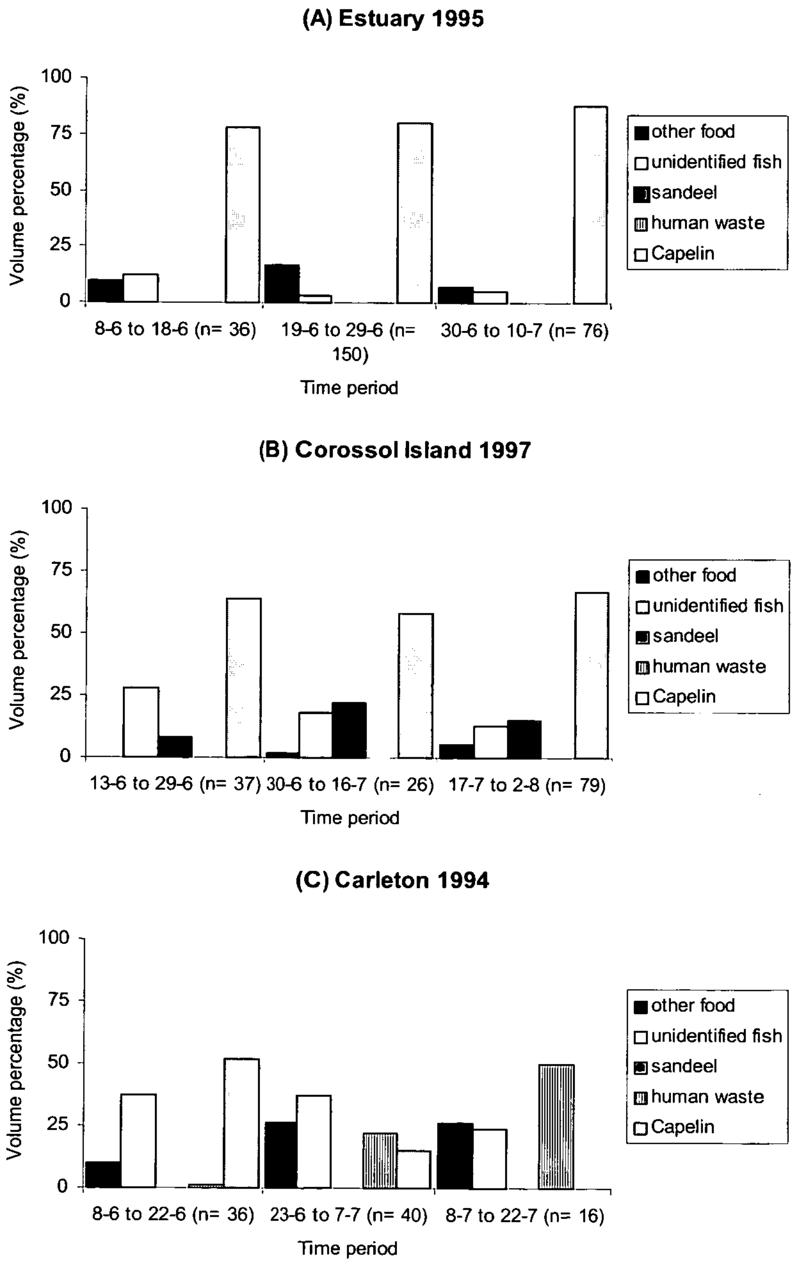
Table 5. Composition of regurgitations of Herring Gull chicks collected between 9 June and 11 July in 1994 (n = 86) and 1995 (n = 262) at five St Lawrence Estuary colonies.
Tabel 5. Samenstelling van braaksels van Zilvermeeuwenkuikens verzameld tussen 9 juni en 11 juli in 1994 (n = 86) en 1995 (n = 262) op vijf kolonies in het St Lawrence estuarium.

	1994				1995			
Taxon	frequency (%)		volume (%)		frequency (%)		volume (%)	
Capelin	35	(40.7)	564.7	(36.1)	228	(87.0)	2832.5	(83.4)
gunnels	5	(5.8)	33.3	(2.1)	2	(0.8)	25.0	(0.7)
Rainbow Smelt	1	(1.2)	0.1	(<0.1)	5	(1.9)	94.0	(2.8)
clupeids	0	(0.0)	0	(0.0)	5	(1.9)	93.0	(2.7)
Winter Flounder*	1	(1.2)	7.0	(0.4)	0	(0.0)	0	(0.0)
unidentified fish	10	(11.6)	318.0	(20.3)	16	(6.1)	161.0	(4.7)
crustaceans	25	(29.1)	366.0	(23.4)	2	(0.8)	0.6	(<0.1)
annelids	16	(18.6)	175.3	(11.2)	2	(0.8)	3.0	(0.1)
insects	6	(7.0)	9.0	(0.6)	13	(5.0)	5.4	(0.2)
human waste	4	(4.7)	90.0	(5.8)	0	(0.0)	0.0	(0.0)
other food**	1	(1.2)	0.1	(<0.1)	7	(2.7)	183.0	(5.4)
Total			1563.5	(100.0)			3397.5	(100.0)

**Pseudopleuronectes americanus* **Meadow vole *Microtus pennsylvanicus*, green sea urchin *Strongylocentrotus droebachiensis*, gull egg, unidentified animal flesh

that for the Estuary in 1994, 85.7% of the volume of crustaceans came from a single visit to Battures aux Alouettes, on 11 July, which in fact was the only time (over two years) that this colony was sampled. All (n = 19) regurgitations collected then were composed exclusively of euphausids (*Thysanoessa raschii* and *Meganyctiphanes norvegica*). Also on 11 July, 11 out of 17 regurgitations gathered at the Kamouraska Islands colony were entirely composed of earthworms, representing 93.0% of the volume of annelids for the Estuary in 1994. With the exception of the significantly lower occurrence of gunnels in 1995, other annual variations in prey occurrence for the Estuary relate to the absence of uncommon prey types in one year or the other.

At Corossol Island (Table 6), sandeel, which was rather uncommon in 1996's regurgitations (1.4% of total mass), occurred significantly more often and was among the main prey fed to young Herring Gulls in 1997 (13.1% in mass). Insects (under the category 'other food' in Table 4) were also present significantly more often in 1996 than in 1997. A larger quantity of human wastes was found in 1996 (6.1% of total mass, versus 0.8% in 1997), but its occurrence did not differ between years (it was observed in three regurgitations in each year). Finally, shrimps Malacostraca (few) and herring *Clupea harengus*


(A) Estuary 1995
Volume percentage (%)
100
75
50
25
0
8-6 to 18-6 (n= 36)
19-6 to 29-6 (n= 150)
30-6 to 10-7 (n= 76)
Time period
other food
unidentified fish
sandeel
human waste
Capelin
(B) Corossol Island 1997
Volume percentage (%)
100
75
50
25
0
13-6 to 29-6 (n= 37)
30-6 to 16-7 (n= 26)
17-7 to 2-8 (n= 79)
Time period
other food
unidentified fish
sandeel
human waste
Capelin
(C) Carleton 1994
Volume percentage (%)
100
75
50
25
0
8-6 to 22-6 (n= 36)
23-6 to 7-7 (n= 40)
8-7 to 22-7 (n= 16)
Time period
other food
unidentified fish
sandeel
human waste
Capelin

←

Figure 2. Seasonal trends in the volume of prey categories entering the diet of Herring Gull chicks from three areas of the St Lawrence Estuary and Gulf. Data come from regurgitations collected (A) in the Estuary in 1995, (B) at Corossol Island in 1997 and (C) at Carleton in 1994. For each area, sampling was divided in three time periods of equal duration (11, 17, and 15 days respectively).

Figuur 2. Seizoenpatronen in het volume prooisoorten dat deel uitmaakte van het voedsel van Zilvermeeuwenkuikens in het St Lawrence riviergebied (Estuarium en Golf). De gegevens werden verzameld (A) op kolonies in het Estuarium in 1995, (B) op Corossol Eiland in 1997 en (C) bij Carleton in 1994. Voor elk gebied werd de bemonstering in drie perioden van gelijke duur onderverdeeld (respectievelijk 11, 17 en 15 dagen).

(one fish) were recorded only in the larger sample of 1997. In general, regurgitations' composition was quite stable in 1996-1997 at Corossol Island, being largely dominated by capelin.

Seasonal trends Diet sampling that seemed adequate to visually detect real seasonal trends, *i.e.* sampling regular enough and covering most of the nesting season, was run in the Estuary in 1995, at Corossol Island in 1997, and at Carleton in 1994. For each of these data sets, Figure 2 shows the seasonal variation in the volumetric percentage of major prey items over three time-periods of equal length. It was preferable to regroup data by period instead of looking at daily variation because samples were sometimes very small.

In the Estuary in 1995 (Fig. 2a), diet composition was stable with capelin dominating the diet in each 11-day period (between 78% and 88% of total volume). Other prey categories were of minor importance. The picture was quite similar at the Corossol Island colony (Fig. 2b), as capelin was the main food in all three periods (between 58% and 71% of total mass). On the other hand, sandeel abundance in the regurgitations varied noticeably, from a total absence in the first period, to an important part of the diet (23% in mass) in the second period, and finally to an intermediate proportion (13%) in the last period. Actually, sandeel occurred fairly regularly during a short period, late in the season. It was first recorded on July 12 (*i.e.* on the 29th day of a sampling period that extended over 49 days), and last detected on July 26: during 15 days, it was present in about one third of regurgitations, and in 6 out of 8 samples (visits). Other prey types were poorly represented.

In contrast, major seasonal trends in the diet are visible in the graphic for Carleton's regurgitations in 1994 (Fig. 2c). Capelin abundance declined sharply from a little more than half of the volume of regurgitation in the first period (51.7%), to 15.8% and a complete absence in the second and third period, respectively. Actually, capelin was not detected after June 29. Interestingly,

Table 6. Composition of regurgitations of Herring Gull chicks collected between 14 June and 1 August in 1996 (n = 53) and 1997 (n = 142) at the Corossol Island colony.
Tabel 6. Samenstelling van braaksels van Zilvermeeuwenkuikens verzameld tussen 14 juni en 1 augustus in 1996 (n = 53) en 1997 (n = 142) op Corossol Eiland.

	1996				1997			
Taxon	frequency (%)		mass (%)		frequency (%)		mass (%)	
Capelin	34	(64.2)	970.0	(73.7)	75	(52.8)	2515.0	(68.2)
Mackerel*	1	(1.9)	34.0	(2.6)	0	(0.0)	0.0	(0.0)
clupeids	0	(0.0)	0.0	(0.0)	1	(0.7)	35.0	(0.9)
sandeel	2	(3.8)	18.5	(1.4)	22	(15.5)	484.0	(13.1)
unidentified fish	15	(28.3)	202.0	(15.4)	38	(26.8)	508.0	(13.8)
shrimps	0	(0.0)	0.0	(0.0)	6	(4.2)	104.0	(2.8)
human waste	3	(5.7)	80.0	(6.1)	3	(2.1)	31.0	(0.8)
insects	4	(7.5)	11.0	(0.8)	2	(1.4)	12.0	(0.3)
Total			1315.5	(100.0)			3689.0	(100.0)

* *Scomber scombrus*

food of anthropogenic origin underwent an almost exact opposite trend, passing from 2.8% to 19% and reaching 50.2% in volume in the last period. The volume of 'other food' (*i.e.* other fish species, crustaceans, birds, molluscs, insects and annelids) also increased between the first and second period (from 11.8% to 26.2%), and remained high at 26.9% in the third period.

DISCUSSION

Fish was the main food of young Herring Gulls at all locations. Also, 80% to 97% of the volume of fishes that were identified to species was capelin (depending on locality and year). In brief, capelin constituted the bulk of young Herring gulls' diet in the Estuary and Gulf of the St. Lawrence River. The menu would be opportunistically completed by many other species of fish (e.g. sandeel, herring, smelt), crustaceans (mostly shrimps and euphausids), annelids (earthworms and polychaetes), molluscs, urchins, insects, bird eggs, small mammals, and by human wastes. Overall, other kinds of food appeared to be of minor importance compared to capelin. However the diet was quite variable temporally, and regional differences were also observed. Also interesting to note is the total absence of fish offal or discards from the diet.

Regional variations of diet The most obvious regional difference is the low abundance of capelin in gulls' diet at Carleton, counterbalanced by a large volume of human waste and a high occurrence of the 'other food' category. Data on food availability would be necessary to confirm whether Carleton's gulls eat

Table 7. Composition of regurgitations of Herring Gull chicks collected between 8 June and 22 July in 1994 (n = 92) at the Carleton colony.
Tabel 7. Samenstelling van braaksels van Zilvermeeuwenkuikens verzameld tussen 8 juni en 22 juli in 1994 (n = 92) op Carleton.

Taxon	frequency (%)		volume (%)	
Capelin	20	(21.7)	307.4	(20.0)
Rainbow smelt	1	(1.1)	9.0	(0.6)
Clupeids	1	(1.1)	38.0	(2.5)
Other fish*	3	(3.3)	39.0	(2.5)
Unidentified fish	53	(57.6)	516.2	(33.6)
Crustaceans	8	(8.7)	95.0	(6.2)
Annelids	2	(2.2)	3.1	(0.2)
Birds**	4	(4.3)	72.0	(4.7)
Molluscs	5	(5.4)	52.1	(3.4)
Insects	11	(12.0)	43.4	(2.8)
Human waste	10	(10.9)	363.0	(23.6)
Total			1538.1	(100.0)

*Atlantic Tomcod *Microgadus tomcod*, Threespine Stickleback *Gasterosteus aculeatus* and Witch Flounder *Glyptocephalus cynoglossus* **Chicks and eggs of terns *Sterna sp.*

less capelin because other food sources are easily available, or rely on alternative food sources because capelin is less abundant than anywhere else. However, the latter hypothesis seems more likely, since capelin is a cold water species whose abundance is highest in the northern part of the Gulf and in the Estuary (Scott & Scott 1988; Grégoire *et al.* 1997). Thus, in conditions where capelin was presumably less available than around Corossol Island and in the Estuary, gulls at Carleton provided their young with a more varied diet. The fact that a large proportion of food in Carleton gulls' diet originates from terrestrial and tidal habitats also suggests an adaptation of the gulls in terms of changing foraging habits.

Another regional particularity in the diet of young Herring Gulls was the notable presence of sandeel at Corossol Island only. The absence of sandeel in the Estuary fits the distribution of the species (Scott & Scott 1988). Based on the same reference it is almost surprising that no sandeel were found in Carleton, but a large proportion of fishes remained unidentified.

Inter-annual variations A major part of the large quantities of crustaceans and annelids that characterised gulls' diet in the Estuary in 1994 came from two colonies sampled on 11 July. Daytime surface swarming of the euphausid *M. norvegica* has been observed to attract many predators, including the Herring Gull (Brown *et al.* 1979). The fact that on 11 July, all regurgitations collected at Battures aux Alouettes (Estuary) were composed exclusively of euphausids suggests that such a phenomenon (euphausids daytime surface swarming) occurred near the colony on that day. As for the unusual abundance of earthworms in samples from Kamouraska Island on 11 July, it could be explained by the ploughing of a nearby agricultural land. Indeed, large numbers of Herring Gulls are often observed during field ploughing, as they follow the machinery and pick up exposed earthworms.

Therefore we must conclude that most of the apparent annual variation in gulls' diet in the Estuary is a consequence of irregular and uneven sampling. In fact, if we exclude the visits at Battures aux Alouettes and Kamouraska Islands on 11 July, and take into account that most unidentified fish in 1994 must have been capelin, the diet of young Herring Gulls in the Estuary appears nearly stable in 1994-1995. Because of the opportunistic ability of Herring Gulls to detect and take advantage of a sudden food source availability, biases in diet assessment on a given breeding season are easily introduced, unless sampling is exhaustive and well distributed over time.

The other notable annual variation of gulls' diet was the higher abundance of sandeel at Corossol Island in 1997, compared to 1996. However, while sandeel was regularly represented during 15 days in 1997, sampling of gulls' diet in 1996 did not cover most of the chick rearing period, so that a momentary abundance of sandeel in waters surrounding Corossol Island could easily have gone undetected through gulls' diet in 1996.

Seasonal trends It is apparent that the sometimes important daily variations in young Herring Gulls' diet were mainly due to small samples (e.g. $n < 10$). In a few cases where larger samples were collected on consecutive days, the diet actually appeared more stable. It seems however that momentary specialisation of the diet will occur in association with punctual phenomena such as fish/crustacean surface swarming, or any other extra availability of food. In fact, sampling in this study was not designed to assess daily variations in the diet. Nevertheless, we were able to detect an obvious seasonal trend in gulls' diet at the Carleton colony in 1994. As capelin, that constituted half of the volume of regurgitations in the first third of the season, gradually vanished to a complete absence from the diet, the proportions of human wastes and other kinds of food (crustaceans and molluscs in particular) increased accordingly.

Comparisons with other studies A comparison of results from several studies of Herring Gull's diet around the world underscores the adaptability of the species (e.g. Burger 1988). Undoubtedly as reflected by the regional availability of food sources, the diet may either be dominated by a particular species of fish (Spaans 1971; Haycock & Threlfall 1975; Fox *et al.* 1990; Belant *et al.* 1993), bivalves (Pierotti 1983; Bukacińska *et al.* 1996), fishery discards (Furness 1984) or dump waste (Harris 1965; Sibly & McCleery 1983). Our study demonstrates once again that capelin is a key species in the food webs of seabirds in the St. Lawrence Estuary and Gulf's ecosystems (e.g. Rail *et al.* 1996), as it is elsewhere in the NW Atlantic (Brown & Nettleship 1984; Carscadden 1984).

Beyond these observations, the comparison of results between studies is difficult because the use of different methods of sampling, (e.g. pellets, food remains, regurgitations, observation) analysis and data presentation (frequency of occurrence, numerical frequency, volume, etc.) obviously influence diet assessment (Duffy & Jackson1986; Buckley 1990). Also, the fact that the diet of adults and young chicks may differ (Spaans 1971; Mudge & Ferns 1982; Cavanagh 1992) is rarely taken into account and samples from all age categories are often lumped together. For example, adult gulls may prefer to feed young chicks with fish instead of nutritionally inferior landfill waste (Cavanagh 1992). Thus the results presented in our study may not be representative of adult diet.

Herring Gull as bioindicator of marine resources The extraordinary adaptability of the Herring Gull enables the species to rely on a variety of food sources, and to quickly adjust its diet and foraging habits according to local variations in food availability. This suggests that the species would be an effective bioindicator for local trends in the relative abundance of its prey, especially capelin. However, assessing the availability of prey irregularly present in gulls' diet would require a more intensive, careful sampling.

Also, annual diet sampling of a network of gull colonies, distributed in the Estuary and Gulf, could be used to monitor large scale variations in abundance and distribution of prey species. For example, capelin distribution expanded in the southern part of the Gulf of St. Lawrence since the early 1990's, apparently as a result of abnormally cold water temperatures (Grégoire *et al.* 1997). We assume that the occurrence of capelin in young Herring Gulls' diet at Carleton in 1994 is an indicator of this phenomenon; since in 'normal' conditions (*i.e.* warm water temperature in the vicinity of Carleton) capelin would have been even less abundant in gulls' diet.

Conclusion and recommendations This study provides baseline data that could be useful for future investigation of the relationship between trends in Herring Gull populations and food availability in the Estuary and Gulf of the St. Lawrence River. Our assessment of Herring Gull chicks' diet demonstrated the generalist and opportunist character of the species. The diet was varied and variable, spatially and temporally. Nevertheless, capelin, a forage fish that is most important in term of biomass in the food chain in the St. Lawrence Estuary and Gulf, constituted the bulk of gulls' diet. At the colony of Carleton, located in the southern Gulf, capelin was less abundant, and more human waste completed the chicks' diet, in comparison with Corossol Island and Estuary colonies.

Our difficulty to analyse the diet spatially and temporally despite an overall considerable sampling effort demonstrates the usefulness to plan for a regular, well-balanced sampling. A minimum of ten regurgitations per visit would have been necessary to account for daily variations. To minimise sampling biases, several visits to a colony should be evenly spaced throughout the season, sample size on each visit should be kept nearly constant, and ultimately, results from each visit should be weighed equally.

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SAMENVATTING

De geweldige toename van veel soorten meeuwen in het Noord-Atlantische gebied in de afgelopen eeuw wordt vaak geweten aan verbeterde omstandigheden, zoals een toegenomen aanbod van voedsel op open vuilstortplaatsen en bij vissersschepen (visafval). De Zilvermeeuw Larus argentatus *is een soort waarvan veel populaties de afgelopen tientallen jaren echter onder druk staan, zo ook in oostelijk Canada, in het mondinggebied van de St Lawrence Rivier, waar het onderzoek waarover in dit artikel wordt gerapporteerd werd uitgevoerd. Als voedsel een oorzaak van de toename zou zijn geweest, ligt het voor de hand om te veronderstellen dat een verandering in voedselaanbod aanleiding heeft gegeven voor de afname die wordt waargenomen. Zoals zo vaak werden eerst conclusies getrokken (de afname zou samenhangen met een afname in het aanbod van visafval bij trawlers), waarna geconstateerd moest worden dat de noodzakelijke gegevens om tot zo'n uitspraak te kunnen komen feitelijk ontbraken. De onderzoekers constateerden dat er nauwelijks adequate gegevens voorhanden waren over de voedselkeuze van Zilvermeeuwen in het gebied. Zilvermeeuwen zijn opportunistische meeuwen die een grote verscheidenheid van prooien op het menu hebben staan. In dit artikel wordt het voedsel van kuikens (aan de hand van uitgebraakt voedsel) beschreven en vergeleken over de jaren 1994-97 in vijf kolonies in het St Lawrence estuarium en twee kolonies in de Golf van St Lawrence (steeds verzameld tussen 8 juni en 1 augustus).*

Het voedsel van de meeuwenkuikens bleek bijzonder gevarieerd te zijn, maar liefst 85.2% van het opgebraakte voedsel (massa/volume) van de in totaal 635 braaksels bestond uit vis. Lodde Mallotus villosus, *een kleine spieringachtige vis, was veruit de belangrijkste prooi (61.7% in frequentie, 62.5% als massapercentage). Uiteraard was het monsterprogramma niet uitputtend (635 monsters verdeeld over zeven kolonies in vier onderzoeksjaren over een periode van ruim 50 dagen per seizoen), en de onderzoekers hadden daardoor nogal wat last van 'verrassingen'. Zo werd het voedsel tijdens een bezoek op 11 juli 1994 in het estuarium plotseling gedomineerd door krillachtige garnaaltjes, vermoedelijk als gevolg van een plotseling en bovendien nogal zeldzaam aanbod van overdag naar de oppervlakte zwermende diertjes. Het weglaten van dergelijke 'uitbijters' in de resultaten laat een veel minder gevarieerd dieet zien en het maakte dat de verschillen van jaar tot jaar en van plaats tot plaats toch vrij beperkt waren.*

Geconstateerd wordt, vooral na een vergelijking met vergelijkbaar voedselonderzoek elders in de wereld, dat de voedselkeuze van de Zilvermeeuw een belangrijk inzicht kan geven in veranderingen in het voedselaanbod in de onmiddellijke omgeving van de kolonies. Om ten volle als

'bio-indicator' geschikt te zijn, is het echter noodzakelijk om plotselinge en bovendien kleinschalige fluctuaties in het aanbod te kunnen onderscheiden van het grote patroon. Daarvoor is een uitgebreid monsterprogramma noodzakelijk, met precieze aanpassingen in de onderzoeksopzet zodat de onderliggende vraag (bijvoorbeeld variaties in de loop van een seizoen, in de ruimte, of tussen jaren) ook inderdaad beantwoord kan worden. De hier gepresenteerde resultaten zullen vooral van betekenis zijn als basismateriaal voor toekomstig onderzoek aan het voedsel van Zilvermeeuwen in oostelijk Canada. Bijzonder inzicht in de achtergronden van de afnemende populatie heeft dit onderzoek nog niet gegeven, behalve dat 'discards' (snijafval en ondermaatse vis in de commerciële visserij), tegen de verwachting in, in het geheel niet op het menu van Zilvermeeuwenkuikens bleek te staan.

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Appendix 1. List of prey items identified to lowest taxonomic rank in 534 regurgitations of Herring Gull chicks, collected in the St. Lawrence Estuary and Gulf in 1994-1997 (**Prey type** [Class/order/family] Lowest taxon): **Fish** [Ammodytidae] *Ammodytes* sp., [Clupeidae] *Clupea harengus*, unidentified clupeidae, [Gadidae] *Microgadus tomcod*, [Gasterosteidae] *Gasterosteus aculeatus*, [Osmeridae] *Mallotus villosus, Osmerus mordax*, unidentified osmeridae, [Pholidae] *Pholis fasciata, Pholis* sp., [Pleuronectidae] *Pseudopleuronectes americanus, Glyptocephalus cynoglossus*, [Scombridae] *Scomber scombrus*, and unidentified fish; **Crustaceans** [Amphipoda] *Gammarus* sp., [Mysidacea] unidentified Mysidae, [Decapoda] *Eualus pusiolus, Crangon septemspinosa,* unidentified shrimp, *Hyas araneus*, *Cancer irroratus*, [Euphausiacea] *Meganyctiphanes norvegica, Thysanoessa raschi,* unidentified euphausiacea, and unidentified crustaceans; **Molluscs** [Gastropoda] *Littorina saxatilis,* unidentified gasteropod, [Bivalvia] *Mytilus edulis,* and unidentified molluscs; **Echinoderms** [Echinoidea] *Strongylocentrotus droebachiensis*; **Annelids** [Polychaeta] *Nereis virens*, [Oligochaeta] *Lumbricus* sp.; **Insects** [Diptera] unidentified muscidae, tipulidae, diptera, [Hymenoptera] unidentified formicidae, vespidae, and hymenoptera, [Coleoptera] unidentified carabidae and coleoptera, [Lepidoptera] unidentified butterfly, and unidentified insect; **Birds** [Laridae] *Sterna* sp. (eggs and chicks), unidentified larid egg; **Mammals** [Cricetidea] *Microtus pennsylvanicus*; **Human waste** miscellaneous food remains

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.*

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(1): 35-44.

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.

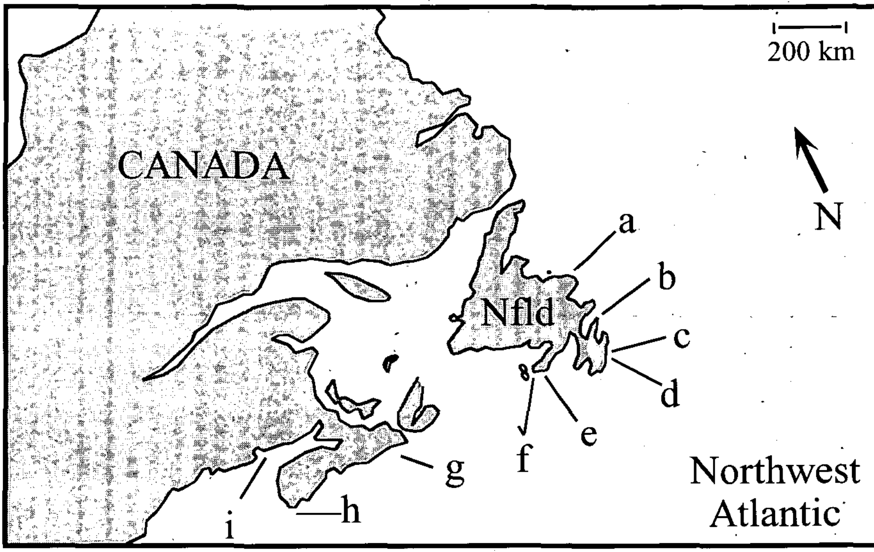

Figure 1. Locations of major Leach's Storm-Petrel colonies in eastern North America. (a) Wadham Islands c. 20 000 breeding pairs (Cairns et al. 1989); (b) Baccalieu Island c. 3 3600 000 (Sklepkovych & Montevecchi 1989); (c) Gull Island c. 530 000 (Cairns & Verspoor 1980), (d) Great Island c. 270 000 (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 3600 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 ± 1 standard error and 95% confidence limits are presented in parentheses.

RESULTS

Breeding population size In 1997, there was 72 696 m^2 of grass-shrub meadow and 128 460 m^2 of forest available on Great Island. We estimate the number of breeding pairs of Leach's Storm-Petrels was 63 972 ± 7778 (48 315 - 79 629; 95% CL) in grass-shrub meadow habitats and 205 793 ± 19 991 (165 551 - 246 035) in forest habitat for a total of 269 765 ± 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 nestholen (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)		burrows			population
	available	sampled	*n* per m^2	occup./total	occupied per m^2	estimated (p)
Grass-shrub						
1979	117 780	384 (0.33%)	1.26[1]	146 / 236[1]	0.88 ± 0.09[1]	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[1]	91 / 135[1]	0.88 ± 0.09[1]	148 910
1997	128 460	200 (0.16%)	2.21	227 / 313	1.60 ± 0.16	205 793 ± 19 991

[1]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 270m^2 grasland met struikjes (0.37% van het aanwezige terrein) en 450m^2 bosgebied (0.35% van het terrein).

	Grass shrub habitat		Forest habitat	
Date	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 ± 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 omringende 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.

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

Short notes

SOFT-PLUMAGED PETRELS *PTERODROMA MOLLIS* AND ATLANTIC PETREL *PTERODROMA INCERTA* AT 60°S IN THE DRAKE PASSAGE

DONSSTORMVOGELS PTERODROMA MOLLIS *EN ATLANTISCHE STORMVOGELS* P. INCERTA *IN DE DRAKE PASSAGE OP 60° ZUIDERBREEDTE*

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Dozens of Soft-plumaged Petrels Pterodroma mollis *and a single Atlantic Petrel* P. incerta *were observed in Drake Passage, far south of their normal range in the South Atlantic. It is suggested that these birds were immatures or non-breeding adults.*

Berry M. & H. Meltofte 2000. Soft-plumaged Petrels *Pterodroma mollis* and Atlantic Petrel *Pterodroma incerta* at 60°S in the Drake Passage. Atlantic Seabirds 2(1): 45-46.

On 9 February 2000, we observed dozens of Soft-plumaged Petrels *Pterodroma mollis* and a single Atlantic Petrel *P. incerta* in the Drake Passage between South America and the Antarctic Peninsula. This is far south of their known range, which for both species in the South Atlantic is given at just south of the Falkland Islands, or about 1000 km to further to the north (Harrison 1983; del Hoyo *et al.* 1992). The sightings were made from MS *Grigoriy Mikheev* on cruise to the Antarctic Peninsula.

The first Soft-plumaged Petrel was observed at approximately 58°49'S, 59°19'W, when we began the observations in the early morning, and the last was seen at 60°37'S, 56°46'W in the late afternoon. The greatest abundance occurred between 59°38'S, 58°38'W and 60°01'S, 57°54'W, during which period we observed multiple small groups of seven to twelve individuals. We estimate a total number of between 50 and 80 individuals, dependent on the number of re-sightings. The single Atlantic Petrel was observed at 60°37'S, 56°46'W, flying with a Soft-plumaged Petrel.

All Soft-plumaged Petrels showed uniform dark upperparts, dark patterned underwings, pale bellies and the characteristic head and neck patterns. The

Atlantic Petrel was a bit larger than the Sort-plumaged Petrel it accompanied and was all dark, except for its diagnostic white belly. Most, or perhaps all, of the Soft-plumaged Petrels showed active moult of primaries and rectrices, with at least one or two feathers missing on each individual. This suggests, in combination with the fact that it was within the normal austral breeding season, that the birds were non-breeding adults or immatures.

The only other records of Soft-plumaged Petrels in the Drake Passage that we know of, were made by Brown *et al.* (1975) who saw six individuals at 59°32'S, 58°03'W on 18 February 1970 and Kaj Kampp (*in litt.*) who saw 14 individuals south to 60°30' on 19 March 1998, both well south of the Antarctic Convergence. None were seen by us, nor by Kampp, during seven previous passages in December and January 1992-1999. Atlantic Petrels may be more frequent in Drake Passage, given reported sightings by Brown *et al.* (1975) and Enticott (1991), although most records were north of 49°S.

Op 9 februari 2000 werden op een cruise naar het Antarctisch Schiereiland naar schatting 50-80 Donsstormvogels Pterodroma mollis waargenomen en een enkele Atlantische Stormvogel P. incerta, op ongeveer 60°Z in de Drake Passage. Voor zover bekend komen beide soorten normaal niet veel verder dan juist ten zuiden van de Falkland Eilanden voor, ongeveer 1000 km noordelijk van de hier beschreven plaats van waarnemen. De actieve vleugelrui en het feit dat de waarneming midden in de Australe zomer plaatsvond maakt het aannemelijk dat het hier om niet-broedende adulten of om onvolwassen dieren is gegaan.

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MASS MORTALITY OF COMMON EIDERS *SOMATERIA MOLLISSIMA* IN THE WADDEN SEA, WINTER 1999/2000: FOOD RELATED PARASITE OUTBREAK?

MASSALE STERFTE VAN EIDEREENDEN IN DE WADDENZEE, WINTER 1999/2000: VOEDSELGERELATEERDE UITBRAAK VAN PARASIETEN?

Between November 1999 and May 2000, large numbers of dead and dying Eiders *Somateria mollissima* washed ashore in the Dutch and German Wadden Seas. Eiders roosting near the coast were reported to be in a very poor condition and most were unable to fly. Between December and May, well over 20 000 Eiders died in the Dutch Wadden Sea (NZG/NSO database) and just over 2000 were reported from German waters (B. Reineking *pers. comm.*). A long-term time series of beached bird surveys showed that the mortality was between 4 and 7x background levels (excluding mortality due to oil): the most serious non-oil related mortality outbreak in Common Eiders in these waters since the mid-1960s (Swennen 1972; Camphuysen 1997, 2000). Juvenile Eiders predominated early in the incident, more and more adults were found later in the epizootic.

All beached Eiders were in an exceptionally poor condition (subcutaneous and deposited fat stores depleted, very poor condition breast muscle; C.J. Camphuysen & T. Kuiken unpubl. data) and the birds had lost at least 25-35% of normal body mass. The most probable cause of the emaciation is a lack of adequate food (starvation). The most significant pathologic finding besides the severe emaciation was multifocal enteritis caused by a parasite infection. Virtually all dissected Eiders were heavily infected with endoparasites, mainly the thorny-headed worm *Profilicollis botulus* (Acanthocephala) in the intestines, but including potentially pathogenic parasites such as the Nematod *Amidostomum acutum* in the gizzard (H. Cremers *unpubl. data*). Many acanthocephalids had penetrated the intestinal wall of the Eiders and protruded into the abdomen. The parasite infection is regarded as being the proximate cause of death. The parasite burden may be indicative of a shift of the Eiders towards secondary prey (Green Shore Crabs are the intermediate host of *P. botulus*), in immune status or some other factors.

Eiders need to select prey with a favourable flesh content/shell thickness ratio. Importantly, the lower quality threshold value of cockles for the Eider is unknown. The (third) mild winter (in a row) may have suppressed cockle condition. Besides, the Dutch Wadden Sea is currently under stress by widespread mechanical Common Cockle *Cerastoderma edule* fisheries and Blue Mussel *Mytilus edulis* cultures. The mass-mortality of Eiders, molluscivorous seaducks with cockles and mussels as their main prey could be interpreted as a signal of a malfunctioning ecosystem, whether or not negatively influenced by the fisheries.

There was no histologic evidence for a virus related background of the mortality (T. Kuiken unpubl. data). From a Dutch (RIKZ) water quality monitoring programme, using mussels as bioindicators, Hg, Cd, PCB, PAH, and HCB levels can be classified as 'normal', i.e. not indicating a probable cause of this mortality event (M. Eggens unpubl. data). Continued disturbance at remaining food patches (Eiders are purposefully disturbed at mussel cultures), the search failure to find alternative prey, intraspecific competition for a scarce prey and starvation itself can lead to chronic stress (high levels of corticosterone) which in turn inevitably leads to immunosuppression. On the basis of these mechanisms, one would predict dominant classes of birds to succumb last (adults, the juveniles dying first) and a large variety of diseases to be identified in dead and dying birds as a result of the general reduction in disease resistance.

There are major gaps in present knowledge, such as factors related to the quality of prey, prey distribution and prey availability. The information about the food base of the Eiders was spotty and more directed to the needs of the fishing industry than to the monitoring of food availability for Eiders. Some vital information, such as the lower quality threshold value for cockles, is not known. Year-to-year monitoring of the health status of the Eider population in the Wadden Sea is absent, and yet it is vital to have such surveillance to be able to deal with mortality events such as this one. The data collected during this epizootic will now be analysed and be prepared for publication in due course. The many aspects of the epizootic will probably lead to some highly specialised publications that may appear scattered over a wide variety of (specialised) journals. Meanwhile, particularly because there are so many uncertainties in this and similar incidents, we are keen to hear other peoples opinions and experiences about this and similar events.

SAMENVATTING

Tussen november 1999 en mei 2000 jaar zijn er in de Nederlandse Waddenzee tenminste 20.000 Eidereenden omgekomen en daarnaast nog eens ruim 2000 in de Duitse Waddenzee. De massale sterfte van deze schelpenetende eendensoort wordt gezien als een signaal van een malfunctionerend ecosysteem. Nadere inspectie van de Eidereenden wees uit dat de vogels tenminste 25-35% van hun normale lichaamsgewicht hadden verloren, dat het vooral juveniele (eenjarige) exemplaren betrof, en dat de darm in de meeste gevallen stampvol zat met een venijnige parasiet, de Acanthocephaal Profilicollis botulus. *De parasietinfectie was opvallend, maar vermoedelijk slechts een bijverschijnsel (proximate doodsoorzaak). Er zijn geen aanknopingspunten om te veronderstellen dat er vergiftiging of een virusuitbraak in het spel was. De vermagering van de eenden en wijst op verhongering door voedselgebrek (misschien door een geringe kwaliteit van de aanwezige kokkels). De intraspecifieke competitie van Eiders op de schaarse voedselvoorraden, in combinatie met de voortdurende verstoring van eenden op een aantal mosselpercelen, kan leiden tot chronische stress en een hoge spiegel van het stresshormonen. Een aanhoudend hoge spiegel leidt tot aantasting van het immuunsysteem, waardoor de vogels vatbaar worden voor ziektes en parasieten.*

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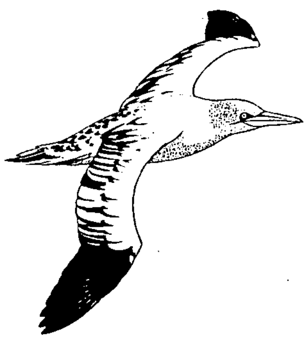
the **Seabird Group**

was founded in 1966 to circulate news of work in progress on seabirds and to promote research. It is run by an elected Executive Committee and maintains close links with the three major British national ornithological bodies the British Ornithologists' Union, the British Trust for Ornithology, and the Royal Society for the Protection of Birds.

Membership (£10 per annum, £9 if paid by banker's order, £5 for students) is open to all with an interest in seabirds. For details please contact the Membership Secretary (Sheila Russell, Clober Farm, Milngavie, Glasgow G62 7HW, Scotland U.K., E-mail: Sheila-Russell@Cloberfarm.in2home.co.uk) – payment by banker's order helps the Group. At least three issues of *Atlantic Seabirds* and Newsletters are circulated to members each year.

Current Executive Committee Chair S. Wanless, Secretary J. Uttley, Treasurer J.C. Davies, Membership Secretary S. Russell, *AS* Editor J.B. Reid, Newsletter editor M.L. Tasker, also A. Douse, J.D. Okill, E.K. Dunn and S. Sutcliffe.



Nederlandse Zeevogelgroep (NZG)

(Dutch Seabird Group), sectie van de Nederlandse Ornithologische Unie, opgericht 1 januari 1991, als voortzetting van de Club van Zeetrekwaarnemers (1972-1990) en het Nederlands Stookolieslacht-offer-Onderzoek (1977-1990). De Nederlandse Zeevogelgroep stelt zich tot doel: het stimuleren van zeevogelonderzoek in en vanuit Nederland en het uitwisselen van informatie met de uitgave van het tijdschrift, aanvankelijk *Sula*, vanaf 1999 *Atlantic Seabirds.*

Voor zover samenvallend met onderzoek aan zeevogels worden activiteiten aan zeezoogdieren mede in de doelstelling betrokken. Door een viertal werkgroepen wordt onderzoek gestimuleerd naar broedende zeevogels, de verspreiding van vogels en zoogdieren op open zee (offshore), strandingen, zeetrek en de gevolgen van olievervuiling. De contributie van de NZG bedraagt *f*25 per jaar.

Dagelijks bestuur Voorzitter en Nieuwsbrief redacteur M.F. Leopold, Secretaris J.A. van Franeker, Penningmeester Y. Hermes, *AS* Eindredacteur C.J. Camphuysen, en verder A.J. van Dijk, E.W.M. Stienen en C.J.N. Winter.

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