Distribution, biology and prey selection of the introduced Norway Rat *Rattus norvegicus* at Kiska Island, Aleutian Islands, Alaska

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At Kiska Island, Alaska, USA we quantified age, sex, size, distribution and predation of Least Auklets *Aethia pusilla* by non-indigenous Norway Rats *Rattus norvegicus*, to evaluate their impact on auklet reproductive success. Rat distribution was assessed by surveying accessible parts of Kiska Island for rat sign and prey hoards. To quantify prey selection and infer diet, the contents of all hoards found were identified. Age, sex and size structure of the rat population was assessed using limited snap trapping on and off the Sirius Point auklet colony. Norway Rat sign was abundant in all areas near breeding seabirds and marine sources of food but rat sign abundance varied among years at Sirius Point. Although we found a larger proportion of juvenile to adult rats (0.54 : 0.46, $p < 0.01$) at Sirius Point, no significant differences were found in the proportion of reproductive to non-reproductive females (0.50 : 0.27, $p > 0.05$) or in overall adult body size (257 g and 37 cm : 236 g and 35 cm, $p > 0.05$) between Sirius Point and Christine Lake where breeding auklets are absent. Surplus killing and food hoarding by rats was noted in all years during the auklet laying period, with adult Least Auklets being the principal prey taken (4–148 individuals per hoard, n = 16 hoards). Our observations were consistent with the notion that rats have a negative impact on auklet populations, but for management purposes further information on whether rats are the sole cause of auklet reproductive failure is required.

Key words: Norway Rats, *Rattus norvegicus*, Least Auklets, *Aethia pusilla*, Non-indigenous species, Food hoarding, Surplus killing, Island conservation.

INTRODUCTION

EXTINCTIONS of insular avifaunas as the result of human predation, disturbance and introduction of non-indigenous species (NIS), especially rats *Rattus* spp., have occurred since human occupation of islands began (Steadman 1995, 1999; Steadman *et al.* 2002). Since 1600, 93% of the 93 species and 83 subspecies of birds that have gone extinct have been insular forms (King 1985). Seventy per cent of the extinctions of island birds have been attributed to predation, and of these 54% have been attributed to rats (King 1980). Non-indigenous rat species are now present on more than 80% of major islands and are frequent predators of seabirds (Moors and Atkinson 1984; Atkinson 1985; Shrader-Frechette 2001). Three species of *Rattus* (Black Rat *R. rattus,* Polynesian Rat *R. exulans* and Norway Rat *R. norvegicus*) are known to have caused declines and extirpations of insular avifauna (Harris 1970; Atkinson 1985; Bertram 1995; Key *et al.* 1998; McChesney and Tershy 1998).

Norway Rats were introduced on to Kiska Island (Aleutian Islands, Alaska; Fig. 1) during military occupation of the island in the Second World War (Murie 1959). Rats were noted as a predator of Least Auklets *Aethia pusilla* at the Sirius Point auklet colony in 1988 and 1996 (Alaska Maritime National Wildlife Refuge, unpubl. data). The Sirius Point auklet colony at Kiska is likely the largest auklet colony in Alaska and experienced almost complete reproductive failure in 2001 and 2002, at least partly due to predation by Norway Rats (Major 2004; Major *et al.* ms submitted). Least Auklets are the smallest of the alcids, having a mean adult body mass less than 50% of the mean body mass of an adult Norway Rat (see Roby and Brink 1986; Moors 1990; Jones 1993). Least Auklets may be particularly vulnerable to predation by Norway Rats because they nest in large colonies in accessible rock crevices (Bédard 1969; Knudston and Byrd 1982). However, auklets are available to terrestrial predators only during their short breeding season (first eggs laid in mid-May, last fledglings depart in early August).

Norway Rats are an omnivorous, generalist predator known to prey on nesting birds (including adults, eggs and nestlings) and intertidal invertebrates (Landry 1970; Moors 1990; Drever and Harestad 1998). When compared with two other *Rattus* species, Norway Rats have the greatest impact on burrow and surface nesting seabirds (Imber 1975; Moors and Atkinson 1984). Surplus or excessive killing (Kruuk 1972; Carbyn 1983) and food caching, or hoarding, have been described by Okansen *et al.* (1985) as a hunting strategy for small generalist predators like Norway Rats. These authors suggest that even partial consumption of a hoard can increase a predator's fitness. Thus, surplus or excessive killing could be adaptive for predators that live in cold or dry environments, where hoards of prey items would not decay quickly. In addition, hoarding behaviour of Norway Rats has been shown to be related to the level of food deprivation or starvation (Fantino and Cabanac 1980; Cabanac 1985; Cabanac and Swiergiel

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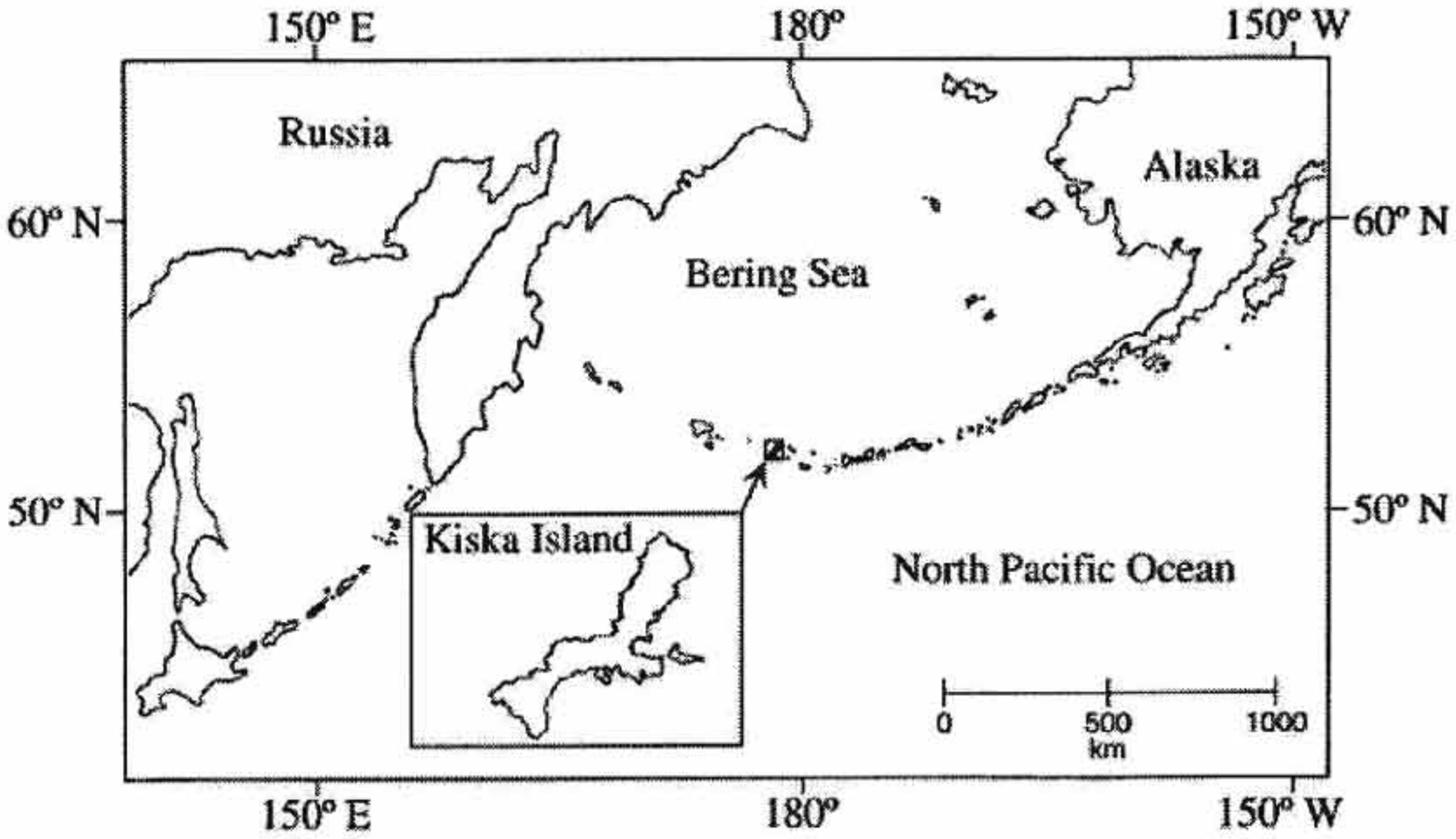

Fig. 1. Map of the North Pacific showing the location of Kiska Island.

1989). Thus at a location such as the auklet colony at Kiska, hoarding behaviour of rats would be expected to occur when auklets first arrive at the colony site in early spring.

Many studies have addressed the impacts of introduced rats on island ecosystems (e.g., Bertram and Nagorsen 1995; Campbell and Atkinson 2002), methods to eradicate them (e.g., Donlan *et al.* 2003) and successful control and eradication programmes (e.g., Jouventin *et al.* 2003; Rufaut and Gibbs 2003). Yet, it is known that the eradication of an introduced key species can cause ecological catastrophes and careful pre-control study needs to be accomplished to asses the complex population interactions among island species (Courchamp *et al.* 2003). However, few studies have looked at the general biology of NIS and specifically that of introduced rats. Accordingly, the purposes of this study were to quantify the age, sex and size structure and the distribution of Norway Rats at Kiska, to measure their predation and selection of Least Auklets, ultimately to evaluate the impact of rat predation on Least Auklet population viability.

The auklet colony site at Sirius Point, Kiska Island is extremely important for two related reasons, the large amount of breeding habitat available and its continual renewal through frequent volcanic activity (Miller *et al.* 1998). These facts make Kiska a potentially important source population for many other Aleutian auklet colonies and an attractive nesting site for prospecting individuals and immigrants from colonies where vegetative cover is increasing and suitable nesting habitat is disappearing due to plant succession. Therefore, if rats regularly cause auklet reproductive failure at Kiska negative effects on the Bering Sea Least Auklet metapopulation would be expected.

METHODS

Study Area — Our research was undertaken at Kiska Island (52°N, 177°E, Fig. 1), part of the Alaska Maritime National Wildlife Refuge (AMNWR), the second largest island in the Rat Islands group in the western Aleutian Islands, Alaska, USA. Kiska is 39.8 km long and varies in width from 2.8 km to 11 km, with a total area of 28 177 ha. At Sirius Point (52°08'N, 177°37'E) a large Least and Crested Auklet *A. cristatella* colony is situated on two lava domes located at the base of the northern slope of Kiska Volcano. The most recent dome formed during January 1962–September 1969, the last major eruption of the volcano (Miller *et al.* 1998). The auklet colony has an occupied surface area of 1.8 km^2 and hosted more than 1 million breeding Least Auklets in 2001 (I. L. Jones, unpubl. data).

Distribution — Distribution of Norway Rats during 2001–2003 was assessed by utilizing rat sign (i.e., scat, digging, prey remains, etc.) and limited snap trapping to indicate presence or absence because we were unable to identify an ideal quantitative trap line sampling protocol applicable to all parts of Kiska Island. At the auklet colony, we used rat sign detections to indicate presence because routinely operated rat trap-lines (e.g., Stapp 2002) in and around the auklet colony would have killed many auklets. Furthermore, live traps and snap traps baited with peanut butter, apple, auklet flesh and other food items were ignored by rats at the colony site, presumably because of the abundance of fresh food (auklet adults, nestlings and eggs). Rat traps in auklet-proof wooden boxes failed to catch rats when used by AMNWR biologists in an earlier study at Kiska. We undertook limited trapping near the auklet colony by setting unbaited traps along obvious worn rat trails in a few areas with tall grass (avoided by auklets).

Much of the colony site was inaccessible to rat investigations due to countless crevices and caves >10 m deep in the lava domes.

Spring and summer rat abundance and distribution on the northern part of Kiska Island were inferred by noting location, presence/absence and type of rat sign [feces, trails, diggings, and prey remains (of eggs, adults, and nestling auklets)] during ground searches from sea level to the volcano summit. Our ground searches included the northwest side of Kiska Island from Sirius Point to Witchcraft Point, the shores of Christine, East and West Kiska Lakes (Fig. 2); beaches in Kiska Harbor; meadows around North Head and nearby Salmon and Trout Lagoons; and subalpine meadows between Kiska Harbor and Conquer Point, including the large west-facing beach below this point (51°59.31'N, 177°29.48'E). Locations were confirmed using a Garmin GPS12XL handheld 12 channel GPS unit on georeferenced 1:25 000 topographic maps of Kiska Island (datum: NAD27 Alaska). Rat presence in a subalpine *Calamagrostis* meadow at 60 m asl between the west side of Sirius Point and Wolf Point (52°07.59'N, 177°35.12'E) outside the auklet colony was quantified using a trap-line (30 snap traps baited with peanut butter) for the period 19–26 June 2002. This trap-line was checked once every 24 hours and subsequently relocated to a grass-covered lava flow at 90 m asl (52°07.53'N, 177°35.10'E) for the period 26 June –25 July. Rat presence/absence data were assessed from the three years of the study to detect annual variation in the distribution of rats both on and off the Sirius Point auklet colony.

Norway Rat sex ratio, age-structure and morphometrics — Rats were caught using snap traps set at the auklet colony and along the beach berm at Christine Lake (7 km south of the auklet colony, 52°04.99'N, 177°33.10'E). As part of a larger study assessing the impacts of rats on auklet reproductive success and adult survival at Sirius Point we limited our rat trapping to two intervals per auklet breeding season (in late May–early June and late July–early August in 2002 and 2003). At the auklet colony site, snap traps were set unbaited in obvious worn rat trails in dense grass. At Christine Lake, traps were baited (2–3 g per trap) with fresh fish flesh (Dolly Varden *Salvelinus malma*) and placed near the beach and on obvious worn rat trails along the lakeshore. We tested Dolly Varden as bait at Christine Lake because it is likely a regular component of rat diet there. Traps were set overnight and checked early the next morning

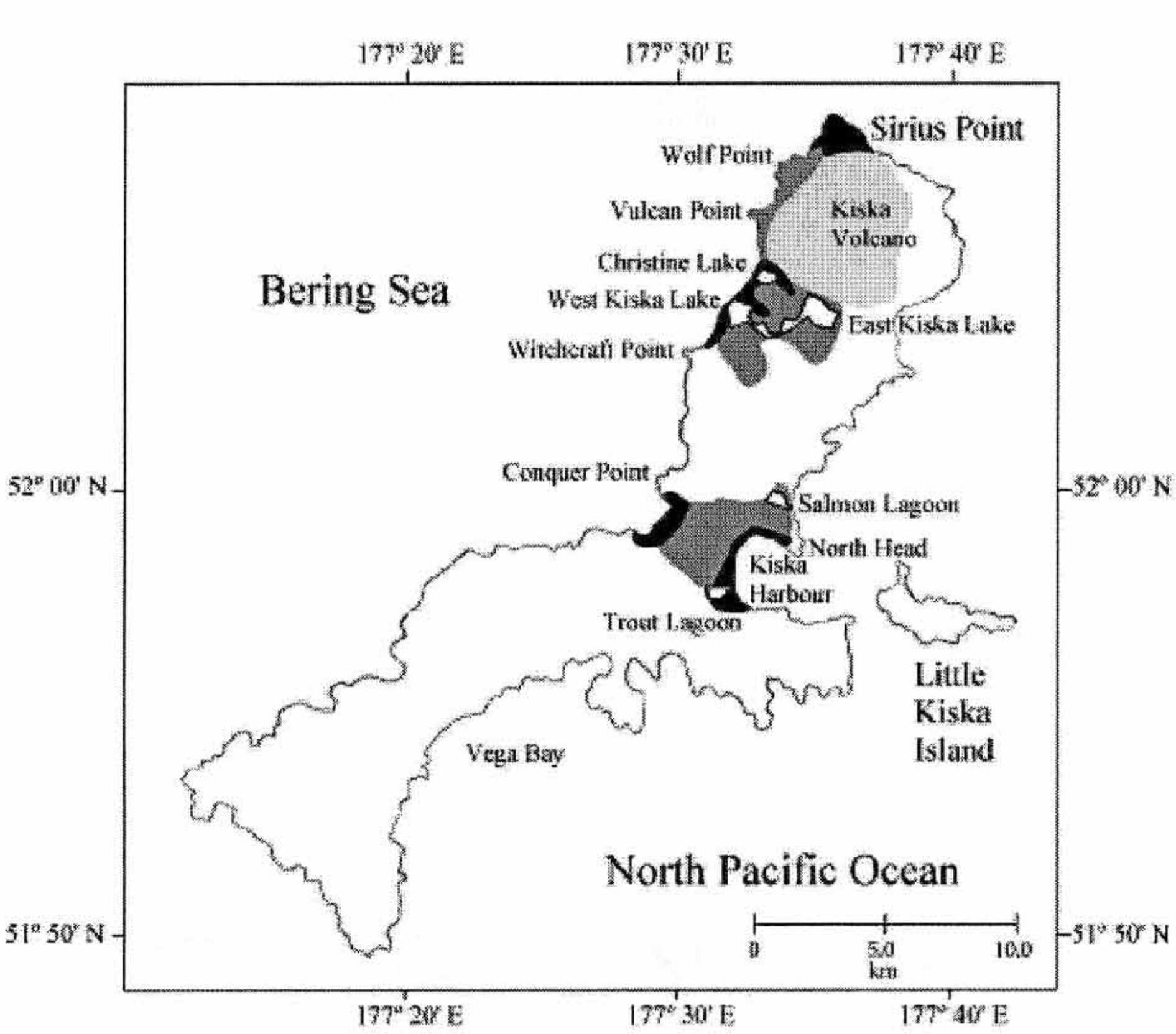

Fig. 2. Map of Kiska Island showing rat distribution (white areas were not visited during the study, light grey represents the absence of rats, dark grey represents low abundance of rat sign, and black represents high abundance of rat sign). Rats are apparently absent from Little Kiska Island.

until at least 10 rats were caught (~48 trapping nights per interval). In 2003, rats were also trapped at East Kiska Lake (an inland freshwater lake near Christine Lake; 52°04.47'N, 177°35.10'E) with snap traps baited with fresh Dolly Varden (~30 trapping nights per interval). Body mass and total length (body + tail) were measured on all rat specimens taken in both years; and in 2003, tail length was also measured. Rats were sexed by dissection and we noted reproductive condition (i.e., pregnant and number of embryos, or lactating) of mature females (more than 150 g and >32 cm total length). We used Chi-squared tests to explore differences in the proportions of males to females, juveniles to adults and reproductive females to non-reproductive females between the auklet colony and the lakes. In addition we used multivariate analysis of variance (MANOVA) to examine relationships among adult Norway Rat morphometrics, sex and location.

Rat diet composition and prey selection — Norway Rat food hoards were located, excavated, examined, and their contents noted to infer diet at the Sirius Point auklet colony. The condition of each cached item (whether fresh, slightly decayed or in the late stages of decay) was noted. For each auklet, wing chord (to the nearest 1 mm) and knob size (ornament located on the upper part of the bill, to the nearest 0.1 mm) were measured. Auklets were sexed by dissection unless they were badly decomposed, and plumage class was noted (0 – white, 1 – lightly flecked, 2 – moderately flecked, or 3 – heavily flecked; Jones 1990). Using Grant's (1972) methods we tested whether auklets taken by rats were disproportionately higher quality individuals. Using MANOVA we compared mean knob size, wing chord length and plumage class of auklets caught randomly on the colony surface to those found in rat food hoards. We also compared differences between the variances around these means using the F distribution. This has natural selection (Endler 1986) and conservation consequences if rat prey selection causes more damage to the higher quality individuals, those most likely to fledge a chick.

RESULTS

Rat distribution — Norway Rat sign was abundant in all coastal areas of Kiska Island with an accessible intertidal zone (i.e., everywhere except below steep sea cliffs) in all years (2001–2003; Fig. 2). Numerous rat tracks were observed near and above the high water mark on all sandy sea beaches visited. Norway Rat sign was also plentiful along the entire shoreline of Christine and West Kiska Lakes, within 500 m of the ocean. Anecdotal evidence (abundance of rat sign and ease of rat capture in snap traps) suggested that Norway Rat abundance early in the auklet breeding season varied highly among years at Sirius Point. Early season Norway Rat sign around Sirius Point was most abundant in 2002 and relatively scarce in 2003. However, in all years (2001–2003) Norway Rat sign was abundant by the middle of the auklet breeding season. Around our camp site at Sirius Point, Norway Rats entered our food cache for the first time in 2003, even though rat sign in the camp area was less abundant in that year. Evidence of over-winter occupation (abundant weathered droppings found in late May) was present in areas with access to intertidal boulder beaches and nearby fumaroles and on a steep hillside with dense grasses and herbs 200 m south of the colony site at 52°07.78'N, 177°35.40'E. Norway Rat sign was rare on plateaus and inland meadows and no sign was found above 200 m asl. Trapping success at inland meadows between Sirius Point and Wolf Point was zero (1 080 trapping nights). The most inland (from the ocean) detection was of two adult male rats trapped at the north end of East Kiska Lake (an inland freshwater lake) in June 2003 (30 trapping nights at 52°04.47'N, 177°35.04'E).

Norway Rat sex ratio, age-structure and morphometrics — Based on 64 adult and 50 juvenile rats captured and measured, we found no significant differences in the sex ratio between Sirius Point (auklet colony) and Christine Lake (auklets absent; $\chi^2 = 2.83$, df = 1, $p > 0.05$). However, at Sirius Point the sex ratio was approximately 2:1, significantly biased towards males ($\chi^2 = 5.33$, df = 1, $p > 0.01$), while at Christine Lake the sex ratio was approximately 0.8:1, not significantly different from 50:50 ($\chi^2 = 0.80$, df = 1, $p > 0.05$). The proportion of juvenile to adult rats differed significantly between locations with significantly more juvenile rats caught at Sirius Point (0.54; 95% CI = 0.43–0.64) than at Christine Lake (0.30; 95% CI = 0.19–0.38; $\chi^2 = 7.11$, df = 1, $p < 0.01$). However, the proportion of adult females with obvious signs of reproductive status (either pregnant or lactating) did not differ significantly between Sirius Point (0.50; 95% CI = 0.25–0.75) and Christine Lake (0.27; 95% CI = 0.09–0.41; $\chi^2 = 1.36$, df = 1, $p > 0.05$). However, this difference may be due to the small sample size of females from Sirius Point. Adult Norway Rats at Sirius Point tended to have a larger overall mean size (Fig. 3). Nonetheless, MANOVA revealed that size differences were not significant between sex, location and the interaction between sex and location (Table 1).

Rat diet composition, prey selection and hoarding — Food hoarding by Norway Rats on Kiska Island was observed in all three years of this study (Table 2). Hoards of cached auklets found early in the breeding season (late May-early

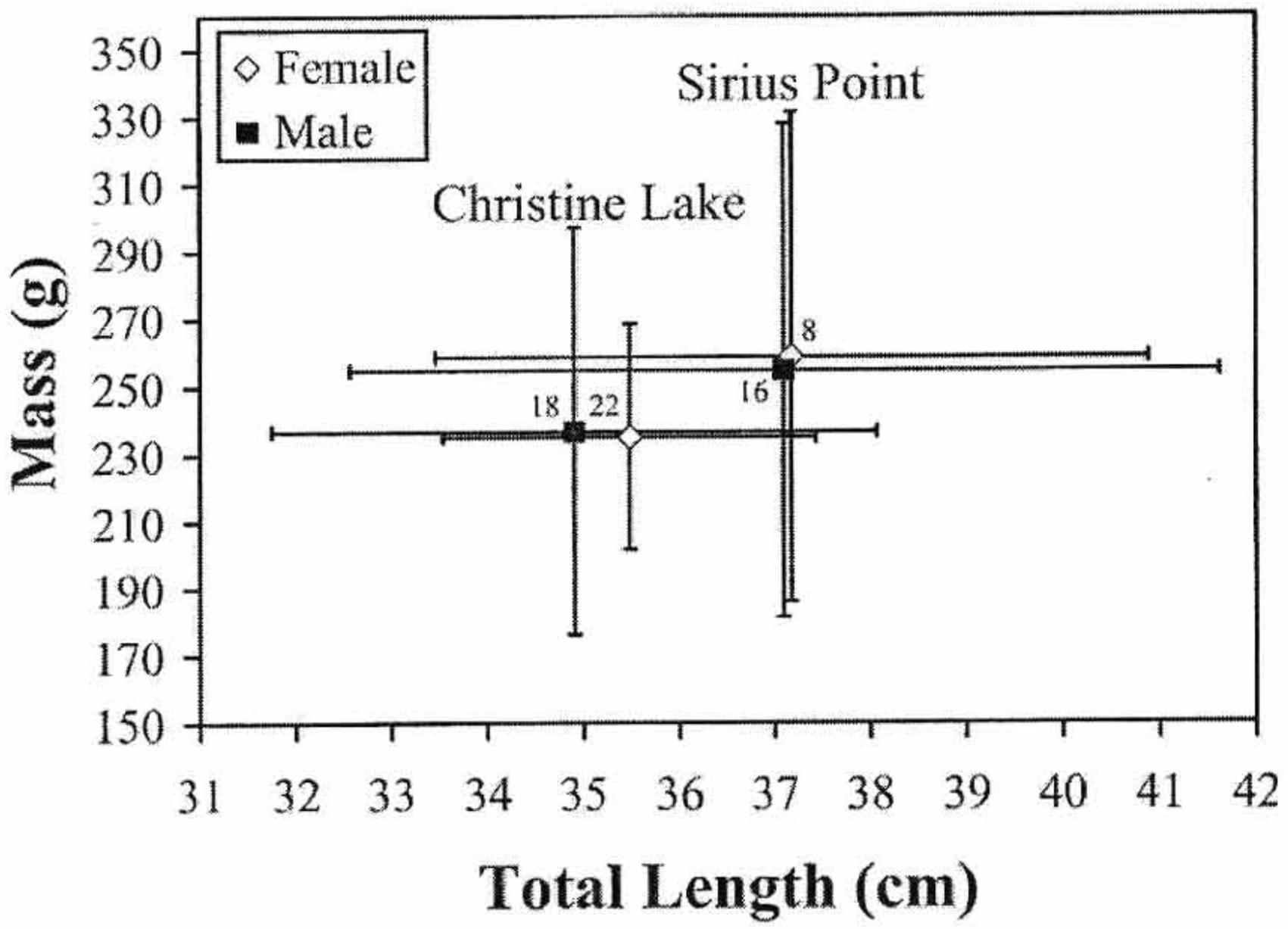

Fig. 3. Comparison of the overall mean size (mass and total body length) of adult Norway Rats caught at Sirius Point and Christine Lake in 2002 and 2003. Data are means ± one standard deviation with sample size indicated above the mean.

June) included caches of >100 freshly killed adult Least Auklets. Those found later in the breeding season contained eggs (usually addled) and adult Least Auklets in late stages of decomposition with little evidence of consumption. No hoards of fresh birds were found after early June. No hoards contained Least Auklet sub-adults or nestlings, although these were frequently taken later in the season. Each

Table 1. Results of MANOVA Wilks' Λ statistic examining the effects of sex, location and the sex * location interaction term on the length and mass of adult Norway Rats measured at Sirius Point and Christine Lake, Kiska Island, Alaska during 2002–2003.

Factor	Wilks' Λ	f	df	p
Sex	0.99127	0.207	2, 47	0.814
Location	0.93869	1.535	2, 47	0.226
Sex * Location	0.98538	0.349	2, 47	0.707

Table 2. Contents of Norway Rat hoards discovered in the Sirius Point auklet colony, Kiska Island, Alaska, 1988–2003.

Date	Contents	Location	Comments
June 15, 1988	27 Least Auklet	old lava	AMNWR unpubl. data
June 15, 1988	8 Least Auklet	old lava	AMNWR unpubl. data
June 23, 1988	20 Least Auklet	old lava	AMNWR unpubl. data
June 23, 1988	>8 Least Auklet	old lava	AMNWR unpubl. data
August 23, 1996	19 Least Auklet in 4 hoards	new lava dome	Bodies decomposed, AMNWR unpubl. data
June 2, 2001	38 Least Auklet	52°07.66'N, 177°36.22'E	Bodies fresh, bodies decomposed by early July
July 13, 2001	>4 Least Auklet	52°07.93'N, 177°35.16'E	Bodies decomposed, hoard mostly inaccessible
May 26, 2002	122 Least Auklet, fresh 7 Fork-tailed Storm-Petrel	52°07.90'N, 177°35.36'E	Bodies fresh, hoard located in burrow complex with female rat and nine pups
May 30, 2002	34 Least Auklet, fresh >10 Least Auklet eggs	52°08.00'N, 177°35.80'E	Bodies fresh, hoard mostly inaccessible
June 4, 2002	13 Least Auklet, fresh 29 Least Auklet eggs 4 Crested Auklet eggs	52°08.01'N, 177°35.81'E	Hoard mostly inaccessible
June 29, 2002	148 Least Auklets >6 Least Auklet eggs	52°07.93'N, 177°35.16'E	In a fumarole, bodies very decomposed
June 2, 2003	>20 Least Auklet, fresh >10 Least Auklet eggs	52°07.92'N, 177°35.75'E	Bodies fresh, hoard mostly inaccessible
June 13, 2003	8 Least Auklet 11 Least Auklet eggs	52°07.91'N, 177°35.75'E	Hoard mostly inaccessible, 15 m from previous hoard

year we found a few adult Crested Auklets that had obviously been predated by rats, but none were found in hoards.

All Least Auklets found in rat food hoards were taken early in the auklet breeding season and all were adults (> two years old). One-way ANOVA to compare the knob size of auklets caught randomly on the banding plot revealed that those birds measured early in the breeding season (prior to the mean hatch date) had a significantly larger mean knob size (1.46, 95% CI = 1.31–1.62) than those measured randomly on the banding plot after the mean hatch date (1.12, 95% CI = 0.96–1.27; $F_{1, 166} = 7.49$, $p < 0.01$). Since all hoarded birds were measured in early June (prior to the mean hatch date) only those birds measured randomly on the banding plot prior to the mean hatch date (14 June–27 June 2001, 08 June–06 July 2002) were used in the analysis. MANOVA revealed no significant differences for mean wing chord length, knob size or plumage class in auklets found in the hoards compared to those captured randomly on our banding plot (Wilk's $\Lambda = 0.98$, $F_{3, 152} = 1.06$, $p > 0.05$; Table 3). Additionally, a comparison of the sample variances revealed significant differences between the variances for birds caught randomly and those found in hoards for knob size ($F_{54, 109} = 1.77$, $p < 0.01$) and plumage class ($F_{108, 56} = 2.29$, $p < 0.001$). Whereas, the sample variance for wing chord length did not differ significantly between hoarded birds and those captured randomly on the banding plot ($F_{56, 115} = 1.11$, $p > 0.05$).

Later in the season (July-early August), in all years, we found remains of Least Auklet chicks and adults scattered throughout the Sirius Point auklet colony with no evidence of hoarding. During chick-rearing adults were taken by rats while attempting to feed their chicks (e.g., a rat-depredated adult found in the entrance of its breeding crevice, its food load spilled, chick also depredated, July 2002). Chicks of all ages were taken, and almost all corpses found had only the eyes and brains consumed, including fledglings that were taken by rats prior to colony departure (e.g., 15 fledglings found freshly killed with eyes, brains and small amounts of breast muscle removed; August 5, 2002).

DISCUSSION

The overall picture presented by our study was of introduced Norway Rats being widely distributed along coastal areas of Kiska Island both within, and far from, the auklet colony. At Sirius Point, rats had relatively easy access to an extreme abundance of avian prey (Least Auklets). As for Black Rats that were more abundant and larger in size where they could subsidize their diet with marine sources of food on the Shiant Islands, Scotland (Key *et al.* 1998; Maclennen *et al.* 2000; Stapp 2002), we suspected that Norway Rats at Kiska would be larger in size and show increased reproductive activity at the Sirius Point auklet colony. Our results indicated that this was not the case and suggested that during our sampling periods, rats at Christine Lake and Sirius Point had a similar amount or quality of prey available. In addition we looked for differences in the abundance of Norway Rat sign at Sirius Point compared to other locations on the island. Although there was an extreme abundance of rat sign at Sirius Point in summer, we found a similar amount of sign at Christine Lake. The general picture was that rats were abundant in all areas with access to productive intertidal zones, but that the presence of the large auklet colony at Sirius Point allowed for a temporary annual population explosion during June and July when auklets were present.

Food deprivation and starvation has been shown to stimulate hoarding behaviour in rats (Fantino and Cabanac 1980; Cabanac 1985; Cabanac and Swiergiel 1989). Under the assumption that Norway Rats hoard all available prey types, their principal prey in the vicinity of Sirius Point during 2001–2003 was adult Least Auklets. We hypothesized that at Kiska, Norway

Table 3. Summary of means and variances of wing chord, knob size and plumage class of Least Auklets captured randomly (population) to those found in rat hoards (hoard). Means are shown in mm for wing chord and knob size, plumage class as: 0 – white, 1 – lightly flecked, 2 – moderately flecked, or 3 – heavily flecked.

Trait	Group	n	Mean ± SE (range)	95% CI	Variance
Wing chord	Hoard	116	98.69 ± 0.20 (93.00 – 104.00)	98.29–99.09	4.77
	Population	57	98.21 ± 0.30 (94.00 – 104.00)	97.60–98.82	5.28
Knob	Hoard	110	1.51 ± 0.04 (0.5 – 2.6)	1.43– 1.59	0.18
	Population	55	1.46 ± 0.08 (0.4 – 3.2)	1.31– 1.62	0.33
Plumage class	Hoard	109	2 ± 0.05 (1–3)	2.03– 2.23	0.28
	Population	57	2 ± 0.05 (1–3)	1.96– 2.14	0.12

Rats would begin hoarding when auklets return to Sirius Point in late April and early May to breed, because of the lack of food available during the preceding winter. We predicted that hoarding would become less frequent and likely cease by the middle of the auklet incubation period when rats would no longer experience food deprivation. These hypotheses were supported by the complete absence of sub-adults and nestlings from rat hoards and the fact that all hoards found after early June contained adult Least Auklets in late stages of decomposition with minimal sign of recent addition or utilization. Although surplus killing of auklets by Norway Rats at Sirius Point occurred only briefly during the auklet breeding season, because of the timing of the hoarding the conservation consequences are potentially very large.

Piatt *et al.* (1990) and Jones (1992) showed that breeding adult auklets arrive at the colony first and establish their breeding territories. The age/experience hypothesis (Hedgren 1980) suggests that the earliest birds to arrive at breeding colonies are those that are older and more experienced, and thus those most likely to fledge a chick. This hypothesis has been supported for many species of birds including alcids [e.g., Thick-billed Murres *Uria lomvia* (DeForest and Gaston 1996)]. At Sirius Point those birds found hoarded by Norway Rats early in the auklet breeding season would therefore be those individuals most likely to fledge a chick. This may have a much greater negative impact on the Least Auklet population than if rats were taking birds randomly (breeding and non-breeding individuals) because the killing and hoarding of experienced adults removes the most productive members of the population. Thus, the combined consequences of prey selection and excess killing may be large.

In addition, a second wave of rat predation occurring when the spring cohort of juvenile rats born in late May become independent and auklet chicks begin to hatch may also have a great population consequence. At this stage rats depredated nestlings and disturbed and depredated adults as they attempted to provision chicks, decreasing both adult and nestling survival. During this period, rather than being concentrated in hoards, we found rat-depredated auklet carcasses and body parts scattered widely over the surface of the auklet colony site.

A population viability analysis for Least Auklets at Kiska Island suggested the most important life history stage for conservation of this species is nestling survival, and that under current conditions the Sirius Point colony will likely decline by 92% in 30 years (Major 2004). We believe it was the combined effects of the early season excess killing and the destruction of nests later in the season that explains the low productivity (i.e., nestling survival) at Kiska and the consequent predicted population decline. Only by eradication of Norway Rats from Kiska Island may a rapid auklet population decline at Sirius Point be avoidable.

Six Fork-tailed Storm-Petrels *Oceanodroma furcata* were found in one rat food hoard in 2002. This species was not currently known to breed at Kiska even though there is suitable habitat available and birds were occasionally heard vocalizing at night near camp. Storm-Petrels are widespread in the Aleutian Islands and are an abundant breeder on Buldir Island (approximately 119 km west of Sirius Point). The presence of this species in the food hoard suggests their persistence under continued rat predation at Kiska. Leach's Storm Petrels *Oceanodroma leucorhoa*, Ancient Murrelets *Synthliboramphus antiquus* and Cassin's Auklets *Ptychoramphus aleuticus* are currently absent as breeding species and were likely extirpated from Kiska, along with Song Sparrows *Melospiza melodia*, some time after rats were introduced to the island. If Norway Rats are eradicated from Kiska Island these species would likely recolonize.

We believe that the auklet colony on Kiska Island is of great conservation concern because neighbouring auklet colonies are both relatively small and are likely experiencing declines due to encroaching vegetation cover. We suspect auklets may immigrate to Kiska because of the quantity and quality of nesting habitat (recent lava flows) available. In addition, volcanic activity at Kiska will likely continue to create new auklet habitat making this colony site important for the overall population viability of Least Auklets in the Aleutian Islands. Taken together, our study's results indicate that predation and disturbance by Norway Rats at the Sirius Point colony site is very destructive and urgently requires mitigation. We suggest continued monitoring of both rats and auklets at this colony and rat control experiments to confirm that rats are the sole cause of the auklet breeding failure at Kiska and to evaluate what control measures are most effective. In the long term, we recommend rat eradication from Kiska Island to conserve the important Least Auklet colony site, to restore other seabird populations, and to bring back the unique ecology of this oceanic island.

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