Least and Crested Auklet productivity and survival in relation to introduced Norway Rats at Sirius Point, Kiska Island, Alaska in 2004, with survey results for the eastern side of the auklet colony

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Norway rats (*Rattus norvegicus*) were introduced to Kiska Island, western Aleutian Islands, Alaska during the 1940s (Murie 1959). Rats are presently widespread on the island and conspicuous evidence of rat predation on Least and Crested Auklets was found by Alaska Maritime National Wildlife Refuge (AMNWR) biologists that visited the large auklet colony at Sirius Point (52°08'N 177°37'E) during 1996, 2000 (Art Sowls and Mark Rauzon personal observations), 2001 (Jones et al. 2001), and 2002 (Major and Jones 2002). Near complete breeding failures, the first instances described from any auklet colony, were documented in 2001 and 2002. Rats were scarce, especially early in the breeding season, and productivity was near normal (c. 50%) at Sirius Point in 2003 (Major and Jones 2003, Major 2004). Introduced Norway rats are known to have caused declines at or extirpated colonies of small seabird species (e.g., Ancient Murrelets at Langara Island, Queen Charlotte Islands, British Columbia, Gaston 1994) by predating adults, eggs and nestlings. Thus it is believed that the auklet colony at Sirius Point may currently be threatened by rat predation (Major 2004). The situation at Sirius Point is of particular concern because this location contained the largest auklet colony in the Aleutian Islands and possibly Alaska.

Norway rats could cause auklet population declines by killing adults (reduction in adult survival), lowering productivity by predating eggs and disturbing incubating adults (reduction of hatching success), and predating nestlings (reduction in fledging success). To assess the impact of rats on auklets at Kiska, auklet productivity and survival have been measured and compared to islands free of introduced mammalian predators (Buldir and Kasatochi; Major 2004) using standardized protocols (e.g., US Fish and Wildlife Service 1996, White and Burnham 1999).

In this report we describe the results of measurements of auklet productivity and survival at Kiska in 2004, compare these to results from previous years at Kiska and to other (rat-free) islands, and present the results of a survey of the eastern part of the colony. We synthesize the latest information to generate informed speculation about the conservation status of the auklet colony at Sirius Point.

Methods

Auklet productivity

As in 2001-2003, Least and Crested Auklet breeding crevices' productivity was monitored using USFWS standardized procedures (US Fish and Wildlife Service 1996). If a crevice failed it was carefully checked for the cause of failure, including signs of rat predation on the adults, eggs and nestlings. In order to evaluate the effects of rats on the Sirius Point colony, productivity data from Kiska was compared to that from Kasatochi and Buldir Islands where there are no introduced rats, and to previous years from Kiska.

Three study plots established during 2001-2003, which are believed to be representative of the entire colony at Sirius Point (Jones et al. 2001) were again used for the productivity estimates in 2004 (Figure 1). In 2004, 197 Least and 31 Crested Auklet crevices were monitored. A total of 27 additional crevices was monitored in an area to which rat poison was applied in April 2004 (P. Dunlevy, personal communication; Figure 1). Auklet productivity had not been previously monitored in the area of rat poisoning and this study plot was added in early June 2004 because the location of the poisoned area was unknown to us until then. This plot was used to assess auklet productivity in an area in which rats were 'controlled' by poison.

Auklet survival

Adult interannual survival of Least Auklets was 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 2004 field season were regularly carried out from the blind during the daily activity periods throughout the entire breeding season (May through July 2004). Resighting data were used to update recapture history files that were initiated in 2001. With the 2004 resightings there were four 'occasions' suitable for survival analysis, allowing two estimates of survival rate: 2001-2002 and 2002-2003.

Norway Rat feeding ecology and distribution

Liver and pectoral muscle tissue of nine Norway rats killed with snap traps at East Kiska Lake during early June and again in late July and early August was sampled.

These samples were dried for three hours at 60° Celsius and stored in glass vials for late aanaalysis of stable isotopes. 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 (i.e. adult auklet, egg) was recorded. We also searched for signs of rats (trails, fresh droppings, predated adults, eggs, and juvenile auklets) throughout the season.

Colony survey

We resurveyed the eastern part of the Kiska colony (Bob's plateau, the least-known part of the auklet colony; Jones et al. 2001) to delineate its location and relative density. This area was surveyed in a preliminary manner in 2001 (Jones et al. 2001). Our survey grid was based on 100 m by 100 m cells; each survey plot was located at a randomly derived point within each cell so the mean distance between points was 100 m. The initial survey grid and list of position fixes for each survey plot was obtained by overlying the random grid (Microsoft Excel spreadsheet, text format) on a US Army topographic map of Kiska using the GPSy Pro (Macintosh software) mapping application. We deleted plots that fell in the ocean and other boundary areas thought to be well outside the auklet colony, based on the 2001 colony map (Jones et al. 2001, Fig 1). To generate a convenient order for visiting the survey points, the plot positions were ranked by their UTM Northings and numbered in 100 m (N-S) by c. 500 - 800 m (E-W) swaths that spanned Bob's Plateau east to west (Fig. 2). The resulting list of 114 survey points was uploaded to our 12-channel GPS receivers (Garmin GPS12XL and Garmin GPSmap 76S) for use in the field. At each survey plot (circular area with 2.5 m radius around each point, 20 m^2 area) we recorded the date and time of our visit, whether occupied auklet breeding crevices were present or absent, auklet density based on sign (0, L, M or H; following Renner et al. ms in preparation), similar to ILJ's method (0, 1-10, 11-100, >100 active crevices per 100 m^2, Jones et al. 2001) and the proportion of vegetation and rock cover to the nearest 5% for the following categories: bare rock, snow, grass, moss, and herb (any of fern, *Salix* sp., *Streptopus amplexifolius*,*Anemone narcissiflora, Lupinus nootkatensis, Angelica lucida*, and other broad-leaved plants). We did not count droppings et c. within each survey plot, as these counts are likely to vary unpredictably with habitat type, date, time since previous heavy rain, and observer biases.

Results

Auklet productivity

Least Auklet hatching success was 83% on the New Lava, 91% on Old Lava low, 63% on Old Lava high and 93% on the rat poison plot in 2004 (Table 1). Hatching success on did not differ significantly between the three control plots and the rat poison plot (Table 3). Overall hatching success was 85% on Kiska in 2004, compared to 76% (2001) and 64% (2002) and 82% (2003). In 2004 the majority of crevices that did not hatch were the result of egg abandonment (n = 20, or 66% of crevices that failed during incubation). Only one crevice had the egg visibly predated by a rat (Table 1). Least Auklet fledging success was 68% on the New Lava, 52% on Old Lava low, 60% on Old Lava high, and 76% on the rat poison plot in 2004 (Table 1). Fledging success did not differ significantly between the control and poison plots (Table 3). Chicks either disappeared or died of starvation; no chicks exhibited signs of rat predation. Overall fledging success on Kiska was 62%, which was significantly higher than observed in 2001 (18%) and 2002 (16%) but similar to that found in 2003 (61%) (Jones *et al*. 2001, Major and Jones 2002, 2003). In 2004, reproductive success was 57% on the New Lava, 48% on Old Lava Low, 49% on Old Lava High and 76% on rat poison plot, there was no significant difference between the control and poison plots (Table 3). Least Auklet hatching, fledging and overall reproductive success at Buldir was 88%, 61% and 53%; and at Kasatochi was 82%, 64% and 53% in 2004, compared to 85%, 62% and 52% at Kiska (Table 2). Hatching, fledging and overall reproductive success at Kiska were very similar to Buldir and Kasatochi in 2004 (Table 4).

Crested Auklet hatching success was 80% on the New Lava, 79% on the Old Lava Low and 83% on the Old Lava High plot (Table 5). Fledging success was 100% on the New Lava, 73% on the Old Lava Low and 90% on the Old Lava High plot (Table 5). Overall reproductive success was 80% on the New Lava, 57% on the Old Lava Low and 75% on the Old Lava High (Table 5). Crested Auklet hatching, fledging and overall reproductive success at Kiska differed little from either Buldir or Kasatochi in 2004 (Table 6).

Auklet adult survival and banding

Program MARK indicated the best model for Least Auklet survival at Kiska was one in which survival rate ϕ varied by year with constant recapture rate across years (Table 7). The survival estimates for Least Auklets at Kiska were 89% (2001-2002) and 95% (2002-2003) (Table 8).

Norway rat feeding ecology and distribution

Around Sirius Point Norway rat sign was scarce throughout the 2004 auklet breeding season. No caches of rat-predated auklets were found in 2004. Norway rats were very abundant during both our trips to the lake district in 2004. Appendix 1 contains the list of sampling locations used in 2004 for stable isotope analysis.

Colony survey

The results of the colony survey are illustrated in Figure 2. The survey data are contained in Appendix 2.

Other observations

A summary of Norway rat sign (droppings, dead auklets with chewed brains) found during the 2004 field season is attached in Appendix 3.

A list of bird species identified during fieldwork in 2003 is attached in Appendix 4.

Discussion

In 2004, auklet reproductive success at Kiska was similar to that recorded at Kiska in 2003 and close to that recorded at rat-free Buldir and Kasatochi Islands in 2004. We now have four continuous years of productivity monitoring data available from Kiska, two showing near complete reproductive failure (2001 and 2002, when Norway rats were abundant; Jones et al. 2001, Major and Jones 2002) and two showing normal breeding performance typical of rat-free islands (2003 and 2004; Major and Jones 2003, this report). In 2001 and 2002, numerous caches of rat-predated adult auklets were found, numerous eggs disappeared without trace from breeding crevices, and numerous chicks died from exposure in crevices, were predated, or disappeared without trace. In 2003 and 2004 few (2003) or no (2004) rat caches of adult auklets were

found, eggs less frequently disappeared without trace from crevices, and chicks died less frequently and in later stages of development. Taken together, these observations are consistent with auklet productivity fluctuating drastically at Kiska in direct response to varying numbers of Norway rats. The best suggestion may be that in years when introduced Norway rats are abundant, they disrupt auklet reproduction at Kiska by killing and disturbing adult auklets and by taking eggs and nestlings. Although mounting evidence implicates rats in auklet breeding failure, this does not eliminate the possibility that other causes (e.g., prey scarcity at sea) could also contribute to variable auklet breeding success. However, trends in productivity from nearby Buldir island do not suggest that 2001 and 2002 were poor years for local prey availability nor that 2003 and 2004 were particularly good years – more evidence consistent with the hypothesis that rats, not food abundance, were the cause of breeding failure at Kiska. Auklets at Buldir an Kiska are assumed to be exploiting the same prey base due to the close proximity of the two colonies (100 km).

With four years of resighting data of birds marked at one study plot on the new lava at Kiska, we are at a stage when some preliminary conclusions can be made about Least Auklet annual adult survival rates. Even though evidence of rat predation was observed on the survival monitoring plot, adult survival was remarkably high during both 2001-2002 and 2002-2003, the years when rats were most abundant at the auklet colony site. Interannual survival rates of 89% and 95% recorded at Kiska are similar to or higher than that recorded in most years at nearby rat free Buldir Island. This is consistent with the idea that rats do not impact adult auklet survival in a biologically significant manner, even though thousands of adult auklets are killed by rats and stored in caches in years when rats are abundant. It must be remembered that our survival estimates come from a single (albeit representative) location in the colony, so the survival data must be interpreted with caution. We believe the survival data are meaningful because of the plot's central location in an area of the colony site where rat sign was present in all years. Why should survival rates at Kiska be so high in the years when productivity was so low? We suggest that because most birds abandoned their breeding efforts either during incubation or early chick rearing in 2001 and 2002 (likely due mainly to rat activities), they did not experience the normal survival costs of complete reproductive effort (Major 2004). High survival during the period when rats

were abundant (2001, 2002) is also inconsistent with the idea that breeding failure was due to food shortage, because low Least Auklet survival rates at Buldir are known to be associated with poor oceanographic conditions (Jones et al. 2002).

Immediately upon our arrival at Sirius Point in 2004, we noticed a lack of rat sign (trails, tracks, droppings) compared to that observed in previous years, especially 2001 and 2002. Subsequent searches for caches of dead auklets killed by rats revealed none in 2004. We have no quantitative method of measuring rat abundance at Sirius Point, but our observations suggested strongly that rats were scarce in the vicinity of the auklet colony in 2004. Sirius Point has poor overwintering habitat for rats, with limited access to the intertidal zone due to steep sea cliffs and poorly vegetated lava substrate. In both 2003 and 2004, the slopes near the camp in Tangerine Cove were denuded of previously common herbs (e.g., the orchid *Platanthera dilatata* x *convallariaefolia*; ILJ personal observations). We suggest that rat populations near Sirius Point may decline when the nearby supply of overwinter plant food is depleted (e.g., after several years of abundant rats). In 2004, rats appeared to be as abundant as ever at the lake district south of the volcano, where access to the intertidal zone is unlimited.

Data from 2004 provide the clearest evidence that rats are the direct cause of auklet breeding failure at Kiska, yet these failures clearly do not occur every year. When rats are scarce, auklet productivity is normal at the colony at Sirius Point. This may explain why a large auklet colony has persisted for many decades following the introduction of rats to Kiska Island. To predict the fate of this auklet colony, we need to know the frequency of years with abundant rats. Only continued monitoring will indicate this. In the meantime, Population Viability Analysis modeling suggests that rapid population decline is likely even if breeding failure occurs in only 50% of years (Major, ms in prep.).

Experimental poisoning of rats took place at Sirius Point during April 2004 (P. Dunlevy, pers. comm.). Auklet productivity was high (70%) in the area where the poisoning occurred, but not significantly higher than control plots due to the low sample size (n = 27 crevices) in the poisoned area. Unfortunately, no previous productivity monitoring had been carried out in the poisoned area, so the design of the experiment could not

exclude the possibility that productivity in this area is normally higher irrespective of poisoning of the rat population. We suggest a Before-After-Controlled-Impact experimental design (Green 1979) be employed in future experiments to evaluate the effectiveness of removing rats.

Survey data from 2004 clarify the extent of the eastern part of the colony that was poorly surveyed in the first survey attempt in 2001 (Jones et al. 2001). Although the two surveys used different protocols, one notable difference in the results was apparent. The 2004 surveyor, Johanne Dussureault, classified the majority of plots on Bob's plateau as 'high density' based on the protocol being developed by Renner et al. (ms in prep.). Visits to this area in 2001 by Ian Jones resulted in scores of 'medium' density for most plots visited and it was noted that much of Bob's plateau was 'low' density in Ian's perception. Thus even with two slightly different protocols in use, it was apparent that the two surveyors had quite different perceptions of auklet density on Bob's plateau. It is unlikely that the different density classifications resulted from auklet population increase. Rather, we believe that the assignment of density classifications is rather subjective, or at best not repeatable between different observers. This underscores the value of presence-absence indication and colony boundaries as the most valuable aspects of survey protocols.

Conclusions and recommendations

1. The Least Auklet population at Sirius Point experienced near failure of breeding during 2001-2002 when rat sign was abundant at the colony site throughout the auklet breeding seasons. In 2003 and 2004 when rat sign was scarce, auklets experienced levels of productivity similar to rat free Buldir and Kasatochi Islands.
2. No caches of rat-predated adult auklets were found in 2004.
3. The results of four years of monitoring at Kiska are consistent with the idea that in some years introduced Norway rats cause auklet breeding failure at Kiska.
4. Adult auklet survival rates were high in two years when rat sign was abundant and productivity low, suggesting that rat predation does not have a significant effect on auklet annual survival at Sirius Point.

5. PVA modeling should be employed to assess the likely impact of different frequencies of breeding failure on the future size of the auklet population breeding at Sirius Point, Kiska Island.
6. A quantitative method for monitoring rat populations is required and should be implemented starting in 2005.
7. Rat population ecology needs to be studied quantitatively at Kiska to ascertain the causes of the observed drastic inter-annual population fluctuations.
8. Future rat control experiments using poison should employ a Before-After-Controlled-Impact experimental design.
9. 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.
10. Further years of monitoring of auklet productivity and survival and rat activity should be considered because both auklet and rat demography fluctuate.
11. It is not too early to start making plans for the removal of introduced Norway rats from Kiska Island.

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Table 1 Least Auklet productivity and known causes of breeding failure at Kiska Island in 2004.

	Lava Dome	Old Lava Low	Old Lava High	Total	Rat Plot[1]
Crevices monitored, n (a)	88	46	63	197	27
Number hatched (b)	73	42	52	167	25
Egg abandoned	3	2	3	8	1
Egg disappeared					1
Egg broken	1			1	
Egg predated	1			1	
Crevice collapsed					
Dead adult in crevice					
Number fledged (c)	50	22	31	103	19
Chick disappeared	8	8	4	20	1
Dead chick	15	12	17	44	5
Hatching success (b/a) %	0.83	0.91	0.83	0.85	0.93
Fledging success (c/b) %	0.68	0.52	0.60	0.62	0.76
Reproductive success (c/a) %	0.57	0.48	0.49	0.52	0.70

[1] Norway rats were experimentally poisoned in the area of the plot during April 2004

Table 2 Least Auklet productivity at Kiska, Buldir and Kasatochi Island in 2004.

	Kiska				Buldir[1]	Kasatochi[1]
	Lava Dome	Old Lava Low	Old Lava High	Total		
N(a)	88	46	63	197	81	91
Number hatched (b)	73	42	52	167	71	75
Number fledged (c)	50	22	31	103	43	48
Hatching success (b/a)	0.83	0.91	0.83	0.85	0.88	0.82
Fledging success (c/b)[a]	0.68	0.52	0.60	0.62	0.61	0.64
Reproductive success (c/a)	0.57	0.48	0.49	0.52	0.53	0.53

[1] Drummond and Kissler 2004.

[a] chicks were consider fledged if they were 25 days old before disappearing from the nest or 21 days old at the time of the last visit if chicks were still present.

Table 3 Chi-square tests for statistical differences in hatching, fledging and overall reproductive success between productivity plots (n = 197) and rat poisoning plot (n = 27) on Kiska for Least Auklets in 2004.

	χ^2	df	p-value
Hatching Success	1.186	1	0.276
Fledging Success	1.926	1	0.165
Reproductive Success	3.132	1	0.077

Table 4 Chi-square tests for statistical differences in hatching, fledging and overall reproductive success among Kiska, Buldir and Kasatochi Islands for Least (LeAu) and Crested (CrAu) auklets in 2004.

Species		Hatching Success			Fledging Success			Reproductive Success		
		χ^2	df	p-value	χ^2	df	p-value	χ^2	df	p-value
LeAu	Kiska - Buldir	0.387	1	0.534	0.026	1	0.872	0.015	1	0.903
	Kiska - Kasatochi	0.257	1	0.612	0.119	1	0.730	0.005	1	0.942
CrAu	Kiska - Buldir	0.000	1	0.996	6.043	1	0.014	4.479	1	0.034
	Kiska - Kasatochi	0.763	1	0.382	0.146	1	0.702	0.063	1	0.802

Table 5 Crested Auklet productivity and known causes of breeding failure at Kiska Island in 2004.

	Lava Dome	Old Lava Low	Old Lava High	Total
Crevices monitored, n (a)	5	14	12	31
Number hatched (b)	4	11	10	25
Egg abandoned	0	3	2	5
Egg disappeared	0	0	0	0
Egg broken	0	0	0	0
Egg predated	1	0	0	1
Crevice collapsed	0	0	0	0
Dead adult in crevice	0	0	0	0
Number fledged (c)	4	8	9	21
Chick disappeared	0	2	1	3
Dead chick	0	1	0	0
Hatching success (b/a) %	0.80	0.79	0.83	0.81
Fledging success (c/b) %	1.00	0.73	0.90	0.84
Reproductive success (c/a) %	0.80	0.57	0.75	0.68

Table 6 Crested Auklet productivity at Kiska, Buldir and Kasatochi Islands in 2004.

	Kiska				Buldir[1]	Kasatochi[1]
	Lava Dome	Old Lava Low	Old Lava High	All		
N(a)	5	14	12	31	67	107
Number hatched (b)	4	11	10	25	54	93
Number fledged (c)	4	8	9	21	30	75
Hatching success (b/a)	0.80	0.79	0.83	0.81	0.81	0.87
Fledging success (c/b)[a]	1.00	0.73	0.90	0.84	0.56	0.81
Reproductive success (c/a)	0.80	0.57	0.75	0.68	0.45	0.70

[1] Drummond and Kissler 2004.

[a] The chicks were consider fledged if they were 26 days old before disappearing from the nest or 22 days old at the time of the last visit if chicks were still present.

Table 7 Comparison of the different Program MARK survival-recapture models for Least Auklets on Kiska Island in 2001-2004, where ϕ is survival, p is the recapture probability, and t is time. Confidence intervals corrected for c-hat = 2.106.

Model	AICc	Δ AICc	AICc Weight	# Parameters	Deviance
ϕ(year) ρ(.)	269.241	0.00	0.342	4.0000	7.592
ϕ(.) ρ(year)	269.268	0.03	0.338	4.0000	7.619
ϕ(Year) ρ(year)	270.083	0.84	0.225	5.0000	6.397
ϕ(.) ρ(.)	271.799	2.56	0.095	2.0000	14.201

Table 8 Least Auklet survival estimate for 2001-2004 as determined by model ϕ(varying by year) p(constant) from the Program MARK, where ϕ is survival, ρ is the recapture probability, and t is time.

Parameter	Estimate	Standard Error	95% Confidence Interval	
			Lower	Upper
ϕ (2001-2002)	0.889	0.003	0.805	0.939
ϕ (2002-2003)	0.946	0.027	0.861	0.980
(ϕ (2003-2004)[1]	0.797	0.050	0.682	0.878)
ρ	0.950	0.018	0.899	0.976

[1] the estimate for 2003-2004 does not account for missed birds and thus is a minimum estimate only.

Figure 1 Geographical extent of auklet colony and location of camp, banding plot, productivity plots, and rat poison plot at Sirius Point, Kiska Island in 2004

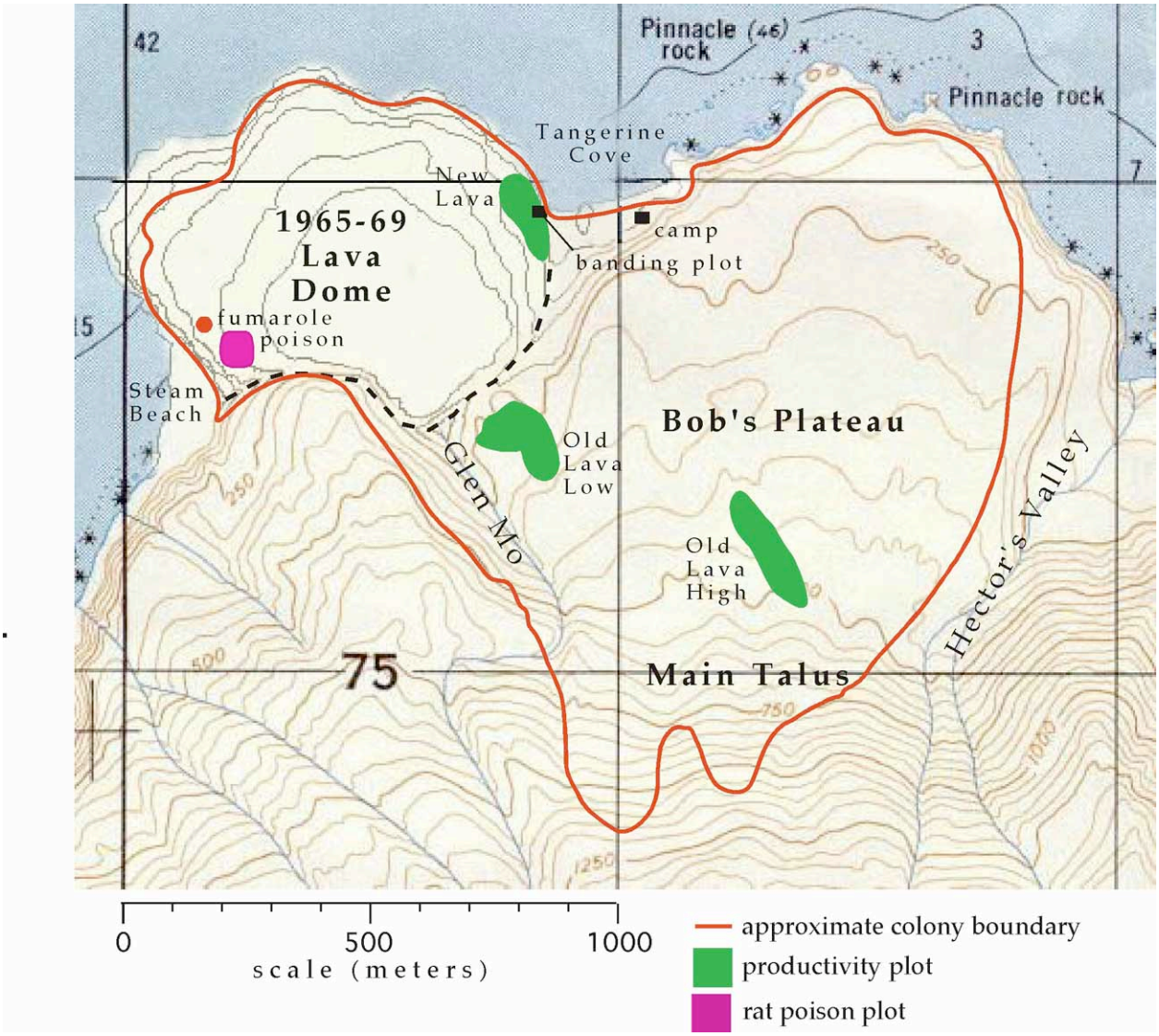
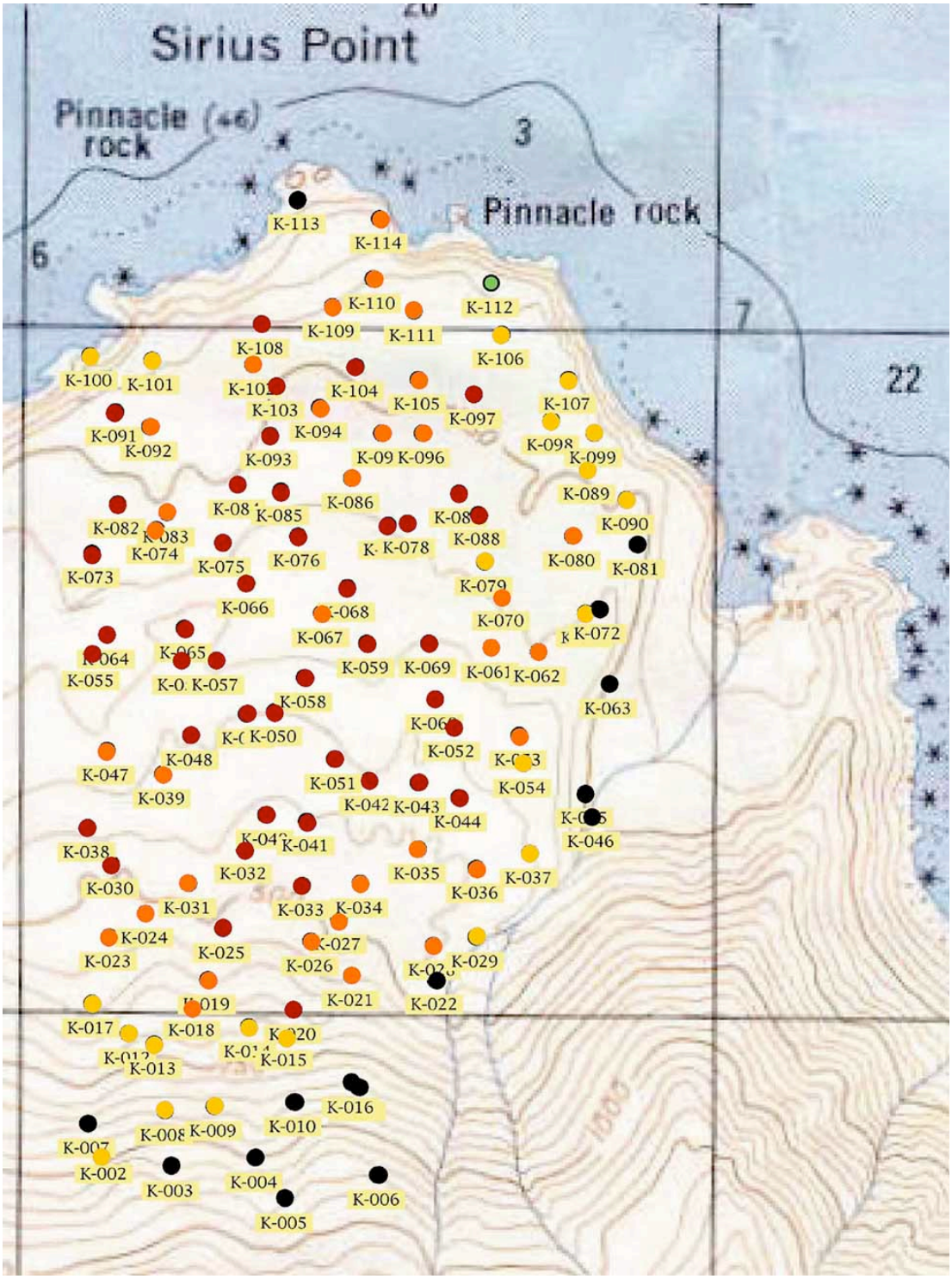


Figure 2 Survey results map of area covered by survey plots overlaid on the US Army topo (UTM grid, datum is NAD 27 Alaska). Red dots indicate plots with high density, orange medium density, yellow low density, black birds absent from survey plot and green (one point) plot not checked.



Appendix 1 Tissue samples taken for stable isotope analysis in 2004.

Location	Species	Date	Number	Tissues sampled
East Kiska Lake	Norway Rat	June 12, 2004	1	Pectoral Muscle, Liver
		July 5, 2004	2	Pectoral Muscle, Liver
		July 7, 2004	1	Pectoral Muscle, Liver
		July 25, 2004	1	Pectoral Muscle, Liver
		July 26, 2004	2	Pectoral Muscle, Liver
		July 27, 2004	2	Pectoral Muscle, Liver
Rats captured			9	

Appendix 2 Data summary for 114 survey plots in the vicinity of the Bob's Plateau near Sirius Point, Kiska Island, 2004 (all plots in UTM zone 60 U).

							vegetation				
Plot	UTM N	UTM E	Birds?	Date	Time	Density	% cover	primary	secondary	other	substrate
k-002	5774781	541070	P	2-Jul-04	17:30	L	70	90% moss	5% grass	5% herb	talus
k-003	5774755	541168	A	2-Jul-04	17:44	0	70	85% moss	10% grass	5% herb	talus
k-004	5774770	541289	NH	12-Jul-04	15:34	0	0	n/a	n/a	n/a	SNOW
k-005	5774711	541331	A	12-Jul-04	15:40	0	70	45% moss	40% grass	5% willow	talus
k-006	5774745	541465	A	12-Jul-04	15:56	0	90	80% grass	10% herb	10% moss	talus
k-007	5774816	541046	NH	2-Jul-04	17:19	0	n/a	n/a	n/a	n/a	SNOW
k-008	5774838	541157	P	2-Jul-04	18:01	L	90	45% grass	40% moss	5% herb	talus
k-009	5774845	541229	P	2-Jul-04	18:14	L	90	50% moss	40% herb	10% grass	talus
k-010	5774851	541343	A	12-Jul-04	15:23	0	90	50% moss	40% herb	10% grass	talus
k-011	5774874	541435	NH	12-Jul-04	15:11	0	90	65% grass	55% herb		talus
k-012	5774947	541103	P	2-Jul-04	16:51	L	80	50% grass	45% herb	5% moss	talus
k-013	5774934	541140	P	2-Jul-04	17:05	L	90	75% herb ,	25% grass		talus
k-014	5774959	541276	P	2-Jul-04	15:27	L	90	80% herb,	15% grass	5% moss	talus
k-015	5774946	541328	P	2-Jul-04	15:41	L	90	45% moss,	40% herb	5% grass	talus
k-016	5774881	541425	NH	12-Jul-04	15:06	0	90	50% herb	40% grass	10% moss	talus
k-017	5774992	541050	P	2-Jul-04	16:37	L	90	35% grass	35% herb	30% moss	talus
k-018	5774989	541196	P	2-Jul-04	16:19	M	70	70% herb	20% grass	10% moss	talus
k-019	5775028	541216	P	2-Jul-04	16:01	M	90	55% grass	45% herb		talus
k-020	5774986	541342	P	2-Jul-04	15:05	H	90	35% herb	35% grass	20% moss	talus
k-021	5775034	541424	P	2-Jul-04	14:50	M	80	40% herb	40% grass	20% moss	talus
k-022	5775030	541545	NH	12-Jul-04	14:46	0	90	75% herb	25% grass		soil
k-023	5775090	541073	P	16-Jul-04	17:38	M	90	90% grass	10% herb		talus
k-024	5775125	541126	P	16-Jul-04	17:29	M	90	80% herb	20% grass		talus
k-025	5775104	541239	P	16-Jul-04	17:12	H	70	95% herb	5% grass		talus
k-026	5775085	541364	P	2-Jul-04	14:38	M	80	80% herb	10% grass	10% moss	talus
k-027	5775116	541405	P	2-Jul-04	14:28	M	80	85% herb	15% grass		talus
k-028	5775079	541543	P	12-Jul-04	14:42	M	90	55% grass	45% herb		talus
k-029	5775094	541603	P	12-Jul-04	14:33	L	90	55% herb	45% grass		talus
k-030	5775194	541076	P	16-Jul-04	17:44	H	90	50% herb	50% grass		talus
k-031	5775167	541188	P	16-Jul-04	17:21	M	90	60% grass	40% herb		talus
k-032	5775217	541268	P	16-Jul-04	16:29	H	80	50% grass	50% herb		talus
k-033	5775166	541352	P	16-Jul-04	16:37	H	90	75% herb	25% grass		talus
k-034	5775170	541436	P	2-Jul-04	14:08	M	80	55% herb	40% grass	5% moss	talus
k-035	5775220	541519	P	2-Jul-04	13:53	M	90	95% grass	5% herb		talus
k-036	5775194	541603	P	12-Jul-04	14:23	M	90	75% grass	25% herb		talus
k-037	5775216	541682	P	12-Jul-04	14:07	L	90	55% grass	45% herb		talus
k-038	5775248	541042	P	16-Jul-04	17:51	H	90	80% herb	20% grass		talus

k-039	5775327	541149	P	16-Jul-04	18:01	M	90	85% grass	15% herb		talus
k-040	5775269	541298	P	16-Jul-04	16:23	H	80	85% grass	15% herb		talus
k-041	5775260	541358	P	16-Jul-04	16:18	H	80	65% herb	30% grass	5% moss	talus
k-042	5775319	541447	P	2-Jul-04	12:41	H	80	80% herb	20% grass		talus
k-043	5775316	541520	P	2-Jul-04	12:57	H	80	60% grass	40% herb		talus
k-044	5775295	541578	P	2-Jul-04	13:36	H	90	85% grass	15% herb		talus
k-045	5775305	541761	NH	12-Jul-04	16:41	0	90	50% grass	50% herb		soil
k-046	5775268	541771	NH	12-Jul-04	16:38	0	90	90% grass	10% herb (lily)		soil
k-047	5775360	541068	P	16-Jul-04	18:07	M	90	55% herb	45% grass		talus
k-048	5775384	541190	P	16-Jul-04	18:16	H	90	90% grass	10% herb		talus
k-049	5775416	541268	P	16-Jul-04	16:01	H	80	85% grass	15% herb		talus
k-050	5775418	541310	P	16-Jul-04	15:56	H	90	75% grass	25% herb		talus
k-051	5775350	541397	P	16-Jul-04	16:11	H	90	55% herb	45% grass		talus
k-052	5775399	541568	P	2-Jul-04	12:20	H	80	65% herb	35% grass		talus
k-053	5775386	541664	P	12-Jul-04	13:27	M	90	65% grass	35% herb		talus
k-054	5775346	541672	P	12-Jul-04	13:54	L	90	90% grass	10% herb		talus
k-055	5775497	541045	P	16-Jul-04	18:43	H	90	90% grass	10% herb		talus
k-056	5775492	541176	P	16-Jul-04	18:26	H	80	60% grass	40% herb		talus
k-057	5775492	541224	P	16-Jul-04	18:22	H	90	60% herb	40% grass		talus
k-058	5775468	541353	P	16-Jul-04	15:50	H	90	55% herb	45% grass		talus
k-059	5775518	541441	P	16-Jul-04	15:45	H	90	60% herb	40% grass		talus
k-060	5775439	541543	P	2-Jul-04	11:58	H	90	45% herb	55% grass		talus
k-061	5775514	541623	P	12-Jul-04	13:05	M	90	60% grass	40% herb		talus
k-062	5775510	541692	P	12-Jul-04	13:13	M	90	75% grass	25% herb		talus
k-063	5775464	541793	NH	12-Jul-04	16:51	0	90	95% grass	5% herb		talus
k-064	5775529	541067	P	16-Jul-04	18:38	H	90	55% herb	45% grass		talus
k-065	5775539	541179	P	16-Jul-04	18:30	H	80	65% herb	35% grass		talus
k-066	5775604	541268	P	16-Jul-04	15:17	H	80	85% grass	15% herb		talus
k-067	5775561	541376	P	16-Jul-04	15:37	M	90	65% grass	35% herb		talus
k-068	5775599	541415	P	16-Jul-04	15:29	H	90	50% herb	50% grass		talus
k-069	5775521	541533	P	2-Jul-04	11:37	H	90	85% grass	15% herb		talus
k-070	5775590	541637	P	12-Jul-04	12:50	M	90	60% grass	40% herb		talus
k-071	5775566	541758	P	12-Jul-04	17:09	L	90	65% herb	35% grass		talus
k-072	5775573	541777	A	12-Jul-04	17:03	0	90	95% grass	5% herb		talus
k-073	5775647	541045	P	16-Jul-04	18:51	H	90	75% herb	25% grass		talus
k-074	5775682	541137	P	16-Jul-04	19:08	M	90	80% grass	20% herb		talus
k-075	5775663	541232	P	16-Jul-04	15:12	H	90	65% herb	35% grass		talus
k-076	5775673	541343	P	16-Jul-04	15:04	H	90	70% grass	30% herb		talus
k-077	5775692	541471	P	12-Jul-04	12:32	H	90	60% grass	40% herb		talus
k-078	5775695	541499	P	12-Jul-04	12:29	H	90	55% grass	45% herb		talus
k-079	5775638	541613	P	12-Jul-04	12:41	L	90	75% grass	25% herb		talus

k-080	5775678	541738	P	12-Jul-04	17:21	M	90	65% grass	35% herb	talus
k-081	5775667	541833	A	12-Jul-04	17:29	0	90	85% grass	15% herb	talus
k-082	5775720	541080	P	16-Jul-04	19:20	H	90	80% grass	20% herb	talus
k-083	5775708	541153	P	16-Jul-04	19:13	M	90	95% grass	5% herb	talus
k-084	5775750	541255	P	16-Jul-04	14:19	H	90	80% grass	20% herb	talus
k-085	5775739	541316	P	16-Jul-04	14:25	H	90	65% grass	35% herb	talus
k-086	5775758	541419	P	16-Jul-04	14:52	M	90	75% herb	25% grass	talus
k-087	5775738	541574	P	12-Jul-04	12:13	H	90	60% grass	40% herb	talus
k-088	5775708	541603	P	12-Jul-04	12:17	M	90	65% grass	35% herb	talus
k-089	5775774	541760	P	12-Jul-04	17:48	L	90	85% grass	15% herb	talus
k-090	5775730	541817	P	12-Jul-04	17:37	L	90	75% grass	25% herb	talus
k-091	5775854	541077	P	16-Jul-04	19:36	H	90	65% grass	35% herb	talus
k-092	5775833	541127	P	16-Jul-04	19:30	M	90	85% grass	15% herb	talus
k-093	5775821	541300	P	16-Jul-04	14:03	H	90	85% grass	15% herb	talus
k-094	5775863	541370	P	16-Jul-04	13:47	M	90	85% grass	15% herb	talus
k-095	5775825	541461	P	12-Jul-04	11:53	M	90	75% grass	25% herb	talus
k-096	5775826	541520	P	12-Jul-04	12:05	M	90	55% grass	45% herb	talus
k-097	5775882	541595	P	12-Jul-04	11:42	H	90	70% grass	30% herb	talus
k-098	5775845	541707	P	12-Jul-04	18:04	L	90	75% grass	25% herb	talus
k-099	5775827	541769	P	12-Jul-04	17:56	L	90	95% grass	5% herb	talus
k-100	5775935	541037	P	16-Jul-04	20:07	L	70	90% grass	10% moss	talus
k-101	5775928	541129	P	16-Jul-04	19:48	L	90	90% grass	10% herb	talus
k-102	5775924	541275	P	16-Jul-04	13:24	M	90	70% grass	30% herb	talus
k-103	5775894	541309	P	16-Jul-04	13:32	H	90	55% grass	45% herb	talus
k-104	5775922	541422	P	12-Jul-04	11:24	H	90	90% grass	10% herb	talus
k-105	5775904	541515	P	12-Jul-04	11:30	M	90	80% grass	20% herb	talus
k-106	5775969	541633	P	12-Jul-04	18:27	L	90	85% grass	15% herb	talus
k-107	5775905	541732	P	12-Jul-04	18:15	L	90	100% grass		talus
k-108	5775984	541285	P	16-Jul-04	13:13	H	90	65% grass	35% herb	talus
k-109	5776010	541389	P	16-Jul-04	12:53	M	90	60% herb	40% grass	talus
k-110	5776050	541448	P	12-Jul-04	10:59	M	90	95% grass	5% herb	talus
k-111	5776002	541506	P	12-Jul-04	11:13	M	90	95% grass	5% herb	talus
k-113	5776163	541336	A	16-Jul-04	12:32	0	10	0%	0%	rock
k-114	5776137	541457	P	12-Jul-04	10:44	M	80	75% grass	25% moss	talus

Appendix 3 Summary of Norway rat sign found at Kiska Island in 2004.

Date	*Location*	*Comments*
Early – mid June	Sirius Point Auklet Colony	Sign is not abundant, there is some sign of rats on the colony (we found 10 predated eggs).
June 1, 2004	Steam beach trail.	Two predated LeAu eggs were found on the trail.
June 8, 2004	New lava plot – nest C4	CrAu egg was found in nest C4 in the New Lava plot predated by rat.
June 9-12, 2004 *Spike Camp #1*	East Kiska Lake	Abundant rat sign in the littoral zone of the lake. Rat tracks found in the sand along the beach.
June 9-12, 2004	Christine Lake	Abundant rat sign in the intertidal. Rat tracks found in the sand along the beach. A white and brown rat was seen under the beach boulders.
June 13, 2004	Between the High lava and Low lava plot.	A predated LeAu egg was found outside a crevice. There were 3 small holes on the eggshell at different location. Fresh yolk still present.
June 20, 2004	Steam beach trail.	We found 1 egg (LeAu) and 1 dead chick (LeAu) side by side in the grass by the trail.
June 20, 2004	Steam beach trail.	Cache 1: We found a rat cache with 11 eggs (LeAu) all predated.
June 24, 2004	Between the High lava and Low lava plot.	A LeAu egg was found predated on the ground outside of a crevice.
June 24, 2004	Camp	Rats chewed bridge between the cabin and stairs.
June 26, 2004	One Cove over cove	A CrAu egg was found predated by rat.
June 26, 2004	Tangerine Cove	Rat droppings were found on the trail that goes from our cabin to the east of Tangerine beach.
Late June – Early July	Sirius Point Auklet Colony	Sign is not abundant, there is some sign of rats on the colony. We found Rat droppings in one occasion and some eggs were found predated.
July 4, 2004	Junction lane (old lava)	We found some areas on the west slope where rats have been digging on the grassy hill.
July 4-7, 2004 Spike Camp #2	East Kiska Lake	Abundant rat sign in the littoral zone of the lake. Rat tracks found in the sand along the beach.
	Inland between Christine Lake and East Kiska Lake	Abundant rat sign closer to East Kiska Lake, trails visible in the grass close to the marshy area.
July 24-27, 2004 Spike Camp #3	East Kiska Lake	Chewing sign on the old traps that we had cache at our spike camp beside East Kiska lake, 30 m away from the beach (beside the stream). Abundant rat sign in the littoral zone of the lake. Rat tracks found in the sand along the beach.
July 27, 2004	Steam beach trail (before Junction lane)	2 LeAu chicks were found with brain eaten by rats.
Late July – Early August	Sirius Point Auklet Colony Steam beach trail to Junction lane.	Lots of fledgers present in these valleys (50-60). Rat predation not abundant. Most of the chicks that were found dead were not showing any predation sign, (except for the previous 2). Causes of death were exhaustion and food deprivation.

Appendix 4 Birds seen during Sirius Point Study, May 25 – August 5, 2004.
Breeding species in bold face.

Common Loon	*Gavia immer*	Heard and seen at East Kiska Lake
Laysan Albatros	*Diomedea immutabilis*	Common off Sirius Point
Fork-tailed Storm Petrel	*Oceanodroma furcata*	Rare off Sirius Point. Heard occasionally at night at camp.
Pelagic Cormorant	***Phalacrocorax pelagicus***	Common, breeds locally.
Red-Faced Cormorant	***Phalacrocorax urile***	Common, breeds locally.
Canada Goose	*Branta canadensis leucopareia*	Flocks of Aleutian Canada Goose flying by Sirius Point regularly. 30 geese were found grazing between Christine and East Kiska Lake on 2 occasions. Not breeding.
Mallard	*Anas platyrhynchos*	One male was on Christine Lake in early July.
Green-Winged Teal	***Anas crecca***	Common at Christine Lake and ponds in that area, one brood of ducklings observed on July 6.
Northern Pintail	*Anas acuta*	One female flushed on the Junction trail close to the High Lava Plot.
Greater Scaup	***Aythia marila***	Forty-six at Christine and East Kiska Lake and all ponds around that area on July 6, two broods of ducklings.
Common Eider	*Somateria mollissima*	Two birds (male and female) were seen in the ocean off Christine Lake.
Harlequin Duck	*Histrionicus histrionicus*	One male occasionally seen in Tangerine Cove.
Common Merganser	*Mergus merganser*	One found on Christine Lake in June 2004.
Red-breasted Merganser	***Mergus serrator***	Common at Christine Lake where they breed, at least three broods observed in late July.
Black Oystercatcher	*Haematopu bachmani*	Six birds were observed at Hectors Cove.
Rock sandpiper	***Calidris ptilocnemis***	Common at Christine and East Kiska Lake. Nest found on the beach of East Kiska Lake. A juvenal with parents was seen at the shoreline of East Kiska Lake. Many adults were observed while performing the broken wing play.
Parasitic Jaeger	**Stercorarius parasiticus**	About 25 pairs were seen near Christine Lake. No nest with eggs or chicks was found. Probably breeds in that area.
Glaucous-winged Gull	***Larus glaucescens***	Common at the Auklet colony (up to 57 gulls seen in Tangerine Cove). Nests were found at the Kittiwake colony.
Black-legged Kittiwake	***Rissa tridactyla***	Common, breeds near Steam Beach
Common Murre	*Uria aalge*	Uncommon in Tangerine Cove and One cove over Cove. Breeds locally (Pillar Rock)
Pigeon Guillemot	***Cepphus columba***	Rare in Tangerine Cove and One cove over Cove. Breeds locally?
Paraket Auklet	***Cyclorhynchus psittacula***	Up to 60 regular in Tangerine Cove and One cove over Cove. Adults entered crevices near the cabin, between boulder at the East point of Tangerine Cove and under boulders in One cove over Cove. No eggs were found (crevices inaccessible).
Crested Auklet	***Aethia cristatella***	Abundant breeder, Sirius Point.
Least Auklet	***Aethia pusilla***	Abundant breeder, Sirius Point.
Whiskered Auklet	***Aethia pygmaea***	Rare breeder, Sirius Point, occasionally heard at night at the beach.
Horned Puffin	***Fratercula corniculata***	Uncommon at One Cove over Cove, Hectors valley and at the Kittiwake colony.

Appendix 3 Birds seen during Sirius Point Study (continued).

Tufted Puffin	***Fratercula cirrhata***	Common at One Cove over Cove, Hectors valley and at the Kittiwake colony.
Bald Eagle	***Haliaeetus leucocephalus***	Common breeder. Nests found at Hectors valley and Witchcraft Point.
Peregrine Falcon	***Falco peregrinus***	Common breeder. Nest found on Sirius Point and close to East Kiska Lake.
Rock Ptarmigan	***Lagopus mutus***	Common on slope of volcano. Several chicks were observed.
Northern Raven	*Corvus corax*	Two birds frequented Sirius Point area throughout the summer. One raven was also seen at Christine Lake area.
Winter Wren	***Troglodytes troglodytes***	Common at Sirius Point and along the beach from Christine Lake to Witchcraft Point.
Siberian Rubythroat	*Luscinia calliope*	Two birds frequented the valley between the Old Lava and New Lava Dome at the beginning of the season, early June.
Yellow Wagtail	*Motacilla flava*	One bird observed on May 25 at Steam Beach.
Lapland Longspur	***Calcarius lapponicus***	Uncommon on the Lava Plot. Common in meadows.
Eye-browed Thrush	*Turdus obscurus*	Three birds frequented the area around the camp in early June.
Song Sparrow	*Melospiza melodia maxima*	Two birds were observed while feeding at One cove over
Snow Bunting	***Plectrophenax nivalis***	Common in stony habitat**.**
Gray-crowed Rosy Finch	***Leucosticte arctoa***	Uncommon at Auklet colony and Christine Lake.