Breeding Ecology and Behavior of Kittlitz's Murrelet in Kodiak National Wildlife Refuge, Alaska, 2008

By E.M. Burkett, J.F. Piatt, M.J. Lawonn, and W.H. Pyle

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Breeding Ecology and Behavior of Kittlitz's Murrelet in Kodiak National Wildlife Refuge, Alaska, 2008

By E.M. Burkett, J.F. Piatt, M.J. Lawonn, and W.H. Pyle

Abstract

Kittlitz's murrelet (*Brachyramphus brevirostris*) is a rare seabird that nests in coastal mountains of Alaska and the Russian Far east. Little is known of their nesting ecology because of the relative inaccessibility of their breeding habitat and dispersed nesting behavior. To address this information gap, we initiated a 5-year project during summer, 2008, to evaluate breeding ecology in western Kodiak National Wildlife Refuge. Following protocols established in a 2008 study plan (Appendix G), we systematically searched for nests and monitored nests found. We sampled and compared habitat characteristics at nest sites and at plots distributed in surrounding rocky terrain to ascertain habitat preferences. Finally, we observed and recorded the inland flight and call behavior using a modified audio-visual survey protocol originally designed for the closely related marbled murrelet (*Brachyramphus marmoratus*).

Five nests were discovered and monitored over a 10-week study period, all within large patches of barren ultramafic rocks formations . Because none of the nests survived the incubation stage, we were unable to evaluate chick meals or chick growth rates. We recorded nest characteristics and quantified the ground cover surrounding nest sites, and used Discriminant Function Analysis (DFA) to quantify possible nesting site characteristics of Kittlitz's Murrelets. Nests tended to be found at high elevation (>400 m), on scree slopes where rocks are 1-10 cm in size, and where the ground is almost completely barren (no moss, grass, flowering plants or

shrubs). Pre-dawn audio-visual surveys revealed a range of activity and behaviors. Adult Kittlitz's murrelets fly inland throughout the breeding season (May-August) and often vocalize while flying. Peak murrelet activity, including flight and call behavior, occurred in July. Murrelets continued to fly inland and interact through their flight and calling behavior after all known nests in the vicinity had failed. Activity was recorded at two outlying ultramafic sites, suggesting that these areas also support habitat suitable for nesting.

Key Words: Kittlitz's murrelet, *Brachyramphus brevirostris,* Kodiak National Wildlife Refuge, nesting biology, reproductive success, audio-visual survey, habitat use.

Introduction

Kittlitz's murrelet is a rare and rapidly declining seabird of the North Pacific, and certainly one of the least-studied birds in North America. The bulk of breeding murrelets are thought to nest in Alaska. Results from surveys at coastal sites in the Gulf of Alaska revealed significant long-term declines (Kuletz et al. 2003, Van Pelt and Piatt 2003, Drew and Piatt 2008), which prompted the U.S. Fish and Wildlife Service (USFWS) to designate the species as a candidate for listing under the Endangered Species Act (USFWS 2003). Causes of this decline are not completely understood, but may be attributed to a combination of anthropogenic disturbances such as oil spills, gillnet bycatch and vessel activity (Wynne et al. 1992, van Vliet and McAllister 1994, Agness 2006) and environmental changes such as fluctuations in marine food webs (Piatt and Anderson 1996, Anderson and Piatt 1999), and loss of foraging habitat due to glacial recession (Kuletz et al. 2003).

Kittlitz's murrelet nests are usually located at high elevations (average >500m) on talus-strewn slopes near crests of mountain ridges and peaks within 30 km of the nearest coast (Day et

al. 1983, Piatt et al. 1999). The remoteness and ruggedness of nesting habitats preferred by this species have discouraged detailed study of this species in the past, and the resulting lack of knowledge about Kittlitz's Murrelet breeding success and nesting ecology makes effective management and protection of this species more difficult.

This report summarizes results from the first year of a planned 5-year study of the breeding ecology of Kittlitz's murrelets in Kodiak National Wildlife Refuge, Alaska. This work is being conducted in parallel with similar studies of Kittlitz's murrelet on Agattu Island, western Aleutians (Kaler et al. 2008). Here we summarize the results of systematic nest searches, observations of reproductive biology, characterization of nesting habitat, and audio-visual surveys in the refuge during the summer of 2008. In addition, we present recommendations for research next year.

Specific objectives of this study were to:

1. Locate and study as many Kittlitz's murrelet nests as possible;
2. Characterize nesting habitat (e.g., altitude, rock type, vegetation, etc.);
3. Monitor incubation duty of adults at nests and delivery of meals to chicks;
4. Identify prey in chick meals;
5. Measure rate of chick growth;
6. Measure hatching, fledging and reproductive success;
7. Collect blood, feathers or egg-shell fragments for genetic study of populations; and
8. Conduct audio-visual surveys for adult murrelets flying to and from nest sites

Methods

Study Area and Climate

Kodiak Island (57.396° N, 153.483° W) is located in the northern Gulf of Alaska, and is the largest island in the Kodiak Archipelago with an area of 8,975 km^2 (Figure 1). No point on the island is more than about 25 km from the sea. Kodiak Island has a maritime climate with highly variable precipitation rates between the east and west coasts. The entire Kodiak Archipelago has rough coastlines consisting of many inlets, bays, and mountains that create a wide spectrum of different habitats within a relatively small area. Mountains cover the bulk of Kodiak Island's interior, and the highest peaks exceed elevations of 1300 m. Northeast Kodiak Island is covered by Sitka spruce (*Picea sitchensis*) forests while the southwest corner of the island is composed of a mixture of low-growing vegetation comprising upland and lowland tundra, shrub and forb communities. There, common land cover types include crowberry (*Empetrum nigrum*), Sitka alder (*Alnus sitchensis*), and mixed forb meadow (Fleming and Spencer 2006).

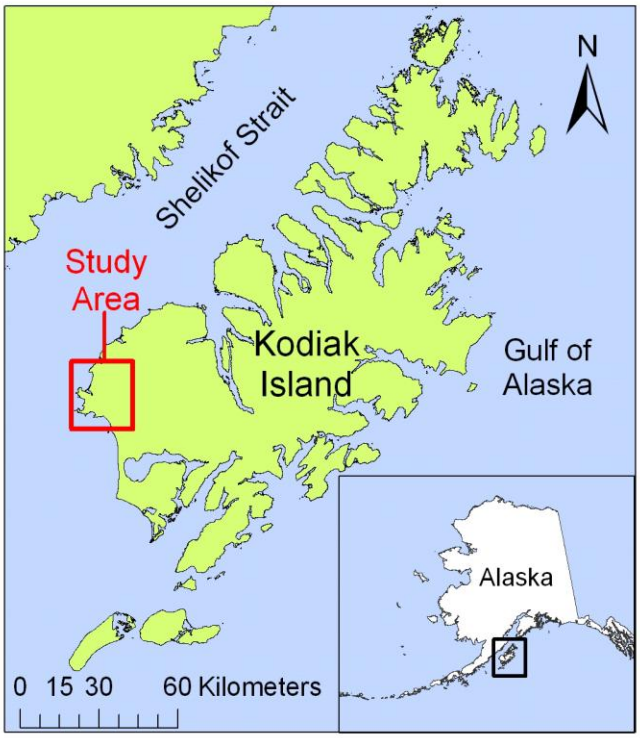

Figure 1. Map showing study area within Kodiak Island outlined

Our study area (based at 57.410°N, 154.522°W) included a three-spoke ridge system, of which about 2.1 km^2 comprised outcrops of ultramafic bedrock (Wilson et al. 2005). Ultramafic rock is a class of igneous or meta-igneous rock with a high metal content that usually supports

minimum cover of vegetation, often species adapted to grow in soil with limited elemental nutrients (Proctor and Nagy, 1992). As a result of the severity of these ultramafic parent materials, vegetation is scant across much of the study site. The scree-covered slopes of the study site are in marked contrast to adjacent non-ultramafic slopes of similar elevation, which are covered with lush plant growth. In the Kodiak Archipelago, outcrops of ultramafic bedrock are rare, probably comprising <0.1% exposed bedrock substrate. Most of these exposures, totaling about 9.6 km^2, are restricted to a few mountains between the Karluk River and Olga Bay on western Kodiak Island.

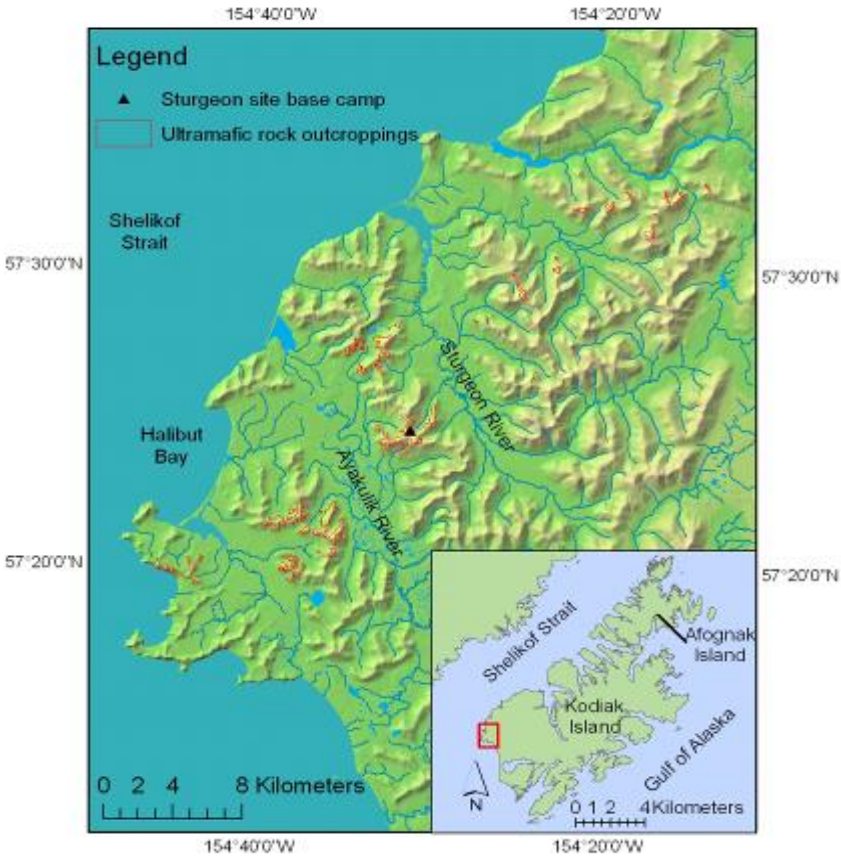

Figure 2. Ultramafic rock outcroppings in west section of Kodiak Island National Wildlife Refuge

Our base camp was established southwest of the Sturgeon River in a valley between two ridges in the study area (Figure 2). The study area lies inside the Kodiak Glacial Refugium. Within the refugium area, ridges above 500-m asl remained ice-free during the last Pleistocene Era glacial advance (Mann and Peteet 1994) and no glaciers are present in this area today. This distinguishes our study area from other glaciated or formerly-glaciated regions of the Alaska mainland coast where Kittlitz's murrelets more commonly occur. Mountains peaks in this

area are mostly low elevation (400-500 m), making this a relatively accessible and safe place to study the nesting ecology of Kittlitz's Murrelets. Weather was recorded daily at our base camp using visual observations and a Kestrel Pocket Weather Recorder (Appendix A). During the ten-week study period the mean high and mean low temperatures recorded were 13.3°C (range 5.0-22.7°C) and 5.6°C (range 0.1-9.9°C), respectively. The mean daily precipitation was 0.22 cm", dry in comparison to the city of Kodiak, where the average monthly precipitation rates during June, July, and August all exceeded 10 cm. Barometric pressure (in Hg) ranged from 27.00 to 36.15. In general, the climate during summer, 2008, was cool and wet. Winter conditions persisted later than usual, and mild conditions typical of summer did not begin until August (Appendix A). We do not report further on weather conditions here, but will consider weather impacts on murrelet biology and behavior in the future, when we have data from several seasons for comparison.

Nest Searching and Monitoring

Fieldwork in Kodiak National Wildlife Refuge commenced on June 4 and ceased on August 13. Nests were located by ground-searching suitable terrain (e.g., see Day and Stickney 1996, Kaler et al. 2008). U.S. Geological Survey quad maps and GPS receivers were used to log the effort and ensure that searches were conducted systematically. Searchers walked parallel to the fall line of slopes and 3-10 m abreast of each other, i.e., at a little less than double the approximate startling distance of an incubating murrelet (R. Kaler, J. Piatt, pers. obs.). Search efforts were concentrated within the ultramafic zone along ridges, peaks, and slopes.

Nests were treated according to the Kittlitz's murrelet Nest Searching and Monitoring Instructions developed by Robb Kaler and John Piatt (for details, see Appendix G). To distinguish flushed adults from marbled murrelets we confirmed visually the diagnostic outer

white rectrices of adult Kittlitz's murrelets. Each egg and nest was photographed, as well as the surrounding ground cover, terrain, and view of Shelikof Strait. The date of hatching for each egg was determined by floating each egg in water and estimating the stage of embryonic development based on a 30 day incubation period (Westerskov 1950). To minimize our disturbance we avoided nest-searching within about 100 m of active nests and used spotting scopes and binoculars to assess nest status from a vantage point that provided a view of the nest. After initial discovery, nests were checked with a spotting scope to assess whether the adult bird had resumed incubation, and to monitor the fate of the eggs. Timing of the revisits was determined by weather, accessibility, and projected hatch date of the egg. By keeping nest visits to a minimum we hoped to lessen our disturbance of the incubating adult, and decrease the possibility of attracting predators to the nest site. We tried to assess the potential for predation by noting all species observed throughout the summer that could potentially prey on Kittlitz's Murrelets in this area.

Attempts to relocate nests and assess them from a distance without flushing the adult were successful in all but one case. Although an additional protocol called for deployment of motion-detection cameras to monitor the nestling stage, only one camera (Team Primos Silent Image) was deployed. On July 24 a camera was placed on the ground 3-4 m from nest #0805, supported by a small rock pile that also served to camouflage the shape of the camera. The camera was set to be triggered by any movement or infrared activity. After the camera was deployed we did not return to collect it until August 11.

Nest Characteristics

Nest site characteristics were surveyed and recorded after nests were no longer occupied. Nests were surveyed at three spatial levels. At the small scale, each nest cup and any surrounding

nest rocks were characterized and, at a larger scale, two circular plots (5-m and 25-m radius) surrounding the nest cup were also surveyed. Nest diameter and depth were measured, and the composition of the nest cup and its circumference were characterized. We also identified and measured key "nest rocks", which are boulders adjacent to the nest cup that are large enough to act as a barrier against rock fall, buffer from the elements, or conceal the nest, egg, incubating adult, or chick from predators. If a large clump of moss appeared to serve any of these purposes, it was measured like a nest rock. We also noted nest aspect (compass direction nest was facing, in degrees) and whether the ocean could be seen from the nest site.

Geographic and landscape data (geographic coordinates, elevation, slope, etc.) were recorded at the center of each nest plot. Using a 5-m radius plot centered on each nest site, we estimated percentage cover values of 13 types of ground cover (e.g., % rocks of varying sizes, % moss, etc., see Nest Vegetation Datasheet, Appendix G). Using a 25-m radius plot centered on each nest site, we estimated the percentage of ground cover that was vegetated and non-vegetated, or covered in snow or water. Each plot was assigned a category using the Alaska Vegetation Classification system of Viereck et al. (1992) and the Kodiak Archipelago Land Cover classification system (Fleming and Spencer 2006).

To evaluate nest site selection, we collected the same data from plots set adjacent to nest sites, plots set on an elevation gradient below nest sites, and plots set randomly in ultramafic terrain. Adjacent to nest sites, 2 plots were sampled. These non-use plots were distributed at a random bearing and random distance (between 50 and 150-m) from nest sites (Figure 3). Similarly, we sampled 3 plots located at 50-m elevation intervals below each nest site (Figure 4). One elevation plot was surveyed at 50-m elevation directly below the nest plot, and two other non-use elevation plots were sampled on either side and at random distances (between 50 and

300-m) from this center plot and at the same elevation. This was repeated at 50-m elevation increments below the first set of three elevation plots until the valley floor was reached. At each elevation plot, 5-m and 25-m radius areas were surveyed to collect the same types of data surveyed at nest and adjacent plots (See Nest Vegetation Datasheet, Appendix G). To allow for comparison of 5-m radius elevation plots within different altitude ranges, the elevation plots (n=42) were sub-divided into five altitude levels (<250m, 250-300m, 300-350m, 350-400m, and >400m). Finally, we sampled 50 plots randomly distributed in ultramafic terrain.

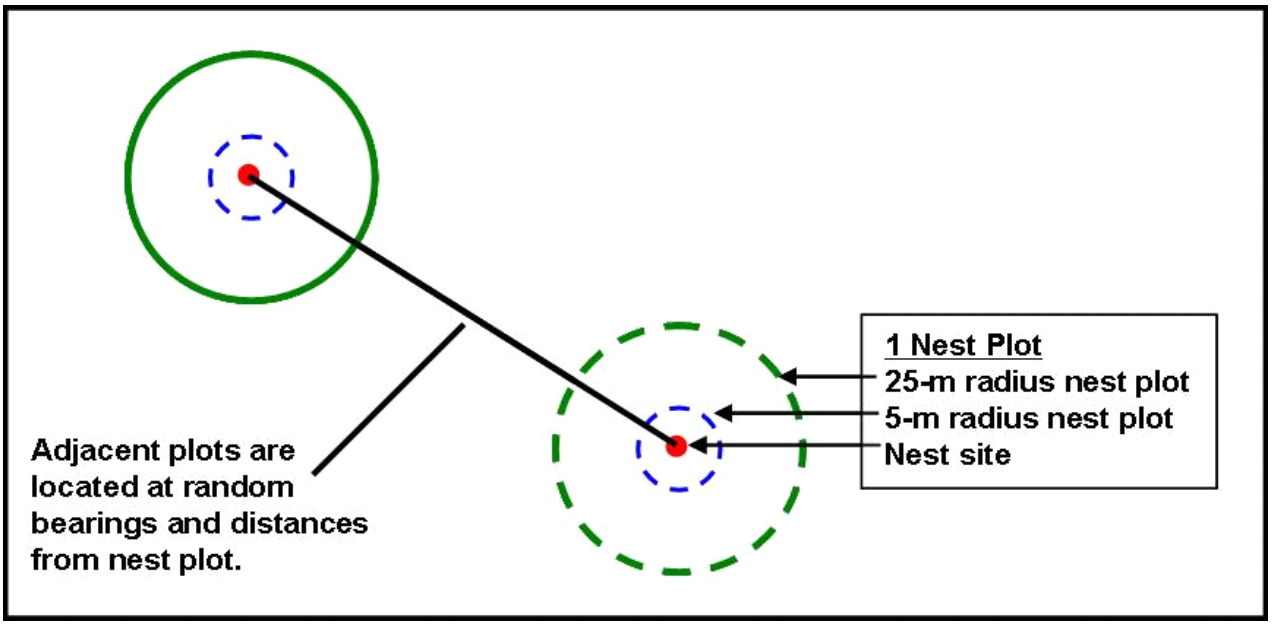

Figure 3. Nest and adjacent vegetation plots. Nest plots were located at the center and consisted of a 5-m radius plot for estimation of percent ground cover and a 25-m radius plot for measuring topographical features and estimating percent of habitat cover (Viereck et al. 1992). Two adjacent plots were located at random distances and bearings from the nest site.

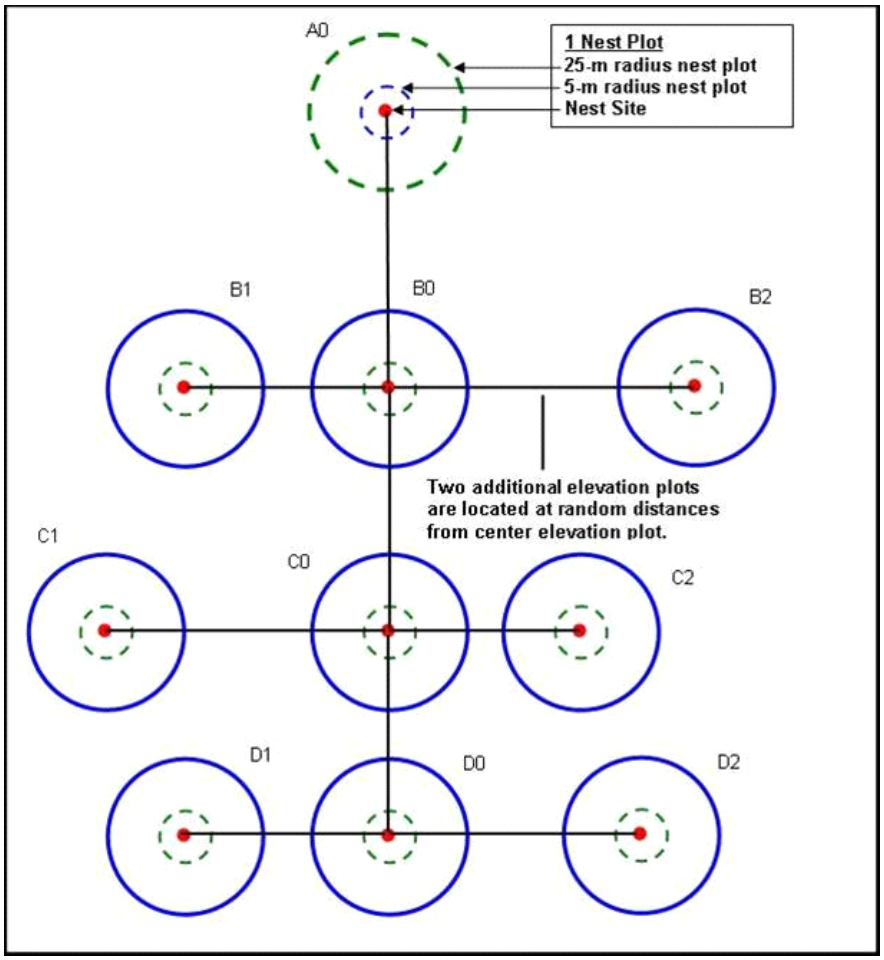

Figure 4. Elevation Plots. Center elevation plots (B0) were located directly below nest plots (A0) at 50-m lower elevation. Two additional elevation plots (B1 & B2) were surveyed at random distances (50-150 m) to the right and left of the center elevation plot. At each elevation plot the same 25-m and 5-m radius nest plot worksheet was used as at the nest plots. Each plot was labeled as shown above. In some cases, there was an additional "E" level.

Audio-visual Surveys

For marbled murrelets, audio-visual surveys have been established as a valuable technique for gathering information on such things as habitat occupancy, potential nesting habitat, nest locations, and inland flight behavior (Evans-Mack et al. 2003). Results from these surveys provide useful information to managers and facilitate assessment of critical habitat and the regulation of human activities. There are no established protocols for surveying Kittlitz's

murrelets. Therefore, we adapted the well-established marbled murrelet protocol for use in surveying Kittlitz's murrelets, which generally nest at 500-1000 m elevation on alpine barrens.

We recorded Kittlitz's Murrelet activity at ten locations in the study area and in two outlying areas near Anvil Mountain and Duncan Lake (Appendix B). Station locations were chosen by their proximity to known flyways and quality nesting habitat (Day and Barna 2007). Survey stations varied from the densely vegetated valley floor at our base camp to sites along the ridgeline that had little vegetative cover and consisted mainly of loose scree or bedrock. Station elevations ranged from 79 m to 443 m. We recorded the percentage of vegetative and rock ground cover at each audio-visual station, and recorded the GPS position (Garmin GPS Map 76Cx) of all stations in order to relocate these stations in the future.

The exact methods for audio-visual surveys can be found in Evans-Mack et al. (2003) and the 2008 protocol (Appendix G). The following is a summary of our methods. Audio-visual counts generally began 1.5 hours before sunrise and extended until one hour after sunrise. Some dawn watches were begun as early as 2 hours before sunrise, but this earlier start did not yield significant additional detections. If any detection was observed during the last half hour of this period the survey was extended until 30 minutes after the last detection. Official sunrise times for Kodiak Island in 2008 were obtained from the United States Navy. Observers recorded observations on a data sheet (See KIMU Stakeout Survey Sheet, Appendix G). Following marbled murrelet inland survey protocol, a detection was defined as the visual or auditory observation of one or more murrelets acting together in a similar manner and initially occurring at the same time (Naslund 1993, Paton 1995, Ralph et al. 1994). If a series of calls (or the sound of wing beats) was followed by five seconds of silence and then a new set of calls began, then these two instances were considered separate detections. Two visual observations separated by a

period of five seconds out of view were considered two separate detections. With each detection we recorded the time, detection type (audio-visual, audio only, or visual only), number of vocalizations, and approximate distance of the bird(s) from surveyors. If the detection included visual confirmation we noted how many birds were present and the estimated height of the bird flight path. For instances where we did not see birds, but could tell that multiple birds were calling we noted the number of birds present as greater than or equal to the number of birds heard. This was to allow for the possibility that there may be non-calling birds flying with calling birds.

During each survey we noted the weather conditions, the presence of predators, and attempted to describe any murrelet behavior we saw or heard in words and through rough sketches. Using topographic maps of the study area, we drew the flight paths of detected Kittlitz's murrelets. However, because the majority of our detections were audio only, these hand-drawn accounts of murrelet flight paths merely approximate the birds' exact movements and serve as a tool when interpreting inland behavior of murrelets during the breeding season. Although stations were positioned > 300 m from each other, simultaneous surveys conducted at adjacent stations on the same morning often had overlapping detections. Occasional windy conditions with gusts exceeding 30 km/hr that may have impeded the observer's ability to hear Kittlitz's murrelets calling at distances >200 m from the observer. Overlapping detections and noise interference due to wind could impact detectability and survey results. Also, a more experienced surveyor could potentially record detections much more accurately than an inexperienced observer (Meyer et al. 2004).

Results

Nest Searching and Monitoring

All ultramafic rock areas within the main study area were searched two or more times between early June and late July. Searches were replicated to account for the possibility of late nesters or second-nesting attempts. In total, four active and one failed Kittlitz's murrelet nests were discovered near the Sturgeon Site and Duncan Lake (Figure 5). At each active nest an adult bird was flushed off the nest, and immediately identified visually. The diagnostic white outer rectrices of the Kittlitz's Murrelet were used to positively identify this species. The failed nest contained shell fragments and fresh egg contents, which were collected for DNA analysis.

Once an incubating bird was flushed, the nest was located and egg and nest data quickly collected. Although the eggs varied slightly in size and pattern they all fit prior descriptions of Kittlitz's murrelet eggs (Day et al. 1983, Piatt et al. 1999). All were pale olive-green broken by lavender-grey and brown splotches of varying sizes (See Figures 6-10). These spots and speckles were generally larger on the obtuse end of the egg. Three of four eggs floated in water with angles ranging between 30-50° (Table 1). The projected hatch dates of all nests ranged from early July to early August. It is unclear whether nests found later in the season represented initial or second nesting attempts. All discovered nests failed before hatching.

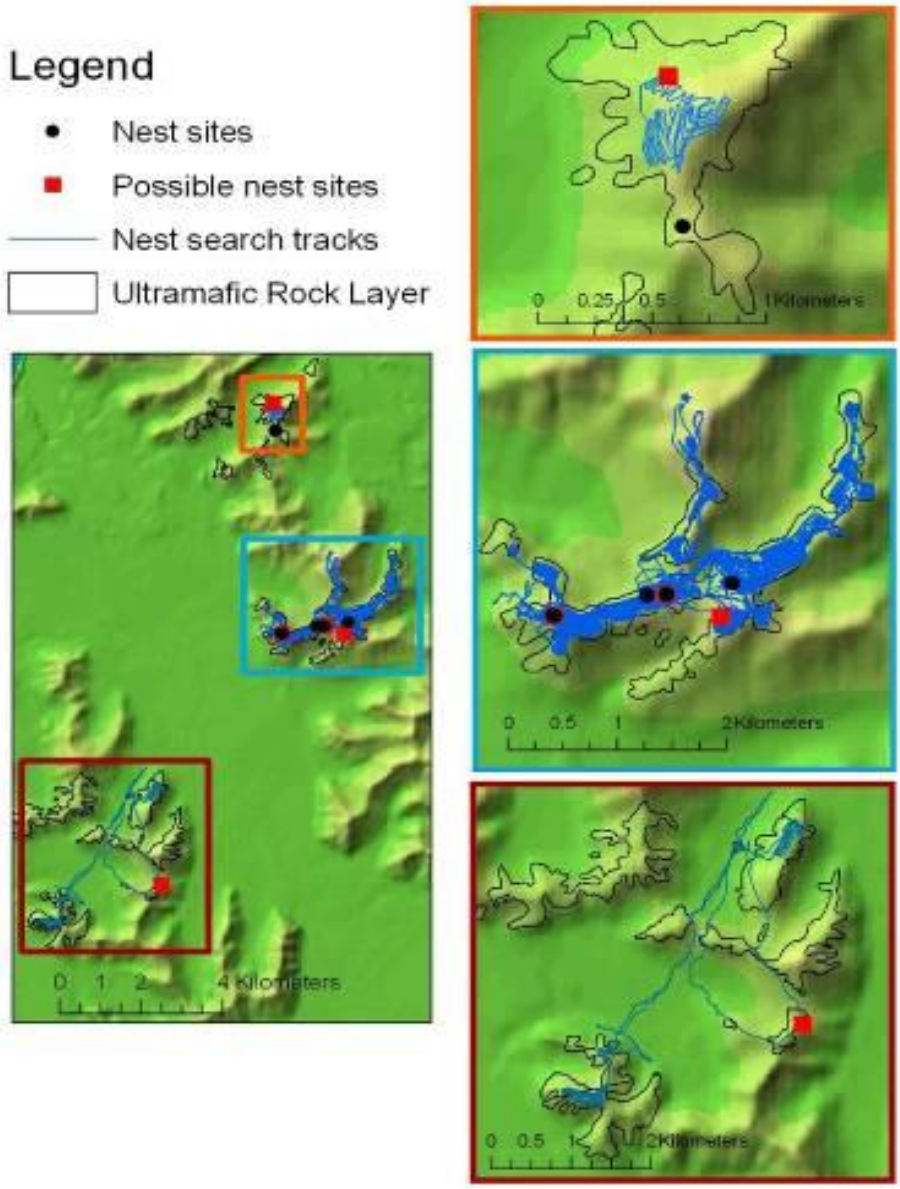

Figure 5. Map showing nest searchers' tracks, nests and possible nest sites within main study area (Sturgeon site, middle) and two outlying areas (Duncan Lake, upper; Anvil Mt., lower).

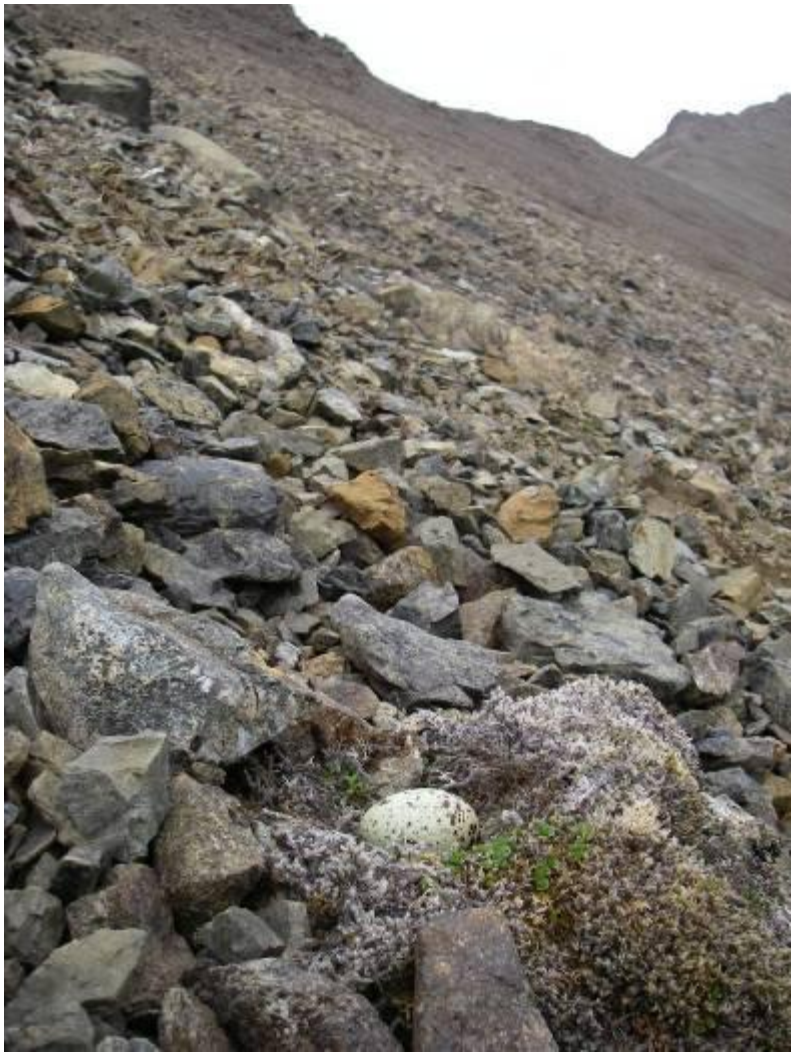

Figure 6a. Nest #0801 containing egg immediately after adult was flushed off the nest.

Figure 6b. Nest #0801 egg.

Figure 7a. Nest #0802 with egg showing cloacal white substance on egg and rock, possibly deposited during egg-laying.

Figure 7b. Nest #0802 with egg showing selected nesting habitat and nest rock.

Figure 8a. View of Grant's Lagoon seen from Nest #0803-1.

Figure 8b. Nest #0803-1 with egg immediately after adult was flushed off the nest.

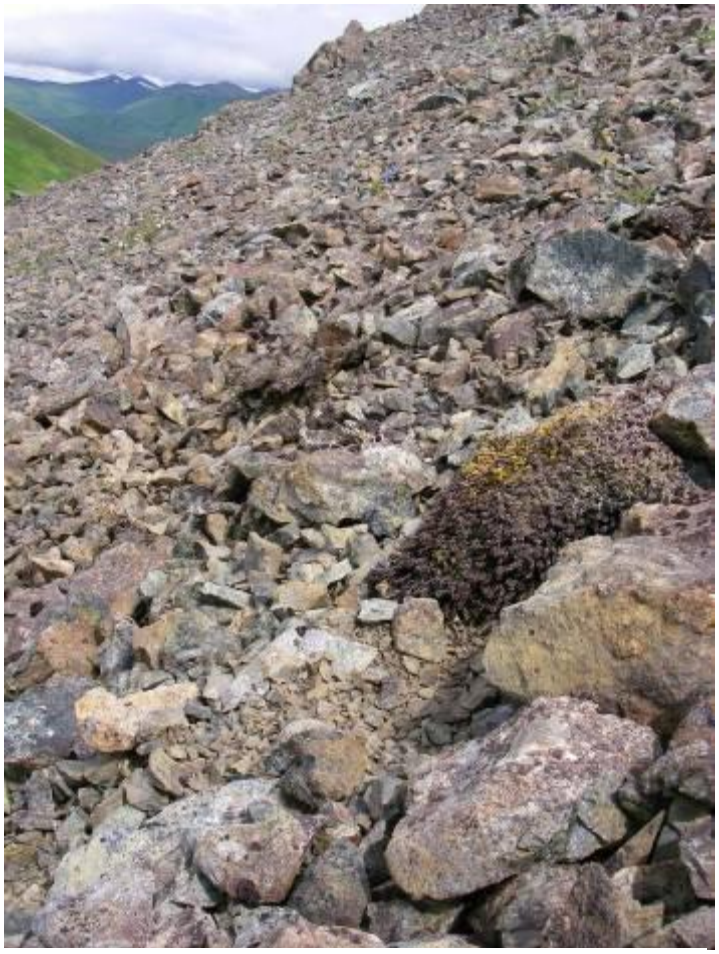

Figure 9a. Nest #0804-1 showing nest rocks, moss and nesting habitat.

Figure 9b. Nest #0804-2 shown as found containing egg shell fragments and embryo materials.

Figure 10a. Nest #0805 containing egg and showing surrounding nest rocks and vegetation.

Figure 10b. Nest #0805 egg float showing 40° sink angle.

Table 1. Status of Kittlitz's Murrelet nests found on Kodiak Island, summer 2008.

Nest ID	Date found	Egg float results	[1]Projected hatch date	Last date egg/adult seen	Last date checked	Fate
KODKIMU0801	9-Jun-08	Sink 50°	3-Jul-08	9-Jun-08	1-Jul-08	failed during incubation
KODKIMU0802	28-Jun-08	Sink 0°	28-Jul-08	11-Jul-08	14-Jun-08	egg abandoned
KODKIMU0803-1	30-Jun-08	Sink 30°	25-Jul-08	30-Jun-08	7-Jul-08	failed during incubation
KODKIMU0804-2	5-Jul-08	-	-	-	5-Jul-08	failed during incubation
KODKIMU0805	12-Jul-08	Sink 40°	4-Aug-08	26-Jul-08	11-Aug-08	failed (fox predation likely)

[1]Projected hatch dates based on egg float curves (Westerskov 1950, Kaler et al. 2008)

An audio detection on the ground observed during an audio-visual survey was used to estimate the approximate location of nest #0802. After hearing several calls that seemed to be stationary and coming from the same ground location, this area became the focus of ground-search efforts. An active nest was subsequently found in the vicinity of the ground calls, after flushing the adult. The egg sank in water at a 0° angle, suggesting that the egg was laid within the previous 48 hours (Table 1). There was also a dried smear of cloacal matter on the egg and a small rock next to the egg, supporting our conclusion that the egg was laid quite recently.

One unattended nest (#0804-2) was found with murrelet eggshell fragments and egg contents scattered within the nest area. We assume that the failed nest and its contents belonged to a Kittlitz's murrelet rather than a marbled murrelet because no marbled murrelets were ever observed during the study. Genetic tests of the collected items will be used to confirm our conclusion.

Five empty nest scrapes were found that may have been used by Kittlitz's Murrelets. These nests did not contain any shell fragments, feathers, or other definitive proof of recent use, but were so similar to known Kittlitz's Murrelet nests that their location was recorded and in some cases, nest measurements taken. Two of these empty nest scrapes were located 5 m or less from a known Kittlitz's murrelet nest: Less than 3 m upslope from nest #0804-2 and 5 m upslope of nest #0803-1. Similarly, two empty nest scrapes were found 3-m apart on a slope near Duncan Lake, but neither contained any evidence of recent use. One isolated empty nest scrape was located near Anvil Mountain. The location

of all empty nest scrapes was recorded, and two of these empty scrapes (#0803-2 and #0804-1) were surveyed at the 5-m and 25-m plot level, and are included in our data as "Possible nest sites".

Most nest failures were attributed to predation. The most common potential predators observed included bald eagle (*Haliaeetus leucocephalus*), black-billed magpie (*Pica Hudsonia*), and common raven (*Corvus corax*) (Table 2).

Table 2. Possible Kittlitz's Murrelet predator species observed at Kodiak Island study area, 4 June-13 August, 2008 (62 days).

Species		Date first observed	Date last observed	No. days observed	Max no. observed/day	Comments
Common name	Scientific name					
Bald Eagle	*Haliaeetus leucocephalus*	5-Jun	11-Aug	42	4	Seen on a near-daily basis
Red Fox	*Vulpes vulpes*	5-Jun	3-Aug	9	2	1 photographed at nest site
Black-billed Magpie	*Pica hudsonia*	5-Jun	6-Aug	33	8	Usually in valley
Golden Eagle	*Aquila chrysaetos*	7-Jun	18-Jul	5	1	
Common Raven	*Corvus corax*	9-Jun	12-Aug	24	3	Usually flying above ridgeline
Merlin	*Falco columbarius*	8-Aug	8-Aug	1	1	Rare
Kodiak Brown Bear	*Ursus arctos middendorffi*	6-Jun	6-Aug	7	3	
Peregrine Falcon	*Falco peregrinus*	9-Jun	9-Jun	1	1	Rare

We suspect that one nest failed because of a rock slide, since we observed a chipped egg and subsequent abandonment of the nest by adults. It is possible that nests were initially abandoned due to disturbance from research activity, then subsequently depredated.

Nest Characteristics

Nest cups ranged from a bowl-shaped depression in a cushion of moss to a slight dish created in loose gravel. Mean nest diameter was 162 mm (range 140-200 mm, SD=24.9, SE=12.4, n=5), mean nest depth was 32 mm (range 22-4 0 mm, SD=6.8, SE=3.4, n=5), and mean nest aspect was 325° (SD 25.8, SE 12.9, n=5) (Table 3). All but one nest scrape was made in loose gravel-sized rock, with the exception being made within a patch of moss. Within 5-m radius nest plots the mean overall rock cover was 93% (SD=1.0, SE=0.2, n=5) (Table 4). The majority of rock was 1-10 cm in diameter. Nearly half of the remaining 7% vegetative cover was comprised of prostrate woody-stemmed plants such as crowberry and *Dryas* spp. Within the 25-m radius plots (Table 5) the mean non-vegetative ground cover was 93%

(SD=1.3, SE=0.3, n=5), and all nests fell into the Viereck Classes IIIc(2)a or IID(2)c (Viereck et al. 1992). There was little or no snow and water at any nest or possible nest site. Mean slope at nest sites was 30° (SD=4.6, SE=2.3, range 22°-34°, n=5), mean aspect was 309° (SD=19.1, SE=9.6, range 290-330°, n=5), and mean elevation was 394 m (SD=27.4, SE=13.7, range 361 – 426 m, n=5) (Table 6). "Position on Slope" is the position of each nest relative to the highest elevation of the slope, given as a percentage, and most nests were within the top 20% of the mountain slope.

Table 3. Nest cup characteristics

Nest ID	Diameter (mm)	Depth (mm)	Aspect (degrees)	Dimensions (LxWxH cm) of nest rocks			
				1	2	3	4
Known nest sites							
KODKIMU0801	140	40	330	17x15.5x7.5	[1]28x11.5x11	N/A	N/A
KODKIMU0802	140	35	0	45x19x18	14x13x5	17x7x35	11x7x3
KODKIMU0803-1	200	35	288	21x17x7	16.5x11x10	11x8x7.5	14x12.5x7
KODKIMU0804-2	170	30	329	10.5x9x5	11.5x10x6	16x14.5x10.5	12.5x10x6
KODKIMU0805	160	22	320	30x22.7x18.1	28x16x16,7	N/A	N/A
mean	162	32	325				
standard deviation	24.9	6.8	25.8				
standard error	12.4	3.4	12.9				
Possible nest sites							
KODKIMU0803-2	175	35	322	28x18x12	N/A	N/A	N/A
KODKIMU0804-1	190	44	314	14.5x19x12.5	25x13.5x9.5	12x11.5x5	[1]20x29x11
mean	183	40	318				
standard deviation	10.6	6.4	5.66				
standard error	10.6	6.4	5.66				

[1]Nest rocks were actually moss clumps, see text

Table 4. Composition of ground cover on 5-m radius nest plots.

[Vegetative cover heading "O.C.L." refers to orange crustose lichen; Values of 0.1 and 0.01 represent '<1' and '<<1' values on original data sheet; n=49; means of % values calculated after arcsin-square root transformation]

Nest Plot ID	% Soil Cover	Percent rock of given diameter (cm)							Percent vegetative cover by type							
		<1	<5	<10	10-30	>30	Overall	>20[1]	Lichen	O.C.L.	Moss	Grass	Forb	Fern	Shrub	Overall
Known nest sites																
KODKIMU0801-A0	2.00	25	40	10	15	2	94	10	1	0.10	2	1	0.1	0	1	5
KODKIMU0802-A0	0.10	20	30	31	15	2	98	10	5	0.10	0.1	0.1	1	0	1	2
KODKIMU0803-1-A0	0.10	30	30	23	5	2	90	5	1	0.10	2	0.1	0.1	0	8	10
KODKIMU0804-2-A0	0.01	10	25	35	20	5	95	10	5	0.01	2	1	1	0	0	4
KODKIMU0805-A0	0.01	1	4	20	50	10	85	45	1	0.01	4	1	2	0	15	20
mean	0.20	15	24	23	19	3.7	93	14	2	0.05	1.7	0.5	0.7	0.0	3.1	7.2
standard deviation	0.30	3.6	3.4	1.5	4.2	0.6	1.0	4.0	0	0.01	0.4	0.1	0.2	0.0	2.6	1.6
standard error	0.08	0.9	0.8	0.4	1.0	0.2	0.2	1.0	0	0.00	0.1	0.0	0.1	0.0	0.6	0.4
Possible nest sites																
KODKIMU0803-2	1	40	40	12	1	1	95	1	2	0.01	3	2	0.1	0	0	5
KODKIMU0804-1-A0	0.01	15	29	22	25	10	100	2	3	0.01	2	0.1	2	0	0	7
mean	0.30	27	34	17	9.4	4.4	99	1.5	2	0.01	2.5	0.8	0.8	0.0	0.0	6.0
standard deviation	0.41	4.1	0.7	0.9	8.7	2.4	2.5	0.1	0	0.00	0.1	0.6	0.6	0.0	0.0	0.1
standard error	0.41	4.1	0.7	0.9	8.7	2.4	2.5	0.1	0	0.00	0.1	0.6	0.6	0.0	0.0	0.1

[1]Rocks >20cm were considered potential nest rocks, this measure taken separate from total 100% cover

Table 5. Composition of ground cover on 25-m radius nest plots
[means of % values calculated after arcsin-square root transformation]

Nest Plot ID	Vegetated (%)	Unvegetated (%)	Water (%)	Snow (%)	Viereck Class	Kodiak Land Cover
Known nest sites						
KODKIMU0801-A0	10	90	0	0	IIIc(2)a	57
KODKIMU0802-A0	1	99	0	0	IIIc(2)a	57
KODKIMU0803-1-A0	15	85	0	0	IID(2)c	57
KODKIMU0804-2-A0	5	95	0	0	IIIc(2)a	57
KODKIMU0805-A0	10	90	0	0	IID(2)c	42
mean	7.3	93	0	0		
standard deviation	1.3	1.3	0	0		
standard error	0.3	0.3	0	0		
Possible nest sites						
KODKIMU0803-2	10	90	0	0	IIIc(2)a	57
KODKIMU0804-1-A0	5	95	0	0	IIIc(2)a	57
mean	7.3	93	0	0		
standard deviation	0.5	0.5	0	0		
standard error	0.5	0.5	0	0		

Table 6. Geographic and landscape data at nest sites

[Nest IDs and data consistent with 5-m and 25-m radius plots and nest site characteristics.]

Nest ID	Latitude	Longitude	Position on Slope	Slope (degrees)	Aspect (degrees)	Elevation (m)	Distance to ridge (m)
Known nest sites							
KODKIMU0801	57?24.405'	154?31.863'	Top 20%	32	330	361	58
KODKIMU0802	57?24.482'	154?31.083'	Top 20%	34	290	400	55
KODKIMU0803-1	57?24.286'	154?32.715'	Top 10%	22	303	426	55
KODKIMU0804-2	57?24.417'	154?31.682'	Top 10%	29	329	412	18
KODKIMU0805	57?27.276'	154?32.990'	Top 30%	31	294	371	29
mean				30	309	394	43
standard deviation				4.6	19.1	27.4	18
standard error				2.3	9.6	13.7	9.1
Possible nest sites							
KODKIMU0803-2	57?24.284'	154?32.705'	Top 10%	22	301	431	48
KODKIMU0804-1	57?24.296'	154?31.175'	Top 10%	29	321	413	17
mean				25	311	422	33
standard deviation				4.6	14.1	12.7	22
standard error				4.6	14.1	12.7	21.9

Most of the adjacent and elevation non-use plots we surveyed were within the Sturgeon study area (Figure 11). Two adjacent plots were also surveyed at nest #0805 in the outlying northern area near Duncan Lake, but these are not shown here. Most of the random plots (n=51) that we surveyed fell within the ultramafic rock boundary (Figure 12). The raw geographic and landscape data at all non-use and random plots, and their summary statistics, are

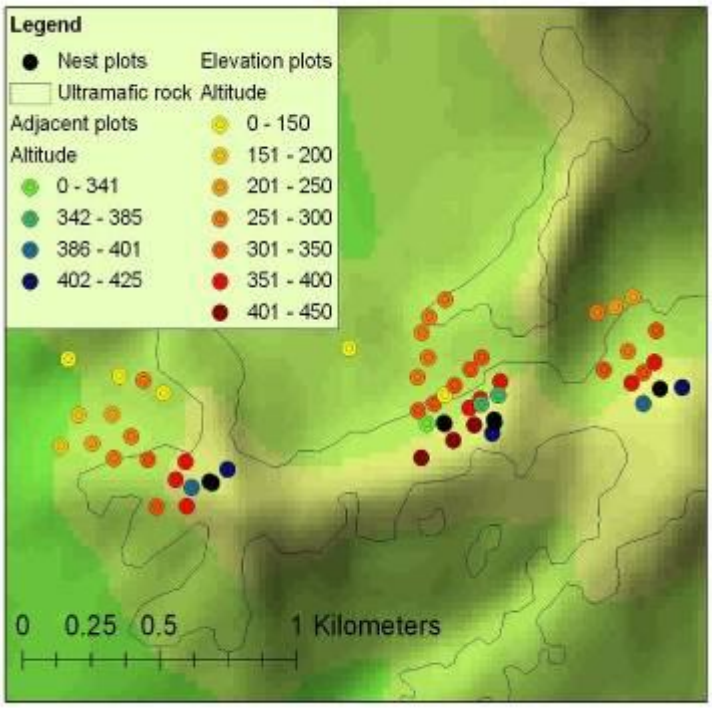

Figure 11. Nest, adjacent, and elevation plots within Sturgeon study area.

compiled in Appendices C & D. Ground cover composition differed among nest, adjacent, elevation, and random plots for the 5-m radius sample area (Table 7). Known nest sites (n=5) and possible nest sites (n=2) showed a mean overall rock cover of 93.1% and 98.7%, respectively, while adjacent plots (n=10) had only 59.2% mean rock cover. Plots selected at random within the ultramafic search area had only 39% mean rock cover. As expected, the low elevation plots (<250m) exhibited the least amount of rock cover (2.9%). As elevation plots increased in altitude, vegetative cover decreased while rock cover increased (e.g., plots >400m exhibited 75.1% rock cover).

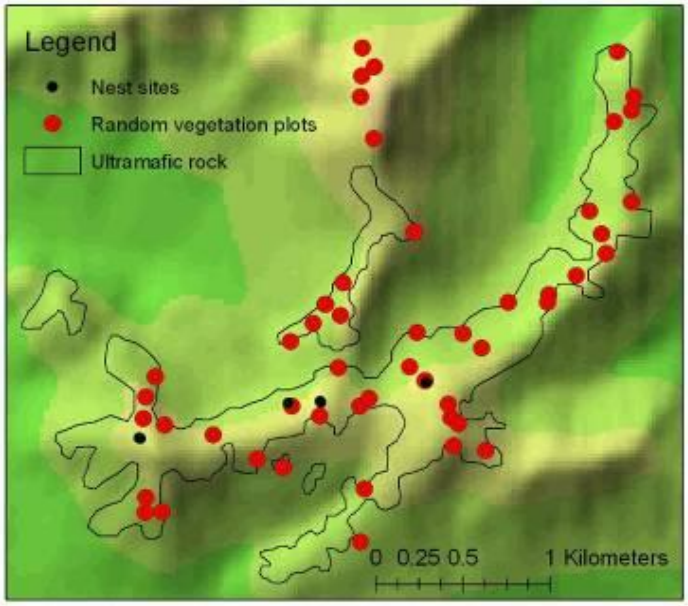

Figure 12. Random vegetation plots in Sturgeon study area.

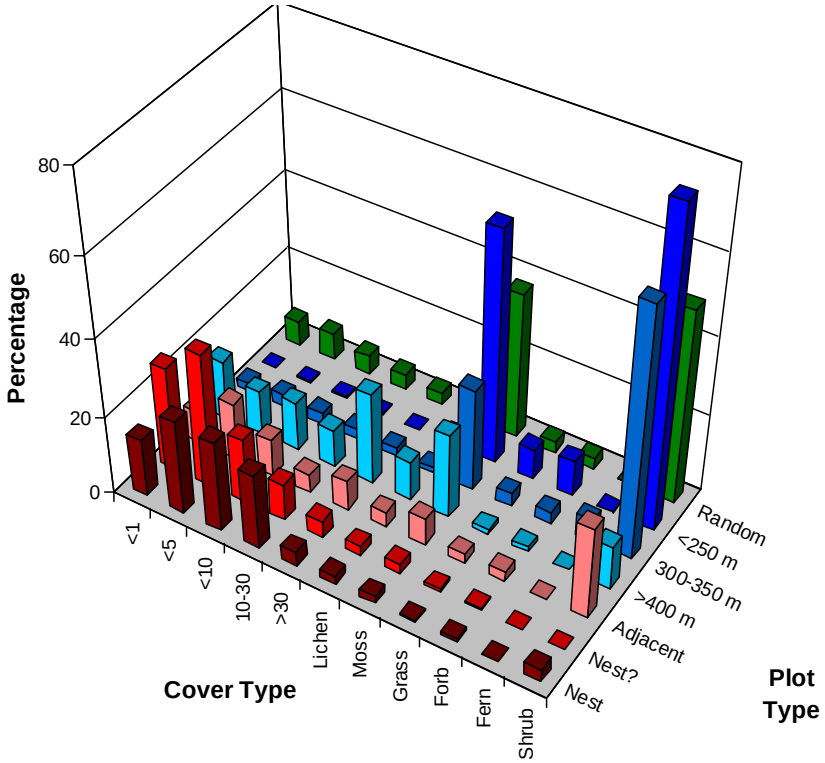

Figure 13. Mean percent ground cover type at all 5-m plots. Elevation plots are separated into three categories by altitude.

.

Table 7. Means, standard deviation and error for composition of ground cover within 5-m radius at nest sites, random plots, and non-use plots.

[Vegetative cover heading "O.C.L." refers to orange crustose lichen]

	% Soil	Percent rock of given diameter (cm)							Percent vegetative cover by type							
		<1	<5	<10	10-30	>30	Overall	>20[1]	Lichen	O.C.L.	Moss	Grass	Forb	Fern	Shrub	Overall
Known nest sites (*n* =5)																
mean	0.2	15.0	24.2	23.1	19.2	3.7	93.1	14.1	2.2	0.1	1.7	0.5	0.7	0.0	3.1	7.2
sd	0.3	3.6	3.4	1.5	4.2	0.6	1.0	4.0	0.5	0.0	0.4	0.1	0.2	0.0	2.6	1.6
se	0.08	0.92	0.85	0.37	1.05	0.16	0.24	1.00	0.12	0.00	0.09	0.04	0.06	0.00	0.65	0.39
Possible nest sites (*n* =2)																
mean	0.3	26.5	34.4	16.7	9.4	4.4	98.7	1.5	2.5	0.0	2.5	0.8	0.8	0.0	0.0	6.0
sd	0.4	4.1	0.7	0.9	8.7	2.4	2.5	0.1	0.1	0.0	0.1	0.6	0.6	0.0	0.0	0.1
se	0.41	4.06	0.67	0.90	8.70	2.43	2.52	0.09	0.05	0.00	0.05	0.61	0.61	0.00	0.00	0.09
Adjacent plots (n=10)																
mean	0.2	8.4	14.8	9.5	4.9	7.6	59.2	6.5	4.0	0.4	6.9	2.3	2.6	0.0	23.6	37.2
sd	0.2	3.6	5.7	2.8	1.5	7.3	16.4	5.7	2.3	0.6	2.2	1.4	0.2	0.2	17.1	17.9
se	0.02	0.36	0.58	0.29	0.15	0.75	1.73	0.58	0.23	0.06	0.22	0.14	0.02	0.02	1.80	1.90
Random plots (*n* =51)																
mean	0.1	6.3	6.9	5.0	4.0	3.2	39.0	4.0	2.9	0.4	37.5	2.9	2.9	0.2	49.4	61.8
sd	0.1	5.3	5.5	3.7	2.3	4.3	26.3	4.0	1.9	0.7	17.3	1.1	1.2	1.8	22.0	24.8
se	0.00	0.11	0.11	0.07	0.05	0.08	0.57	0.08	0.04	0.01	0.36	0.02	0.02	0.04	0.47	0.53
Elevation plots (<250m; n=8)																
mean	0.2	0.2	0.3	0.5	0.1	0.1	2.9	0.1	2.4	0.0	59.5	7.8	9.2	0.3	84.7	97.8
sd	0.3	0.7	0.9	1.6	0.6	0.6	3.4	0.6	0.8	0.1	7.4	3.1	0.7	1.9	6.5	3.6
se	0.04	0.08	0.12	0.20	0.08	0.08	0.43	0.08	0.11	0.02	0.95	0.39	0.08	0.24	0.83	0.46
Elevation plots (250-300m; n=11)																
mean	0.4	0.3	0.4	0.6	1.1	0.6	6.9	0.9	1.7	0.1	32.3	9.7	13.2	4.6	73.4	95.2
sd	0.8	1.3	2.1	2.6	3.2	1.9	10.3	2.5	1.9	0.2	17.3	3.9	4.9	8.8	9.8	12.3
se	0.07	0.11	0.19	0.23	0.30	0.18	0.96	0.23	0.17	0.02	1.66	0.36	0.45	0.82	0.92	1.16
Elevation plots (300-350m; n=12)																
mean	0.6	2.3	3.4	2.8	2.5	2.0	27.2	1.4	1.1	0.0	26.1	3.4	2.9	5.6	63.6	78.5
sd	1.7	3.9	5.6	4.9	4.5	5.7	29.0	2.7	1.2	0.1	18.5	2.5	0.5	14.6	33.8	32.9
se	0.14	0.33	0.47	0.42	0.38	0.48	2.67	0.23	0.10	0.01	1.64	0.21	0.04	1.28	3.17	3.08
Elevation plots (350-400m; n=8)																
mean	0.1	15.5	18.0	16.3	12.9	6.9	81.4	13.7	5.0	0.3	14.3	3.6	4.9	0.0	16.4	24.0
sd	0.2	1.2	1.1	1.5	2.0	2.3	11.7	2.1	0.7	0.2	5.1	2.2	1.7	0.0	9.1	9.8
se	0.02	0.15	0.13	0.18	0.25	0.29	1.52	0.27	0.09	0.02	0.64	0.28	0.21	0.00	1.16	1.26
Elevation plots (>400m; n=3)																
mean	0.1	15.0	11.1	12.6	9.6	23.3	75.1	16.2	9.9	1.8	21.5	1.3	1.3	0.0	10.9	25.0
sd	0.0	0.0	1.0	1.5	0.7	0.1	5.6	1.0	3.7	0.9	3.4	0.1	0.1	0.0	1.4	5.5
se	0.00	0.00	0.49	0.75	0.37	0.06	2.80	0.52	1.86	0.47	1.71	0.03	0.03	0.00	0.72	2.80

[1]Rocks >20cm were considered potential nest rocks, this measure taken separate from total 100% cover

A total of 14 ground cover variables were measured at the 5-m plot level, and 11 of these showed high variability among plot types and sub-types (Fig. 13). Adjacent and nest plots show a similar high frequency of rock sizes <1cm, <5cm, and <10cm in diameter. Adjacent plots also have

many small rocks, but show a higher percentage of shrub, moss, and lichen cover than nest sites. Elevation plots >400m resemble adjacent plots in their ground cover percentages. Lower elevation plots and random plots show a much higher amount of vegetative cover, especially shrub and moss, and a very low percentage of any rock size. Discriminant function analysis (DFA) was used to assess whether overall characteristics of nest sites were really different from adjacent, random or elevation plots. Preliminary analysis does suggest that nest sites do have a unique set of characteristics that set it apart from surrounding habitat (Fig. 14), even adjacent plots which to the human eye seem virtually indistinguishable from nest plots. This analysis will be repeated after more data on collected on nest plots, which currently comprise the smallest subset of plots for this comparative analysis.

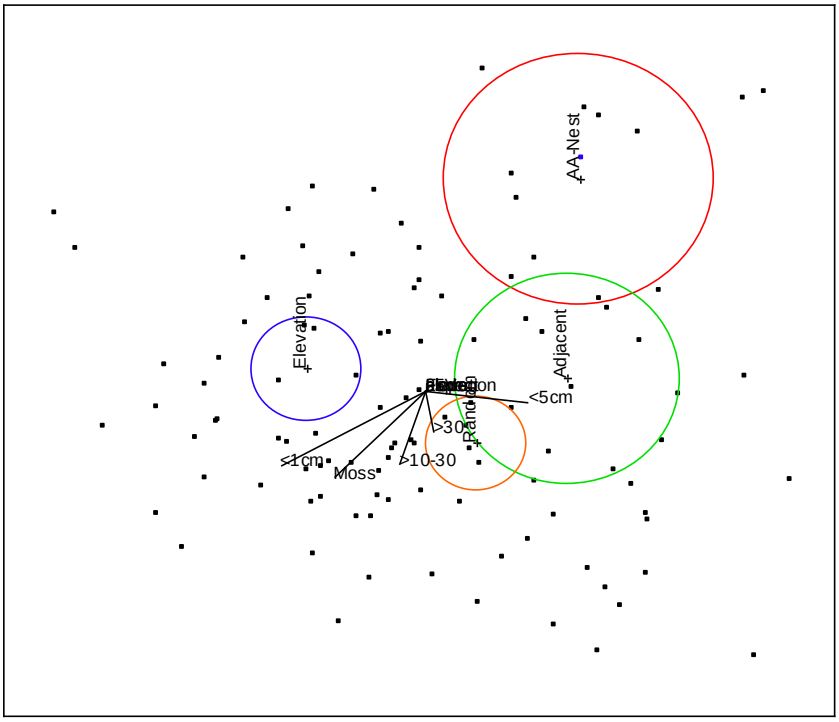

Figure 14. Visual of Discriminant Function Analysis (DFA) results.

Within a 25-m radius, percentage of vegetated and unvegetated cover at most plots generally reflected the same overall ground cover values estimated on the corresponding 5-m plots (Figure 8). Known nests, possible nests, and elevation plots >400m had the highest overall unvegetated coverages with 93%, 93%, and 82%, respectively. Digital pictures were taken at each elevation and adjacent plot site to document the typical ground cover seen at different elevations in the study area (See Appendices E and F for examples).

Table 8. Means, standard deviation and error for landscape data and composition of ground cover within 25-m radius at nest sites, random plots, and non-use plots.

	Vegetated (%)	Unvegetated (%)	Water (%)	Snow (%)	Slope (degrees)	Elevation (m)	Aspect (degrees)
Known nest sites (n=5)							
mean	7.3	93	0	0	30	394	309
sd	1.3	1.3	0	0	4.6	27.4	19
se	0.3	0.3	0	0	2.3	12.3	10
Possible nest sites (n=2)							
mean	7.3	93	0	0	25	422	311
sd	0.5	0.5	0	0	4.6	12.7	14
se	0.5	0.5	0	0	4.6	9.00	14
Adjacent plots (n=10)							
mean	39	61	0	0	26	317	320
sd	11	11	0	0	6.8	66	-
se	1.1	1.1	0	0	0.9	9.22	-
Random plots (n=)							
mean	59.8	40	0	0	23	351	347
sd	18.6	19	0	0	7.4	74.8	-
se	0.39	0.4	0	0	1.0	10.5	-
Elevation plots (< 250m; n=8)							
mean	80	20	0	0	23	214	309
sd	28	28	0	0	5.1	33.7	50.4
se	3.8	3.8	0	0	1.8	11.9	17.8
Elevation plots (250-300m; n=11)							
mean	94	5.7	0	0	23	268	317
sd	7.5	7.3	0	0	8.2	12.6	-
se	0.7	0.7	0	0	2.5	3.80	-
Elevation plots (300-350m; n=12)							
mean	77	23	0	0	27	316	326
sd	27	27	0	0	7.5	13.3	-
se	2.5	2.5	0	0	2.2	3.84	-
Elevation plots (350-400m; n=8)							
mean	27	73	0	0	30	363	312
sd	6.1	6.1	0	0	3.6	10.8	38.2
se	0.8	0.8	0	0	1.2	3.59	12.7
Elevation plots (>400m; n=3)							
mean	18	82	0	0	30	411	345
sd	0.1	0.1	0	0	4.6	0.58	5.00
se	0.1	0.1	0	0	3.3	0.41	3.54

Audio-visual Surveys

Overview

A total of 1,073 detections (see methods for definition) were recorded during 49 audio-visual surveys performed over a ten week period. At least one detection was recorded on 45 of the 49 mornings. Seven of the 10 survey stations were located within the main Sturgeon study area (Fig. 15, Appendix B). Stations established outside the study area included 2 to the north (Duncan Lake) and one to the south (Anvil Mt.) Five or more surveys were conducted at 4 of the 10 stations (Appendix B). The base camp (Sturgeon site) was the main survey station, and a total of 26 surveys were conducted there during the 10-week study period. In some locations, mainly outlying sites, only 1-3 surveys were conducted to confirm the presence of murrelets.

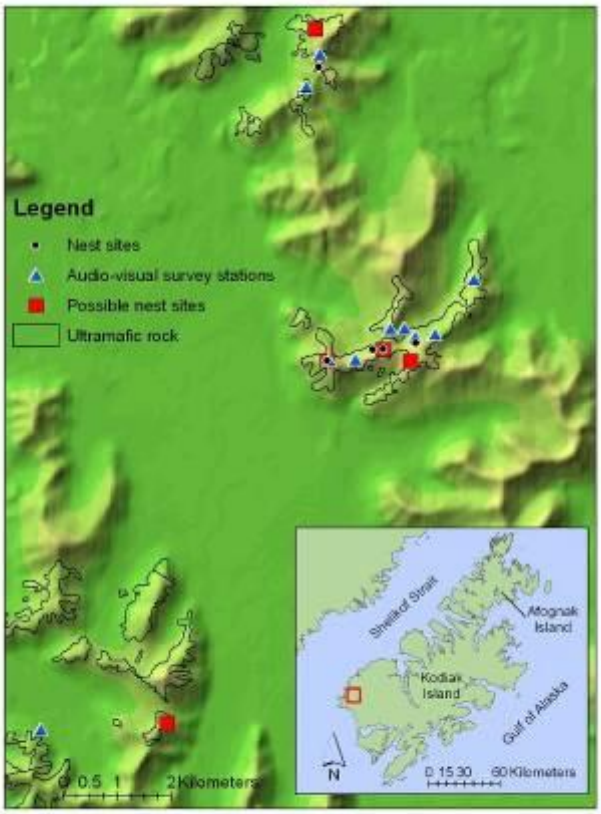

Figure 15. Map showing 10 audio-visual survey stations, 5 nests, and 5 possible nests.

Flight Behavior

Many inland flight behaviors of Kittlitz's murrelets were witnessed during this study. Although the majority of detections were audio only, it was possible to estimate the flight path of calling birds in many cases. Observers stationed at ridge-top survey stations were occasionally able to see murrelets firsthand when they flew along the ridgeline, roughly parallel to topographical elevation contours. These observations suggest that murrelets use saddles along the ridgeline as flight corridors between valleys,

and may use the ridges themselves as navigational landmarks. In addition to flying low along the ridgelines, murrelets were observed flying directly above and circling within the valley up to at least 125 m above the valley floor. In a few instances, murrelet wingbeat sounds but not calls were heard. Wing-beats were positively identified as Kittlitz's murrelet because we witnessed no other birds in the Sturgeon area with a similar fast-paced wing beat that could have been confused with this species.

Interactive behavior between birds was witnessed on several occasions. On July 5th observers conducting an audio-visual survey at the base camp saw a flock of five murrelets flying in close formation. Observers first heard this group at 06:10 h in the northeast, and could estimate their southeast direction flight path as the birds vocalized almost continuously. The observation of multiple calls occurring at the same time made it apparent that at least three birds were flying together. A shift in the direction of calls revealed that the flock had shifted to a westerly flight path leading them directly over the base camp site. At this time both observers visually identified five murrelets flying an estimated 300 m off the ground. Observers noted: "the five birds were flying so close together that they could have fit inside a cubic meter box." As they flew overhead they seemed to be interacting by changing their flight distances from each other erratically and calling. The birds then changed direction once more and headed towards the northeast. This final direction completed a circular flight path.

Many noteworthy flight behaviors were observed on July 23rd, including the seasonal peak of daily detections. In total, observers recorded more than 200 detections. Multiple flocks flying approximately 5-m or less above the ridge top repeatedly passed one observer standing at a ridge top station. A new vocalization described by an observer as an "in flight 'squeak' similar to a very loud squeak of a mouse" was accompanied by the "moderately fast/erratic flight between a pair of birds less than 1 m apart in flight". On this same morning, observers witnessed a flock of 7 murrelets flying together, and a flock of 5 murrelets was joined by 2 more birds while flying down-valley above the base

camp. These were the largest flocks of murrelets observed flying within the study area. Prior to this date, we had not observed single birds leaving or joining other groups. Also on July 23rd, we saw murrelets engaging in "slow, erratic flight, with short radius turns, and fluttering, swift-like wing beats. At times (these) birds almost appeared to be hovering in the air, their ground speed was so low". Finally, we also observed that flocks routinely lost and/or gained 30-100 m elevation during their flights on July 23rd.

Nest Visitation

Survey station 4 was located approximately 100 m from nest #0802, but was shielded from view by a small rise in slope. From this station an observer could detect most calls or wing beats coming from the vicinity of the nest. On July 1st at 04:00 h an observer heard two calls and the wing beats of a murrelet in the vicinity of the nest. Five minutes later a single call was heard coming from the ground in the vicinity of the nest. Within another minute, an adult Kittlitz's murrelet flew low (<2m) past the observer at a distance of 10 m and towards the nest area. The observer noted that the bird could have avoided swerving around outcrops if it had risen in altitude, but instead it chose to fly low and maneuver around large rock outcroppings. Between 04:07 h and 04:09 h the observer detected two separate wing beat episodes, and the second was accompanied by the visual observation of a murrelet flying 15 m down-slope of the observer. This bird changed its direction and flew in an arc that curved upwards and back towards the nest area. This was the last detection in the nest area during this survey.

Patterns of Attendance

Mean total detections per survey ranged between 15 and 45 (Table 9). Total vocalizations per survey site (defined as a single, distinct call belonging to a Kittlitz's Murrelet) ranged between 70 and 381, but as many as 839 vocalizations were recorded. The shortest activity period was 1 minute, recorded on a morning where there was one detection. The longest activity period was 4 hours 22 minutes, recorded at station 5 on July 19th. Mean activity period duration (h:mm) at stations 1, 2, 4, and

Table 9. Means and standard deviation of daily detection and vocalization counts and duration of daily activity periods (h:mm) for Kittlitz's Murrelets at four survey stations, Kodiak Island, June 6-August 11, 2008.
[*n* = number of surveys held at each station]

Measure of Activity	Survey Station			
	1	2	4	5
n	26[1]	5	5	6
Total detections	408	76	136	269
range	1-68	1-26	9-55	3-113
mean	16	15	27	45
sd	17.0	9.2	17.3	49.7
Total vocalizations	2764	350	456	1910
range	0-536	2-115	50-148	5-839
mean	106	70	91	318
sd	134	46	36	370
Total duration of activity periods	22:46	7:37	10:47	14:15
range	0:01-3:44	0:01-3:01	1:26-2:29	0:21-4:22
mean	1:02	1:31	2:09	2:22
sd	0.04	0.05	0.02	0.06

[1]n=22 for activity period data

5 were 1:02, 1:31, 2:09, and 2:22, respectively. Of the 889 detections made at stations 1, 2, 4 and 5, 840 were audio, 30 visual, and 19 audio-visual detections. Nearly all visual-only detections were recorded by observers positioned at survey sites (stations 2, 4, and 5) situated along the ridgeline where birds were often seen flying low (1-5m) above the ground. In the valley, observers rarely saw murrelets without hearing bird(s) call first.

While groups of up to seven birds were observed, the majority of detections were of one or two birds (Fig. 16). The majority of detections were noted during the hour immediately surrounding sunrise (Fig. 17). However, on some mornings birds continued calling and flying within the study area up to three hours after sunrise.

Seasonal Patterns in Behavior

There was a rise in murrelet activity in both early and late July, revealed by the pattern of detections (audio, audio-visual, and visual) during this month (Fig. 18). There was a corresponding increase in the number of vocalizations heard at station 1(Fig. 19). The duration of daily activity periods within the main study area increased between late-June and late-July (Fig. 20). To assess whether flock-size changed seasonally, data was subdivided into two periods, June 8-July 22 and July 23-August 11(the approximate halfway point of the entire survey period). Larger group sizes were observed more in the later half of the survey period (Fig. 21).

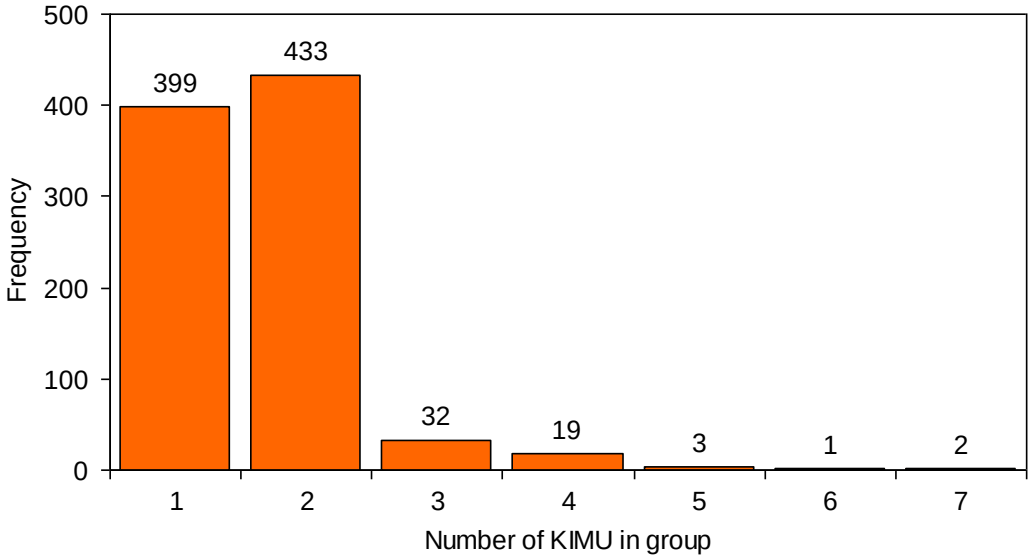

Figure 16. Group size of Kittlitz's Murrelet detections in Kodiak Island study area, June 8-August 11, 2008.

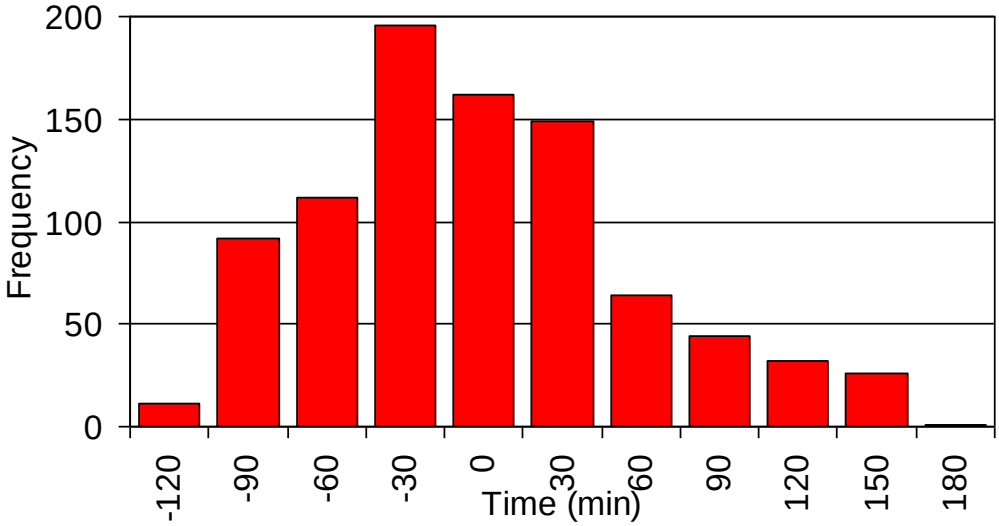

Figure 17. Detections relative to sunrise in Sturgeon study area, Kodiak Island, June 8-August 11, 2008. [0=sunrise]

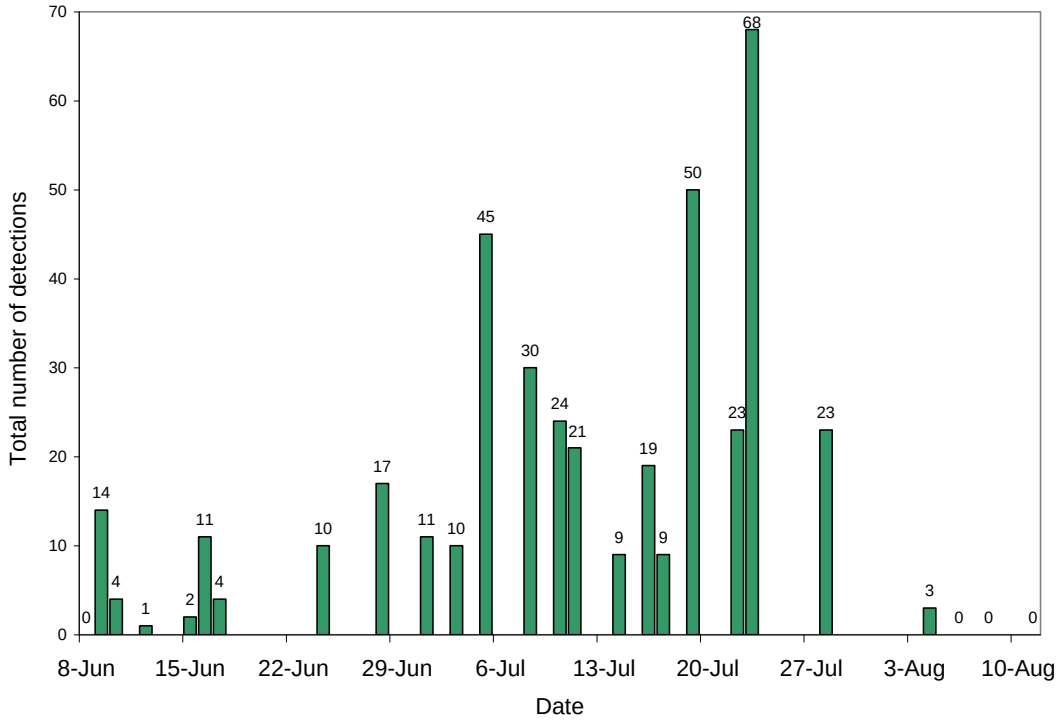

Figure 18. Total detections during audio-visual surveys at Sturgeon site, Kodiak Island, June 8-August 11, 2008.

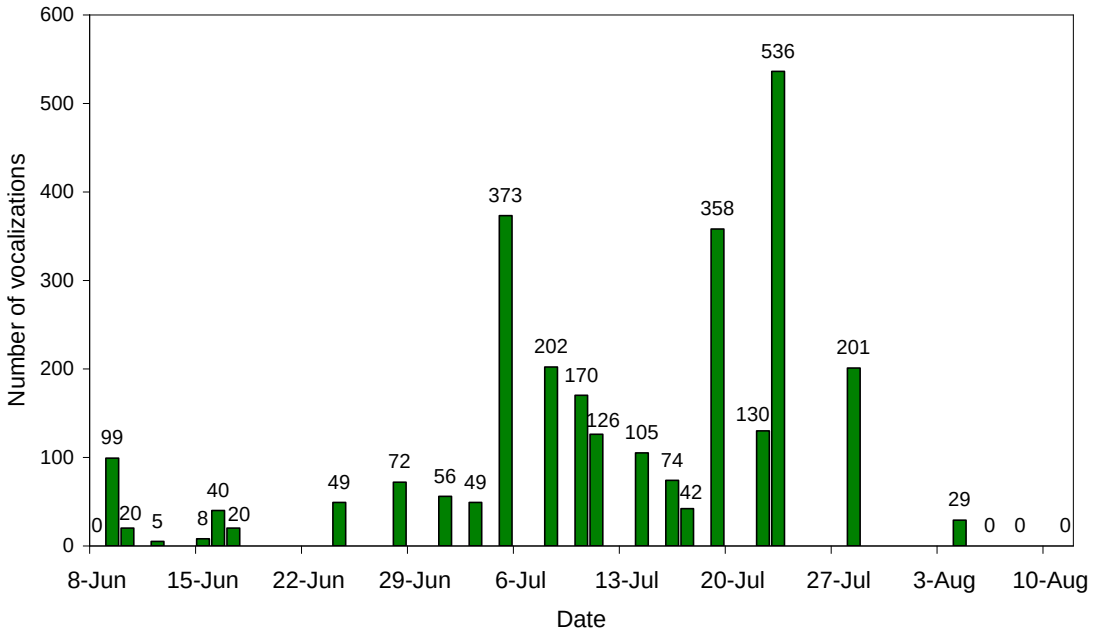

Figure 19. Kittlitz's Murrelet vocalizations at Sturgeon Site, Kodiak Island June 8-August 11, 2008

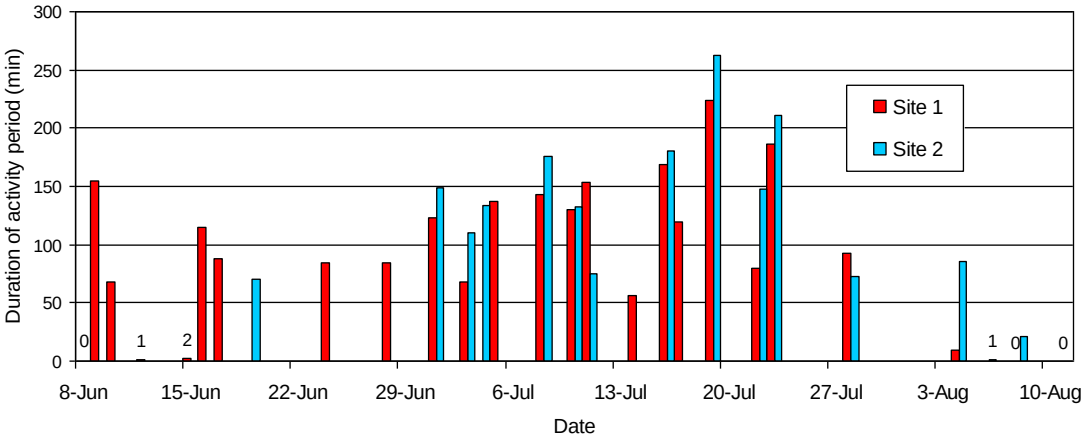

Figure 20. Duration of daily activity periods at Kodiak Island study area, June 8-August 11, 2008. [Site 1=Station 1; Site 2=Station 2, 4, or 5]

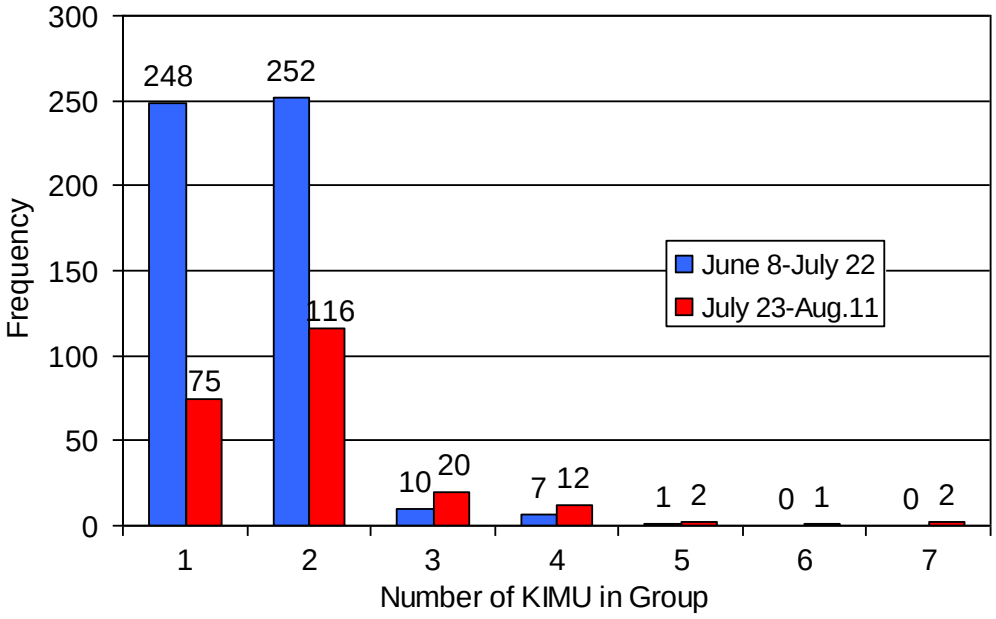

Figure 21. Group size of Kittlitz's Murrelet detections in Kodiak Island study area, June 8-August 11, 2008.

Discussion

In July, 2007 a refuge crew conducting a plant survey heard Kittlitz's murrelets calling within the Sturgeon study area. Subsequently, a radar crew deployed to the site documented consistent, intensive use of the airspace over the area by Kittlitz's murrelet (Day and Barna 2007). To confirm the possibility that aerial observations were associated with nesting, we developed and implemented this study. Systematic ground searching led to the discovery of five nests, and 5 additional empty "murrelet-like" nests in the ultramafic terrain of the Sturgeon study area. On Agattu Island, Alaska, researchers also located multiple Kittlitz's murrelet nests by focusing ground-search efforts in the terrain type where nests were previously found (Kaler et al. 2008, 2009). Prior to this study, most recorded Kittlitz's murrelet nests were discovered unintentionally by hikers or researchers who inadvertently flushed an incubating adult bird or encounterned a nestling.

Our attempts to locate nests without flushing the adult during the incubation period were not successful. Nests set in scree and small talus covering these mountain slopes are extremely cryptic; in all cases the flushed bird was not seen until it was airborne. Locating nests without flushing the adult may be feasible if nest locations are reused year after year, but flushing the adult is the most efficient way to locate nests for the first time. Although we were able to find one nest using a stationary ground audio detection observed during an audio-visual survey, it took over two hours of searching in the area where the call was made to finally locate the nest by flushing the adult. Given the cryptic coloration of Kittlitz's Murrelet and the ruggedness of its preferred nesting habitat, it is unlikely that attempts to spot incubating birds using binoculars or a spotting scope is practical, or even possible, in most cases, even when observers believe they have a rough estimate of a nest location.

None of the five nests we discovered were successful, and only one egg possibly made it to the chick stage. The high failure rate of the nests we discovered could be attributed to a number of factors.

One nest was probably abandoned after a rockfall occurred, flushed the adult, chipped the egg, and made it unviable. Several nests could have been depredated since potential nest predators were seen regularly throughout the summer. Researchers standing at nest sites, even for a brief (<10 min) period of time, could attract aerial predators to the site by direct observation or by later observation of human footprints and disturbed rock habitat. Although we never saw any direct evidence for it, our research activities could have induced nest abandonment which was then followed by nest depredation (Piatt et al. 1990). Similarly, it is possible that frequent inclement weather induced abandonment during the incubation or nestling stage, or may cause direct mortality of chicks owing to exposure (Piatt et al. 1990, Kaler et al. 2008, 2009).

Four of the five nests we discovered were similar in appearance to previous descriptions of Kittlitz's murrelet nests (Day et al. 1983, Piatt et al. 1999). Each nest was located at the base of a larger rock or group of rocks that could probably serves as a barrier to rock-fall, sight barrier to predators, or landmark for attending adults (Fig. 6-10). In contrast, one nest occurred within a patch of moss, possibly a natural bowl, within a group of rocks on a talus-covered slope. The five documented nests occurred at a lower elevation than previously known Kittlitz's murrelet nests (Day et al. 1983). In this part of Kodiak Island appropriate nesting habitat is available at a lower altitude due to the fact that few plant species can grow within ultramafic rock zones. All nests were in direct view of the ocean. While this tendency could be an artifact of small sample size, it is possible that Kittlitz's Murrelet prefers to orient nests in relation to the ocean or other landscape features (e.g., a river valley leading to the sea). Such orientation could facilitate site access by adults and successful fledging by chicks.

We discovered three cases where an apparent nest scrape occurred within 5-m of an active nest. Nests located in proximity to one another have been observed in the marbled murrelet, and it seems likely that these paired nests belonged to the same mating couple (Naslund 1993). Furthermore, they

may represent repeated nesting attempts within one breeding season, reflect inter-annual nest site fidelity, or result from selection for specific landscape characteristics that different Kittlitz's murrelets may seek out when choosing a microhabitat for nesting.

Kittlitz's murrelets appeared to select nest sites based on several factors. Small rocks (1-10 cm) were abundant in nest plots and adjacent plots, but the latter had more moss and shrub cover and were usually devoid of large barrier rocks. Nests were most common at higher altitudes, but compared to nest plots, elevation plots at similar altitudes (360-430m) contained more moss and shrub ground cover, suggesting that presence of vegetation may influence adult Kittlitz's Murrelets' nesting preferences. Our data suggest that Kittlitz's Murrelets show a marked preference for relatively vegetation-free areas with an abundance of rock between 1 and 30 cm, with higher-elevation sites preferred over lower elevation sites.

Observers conducting audio-visual surveys discovered that Kittlitz's Murrelets were most active during the hours surrounding sunrise. Marbled Murrelets flying inland to and from nest sites also exhibit this pattern (Doerr and Walsh 1994). The majority of detections were of one or two birds only (Fig. 16). Audio-visual surveys of Marbled Murrelets also note a larger number of small group sizes (Jodice and Collopy 2000). We observed larger flocks (3-7 birds) during the second half of our study (Fig. 21), which could be attributed to non-breeding birds or nesting phenology.

Results from audio-visual surveys indicated that this method can be applied to index relative activity, and in some cases, habitat occupancy (Naslund 1993). Samples could be biased by a few birds that call frequently and under-representation of non-calling birds. Vocalizations in the open valley could sometimes be heard from a long distance (>500m), which may not be possible in most surveys of marbled murrelet where sound is attenuated by conifer forest surrounding observers. Occupancy estimates could be biased if some birds used the Sturgeon study area as a passageway to their true

nesting sites further inland. Surveying Kittlitz's murrelets was challenging because the birds often flew above the ceiling where they were invisible to observers, and during the hours surrounding sunrise, birds that flew low along ridgelines were camouflaged by the rocky background.. The rare instances when birds were detected visually before being heard, or without the birds calling at all, occurred at survey stations established near ridge tops.

Results of our study demonstrates that habitat occupancy can be established by concurrent audio-visual surveys and nest searches (Burger and Bahn 2004). Our detection of murrelets during audio-visual surveys and our discovery of five nests definitively established that breeding Kittlitz's murrelets occupied ultramafic terrain at the Sturgeon study area and Duncan Lake vicinity to the north. Occupancy of another outlying site was suggested from detections recorded during audio-visual surveys. An occupied site for marbled murrelets is defined as any location where murrelets are observed flying below the canopy or circling within a forested area; these behaviors strongly suggest that the site has some significance for breeding birds (Burger and Bahn 2004). In the case of Kittlitz's murrelet, we suggest that circling flight paths and birds flying low along the ridgelines may indicate occupancy. Frequent calling and group flight activity could also indicate that the area may support nesting.

This study was first to examine inland flight behavior of Kittlitz's murrelet over the breeding season. A peak in marbled murrelet inland activity in July has been attributed to post-fledging territorial behavior termed "jubilation display" (Doerr and Walsh 1994). Any change in the frequency of detections made by observers could also be attributed to the irregular inland flight habits of non breeding birds (Jodice and Collopy 2000). We witnessed a similar peak in Kittlitz's murrelet activity during July. While these increases are noteworthy, an increase in detections does not mean that more birds were present, but merely that more birds were calling.

Studies have also shown that adults call more frequently once their chick has hatched, as nest attendance increases during the feeding stage (Jodice and Collopy 2000). However, the increase in activity in our study area continued through the end of July, even after all nests in the area had failed. It is possible that failed breeders remained in the vicinity of their nest sites to maintain their territory or to fulfill a social role. It is also possible that adults we observed were associated with undiscovered nests in the Sturgeon area. Non-breeding birds potentially call more than those that have a nest, because they are not at risk of losing any offspring if noticed by predators. Non breeding birds could have contributed to varying detection numbers over the 10 week study period (Naslund 1993, Paton 1995).

Implications for 2009 Study

Our study plan will be revised in April 2009 based on results and experiences acquired in 2008. A preliminary forecast of the 2009 plan follows. It will include two additional study sites: the vicinity of Duncan Lake, where nesting was documented in 2008, and the vicinity of Anvil Mountain, where birds were observed and a possible nest was found. Collectively, the 3 study sites contain most (75%; 7.2/9.6 km^2) of the ultramafic terrain and potentially suitable nesting habitat of Kittlitz's murrelet in western Kodiak Island. Study area expansion will increase the sample of nests, possibly as many as 20/year and it will disperse research activity, which should reduce potential for adverse research influence. Nests will be monitored primarily with small weatherproof digital cameras situated and concealed nearby and programmed to acquire images at 1-min intervals. . We will combine radar technology with observer-based audio-visual surveys in an effort to pinpoint the exact movements of murrelets in this area of Kodiak National Wildlife Refuge. We will record early morning vocalizations using a SongMeter recording device to help assess the frequency of vocalizing in nesting areas. The importance of keeping future audio-visual surveys consistent with those that have already been conducted will be stressed. By

making slight changes to the Marbled Murrelet Inland Survey Protocol, a universal method for conducting Kittlitz's murrelets Inland Surveys can be developed.

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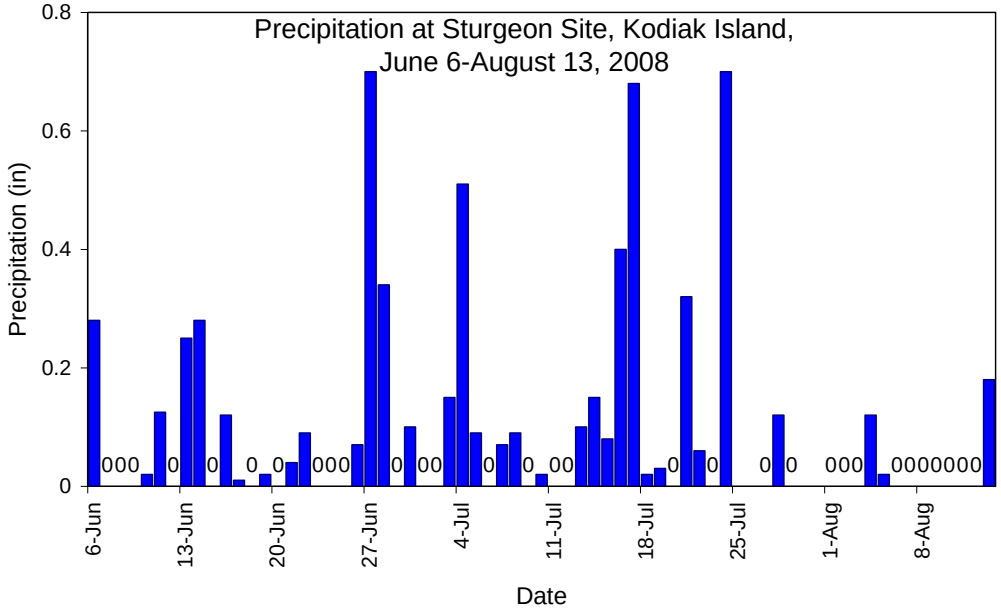
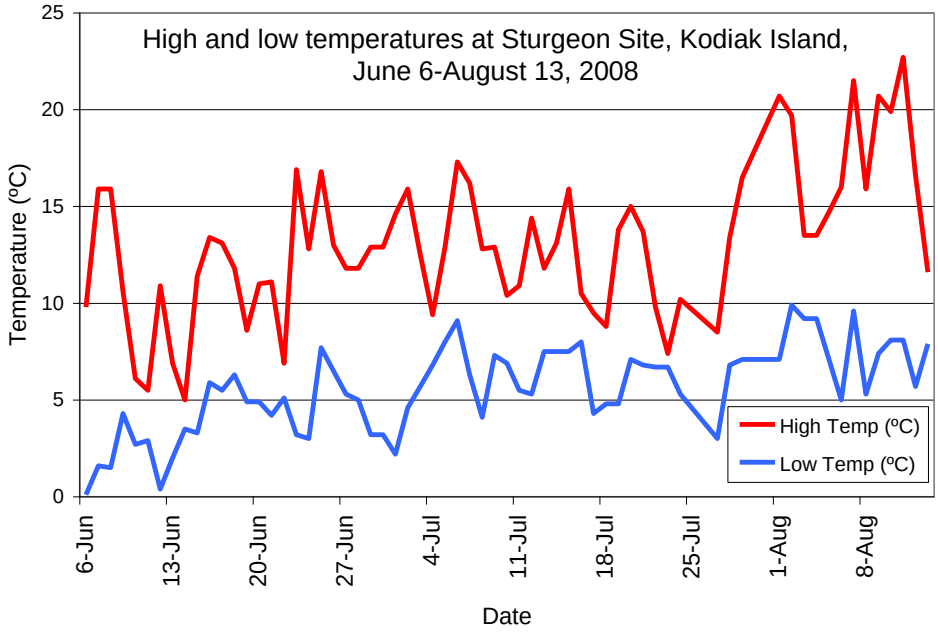
Appendix A. Weather recorded at Sturgeon site base camp, 6 Jun-13 Aug, 2008

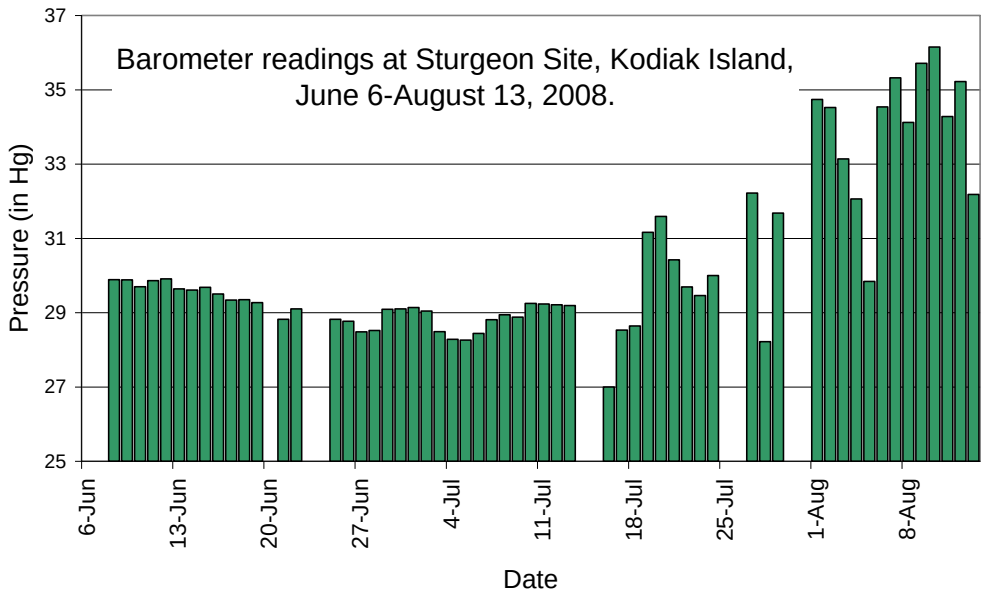
[UNL = unlimited(clear sky); nd = no data available]

Date	Cloud Cover (%)	Ceiling (ft)	Wind (mph)	Wind Direction	Visibility (mi)	Precipitation (in)	High Temp (°C)	Low Temp (ºC)
6-Jun-08	20	2000	5-10	SE	>5	0.28	9.8	0.1
7-Jun-08	100	900	10-30	SE	3	0.00	15.9	1.6
8-Jun-08	5	UNL	5	SW	>5	0.00	15.9	1.5
9-Jun-08	100	800	5-10	SE	0.5	0.00	10.6	4.3
10-Jun-08	100	900	5	SW	1	0.02	6.1	2.7
11-Jun-08	100	1000	5	SE	2	0.13	5.5	2.9
12-Jun-08	15	2200	5-10	S	5	0.00	10.9	0.4
13-Jun-08	100	2200	10-40	S	5	0.25	6.9	2.0
14-Jun-08	100	900	15-20	S	2	0.28	5.0	3.5
15-Jun-08	50	900	5-10	S	5	0.00	11.4	3.3
16-Jun-08	100	1000	6	S	3	0.12	13.4	5.9
17-Jun-08	100	800	6.1	S	0.25	0.01	13.1	5.5
18-Jun-08	100	800	8.5	SSW	0.25	0.00	11.8	6.3
19-Jun-08	100	1200	3	SSW	3	0.02	8.6	4.9
20-Jun-08	100	1000	5	SW	2	0.00	11.0	4.9
21-Jun-08	100	1000	2	SW	5	0.04	11.1	4.2
22-Jun-08	100	2500	0.00	Calm	5	0.09	6.9	5.1
23-Jun-08	10	5000	4.00	NE	5	0.00	16.9	3.2
24-Jun-08	100	2500	1.00	S	5	0.00	12.8	3.0
25-Jun-08	100	3000	10.80	N	5	0.00	16.8	7.7
26-Jun-08	100	1300	5.00	E	5	0.07	13.0	6.5
27-Jun-08	100	3000	0.00	Calm	5	0.70	11.8	5.3
28-Jun-08	95	1800	5.00	WSW	5	0.34	11.8	5.0
29-Jun-08	10	UNL	5.00	NNE	UNL	0.00	12.9	3.2
30-Jun-08	100	2000	0.00	Calm	5	0.10	12.9	3.2
1-Jul-08	100	2500	5.00	S	5	0.00	14.6	2.2
2-Jul-08	100	3000	5.00	N	3	0.00	15.9	4.6
3-Jul-08	100	1500	6.00	SW	3	0.15	12.5	5.7
4-Jul-08	100	1600	8.00	NNE	5	0.51	9.4	6.8
5-Jul-08	100	1700	7.00	NE	5	0.09	12.9	8.0
6-Jul-08	100	3000	5	N	5	0.00	17.3	9.1
7-Jul-08	100	1100	0	Calm	3	0.07	16.2	6.3
8-Jul-08	100	1300	5-10	S	5	0.09	12.8	4.1
9-Jul-08	100	1200	5-10	nd	5	0.00	12.9	7.3
10-Jul-08	100	1600	5-10	SE	UNL	0.02	10.4	6.9
11-Jul-08	100	4000	5	NE	UNL	0.00	10.9	5.5
12-Jul-08	70	4000	5	SSW	UNL	0.00	14.4	5.3
13-Jul-08	100	2000	5	S	5	0.10	11.8	7.5
14-Jul-08	100	0	5	nd	0.5	0.15	13.1	7.5
15-Jul-08	100	900	5-10	nd	1	0.08	15.9	7.5
16-Jul-08	100	1500	15	SW	1	0.40	10.5	8.0
17-Jul-08	90	1800	10	SE	5	0.68	9.5	4.3
18-Jul-08	100	2000	2	SW	5	0.02	8.8	4.8
19-Jul-08	100	1000	3	SW	4	0.03	13.8	4.8
20-Jul-08	100	1700	10-15	SE	5	0.00	15.0	7.1
21-Jul-08	100	1800	10-20	SW	5	0.32	13.7	6.8
22-Jul-08	100	1500	10	SW	3	0.06	9.8	6.7
23-Jul-08	100	2000	1-2	SW	5	0.00	7.4	6.7
24-Jul-08	98	2000	0-5	NE	4	0.70	10.2	5.3
25-Jul-08[1]	0	UNL	10	W	5	0.00	13.1	5.4
26-Jul-08[1]	50	4000	10-20	W	5	0.01	18.7	6.1
27-Jul-08	90	4000	0	Calm	5	0.00	8.5	3.0
28-Jul-08	0	UNL	3	N	5	0.12	13.4	6.8
29-Jul-08	70	2000	10	NE	5	0.00	16.5	7.1
30-Jul-08[2]	0	UNL	0	Calm	5	0.00	16.6	8.1
31-Jul-08[2]	0	UNL	2	E	5	0.00	19.1	7.3
1-Aug-08	20	UNL	0	Calm	UNL	0.00	20.7	7.1
2-Aug-08	100	900	5	E	nd	0.00	19.7	9.9
3-Aug-08	100	nd	0	Calm	nd	0.00	13.5	9.2
4-Aug-08	100	1000	5	E	5	0.12	13.5	9.2
5-Aug-08	100	900	0	Calm	5	0.02	14.7	7.1
6-Aug-08	10	UNL	0	Calm	UNL	0.00	16.0	5.0
7-Aug-08	100	5000	5	S	UNL	0.00	21.5	9.6
8-Aug-08	10	UNL	0	Calm	UNL	0.00	15.9	5.3
9-Aug-08	10	UNL	2	S	UNL	0.00	20.7	7.4
10-Aug-08	0	UNL	2	S	UNL	0.00	19.9	8.1
11-Aug-08	100	200	0	Calm	1	0.00	22.7	8.1
12-Aug-08	30	UNL	8	NE	UNL	0.00	16.6	5.7
13-Aug-08	100	1300	12	NE	5	0.18	11.6	7.9

[[1]Weather on these dates was collected in Duncan Lake Vicinity, [2]Weather on these dates was colle
near Anvil Mountain]


Precipitation at Sturgeon Site, Kodiak Island,
June 6-August 13, 2008
Precipitation (in)
0.8
0.6
0.4
0.2
0
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
Date


High and low temperatures at Sturgeon Site, Kodiak Island,
June 6-August 13, 2008
Temperature (ºC)
25
20
15
10
5
0
High Temp (ºC)
Low Temp (ºC)
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
Date


Barometer readings at Sturgeon Site, Kodiak Island,
June 6-August 13, 2008.
Pressure (in Hg)
37
35
33
31
29
27
25
6-Jun
13-Jun
20-Jun
27-Jun
4-Jul
11-Jul
18-Jul
25-Jul
1-Aug
8-Aug
Date

Appendix B. Landscape data and ground cover at audio-visual survey stations on Kodiak Island, AK, Jun-Aug 2008.

Site	Station #	No. of surveys completed	Latitude	Longitude	Elevation (m)	Slope (degrees)	% Vegetative cover in given radius			% Rock cover in given radius		
							25-m	100-m	200-m	25-m	100-m	200-m
Sturgeon	1	26	57 24.628'	154 31.293'	242	0	100	95	80	0	5	20
Sturgeon	2	5	57 24.572'	154 30.730'	339	5	1	1	10	99	99	90
Sturgeon	3	1	57 24.618'	154 31.566'	369	25	50	40	40	50	60	60
Sturgeon	4	5	57 24.537'	154 31.094'	355	30	20	10	10	80	90	90
Sturgeon	5	6	57 24.296'	154 32.182'	408	5	70	50	40	30	50	60
Sturgeon	6	1	57 24.285'	154 32.669'	443	5	10	10	20	90	90	80
Sturgeon	7	1	57 25.140'	154 30.032'	315	5	10	10	20	90	90	80
Duncan	8	2	57 27.410	154 32.978	-	-	-	-	-	-	-	-
Duncan	9	1	57 26.996	154 33.251	330	-	-	-	-	-	-	-
Anvil	10	1	57 20.443'	154 37.807	79	5	100	100	90	0	0	10

Appendix C. Geographic and ground cover data at elevation and adjacent non-use plots.

Geographic data for elevation and adjacent non-use plots.

[Plot IDs correspond with both 5-m and 25-m radius plots.]

Non-Use Plot ID	Latitude	Longitude	Slope (degrees)	Elevation (m)	Aspect (degrees)	GPS error (+/- m)
KK0801-A1	57˚24.444'	154˚31.731'	28	372	325	4
KK0801A2	57˚24.405'	154˚31.929'	32	351	335	5
KK0801-AA0	57˚24.375'	154˚31.831'	33	410	345	6
KK0801-AA1	57˚24.405'	154˚31.755'	33	411	340	8
KK0801-AA2	57˚24.341'	154˚31.945'	25	411	350	5
KK0801-B0	57˚24.333'	154˚31.903'	29	310	350	5
KK0801-B1	57˚24.461	154˚31.864'	29	315	345	4
KK0801-B2	57˚24.429'	154˚31.960'	31	309	340	8
KK0801-C0	57˚24.491'	154˚31.966'	20	263	295	7
KK0801-C1	57˚24.529'	154˚31.929'	18	261	310	5
KK0801-C2	57˚24.543'	154˚32.216'	25	263	342	6
KK0802-A2	57˚24.452'	154˚31.141'	30	400	312	4
KK0802-A1	57˚24.484'	154˚31.001'	26	425	4	5
KK0802-B0	57˚24.510'	154˚31.143'	31	350	320	4
KK0802-B1	57˚24.529'	154˚31.103'	31	351	285	4
KK0802-B2	57˚24.490'	154˚31.185'	33	351	330	4
KK0802-C0	57˚24.550'	154˚31.202'	25	300	329	4
KK0802-C1	57˚24.590'	154˚31.099'	31	301	5	4
KK0802-C2	57˚24.513'	154˚31.288	33	303	338	10
KK0802-D0	57˚24.620'	154˚31.317'	3	257	71	4
KK0802-D1	57˚24.651'	154˚31.187'	24	249	0	4
KK0802-D2	57˚24.632'	154˚31.250'	11	249	342	4
KK0803-A1	57˚24.310'	154˚32.651'	30	420	98	6
KK0803-A2	57˚24.274'	154˚32.780'	22	401	225	6
KK0803-B0	57˚24.288'	154˚32.839'	25	376	294	3
KK0803-B1	57˚24.322'	154˚32.803'	25	374	315	4
KK0803-B2	57˚24.239'	154˚32.794'	30	376	240	4
KK0803-C0	57˚24.324'	154˚32.940'	30	325	318	5
KK0803-C1	57˚24.450'	154˚32.889'	28	325	253	5
KK0803-C2	57˚24.236'	154˚32.905'	37	325	221	6
KK0803-D0	57˚24.368'	154˚33.004'	24	277	322	5
KK0803-D1	57˚24.473'	154˚32.964'	28	274	267	5
KK0803-D2	57˚24.325'	154˚33.064'	27	275	305	4
KK0803-E0	57˚24.408'	154˚33.073'	26	232	360	5
KK0803-E1	57˚24.480'	154˚33.051'	25	232	250	6
KK0803-E2	57˚24.352'	154˚33.144'	27	225	314	3
KK0803-F0	57˚24.405'	154˚33.195'	24	173	311	5
KK0803-F1	57˚24.509'	154˚33.237'	20	173	220	5
KK0803-F2	57˚24.346'	154˚33.258'	23	177	318	7
KK0804-2-A1	57˚24.461'	154˚31.669'	25	377	69	5
KK0804-2-A2	57˚24.390'	154˚31.688'	9	412	182	5
KK0804-2-B0	57˚24.454'	154˚31.735'	34	363	360	4
KK0804-2-B1	57˚24.487'	154˚31.664'	29	356	342	3
KK0804-2-B2	57˚24.436'	154˚31.775'	34	359	333	4
KK0804-2-C0	57˚24.417'	154˚31.682'	13	312	334	5
KK0804-2-C1	57˚24.530'	154˚31.734'	13	312	324	6
KK0804-2-C2	57˚24.477'	154˚31.829'	22	310	342	4
KK0804-2-D0	57˚24.605'	154˚31.926'	35	261	329	4
KK0804-2-D1	57˚24.638'	154˚31.870'	30	261	342	4
KK0804-2-D2	57˚24.575'	154˚31.952'	21	259	265	5
KK0805-A1	57˚27.305'	154˚33.047'	25	341	264	6
KK0805-A2	57˚27.234'	154˚32.970'	25	385	192	5
mean			26	317	320	5
standard deviation			6.8	66.5	-	1
standard error			0.9	9.22	-	0.2

Composition of ground cover on 5-m radius elevation and adjacent non-use plots.

[Vegetative cover heading "O.C.L." refers to orange crustose lichen; Values of 0.1 and 0.01 represent '<1' and '<<1' values on original data sheet; n=49; means of % values calculated after arcsin-square root transformation]

Non-use Plot ID	% Soil	Percent rock of given diameter (cm)							Percent vegetative cover by type							
		0.1	<5	0.1	10-30	>30	Overall	>20[1]	Lichen	O.C.L.	Moss	Grass	Forb	Fern	Shrub	Overall
KK0801-A1	1	20	35	25	10	5	96	10	2	1	3	1	1	0	2	5
KK0801A2	0.01	15	35	15	10	5	80	10	3	2	5	3	2	0	15	20
KK0801-AA0	0.1	15	15	15	10	25	80	25	15	2	18	1	1	0	10	20
KK0801-AA1	0.1	15	15	20	15	25	90	15	1	0.1	10	1	1	0	5	10
KK0801-AA2	0.1	15	5	5	5	20	50	10	20	5	40	2	2	0	20	50
KK0801-B0	5	0	0	0	0	0.1	5	0.1	0.1	0	80	2	5	1	90	99
KK0801-B1	0.01	0	0	0	0	0	0	0	0	0	20	5	5	10	98	100
KK0801-B2	0	0	0	0	0	0	0	0	1	0	90	2	1	3	99	100
KK0801-C0	0	0	0	0	0	0	0	0	0	0	0	30	40	50	80	100
KK0801-C1	0	0	0	0	0	0	0	0	0	0	75	25	20	40	80	100
KK0801-C2	0	0		0	0	0	0	0	1	0	0	20	30	15	90	100
KK0802-A2	0.1	3	26	25	10	5	69	5	5	0.01	2	0.1	2	0	0.1	4
KK0802-A1	0.1	20	18	20	10	2	70	5	5	0.1	25	2	2	0	2	30
KK0802-B0	0.01	15	15	25	25	5	85	15	5	0.1	5	1	2	0	7	15
KK0802-B1	0.01	19	19	30	20	7	95	20	5	1	2	0.1	2	0	0.1	5
KK0802-B2	0.01	20	27	27	20	5	99	20	5	0.01	25	25	25	0	25	1
KK0802-C0	0.01	5	15	20	19	1	60	5	5	0.01	20	0.1	6	0	15	40
KK0802-C1	0.01	10	20	25	25	15	95	20	5	0.1	3	1	1	0	0	5
KK0802-C2	0.1	25	35	20	10	5	95	5	5	0.1	2	1	2	0	0.1	5
KK0802-D0	1	0	0	0	0	0	1	0	0	0	10	30	40	0	50	100
KK0802-D1	0.01	5	5	5	5	0.01	20	0.01	5	0	40	7	10	0.1	60	80
KK0802-D2	0.1	1	4	10	0.1	0	15	0	0.1	0	50	10	7	15	75	85
KK0803-A1	0.01	5	5	10	5	45	70	46	5	0.1	25	1	2	0	25	30
KK0803-A2	0.01	15	15	10	5	25	70	28	4	1	6	1	3	0	26	30
KK0803-B0	0.1	30	28	20	20	2	100	10	3	0.1	4	1	2	0	9	15
KK0803-B1	1	16	10	5	4	3	39	5	5	0.1	50	3	4	0	65	70
KK0803-B2	0.01	20	25	10	5	1	61	5	5	0	20	2	5	0	35	40
KK0803-C0	0.1	10	10	5	5	0.1	30	3	5	0.1	35	2	5	0	65	70
KK0803-C1	10	0	0	0	0	0	10	0	0	0	10	0.1	1	0	100	100
KK0803-C2	0	7.5	15	7.5	10	50	90	2	5	1	5	0.1	1	0	7	10
KK0803-D0	0.01	0	0	0	0	0	0	0	10	0	75	3	15	0	95	100
KK0803-D1	1	0	0	0.1	1	1	3	0.1	10	0.01	90	3	0.1	0	80	96
KK0803-D2	0.01	10	10	10	20	5	55	10	5	1	25	1	3	0	30	40
KK0803-E0	0.01	0	0	0	0	0	0	0	2	0	80	5	5	0	99	100
KK0803-E1	0	0	0	0	0	0	0	0	0	0	10	0	5	0	100	100
KK0803-E2	2	0.1	0.1	0.1	0.1	0.1	3	0.1	3	0	70	3	15	0	90	99
KK0803-F0	0.1	0	0	0	0	0	0	0	5	0	70	25	15	0	65	100
KK0803-F1	0.1	0	0	0	0	0	0	0	5	0	70	25	15	0	65	100
KK0803-F2	2	0	0	0	0	5	7	5	5	1	85	5	5	0	90	95
KK0804-2-A1	2	1	3	5	0.1	40	51	0.1	30	5	10	5	5	0	30	50
KK0804-2-A2	0.01	30	45	5	10	0.1	90	1	3	0.01	1	0.1	2	0	7	10
KK0804-2-B0	1	10	10	20	30	25	96	30	5	1	2	1	1	0	1	5
KK0804-2-B1	0.01	10	10	15	5	20	60	25	15	1	25	5	5	0	5	40
KK0804-2-B2	0.01	5	20	10	10	5	50	5	1	0.1	10	5	5	0	30	50
KK0804-2-C0	0	0	0	0	0	0	0	0	0	0	5	5	10	90	100	100
KK0804-2-C1	0	0	0	0	0	0	0	0	0	0	95	15	2	5	97	100
KK0804-2-C2	10	0	0	0	0	0	10	0	0	0	10	30	5	50	60	100
KK0804-2-D0	0.01	0.01	0.01	0.01	2	18	20	18	5	2	60	5	5	0	70	80
KK0804-2-D1	5	0	0	0	0	0	5	0	0	0	10	5	2	1	97	100
KK0804-2-D2	5	0	0	0	0	0	5	0	0	0	50	15	20	15	90	100
KK0805-A1	0.1	1	2	1	1	0	5	0.1	0.1	0.01	5	18	3	2	80	97
KK0805-A2	0.1	0.1	0.1	0.1	0.1	0	1	0.01	0.1	0	3	3	5	0	95	98
mean	0.3	3.7	5.1	4.4	3.3	3.1	33	3.3	2.8	0.2	25.2	4.7	5.5	1.2	50.6	69.9
sd	0.6	3.9	5.3	4.3	3.4	4.8	25	4.1	1.7	0.3	13.3	2.7	2.2	6.4	22.6	26.4
se	0.01	0.08	0.10	0.08	0.07	0.09	0.52	0.08	0.03	0.01	0.27	0.05	0.04	0.13	0.47	0.56

[1]Rocks >20cm were considered potential nest rocks, this measure taken separate from total 100% cover

Composition of ground cover on 25-m radius elevation and adjacent non-use plots
[means of % values calculated after arcsin-square root transformation]

Non-Use Plot ID	Vegetated (%)	Unvegetated (%)	Water (%)	Snow (%)	Viereck Class	Kodiak Land Cover
KK0801-A1	15	85	0	0	IIIc(2)a	57
KK0801A2	60	40	0	0	IIIc(2)a	57
KK0801-AA0	20	80	0	0	IID(2)c	42
KK0801-AA1	15	85	0	0	IIIc(2)a	57
KK0801-AA2	20	80	0	0	IIIc(2)a	57
KK0801-B0	99	1	0	0	IID(2)c	3
KK0801-B1	99	1	0	0	IIc(2)k	36
KK0801-B2	99	1	0	0	IIIc(2)k	36
KK0801-C0	100	0	0	0	IIc(1)e	9
KK0801-C1	100	0	0	0	IIc(2)k	36
KK0801-C2	100	0	0	0	IIc(1)e	9
KK0802-A2	4	96	0	0	IIIc(2)a	57
KK0802-A1	35	65	0	0	IIIc(2)a	4
KK0802-B0	15	85	0	0	IIc(2)k	57
KK0802-B1	10	90	0	0	IIIc(2)a	57
KK0802-B2	2	98	0	0	IIIc(2)a	57
KK0802-C0	60	40	0	0	IIIc(2)a	4
KK0802-C1	10	90	0	0	IIIc(2)a	57
KK0802-C2	25	75	0	0	IIIc(2)a	57
KK0802-D0	100	0.1	0.1	0	IIc(2)k	36
KK0802-D1	75	25	0	0	IID(1)a	4
KK0802-D2	85	15	0.1	0	IID(2)c	3
KK0803-A1	35	65	0	0	IIc(2)k	42
KK0803-A2	15	85	0	0	II c(2)k	42
KK0803-B0	20	80	0	0	II c(2)k	57
KK0803-B1	60	40	0	0	II c(2)k	36
KK0803-B2	30	70	0	0	II c(2)k	42
KK0803-C0	65	35	0	0	II c(2)k	42
KK0803-C1	99	1	0	0	II B(1)6	9
KK0803-C2	5	95	0	0	II D(2)c	6
KK0803-D0	90	10	0	0	II D(2)c	3
KK0803-D1	95	5	0	0	II D(2)c	3
KK0803-D2	70	30	0	0	II c(2)k	42
KK0803-E0	98	2	0	0	II D(2)c	42
KK0803-E1	100	0	0	0	II B(1)6	9
KK0803-E2	95	5	0	0	II D(2)c	42
KK0803-F0	99	1	0	0	II c(2)k	36
KK0803-F1	100	0	0	0	II D(2)c	36
KK0803-F2	95	5	0	0	II D(2)c	42
KK0804-2-A1	40	60	0	0	II D(2)c	42
KK0804-2-A2	25	75	0	0	II D(2)a	57
KK0804-2-B0	20	80	0	0	II D(1) a	57
KK0804-2-B1	45	55	0	0	II c(2)a	4
KK0804-2-B2	50	50	0	0	II c(2)k	42
KK0804-2-C0	100	0	0	0	II B(1)6	36
KK0804-2-C1	100	0	0	0	II D(2)c	3
KK0804-2-C2	99	1	0	0	II C(2)k	36
KK0804-2-D0	65	35	0	0	II C(2)k	42
KK0804-2-D1	97	3	0	0	II c(2)k	36
KK0804-2-D2	100	0	0	0	II c(2)k	36
KK0805-A1	90	10	0	0	II c(2)k	42
KK0805-A2	85	15	0	0	II c(2)k	42
mean	69.0	31	0	0		
sd	21.4	21	0	0		
se	0.44	0.4	0	0		

Appendix D. Geographic and ground cover data at random plots.

Geographic data for random plots.

[Plot IDs correspond with both 5-m and 25-m radius plots; n=51]

Random Plot ID	Latitude	Longitude	Slope (degrees)	Elevation (m)	Aspect (degrees)	GPS error (+/- m)
1	57˚24.371'	154˚30.935'	24	447	78	4
2	57˚24.226'	154˚32.038'	24	354	195	5
3	57˚25.024'	154˚30.167'	30	260	310	10
4	57˚25.535'	154˚30.032'	25	212	328	4
5	57˚24.416'	154˚32.680'	23	368	78	7
6	57˚24.737'	154˚30.404'	15	334	310	5
7	57˚24.954'	154˚31.174'	28	348	118	4
8	57˚24.099'	154˚32.667'	20	334	208	8
9	57˚24.480'	154˚24.628'	33	303	21	6
10	57˚24.788'	154˚31.570'	28	338	305	5
11	57˚24.736'	154˚30.625'	15	247	322	5
12	57˚25.396'	154˚29.934'	24	236	93	5
13	57˚24.764'	154˚30.391'	26	326	320	5
14	57˚24.636'	154˚31.134'	22	264	358	6
15	57˚23.974'	154˚31.436'	11	267	190	5
16	57˚25.472'	154˚31.418'	36	495	0	5
17	57˚24.204'	154˚31.888'	18	310	185	5
18	57˚24.053'	154˚32.572'	26	292	169	6
19	57˚25.246'	154˚31.412'	26	515	148	5
21	57˚24.397'	154˚31.845'	31	378	340	8
22	57˚25.059'	154˚29.941'	25	305	55	5
23	57˚24.053'	154˚32.673'	29	289	199	7
24	57˚24.140'	154˚31.422'	22	331	290	6
25	57˚24.300'	154˚32.290'	29	380	338	4
26	57˚24.963'	154˚30.099'	14	325	325	7
27	57˚25.350'	154˚29.946'	15	240	90	4
28	57˚25.525'	154˚31.490'	33	408	344	6
29	57˚24.524'	154˚31.180'	34	323	321	4
31	57˚24.367'	154˚31.685'	14	401	165	3
32	57˚25.315'	154˚30.041'	17	222	330	5
33	57˚24.685'	154˚31.582'	24	381	320	6
34	57˚25.439'	154˚31.489'	34	517	321	6
35	57˚24.524'	154˚31.582'	16	342	351	6
36	57˚24.485'	154˚31.086'	33	399	309	3
37	57˚24.486'	154˚31.088'	33	394	321	5
38	57˚24.402'	154˚31.458'	13	360	85	5
39	57˚24.332'	154˚32.571'	32	374	43	8
40	57˚24.413'	154˚30.952'	13	436	75	4
41	57˚25.375'	154˚31.495'	24	544	302	5
42	57˚24.630'	154˚30.882'	23	363	352	19
43	57˚24.351'	154˚30.891'	34	436	68	4
44	57˚24.899'	154˚30.064'	5	346	80	5
45	57˚24.599'	154˚31.863'	12	290	270	4
46	57˚24.345'	154˚32.696'	16	404	0	5
47	57˚24.424'	154˚31.405'	16	343	35	4
49	57˚24.271'	154˚30.736'	21	404	44	5
50	57˚24.283'	154˚30.915'	24	428	201	4
51	57˚24.657'	154˚31.734'	26	318	305	5
52	57˚24.593'	154˚30.766'	26	332	331	7
53	57˚24.719'	154˚31.667'	31	316	305	7
54	57˚24.823'	154˚30.250'	19	341	340	5
mean			23	351	347	6
sd			7.4	74.8	-	2
se			1.0	10.5	-	0.3

Composition of ground cover on 5-m radius random plots.

[Vegetative cover heading "O.C.L." refers to orange crustose lichen; Values of 0.1 and 0.01 represent '<1' and '<<1' values on original data sheet; n=51; means of % values calculated after arcsin-square root transformation]

Random	%	Percent rock of given diameter (cm)							Percent vegetative cover by type							
Plot ID	Soil	<1	<5	<10	10-30	>30	Overall	>20[1]	Lichen	O.C.L.	Moss	Grass	Forb	Fern	Shrub	Overall
1	0.01	40	30	15	5	0.1	90	4	5	0.01	10	1	1	0	10	10
2	0.1	15	15	10	10	10	60	15	2	1	5	1	1	0	40	40
3	0	0	0	0	0.1	0	0	0.1	0.1	0	90	2	3	0	95	99
4	0	0.1	1	0.1	0.1	0	1	0	2	0.1	90	2	3	0	60	98
5	0.1	2	2	2	1	0	7	0.1	3	0.01	45	4	2	0	85	93
6	1	10	15	10	15	30	81	25	10	5	10	1	2	0	15	20
7	1	15	5	5	10	4	40	10	2	0.1	50	3	5	0	45	60
8	0	30	30	25	10	3	98	5	2	0.01	1	0.1	0.1	0	1	2
9	1	3	4	6	25	2	41	12	3	0.1	55	3	6	0	50	60
10	0.1	1	2	1	5	1	10	3	3	0.1	85	2	2	0	90	90
11	0	0	0	0	0	0	0	0	0	0	85	2	2	0	90	100
12	0.1	0	0	0	0	0	0	0	0.01	0	95	5	10	25	95	100
13	0	1	2	0.1	1	0.1	4	0.01	10	0.1	50	5	5	0	80	95
14	0.1	10	10	15	10	5	50	7	0.1	0.1	30	10	15	0	50	50
15	0.01	35	35	25	5	5	100	5	0.1	0	2	3	1	0	1	5
16	0.1	0	0	1	20	30	51	42	15	2	50	1	5	0	45	49
17	0.01	30	30	20	15	4	99	5	0.1	0.1	0.1	0.1	0.1	0	0.1	1
18	0.1	25	20	5	2	10	62	12	2	0.1	25	3	7	0	30	38
19	0	0	0	0	0	0.1	0	0.1	1	0	90	15	7	0	95	100
21	0.1	5	5	10	10	50	80	30	15	10	20	5	5	0	5	20
22	0.1	0	0	0	0	0	0	0	0	0	80	20	20	0	90	100
23	0	20	10	10	10	40	90	43	10	1	8	1	1	0	1	10
24	0	0	0	0	0	0	0	0	5	0	80	7	2	0	95	100
25	0	10	20	20	10	30	90	30	5	2	10	0.1	1	0	5	10
26	0.1	36	40	10	9	2	97	1	1	0.1	0.1	1	0.01	0	3	4
27	0.1	0	0	0	0	0	0	0	0	0	20	5	20	40	100	100
28	0.1	0	0	0.1	10	25	35	28	20	3	60	3	1	0	58	65
29	0.1	5	5	20	20	0.1	50	5	5	0.1	40	5	5	0	45	50
31	0	30	30	7	2	1	70	1	1	0.1	0.1	2	1	0	30	30
32	0.1	0	0	0	0	0	0	0	0	0	10	20	5	15	95	100
33	0.1	20	40	9	10	20	99	15	0.1	0.01	0.1	1	0.1	0	0	1
34	1	8	10	10	15	10	54	20	15	5	30	2	18	0	30	46
35	0.1	5	5	5	5	10	30	15	30	10	55	2	1	0	60	70
36	0.1	10	40	40	8	2	100	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1
37	0.1	25	30	35	7	3	100	5	0.01	0.01	0.1	0.01	0.01	0	0.1	0.1
38	0.1	5	5	5	5	10	30	5	15	1	50	5	2	0	60	70
39	0	0	0	0	0	0	0	0	1	0	80	5	5	0	97	100
40	0.1	40	15	20	5	0	80	1	5	2	15	0.1	0.1	0	15	20
41	0.1	1	2	2	5	3	13	4	4	1	65	3	5	0	70	83
42	0	0.1	0.1	0.01	0	0	0	0	10	0	80	15	5	3	95	99
43	0.01	25	25	15	10	5	80	5	2	1	10	1	2	0	15	20
44	0	0	0	0	0	1	1	1	0.1	0.1	90	10	2	0	98	99
45	0	1	1	1	1	2	6	0.1	5	0.1	85	1	1	0	90	95
46	0.1	10	20	10	5	0	45	2	5	0.1	15	2	2	0	50	55
47	0.1	10	15	10	7.5	7.5	50	2	1	0	20	4	1	0	40	50
49	0.01	15	15	5	5	0.1	40	2	1	0.01	15	1	2	0	50	60
50	0.01	0.1	0.1	0.1	0.1	0.1	1	0.01	2	0.01	80	5	5	0	95	99
51	0.01	5	5	10	10	20	50	10	10	5	50	1	1	0	10	50
52	0.1	38	37	20	5	0.1	100	2	1	0.1	0.1	0.1	0.1	0	0.01	1
53	0	0	0	0	0	0	0	0	0.1	0	90	5	5	7	95	100
54	0.01	0.01	0.1	0.1	0	0	0	0	5	0.1	90	3	5	0	99	99
mean	0.1	6.3	6.9	5.0	4.0	3.2	39	4	2.9	0.4	37.5	2.9	2.9	0.2	49.4	61.8
sd	0.1	5.3	5.5	3.7	2.3	4.3	26	4	1.9	0.7	17.3	1.1	1.2	1.8	22.0	24.8
se	0.00	0.11	0.11	0.07	0.05	0.08	0.57	0.08	0.04	0.01	0.36	0.02	0.02	0.04	0.47	0.53

[1]Rocks >20cm were considered potential nest rocks, this measure taken separate from total 100% cover

Composition of ground cover on 25-m radius random plots.

['N/A' under Viereck Class means there was no vegetation at site; n=51; means of % values calculated after arcsin-square root transformation]

Random Plot ID	Vegetated (%)	Unvegetated (%)	Water (%)	Snow (%)	Viereck Class	Kodiak Land Cover
1	15	85	0	0	III C(2)a	57
2	40	60	0	0	II D(2)c	42
3	95	5	0	0	II c(2)k	42
4	98	2	0	0	II C(2)k	36
5	75	25	0	0	II C(2)k	42
6	25	75	0	0	II D(2)c	57
7	50	50	0	0	IIC(2)k	42
8	2	98	0	0	III C(2)a	57
9	65	35	0	0	II D(2)c	42
10	90	10	0	0	IID(2)c	4
11	97	3	0	0	II D(2)c	3
12	99	1	0	0	II C(2)k, II D(2)c	36
13	90	10	0	0	II D(2)c	3
14	60	40	0	0	II c(2)k	36
15	30	70	0	0	II B(1)c	57
16	40	60	0	0	II C(2)f	42
17	30	70	0	0	N/A	57
18	40	60	0	0	II D(2)c	42
19	100	0	0	0	IID(2)	42
21	10	90	0	0	III B(1)c	57
22	99	1	0	0	II D2(c)	3
23	8	92	0	0	III C(2)a	6
24	80	20	0	0	II C(2)k	36
25	5	95	0	0	II D(2)c	57
26	15	85	0	0	II D(2)c	57
27	99	1	0	0	II B(2)6	36
28	70	30	0	0	II c(2)f	42
29	50	50	0	0	II D(2)c	42
31	80	20	0	0	II D(2)c	42
32	99	1	0	0	II B(2)6	36
33	1	99	0	0	III C(2)a	57
34	35	65	0	0	II D(2)c	4
35	50	50	0	0	II D(2)c	3
36	2	98	0	0	N/A	57
37	1	99	0	0	N/A	57
38	70	30	0	0	II D(2)c	42
39	100	0	0	0	II C(2)k	42
40	50	50	0	0	II D(2)c	57
41	65	35	0	0	II D(2)c	3
42	98	2	0	0	II C(2)k	36
43	40	60	0	0	II D(2)c	4
44	80	20	0	0	II D(2)c	3
45	80	20	0	0	II D2(c)	3
46	55	45	0	0	II C(2)k	42
47	50	50	0	0	IID(2)c	42
49	60	40	0	0	II D(2)c	3
50	95	5	0	0	II D(2)c	3
51	30	70	0	0	II D2(c)	42
52	1	99	0	0	III C(2)a	57
53	99	1	0	0	IID2(c)	36
54	98	2	0	0	II D(2)c	42
mean	59.8	40.2	0	0		
sd	18.6	18.6	0	0		
se	0.39	0.39	0	0		

Appendix E. Pictures of vegetative & non-vegetative cover at elevation plots.

Appendix E. Example of ground cover at elevation plot <250m.

Appendix E. Example of ground cover at elevation plot 250-300m.

Appendix E. Example of ground cover at elevation plot 300-350m. Flag marks the center of plot.

Appendix E. Example of ground cover at elevation plot 350-400m. Flag marks the center of plot.

Appendix E. Example of ground cover at elevation plot >400m.

Appendix F. Picture of vegetative and non-vegetative cover at adjacent plot.

Appendix G. 2008 Kittlitz's Murrelet Study Plan

Kittlitz's Murrelet Study Plan
Version 04
May 2008

I. Title: Breeding Ecology of Kittlitz's Murrelet on National Wildlife Refuges in Alaska

II. Period of Performance: May 1, 2008 to May 1, 2012

III. Principal Contacts:

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IV. Abstract:

The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is a rare seabird that nests in remote alpine terrain throughout its range. Nest sites are generally located on inaccessible mountain slopes, volcanoes, or remote islands in the Gulf of Alaska and Aleutians. Consequently, very little is known of the nesting ecology of this species, and demographic data are virtually non-existent. Populations have declined by 70-85% in most areas of their range and several factors are contributing to the declines including natural changes in food supplies, glacial recession, oil spill mortality, vessel disturbance in foraging areas, and gillnet mortality. Management of the species will be facilitated by improving our understanding of how these factors affect population dynamics. In turn, this requires measuring and modeling murrelet demography, i.e., reproductive success, recruitment and adult survival. We plan to address this critical information need by conducting a multi-year study of Kittlitz's Murrelet nesting ecology at Kodiak and Agattu islands, where accessible nests may permit us to collect 50+ nest-years of data on breeding biology during the next 5 years.

Key Words: Kittlitz's Murrelet, *Brachyramphus brevirostris*, endangered species, nesting biology, reproductive success, population dynamics, demographics, habitat use, Aleutian Islands, Kodiak, National Wildlife Refuge

V. Problem Statement/Justification

The Kittlitz's Murrelet (*Brachyramphus brevirostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least-studied birds in North America. Kittlitz's Murrelets are generally found in glaciated regions of Alaska, and many aspects of its life history result from adaptation to life in glacially-influenced habitats. Long-term population monitoring in core Kittlitz's Murrelet areas has revealed that ca. 70-85% of local populations have disappeared during the past 20 years or less (Kuletz et al. 2003, Van Pelt and Piatt 2003, Drew et al. 2008). Owing to these factors, the U.S. Fish and Wildlife Service (USFWS) has added Kittlitz's Murrelet to its roster of candidate species for listing under the Endangered Species Act, and recently (USFWS 2007) elevated it from Listing Priority Number (LPN) 5 to LPN 2 (highest possible priority for a species with >1 species in the genus).

Causes for the decline of Kittlitz's Murrelet are uncertain, but probably include effects of human activities such as oil spills, gillnet bycatch and vessel disturbance— which are well documented (e.g., Wynne et al. 1992, van Vliet and

McAllister 1994, Agness 2006)— to more poorly-defined effects of natural changes in their environment, including changes in marine food webs and diets (Piatt and Anderson 1996, Anderson and Piatt 1999), and either foraging or nesting habitat modification (or loss) resulting from glacial recession (Kuletz et al. 2003). Whether mediated through changes in food supply or critical habitats, population declines may be strongly influenced by changes in demography—particularly in reproductive success (Day and Nigro 2004) or adult survival.

Unfortunately, Kittlitz's Murrelet are non-colonial and most aspects of its breeding biology remain obscure (Day et al. 1999). Adults generally nest solitarily, inland within 30 km of the coast, at high elevations (average >500m), on talus-strewn slopes near mountain peaks (Day et al. 1983). Owing to the difficulties of finding and observing their nests, very little data has been collected on the breeding biology and life history of the species. Vital demographic parameters such as breeding success, recruitment and survival are unknown. As for the closely-related Marbled Murrelet (*B. marmoratus*), knowledge of these demographic parameters is essential for modeling population dynamics and assessing the vulnerability of the species to human and natural perturbations (Piatt et al. 2007). The gap in basic knowledge about their nesting habitat, chick growth rates and diet, as well as overall breeding success of Kittlitz's Murrelets, makes effective management or protection of this species on Federal lands more difficult.

For many seabirds, data on reproductive success and population trends are collected with relative ease at breeding colonies where large numbers of birds aggregate in dense colonies (Dragoo et al. 2007). However, only about 40 nests of the Kittlitz's Murrelet have ever been documented across the species' entire North Pacific and Bering Sea range, of which about one quarter were from Agattu Island in the western Aleutions (Day et al. 1999, van Vliet 2003, Kaler et al. 2008, USFWS 2008). Despite morphological and behavioral adaptations to avoid predation, Kittlitz's and its congener the Marbled Murrelet , appear to experience high rates of predation at the nest (Singer et al. 1991, Nelson and Hamer 1995, Kaler et al. 2008). 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). Few quantitative data on nesting biology of Kittlitz's Murrelet have been collected and much of our understanding of Kittlitz's Murrelet ecology is extrapolated from the closely related Marbled Murrelet.

We plan to substantially increase our knowledge of the nesting ecology of Kittlitz's Murrelet by focusing efforts in National Wildlife Refuges (NWR) in Alaska known to support nesting murrelets. This includes Kodiak NWR, where one nest was discovered on Kodiak Island in 2006, and concentrated flying and vocalizing activities strongly suggest nesting at four other locations (Saltonstall 2003, Studebaker 2007, Day and Barna 2007). It also includes the Alaska Maritime NWR where a nest was found on the Barren Islands and Atka Island (Day et al. 1983), and where one nest was discovered at Agattu Island in the western Aleutians in 2005 (Kaler 2006), and an additional 11 nests were found in 2006 with dedicated search effort (Kaler et al. 2008). Most murrelet nests on these refuges are relatively accessible: they occur at moderate altitudes, are free from permanent snow or ice fields during summer, and are found on rocky talus slopes of moderate grade that do not require technical climbing skills.

In contrast, most murrelet nests found in the Gulf of Alaska have been discovered opportunistically by geologists or surveyors in extreme habitats (up to 2000 m elevation) on volcanoes of the Alaska Peninsula or rugged slopes of the Chugach and Wrangell mountain ranges in the northern Gulf of Alaska (Day et al. 1983, Day 1995, Piatt et al. 1999). While radio or satellite telemetry may allow us to identify Kittlitz's Murrelet nesting areas in the eastern range of their distribution (Romano et al. 2007, Kissling et al. 2007), access to those nests by foot may still prove to be impossible owing to rugged terrain (Kissling et al. 2007). We conclude that our best opportunity to study a substantial sample size of Kittlitz's Murrelet nests is to focus on island refuges in the Gulf of Alaska and Aleutians where alpine habitat— and Kittlitz's Murrelet nesting habitat— is found at lower elevations and in less rugged terrain. At the very least, we have an excellent opportunity to gather demographic data in the western half of the species range for later comparison with similar data that may eventually be collected in the eastern half of its range.

VI. Objectives

The overall objective of the study is to study the nesting ecology of Kittlitz's Murrelet (KIMU) at various locations in the Alaska National Wildlife Refuge system.

The specific objectives are to:
(1) Locate and study as many Kittlitz's Murrelet (KIMU) nests possible
(2) Characterize nesting habitat of KIMU
(3) Quantify attendance of adults at nest sites and chick meal delivery rates
(4) Identify prey in delivered meals and assess diet composition of chicks
(5) Quantify growth rates of KIMU chicks during the nestling stage
(6) Measure hatching, fledging and reproductive success of KIMU

(7) Collect blood, feathers or egg-shell fragments for genetic study of KIMU populations
(8) Conduct audio-visual surveys for adult KIMU flying inland, using standardized protocols

VII. Procedures

Nest Searching and Monitoring.---Nests will be located by ground-searching of suitable terrain (e.g., see Day and Stickney 1996, Kaler et al. 2008). Whenever possible, USGS quad maps and/or GPS receivers will be used to log search effort and ensure that searches are conducted in a systematic way so as to maximize search coverage (e.g., using grids or parallel search tracks). When searching, investigators will stay within 5-10 m abreast of each other, i.e., at approximate startling distance of an incubating murrelet (R. Kaler, J. Piatt, pers. obs.). Search efforts will be concentrated at high elevation rocky, talus covered areas along ridges, peaks, or terraced slopes. Attempts will be made to locate nests without flushing the adult during the incubation period. This may be quite feasible for nests that have been re-located from previous study, but flushing the adult on first encounter is the most likely way to locate first-time nests.

To examine possible adverse effects of researcher visits on breeding success (on adults, eggs, chicks), and where we have multiple nest sites available for study, we will pair a nest with its nearest neighbor. One nest out of each pair (randomly chosen) will be visited every 3-4 days during the incubation period and will be defined as *disturbed*. The other nest out of each pair (*control*) will be visited four times during the entire breeding period (once at discovery, twice during the brood period [5-8 d, 20-26 d], and once at fledge (>30 d)). For monitoring disturbed nests during the incubation period, survival of the egg will be determined by resighting the adult at the nest from a distance ≥ 30 m. As the egg nears its predicted hatching date based on egg float curves (Westerskov 1950, Kaler et al. 2008), nests in the disturbed treatment will be checked every one to two days in order to detect the hatching event.

During the nestling period, nests receiving the disturbed treatment will also be monitored by infra-red or motion-detecting cameras placed at 3 to 10 m from the nest. These cameras will record each arrival of adult birds carrying fish to chicks at each nest site. Time-date-stamped photos will be examined later in order to estimate rates of chick meal deliveries. Photographs of adults carrying fish will be later examined to identify prey items (Arimitsu and Piatt 2006). Data from cameras will be downloaded and batteries will be replenished on a regular basis (every 5-10 days). If nest sample size remains below 6 nests, we will deploy cameras at all nests.

Visits to the disturbed nests during the nestling period will be conducted every three to four days. During each visit, chicks will be weighed (± 1 g) and the length of the right wing will be measured (± 1 mm) from the carpus to the tip of the longest primary with the wing held flat and straight along a ruler. Natural ("bent") wing length will also be taken by not pressing the wing flat along the wing ruler. Calipers will be used to take linear measurements of the total head, exposed culmen, tarsus, and tail length. A blood sample will be collected from each nestling for genetic analyses and sex determination. Feather samples will also be taken. At any nests where egg-shell fragments are found, these will be collected and preserved. All nest visits will be conducted at the same time of day for each nest to maintain consistency of measurements. Procedures for monitoring can be found in Appendix A (Nest Monitoring Instruction).

Nest Vegetation Data Collection.---Nest site characteristics will be measured after completion of nesting. Vegetation data will be collected at each nest site and at 2-4 non-use plots placed at a random bearing and random distance between 50 and 100 m (Figure 1). 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. 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 to classify estimated percentages into 13 groups of ground cover. See Nest Vegetation Data Collection Instruction and datasheet (Appendix B).

Audio-visual surveys for adult KIMU flying inland.--- The movements and activities of KIMU as they make their way inland to and from nest sites have rarely been witnessed. Observations to date have included both sighting of actual birds flying and their vocalizations. If this is typical behavior for KIMU, it may offer a new opportunity to identify nesting habitat from the presence and behavior of birds, and a means to survey the relative abundance of animals on the refuges. A similar approach has been very effective for surveying Marbled Murrelets, and so we will adopt (with some modifications) the protocols that have been carefully developed by the Pacific Seabird Group for study of that species (Mack et al. 2003; see appended document entitled: "Methods for surveying marbled murrelets in forests: A revised protocol for land management and research").

VIII. Statistical Analyses

Nest vegetation data.---To help determine habitat characteristics associated with Kittlitz's Murrelet nest sites, a discriminant function analysis (DFA) will be conducted to compare nest plots, adjacent non-use plots, and random area plots. A stepwise discriminant analysis with habitat characteristics will be used to assess which measured characteristics best discriminated between nest plots and non-use plots (Johnson 1998). A significance level of $\alpha = 0.5$ will be used for parameter entry into the analysis while a significance level of $\alpha = 0.2$ will be used for parameter retention (Johnson 1998). A DFA will

then be conducted using the resulting significant habitat characteristics. A cross-validation procedure will be used to determine misclassification rates for nest and non-use plots (Johnson 1998). These analyses will be conducted using Proc STEPDISC and Proc DSCRIM (SAS Institute, 2005). Prior to the analyses, all non-normal data will be log transformed to meet the assumptions of normality.

Chick growth rates.---Growth curves will be developed for six Kittlitz's Murrelet body characteristics (mass, wing length, total head length, culmen length, tarsometatarsus length, and tail length) to estimate parameters using non-linear regression and the Marquardt algorithm (Proc NLIN, SAS Institute, 2005). The logistic equation to be used is:

$$M = \frac{A}{1+e^{-K(age-I)}},$$

in which M is a body characteristic (e.g., mass), A is the asymptote of the growth curve for that trait, K is the growth rate constant, e is the base of the natural logarithms, and I is the inflection point (in days) of the curve (Ricklefs 1967, 1968). A will be fixed as either the asymptotic mass of nestling or at maturity (adult = 224 g; Day et al. 1999). Day of hatch will be designated as day 1 for all calculations. Modeling of growth curves can only be applied to chicks with measures taken every few days. For control nests, only 2 measurements will be available for estimating growth, and for these we will calculate the instantaneous maximum growth rate, calculated by fitting the steepest possible tangent to growth curves (Sealy 1973, Drent and Daan 1980, Gaston 1985). Instantaneous growth rates will also be estimated for those chicks measured more frequently. For interspecific comparison, the time required for a nestling to grow from 10 to 90% of the asymptotic weight ($t_{10\text{-}90}$) and overall growth rate constant (K) will be calculated (Ricklefs 1967, 1968). Data will be presented as mean ± SE with a α-value of 0.05 for all statistical analyses, unless otherwise specified.

Demographic data.---Demographic analyses will be conducted with Program Mark, a dedicated software package for analysis of live encounter, dead recovery and radio-telemetry data that combines maximum likelihood estimation (MLE) with an information-theoretic framework (Cooch and White 2006, White and Burnham 1999). The daily probability of survival for murrelet nests will be estimated using the nest survival procedure of Program Mark (Rotella et al. 2004). Encounter histories will be coded for each nest with four types of information: the day of discovery (k), the last day the nest was known to be active (l), the day the nest hatched or was discovered to have failed (m), and the fate of the nest (f, where 0 = successful and 1 = unsuccessful). The nest survival procedure improves on the Mayfield estimates (Mayfield 1961, 1975) of nest success because nest survival is not assumed to be constant over time, and daily survival rates can be modeled as a function of seasonal and environmental factors such as severe weather conditions and timing of nest initiation.

IX. Proposed Project Schedule

The project timetable will include: nest searching and monitoring in the spring and summer; digital photo and video review in the fall and winter; analyses of nest site selection, nest survival and demographics during the fall and winter; and preparation of reports each winter (Table 1).

Table 1. Timetable for research tasks and deliverable results in project years 1 to 5.

Year 1 2008	J	F	M	A	M	J	J	A	S	O	N	D
Draft study plans; hire staff and purchase equipment				■	■							
Field season preparation; staff training					■	■						
Fieldwork: travel, deployment and recovery of remote camps					■	■	■	■				
Nest searching and monitoring; camera deployment and maintenance						■	■	■				
Productivity and chick growth rate data collection							■	■				
Nest site habitat data collection (post nesting)							■	■				
Compile field data, analyze video recordings, data analysis								■	■	■	■	
Annual report preparation detailing results of first season									■	■	■	■
Year 2 2009	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Field season preparation; hire staff and purchase equipment	■	■	■	■								
Staff training; camp preparation				■	■							
Fieldwork: travel, deployment and recovery of remote camps					■	■	■	■				

Nest searching and monitoring													
Productivity and chick growth rate data collection													
Nest site habitat data collection (post nesting)													
Compile field data, analyze video recordings, data analysis													
Annual report preparation detailing results of second season													
Year 3	2010	J	F	M	A	M	J	J	A	S	O	N	D
Field season preparation; hire staff and purchase equipment													
Staff training; camp preparation													
Fieldwork: travel, deployment and recovery of remote camps													
Nest searching and monitoring													
Productivity and chick growth rate data collection													
Nest site habitat data collection (post nesting)													
Compile field data, analyze video recordings, data analysis													
Annual report preparation detailing results of third season													
Year 4	2011	J	F	M	A	M	J	J	A	S	O	N	D
Field season preparation; hire staff and purchase equipment													
Staff training; camp preparation													
Fieldwork: travel, deployment and recovery of remote camps													
Nest searching and monitoring													
Productivity and chick growth rate data collection													
Nest site habitat data collection (post nesting)													
Compile field data, analyze video recordings, data analysis													
Final report preparation detailing results of all four seasons													
Manuscript preparation													
Year 5	2012	J	F	M	A	M	J	J	A	S	O	N	D
Final results of study presented at the Pacific Seabird Group conference													
Manuscript preparation and review													
Manuscript submission to peer-reviewed journals													

X. Special Provisions:

Bird handling and capture: State and federal permits for the capture and handling of Kittlitz's Murrelet chicks and study of nest sites will be obtained prior to the field season. Birds will be captured using standard techniques employed by the refuges. Blood and feather samples will be taken from all captured birds. All work will be reviewed and approved by the USGS Animal Care and Use Committee (ACUC) prior to implementation.

XI. Information Transfer
Expected products:

1) Annual progress reports to USGS and USFWS
2) Final report on findings of overall study to USGS and USFWS
3) Proposed work is expected to yield at least one major paper in peer-reviewed journal documenting the nesting ecology of Kittlitz's Murrelets in Alaska. .

Data/metadata management: All data collected will be archived in a project database using Microsoft Access (major data categories include habitat characteristics, attendance and chick feeding, diet, chick growth, reproductive success, sample disposition). Data will be distributed to USFWS and USGS collaborators. Raw field data will be filed with Supervisory Refuge Wildlife Biologists at each refuge.

Technology/information transfer: The end user of the information generated by this study is the USFWS, which has primary responsibility for managing Kittlitz's Murrelet populations. Data and results will be shared with the U. S. Fish and Wildlife Service, other agencies and the public through reports, papers, and shared data archives (see above). Funds are budgeted for the principal investigators to attend scientific conferences, providing further dissemination and discussion of results.

Annual and final reports will be filed with Refuges, Ecological Services and Migratory Birds of FWS, and with USGS Alaska Science Center.

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Figure 1. Nest and non-use vegetation plots. The nest plot will be located at the center and will consist 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). Two to four non-use plots will be located at random distances and bearings from the nest site.

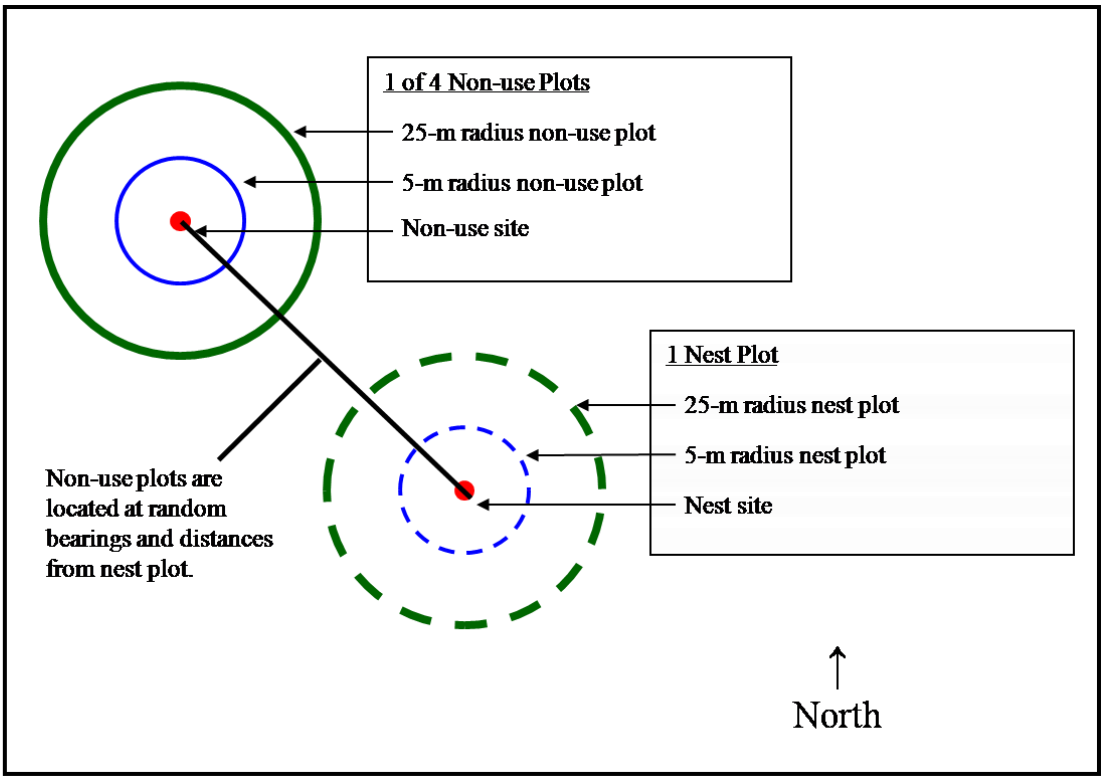
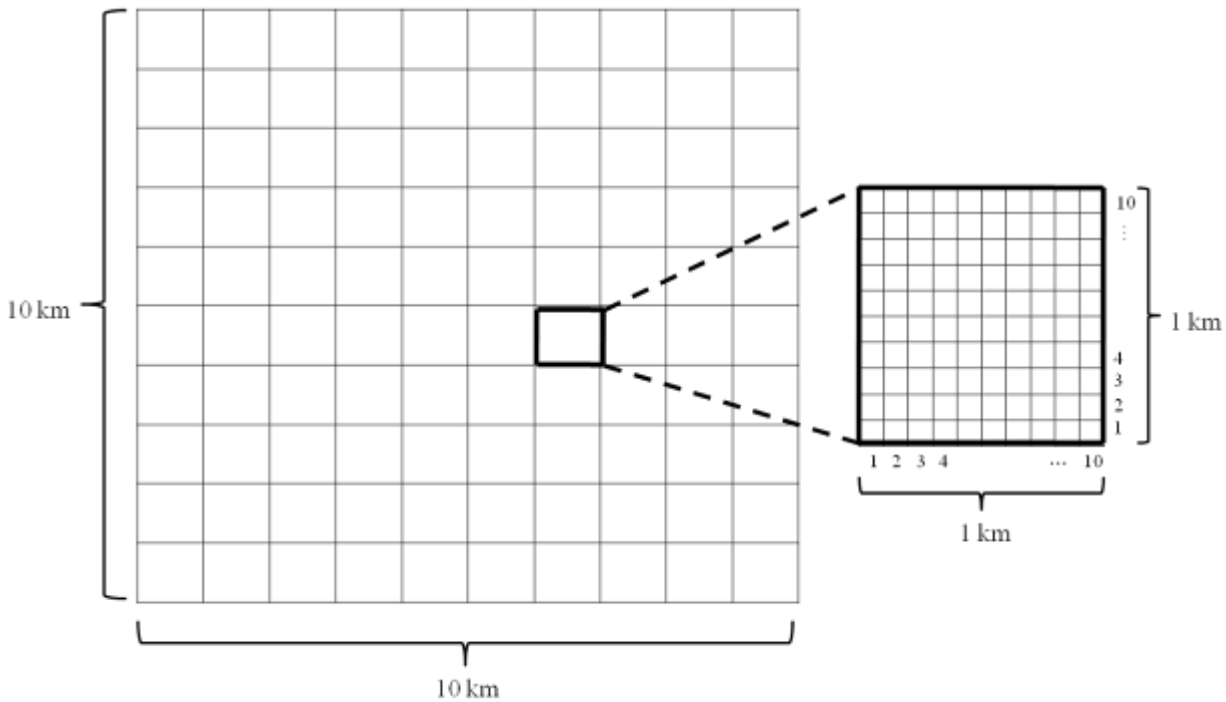


Figure 2. Random plot location grid using x and y points (1 through 10) to select two vegetation plots, located in 1 km by 1 km blocks containing alpine habitat (areas >300 m above sea level), located in 10 km by 10 km sampling grid.



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 2nd 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 [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.

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

- Visit nest 4 times; once at discovery, once at 5-6 d of age during chick-rearing, 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 cirles. 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. See Nest Vegetation Data Collection Instruction, datasheet, random bearing (0-359), random distance (50-100 m), random x- and y-coordinate selection

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation Non-use Plots Random Bearings (0-359 degrees)

182	59	53	100	98	76	72	72	83	95
54	58	73	67	94	53	63	86	99	91
86	56	79	66	72	93	100	76	84	75
56	93	59	92	61	54	69	89	92	94
66	74	82	61	87	72	76	58	55	99
64	65	97	92	88	84	97	76	85	75
92	86	54	100	77	67	70	68	76	93
95	67	91	57	56	64	51	73	77	72
99	56	70	99	77	77	85	50	75	58
53	98	91	66	61	74	79	94	57	77
99	78	50	76	85	87	64	72	63	68
95	79	65	77	73	87	86	76	100	54
73	55	90	95	82	70	53	92	86	76
53	80	58	65	73	58	56	68	73	52
65	74	96	80	74	82	87	56	94	66
94	91	84	91	90	86	54	100	91	77
61	88	71	90	67	97	90	62	74	68
77	64	97	50	52	77	97	74	60	97
72	75	51	82	55	76	80	77	50	68
54	67	58	78	96	78	96	85	82	100
86	69	90	97	64	87	63	57	74	60
81	96	96	57	87	98	50	55	68	68
63	68	87	55	72	68	61	86	63	80
95	59	89	50	60	59	91	93	95	55
76	58	66	61	75	63	98	84	78	72
68	66	93	84	77	57	99	99	59	72
100	72	76	81	58	57	53	53	91	90
55	70	74	60	74	58	75	84	90	63
53	63	97	53	67	100	71	71	51	53
70	83	81	80	52	78	52	93	60	80
96	69	98	59	94	67	61	88	90	80
63	70	89	79	76	52	53	77	72	96
50	88	61	53	85	71	55	65	74	62
61	50	78	72	74	70	66	56	94	88
66	80	97	93	82	81	84	60	87	85

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation Non-use Plots Random Distances (50-100 m)

75	74	64	80	50	79	72	99	69	69
99	76	85	100	81	88	52	82	57	53
69	100	64	94	74	51	65	100	68	64
67	65	99	73	69	77	96	57	90	79
97	98	96	60	54	89	86	63	65	91
50	58	55	82	61	93	72	62	76	68
63	84	88	100	75	91	66	70	99	62
51	94	71	79	93	60	87	97	68	80
100	80	58	94	98	74	50	70	62	81
93	72	70	56	88	88	54	95	84	97
87	89	87	100	88	57	87	75	87	64
79	67	80	81	67	78	54	80	71	77
93	76	88	62	87	52	69	52	73	57
60	88	64	82	87	79	80	64	57	83
54	100	96	51	61	61	78	86	62	77
98	56	99	73	60	75	54	57	66	89
65	79	92	52	96	59	51	95	100	56
65	84	78	67	70	68	74	55	68	78
78	76	78	77	84	99	55	55	57	88
71	62	58	50	95	62	75	97	54	52
90	61	50	82	94	62	50	96	100	89
79	91	74	98	65	64	87	59	78	74
59	84	97	68	55	90	91	55	81	96
56	73	54	66	87	55	86	93	95	69
83	60	58	73	81	61	78	86	67	97
77	68	66	77	89	73	59	55	82	83
86	63	50	68	61	97	60	71	72	84
58	61	81	83	65	93	99	89	69	92
60	73	99	64	58	94	50	80	94	70
72	62	87	66	91	52	80	62	90	67
59	83	77	90	74	99	53	60	50	54
66	97	97	55	75	99	98	86	89	86
87	84	96	91	69	71	75	86	90	52
61	70	98	89	79	59	97	61	79	52
60	92	98	94	50	94	64	91	51	72
82	78	65	64	100	98	77	65	54	87
79	96	53	71	97	94	95	50	81	50

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation Non-use Plots Random Bearings (0-359 degrees)

182	59	53	100	98	76	72	72	83	95
54	58	73	67	94	53	63	86	99	91
86	56	79	66	72	93	100	76	84	75
56	93	59	92	61	54	69	89	92	94
66	74	82	61	87	72	76	58	55	99
64	65	97	92	88	84	97	76	85	75
92	86	54	100	77	67	70	68	76	93
95	67	91	57	56	64	51	73	77	72
99	56	70	99	77	77	85	50	75	58
53	98	91	66	61	74	79	94	57	77
99	78	50	76	85	87	64	72	63	68
95	79	65	77	73	87	86	76	100	54
73	55	90	95	82	70	53	92	86	76
53	80	58	65	73	58	56	68	73	52
65	74	96	80	74	82	87	56	94	66
94	91	84	91	90	86	54	100	91	77
61	88	71	90	67	97	90	62	74	68
77	64	97	50	52	77	97	74	60	97
72	75	51	82	55	76	80	77	50	68
54	67	58	78	96	78	96	85	82	100
86	69	90	97	64	87	63	57	74	60
81	96	96	57	87	98	50	55	68	68
63	68	87	55	72	68	61	86	63	80
95	59	89	50	60	59	91	93	95	55
76	58	66	61	75	63	98	84	78	72
68	66	93	84	77	57	99	99	59	72
100	72	76	81	58	57	53	53	91	90
55	70	74	60	74	58	75	84	90	63
53	63	97	53	67	100	71	71	51	53
70	83	81	80	52	78	52	93	60	80
96	69	98	59	94	67	61	88	90	80
63	70	89	79	76	52	53	77	72	96
50	88	61	53	85	71	55	65	74	62
61	50	78	72	74	70	66	56	94	88
66	80	97	93	82	81	84	60	87	85

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation Non-use Plots Random Distances (50-100 m)

75	74	64	80	50	79	72	99	69	69
99	76	85	100	81	88	52	82	57	53
69	100	64	94	74	51	65	100	68	64
67	65	99	73	69	77	96	57	90	79
97	98	96	60	54	89	86	63	65	91
50	58	55	82	61	93	72	62	76	68
63	84	88	100	75	91	66	70	99	62
51	94	71	79	93	60	87	97	68	80
100	80	58	94	98	74	50	70	62	81
93	72	70	56	88	88	54	95	84	97
87	89	87	100	88	57	87	75	87	64
79	67	80	81	67	78	54	80	71	77
93	76	88	62	87	52	69	52	73	57
60	88	64	82	87	79	80	64	57	83
54	100	96	51	61	61	78	86	62	77
98	56	99	73	60	75	54	57	66	89
65	79	92	52	96	59	51	95	100	56
65	84	78	67	70	68	74	55	68	78
78	76	78	77	84	99	55	55	57	88
71	62	58	50	95	62	75	97	54	52
90	61	50	82	94	62	50	96	100	89
79	91	74	98	65	64	87	59	78	74
59	84	97	68	55	90	91	55	81	96
56	73	54	66	87	55	86	93	95	69
83	60	58	73	81	61	78	86	67	97
77	68	66	77	89	73	59	55	82	83
86	63	50	68	61	97	60	71	72	84
58	61	81	83	65	93	99	89	69	92
60	73	99	64	58	94	50	80	94	70
72	62	87	66	91	52	80	62	90	67
59	83	77	90	74	99	53	60	50	54
66	97	97	55	75	99	98	86	89	86
87	84	96	91	69	71	75	86	90	52
61	70	98	89	79	59	97	61	79	52
60	92	98	94	50	94	64	91	51	72
82	78	65	64	100	98	77	65	54	87
79	96	53	71	97	94	95	50	81	50

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation, Random Plot x-coordinate selection (1-10)

1	8	8	10	1	8	6	3	9	2
4	10	4	6	7	9	7	3	2	5
5	9	5	6	8	5	7	3	8	7
6	9	2	6	9	4	7	2	10	4
4	1	4	5	6	1	5	6	10	10
7	3	2	8	5	6	7	10	4	2
7	1	3	7	4	4	3	7	1	4
3	7	1	5	8	9	7	1	1	1
7	5	3	7	1	10	5	6	7	3
8	4	5	5	3	10	7	7	10	6
4	7	10	10	2	9	6	1	4	1
2	9	10	4	10	4	2	5	10	2
10	5	7	7	7	10	5	2	1	2
5	1	8	7	9	9	9	9	2	1
9	1	5	1	10	2	6	4	7	9
4	4	4	9	5	4	2	4	1	10
4	4	7	10	8	7	6	4	6	3
5	9	4	10	2	4	9	1	10	9
5	7	3	3	7	8	8	8	9	9
3	8	8	10	7	8	7	1	10	6
6	2	3	2	7	4	9	3	2	2
4	1	3	9	6	9	6	10	8	1
1	7	1	6	6	1	5	10	4	3
8	10	1	9	4	1	2	8	6	4
7	6	3	6	9	1	2	8	1	2
7	9	7	10	6	7	2	8	5	10
5	7	2	1	7	6	9	2	1	4
4	9	4	2	6	10	10	3	6	1
1	8	4	4	4	7	9	8	1	4
8	6	5	5	1	4	5	5	8	4
4	6	9	4	6	7	9	8	6	3
1	1	5	7	5	7	2	6	1	7
10	2	5	10	7	6	2	6	1	2
2	9	5	3	4	2	1	10	8	1
6	2	1	10	9	4	8	2	4	5

Kittlitz's Murrelet Breeding Ecology, Nest Vegetation, Random Plot y-coordinate selection (1-10)

9	10	5	10	3	5	1	4	6	10
4	4	1	10	8	10	2	3	9	10
10	1	6	8	5	10	5	8	9	5
2	4	1	8	1	8	5	4	3	1
7	3	10	4	7	4	6	3	3	9
1	6	7	1	6	5	5	5	8	1
6	4	5	2	1	2	4	1	3	9
9	8	2	5	10	7	10	7	6	5
9	5	10	6	4	8	6	5	2	6
6	2	3	10	5	2	2	9	2	10
1	7	10	5	6	2	9	1	10	7
8	2	3	2	8	9	7	3	7	5
5	6	1	4	3	6	9	6	7	6
4	1	1	8	5	4	1	9	7	2
9	8	7	2	9	6	6	3	8	2
1	8	1	7	4	2	7	1	1	7
2	7	7	5	2	1	7	3	4	7
7	3	8	1	5	10	9	3	1	1
5	6	4	3	5	1	5	10	3	7
9	2	9	5	8	6	7	3	8	5
1	9	10	5	10	2	6	8	2	4
10	4	5	9	1	1	5	9	5	1
8	2	9	6	4	2	4	4	8	6
6	8	1	7	3	10	9	3	4	5
7	4	1	8	5	6	7	3	6	9
5	6	10	8	5	7	2	8	7	6
6	6	8	9	3	8	9	1	10	8
3	4	6	10	5	5	4	8	8	1
6	9	10	10	10	4	7	3	8	9
7	1	5	4	4	1	8	2	2	5
4	7	6	7	3	9	6	10	1	10
1	6	9	1	2	2	5	3	8	4
7	10	1	10	2	10	5	10	1	4
5	10	10	5	9	9	1	3	4	7
1	4	2	7	1	9	10	5	8	1

The following data sheets can be used to sample nest plots, adjacent non-use plots, and elevational non-use plots. Either use these sheets 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 all the relevant information in a field notebook, and transcribe to clean data sheets later.

KIMU Nest Vegetation Datasheet - _____ Island 2008

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 - Taking samples for genetic studies of Kittlitz's Murrelet
[2008 INSTRUCTIONS by Vicki Friesen]

BLOOD: Take some small-gauge hypodermic needles (no syringe needed) or lancets, cotton swabs, either ethanol or rubbing alcohol, filter paper, and either plastic baggies or cryovials with 70% ethanol. Wipe the underwing with the alcohol and cotton swabs (at the joint of the upper and middle wings). The brachial vein should stand out where it crosses the upper wing bone (humerus). Prick the vein with a new needle/lancet. Dab up several drops of blood onto the filter paper. Label, and either (1) air dry the paper, and put it in its own bag or (2) place in it's own labeled cryovial in alcohol. Good to get repetitive samples for later distribution, so preserve take THREE different samples for each bird. If filter paper can be well dried in air, no need to put in alcohol. In either case, samples don't need to be frozen for the short-term, but freeze them on return to civilization. Never reuse needles and materials for sampling (!) or you will get cross-contamination of DNA.

FEATHERS: For mature feathers, simply place 2-3 feathers from each bird in their own labeled envelop. Freeze on return to civilization. These are a last-resort source of DNA, as there is little DNA in mature feathers. For blood feathers (aka 'pin' feathers), pluck 2-3 feathers from each bird and cut the bottom part into a labeled cryovial with 70% ethanol. Freeze on return to civilization.

SHELL FRAGMENTS: For shell fragments, place them in an envelope or other clean container. They do not need to be placed in ethanol. It does not hurt them to be frozen when freezing facilities are available.

OTHER: Wing or other fragments from carcasses can either be stored dry or in ethanol, then frozen when possible.

STABLE ISOTOPES – Note that the blood and feathers collected in this manner can also be used to examine stable isotope ratios of chicks. This may provide some insight into individual variation in chick diets, and allow us to compare chick diets among islands. Samples collected in 2008 will be examined by Keith Hobson.

Appendix D - Camera Protocols
[2008 Instructions by John Piatt]
Once a nest has been located, we will attempt to monitor the behavior of adults feeding chicks using rugged outdoor wildlife observation cameras. In 2008, we have a selection of cameras for testing in the field. All have some common features including: programmable digital photography, weather-proof containers, sustainable power sources for days or weeks of remote operation, day and night (IR flash) photo ability, and a thermal infrared detector to trigger the camera when a bird appears in the field of view. Depending on the model, cameras can be programmed to shoot a series of photos when triggered, ideally capturing the arrival and departure of adult murrelets at the nest, and possibly allowing us to identify the prey fish being carried by the adult. The specifics of how to operate each camera model is provided in its documentation.

Following are guidelines for setting and placing a camera next to a murrelet nest. You may wish to vary any of these suggestions as suits your terrain and need. We recommend you play with camera settings and compare results in a camp setting, before deploying at the nest.

The Camera (Reconyx PC85 and RM30 types):
Critical to keep cameras dry internally. Use silica grease to lubricate O-rings. Use dessicant packs to keep inside dry. Only open if you have dry hands, and rain will not fall into camera. This may require you set up a small tent nearby and use it for temporary shelter.

Recommended settings: Maximum resolution pictures, Maximum passive IR sensitivity to motion, Fastest shutter speed, Program to take 30 pictures in sequence when triggered, each picture separated by 30 seconds, for a total of 15 minutes for each time it is triggered. When you first set up camera, establish all these setting and set time/date, and add camera ID identification stamp; please use "USGS-2008". All programming is done on the PC while Compact Flash (CF) card is plugged in via USB, and stored on the CF card. CF cards will retain programming while being switch in/out of camera.

Expected frequency and number of photos: At Red Mountain (Naslund in prep.), KIMU visited nests for average of about 9 minutes (range 4-13), 4-7 times a 24 hour period. If camera only triggers when visited by adult, then may capture 30x7=210 pics per day. If movement detection threshold is triggered by chick moving around nest, you could get a lot more pictures each day. Cameras can take at least 1500 pics before battery needs changing, therefore last about 1 week at above rate. CF cards can easily hold this many pictures. Battery power is reduced in cold, so some practice runs in field camp should be conducted to test capacities of batteries and CF cards. Important to focus thermal IR trigger on very center of area you wish to detect motion, which is NOT the nest itself (with chick in it), but just to the left or right of the nest, where adults are expected to come and go with fish.

Setup: Cameras are not telephoto, and so need to be placed close to the nest, but not so close as to frighten adults. Also, while thermal IR can supposedly pick up large animals out to 50 ft, small birds will need to be much closer to trigger the camera. Suggest a distance of ca. 10 feet for starters. Should only be placed at nest AFTER incubation complete, and chick has hatched. Use VERSAMOUNT to attach camera to large boulder, with a few feet elevation of camera so that it is looking down slightly on the nest site (this will help with view of nest, but also allow rain to drain off top of camera, and shade lens a little from rain). The thermal IR beam points straight out from center of camera, and you need to use the "walktest" feature of camera to test that it is sensing movement in exactly right location. Do not "walk" in front of camera to test it, you are way too big a target. Lie down next to nest, and use your hand only (keep arms motionless as possible) to try and trigger motion detector. Camera should be completely programmed before you set up on versamount, attach camera and get it aimed on site. Then you can use walktest to get exact aim and distance perfect, then walk away. Camera will go into pre-programmed photography mode in a few minutes.

Maintenance: You should be able to get at least a few days, possible weeks, of picture taking, before needing to switch out batteries or CF memory cards. At beginning, however, it would be good to check camera in 24 or 48 hours to see how well it is functioning, and then make appropriate adjustments to settings. You may then leave it longer, as you get comfortable with its capabilities. When you check a camera, be prepared to replace memory card and batteries. Bring towels and tent for cover if it is raining or foggy. You must keep inside of camera dry! Open only in shelter, or when completely dry weather. Check batteries with built-in checker, or bring voltmeter. Switch out CF card in any case, so you can check its contents back at camp on the computer. Label all CF cards so you know which is which, and make sure all of them are programmed as you wish for that nest. When finished with camera, replace it on versamount, double check aim, and leave it to take more pictures. Bring CF card back to camp and download pictures off card and on to computer. Make sure you observe good housekeeping on file names and folders on the computer, so that we can go back and reconstruct the sequence of downloads

from the folder names and file sequences. Double check date and time settings on each camera before setting it for the next watch. After you have saved all photos to computer, back up those pictures onto the portable WD Passport backup drive. After computer backups are saved, then delete photos from camera CF memory card.

It may take some tweaking to get the right combination of settings (distance of camera from nest, height of camera, trigger sensitivity, number of photos per trigger, time interval between triggers, etc.). Feel free to experiment, but keep notes of what you are doing, so we can improve performance next year. Also, if you keep changing settings, then you need to check and download pictures more frequently in order to assess performance of those settings.

Appendix E: Murrelet Dawn Watches
[2008 Instructions by John Piatt]

Even if we suspect that Kittlitz's Murrelet (KIMU) is nesting in a particular area, chances are that we will not be able to find the actual nest by randomly searching. We need some clues; either by establishing a "search image" of nest site habitat (which depends, of course, on finding some nests in the first place); or by observing the behavior and vocalizations of murrelets while they are flying to and from nest sites. Radar can be quite effective for that (Day and Barna 2007), but we are not using radar this summer. To date, audio-visual observations of KIMU flying to and from nests inland are much rarer than records of actual nests that have been found (mostly by accident). This is probably due in most part to the fact that people generally stumble upon KIMU nests during broad daylight and flush the adult from the nest, never to be seen again by the observer who keeps on hiking. Adult murrelets fly into and away from their nests mostly during the 2-3 hours before sunrise, and not surprisingly, few folks are up and observing in alpine KIMU habitat in Alaska at that time of day.

However, with concerted effort, we may find that we can use Audio-Visual Dawn Watches to 1) identify high potential KIMU nesting habitat, 2) actually locate individual nests, 3) study the inland flight behavior of KIMU, and, 4) quantify the relative abundance of KIMU on refuge lands, and compare relative abundance within different areas of the refuges or among refuges. Ultimately, this is the kind of information managers need for managing KIMU on public lands, i.e., for assessing critical habitat and regulating human activities.

There is no established protocol for surveying KIMU. However, there is an extensive literature and well developed protocol for surveying Marbled Murrelets (MAMU) inland, and we are just going to adopt these protocols with a few changes to accommodate the fact that MAMU nest mostly in old-growth forests whereas most KIMU nest at 500-1000 m elevation on wind-swept alpine barrens. Methods for conducting MAMU surveys from a fixed location were initially evaluated and modified through research in Oregon and California during the 1980s. The Pacific Seabird Group (PSG), a professional scientific organization, took a lead role in coordinating and promoting research on murrelets, and spearheaded the development of a common, standardized protocol. So-called "PSG Protocols" have been conducted since 1992 on federal, state, and private forest lands, following protocols put forth at various time by C.J. Ralph, Kim Nelson, and numerous other MAMU biologists. These protocols were designed to provide researchers and land managers with standardized techniques to detect murrelets in forests. Since 1994, continued inland surveys and research directed at various aspects of this species' breeding ecology have generated new insights on nesting behavior, activity patterns, and habitat use.

I have adapted the PSG Protocol that was last revised in 2003 by Mack et al. In a separate PDF of this protocol, I have highlighted in yellow all the really pertinent sections of the MAMU protocol, and I have identified where we need to make some changes in protocol for ground-nesting KIMU. I have also modified a MAMU data sheet for recording audio-visual observations on murrelets (see below attachment). Every opportunity to conduct AV Watches for KIMU should be taken when time permits, starting with surveys in vicinity of known nest sites, known flyways, and the high potential habitat areas.

USN Sunrise and Sunset Times for Adak, 2008 (Aleutian Daylight Savings Time)

	May		June		July		August	
Day	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h m	h m	h m	h m	h m	h m	h m	h m
1	716	2212	633	2257	632	2309	710	2235
2	714	2214	632	2258	633	2308	712	2233
3	712	2216	631	2259	634	2308	713	2231
4	710	2217	631	2300	635	2307	715	2229
5	709	2219	630	2301	636	2307	716	2228
6	707	2221	629	2302	636	2306	718	2226
7	705	2222	629	2303	637	2305	719	2224
8	703	2224	628	2304	638	2305	721	2222
9	702	2225	628	2304	639	2304	723	2220
10	700	2227	628	2305	640	2303	724	2218
11	658	2229	627	2306	642	2302	726	2216
12	657	2230	627	2306	643	2301	727	2214
13	655	2232	627	2307	644	2300	729	2212
14	654	2233	627	2307	645	2259	731	2210
15	652	2235	627	2308	646	2258	732	2208
16	651	2236	627	2308	647	2257	734	2206
17	649	2238	627	2309	649	2256	736	2204
18	648	2239	627	2309	650	2255	737	2202
19	647	2241	627	2309	651	2254	739	2200
20	645	2242	627	2310	653	2253	740	2158
21	644	2244	627	2310	654	2251	742	2156
22	643	2245	628	2310	655	2250	744	2154
23	641	2246	628	2310	657	2249	745	2152
24	640	2248	628	2310	658	2247	747	2149
25	639	2249	629	2310	700	2246	748	2147
26	638	2250	629	2310	701	2244	750	2145
27	637	2251	630	2310	703	2243	752	2143
28	636	2253	630	2309	704	2241	753	2141
29	635	2254	631	2309	706	2240	755	2138
30	634	2255	632	2309	707	2238	757	2136
31	633	2256	100	100	709	2236	758	2134

USN Sunrise and Sunset Times for Kodiak, 2008 (Alaska Daylight Time)

	May		June		July		August	
Day	Rise	Set	Rise	Set	Rise	Set	Rise	Set
	h m	h m	h m	h m	h m	h m	h m	h m
1	616	2158	517	2259	514	2313	605	2225
2	614	2201	516	2300	515	2312	607	2223
3	612	2203	515	2301	516	2311	610	2220
4	609	2205	514	2303	517	2310	612	2218
5	607	2207	513	2304	518	2309	614	2216
6	605	2209	512	2305	520	2308	616	2213
7	602	2211	512	2306	521	2307	618	2211
8	600	2214	511	2307	522	2306	620	2209
9	558	2216	510	2308	524	2305	622	2206
10	556	2218	510	2309	525	2304	624	2204
11	553	2220	509	2310	527	2303	627	2201
12	551	2222	509	2311	528	2301	629	2159
13	549	2224	508	2312	530	2300	631	2156
14	547	2226	508	2312	531	2259	633	2154
15	545	2228	508	2313	533	2257	635	2151
16	543	2230	508	2314	535	2256	637	2149
17	541	2232	507	2314	536	2254	639	2146
18	539	2234	507	2314	538	2252	642	2144
19	537	2236	508	2315	540	2251	644	2141
20	536	2238	508	2315	542	2249	646	2138
21	534	2240	508	2315	544	2247	648	2136
22	532	2242	508	2315	546	2245	650	2133
23	530	2244	509	2315	547	2244	652	2130
24	529	2246	509	2315	549	2242	654	2128
25	527	2247	510	2315	551	2240	657	2125
26	526	2249	510	2315	553	2238	659	2122
27	524	2251	511	2314	555	2236	701	2119
28	523	2252	511	2314	557	2234	703	2117
29	521	2254	512	2314	559	2231	705	2114
30	520	2256	513	2313	601	2229	707	2111
31	519	2257			603	2227	709	2109

Supplemental Information:

References you should have to assist in data collection:

Arimitsu, M.L., and J.F. Piatt. 2004. Field guide to identifying Kittlitz's Murrelet forage fish. USGS Alaska Science Center, Anchorage, Alaska. <http://www.absc.usgs.gov/research/seabird_foragefish/products/protocols/KIMU_Fish_Guide_Final.pdf>

Mack, D.E., W. P. Ritchie, S. K. Nelson, E. Kuo-Harrison, P. Harrison, and T. E. Hamer. 2003. Methods for surveying Marbled Murrelets in forests: a revised protocol for land management and research. Pacific Seabird Group Technical Publication Number 2. Available from http://www.pacificseabirdgroup.org.

Viereck, L. A., C. T. Dyrness, A. R. Batten, and K. J. Wenzlick. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 278 pp.

If you have questions or issues come up in the field, and you need assistance, contact:

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Vern Byrd, USFWS Alaska Maritime NWR, 907-226-4608
Bill Pyle, USFWS, Kodiak NWR, 907-487-2600

FOLLOWING FORMS:
KIMU nest location data sheet
KIMU chick growth data sheet
Parameter definitions for chick growth data sheet.
Stakeout form for audio-visual surveys (front and back pages)

Kittlitz's Murrelet – Initial Nest Location Data Sheet

Nest ID _____ Study Area _____ Date _____Observer (s)_____

Distance/Bearing to nest from rock cairn _____/_____ Latitude_____ Longitude_____
Datum_____

Direction Adult flushed_____ Confirmed Species ID_Y / N_____
Elevation_____%Slope_____

Predator (s) observed_____

Location Description/field sketch

Egg Measurements

Mass w/bag (g)	Bag (g)	Final Mass *(g)	Length (mm)	Width (mm)	Float	Photo (Y/N)

*Final Mass = Mass w/bag – Bag

Kittlitz's Murrelet Chick Growth Data Sheet

Nest ID _____Study Area _____Date _____Observer(s)_____
Predators observed_____

Mass w/bag (g) _____

Bag (g)_____

Final Mass (g) (Mass w/bag – bag)_____

Wing chord (mm) (natural)_____

Wing chord (mm) (flat)_____

Tail (mm)_____

Culmen (mm)_____

Total Head (mm)_____

Tarsus (mm) _____

Feathers collected (Yes/N0)

Blood Sample (Yes/No)

Egg Tooth (Yes/N0)

Fecal ring sample collection (Yes/No)

Visual estimation of % down covering the body_____

Comments_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Parameter Definitions for Kittlitz's Murrelet Chick Growth Data Sheet

1. Nest ID- assign nest identification to each nest using the following information: year, species acronym, and consecutive nest (e.g., 08KIMU01).

2. Study Area- e.g., Agattu Island, Kodiak Island, Icy Bay, Kenai Fjords, etc.

3. Date- day, month, year (e.g., 16 JUN 2008).

4. Observer (s)- record the full name of all observers present.

5. Predators observed- record information regarding species, behavior, number of individuals observed, etc. DO NOT APPOACH NEST IF PREDATORS ARE PRESENT.

6. Mass w/bag- record mass of chick weighed in the bag to the nearest ±1 g.

7. Mass of bag- record mass of bag WITHOUT chick.

8. Final mass- subtract mass of bag with chick from mass of bag.

9. Wing Chord (natural)- using a ruler, measure the length of the right wing to the nearest ± 1 mm in the natural position from the carpal to the tip of the longest primary.

10. Wing Chord (flat)- measure the length of the right wing to the nearest ± 1 mm from the carpal to the tip of the longest primary by flattening the wing against a ruler.

11. Tail- slide the ruler between rectrices until it reaches the base of the tail. Measure from the base of the tail to tip of the rectrices to the nearest ± 1 mm. Tail does not appear until >15 d.

12. Culmen- use calipers to measure the culmen to the nearest ± 0.1 mm from the tip to the base of the upper mandible.

13. Tarsus- use calipers to measure the length of the tarsus to the nearest ± 0.1 mm from the tibia/metatarsal joint (indentation) to the where the ankle bends. Measure on the posterior side of the leg.

14. **Feathers-** indicate if down or contour feathers were collected at the nest, and if contour feathers were "in blood" (i.e., base of feather was growing).

15. Blood sample- indicate if a blood sample was collected and how many separate samples preserved.

16. Egg Tooth- record if egg tooth is present on bill.

17. Fecal ring sample collection- During brood rearing, indicate if samples of the fecal ring from around the nest scrape were collected (when collecting, avoid extensive disturbance of the nest).

18. Visual estimation of % down on chick- this will be especially important as the chick nears fledging. Approximate the amount of down covering the chick's body and head.

19. Comments- record information regarding chick behavior (e.g., lots of vocalization, etc.), detailed information regarding any predators in the area, presence of adult KIMU, etc.