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Apparent survival of adult Thayer's and Glaucous Gulls nesting sympatrically in the Canadian high Arctic

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We estimated apparent survival of 33 adult Thayer's Gulls *Larus thayeri* and 21 adult Glaucous Gulls *Larus hyperboreus* nesting sympatrically at a small colony on St. Helena Island, Nunavut, in Canada's high Arctic, using five consecutive years (2003–2007) of capture-mark-resight data. Resighting probabilities were high in all years for both species (0.97). Mean survival for Thayer's (0.81 ± 0.05) was low, but for Glaucous Gulls (0.86 ± 0.05) was comparable to estimates of survival reported for large gulls elsewhere. Both species showed high annual variation in survival, with one year each of noticeably lower survival, suggesting that some factors acting on survival may have differed between species and could reflect different species' exposure to natural or anthropogenic stressors. Our findings contribute to the limited demographic information on these polar gulls, and provide a basis for future comparisons should they be affected by changes in their polar environments.

Key words: capture–mark–resight (CMR), Thayer's Gull, Glaucous Gull, adult, survival

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Adult survival is a key parameter affecting population trends, especially among long-lived species (Lebreton & Clobert 1991). Understanding sources and patterns of variation in adult survival is particularly important for assessing population dynamics and consequently managing populations (Perrins *et al.* 1993, Saether *et al.* 1996). Little is known about adult survival of most colonial seabirds in the high Arctic, at a time when Arctic environments are rapidly changing (ACIA 2005), and thus our ability to understand and predict the impacts of these environmental stressors on Arctic seabirds is compromised. This is especially true for Arctic specialist species, as climate change (i.e. rapid warming in Arctic regions) is likely to have disproportionately profound negative effects on their long-term viability (McCarty 2001). Further, the logistical challenges of working with cliff nesting species in high Arctic environments have resulted in disproportionately large knowledge gaps for species such as Thayer's Gull *Larus thayeri* and Glaucous Gull *L. hyperboreus*, both considered among the least known of all North American gull species (Gilchrist 2001, Snell 2002). Also, because both species breed in environments largely spared of direct anthropogenic influence (Gilchrist 2001, Snell 2002), it might be suspected that the birds themselves are unaffected by human activities. However, this is likely incorrect given the knowledge of: 1) important concentration of pollutants in polar regions (MacDonald *et al.* 2000, Bustnes *et al.* 2003), and 2) winter occurrence of both species in areas heavily

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Figure 1. A pair of Glaucous Gulls on a rock tower at St. Helena Island, high Arctic Canada (photograph by Cynthia Gilbert, 2005).

populated or heavily used by humans (Brown *et al.* 1975; HGG, KAA, unpubl. data). Although neither species presently is considered at risk, only 6 300 pairs of Thayer's Gulls are believed to occur within the species' breeding range (Snell 2002), while an estimated 85 000 pairs of Glaucous Gulls are thought to occupy the species' North American breeding range (Gilchrist 2001). Unfortunately, these population estimates lack robust confidence intervals, trends are either lacking or poorly known and are prone to significant sources of error. Recently, negative trends in Glaucous Gull populations associated with seabird colonies in the Canadian Arctic have been detected (e.g. Gaston *et al.* 2009, and unpubl. data).

Thayer's and Glaucous Gulls are large gulls that exhibit high site fidelity, and typically form small colonies on coastal cliffs separated by tens to hundreds of kilometres in the Canadian Arctic (Gilchrist 2001, Snell 2002). Thayer's Gulls feed almost exclusively away from their colony, at sea, and provision their chicks primarily with fish. Many are known to stage and overwinter at Pacific coastal sites (Snell 2002; HGG, KAA, unpubl. data). Glaucous Gulls feed at sea, but also depredate the eggs and young of other birds nesting near their colony (usually waterfowl or seabirds; Gilchrist & Gaston 1997, Gilchrist 2001). Glaucous Gulls that nest in the eastern Canadian Arctic probably overwinter in the Atlantic Ocean (Brown *et al.* 1975, Gilchrist 2001). Only two published survival estimates exist for Glaucous Gulls. One was obtained from a European population (Bustnes *et al.* 2003), the other was obtained from a population nesting sympatrically with Brünnich's Guillemot *Uria lomvia* in the southern part of the Glaucous Gull's North American breeding range (Gaston *et al.* 2009). In contrast, the present study examines a population breeding in a small mixed colony, in the northern part of the species' range, 1500 km distant from the site of the latter study. No published survival estimates exist for the Thayer's Gull or the closely related Iceland Gull *L. glaucoides*.

We investigated apparent survival (i.e. survival confounded by permanent emigration; White and Burnham 1999) of adults of these two large larid species nesting sympatrically on a remote, small island in the Canadian high Arctic. We assessed the influence of sex, species, year, and species-year interactions on apparent survival and resighting using program MARK. This broadly-accepted approach to analysis of cap-

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ture–mark–resight data was taken as it provides an easy and robust method of making comparisons among populations and species, while providing confidence intervals around survival and encounter probability estimates (Cooch & White 2009). We compared our findings with previously published survival estimates of other gull species.

METHODS

Study area and species

We observed breeding gulls nesting on St. Helena Island, Nunavut, Canada (76°17'N 89°09'W), a small (0.7 km^2) island located within the Hell Gate Polynya of the Canadian high Arctic between Devon and Ellesmere islands. Strong tidal currents that flow through the narrow passages and over shallow reefs on both sides of the island are responsible for early ice break-up and presence of open water for up to six months of the year. The island lacks tall vegetation and is characterized by a prominent central ridge system featured with scattered small buttresses, escarpments and talus slopes ≤ 25 m tall. The flat areas surrounding the central ridge host bedrock outcrops and several free standing towers with vertical or near-vertical walls ≤ 10 m tall (Fig. 1). The colony island includes similar numbers of nests of both species (Thayer's Gulls: mean = 19, min = 16 (2004, 2007), max 21 (2005); Glaucous Gulls: mean = 16, min = 12 (2007), max = 19 (2004)). The nearest Thayer's Gull colony is approximately 40 km to the northwest, and several scattered, small Glaucous Gull colonies (< 10 pairs each) are located 30 km to the northwest. The Northern Fulmar *Fulmarus glacialis* colony located 3 km to the south at Cape Vera hosts 10–20 solitary nesting pairs of Glaucous, but not Thayer's Gulls (Mallory, unpubl. data).

We were present on the island during the breeding season in each year (2003–07) for no less than four weeks except in 2003 when only marking of birds took place; our presence in 2004–07 included the prospecting, egg-laying and incubation periods for both species.

Ringing and resighting. In all years we climbed or rappelled to nest sites and captured gulls using wire box-traps or by noosing them around their legs using fabric cord. Prior to catching attempts, we placed gull eggs in an insulated carrying case and replaced them with wooden replicas. The occasional exception to this approach occurred among cliff-nesting Thayer's Gulls, because this would have required excessive disturbance to the colony. No eggs were lost nor nests abandoned as a result of our capture and ringing efforts.

We marked each gull with a numbered stainless-steel ring as well as a unique combination of coloured plastic rings. Sex initially was assessed using measurements collected when rings were placed, then confirmed on the basis of position during copulation (Pradel 2008). Marked gulls were monitored (resighted) using spotting scopes and binoculars. For those gulls that attended nest sites, resighting efforts were conducted systematically from wooden observation blinds distributed throughout the colony at least twice per 24 hr period and totalling ≥ 4 hr daily, and opportunistically during the course of other research activities. Our analytical approach collapsed multiple observations of an individual to a single 'occasion' per year, effectively requiring a single sighting to be recorded as 'alive' (see Statistical Analyses below). Nonetheless, frequent observations were made during our stays on the island to minimize identification error and the possibility of missing ringed individuals. All gull nest sites on the island were observed easily from one or several vantage points.

Statistical analyses

Following an assessment of goodness-of-fit (GOF), we investigated resighting and apparent survival probabilities using our capture–mark–resight (CMR) data. We applied single state, open-population, live-encounter, Cormack–Jolly–Seber models specified in Program MARK (Pollock *et al.* 1990, White & Burnham 1999, Williams *et al.* 2002) and the Information-Theoretic approach to model selection (Burnham & Anderson 2002).

Given that only five sampling occasions were available and sample sizes were small, even major violations of the basic assumptions would be difficult to detect with the available GOF tests (Choquet *et al.* 2005). In addition, the mark–resighting data convincingly show that heterogeneity (due to, e.g. transience or trap-dependence) was minimal in our dataset: only three individuals (one Glaucous, two Thayer's) eluded detection on the first occasion following release (second diagonals, Table 1). Otherwise, birds that returned were immediately detected (first diagonals, Table 1) and those that did not were never seen again ('Total' column, Table 1). Nevertheless, we assessed transience and trap-dependence in our data using one-sided Tests 3.SR and two-sided Tests 2.CT in program U-CARE (Choquet *et al.* 2005). Transience is a source of heterogeneity resulting from permanent emigration from the study area by some individuals following marking. Trap-dependence can originate from individuals in a population that are anomalously easy (trap-happy) or difficult (trap-

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shy) to resight. The null hypotheses under these tests are that newly and previously marked animals are subsequently resighted with the same probability (3.SR), and that the probability of recapture on occasion *i*+1 is the same for animals marked on or before occasion *i* (2.CT). For the GOF assessment in U-CARE, we fitted a year-dependent model, Φ(year)p(year), separately for Thayer's and Glaucous Gull datasets (Φ = apparent survival probabilities, p = resighting probabilities). We estimated the overdispersion parameter ĉ using the median ĉ approach in program MARK (Anderson *et al.* 1994; White *et al.* 2001) and our most general model, Φ(species × year)p(species + year).

Assuming adequate GOF, we explored the dependence of the resighting processes on year and species while maintaining species and year fitted to survival probabilities. Four models were used in this part of our analysis:

Φ(species × year) p(species + year); Φ(species × year) p(year); Φ(species × year) p(species); Φ(species × year) p(.)

where '×' identifies an interaction, '+' additive effects and '.' refers to no effects fitted to the parameters. Although sparse data precluded inclusion of interactions in this part of our analysis, resighting rates were close to 1 in all years of the study suggesting little variance in this parameter. Survival probabilities were modelled while maintaining the previously established effects of resighting rates. Modelling survival consisted of all possible combinations of species, year, and their interactions prior to fitting sex to the best supported model. Given the few individuals that we had available of each sex from each species, we did not fit sex to any other model; in our view, a rigorous assessment of sex will require additional data. Survival over the last interval for Thayer's Gull was fixed to 1.0 in all models, as all Thayer's Gulls that were marked or observed in 2006 were observed at the colony in 2007 (last row, Table 1).

We used Akaike's Information Criterion adjusted for small sample size (AIC_c) and related Information Criteria to determine support for model effects. In accordance with model weights and evidence ratios presented by Burnham & Anderson (2002), for this assessment we only considered models within 6 AIC_c units of the top model ($\Delta AIC_c = 0$); all others were considered as unsupported by the data. Model averaging was used to arrive at estimates of apparent survival and resighting probabilities that accounted for model selection uncertainty (Burnham & Anderson 2002). Values reported are means ± SE.

RESULTS

Capture–mark–resight analysis

Dataset. We captured and marked 33 and 21 Thayer's and Glaucous Gull adults between 2003 and 2006, respectively (Table 1, Appendix 1). We did not observe loss of metal or alphanumeric plastic rings placed on adult gulls. Our use of additional colored plastic rings

Table 1. Reduced m-array (Burnham *et al.* 1987) summarizing capture–mark–resight data from Glaucous and Thayer's Gulls marked as breeding adults and monitored at Saint Helena Island from 2003 to 2007. Note that all Thayer's Gulls released in 2006 were encountered in 2007.

		Encountered for the first time after release				
Release year	No. released	2004	2005	2006	2007	Total
Glaucous Gull						
2003	11	10	0	0	0	10
2004	14		11	1	0	12
2005	15			14	0	14
2006	17				10	10
Thayer's Gull						
2003	19	14	1	0	0	15
2004	22		21	0	0	21
2005	27			17	1	18
2006	18				18	18

Table 2. Model averaged estimates of apparent survival and resighting probabilities (2004–2007) from models 1–9 in Table 3 for male Thayer's and Glaucous Gulls. Female estimates were within 0.01 units of males.

Group	Interval/ occasion [1]	Estimate	SE	95% confidence interval
Survival probabilities				
Glaucous Gull				
	2003–04	0.870	0.076	0.641–0.962
	2004–05	0.906	0.077	0.624–0.982
	2005–06	0.838	0.089	0.590–0.949
	2006–07	0.641	0.144	0.345–0.859
Thayer's Gull				
	2003–04	0.806	0.079	0.607–0.918
	2004–05	0.899	0.072	0.655–0.977
	2005–06	0.733	0.090	0.526–0.872
	2006–07	Fixed = 1.0		
Resighting probabilities				
Both	2003–07	0.968	0.020	0.894–0.991

[1] Refers to survival/resighting, respectively.

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ensured that we easily could identify individuals over time throughout the study, as indicated both by goodness-of-fit tests and our high estimates of resighting probabilities (Table 2).

Goodness of fit. Test 3.SR provided no evidence of transience in either species: Glaucous (standardized log odds-ratio (SLOR) = 0.449, $P = 0.33$) and Thayer's Gulls (SLOR = –0.127, $P = 0.55$). It was necessary to combine species data (pool groups) to estimate component 2.CT. Significant trap-dependence was not detected by this test: SLOR = –1.5123, $P = 0.13$. Reflecting these tests and observations, our overall estimate of overdispersion (Φ) was < 1. Given these results, we were satisfied that our data adequately fit the CJS model so made no adjustment for overdispersion (Anderson *et al.* 1994).

Factors affecting resighting. All of the models fitted to assess species and year effects in the resighting process (5, 7, 8 and 9; Table 3) were within 6 AIC_c units of the top model in this subset (i.e. the models used to assess factors affecting resighting probabilities). However, the top model (5) in this subset was the constant (no effects) model suggesting that year and species effects were not supported by the available data; confidence intervals widely bounded zero for these effects. Thus, we assessed structure in the survival process while maintaining no effects fitted to our resighting probabilities ($p(.)$).

Factors affecting survival. All models fitted to assess structure in the survival process (models 1–6) were within 6 AIC_c units of the top model (Table 3). In contrast to the assessment of resighting probabilities, additive year and species effects (models 1 and 2) provided a modest improvement in model support over the time and species invariant (constant) survival model (3). Models including year × species interactions and sex ranked lower than the constant survival model suggesting that these effects were not supported by the available data. The confidence interval for the interaction and sex effects widely bounded zero.

To account for model selection uncertainty, models 1–9 (Table 3) were used to calculate model averaged estimates of survival and resighting probabilities (Table 2). Estimates for females and males were identical to within 0.01 units, so only the latter are presented here (Table 3). Resighting probabilities and their standard errors were identical to within 0.001 units for the two species so these are represented by a single estimate in Table 3.

Results of model averaging yielded mean survival estimates for Thayer's Gulls (0.814 ± 0.05) and Glaucous Gulls (0.860 ± 0.05). Note that these means are affected by a single, non-overlapping, low survival event for each species (Table 2).

Supplementary data. The migration and wintering ranges of Thayer's and Glaucous Gulls that nest in the Canadian Arctic are poorly known (Gilchrist 2001, Snell 2002). However, of 33 Thayer's Gull individuals ringed as adults on St. Helena Island, one individual captured in 2003, and subsequently resighted at the colony in all years of the study, was observed and photographed on 23 February 2008 near Cumberland, British Columbia (49°30'N, 125°00'W). In addition, of 55 Thayer's Gull chicks ringed during the study, two immature Thayer's Gulls (of 22 ringed in 2006) were later observed along the Pacific coast of western North America: a 6 month-old individual on 3 February 2007 near Long Beach, Washington (46°18'N, 124°00'W) and a 10 month-old individual on 2 June 2007 near Gustavus, Alaska (58°25'N, 135°50'W).

Table 3. Models and selection criteria used to determine support for competing models and their effects.

Model	ΔAIC_c	AIC_c weight	Model likelihood	NP	Deviance
(1) Φ(species + year) p(.)	0.000	0.285	1.000	6	142.045
(2) Φ(year) p(.)	0.179	0.260	0.914	5	144.404
(3) Φ(.) p(.)	1.405	0.141	0.496	2	151.981
(4) Φ(species + year + sex) p(.)	1.963	0.107	0.375	7	141.796
(5) Φ(species × year) p(.)	2.127	0.098	0.345	9	137.436
(6) Φ(species) p(.)	3.312	0.054	0.191	3	151.802
(7) Φ(species × year) p(species)	4.430	0.031	0.109	10	137.426
(8) Φ(species × year) p(year)	7.829	0.006	0.020	12	136.091
(9) Φ(species × year) p(species + year)	10.222	0.002	0.06	13	136.063

NP = number of estimable parameters in the model, Φ = survival parameter, p = resighting parameter, (.) no effects, '×' effects interact, '+' effects are additive, AIC_c for model was 154.662.

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DISCUSSION

Relatively little is known of the ecology of large gulls in Arctic Canada, despite their ubiquitous presence at other seabird colonies, around aboriginal communities, and along much of the extensive coastline (Gilchrist 2001, Snell 2002). In the Canadian high Arctic, these species breed in small, dispersed colonies that may be very remote and logistically difficult and expensive to access. As such, the Thayer's Gull remains virtually unstudied, and information on Glaucous Gulls comes principally from research on foraging by breeding adults at colonies of other seabird species (Gilchrist & Gaston 1997, Gaston *et al.* 2009), or from contaminant research (Braune *et al.* 2002). Our study confirms the interpretation by Snell (2002) of a westward autumn migration of juvenile and adult Thayer's Gulls from the eastern Canadian Arctic (from ring resightings), and may provide evidence of a southeastern movement of Glaucous Gulls to wintering habitat off Newfoundland (based on mortality patterns, see below). Moreover, we provide a first estimate of apparent adult survival for the Thayer's Gull, and a second estimate of survival for the Glaucous Gull in its North American breeding range (Table 4).

Annual variation in survival and the factors driving this process have received much attention by ecologists in recent years (e.g. Weimerskirch 2002). Although Thayer's and Glaucous Gulls nested sympatrically on St. Helena Island, we found different patterns in estimates of annual survival (Table 2). Differences were most pronounced in 2006–07 and in 2005–06 (Table 2). Here, we speculate that observed differences were the result of differential exposure to mortality factors linked to dissimilar life history traits (i.e. migration habits, wintering locations, and/or foraging strategies). For example, Glaucous Gulls often scavenge carrion, and this could make them more susceptible to diseases including avian cholera. An outbreak of avian cholera occurred in the northwest North Atlantic Ocean during the winter of 2006–07 and caused the death of large numbers of *Larus* gulls, including Glaucous Gulls (G. Robertson, Canadian Wildlife Service, pers. comm.). Although speculative, the low survival of Glaucous Gulls on St. Helena Island that we observed in 2006–07 would be consistent with some of our gulls dying in the cholera outbreak. Thus, our results provide some evidence that survival bottlenecks occur during the nonbreeding period in adults of both species, although these bottlenecks need not coincide, or be of the same nature and/or degree.

As an alternative explanation for the depressed survival of Glaucous Gulls in 2006–07, gulls might have bred elsewhere in the summer of 2007 or not bred at

Table 4. Mean adult annual survival rate of Thayer's and Glaucous Gulls ringed in the Canadian high Arctic, compared with those of other gulls with study location, analytical method, and SE.

Species	Study location	Method[c]	Survival rate (± SE)	Source
California Gull *Larus californicus*	Wyoming, USA	CMR	0.88 ± 0.05[a]	Pugesek *et al.* (1995)
Herring Gull *Larus argentatus*	Brittany, France	CMR	0.88 ± 0.01	Pons & Migot (1995)
	Isle of May, UK	CMR	0.88 ± 0.13	Wanless *et al.* (1996)
	Ontario, Canada	CMR	0.91 ± 0.02	Breton *et al.* (2008)
	Nunavut, Canada	CMR	0.87 ± 0.03	Allard *et al.* (2006)
Thayer's Gull *Larus thayeri*	Nunavut, Canada	CMR	0.81 ± 0.05	This study
Lesser Black-backed Gull *Larus fuscus*	Isle of May, UK	CMR	0.91 ± 0.12	Wanless *et al.* (1996)
Glaucous-winged Gull *Larus glaucescens*	Washington, USA	Return rate	0.83 ± 0.02[b]	Reid (1987)
Glaucous Gull *Larus hyperboreus*	Norway	Return rate	0.84 ± 0.03[b]	Bustnes *et al.* (2003)
	Nunavut, Canada	CMR	0.86 ± 0.05	This study
	Nunavut, Canada	CMR	0.84 ± 0.03	Gaston *et al.* (2009)

[c]Capture–mark–recapture (CMR) refers to a family of models (e.g. Cormack–Jolly–Seber, CJS) for estimating population parameters from live resight/recapture data. Return rates report a ratio of birds re-encountered/birds marked. See Williams *et al.* (2002) for more details.
[a] Estimated weighted average values of known sex and unknown sex birds aged 4–10 yrs from Figure 3.

[b] The standard error of the return rate was not reported; the estimator $\sqrt{\hat{p}(1-\hat{p}}_{n+4}$ was used in these cases where $\hat{p}$ is the return rate and n the sample size.

Note: Only means are reported and may not reflect critically important annual variation. (i.e. our 0.81 estimate for Thayer's Gull is 'low' due to a single poor year). Other essential details also are found in the sources cited.

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all. Based on evidence from our data, intermittent breeding (Calladine & Harris 1997) occurred rarely in the populations that we monitored. First, only three birds (two Thayer's, one Glaucous) were seen again after being missed in a single year (Table 2). Consistent with this evidence, a year of skipped breeding among Glaucous Gulls has never been reported (Gilchrist 2001). Concerning breeding dispersal, *Larus* gulls rarely if ever move to other breeding colonies (i.e. breeding dispersal) once they have established breeding in a particular colony, so it is unlikely that a large fraction of the Glaucous Gull colony abandoned our study sites. In 2005 and 2006, a field crew operated for one month during the breeding season at the nearest Thayer's Gull colony (Devil Island, which also had > 10 pairs of Glaucous Gulls present). No ringed birds from St. Helena Island were observed in either year. Our failure to detect a biologically important sex effect likely resulted from sparse data and/or a small effect size, as found in similar studies (Pons & Migot 1995, Wanless *et al.* 1996, Nichols *et al.* 2004).

Mean survival for Thayer's (0.81 ± 0.05) was low, but for Glaucous Gulls (0.86 ± 0.05) was comparable to estimates of survival reported for large white-headed gulls elsewhere (Table 4). The average survival rate for Glaucous Gulls at our high Arctic site was similar to the 0.84 for the species at Coats Island, Nunavut (Gaston *et al.* 2009), also similar to the 0.84 found for the species at Bear Island, Norway (Bustnes *et al.* 2003). The Norwegian population experiences deleterious effects of contaminants on both reproduction and adult survival. Although contaminant levels in Glaucous and Thayer's Gulls on St. Helena Island have not been examined, contaminants in the former species are among the highest of all seabirds in the nearby Northwater Polynya (Buckman *et al.* 2004, Borgå *et al.* 2006). An assessment of the potential role of contaminants on gull survival in Arctic Canada seems warranted.

Faced with the potential for rapid environmental change (ACIA 2005), these gull populations almost certainly will experience important modifications to the abiotic conditions that have historically contributed to food resource availability and community composition in the marine environment. This may lead to changes in both the sources and frequency of mortality events. Although we believe our survival estimates contribute strongly to the establishment of realistic baselines for two species, only long-term monitoring of survival will allow us to detect important deviations from the norm for these and other long-lived seabirds, particularly among those nesting in polar regions.

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SAMENVATTING

Er is weinig bekend over de jaarlijkse overleving van arctische zeevogels. Dergelijke informatie is belangrijk voor het voorspellen en begrijpen van de effecten van klimaatverandering, temeer daar verwacht wordt dat deze effecten het sterkst zullen zijn op hoge breedtegraad. In het onderhavige onderzoek is de jaarlijkse overleving van twee arctische meeuwen geschat, de Thayers Meeuw *Larus thayeri* en de Grote Burgemeester *L. hyperboreus*. De auteurs verzamelden hiervoor van 2003 tot en met 2007 in een kleine kolonie in het hoge noorden van Canada zichtwaarnemingen van 33 adulte Thayers Meeuwen en 21 adulte Grote Burgemeesters met kleurringen. De jaarlijkse overleving van Grote Burgemeesters was vergelijkbaar met die van andere grote meeuwen (gemiddeld 86%), maar die van Thayers Meeuwen was aan de lage kant (81%). Beide soorten hadden in één jaar te maken met een hoge sterfte, maar het jaar waarin dit plaatsvond, verschilde tussen de soorten. Dit verschil duidt erop dat de twee soorten in verschillende gebieden overwinteren en/of verschillend voedsel eten. De lage overleving van Burgemeesters in 2006/07 kan mogelijk in verband worden gebracht met een uitbraak van vogelcholera in de betreffende winter in de noordwestelijke Atlantische Oceaan. (KK)

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Appendix 1. Encounter histories of Thayer's and Glaucous Gull. Capture–mark–resight data from Glaucous and Thayer's Gulls marked as breeding adults and monitored at Saint Helena Island from 2003 to 2007.

Thayer's Gull	Glaucous Gull
11100 1;	11110 1;
10000 1;	11010 1;
10000 1;	10000 1;
11100 1;	11110 1;
11111 1;	11111 1;
11111 1;	11111 1;
11100 1;	11000 1;
11111 1;	11111 1;
11111 1;	11100 1;
10100 1;	11111 1;
11100 1;	11111 1;
11111 1;	01110 1;
11111 1;	01000 1;
11100 1;	01111 1;
11111 1;	01111 1;
11000 1;	00110 1;
10000 1;	00111 1;
11111 1;	00111 1;
10000 1;	00110 1;
01111 1;	00010 1;
01111 1;	00011 1;
01111 1;	00001 1;
01111 1;	00001 1;
01100 1;	00001 1;
01111 1;	00001 1;
01111 1;	00001 1;
01111 1;	
00101 1;	
00100 1;	
00111 1;	
00111 1;	
00100 1;	
00011 1;	
00001 1;	
00001 1;	
00001 1;	
00001 1;	
00001 1;	

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