# Impacts of the Norway Rat on the auklet breeding colony at Sirius Point, Kiska Island, Alaska in 2002

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> *Fresh rat burrows, trails, scat and evidence of feeding in the kelp along the beach were noted at all locations in 1987. A few rat burrows were even noted in old fox trails. The abundance of rat sign in 1987 was vastly different from 1986 when such sign had to be looked for and was not as prevalent. The presence of rat sign in these areas is in itself positive evidence that arctic fox are no longer on Kiska Island.*
>
> Deines and McClelland (1987)

Introductions of alien organisms, especially rats, have been the root of many ecological problems, the most notable of which occur on island flora and fauna. Rat introductions peaked on Pacific islands during World War II (Atkinson, 1985). It is believed that the Norway Rat (*Rattus norvegicus*) was introduced onto Kiska Island, Aleutian Islands, Alaska during the 1940s (Murie 1959). Rat predation on Least and Crested Auklets has been observed in a preliminary study of auklet demography and Norway Rat distribution and abundance at the Sirius Point auklet colony on Kiska Island (52°08'N 177°37'E) by Jones *et al*. (2001). This colony, located on the Alaska Maritime National Wildlife Refuge (AMNWR) may be the largest auklet colony in Alaska and is certainly one of the largest seabird colonies in the northern hemisphere. As an predator of burrow and crevice nesting seabirds, Norway Rats have been known to cause the declines, extirpations and even extinctions of island avifauna and is therefore a threat to seabird populations at Kiska.

Least Auklets are especially susceptible to predation by the Norway Rat because of their small size. Norway rats can predate Least Auklet adults, eggs, and nestlings reducing adult survival and reproductive success, this could lead to a serious population decline. To evaluate the impact of rats, comparisons of auklet productivity, annual adult survival and chick growth are required between the Sirius Point auklet colony and those at islands without introduced rats. Ongoing seabird monitoring programs by AMNWR on Buldir and Kasatochi Islands provide suitable comparisons with the Sirius Point colony, neither of these islands has introduced rats, while both Kiska and Kasatochi had introduced foxes, which were removed in the 1980s. Arctic fox were originally introduced to Kiska in 1835 and were thought to be having a controlling effect on the rats from WWII until the subsequent removal in 1986 when signs of rats on Kiska became more noticeable and abundant (Deines and McClelland 1987). The primary objectives of this study were to quantify the impacts that introduced

rats are having on the auklet colony at Sirius Point and to investigate the biology and demography of the Norway Rat population.

## Methods

*Auklet productivity*

Least and Crested Auklet breeding crevices were monitored for productivity using USFWS standardized procedures (US Fish and Wildlife Service 1996). Each crevice was carefully checked for signs of rat predation on the adults, eggs and nestlings if the crevice failed. The productivity data was also compared with that from other islands that do not have introduced rats (Kasatochi and Buldir) to determine the effects of the rats on the productivity of the auklets at the Sirius Point colony. The three study plots used in 2001 were reused for the productivity estimates in 2002 and are believed to be representative of the entire colony at Sirius Point (Jones *et al.* 2001). On three productivity study plots (Figure 1 and Tables 1-3) 206 Least and 23 Crested Auklet crevices were monitored. Forty additional crevices were located just before hatching and monitored for chick growth and fledging success (Figure 1 and Table 1). The first productivity study plot 'New Lava' was located on the top and east side of the most recent lava dome, which was created during the last eruption of the volcano in 1965-69 (Miller *et al.* 1998). All of the crevices on this plot were within 60 m of the coastline, at an elevation of 25-30 m in an area sparsely vegetated with lichens. At an elevation of 100m and 520m from the coast, located in the valley between the 1965-69 lava dome and Bob's Plateau (52°07.803'N 177°35.731'E) was the second productivity study plot 'Old Lava Low'. This second plot was in an area densely vegetated with *Carex*, *Calamagrostis* sp. and fern overgrowing blocky lava. The third plot 'Old Lava High' was moderately vegetated with *Carex* and fern, it was located at an elevation of 180m, 800m from the coastline, and at the top of Bob's Plateau close to the base of a steep talus slope of blocky lava on the side of Kiska volcano (52°07.699'N 177°36.167'E).

*Least Auklet chick growth*

To evaluate if the nutritional requirements of the chicks on Kiska were being met and were similar to those on Buldir, chick growth was monitored during the 2002

breeding season. Chicks were measured every three days from hatching until fledging in 40 crevices found near the end of incubation. Once a chick was found in a crevice it's age was estimated; wet chick is presumed to be 1 day, dry but wobbly, 2 days, and dry, alert and coordinated, 3+ days. Measurements of mass, tarsus, and wing cord length were taken and were compared to chick growth measurements taken on Buldir during the 2002 breeding season. When a chick was found dead similar measurements were taken and the crevice and chick were examined closely to determine the cause of death.

*Auklet survival and banding*

The adult interannual survival of Least and Crested auklets is to be measured using field procedures developed by Jones (1992a) and the MARK (White and Burnham 1999) analysis program. Resightings of Least and Crested auklets banded during the 2001 field season were regularly carried out from the blind during the daily activity periods throughout the entire breeding season (May through August 2002). Additional resightings are required during 2003 in order to obtain a first estimate of adult annual survival that is comparable to Buldir. Using noose carpets set out on the colony surface within a single 50 $m^2$ plot Least and Crested auklets were captured during June and July. Noose carpets are believed to select breeding and non-breeding auklets randomly from the population (Jones 1992a). Each captured auklet was given a numbered stainless steel leg band and adults were also given a unique combination of three plastic colour bands. When a bird was caught measurements were taken according to standard protocols (Jones and Montgomerie 1992, Jones 1993a, Jones *et al.* 2000). If an adult auklet was caught carrying a chick meal in its throat pouch, the food was sampled and preserved in alcohol to determine whether the prey species and quantity are comparable to those sampled from Buldir and Kasatochi.

*Norway Rat feeding ecology and distribution*

To elucidate aspects of the biology of Norway Rats on Kiska, rats were sampled using snap traps set in various locations around the auklet colony, the lake district and in highly vegetated areas away from the colony during late May and early June and again in late July and early August. Each rat trapped was measured (mass and total length), sexed and had samples of the pectoral muscle and liver tissue taken for stable isotope analysis. The tissue samples were dried for three hours at 60° C and stored in

labeled glass vials. Stable isotopes will be used to determine the foraging ecology of the rats (marine or terrestrial) and their trophic level. Comparisons of auklet colony rats with those trapped at other areas of the island will be used to determine the importance of the auklets in the diet of those rats living in and near the large auklet colony. Throughout the auklet breeding season we searched for rat caches of prey items. When a cache was found, its location, number of individuals and type of organism cached (adult auklet, storm-petrel or egg) was recorded, in addition each adult auklet found cached was measured, sexed and aged (adult or subadult). We also searched for signs of rats (trails, fresh droppings, predated adults, eggs, and juvenile auklets) throughout the season and using this information prepared a map of rat distribution around the northern parts of Kiska Island. Furthermore, we have created a hypothetical map of winter rat distribution around the island using information about vegetation cover and accessibility of the intertidal zone.

## Results

*Auklet productivity*

Least Auklet hatching success was 63% on the New Lava, 58% on Old Lava low, and 66% on Old Lava high in 2002 (Table 1), the hatching success on the three plots did not differ significantly ($\chi^2$=9.924, df=2, p-value=0.69). The overall hatching success was 64% on Kiska in 2002, significantly lower than the hatching success on Kiska in 2001, which was 75.7% ($\chi^2$=7.987, df=1, p-value=0.005; Jones *et al.* 2001). The majority of crevices that did not hatch were the result of the egg disappearing without a trace (n=38, or 19% of crevices that failed during incubation) and the egg being abandoned (n=27, or 13% of crevices that failed during incubation). No direct signs of rat predation were noted in the productivity crevices during the incubation stage although five of the chick growth crevices had the egg visibly predated by a rat (Table 1). In these cases the egg was chewed open on one side with a mature dead embryo inside the broken egg.

Least Auklet fledging success was 6% on the New Lava, 19% on Old Lava low, and 24% on Old Lava high in 2002 (Table 1), the fledging success on the three plots did differ significantly between the New Lava and the Old Lava high plots ($\chi^2$=10.006, df=1, p-value=0.002). Most of the chicks that died were found as small dead chicks with no

apparent injuries (n=57) and most likely died of exposure, a second die off occurred at the late stages of chick growth when underdeveloped chicks were found dead in the crevices with no injuries and most likely died of starvation (n=12). However, 37 chicks went missing without a trace and seven chicks were found dead with obvious signs of rat predation (brain eaten) or with injuries (Table 1). Fledging success on Kiska was 16%, significantly lower than the 17.6% found in 2001 ($\chi^2$=5.726, df=1, p-value=0.02; Jones *et al.* 2001). Notably, we found numerous small dead chicks in crevices that were not part of our sample of productivity monitoring crevices but were incidently examined.

Overall reproductive success was 4% on the New Lava, 11% on Old Lava Low and 16% on Old Lava High (overall 10%; Table 1), overall reproductive success did differ significantly between the New Lava and the Old Lava high plots ($\chi^2$=7.140, df=1, p-value=0.008) in 2002.

Overall Least Auklet reproductive success at Kiska was not significantly different between 2001 and 2002 ($\chi^2$=1.298, df=1, p-value=0.25). Least Auklet hatching, fledging and overall reproductive success on Buldir was 86%, 70% and 61%; and on Kasatochi was 82%, 62% and 52% in 2002 (Table 2). Hatching, fledging and overall reproductive success at Kiska were significantly lower than both Buldir and Kasatochi in 2002 (Table 3).

Crested Auklet hatching success was 60% on the New Lava, 88% on the Old Lava Low and 90% on the Old Lava High plot (Table 4). Fledging success was 0% on the New Lava, 71% on the Old Lava Low and 56% on the Old Lava High plot (Table 4). Overall reproductive success was 0% on the New Lava, 62% on the Old Lava Low and 50% on the Old Lava High (Table 4). There were no significant differences in Crested Auklet hatching, fledging, and overall reproductive success between 2001 and 2002 on Kiska. Hatching, fledging and overall reproductive success on Buldir was 91%, 62% and 56%, on Kasatochi was 83%, 71% and 59% in 2002. Hatching, fledging and overall reproductive success at Kiska were not significantly different then either Buldir or Kasatochi in 2002 (Table 3).

*Least auklet chick growth*

Least Auklet chicks measured at Kiska in 2002 grew slowly and most of them did not make it to fledging (Table 1). Out of a total of 40 crevices that were found at the late stages of incubation on the New Lava Dome close to the New Lava productivity plot, only two Least Auklet chicks made it to fledging (Table 1). These chicks grew slowly in mass, while the wings and tarsus grew at the approximate normal rate (Figure 2). Fledging success of the chick growth crevices was 7%, this was the result of many (n=15) chicks dying when they were very small (0-6 days) with no visible injuries, the other causes of chick loss were due to large chicks that appeared to have been starved, rat predation or disappeared without a trace from the crevice (Table 1). The overall reproductive success of the Least Auklets in the chick growth crevices was 5%, which is comparable to that measured in the productivity plot on the New Lava Dome. Only n=1 chick survived to be measured through until fledging.

*Auklet adult survival and banding*

Intensive banding on Kiska was not carried out in 2002 but we did mark 20 new Least Auklet adults and one new Crested Auklet adult. (Table 5). The interannual resighting rate from 2001 to 2002 was 76.5% (153 of 200 previously marked birds resighted) for Least Auklet and 65.2% (15 of 23 previously marked birds resighted) for Crested Auklets (Table 6).

*Norway Rat feeding ecology and distribution*

A list of tissue samples taken for stable isotope analysis to determine the feeding environment (marine or terrestrial) and the feeding trophic level of the Norway Rats from the Sirius Point auklet colony and from Christine Lake is attached in Appendix 1. The Norway Rats trapped on Kiska in 2002 ranged in age and size from small juveniles to large mature adults (Figure 3). Figure 4 shows where the highest concentrations of Norway Rat sign was found during the breeding season in 2002. We believe the winter distribution of Norway Rats is different and in areas of high vegetative cover and close to the intertidal zone as shown in Figure 5. We observed high levels of rat sign and predation around the New Lava Dome but we did not see any sign of rat on the Old Lava High plot. Norway Rats were also very abundant around coastal areas of the Lake

District south of the volcano, but we did not find any sign of rat in the high elevations (>150 m) of the volcano or inland mossy areas (Figure 4-5).

*Other observations*

A list of Norway Rat sign (droppings, dead auklets with chewed brains) found during the 2002 field season is attached in Appendix 2.

A list of bird species identified during fieldwork in 2002 is attached in Appendix 3.

## Discussion

The impact of the introduced Norway Rats on the large auklet colony at Sirius Point in 2002 again proved to be difficult to assess. Extensive evidence of rat predation was found; we found four auklet caches and numerous dead adults, chicks and eggs with evidence of rat predation. The Least Auklet colony at Sirius Point is presumably declining because of the extremely low reproductive success resulting from the high rate of predation, unexplained death and loss of habit due to vegetative growth. This decline is potentially more serious than simply as the loss of one of the largest auklet colony in Alaska because this colony may well be attracting adults from nearby colonies where breeding habitat is rapidly being lost to vegetative cover (i.e., Kiska may be a major population sink).

During the 2002 breeding season most auklet breeding attempts failed due to lack of parental attentiveness to eggs and particularly nestlings, leading to poor hatching success and extremely low fledging success. Many small chicks apparently died of exposure due to failure of parents to brood them and many older chicks apparently died of starvation. Two hypotheses for these observations are: 1) predation and disturbance of breeding adult auklets by rats leading to inattentiveness to their eggs and nests; and 2) prey shortage due to poor oceanic conditions in the North Pacific and consequent poor primary productivity and secondary productivity (copepod abundance) in 2002, exacerbated by the large population at Sirius Point resulting in a food shortage around the colony due to intra-specific competition.

The first hypothesis cannot be rejected since reproductive success at both the Buldir and Kasatochi colonies was normal and much higher than at Sirius Point, suggesting

the cause of breeding failure was due to something unique to Kiska Island (e.g., rats). The second hypothesis cannot be rejected and may partly explain the extremely low reproductive success at the Sirius Point colony in 2002, but further information on current oceanographic conditions are required. It is notable that in order for a food shortage to be the problem at Sirius Point, this shortage would have to be localized around Kiska. Notably, the death of most Least Auklet chicks due to starvation and exposure is consistent with rats predating and disturbing adults, and also with scarce food supplies near the island.

A localized food shortage around Kiska, a phenomenon known as "Ashmole's Halo", is the result of a density dependent food shortage around a large seabird colony. This halo occurs because while at the breeding colony the birds are constrained in their foraging distance on account of the necessity to return to the colony to incubate, brood and feed their chick, thus competing for the local food resources (Ashmole 1963). With a colony as large as the one at Kiska it is possible that although the waters are productive over-exploitation of the food resources around the colony resulted in a food limiting halo. In addition to the potential food shortage are the pressures of rat predation on this colony and this is evident in the differences between the productivity at the Old Lava High plot and the two other productivity plots. No rat sign was seen on the Old Lava High plot and the overall reproductive success on this plot was higher than that on the New Lava productivity plot. This suggests that even if the colony is under strong density dependent food shortage the additional impacts of rat predation is having an overall negative impact on the colony.

The overall reproductive success of Crested Auklets at the Sirius Point colony was not significantly different from that at either Buldir or Kasatochi. One hypothesis for this is that Crested Auklet adults are too large for a Norway Rat to predate and because the Crested Auklet population is not as large as the Least Auklet population, there is no local food shortage.

The largest die off of chicks occurred at the early nestling stage when the chicks were not yet able to thermoregulate for themselves and require that an adult brood them. Two hypotheses for this are: 1) because of increased rat presence around the colony, the adults are very sensitive to disturbance and will neglect the small chick whenever a rat walks by the crevice, or perhaps when a flashlight is shone into the crevice during a productivity check (hypersensitivity to disturbance unique to Kiska);

and 2) a prey shortage around Sirius Point resulted in the adults needing to leave the small chick unattended in the crevice to feed. Neither of these hypothesis can be rejected, although notably, the discovery of numerous small dead chicks in crevices that were not part of our sample of productivity monitoring crevices suggests the birds were not hypersensitive to nest checks. In order to test this in 2003 we will set up a low disturbance plot where the crevices will only be checked twice, once during early incubation and again near fledging. Food sampling will also be performed to be compared with quantity and quality of food being brought to chicks at the Buldir auklet colony.

Because of the low productivity of the Least Auklets in 2002, chick growth was difficult to measure. The one measurable chick that we did have live through the nestling stage had delayed growth and left the nest while it was still mostly down covered and half the size of the average sized fledgling. This phenomenon was evident in the Least Auklet productivity crevices as well, where we noted that most of the chicks were underdeveloped and those that did live to fledging age (25 days) stayed in the crevice longer than the average nestling (between 35-40 days). At the time of fledging Least Auklet chicks should be at or above the mass of an adult (Jones 1993b, Piatt *et al*. 1990 and Roby and Brink 1986). The fledglings that were measured in 2002 were roughly 30-40 grams; this is less than half the mass of an adult. This occurrence provides additional evidence supporting the hypothesis that parents were inattentive (or had been predated) and were not regularly bringing in food for the chicks. Furthermore, the widespread occurrence of large dead chicks without any signs of injury in both the chick growth and productivity crevices suggests that the chicks were not getting the required amount of nutrition.

One more year of resightings is required before the first survival estimates for adult auklets at the Sirius Point colony can be made. The preliminary results from 2002 only represent only the over-wintering survival and subsequent resighting of adults because they were banded during chick-rearing in 2001, when they would have been much less susceptible to rat predation than during the preceding incubation period.

Norway Rats were widespread and abundant on Kiska in 2002. Rat sign was found in abundance around the New Lava Dome, Steam Beach and Christine Lake. Rats were easily trapped in unbaited traps near the base of the New Lava Dome and in traps baited with char flesh set around the lakes. They were seen in the intertidal zone and

all the chew sticks placed in a transect through the New Lava Dome in 2001 were chewed or missing altogether in 2002. There was no rat sign found in the Old Lava High plot although rat sign was found around the edge of the Old Lava Dome. It is possible that rats were present but because of the highly vegetated state of the Old Lava Dome they were not in easily visible areas. We believe that rat distribution in 2002 around the auklet colony was concentrated around the lower parts of the colony (New Lava dome) where access to auklets and the intertidal is greatest. It is also believed that rat distribution changes seasonally around the colony to areas of highest food concentration. Once the auklets leave the colony after the breeding season the distribution of rats will change to areas of lush vegetation and easily accessible intertidal. However the distribution of rats around the lake district will most likely not change seasonally as the food source is constant throughout the year.

## Conclusions

1. The Least Auklet population at Sirius Point experienced near complete failure of breeding during 2001 2002 due to poor hatching and particularly fledging success. This low reproductive success is drastically lower than nearby rat-free colonies and indicates a population decline is virtually certain.

2. One additional year of resightings is required before the first estimate of Least Auklet adult survival can be achieved. The observed resighting rate (77%) is consistent with at least moderate adult survival during the period when the birds were at sea.

3. Rats contributed directly and possibly indirectly to reproductive failure at the Sirius Point colony by predating Least and Crested Auklet adults, eggs and nestlings.

4. Rats are distributed unevenly around the Sirius Point colony and are most abundant near Steam Beach and Tangerine Cove and least abundant on the higher parts of the colony.

## Recommendations

1. Monitoring of auklet productivity and survival should be continued for at least one more year at Sirius Point in order to assess the generality of the reproductive failure observed in 2001 and 2002 and to obtain an estimate of annual survival rate of Least Auklets.

2. For 2003, the productivity monitoring protocol used at Sirius Point should be altered to include an additional ultra-low-disturbance sample of crevices, to exclude the possibility that our low estimates of reproductive success were due to a unique high sensitivity of auklets to human disturbance at this colony.

3. Time lapse cameras should be set-up at randomly selected crevices to record rat predation events and to indicate when and why the adults are leaving the chicks unattended during the early brooding stage.

4. Further years of monitoring of auklet productivity, survival and rat activity beyond our proposed three year study should be considered because both auklet and rat demography fluctuate over time, and to complement rat control experiments.

5. Foraging ecology of auklets at Sirius Point and nearby Buldir should be investigated more closely to evaluate the possibility that Kiska auklets are food-stressed.

6. A dynamic population model for rats and auklets at Sirius Point should be developed, based on empirical measures of demographic parameters and on indexes of ocean productivity, to predict population change and the time to extinction of the auklet colony at Sirius Point.

7. The Tiglax schedule in 2003 should include at least one half day at Sirius Point on the end-of-season pickup day, so the camp equipment, supplies and weatherport

floor can be appropriately secured and cached for the winter. A new weatherport floor will have to be constructed and landed in May 2003 to replace the existing floor that was not secured in 2002. This new floor should be coated with waterproof paint before loading on Tiglax at Adak.

8. Norway Rats should be removed from Kiska Island, to protect remaining seabird and other bird populations from extirpation, to return the island to a state suitable for recolonization by extirpated bird species (Song Sparrow and several seabird species), to mitigate the most significant ecological impact of WWII (rat introduction), and restore a natural environment similar to the pristine state of the island prior to 1835.

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Table 1 Least Auklet productivity and known causes of breeding failure at Kiska Island in 2002

| | Lava Dome | Old Lava low | Old Lava high | Lava Dome Chick Growth | all (including chick growth) |
|---|---|---|---|---|---|
| Crevices monitored, n (a) | 84 | 53 | 68 | 40 | 205 (245) |
| Number hatched (b) | 53 | 31 | 45 | 28 | 129 (157) |
| egg abandoned | 4 | 10 | 13 | 1 | 27 (28) |
| egg disappeared | 17 | 11 | 10 | 5 | 38 (43) |
| egg broken | 10 | 0 | 0 | 2 | 10 (12) |
| egg predated | 0 | 0 | 0 | 4 | 0 (4) |
| egg displaced from crevice | 0 | 1 | 0 | 0 | 1 (0) |
| Number fledged (c) | 3 | 6 | 11 | 2 | 20 (22) |
| small chick died of exposure | 25 | 13 | 19 | 15 | 57 (72) |
| chick disappeared | 18 | 8 | 8 | 5 | 34 (40) |
| chick rat predated or injured | 3 | 2 | 2 | 3 | 7 (10) |
| large dead chick, starved? | 4 | 4 | 4 | 3 | 12 (15) |
| Hatching success (b / a)% | 63% | 58% | 66% | 70% | 64% (65%) |
| Fledging success (c / b)% | 6% | 19% | 24% | 7% | 16% (14%) |
| Reproductive success (c / a)% | 4% | 11% | 16% | 5% | 10% (9%) |

Table 2 Least Auklet productivity at Kiska, Buldir and Kasatochi Islands in 2002

| | Kiska dome | old low | old high | chick growth | Kiska all (including chick growth) | Buldir | Kasatochi |
|---|---|---|---|---|---|---|---|
| n(a) | 53 | 31 | 68 | 40 | 205 (245) | 51 | 97 |
| Number hatched (b) | 53 | 31 | 45 | 28 | 129 (157) | 44 | 80 |
| Number fledged (c) | 3 | 6 | 11 | 2 | 20 (22) | 31 | 50 |
| Hatching success (b / a) | 63% | 58% | 66% | 70% | 64% (65%) | 86% | 82% |
| Fledging success (c / b) | 6% | 19% | 24% | 7% | 16% (14%) | 70% | 62% |
| Reproductive success (c / a) | 4% | 11% | 16% | 5% | 10% (9%) | 61% | 52% |

Table 3 Chi-square tests for statistical differences in hatching, fledging and overall reproductive success between, Kiska, Buldir and Kasatochi Islands for Least (LeAu) and Crested (CrAu) auklets.

| | Species | | Kiska – Buldir | Kiska – Kasatochi |
|---|---|---|---|---|
| Hatching Success | LeAu | $\chi^2$ | 10.16 | 11.81 |
| | | p-value, df | 0.001, 1 | 0.0006, 1 |
| | CrAu | $\chi^2$ | 1.257 | 2.1E-5 |
| | | p-value, df | 0.26, 1 | 0.99, 1 |
| Fledging Success | LeAu | $\chi^2$ | 22.22 | 20.63 |
| | | p-value, df | <0.0001, 1 | <0.0001, 1 |
| | CrAu | $\chi^2$ | 0.26 | 1.68 |
| | | p-value, df | 0.61, 1 | 0.20, 1 |
| Reproductive Success | LeAu | $\chi^2$ | 66.66 | 64.58 |
| | | p-value, df | <0.0001, 1 | <0.0001, 1 |
| | CrAu | $\chi^2$ | 3.20 | 2.76 |
| | | p-value, df | 0.08, 1 | 0.10, 1 |

Table 4 Crested Auklet productivity at Kiska, Buldir and Kasatochi Islands in 2002

| | Kiska dome | old low | old high | Kiska all | Buldir | Kasatochi |
|---|---|---|---|---|---|---|
| n(a) | 5 | 8 | 10 | 23 | 87 | 109 |
| number hatched (b) | 3 | 7 | 9 | 19 | 79 | 90 |
| number fledged (c) | 0 | 5 | 5 | 10 | 49 | 64 |
| hatching success (b / a) | 60% | 88% | 90% | 83% | 91% | 83% |
| fledging success (c / b) | 0% | 71% | 56% | 53% | 62% | 71% |
| reproductive success (c / a) | 0% | 62% | 50% | 43% | 56% | 59% |

Table 5 Auklet banding at Sirius Point, Kiska Island in 2002

| Date | Least Auklet | | | | Crested Auklet | | | | **Day** |
|---|---|---|---|---|---|---|---|---|---|
| | Adults | Sub-adults | Retraps | Total | Adults | Sub-adults | Retraps | Total | **Total** |
| June 8 | 2 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | **4** |
| June 28 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | **3** |
| July 2 | 6 | 0 | 0 | 6 | 0 | 0 | 0 | 0 | **6** |
| July 5 | 2 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | **3** |
| July 15 | 8 | 0 | 3 | 11 | 0 | 0 | 0 | 0 | **11** |
| **Total** | **20** | **1** | **5** | **26** | **1** | **0** | **0** | **1** | **27** |

Table 6 Least and Crested Auklets banded in 2001, resighted in 2002

| Species | Number banded in 2001 | Number resighted in 2002 | Percent resighted 2001-2002 |
|---|---|---|---|
| Least Auklet | 200 | 153 | 76.5% |
| Crested Auklet | 23 | 15 | 65.2% |

Figure 1 Geographical extent of auklet colony and location of camp, banding plot, productivity plots, and chick growth plot at Sirius Point, Kiska Island in 2002

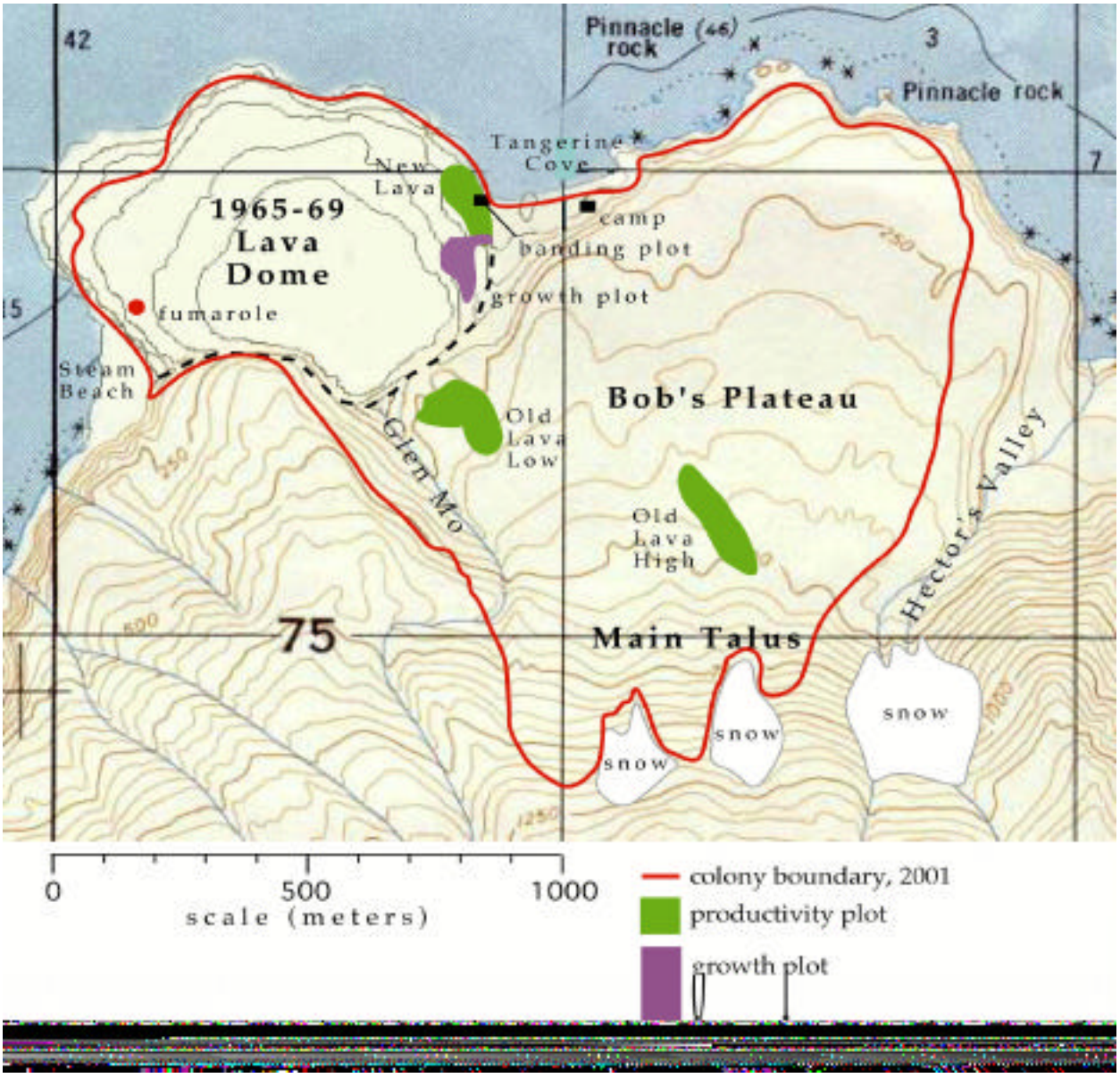


Figure 2 Growth in mass, wing length and tarsus length of Least Auklet chicks at Sirius Point in 2002 in comparison to those measured by Piatt *et al.* (1990) on St. Lawrence Island and Rody and Brink (1986) on the Pribilof Islands.

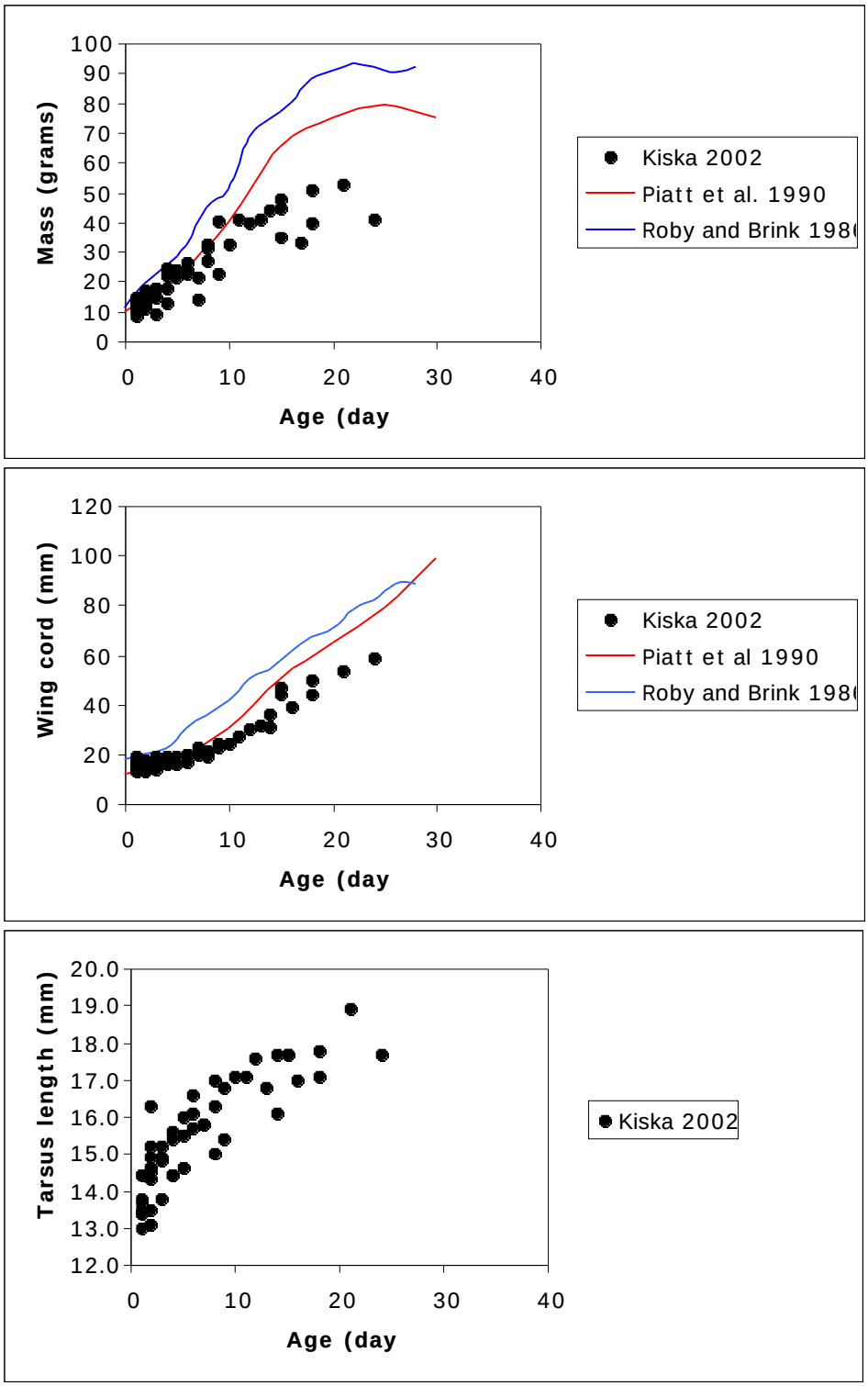


Figure 3 Size distribution of captured Norway Rats on Kiska Island in 2002

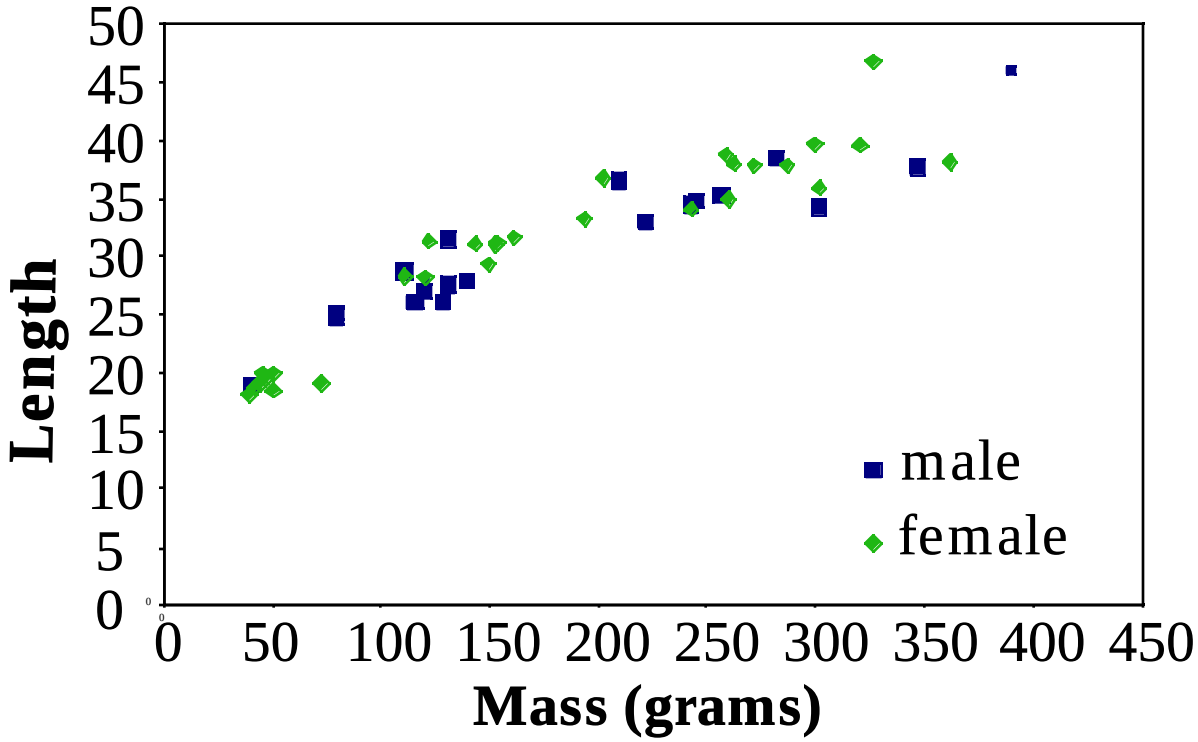
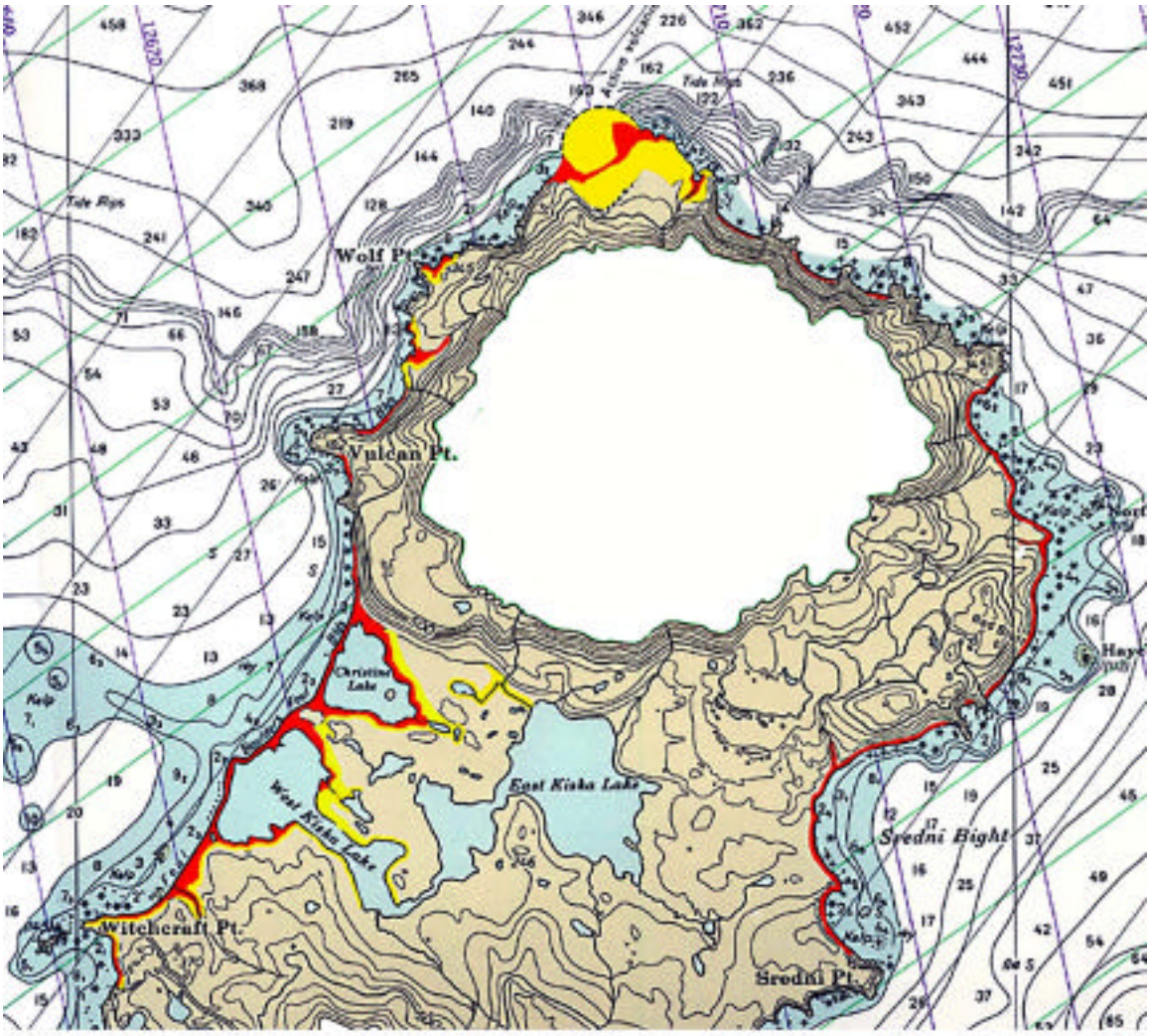


Figure 4 Geographical summer distribution of the Norway Rat on Kiska Island in 2002

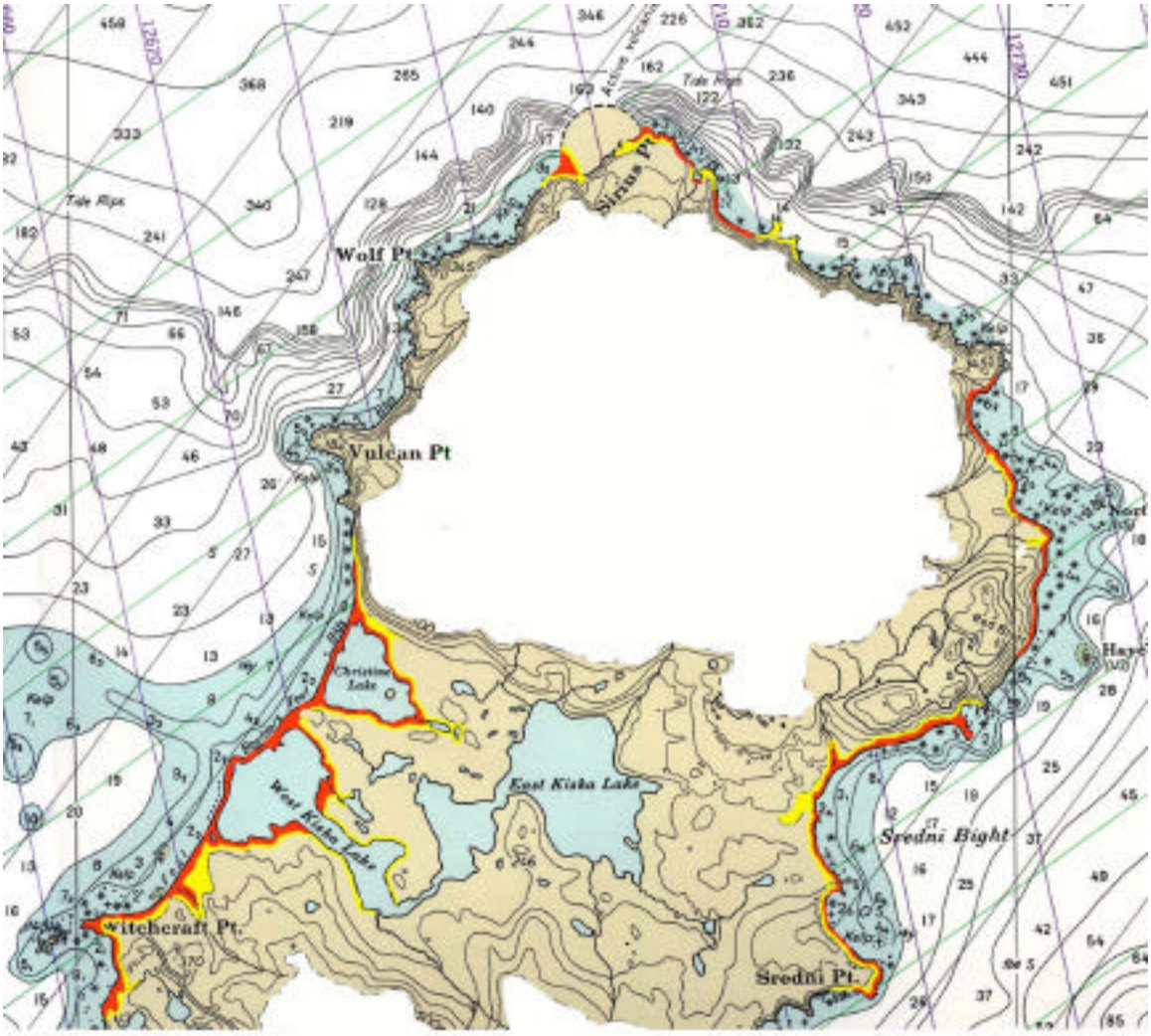



heavily used (continuous territories)

lightly used (present every year)

rarely used (not every year)

Figure 5 Hypothetical winter geographical distribution of Norway Rats on Kiska Island in 2002



Appendix 1 Tissue samples taken for stable isotope analysis in 2002

| Location | Date | Species | Number | Tissues Sampled |
|---|---|---|---|---|
| Sirius Point (Auklet Colony) | Winter 2001-2002 | Norway Rat | 3 | Bones |
| | 4,5-Jun-02 | Norway Rat | 15 | Liver and Pectoral Muscle |
| | 11-Jun-02 | Norway Rat | 2 | Liver and Pectoral Muscle |
| | 17-Jun-02 | Calanus sp. Copepods | >100 | Whole Body |
| | Jun-02 | Crested Auklet | 10 | Liver and Pectoral Muscle |
| | 12-Jul-02 | Norway Rat | 3 | Liver and Pectoral Muscle |
| | 27-Jul-4-Aug-02 | Norway Rat | 10 | Liver and Pectoral |
| | 3-Aug-02 | Least Auklet (fledgers) | 10 | Liver and Pectoral Muscle |
| | 3,4-Aug-02 | Winter Wren | 2 | Liver and Pectoral Muscle |
| | Summer 2002 | American Eagle | 3 | Primary Feather |
| | Summer 2002 | Peregrin Falcon | 1 | Primary Feathers |
| Glen Curly | 26-May-02 | Norway Rat pups | 9 | Liver and Muscle (not pectoral) |
| | 26-May-02 | Least Auklet | 10 | Liver and Pectoral Muscle |
| | 15-Jun-02 | Norway Rat | 2 | Liver and Pectoral Muscle |
| Christine Lake | 3-Jun-02 | Norway Rat | 12 | Liver and Pectoral Muscle |
| | 4-Jun-02 | Amphipods | 10 | Whole Body |
| | 4-Jun-02 | Char | 10 | Liver and Pectoral Muscle |
| | 4-Jun-02 | Aquatic Insects | >100 | Whole Body |
| | 24-Jul-02 | Norway Rat | 16 | Liver and Pectoral Muscle |
| | 24-Jul-02 | FW Algae | ~5grams | Whole Organism |
| | 24-Jul-02 | Sticklebacks | 10 | Whole Body |
| | 24-Jul-02 | Flatworms | 10 | Whole Body |
| Gertrude Cove | 19-Jun-02 | Norway Rat | 1 | Liver and Pectoral Muscle |

Appendix 2 Summary of Norway Rat predation on auklets[1] and caches found in 2002

| Date | Location | Number | Comments |
|---|---|---|---|
| 26-May-02 | Glen Curly, near Steam Beach | 122 | Very large cache of fresh auklets including 7 Fork-tailed Storm Petrels, large grass nest located at the end of one of the cache tunnels with a nest of nine rat pups, the adult rat ran out of the tunnel when it was dug up. |
| 30-May-02 | Near Squid Cave on the New Lava Dome at Sirius Point | 34 | Cache also included auklet eggs, it was located under rocks and the whole cache could not be excavated. |
| 4-Jun-02 | Near Squid Cave on the New Lava Dome at Sirius Point | 13<br>33 eggs | Cache likely contained more auklets and eggs, but it was inaccessible to us. Four of the eggs were Crested Auklet eggs and the rest (29) were Least Auklet eggs. |
| 29-Jun-02 | Fumarole on New Lava Dome near Steam Beach | 148<br>~6 eggs | All auklets were adults and in late stages of decomposition. |
| 17-Jul-02 | Above East side of Tangerine Cove | LeAu adult | Old carcass with eyes, breast and muscle eaten (rat?) |
| | | LeAu chick | Fresh, 2-3 day old chick, no apparent injuries, found dead outside of crevice |
| | Bay above Sirius Point proper | Egg / embryo | Predated egg, only head of embryo remains |
| | | Egg | Old, rat predated |
| | Bay West of Sirius | Rat | Rat trail in the grass |
| | Point, East of camp | LeAu adult | Old carcass with brain eaten |
| | | CrAu egg | Uneaten egg with tooth marks and a puncture |
| | Above East end of | LeAu egg | Uneaten egg with tooth marks and a puncture |
| | Tangerine Cove, | LeAu egg | Predated egg, only head of embryo remains |
| | above camp | LeAu adult | Old carcass with brain eaten |
| | Above East end of Tangerine Cove, base of cliff | Rat | Rat trail through grass |
| 19-Jul-02 | On slope behind blind | LeAu adult | Brain eaten |
| 20-Jul-02 | Southwest end of New Lava Dome | Rat | Fresh rat droppings |
| | New Lava Dome, near Steam Beach | Rat | Den area, two rats seen near burrow entrances |
| | Fumerole, near Steam | Rat | Rat droppings all around fumerole |
| | Beach | Rat | Rat trails all around fumerole |
| 22-Jul-02 | Chick growth plot, New Lava Dome | LeAu chick | Chick app. 2 weeks old with brain eaten |
| 05-Aug-02 | Glen Larry | 15 LeAu fledgers | Fledgers with brain eaten, some with breast muscle chewed also |

[1]All auklets predated were adults unless otherwise stated

Appendix 3 Birds seen during Sirius Point Study, May 24-August 13, 2002 (breeding species in bold face, new species in 2002 in red)

Common Loon *Gavia immer* Heard and seen at Christine Lake.
Red-throated Loon *Gavia stellata* Heard and seen at Christine Lake.
Laysan Albatross *Diomedea immutabilis* Common off Sirius Point.
Black-footed Albatross *Diomedea nigripes* Uncommon off Sirius Point.
Northern Fulmar *Fulmarus glacialis* Common off Sirius Point.
Short-tailed Shearwater *Puffinus tenuirostris* Uncommon off Sirius Point.
Leach's Storm-Petrel *Oceanodroma leucorhoa* Rare off Sirius Point. Heard at night at camp and at Christine Lake.
**Fork-tailed Storm Petrel *Oceanodroma furcata*** Rare off Sirius Point. Frequently heard at night at camp in June. Carcasses found in rat cache – indicates breeding?
**Pelagic Cormorant *Phalacrocorax pelagicus*** Uncommon, breeds locally.
**Red-faced Cormorant *Phalacrocorax urile*** Common, breeds locally.
Swan sp. *Cygnus* sp. Hundreds of droppings along the shore of Christine Lake (evidence of wintering?), likely a Whooper Swan *Cygnus cygnus.*
Canada Goose *Branta canadensis* Flocks flying by Sirius Point regularly, droppings found along route to lakes.
Mallard *Anas platyrhynchos* At least three at Christine Lake June 1-3.
**Green-winged Teal *Anas crecca*** Common at Christine Lake.
Northern Pintail *Anas acuta* At least three at Christine Lake June 1-3.
Eurasian Wigeon *Anas penelope* Flock of 18 at Christine Lake June 2.
**Greater Scaup *Aythia marila*** Lots at Christine Lake June 1-3, several pairs on small ponds.
Harlequin Duck *Histronicus histronicus* Uncommon along beach, Christine Lake.
Common merganser *Mergus mergansor* Uncommon at Christine Lake, June 1-3.
Red-breasted Merganser *Mergus serrator* Common at Christine Lake, June 1-3.
**Bald Eagle *Haliaeetus leucocephalus*** Common breeder.
**Peregrine Falcon *Falco peregrinus*** Common breeder.
**Rock Ptarmigan *Lagopus mutus*** Common on slopes of volcano.
Mongolian Plover *Charadrius mongolus* One at the sand beach near Witchcraft Point, June 2.
Wood Sandpiper *Tringa glareola* Flock of 7 at Sirius Point May 30, 1-2 birds at Christine Lake June 1-3.
Wandering Tattler *Heteroscelus incanus* Up to 4 birds at Christine Lake June 1-3.
Gray-tailed Tattler *Heteroscelus brevipes* One bird at Christine Lake June 2.
Common Sandpiper *Actitis hypoleucos* One bird at Christine Lake June 1-2.
Red-necked Stint *Calidris ruficollis* Up to eight birds at the lake district June 1-3.
Temminck's Stint *Calidris temminckii* One at Christine Lake June 2.
Long-toed Stint *Calidris subminuta* One at Christine Lake June 2.
Rock Sandpiper *Calidris ptilocnemis* Uncommon at Christine Lake, nest with four eggs found June 2, local juveniles seen in July.
Dunlin *Calidris alpina* Four at West Kiska Lake June 2.
**Parasitic Jaeger *Stercorarius parasiticus*** Uncommon off Sirius Point, probably breeds at Christine Lake.
**Glaucous-winged Gull *Larus glaucescens*** Uncommon at auklet colony, breeds on island in Christine Lake, on beach berm at West Kiska Lake.
Glaucous Gull *Larus hyperboreus* One in gull flock at West Kiska Lake seawall June 2.

**Black-legged Kittiwake** ***Rissa tridactyla*** Common, breeds locally.
Red-legged Kittiwake *Rissa brevirostris* Uncommon off Sirius Point.
**Thick-billed Murre** ***Uria lomvia*** Uncommon off Sirius Point, breeds locally (Pillar Rock).
Common Murre *Uria aalge* . Uncommon off Sirius Point, breeds locally (Pillar Rock).
**Pigeon Guillemot** ***Cepphus columba*** Rare off Sirius Point (breeds locally?)
**Marbled Murrelet** ***Brachyramphus marmoratus*** Uncommon, adults seen at Kiska Harbor and Gertrude Cove in early August (breeds locally?).
Ancient Murrelet *Synthliboramphus antiquus* One heard calling from slope above camp on night of June 17.
Cassin's Auklet *Ptychoramphus aleuticus* One heard calling (in flight) at night near camp, early June.
**Parakeet Auklet** ***Cyclorhynchus psittacula*** Uncommon breeder, Sirius Point.
**Crested Auklet** ***Aethia cristatella*** Abundant breeder, Sirius Point.
**Least Auklet** ***Aethia pusilla*** Abundant breeder, Sirius Point.
**Whiskered Auklet** ***Aethia pygmaea*** Rare breeder, Sirius Point, heard at night near camp.
Horned Puffin *Fratercula corniculata* Uncommon off Sirius Point.
**Tufted Puffin** ***Fratercula cirrhata*** Uncommon off Sirius Point (breeding near Wolf Point).
Northern Raven *Corvus corax* Two birds frequented Sirius Point area throughout the summer.
**Winter Wren** ***Troglodytes troglodytes*** Common at Sirius Point, rare along shore of Christine Lake.
Arctic Warbler *Phylloscopus borealis* One at Sirius Point June 8 and June 15 (singing).
Gray-spotted Flycatcher *Muscicapa griseisticta* One near Glen Mo (auklet colony) June 1.
Siberian Rubythroat *Luscinia calliope* Four, three at the auklet colony, one at Christine Lake, May 29 – May 31.
Eye-browed Thrush *Turdus obscurus* At least four in auklet colony May 27 – June 17.
Olive backed Pipit *Anthus hodgsoni* One at Glen Mo May 26.
**Lapland Longspur** ***Calcarius lapponicus*** Common in meadows.
**Snow Bunting** ***Plectrophenax nivalis*** Common in stony habitat.
**Gray-crowned Rosy Finch** ***Leucosticte arctoa*** Uncommon at auklet colony.
Common Redpoll *Carduelis flammea* Two on slope of volcano at 900' June 24.