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BREEDING ECOLOGY OF KITTLITZ'S MURRELET AT AGATTU ISLAND, ALASKA, IN 2008: PROGRESS REPORT

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INTRODUCTION

The Kittlitz's murrelet (*Brachyramphus breverostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least studied in North America. The species is generally associated with glaciated regions of Alaska, except for some of the isolated populations in the Aleutian Islands. Long-term population monitoring in core Kittlitz's murrelet areas in the Gulf of Alaska region has revealed declining trends with up to 80% of local populations disappearing over the past 10 to 20 years (Kuletz et al. 2003, Robards et al. 2003, Van Pelt and Piatt 2003). Causes for the rapid decline of this species are uncertain, but likely include oil spills, gillnet mortality and may also include changes in food abundance, habitat loss due to glacial recession, and vessel disturbance in core foraging areas. Nevertheless, limited knowledge of the ecology of this species hampers conservation efforts (Day and Nigro 2004). Data gaps include basic knowledge about their nesting habitat, mortality factors, demographic vital rates, and diets, all of which are important aspects for addressing recovery planning for this candidate species for listing under the Endangered Species Act.

Data on seabird reproductive success and population trends are typically collected at breeding colonies, but Kittlitz's murrelets do not breed in colonies. Furthermore, as of 2004 only 23 nests had ever been documented for the Kittlitz's murrelet over its entire nesting range; single nests scattered in space and time (Day et al. 1999, G. van Vliet pers. comm). This murrelet apparently uses the strategy of dispersed nesting in areas with sparse or no vegetation, typically at relatively high elevations which are sometimes distant (up to 70 km) from the coast, a strategy suggesting predator avoidance (Thompson 1966, Day et al. 1983, Murphy et al. 1984, Kaler et al. 2008). Limited available data on Kittlitz's murrelets, supplemented with data from the closely related marbled murrelet (*Brachyramphus marmoratus*), provides an outline of life history characteristics. The species lays a single egg which both adults alternate incubating. One to two days after hatching, the cryptic young are left alone at the nest. After approximately four weeks of provisioning by both adults, the chick departs the nest at 40 to 60% of adult mass for the ocean where it completes development without further attendance by either parent (Day et al. 1999, Kaler et al. 2008).

The recent discovery of a breeding population of Kittlitz's murrelets at Agattu Island, Aleutian Archipelago, Alaska, part of the Alaska Maritime National Wildlife Refuge, provides an opportunity to gain insight into the nesting biology of this critically endangered seabird. After the incidental discovery of a single nest in 2005 at Agattu, a more concerted effort in 2006 resulted in the discovery and monitoring of 11 Kittlitz's murrelets (Kaler 2006, Kaler et al. 2008).

In 2008, a comprehensive 4-year monitoring project was initiated at Agattu Island with the following long-term objectives:

1) Describe habitat characteristics of nest sites.
2) Quantify breeding chronology.
3) Determine chick growth rates, nestling diet and adult nest attendance patterns.
4) Measure nest survival rates and overall reproductive success.
5) Collect genetic samples for comparative study of murrelet populations.

This work continues to expand upon preliminary data collected in 2006 and provides additional insight into the nesting biology of Kittlitz's murrelets. These types of data provide managers with much needed information for guiding the development of a conservation plan for

Kittlitz's murrelets throughout the Aleutian Archipelago, as well as help elucidate potential causes of population declines within the core of its range in southeast Alaska.

This progress report for the 2008 season, the first year of the comprehensive study, contains summary data for some but not all of the parameters we measured. Analysis is pending on nest site selection (R. Kaler, USFWS), sex determination and population genetics (V. Friesen, Queen's University), stable isotopes (K. Hobson, Environment Canada) and diet analyses of chicks (M. Arimitsu and J. Piatt, USGS). All data will be incorporated and compared in the final report after the completion of the final season of field data collection.

STUDY AREA

Agattu Island (52.43° N, 173.60° E) is part of the Near Islands group; a group of five islands found farthest west in the Aleutian Archipelago (Fig. 1) and is part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge. Agattu covers an area of 22,474 ha with the majority of land below 230 m in elevation. A mountain range composed of seven sub-massifs lies along the north side and extends from Armeria Bay eastward to Krugloi Point (Fig. 1). The westernmost sub-massif is composed of five peaks that extend to 518 - 693 m, and includes the highest point on the island (693 m).

Daily mean minimum and maximum temperatures during 1 June to 26 August 2008 (weather data were collected at Binnacle Bay; Fig. 1) were 5.3 °C (range 1.8 to 8.3 °C) and 16.2 °C (range 14.9 to 17.5 °C), respectively. Average monthly precipitation during the three month period was 8.2 cm (range 6.3 to 11.2 cm), and wind velocities averaged 28 kilometers per hour (peak gusts periodically reaching 55-115 kilometers per hour).

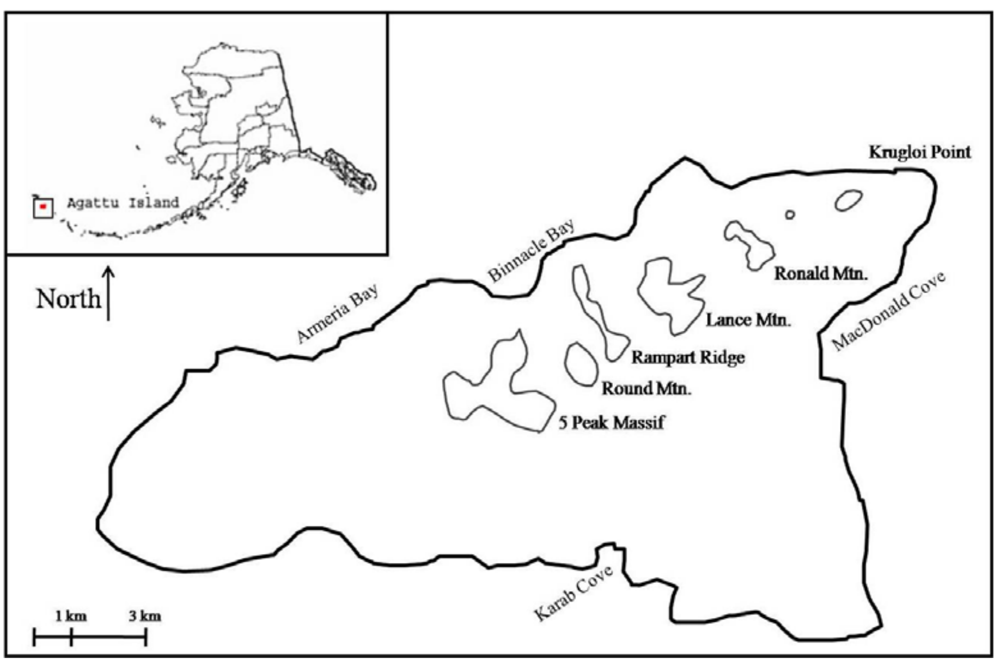

Figure 1. Study location of breeding Kittlitz's murrelets, Agattu Island, Alaska, 2008. Outline of mountains in northeast portion of island represent 300 m contour lines.

Historically, the Aleutian Islands had no native terrestrial mammals west of Umnak Island (Murie 1937; 1959, Gibson and Byrd 2007). Many island populations of native birds were dramatically impacted by the deliberate introduction of arctic foxes (*Alopex lagopus*) by Russian fur farmers during the 18th and 19th centuries (Bailey 1993, Ebbert and Byrd 2002, Williams et al. 2003). Foxes were eradicated from Agattu in the late 1970's, and the dominant bird predators remaining at Agattu include four species of birds. Nest predators of ground nesting birds include glaucous-winged gulls (*Larus glaucescens*) and common ravens (*Corvus corax*). Raptors include peregrine falcons (*Falco peregrinus*) and snowy owls (*Bubo scandiacus*), although the latter species was seen infrequently.

METHODS

Nest Searching and Monitoring

Nests were located by ground-searching of suitable terrain (e.g., Day and Stickney 1996, Kaler et al. 2008). Investigators remained within 5-10 m abreast of each other (i.e., at approximate startling distance of an incubating murrelet; R. Kaler, J. Piatt, pers. obs.) when the habitat permitted. Search efforts were concentrated at high elevation rocky-talus covered areas along ridges, peaks, or terraced slopes. Despite efforts to locate incubating adults without disturbance, the majority of nests were located by flushing the incubating adult at the time of discovery.

Egg length and width were measured using dial calipers (±0.1 mm). Egg mass was measured using a spring scale (±0.5 g), and eggs were floated in water to estimate the stage of embryonic development (Westerskov 1950). To determine timing of nest failures during the egg or chick-rearing period, we placed two temperature loggers (iButtons, DS1922L, Maxim Integrated Products, Dallas Semiconducter, Sunnyvale, CA) programmed to record ambient temperature every hour (±0.5 °C) at each nest site. One temperature logger was placed in the nest scrape and covered with available materials (i.e., rock <10 mm diameter, lichen, moss). The second temperature logger was placed 15 to 50 cm away from the nest beneath a rock in order to record ambient temperature outside of the nest scrape. A nest's failure date was estimated by charting the recorded temperatures of the paired loggers; where temperature merged (i.e., "nest logger" and adjacent "outside logger" recorded similar temperatures) and maintained similar temperature values we determined to be the approximate day of nest failure. Reflective surfaces of loggers were darkened with permanent ink prior to deployment at nest sites.

We revisited nests twice during the incubation period: once 4-7 days after initial discovery to confirm continued nest survival post-discovery and once at the time of estimated hatching to aid in determining stage-specific survival. As each egg neared its predicted hatching date based on egg float curves (Westerskov 1950), we checked nests from a distance ≥ 30 m in order to minimize disturbance to incubating adults.

To examine possible adverse effects of researcher visits on chick growth and brood survival, nests that survived to hatch were paired with their nearest neighbor of similar age and then randomly assigned to either a *disturbed* or *control* group (for both treatment groups n = 4). *Disturbed* nests were visited every 3-4 days during the brood rearing period, while *control* nests were visited five times during the entire brood rearing period; once at discovery, three times during the brood period (5-8 d, 11-12d, 20-26 d), and once at fledge (>30 d).

During each visit to nest sites, chick mass was measured to the nearest 1 g (for masses <100 g) or 2 g (for masses >100 g) using Pesola spring scales. We measured the unflattened (natural) wing length from the wrist to the wing tip (±1 mm) using a wing chord ruler. Dial calipers were used to take linear measurements (±0.1) of the total head, exposed culmen, tarsus, and tail length. A blood sample was collected from each nestling for genetic analyses and sex determination. Feather and down samples were also collected. All nest visits were conducted between 15:00 and 19:00 Alaska Standard Time to maintain consistency of measurements. No chicks were handled during adverse weather (i.e., wind >30 kilometers per hour, mist/rain).

Nests receiving the disturbed treatment were monitored by either a motion-triggered, infrared camera or a digital video recording camera placed between 1.5 to 4 m from the nest. Cameras were deployed after the chick was 5 days old. Because we were concerned that the camera's proximity to the nest might influence the adult's nest attendance, we first placed the nest camera at ≥ 3 m from the nest and used rocks to camouflage the camera's appearance and shape. After continued nest attendance by adults, the camera was incrementally moved 1 m closer to the nest until it was 1.5 m from the nest. One camera was equipped with a telephoto lens, permitting the camera's placement at 4 m from the nest. After both motion and infrared triggers failed to activate cameras, we programmed cameras to record one image every 3-minutes, for 24-hours per day while the nest was active. The 3-minute time delay period between photos was based on the minimum time duration of a nest visit for a Kittlitz's murrelet monitored using real-time video cameras near Kachemak Bay, Alaska (J. Piatt, N. Naslund, pers. comm.). Data from cameras were downloaded every 3-4 days and batteries were replenished every 5-7 days. Procedures for monitoring can be found in Appendix A (Nest Monitoring Instruction).

Nest Site Selection

Nest site characteristics were measured after completion of nesting. Vegetation data were collected at each nest site and at four non-use plots placed at a random bearing and random distance between 50 and 100 m from nest sites (Fig. 2). Using a 25-m radius plot at each nest, or non-use plot, percentage classes of each general vegetation type present were estimated using the classification system of Viereck et al. (1992). Also, topographic data were recorded for each of these 25-m plots. Using a 5-m radius plot nested within the 25-m plot and centered at the nest site or middle of non-use plot center, we classified ground cover into 10 categories using a scoring system we developed (after Frederick and Gutiérrez 1992; see Nest Vegetation Data Collection Instruction Appendix B). To compare known nest sites with "available" nesting habitat at Agattu (areas >300 m above sea level), 50 randomly selected vegetation plots were also surveyed. These random plots followed the same methods using 5- and 25-m radius plots and data were collected during the same time period as nest and non-use plots.

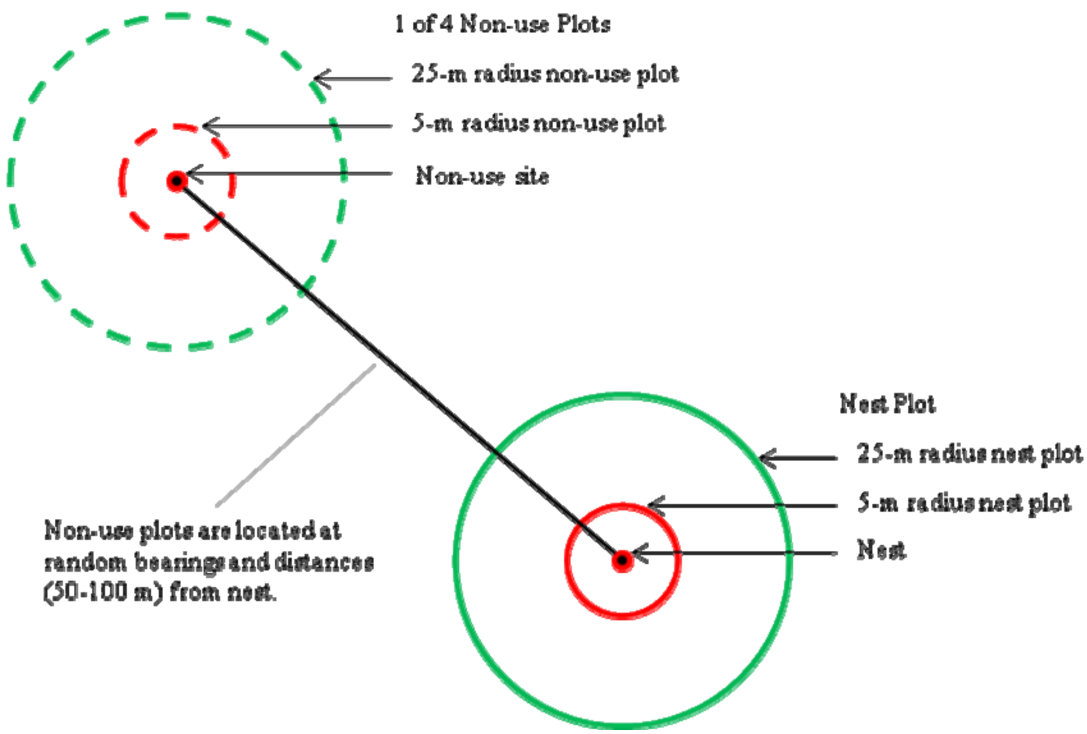

Figure 2. Nest and non-use vegetation plots. The nest plot was located at the center and consisted of a 5-m radius plot for estimation of percent ground cover and a 25-m radius plot for measuring topographical features and estimating percent of habitat cover (Viereck et al. 1992). Four non-use plots were located at random distances and bearings from the nest site.

In cases where more than one nest was located on a single submassif, we used ArcView GIS 3.2a software (Environmental Systems Research Institute, Inc.) to calculate straight-line distances between nest locations, as well as distance to the ocean.

Breeding Chronology

Dates of clutch initiation were calculated by backdating from known hatching dates using a 30 d mean incubation period, similar to the time needed by marbled murrelets (Nelson 1997, Day et al. 1999). A hatching date was assigned to nests using the midway point between the last time the nest contained an egg (incubating adult = egg) and the first day the nest contained a chick. In cases where nests were discovered after hatching, we assigned age based on chick appearance, accumulation of feces at the nest scrape, and flight feather growth. Day of hatch was designated as day 0 for all backdating of nests.

Nestling Diet and Adult Provisioning Patterns

Rates of chick meal deliveries were estimated using time-stamped photos (time-lapse: 1 picture recorded every 3 minutes) or video. When adults attending nests could be uniquely identified based on plumage characteristics, we estimated provisioning rates per parent. Photos or video will be examined by marine forage fish experts to identify prey items (Arimitsu and Piatt 2006).

Data Analysis

Daily survival of eggs and chicks were estimated using the modified Mayfield method (Mayfield 1961, 1975; Bart and Robson 1982, Hines 1996). To calculate Mayfield estimates, the date of failure was assumed to be the midpoint between the last two nest checks. Estimates of time of hatching were accurate to two days, thus exposure days were assigned to the incubation or the nestling periods.

Rates of chick development were calculated for mass (g/day) and wing chord length (mm/day) for each chick during the linear phase of growth by fitting a straight line to the data using the least squares method. We defined linear growth as the time period which mass or wing length measurements increased. Growth rates were averaged across all chicks to calculate a mean growth value. Means are presented ± SE, unless otherwise stated.

RESULTS

Characteristics and Selection of Nest Sites

During 2008, 17 Kittlitz's murrelet nests were located and monitored at Agattu Island (Fig. 3). Nest site locations (25-m radius area around nest) ranged from flat, vegetated and relatively rock-free areas to scree and talus covered mountain slopes (mean slope = 35°, SE = 2.00, range = 15 - 40°, *n* = 17), at a mean elevation of 458 m (SE = 13.76, range = 375 - 562 m, *n* = 17). The average straight line distance from the nest to the sea was 2.1 ± 0.2 km (range = 1.1 - 3.4 km, *n* = 17). The interior dimensions of the nest scrape measured averaged 10.3 x 2.2 cm (diameter: SE = 0.2, range = 9.0 - 11.5 cm, *n* = 17; depth: SE = 0.2, range = 1.4 - 4.0 cm, *n* = 17). The mean vegetative cover was 50% (SE = 3.5%, range = 25 - 70%, *n* = 17).

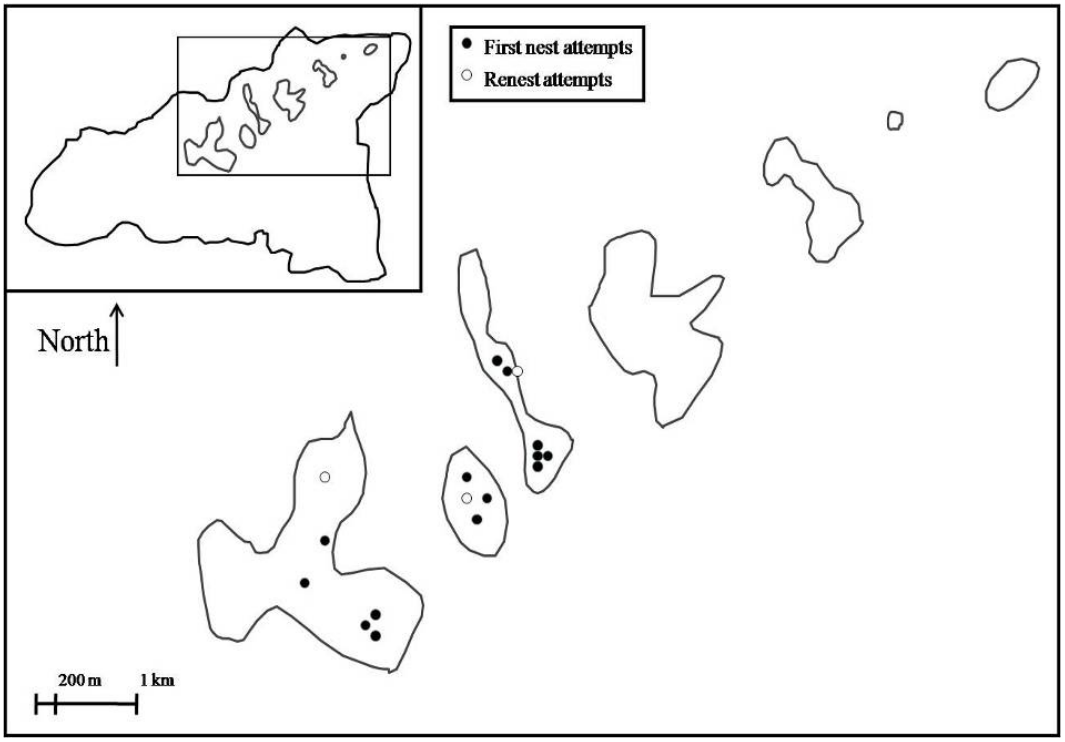

Figure 3. Nest locations of breeding Kittlitz's murrelets, Agattu Island, Alaska, 2008. Outline of mountains represent 300 m contour lines. Points mark locations of first (solid circles) and renest (empty circles) attempts.

Semi-colonial nesting was not observed at Agattu. On the three submassifs where three or four nests were located, distances among neighboring nest sites averaged 287 m (SE = 102, range = 110 - 430 m, *n* = 4), 310 m (SE = 62, range = 220 - 430 m, *n* = 3), and 453 m (SE = 80, range = 260 - 800 m, *n* = 4) apart, respectively (Fig 3).

Nest vegetation data were collected for 17 nest site plots and 68 non-use plots. Additionally, vegetation data were collected for 50 random plots located in the montane strata ≥ 300 m above sea level. An analysis using a discriminant function analysis (DFA) will be conducted to quantify nest site selection by breeding murrelets at a later time.

Breeding Chronology, Egg, Chick, and Chick Growth

The breeding period of Kittlitz's murrelets at Agattu extended from early June to late-August and was highly synchronous. All first nesting attempts were initiated over an 11-day period (range = 1 Jun - 11 Jun), with a mean clutch initiation date of 5 Jun (*n* = 12). The mean hatching date was 5 Jul (range = 30 Jun - 10 Jul, *n* = 8).

All clutches contained one egg. Eggs were sub-elliptical in shape and measured an average of 57.5 x 37.8 mm (first nests only, length: SE = 0.6, range = 54.3 - 60.6 mm; width: SE = 0.8, range = 30.4 - 41.0 mm, *n* = 12; Table 1). The average mass of fresh eggs (≤ 7 d old) was 43.3 g (SE = 3.0, range = 37.5 - 47.5 g, *n* = 3), and ~19% of adult body mass (adult mass = 224 g). Eggs were pale-green with irregular brownish-black, tar-colored spots that ranged from speckling (<1 mm) to patches and streaks (<10 mm). These marks covered the eggs entirely, especially at the blunt end of the egg (Fig. 4).

Figure 4. Kittlitz's murrelet egg at nest, Agattu Island, Alaska, 2008.

Table 1. Kittlitz's murrelet egg measurements collected at Agattu Island, Alaska, 2008.

1st Nests	Nest	Length (mm)	Width (mm)
	08KIMU01	58.7	30.4
	08KIMU02	58.8	39.7
	08KIMU03	59.4	41.0
	08KIMU04	56.0	35.8
	08KIMU05	59.2	38.2
	08KIMU06	56.3	40.2
	08KIMU07	54.3	36.5
	08KIMU09	54.7	36.9
	08KIMU10	57.5	39.5
	08KIMU11	55.8	38.1
	08KIMU12	58.1	39.7
	08KIMU15	60.9	37.5
	Average	57.5	37.8
	SD	2.0	2.8
	n	12.0	12.0
Renests			
	08KIMU08	55.7	36.7
	08KIMU14	60.8	40.0
	08KIMU17	58.5	38.6
	Average	58.3	38.4
	SD	2.6	1.7
	n	3.0	3.0

The linear phase of chick mass increase lasted at least for the first 15 days (Fig. 5). Patterns of chick development became less predictable thereafter, probably associated with either unpredictable provisioning or low quality food.

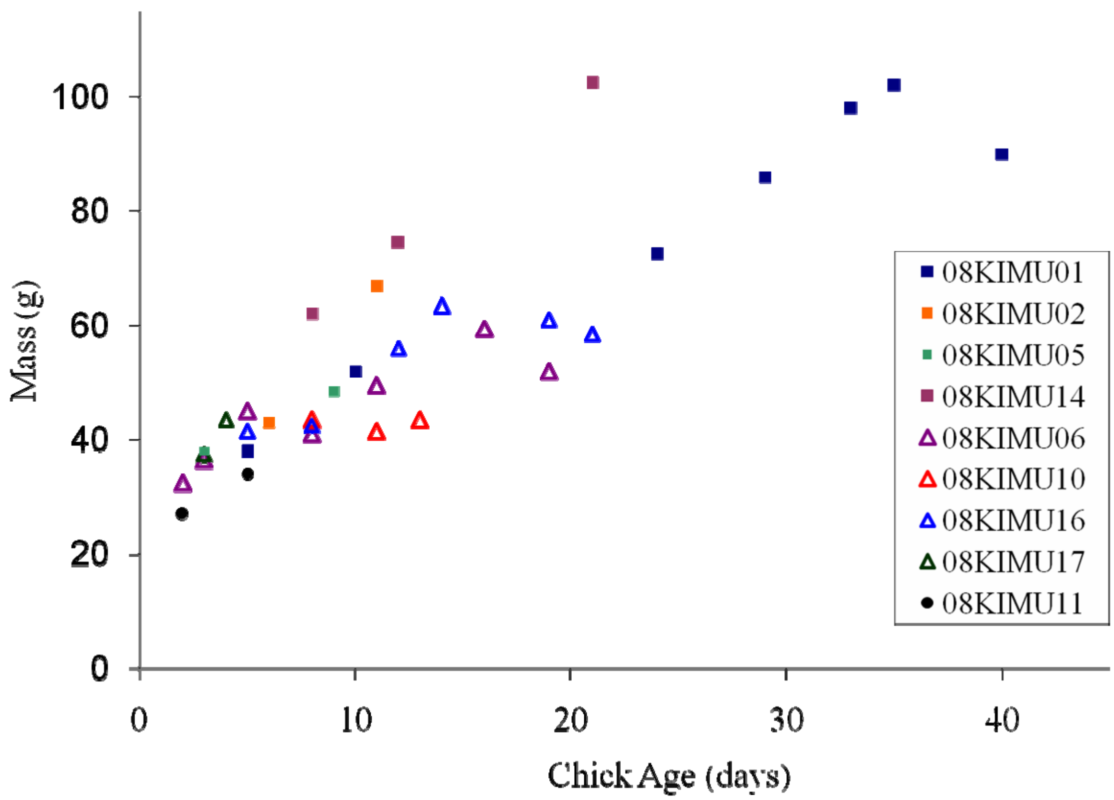

Figure 5. Changes in body mass of Kittlitz's murrelet chicks at Agattu Island, Alaska, 2008. Symbols represent individual chicks; squares are *control* nests receiving fewer visits by researchers during the 30 d brood rearing period, triangles are *disturbed* nests receiving visits by researchers every three to four days up to fledge. Circles represent a single nest which failed early in the nestling period.

Wing chord (including outer primaries) increased linearly throughout development after primaries began to emerge at approximately day 5 of the nestling period (Fig. 6). As the primaries developed, wing chord increased to 107 mm (n = 1), or 75% of adult wing length at 40 d post-hatching (adult wing length = 143 mm).

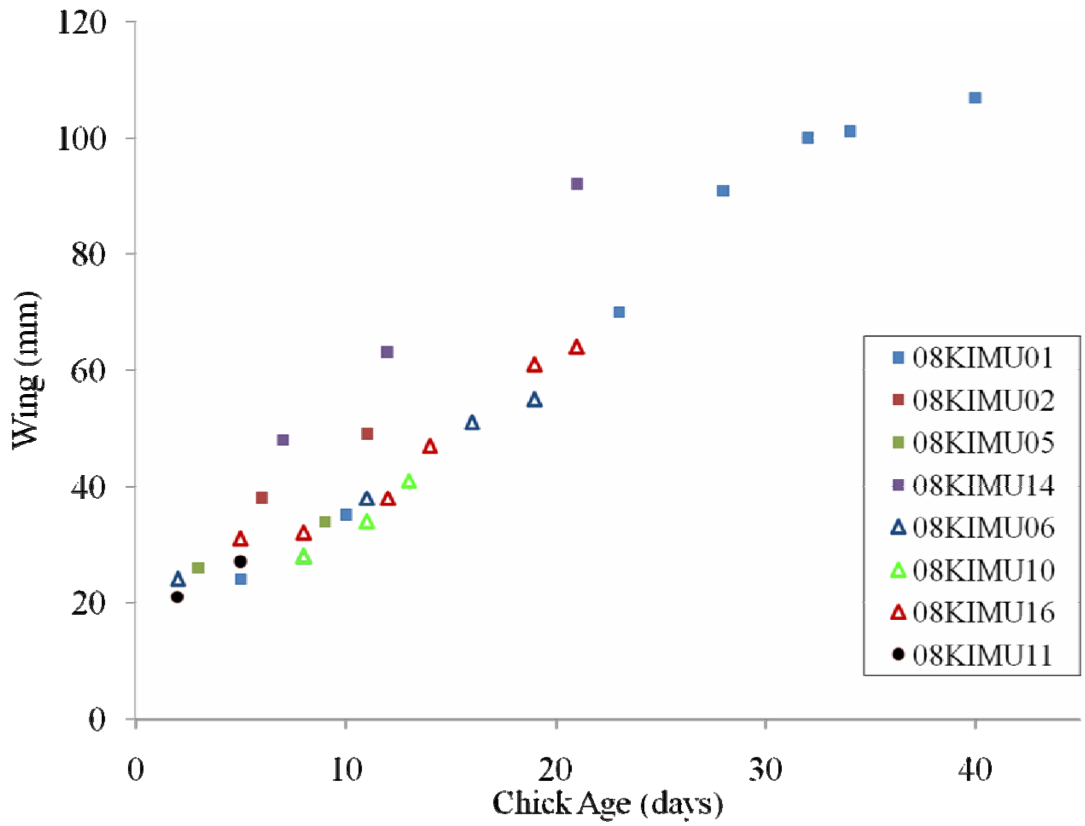

Figure 6. Changes in wing length of Kittlitz's murrelet chicks at Agattu Island, Alaska, 2008. Symbols represent individual chicks; squares are *control* nests receiving fewer visits by researchers during the 30 d brood rearing period, triangles are *disturbed* nests receiving visits by researchers every three to four days up to fledge. Circles represent a single nest which failed early in the nestling period.

Growth rates in chick mass between control and disturbed groups did not differ (Table 2). The pooled mean for mass for the two groups was 2.4 g/day (SE = 0.4, range = 1.0 to 4.8 g/day, *n* = 7). The pooled mean for wing length for the two groups was 2.3 mm/day (SE = 0.2, range = 1.3 to 3.4 mm/day, *n* = 7).

Table 2. Mean growth rates of Kittlitz's murrelet chicks at Agattu Island, Alaska, 2008. Chicks were measured during the linear phase of growth. Individual chicks measured at least 3 times were the sample units.

Parameter	Control	Disturbed	Pooled	Test	Statistic	df	*P*
Mass (g/day)	2.9 ± 0.7 (4)	1.7 ± 0.3 (4)	2.4 ± 0.4 (8)	*t*	1.74	5	0.14
Wing chord (mm/day)	2.4 ± 0.4 (4)	2.3 ± 0.1 (4)	2.3 ± 0.2 (8)	*t*	0.23	5	0.83

Tissue Samples and Genetic Materials Collected for Population Study

Using the brachial vein bleeding technique, blood samples were collected into centrifuge tubes containing Longmire buffer from all chicks at age 8 to 12 days (*n* = 7), as well as onto filter paper (*n* = 7). Chicks that died at the nest due to exposure or starvation were collected and preserved in several ways: heart tissue was collected, minced, and preserved in Longmire buffer (*n* = 3); partial skeletons (*n* = 5), body and organ tissues (*n* = 4) were preserved in 95% ETOH; skins of chicks were field prepared and salted for preservation and eventual museum accession (*n* = 5); or the entire chick was preserved in 95% ETOH (*n* = 2).

Of eggs that failed to hatch or were depredated and could be recovered, egg shells and membranes were dried and stored (*n* = 3) and the dead embryo (non-hatching egg) was preserved in 95% ETOH (*n* =1). All egg shell membranes and shell fragments encountered at hatched nests were collected (*n* = 11), as well as any remains of dead murrelet adults (*n* = 1) or adult body feathers (*n* = 10 nest sites where feathers were collected). Additionally, fresh fecal materials were collected from nest sites and stored with sodium bicarbonate as a way to determine chick diets using otoliths from fishes found in the excrement (*n* = 8). Overall, we collected at least one type of genetic sample from 14 of the 17 nests monitored in 2008.

Nestling Diet and Adult Provisioning Patterns

Adult attendance was most common during dusk and dawn, but occurred throughout the day for some nests. No adults were observed feeding chicks between (0100-0500h). All food loads consisted of single fish carried crosswise in the adults' bill. Three fishes collected from separate nest sites were: pacific cod (*Gadus macrocephalus*; total length: 45 mm), sandlance (*Ammodytes hexagrammos*; total length: 65mm), and Atka mackerel (*Pleurogrammus monopterygius*; total length: 83 mm). Photos and video will be examined to identify specific prey items brought to nestlings by adults.

Average number of nest visits by adults per nest ranged from 1.8 to 6.7 visits per day. The total number of days which a nest was monitored by camera ranged from 4 to 14 days (Table 3). For nests where individual adults could be uniquely identified, the frequency of visits for each parent was calculated. Of the four nests with photos or video footage, nest attendance was skewed at three nests with one adult making the majority of provisioning visits to the nest (Table 4).

Table 3. Parental provisioning by adult Kittlitz's murrelets from time-lapse photos and real-time video during the nestling period at Agattu Island, Alaska, 2008.

Nest	Average visits per day	SD	Range of visit/day	Total visits during nestling period	Total days monitored
08KIMU06	6.3	2.1	6 - 11	76	12
08KIMU10	1.8	1.0	1 - 4	18	10
08KIMU16	6.7	4.3	1 - 16	94	14
08KIMU17	2.3	1.5	1 - 4	9	4

Table 4. Individual feeding rates of adult Kittlitz's murrelets from time-lapse photos and real-time video during the nestling period at Agattu Island, Alaska, 2008.

Nest	Adult	Total nest visits	% of nest attendance
08KIMU06			
	Dark adult	23	31
	Light adult	27	36
	Unknown adult	25	33
	Total visits	75	100
08KIMU10			
	Dark adult	4	22
	Light adult	13	72
	Unknown adult	1	6
	Total visits	18	100
08KIMU16			
	Dark adult	55	58
	Light adult	29	31
	Unknown adult	11	12
	Total visits	95	100
08KIMU17			
	Dark adult	1	9
	Light adult	8	73
	Unknown adult	2	18
	Total visits	11	100

Average duration of a nest visit ranged from 9 to 12 minutes for the four nests with cameras (Table 5). One adult remained at the nest for one hour, but this was an outlier and was likely associated with the disappearance of the mate as the other adult never appeared at the nest site again. The minimum and maximum duration of time between visits for a single adult was 12 minutes and 38 hours, respectively.

Table 5. Duration of nest visits of adult Kittlitz's murrelets at Agattu Island, Alaska, 2008. Time lapse photos were recorded every 3-minutes for 24 hours per day during the nestling period. Values are presented as minutes.

Nest	*n*	Average	SD	Range
08KIMU06	75	0:09	0:06	0:03 - 0:33
08KIMU10	18	0:09	0:04	0:03 - 0:21
08KIMU16	95	0:11	0:07	0:03 - 1:00
08KIMU17	11	0:12	0:03	0:09 - 0:18

Breeding Success

Sixteen murrelet nests were located during the incubation period and one was found at day 5 of the nestling period. Of the 16 nests found during incubation, we treated three as replacement clutches (renests), based on the late dates of nest initiation. Daily nest survival of first nest attempts during the incubation stage was 0.963 ± 0.053 (six losses per 160 exposure days, $n = 13$), and the probability an egg would survive the 30 d incubation period was 0.32 ± 0.13. Daily nest survival for the nestling stage of first nests was 0.946 ± 0.080 (seven losses per 130 exposure days, $n = 8$), and the probability of a chick surviving the 30 d brood-rearing period was 0.19 ± 0.14. Overall, nest survival from clutch initiation to fledging of first nest attempts, calculated as the product of the stage-specific rates over the incubation and nestling periods, was 0.06 ± 0.06.

For first nest attempts, the primary factors associated with nest failures during the incubation stage were egg predation (31%, four of 13 eggs were depredated), most likely by glaucous-winged gulls or common ravens. Two eggs failed to hatch; one was infertile and the other ceased development after ~day 21 of incubation. The remaining seven eggs hatched successfully. The main cause of nest failure during the nestling period was either exposure to inclement weather or starvation (70%, seven of ten chicks were found dead in the nest scrape). Of the other three chicks, two (20%) were depredated, and one fledged from the nest after day 40. The extended duration of the brood-rearing period of the one successful nest suggests plasticity in parental attendance; however, the chick had exhibited mass loss from 102 g at day 35 to 90 g at day 40. At the same time, the wing length continued to grow from 100 mm at day

35 to 107 mm at day 40 and is likely a better measure of a chick's preparedness for nest departure than overall mass.

The three replacement clutches were located during the incubation period and had initiation dates 16, 17, and 35 days later than the latest clutch initiation date of first breeding attempts, respectively. One nest failed due to egg predation, presumably due to glaucous-winged gulls or common raven. Of the two surviving to hatch, one chick was depredated after day 21 and the other died of exposure or starvation at day 7.

RECOMMENDATIONS FOR 2009

The discovery of so many Kittlitz's murrelet nest sites and their relative availability to researchers makes Agattu Island the best site in Alaska to study the breeding ecology of this poorly known species. We recommend continued monitoring of nests using remote, time lapse field cameras to elucidate parental provisioning rates and nestling diets. In fact, deploying cameras to every nest is recommended. The high rate of nest failure due to chick mortalities, either as a result of exposure or starvation, warrants an increased focus on this aspect of murrelet breeding ecology. Researchers should continue to wear camouflage clothing and carefully camouflage cameras. The frequency of visits to nests by researches might be reduced, because there appeared to be slightly, but not significantly, lower growth rates of chicks that were visited more frequently. Affects of researcher visits on chick growth and nest survival should continue to be examined using the two treatment groups. Other than the addition of camera deployment at control nests and their subsequent maintenance, the same protocol for nest monitoring of control nests emphasizing a limited number of visits should be followed (see Appendix A, Nest searching and monitoring instruction).

Temperature loggers provided a coarse estimate of failure dates from most nests, but experimentation with iButton temperature loggers should test new methods for deployment which may increase the accuracy of results (i.e., maximum depth of deployment in nest scrape, selection of top or bottom of logger surface to be exposed to egg or chick and subsequent waterproof/resistance). Additionally, because the accuracy of the temperature loggers was not fine scale enough to detect when the adult resumed incubation of the egg, nests discovered by flushing an incubating adult should be revisited three to four days after discovery to confirm the nest's continued activity.

While cameras placed 1.5 m from nest sites did not affect adult attendance, cameras with telephoto capabilities (preset focus distance) may be preferred because the increased distance from the nest would reduce the likelihood of predators locating chicks at nest sites should they be attracted by the presence of a camera. One drawback of increasing the camera's distance from the nest, however, is reduced image quality due to precipitation (i.e., fog, rain). Good image quality is essential to identification of prey species provisioned to chicks. A second drawback of using cameras with telephoto capabilities is that nests placed in depressions or surrounded by large rocks may be obscured from view using a 4-m fixed distance. Having several cameras set with different focus lengths may be an alternative. Regardless of camera distance, best results were found by placing cameras so they were aimed in a north-facing direction and slightly downward to minimize the collection of precipitation on the camera's lens. Additionally, all cameras were fixed with hoods to reduce reflection from sunlight on the infrared flash and camera lens, as well as provide additional protection from rain (Figure 7).

Figure 7. Game camera deployed at Kittlitz's murrelet nest site at Agattu Island, Alaska 2008. Note camera attachment to large rock with additional rocks placed around camera to break-up shape. Hood mounted on front of camera (arrow) provides additional camouflage by covering reflective surfaces of infrared flash and camera lens. Chick at nest is at lower right corner of photograph (circle).

In summary, we recommend the following changes, and emphasize the following points, for nest monitoring of Kittlitz's murrelets at Agattu Island in 2009:

• Deploy time-lapse cameras at all nest sites; the cause of the high rate of nest failure due to exposure or starvation may be better understood by examining the rate of nest provisioning as well as by determining chick diet. Furthermore, in 2008, the two nests which failed due to predation of the chick were *control* nests.

• Researchers should continue to practice extreme caution while in the vicinity of active Kittlitz's murrelet nests with regard to drawing attention to nest sites. Field personnel should wear camouflage clothing and backpacks, as well as camouflage all cameras deployed at murrelet nests.

• To reduce researcher impact on chick survival, young should never be handled during adverse weather conditions.

• Experimentation with temperature loggers may improve their utility at determining the time of a nest's failure.

• Use of time-lapse cameras equipped with telephoto lens capabilities may be preferred; however, increased deployment distance from nest is likely to reduce photo quality and will certainly render motion and infrared photo triggers inoperative.

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APPENDIX A - Kittlitz's Murrelet Nest Searching and Monitoring

[2008 INSTRUCTIONS by Robb Kaler and John Piatt]

The following is a step-by-step procedure for locating and monitoring nests of Kittlitz's Murrelets located on refuge lands at Agattu and Kodiak Islands, Alaska. Minimizing and recording observer impact on reproductive success is an important secondary objective while conducting nest searching and nest monitoring.

Nest discovered during incubation, adult flushed

1. If the nest is found by flushing the incubating adult, confirm identification of *Brachyramphus* spp. (Kittlitz's versus Marbled Murrelet; outer white tail feathers = KIMU).
2. Record behavior (silent, calling) and departure direction of flushed adult and any additional notes.
3. Record presence and number of potential egg or adult predators (e.g., Peregrine Falcon, Glaucous-winged Gull, Bald Eagle, Common Raven, Snowy Owl, other) in the vicinity at the time of flushing.
4. Photograph egg and nest (use scale and nest number card). Take series of scaled habitat pictures, from close-up of egg, to square meter around egg, to habitat from ca. 2, 4, and 8 m away, and more distant shots (where actual nest is less visible, but showing large-scale habitat features, approach to nest). Digital pictures should be downloaded, labeled and archived as soon as possible. Measure egg length and width (± 0.1 mm; calipers); record egg mass (± 0.5 g); float egg in container with water to estimate stage of embryonic development: [Buoyancy of the egg is related to stage of incubation and hatching date as follows (~30 d incubation period): 0 d = horizontal on the bottom of the container; 5 d = oriented at 45 degrees; 13 d = vertical orientation (90 degrees); 16 d = float to surface; 20 d = ~20 mm diameter circle protrudes above the water surface].
5. Examine nest site carefully for evidence of use of nest site in previous year, i.e., look for small egg shell fragments, bits of old down, and fecal material. All may be present in small quantities, egg shell fragments are most conspicuous and easy to photograph (use macro lens).
6. Using a GPS receiver, mark a waypoint for the nest's location (Garmin Map76S with averaging feature, ±10 m accuracy; record datum [WSG 84, NAD 27, NAD 83, etc.]).
7. Without causing disturbance to the local area (things which may draw attention by avian predators; things which may influence adult recognition or attendance at the nest such as moved rocks and boulders), construct one simple rock cairn ≥ 8 m from the nest. Record bearing and distance to nest.
8. Construct a 2^{nd} rock cairn at 30 m distance and with a view of the nest and smaller rock cairn. Record distance and bearing to the nest from this rock cairn. Using a GPS receiver, mark a waypoint at the second rock cairn.
9. This second cairn will be the observation point for monitoring the nest during the incubation period; minimize disturbance at the nest but be able to resight the incubating adult without flushing the bird. Draw field sketch in a field notebook which can be used to relocate the nest. Use rock features and distances to help.

10. Aim to be at the nest site <10 minutes during monitoring visits. Field crew would preferably wear camouflage or dark colored clothing and have dark colored field packs to reduce drawing attention by predators. At Agattu Island, Glaucous-winged Gulls are likely the primary egg predator of nesting KIMU, at Kodiak it may be ravens or eagles.
11. Visit each nest during the incubation period every 3-4 days to determine presence or absence of the adult. As the day of hatch approaches, visits to nest will increase to every 1-2 days in order to detect the hatching event. Individual nests could be placed in a random order with two types of nest monitoring treatments: a) monitored *regularly* (3-4 d), and b) monitoring *infrequently* (4 times during entire breeding period; once at discovery, twice during brood period (5-6 d, 24-25 d), and once at fledge (>30 d). The second visit to the nest may need to be accelerated to as early as 22-24 days in alpine areas with more extreme environmental conditions, as this may compress the chick-rearing period (Piatt et al. 1999; fledging at 24 days).

Summary of nest data collection during incubation period:

- determine species
- record adult behavior and departure direction
- note predators in area
- photograph egg and nest site at different scales
- measure egg (width, length, mass)
- float egg
- examine nest site for previous use, and document
- record nest location
- construct small rock cairn ≥ 8 m from nest that can be seen with binoculars from ≥ 30 m
- construct larger rock cairn ≥ 30 m from nest and record gps location (observation point)
- draw field sketch to help locate nest site using distance between nest site and land marks or identifiable rocks.

Nest discovered without flushing adult during incubation

1. Avoid flushing bird; back well away from the nesting adult, but it is important to be able to relocate the nest for future monitoring. Take photographs while backing away and view from cairns (below) to help document location for later return (review these before return).
2. Discreetly build a small rock cairn at comfortable distance (>8m) from bird. Record a GPS point, bearing and distance to the incubating adult. Draw a field sketch of the nest location using distances to specific landmarks and rocks.
3. Depending on nest monitoring treatment (disturbed versus control), visit each nest during the incubation period every 3-4 days to determine presence or absence of the adult until the egg hatches.

Nest monitoring- brood rearing

During the nestling period, frequency of nest visits will depend on treatment assigned (DISTURBED versus CONTROL). Nest visits to DISTURBED nests will be conducted every three to four days. All nest visits will be conducted at the same time of day for each nest to maintain consistency of measurements.

During each visit to DISTURBED nests, and during the two visits to CONTROL nests, chicks will be:

1. weighed (± 1 g)
2. length of the right wing will be measured (± 1 mm) two ways:
   A. from the carpus to the tip of the longest primary with the wing held flat and straight along a ruler.
   B. from the carpus to the tip of the longest primary with the natural curve of the wing held along a ruler.
3. Calipers will be used to take linear measurements of the
   A. total head
   B. exposed culmen
   C. tarsus
   D. tail length
4. A blood sample will be collected from each nestling for genetic analyses and sex determination at the first available opportunity (unless chick is just hatched or very young, wet or apparently stressed).
5. If on any occasion you find the chick dead at the nest site, collect the entire specimen and bag it in a whirlpak, cover in 70% ethanol. Take pectoral muscle tissue samples for genetics and stable isotope analyses, e.g., 1-2 g tissue in 5 ml cryovial, in 70% ethanol. Do NOT put in so much that you fill the vial - this is too much and the tissue dissolves. Write date and locality on vial with indelible marker.

Summary of nest data collection for DISTURBED treatment during brood-rearing period:

- Visit every 3-4 d
- Prior to measuring chick, reduce exposure to predation by checking area for predators first, delay work if predators present
- Set-up processing equipment >15-20 m from nest, then remove chick from nest scrape for measurements, and quickly return to nest after work completed. Aim to handle chick for <10 min. Collect growth measurements for young (mass, wing chord [natural], tail, total head, exposed culmen, and tarsus}.
- Photograph chick at each nest visit during brood-rearing.
- Single blood sample during 1st or 2nd visit to nest.

Summary of nest data collection for CONTROL treatment during brood rearing period:

- Visit nest 5 times; once at discovery, once at 5-6 d of age during chick-rearing, once at 9-12 d of age for blood sample, once at 24-26 d of age during brood rearing, and once post-fledging (≥30 d).
- At nest visits during the collect growth measurements for young (mass, wing chord [flattened and natural], tail, total head, exposed culmen, and tarsus}.
- Photograph chick at each nest visit during brood-rearing.
- Single blood sample during 1st or 2nd visit to nest.

APPENDIX B - Kittlitz's Murrelet Nest Vegetation Data Collection

[2008 INSTRUCTIONS by Robb Kaler and John Piatt]
Nest site characteristics will be measured after completion of nesting so that the bird is not disturbed while attempting to breed. Vegetation data will be collected at 1) each nest site, 2) at 2-4 adjacent "non-use" plots placed at random bearings and distances from the nest, and, 3) at "non-use" plots scattered randomly throughout a larger area in which the nest is located, including a gradient of altitudes below and above the altitude at which the nest is found. The adjacent "non-use" plots will provide data on possible micro-habitat differences in site quality (as scale of <100 meters) while the area "non-use" plots will provide data on altitudinal gradients in habitat quality.

At the nest site itself, and in non-use plots, a suite of variables known or suspected to be of some importance in nest-site selection (Day et al. 1983, Piatt et al. 1999, Kaler et al. 2008) will be assessed, including slope, nest "aspect", elevation, distance to nearest ridge, and size of adjacent rocks (see datasheet). Position (GPS location), nest diameter and depth, and composition will also be noted. Actual dimensions of the 3 largest adjacent rocks will be recorded. The nest (or more appropriately, the "nest scrape") composition should be described; e.g. for presence of rocks and pebbles, vegetation in the scrape, and the presence or absence of any material left from previous nesting effort (old egg shell fragments, feathers, fish parts, etc.).

Using a 5-m radius plot centered around the nest site, or non-use plot center, ground cover data will be collected using a scoring system (see below) to classify estimated percentages into 12 groups of ground cover types (see datasheet). These include estimates of gross coverage by soil, vegetation or rocks (by default, what is not covered by soil or vegetation). These categories are broken in to smaller categories; rocks are subdivided into small (<10 cm, softball size), medium (10-30 cm, basketball size), and large (>30 cm, boulders and solid rock outcropping) rocks (with a subcategory for rock sizes [>20 cm] most often used by KIMU to nest against); vegetation is subdivided into lichens (with subcategory of orange crustose lichen that ultilizes high nitrogen nutrient such as guano), moss, grass, forbs (flowering plants) and woody shrubs.

Using a 25-m radius plot at each nest, or non-use plot, percentage classes of each general vegetation type present will be estimated using the classification system of Viereck et al. (1992). Geographical data will be recorded for each 25-m vegetation plot. In addition, at non-use plots, data on location (lat, long) and habitat characteristics (slope, elevation, aspect) will be recorded.

Cover values will be estimated for 5-m radius circle centered around nest or non-use plot. Percentages of coverage by soil, rock, plants, etc., will be estimated using score values as follows: 0 = <<1%; 1 = <1%; 2 = 1-4%; 3 = 5-10%; 4 = 11-25%; 5 = 26-50%; 6 = 51-75%; 7 = 76-90%; 8 = 91-95%; 9 = 96-100%. General habitat categories will be estimated for each 25-m radius plot (Viereck et al. 1992). Elevation above sea level is measured with GPS and confirmed on topographic map. Slope angle is measured in degrees with a clinometer or by estimating visually with a protractor held perpendicular to the horizon. Aspect is the compass direction which the nest site faces measured to the nearest 10 degrees with a hand held compass.

Obviously, nest plots of concentric 5 and 25 m rings are centered on individual nest sites. Non-use plots adjacent to nest plots will be selected in order to assess relatively fine-scale variability in nesting habitat. The four adjacent non-use sites should be chosen at random directions and distances from the nest plot, but options are limited by our desire to measure habitat within a reasonable range of the nest. We choose to sample habitat within 100 m of the original nest. Of course, the center of any adjacent plot must be at least 50 m away from the nest to allow two plots of 25 m radius to fit next to each other. Therefore adjacent non-use plots have to be from 50 to 100 m away from the nest. Non-use plots can be therefore selected randomly by choosing a random number from 50 to 100 (to get distance away) and a random angle from 0-360 (to get the direction away from the nest). It is problematical to select 4 random directions and not have these relatively close circles overlap. Therefore, after randomly selecting the first direction (e.g., 100 deg), then the remaining 3 directions should be at 180, 90 and 90 deg angles from the first direction (i.e., 280, 10, and 190 deg, respectively). Distances in each direction should be chosen as a random number between 50 and 100.

We also wish to examine meso-scale differences in habitat quality, i.e., differences over scales of 100s or 1000s of m. Mountainous terrain used my murrelets changes more rapidly with elevation than with horizontal distance. Thus, one might walk for many km at the same elevation as a nest site (e.g., at 500 or 1000 m) and observe little change in vegetative cover or rock coverage, but move from heavily vegetated scrub or forest at sea level to bare, rocky crustose-lichen barrens at 500-1000 m. Therefore, for characterizing meso-scale variability, we recommend drawing a vertical line through each nest site and running it from lowest to highest elevations from the nest site. The line should be broken into equal elevational sections (e.g., 100 m intervals) and then area use-plots should be sampled at random distances from each side of the line, within each elevational distance interval; the maximum horizontal distance being no greater that the maximum altitude distance. A simple example: Nest found at 450 m on a 600 m peak, whose valley floor starts at 100 m. Elevation sample strips would be at 100-200m, 200-300m, 300-400m, 400-500m, and 500-600m. Maximum horizontal sampling distance would be 500 m (600-100), minimum of 50 m to avoid overlap of circles. Following could be a random selection of sample plots; given as (elevation range, distance of plot to left, distance of plot to right): (100-200, 63, 144), (200-300, 430, 322), (300-400, 57, 499), (400-500, 411, 212), (500-600, 108, 222). Thus for each nest, we would obtain data on 10 plots at varying altitudes. With 5 different nests, we might sample 50 altitudinal plots. With fewer nests, one could sample more latitudinal plots by simply increasing the division of altitude strips from 100 to 50 m, or increase the number of lateral plots sampled in each altitude strip.

To compare known nest sites with "available" KIMU nesting habitat at Agattu (areas >300 m above sea level), 50 randomly selected vegetation plots will be conducted. These random plots will follow the same methods using 5- and 25-m radius plots. Random plot selection will be conducted by overlaying a virtual 10 km by 10 km sampling grid over the mountainous area of Agattu. Each 1 km^2 block within this grid containing alpine habitats (i.e., >300 m above sea level) will be selected. To randomly choose plot locations within these 1 km^2 blocks, a sub-grid of 100 m by 100 m will be superimposed with grid lines placed at every 100 m and delineated as 1, 2, 3, …, 10 along the x- and y-axis. Using the randomization function in Microsoft Office Excel [=RANDBETWEEN(1,10)], x and y points will be chosen. If plots are outside of alpine habitats (<300 m), are inaccessible or cannot be conducted safely, a new point location will be selected.

The following data sheets can be used to sample nest plots, adjacent non-use plots, and random plots. These data sheets should be used for direct data entry in the field (ideally, rite-in-rain versions are available), or, carry a copy of the data sheet with you and write al l the relevant information in a field notebook, and transcribe to clean data sheets later.

KIMU Nest Vegetation Datasheet – Year __________ Island _____________

NEST # ________ Characteristics:

Nest ID #		Observer	
Date visited		Nest active?	
Latitude		Longitude	
Plot type	nest / random	GPS Datum type	
Slope (degrees)		Aspect (degrees)	
Position on slope		Elevation (m)	
Cairn to nest angle (deg)		Observ. point to nest (deg)	
Nest diameter (mm)		Nest depth (mm)	
Nest aspect (deg)		Distance to ridge/peak (m)	
Rock 1 dim. (LxWxH cm)		Rock 2 dimensions	
Rock 3 dimensions			
Nest composition: Comments:			

NEST plot

5-m radius plot			
Measure of ground cover		% Lichen cover	
% Soil cover		% Orange crustose lichens	
% Rock <10 cm diam		% Moss cover	
% Rock10-30 cm diam		% Grass cover	
% Rock >30 cm diam		% Forb cover	
% Avail. nest rock (>20 cm)		% Shrub cover	
		% Overall veg cover	
25-m plot			
Viereck Class			
% Vegetated		% Water	
% Unvegetated		% Snow	
Comments:			

Non-Use Plot # _______ **Relative to Nest # _________**

Dist to nest _______ m **Bearing from nest _________ deg**

5-m radius plot			
Measure of ground cover		% Lichen cover	
% Soil cover		% Orange crustose lichens	
% Rock <10 cm diam		% Moss cover	
% Rock10-30 cm diam		% Grass cover	
% Rock >30 cm diam		% Forb cover	
% Avail. nest rock (>20 cm)		% Shrub cover	
		% Overall veg cover	
25-m plot			
Latitude		Longitude	
Slope (deg)		% Vegetated	
Elevation (m)		% Unvegetated	
Aspect (deg)		% Water	
Viereck Class		% Snow	
Comments:			

Non-Use Plot # _______ **Relative to Nest # _________**

Dist to nest _______ m **Bearing from nest _________ deg**

5-m radius plot			
Measure of ground cover		% Lichen cover	
% Soil cover		% Orange crustose lichens	
% Rock <10 cm diam		% Moss cover	
% Rock10-30 cm diam		% Grass cover	
% Rock >30 cm diam		% Forb cover	
% Avail. nest rock (>20 cm)		% Shrub cover	
		% Overall veg cover	
25-m plot			
Latitude		Longitude	
Slope (deg)		% Vegetated	
Elevation (m)		% Unvegetated	
Aspect (deg)		% Water	
Viereck Class		% Snow	
Comments:			

APPENDIX C - Annotated list of bird and mammal species observed primarily on the north side of Agattu Island, Alaska, 27 May-26 August 2008.

Abundance categories were defined at Agattu Island as follows:
Abundant: 50 individuals per day or 6 per hour
Common: 10-49 individuals per day or 2-5 per hour
Fairly common: 5-9 individuals per day or 1 per hour
Uncommon: 2-4 individuals per day or <1 per hour
Rare: 1 individual per day

Birds

Common loon (*Gavia immer*).--Uncommon. Birds were observed on 48 days between 31 May-26 August. Single pairs were observed on multiple lakes on the south and west sides of the mountains at Agattu. A single adult was observed foraging on multiple days in Binnacle Bay during mid-August.

Red-throated loon (*Gavia stellata*).--Uncommon. On 4 June, a pair was observed nesting on a small lake west of Loon Lake. Adults were commonly heard or seen flying between Loon Lake and Binnacle Bay from 28 May-25 August. On 1 July, two young were observed with adults on Loon Lake. On 18 August, two young were accompanied by two adults in Binnacle Bay and seen regularly there after until our departure from Agattu on 26 August.

Sooty shearwater (*Puffinus griseus*).--Rare. One dead adult was collected from a dense kelp mat that washed ashore on 26 August.

Shearwater spp. (*Puffinus* spp.).--Rare. Approximately 50 unidentified shearwaters were observed foraging ~ 0.5 to 1.5 km north of the westernmost side of Binnacle Bay. Birds observed were foraging with gulls, presumably feeding on a large school of forage fish on 27 June, 1 July, and 6 July.

Fork-tailed storm-petrel (*Oceanodroma furcata*).--Common. Birds were regularly heard at night in Binnacle Bay from 27 May-24 August for a total of 64 days detected. Multiple colonies were encountered and elevation of colonies ranged from 150 to 500 m above sea level. Colonies were located in either boulder fields covered with a dense *Sphagnum* moss or ericaceous dwarf shrub mat or in exposed boulders with no vegetative cover. Adults were commonly heard calling from boulder crevices during the day. Hatched egg shells of storm-petrels (species unknown) were seen at the entrance of crevices beginning 29 July.

Leach's storm-petrel (*Oceanodroma leucorhoa*).--Common. Birds were regularly heard at night in Binnacle Bay from 27 May-24 August for a total of 64 days detected. Multiple colonies were encountered and elevations ranged from 150 to 500 m above sea level. Colonies were located in either boulder fields covered with a dense *Sphagnum* moss or ericaceous dwarf shrub mat or in exposed boulders with no vegetative cover. Adults were commonly heard calling from boulder crevices during the day. Hatched egg shells of storm-petrels (species unknown) were seen at the entrance of crevices beginning 29 July. Two individuals were rescued from the camp latrine (open pit).

Pelagic cormorant (*Phalacrocorax pelagicus*).--Rare. Observed in Binnacle Bay on 17 days from 31 May-25 August. Individuals were seen foraging near the mouth of Binnacle stream or in the middle of the bay.

Red-faced cormorant (*Phalacrocorax urile*).--Rare. First observed on 6 July attending a nest on the east side of Binnacle Bay. Individuals were observed for a total of 10 days from 6 July-10 August and were seen foraging near the mouth of Binnacle stream or in the middle of Binnacle Bay.

Unidentified cormorant spp. (*Phalacrocorax* spp.).--Unidentified cormorants were seen in Binnacle Bay from 28 May-24 August on 19 occasions.

Aleutian cackling goose (*Branta hutchinsii leucopareia*).--Common. Geese were one of the most frequently encountered birds at Agattu and were observed on 84 days from 27 May-25 August. Nests were most often located in patches of tall grass and elevations of nest site ranged from sea level to 400 m. The first goslings were observed on 18 June. In general, movements by adults with young were to higher elevation areas on the island, at least for the north side of Agattu where alpine habitats are available. Adults began molting and congregating in large groups (>20 individuals) around 20 July; by mid-August birds began vocalizing more regularly and were seen flying over the island, usually north, in flocks of 10-20 individuals.

Mallard (*Anas platyrhynchos*).--Rare. A male and female were observed on a small ephemeral lake on the north side of the island on 22 June.

Eurasian green-winged teal (*Anas crecca crecca*).--Rare. A male and female were observed on the water at Binnacle Bay near the shoreline on 5 June. A male and female pair were observed at camp on four separate occasions, in dense vegetation (*Heracleum lanatum, Cacalia auriculata, Aconitum maximum*) near a small, ephemeral wetland from 3 August-26 August.

Greater scaup (*Aythya marila*).--Rare. A male was observed near the mouth of Binnacle stream on 3 August. This male was observed foraging with a male and female Green-winged teal.

Harlequin duck (*Histrionicus histrionicus*).--Fairly common. A group of 2-15 individuals were observed on 32 occasions from 31 May-22 August with the highest frequency of observations in late June. Only one male in breeding plumage was ever observed at one time, and more commonly, females were seen together. Birds were generally observed foraging at the mouth of Binnacle stream and occasionally seen loafing on rocks.

Common eider (*Somateria mollissima*).--Common. Eiders were one of the most frequently observed species in Binnacle Bay and were seen on 91 days from 28 May-26 August. At least 14 pairs were observed throughout the breeding season. After the young hatched, females with ducklings would congregate in groups of 2-8 individuals and fiercely protect the young from Glaucous-winged gulls. Gulls harassed females with recently hatched young, but gull efforts waned over time as the females successfully thwarted the gulls. On one occasion, researchers observed a gull take an 8-10 day old chick from one defending female, at which time 4 other females appeared to help defend the young and one female was able to take the chick away from the gull. Male eiders generally foraged and loafed singly or in small groups with other males or females after chicks hatched.

Recently hatched chicks were first observed on 19 June and then again on 17 July. Males, females, and chicks were commonly seen loafing on rocks.

Peregrine falcon (*Falco peregrinus*).--Uncommon. An adult was observed on 31 May on the east side of Binnacle Bay near a nesting colony of tufted puffins. The falcon was observed flying over the bay and on cliff edges near the colony. Male and female adults (based on size) were observed separately in Binnacle Bay and inland. On 22 June a juvenile was heard on the east side of Binnacle Bay near the tufted puffin colony and two juveniles were commonly heard or seen in Binnacle Bay and inland through 26 August. Juvenile falcons are curious and intrepid and were regularly seen harassing gulls, jaegers, and ravens.

Rock ptarmigan (*Lagopus muta evermanni*).--Uncommon. Rock ptarmigan were observed on 46 days ranging from 30 May to 22 August. Two active nests, each containing nine eggs were located; one on 19 June and one on 29 June. By Backdating of known hatching dates with a 21-day mean incubation period, we determined a clutch initiation date for the two nests of 2 June and 5 June. Using broadcast surveys to determine population size at Agattu, we counted 27 territorial males. For more detail, see Kaler and Kenney (2008).

Rock sandpiper (*Calidris ptilocnemis*).--Uncommon. Small flocks of 2-6 individuals were observed on 73 days from 27 May-25 August. Birds were generally observed in rocky, talus habitat. One or two individuals were occasionally seen or heard along the stream at Binnacle Bay. Two nests were discovered on rocky plateaus at mid-elevation (~150 m) with three and four eggs, respectively. These nests were discovered on 10 and 12 June, respectively. On 24 June, the first juveniles were observed. Birds began forming flocks of 4-6 individuals around late July.

Gray-tailed tattler (*Heteroscelus brevipes*)--.Rare. An adult was observed on 16 August wading along Binnacle stream approximately 500 m from the bay. Vocalization of the bird, as well as visual clues confirmed species identification.

Parasitic jaeger (*Stercorarius parasiticus*).--Uncommon. Primarily dark morph parasitic jaegers were observed on 25 days from 9 June to 19 August. Adults were generally observed in upland habitat singly or in pairs. Jaegers were observed quartering low above hillsides at high elevation.

Glacucous-winged gull (*Larus glaucescens*).--Common. Gulls were observed on a total of 90 days from 27 May to 26 August. Three nests with three eggs each were discovered on the east side of Binnacle stream along the beach and one nest with two eggs was discovered on the west side of Binnacle stream, but was abandoned after researchers set-up camp. The other three nests successfully fledged at least one young and on 17 July six juveniles were observed at Binnacle Bay. Several other nests were found inland. At the south side of Binnacle Bay, at least 10 adult gulls were regularly observed and 10-49 individuals were regularly encountered during hikes through Rampart and Binnacle Valley and the upland habitat, particularly during the brood rearing period of Aleutian cackling geese.

Common murre (*Uria aalge*).--Uncommon. One to four adults were seen foraging in Binnacle Bay on 17 days from 5 July-25 August.

Thick-billed murre (*Uria lomvia*)--. Rare. 1-2 adults were seen foraging in Binnacle Bay on 4 days from 5 July-11 August.

Unspecified murre (*Uria* spp.).--Rare. 1-2 individuals were observed foraging in Binnacle Bay on 12 days from 4 July-17 August.

Pigeon guillemot (*Cepphus columba*).--Fairly common. Four to nine individuals were observed on 79 days from 27 May-26 August. Guillemots were concentrated mostly along the east side of Binnacle Bay. Birds were seen foraging near shore and fish holders were observed in the bay beginning 4 August. Juveniles were present in the bay from 11 July-26 August, but only one juvenile was observed at any time. Guillemots were commonly observed foraging among tufted and horned puffins.

Kittlitz's murrelet (*Brachyramphus brevirostris*).--Uncommon. Seventeen nests were discovered in upland habitat during the field season. Chicks and adults were only seen inland either at nests or, on rare occasions, adult "fish holders" were observed flying at low height above hillsides at medium to high elevation. No adults or fledged young were observed in Binnacle Bay. Audio-visual surveys were conducted sporadically during the months of June and July at the camp in Binnacle Bay and no birds were detected.

Ancient murrelet (*Synthliboramphus antiquus*).--Rare. On the evening of 8, 9 and 10 June a group of approximately 20 ancient murrelets were heard vocalizing near the east side of Binnacle Bay with fork-tailed and Leach's storm petrels.

Horned puffin (*Fratercula corniculata*).--Common. Horned puffins were observed on 52 days from 31 May-26 August. Loose groups of 10-15 individuals were commonly observed foraging on the east side of Binnacle Bay, or resting on the water at the opening of the bay. On 17 June and 6 July, we hiked to the western tip of Binnacle Bay and observed >100 horned puffins in large rafts with tufted puffins. At the westernmost point of Binnacle, there was a mixed-colony of horned and tufted puffins and would likely have been inaccessible to foxes as it located on vertical cliff face.

Tufted puffin (*Fratercula cirrhata*).--Common. 20-50 individuals were commonly observed on 75 days from 27 May-26 August. Puffins were usually observed foraging or resting on the water on the eastern side of Binnacle Bay. A small colony of <100 birds was observed on a rock cliff face on the eastern side of Binnacle Bay and a larger colony of >300 birds were observed on the western point of Binnacle Bay. These colonies would likely have been inaccessible to foxes as these sites are located on vertical cliff faces.

Snowy owl (*Bubo scandiacus*).--Rare. An adult was observed on six occasions from 23 June-6 August. On 29 June, two individuals were seen, with one owl taking a gosling from another owl, which had been kleptoparasitized from a glaucous-winged gull. Observations of owls were mostly on the north side of the island where over 50 owl pellets were collected. Other sightings occurred on the south side of the mountains, usually near the top of the valley between Round and Rampart mountains. More owl pellets (~50) were collected along the lowland area from the westernmost massif to the top of Binnacle Valley.

Common raven (*Corus corax*).--Uncommon. Up to six individuals were seen throughout the season on 70 days from 2 June-26 August. It was common to see ravens in small groups (3-6 individuals) doing synchronized flights and exchanging loud vocalizations. Kleptoparasitism of killed goslings from gulls was observed on several occasions. Ravens were frequently observed in upland habitat and in Rampart and Binnacle valley.

Winter wren (*Troglodytes troglodytes*).--Uncommon. Birds were observed on 48 days from 27 May-26 August, most commonly in dense forbs along the beach. Territorial males were heard calling at camp and on 14 August an adult was observed carrying food. On three separate occasions, an adult was found exploring the inside of our weatherport. Wrens were rarely encountered at inland sites.

Gray-crowned rosy finch (*Leucosticte tephrocotis*).--Uncommon. Observed on 50 days from 27 May-22 August. Birds were seen from low to high elevation. On 15 June, a juvenile was observed walking to the entrance of a rock burrow. No additional young were observed until 5 July, at which time numerous juveniles were seen with parents. Birds were infrequently encountered after 15 August.

Common redpoll (*Carduelis flammea*).--Rare. Two flocks of 15-25 individuals were seen on 2 June and 7 July.

Song sparrow (*Melospiza melodia*).--Uncommon. Birds were observed on 91 days from 27 May-26 August, mostly along the beaches and in dense forbs near the beach. A nesting pair was observed at camp from 27 May-26 August. This pair likely produced three clutches based on behavioral observations of adults carrying food, removing fecal sacs, and attending to recently fledged young. First fledglings were observed on 7 June, the end of July and again on 11 August.

Lapland longspur (*Calcarius lapponicus*).--Fairly common. Birds were observed along grassy slopes throughout the island. Observations were made on 91 days from 27 May- 26 August. Three nests were found with three, five and six eggs, respectively. Nests were located on 19 and 23 June and 10 July. All nests were located in dense grass. The first juveniles were observed on 5 July.

Snow bunting (*Plectrophenax nivalis*).--Fairly common. Small flocks of 2-9 individuals were observed on 68 days from 30 May-24 August. One nest with fours eggs was discovered in a rock crevice on 16 July. On 29 June young were heard vocalizing from a nest and on 30 June, an adult was observed carrying food. The first juvenile was seen on 8 July. Snow buntings were commonly seen inland and at high elevation in rock and boulder habitat and rarely along the beaches.

Mammals

Sea otter (*Enhydra lutris*)—Rare. On 27 May, a dead sea otter was collected from Binnacle beach. On 28 June, an adult was observed foraging in the bay. On 14 June, an adult and young were observed in the bay. The adult was actively "cleaning" the pup and both were entangled in a constant rolling movement as they worked their way from the mouth of the bay to the mouth of Binnacle stream, then back out to the mouth of the bay. An adult was observed in Binnacle Bay on the 2, 8, and 9 July. On all occasions, the adult was observed foraging in kelp and eating near the mouth of Binnacle stream. An adult was observed foraging in Binnacle Bay on 12 and 26 August.

Harbor seal (*Phoca vitulina*).--Uncommon. Two to three adults were observed on 66 days from 27 May-26 August. A small pup was observed with an adult on 14 June and observed thereafter throughout the season. Seals were generally swimming in the nearshore waters or hauled out on rocks during low tide. Beginning 11 August, an adult was observed foraging on pink salmon that were migrating up Binnacle stream.

LITERATURE CITED

Kaler, R. S. A., and L. A. Kenney. 2008. Rock ptarmigan surveys at Agattu Island, Alaska 8-28 June 2008. U. S. Fish and Wildl. Serv. Rep. AMNWR 08/11.

APPENDIX D - Breeding status and abundance of birds observed at Agattu Island, Alaska, 2008.

Species	Date First Observed	Date last Observed	No. Days Observed	Breeding Status	Comments
Red-throated loon	28-May	25-Aug	82	CR	Abundant on multiple days
Common loon	31-May	26-Aug	46	PO	Commonly observed on Lakes throughout west and southsides of the island
Shearwater spp.	27-Jun	6-Jul	3	O	Observed off shore near Binnacle Bay
Fork-tailed storm-petrel	27-May	24-Aug	64	CE	Abundant on multiple days
Leach's storm-petrel	27-May	22-Aug	56	CE	Abundant on multiple days
Red-faced comorant	6-Jul	23-Aug	10	PN	Observed in Binnacle Bay
Pelagic cormorant	31-May	25-Aug	17	O	Observed in Binnacle Bay
Unspecified comorant	28-May	24-Aug	19	O	Observed in Binnacle Bay
Aleutian Canada goose	27-May	25-Aug	84	CR	Abundant on multiple days
Mallard	22-Jun	22-Jun	1	PO	Observed on ephemeral lake on west side of Island
Green-winged teal	5-Jun	26-Aug	5	PO	Observed at camp
Greater scaup	3-Aug	3-Aug	1	O	Observed in Binnacle Bay
Common Eider	28-May	26-Aug	91	CR	Common in Binnacle Bay
Harlequin duck	31-May	22-Aug	32	PO	Common at mouth of Binnacle Stream
Peregrine falcon	31-May	26-Aug	47	CR	Observed in Binnacle Bay
Rock ptarmigan	30-May	22-Aug	46	CR	Abundant on multiple days
Gray-tailed Tattler	16-Aug	16-Aug	1	O	One adult observed up stream from Binnacle Bay
Rock sandpiper	27-May	25-Aug	73	CE	Abundant on multiple days
Parasitic jaeger	9-Jun	19-Aug	25	X	Abundant on multiple days
Glaucous-winged gull	27-May	26-Aug	90	CR	Abundant on multiple days
Common murre	5-Jul	25-Aug	17	O	Observed in Binnacle Bay
Thick-billed murre	5-Jul	11-Aug	4	O	Observed in Binnacle Bay
Unspecified Murre	4-Jul	17-Aug	12	O	Observed in Binnacle Bay
Pigeon guillemot	27-May	26-Aug	79	CR	Abundant on multiple days in Binnalce Bay
Kittlitz's murrelet	2-Jun	18-Aug	42	CR	Only observed in the Mountains
Ancient murrelet	8-Jun	10-Jun	3	O	Heard calling in the evening in Binnacle Bay
Horned puffin	31-May	26-Aug	52	CF	Abundant on multiple days in Binnalce Bay
Tufted puffin	27-May	26-Aug	75	CF	Abundant on multiple days in Binnalce Bay
Snowy owl	23-Jun	16-Aug	6	O	Rare
Common raven	2-Jun	26-Aug	70	O	Abundant on multiple days
Winter wren	27-May	26-Aug	48	CF	Common on multiple days
Gray-crowned rosy-finch	27-May	22-Aug	50	CR	Common on multiple days
Common redpoll	2-Jun	7-Jul	2	O	Rare
Song sparrow	27-May	26-Aug	91	CR	Abundant on multiple days
Lapland longspur	27-May	26-Aug	91	CR	Abundant on multiple days
Snow bunting	30-May	24-Aug	68	CR	Abundant on multiple days

O= Observed/non-breeding
X= Observed in breeding habitat
PO= Pair observed
PC= Courtship
PA= Agitated behavior
PT= Permanent Territory

PN= Nest-site Visitation
CN= Carrying Nest Material
CE= Nest with Eggs
CF= Carrying Food
CY= Nest with Young
CG= Precocial Young

CI= Feeding Recently Fledged Young
CO= Occupied Nest
CR= Recently Fledged Young
C= Confirmed

APPENDIX E - Notable plant observations at Agattu Island, Alaska, 2008.

Botrychium lunaria--On 24 August, a patch of approximately 30 individuals were discovered within a 25-m radius circle. Plants were located on dry, scree soil with intermittent patches of ericaceous dwarf shrubs and *Empetrum nigrum* at approximately 180 m above sea level. All individuals were fully mature with most spores already discharged and some fronds in a withered state. Fifteen specimens were collected and pressed for permanent accession to UAM Herbarium and two specimens were stored in 95% ETOH for genetic analysis. *B. lanceolatum* and *B. boreale* were also present at this location.

Botrychium lunaria, Agattu Island, Alaska, 2008.

Botrychium lanceolatum--On 16 July, two plants were collected from a small, exposed area of rocky soil among a forb patch at 270 m above sea level. On 31 July, two additional plants were located approximately 20 meters apart in dry, rocky soil. At this second site, the larger macro-habitat consisted of dry, rocky soil with little vegetation. On 7 August, a large patch of approximately 40 individuals was found growing on dry, scree soil with intermittent patches of ericaceous dwarf shrubs and *Empetrum nigrum* at approximately 180 m above sea level. *B. lunaria* and *B. boreale* were also observed growing within a 25 meter radius of *B. lanceolatum*. Fifteen specimens were collected and pressed for permanent accession to UAM Herbarium and four specimens were stored in 95% ETOH for genetic analysis.

Botrychium lanceolatum, Agattu Island, Alaska, 2008.

Botrychium boreale--On 24 August, three individuals were observed growing near *B. lunaria* and *B. lanceolatum* on dry, scree soil with intermittent patches of ericaceous dwarf shrubs and *Empetrum nigrum* at approximately 180 m above sea level. All specimens encountered were collected and either pressed or preserved in 95% ETOH for permanent accession at UAM Herbarium and for genetic analysis.

Botrychium boreale, Agattu Island, Alaska, 2008.

B. lunaria (left), *B. boreale* (center), and *B. lanceolatum* (right), Agattu Island, Alaska, 2008.

Polystichum lonchitis--Numerous individuals were encountered at one location on 1 August. Plants were found growing in rock crevices and at the base of a large rock outcropping in a stream bank at approximately 120 m above sea level. This species has been documented at Attu I. and in the eastern Aleutian Islands (Hultén 1968, UAM Herbarium). Representative specimens were collected, pressed, and donated to UAM Herbarium.

Veratrum viride Eschoscholtzii--At least three individual plants were indentified growing in a low flowing stream bank approximately 1 km inland from Binnacle Bay and at 120 m above sea level. This plant was not observed at any other location. To our knowledge, no record exists for this plant at any location in the Aleutian Islands (UAM Herbarium).

Saxifraga foliolosa--One individual plant was collected on 22 July on a scree slope at approximately 450 m above sea level. Collections have been recorded from the central Aleutians, but no records exist for the Near islands (Hultén 1968, UAM Herbarium). This specimen was collected, pressed, and donated to the UAM Herbarium.

Saxifraga hieracifolia--Few plants were encountered. On 18 July, the first individual plant was observed on a scree slope at approximately 515 m above sea level. In late August, three additional specimens were encountered at another location which had similar habitat (scree slope at approximately 500 m above sea level). These later plants had gone to seed at the time of discovery. To date, no record exists for this species in the Aleutian Islands (UAM Herbarium). Two plants were collected, pressed, and donated to UAM Herbarium.

Saxifraga oppositifolia--On 11 June, this species was observed in bloom in a rock crevice at approximately 900 m above sea level. Records exist for Attu I. and Buldir Island (Hultén 1968, UAM Herbarium).

Phyllodoce aleutica x Phyllodoce coerulea--One plant was observed at Agattu on 6 July on a scree slope growing among ericaceous dwarf shrubs at approximately 480 m above sea level. No record exists for *P. coerulea* in the Aleutian Islands, but *P. aleutica* and *P. coerulea* hybrids have been recorded at Attu I (Hultén 1968, UAM Herbarium). This specimen was collected, pressed, and donated to UAM Herbarium.

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APPENDIX F - Plant Chronology at Agattu Island, Alaska, 2008.

Family	Scientific Name	First bloom
Lycopodiaceae	*Lycopodium alpinum*	31-May
	L. annotinum	31-May
	L. clavatum	31-May
Isoetaceae	*Isoetes maritima*	31-Jul
Equisetaceae	*Equisetum arvense*	16-Jun
Ophioglossaceae	*Botrychium boreale*	24-Aug
	B. lanceolatum	16-Jul
	B. lunaria	24-Aug
Athyriaceae	*Athyrium filix-femina cyclosorum*	20-Jun
	Cystopteris fragilis fragilis	5-Jul
Aspidiaceae	*Polystichum lonchitis*	1-Aug
Poaceae	*Agrostis exarata*	10-Aug
	Bromus sitchensis	1-Aug
	Festuca rubra	15-Jul
	Hierochloe odorata	15-Jul
	Hordeum brachyantherum	15-Jul
	Luzula parviflora	31-Jul
	L. multiflora	31-Jul
	Poa arctica	1-Aug
	P. macrocalyx	1-Aug
Cyperaceae	*Carex microchaeta*	15-Jun
	C. pluriflora	20-Jul
	Eriophorum russeolum	15-Jul
	Juncus arcticus	15-Jul
	J. falcatus	15-Jul
Liliaceae	*Frittillaria camschatcensis*	23-Jun
	Maianthemum dilatatum	10-Jun
	Streptopus amplexifolius	15-Jul
	Tofieldia coccinea	6-Jul
	Veratrum viride Eschoscholtzii	24-Jul
Orchidaceae	*Dactylorhiza aristata*	15-Jun
	Platanthera dilatata	21-Jul
	P. tipuloides behringiana	21-Jul
Salicaceae	*Salix arctica*	4-Jun
	S. reticulata	4-Jun
Polygonaceae	*Koenigia islandica*	10-Aug
	Oxyria digyna	7-Jul

	Polygonium viviparium	30-Jun
	Rumex fenestratus	6-Aug
Portulacaceae	*Claytonia sibirica*	16-Jun
	Montia fontana	20-Aug
Caryophyllaceae	*Cerastrium Fischerianum*	10-Aug
	C. aleuticum	10-Aug
	C. beeringianum beeringianum	10-Jun
	Honckenya peploides	28-Jun
	Minuartia arctica	1-Jul
	Sagina intermedia	31-Jul
	Stellaria calycantha	1-Aug
Ranunculaceae	*Aconitum maximum*	9-Aug
	Anemone narcissiflora villosissima	4-Jun
	Coptis trifolia	5-Jun
	Ranunculus bongardii	31-Jul
	R. reptans	31-Jul
	R. trichophyllus	15-Jun
Brassicaceae	*Arabis lyrata kamchatica*	11-Aug
	Cardamine umbellata	23-Jun
	Draba borealis	3-Jun
Saxifragaceae	*Parnassia palustris neogaea*	25-Jul
	Saxifraga aleutica	5-Jul
	S. bracteata	9-Jun
	S. bronchialis	15-Jun
	S. foliolosa	22-Jul
	S. hieracifolia	18-Jul
	S. oppositifolia	27-May
	S. unalaschcensis	30-Jun
	S. punctata	11-Jun
Rosaceae	*Arunucus sylvester*	14-Jul
	Geum calthifolium	4-Jun
	G. macrophyllum	24-Jun
	G. rossii	14-Jan
	Potentilla villosa	9-Jun
	Rubus arcticus stellatus	20-Jun
	R. chamemorous	3-Jun
	Sibbalidia procumbens	26-Jun
	Sorbus sambucifolia	9-Jun
Fabaceae	*Lathyrus maritimus*	10-Jul
	Lupinus nootkatensis	26-Jun
Violaceae	*Viola langsdorffii*	9-Jun

Onagraceae	*Epilobium glandulosum*	15-Jul
Haloragaceae	*Hippuris vulgaris*	31-Jul
	Myriophyllum sibiricum	31-Jul
Apiaceae	*Angelica lucidia*	28-Jun
	Conioselinum chinense	28-Jun
	Heracleum lanatum	28-Jun
	Ligusticum scoticum hultenii	28-Jun
Pyrolaceae	*Pyrola minor*	18-Jul
Empetraceae	*Empetrum nigrum*	27-May
Ericaceae	*Cassiope lycopodioides*	11-Jun
	Loiseleuria procumbens	31-May
	Phyllodoce aleutica aleutica	25-Jun
	P. aleutica x *P. coerulea*	6-Jul
	Rhododendron camtschaticum	13-Jul
	Vaccinium uliginosum	13-Jul
	V. vitis-idaea	23-Jun
Primulaceae	*Primula cuneifolia saxifragifolia*	1-Jun
	P. cuneifolia cuneifolia	1-Jun
	Trientalis europaea arctica	15-Jun
Gentianaceae	*Gentiana propinqua aleutica*	15-Jul
Scrophulariaceae	*Euphrasia mollis*	10-Aug
	Lagotis glauca	31-May
	Pedicularis langsdorffii	20-Jul
	Rhianthus minor borealis	6-Aug
	Veronica americana	30-Jul
	V. grandiflora	17-Jun
	V. stelleri	30-Jul
	V. serpyllifolia	30-Jul
Plantaginaceae	*Plantago macrocarpa*	15-Jul
Rubiaceae	*Galium aparine*	30-Jul
Caprifoliaceae	*Linnaea borealis borealis*	16-Jul
Campanulaceae	*Campanula chamissonis*	14-Aug
	C. lasiocarpa lasiocarpa	22-Jul
Asteraceae	*Achillea borealis*	17-Jul
	Anaphalis margaritaceae	15-Jul
	Antennaria dioica	16-Jul
	Arnica unalaschensis	26-Jul
	Artemesia arctica	31-Jul
	Cacalia auriculata kamtschatica	4-Jul
	Chyrsanthemum arcticum	11-Aug
	Cirsium kamtschaticum	24-Jul

Erigeron humilis	18-Jul
E. peregrinus	25-Jun
Hieracium triste	25-Jul
Senecio cannabifolius	1-Aug
S. pseudoarnica	31-Jul
Taraxacum trigonolobum	1-Jul