Kittlitz's Murrelet Study Plan
Version 2008-03

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

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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. 2004). 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 ANALYSIS

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.

X. 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.

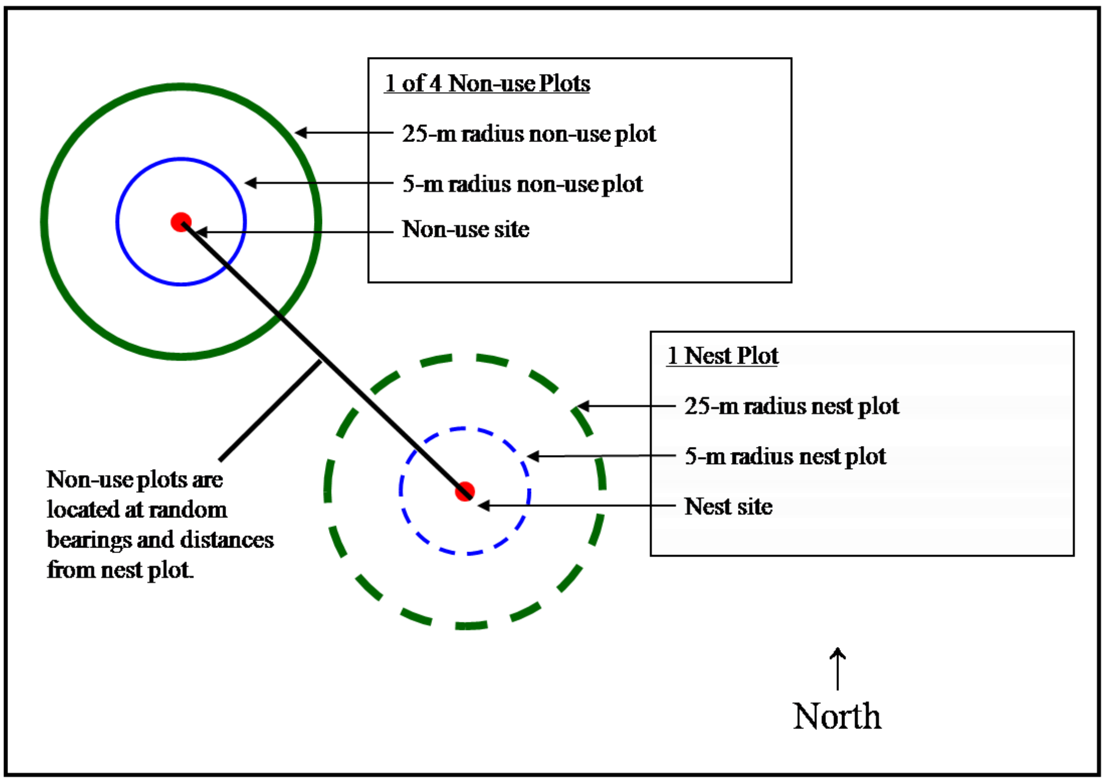
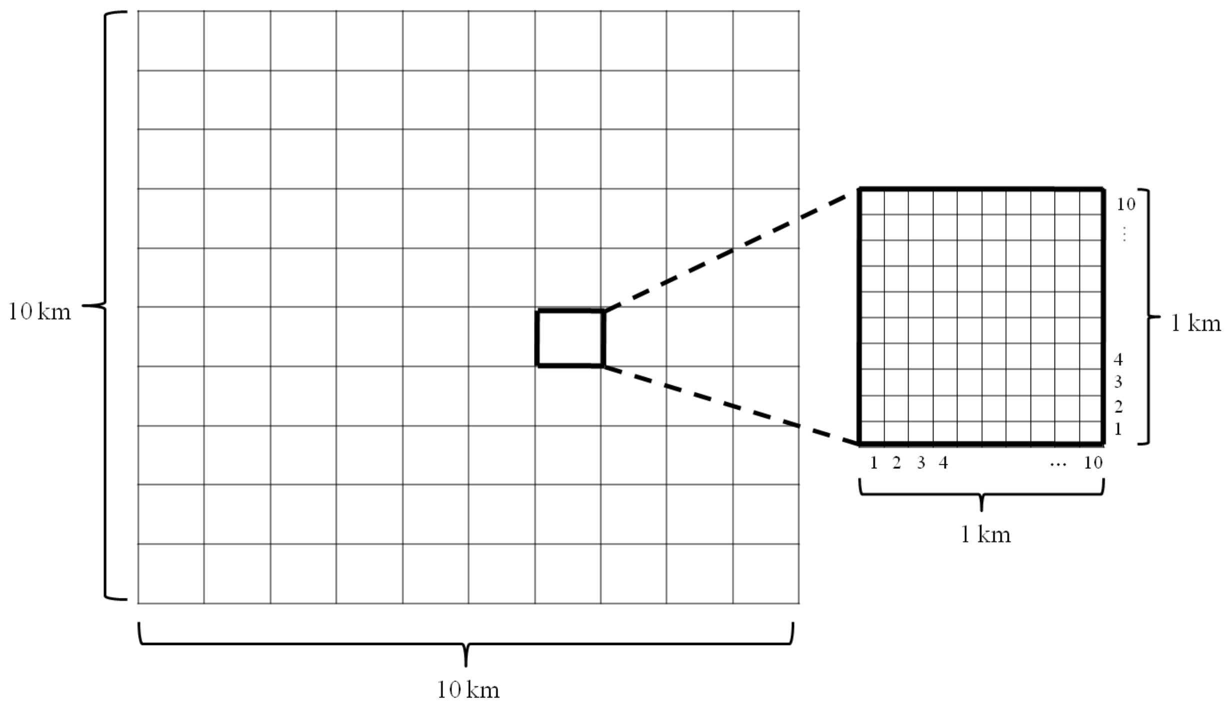


Figure 2. Random plot location grid using x and y points (1 through 10) to select two vegetation plots, located in 1 km by 1 km blocks containing alpine habitat (areas >300 m above sea level), located in 10 km by 10 km sampling grid.



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 1^{st} or 2^{nd} 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 al l 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:

John Piatt, USGS Alaska Science Center, 360-774-0516

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.

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) ____________

Culmen (mm)___________

Bag (g)_______________

Total Head (mm)________

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

Tarsus (mm) __________

Wing chord (mm) (natural)________

Feathers collected (Yes/N0)

Wing chord (mm) (flat)___________

Blood Sample (Yes/No)

Tail (mm)______________

Egg Tooth (Yes/N0)

Fecal ring sample collection (Yes/No)

Visual estimation of % down covering the body______________________________

Comments____

____

____

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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, etc.

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

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 PREDATOR 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.

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.