BREEDING ECOLOGY OF KITTLITZ’S MURRELET
AT AGATTU ISLAND, ALASKA, IN 2009: PROGRESS REPORT

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Key Words: Aleutian Islands, Brachyramphus brevirostris, breeding ecology, growth rates, Near Islands, nest site selection, parental provisioning, reproductive success.

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INTRODUCTION

The Kittlitz’s murrelet (*Brachyramphus breverostris*) is one of the rarest breeding seabirds in the North Pacific and one of the least studied in North America. Long-term population monitoring in core Kittlitz’s murrelet areas in the Gulf of Alaska region has revealed declining trends with up to 80% of local populations disappearing over the past 10 to 20 years (Kuletz et al. 2003, Robards et al. 2003, Van Pelt and Piatt 2003, Kissling et al. 2007). Causes for the rapid decline of this species are uncertain, but likely include both direct and indirect anthropogenic sources of mortality including oil spills, gillnet bycatch, vessel disturbance in core foraging areas, habitat loss due to climate change and glacial retreat, as well as natural sources such as changes in food abundance. Limited knowledge of the ecology of this species hampers conservation efforts (Day and Nigro 2004). Data gaps include basic knowledge about their nesting habitat, mortality factors, demographic vital rates, and diets. Furthermore, while considered a monophyletic species (Gaston and Jones 1998, Day et al. 1999), two recent studies using cytochrome *b* sequences, allozymes, and mtDNA, revealed that the western Aleutian population from Attu Island was genetically differentiated from the south coastal Alaska populations of Kachemak Bay and Glacier Bay (Friesen et al. 1996, MacKinnon 2005), suggesting a subdivided population structure meriting additional study. Focusing research efforts on these knowledge gaps is crucial for developing an effective recovery plan for this candidate species proposed for listing under the Endangered Species Act.

Other than a small portion of birds breeding in the Russian Far East, 95% of the estimated 20,000 Kittlitz’s Murrelets occur in Alaska, with the core of their range being linked with glacial fjords, tidewater glaciers, and glacial stream outflows of southeastern Alaska and Prince William Sound (van Vliet 1993, Day et al. 1999). Patterns of nest site selection also exhibit an association with past and present glacial activity, with nesting habitat having sparse or no vegetation and typically found at relatively high elevations (Thompson 1966, Day et al. 1983, Murphy et al. 1984). While the Aleutian Archipelago has no tidewater glaciers and few glacial river outflows, probable nesting habitat does exist at many alpine areas throughout these islands and breeding has been confirmed at two (Atka Island, Day et al. 1983; Agattu Island, Kaler et al. 2009). Because global warming and glacial recession have been identified as possible causes for the current rapid decline in Kittlitz’s murrelets in southeast Alaska, studying the adaptation of murrelets to the non-tidewater glacier habitat of the Aleutian Islands may provide important insight into understanding this decline.

In 2008, we initiated the first year of a comprehensive 4-year monitoring project to study the breeding ecology of Kittlitz’s murrelets at Agattu Island with the following objectives: 1) describe habitat characteristics of nest sites; 2) quantify breeding chronology; 3) determine chick growth rates, nestling diet and adult nest attendance patterns; 4) measure nest survival rates and overall reproductive success; and 5) collect genetic samples for comparative study of murrelet populations.

This progress report for the 2009 season, the second year of the comprehensive study, contains summary data for some but not all of the parameters we measured. Analysis is pending on nest survival models and nest site selection (R. Kaler, USFWS), sex determination and population genetics (V. Friesen, Queen’s University), and diet analyses of chicks (R. Kaler, USFWS; J. Piatt and M. Arimitsu, USGS). All data will be incorporated and compared in the final report after the completion of the final season of field data collection.
STUDY AREA

Agattu Island (52.43° N, 173.60° E) is part of the Near Islands; a group of five islands found farthest west in the Aleutian Archipelago (Fig. 1) and is also part of the Aleutian Islands Unit of the Alaska Maritime National Wildlife Refuge. Agattu covers an area of 22,474 ha with three-fourths of the island composed of a rolling plateau occurring below 230 m in elevation. The Agattu mountain range, composed of seven sub-massifs and covering one-fourth of the island, extends from the north central side eastward to the island’s northeast point (Fig. 1).

The Near Islands experienced intense glaciation during Wisconsinian time (30,000 to 10,000 years before present; Gates et al. 1971). The cirques and glacial passes of the Agattu range indicate the upward limits of ice at about 300 to 365 m (Schafeb 1971). The passes of the main divide were glaciated, where as all secondary divides are sharp, knife-like ridges, formed by parallel glacial erosion. The westernmost sub-massif is composed of five peaks that rise to 518 - 693 m, and includes the highest point on the island (693 m). Frost action has fractured the bedrock and basalt surface layer and has created expansive talus mountain slopes.

Daily mean minimum and maximum temperatures during 1 June to 24 August 2009 (weather data were collected at the Binnacle Bay camp on the north side of Agattu; Fig. 1) were 6.2 °C (range = 3.7 to 7.4°C) and 13.8 °C (range = 13.3 to 14.5°C), respectively. Average monthly precipitation during the three month period was 8.8 cm (range = 5.6 to 13.4 cm), and wind velocities averaged 28 kilometers per hour (peak gusts periodically reaching 55-115 kilometers per hour).

METHODS

NEST SEARCHING AND MONITORING

Nests were located by ground-searching of suitable terrain (e.g., Day and Stickney 1996, Kaler et al. 2009). Investigators remained within 10 m abreast of each other (i.e., at approximate startling distance of an incubating murrelet) when the habitat permitted. Search efforts were concentrated at high elevation rocky-talus covered areas along ridges, peaks, or terraced slopes. Despite efforts to locate incubating adults without disturbance, the majority of nests (71%, ten of 14) were located by flushing the incubating adult at the time of discovery.

Egg length and width were measured using dial calipers (±0.1 mm). Egg mass was measured using a spring scale (±0.5 g), and eggs were floated in water to estimate the stage of embryonic development (Westerskov 1950, Kaler et al. 2009). To examine possible adverse effects of researcher visits on daily rates of nest survival, discovered nests were paired with their nearest neighbor and then randomly assigned to a disturbed or control treatment group (for both treatment groups n = 7). Disturbed nests were visited every 4-5 days during the incubation and brood rearing period, while control nests were visited only twice during the incubation period (once 4-7 days after initial discovery to confirm continued nest survival post-discovery and once at the time of estimated hatching to aid in determining stage-specific survival). As each egg neared its predicted hatching date based on egg float curves, we checked nests from a distance ≥ 30 m in order to minimize disturbance to incubating adults. No adults were flushed from nests after the initial discovery. During the brood-rearing period, control nests were visited four times (1st = 5-8 d; 2nd = 14-15d; 3rd = 24-26 d, and 4th = >30 d to determine success).
Figure 1. Study location of breeding Kittlitz’s murrelets at Agattu Island, Alaska, 2009. Points represent nest locations of 14 murrelet nests monitored at Agattu from June - August 2009. Triangle represents location of Binnacle Bay camp.
During each visit to nest sites, chick mass was measured to the nearest 1 g (for masses <100 g) or 2 g (for masses >100 g) using Pesola spring scales. We measured the unflattened (natural) wing length from the wrist to the wing tip (±1 mm) using a wing chord ruler. Dial calipers were used to take linear measurements (±0.1) of the total head, exposed culmen, tarsus, and tail length. A blood sample was collected from the right brachial vein from each nestling for genetic analyses and sex determination. All nest visits were conducted between 15:00 and 19:00 Alaska Standard Time to maintain consistency of measurements. No chicks were handled during adverse weather (i.e., wind >30 kilometers per hour, heavy mist or rain).

Nests receiving the disturbed treatment were monitored by time lapse game cameras placed between 1.5 to 2 m from the nest (Reconyx PC90 RapidFire Professional Covert, Holmen, WI). Because of the small size of adult murrelets and their well-insulated plumage, both motion-activated and infra-red triggers do not reliably activate cameras, thus we programmed cameras to record one image every 2-minutes, for 24-hours per day while the nest was active. The 2-minute time delay period between photos was based on the minimum time duration of a nest visit for a Kittlitz’s murrelet monitored using real-time video cameras near Kachemak Bay, Alaska (N. Naslund, pers. comm.). Because cameras recorded images once every two minutes, reported values should be considered as the minimum time duration of a parental visit (i.e., if adults arrived one second before the first image was recorded and departed on second after the final image was recorded). Data from cameras were downloaded every 4-5 days and batteries were replenished every 5-7 days.

**Nest Site Selection**

Nest site characteristics were measured after completion of nesting. Vegetation data were collected at each nest site and at four non-use plots placed at a random bearing and random distance between 50 and 100 m from nest sites. Using a 25-m radius plot at each nest, or non-use plot, percentage classes of each general vegetation type present were estimated using the classification system of Viereck et al. (1992). Also, topographic data were recorded for each of these 25-m plots. Using a 5-m radius plot nested within the 25-m plot and centered at the nest site or middle of non-use plot center, a single observer scored ground cover on a 10-point scale (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%; after Frederick and Gutiérrez 1992). In cases where more than one nest was located on a single submassif, we used ArcView GIS 3.2a software (Environmental Systems Research Institute, Inc.) to calculate straight-line distances between nest locations, as well as distance to the ocean.

**Non-active Nests from Previous Breeding Attempts**

While revisiting known murrelet nests from previous years (2005-2006; 2008), we observed lush patches of vegetation growing at old nest sites. In particular, nests which had persisted into the later stages of the brood-rearing period often contained a dense accumulation of mosses, grasses, and/or forbs. Based upon these observation, we began searching for non-active nests (pre-2009 nests) using the visual cues of a dense vegetative patch in an otherwise sparsely vegetated hillside. Once a potential nest site was detected, we confirmed murrelet use by carefully excavating the scrape to locate murrelet egg shell fragment or chick remains. Only sites containing definitive sign of nesting (murrelet egg shell fragments or chick remains) are reported.
**Breeding Chronology**

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

**Nestling Diet and Adult Provisioning Patterns**

Rates of chick meal deliveries were estimated using time-stamped photos (time-lapse: 1 picture recorded every 2 minutes). For nests where individual adults could be distinguished by their unique plumage characteristics, the frequency of visits for each parent was calculated. Images will be used to quantify chick diet at a later time (R. Kaler, USFWS; J. Piatt and M. Arimitsu, USGS).

**Data Analysis**

Daily survival of eggs and chicks were estimated using the modified Mayfield method (Mayfield 1961, 1975; Bart and Robson 1982, Hines 1996). To calculate Mayfield estimates, the date of failure was assumed to be the midpoint between the last two nest checks. Estimates of time of hatching were accurate to two days, thus exposure days were assigned to the incubation or the nestling periods. Orientation of murrelet nests was analyzed with circular statistics of Program Oriana (ver. 3.11, Kovach Computing Services, Anglesey, Wales, UK).

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

**Results**

**Characteristics and Selection of Nest Sites**

During June to August 2009, 14 Kittlitz’s murrelet nests were located and monitored at Agattu Island (Fig. 1). Nest sites (defined as 25-m radius area around nest) were found on moderate mountain slopes (mean slope = 28°± 1°SE, range = 20° to 35°, n = 14) with a mean elevation of 438 m ± 18 meters above sea level (range = 321 to 553 m, n = 14). The average straight line distance from nest site to the ocean was 2.2 ± 0.1 km (range = 1.3 to 3.2 km, n = 14). The mean vegetative cover was 44% ± 4.4% (range = 20% to 70%, n = 14). Nest scrapes were typically located on the downhill side of a medium to large rock (≥20 cm diameter) or rock ledge associated with bedrock or basaltic formations. Nest sites in 2009 had a random orientation with respect to slope (r = 0.35 ± 0.18; n = 13; Rayleigh test, z = 1.59, P = 0.21). Murrelets were not semi-colonial nesters at Agattu, but may be somewhat aggregated by behavior or scarcity of habitat. On two submassifs where ≥3 nests were located, distances
among neighboring nest sites averaged 283 ± 60 m (range = 30 to 620, n = 5) and 497 ± 106 m (range = 155 to 834 m, n = 4) apart, respectively (Fig. 1).

Nest vegetation data were collected for 13 nest site plots and 52 non-use plots; one nest was reused from 2008 and thus additional vegetation data were not collected. A discriminant function analysis will be conducted to quantify nest site selection by breeding murrelets at a later time (R. Kaler, USFWS).

NON-ACTIVE NESTS FROM PREVIOUS BREEDING ATTEMPTS

In addition to the 14 active nests, we located 25 murrelet nests which had been used in previous years (i.e., pre-2009; Fig. 2, Appendix A). At a minimum, these non-active nests contained murrelet eggshell fragments; three nests contained moss-covered feathers and bones of chicks which apparently failed to fledge (Appendix A; image --KIMU09, image --KIMU10). Based upon the condition of the nest scrape and the depth of egg shell fragments found in nest substrate, we believe only two of the 25 non-active nests found were used in 2008; all other non-active nests were apparently used in 2007 or before.
Figure 2. Non-active nests (pre-2009) of Kittlitz’s murrelets found at Agattu Island, Alaska 2009. Diamonds represent nest locations of 25 nest site located June to August 2009. Triangle represents the location of the Binnacle Bay camp.
Breeding Chronology, Egg, Chick, and Chick Growth

The breeding period of Kittlitz’s murrelets at Agattu in 2009 was protracted. It extended from early June to mid-September (8 June to ~13 September). Median dates of clutch initiation and hatching were 17 Jun (range 8 Jun to 16 Jul, n = 14) and 16 Jul (range = 8 Jul to 8 Aug, n = 11).

All clutches contained one egg or chick. Eggs were sub-elliptical in shape and measured an average of 56.4 x 38.3 mm (length: SE = 1.1, range = 50.2 to 59.9 mm; width: SE = 0.2, range = 37.5 - 39.3 mm, n = 9). The average mass of fresh eggs (≤5 d old) was 43.1 ± 1.2 g (range = 39.0 to 45.5 g, n = 5), ~19% of adult body mass (adult mass = 224 g). Eggs were pale-green with irregular brownish-black, tar-colored spots that ranged from speckling (<1 mm) to patches and streaks (<10 mm). These marks covered the eggs entirely, especially at the blunt end of the egg.

Chick mass increase lasted at least for the first 15 days (Fig. 3). Patterns of chick development became less predictable thereafter, probably associated with either unpredictable provisioning rates or low quality food. Typical sigmoidal growth curves are not evident, probably due in part to minimal sampling (to avoid disturbance) and in part to poor growth rates in mid- to late stages of development.

Wing chord (including outer primaries) increased linearly throughout development after primaries began to emerge at approximately day 5 of the nestling period (Fig. 4). As the primaries developed, wing chord increased to 112 mm (n = 2), or 78% of adult wing length, at 25 d and 30 d post-hatching of the two chicks which fledged (adult wing length = 143 mm).

Growth rates in chick mass between control and disturbed groups could not be compared because insufficient data were available (most chicks exhibited declining masses by the third visit). Furthermore, because the sample size for disturbed nests was one, a measure of variance could not be calculated. The pooled mean for mass for the two groups was 4.0 ± 0.6 g/day (range = 3.0 to 5.0 g/day, n = 3). Wing chord between the two groups did not differ (t = 0.78, df = 3, P = 0.49). The pooled mean for wing length for the two groups was 3.1 ± 0.4 mm/day (range = 2.2 to 4.4 mm/day, n = 5).
Figure 3. Changes in body mass of Kittlitz’s murrelet chicks at Agattu Island, Alaska, July to August 2009. Symbols represent individual chicks; squares are control nests receiving fewer visits by researchers during the 30 d brood rearing period, triangles are disturbed nests receiving visits by researchers every four to five days up to fledge.
Figure 4. Changes in wing length of Kittlitz’s murrelet chicks at Agattu Island, Alaska, July to August 2009. Symbols represent individual chicks; squares are control nests receiving fewer visits by researchers during the 30 d brood rearing period, triangles are disturbed nests receiving visits by researchers every four to five days up to fledge.
Tissue Samples and Genetic Materials Collected for Population Study

Using the brachial vein bleeding technique, blood samples were collected into centrifuge tubes containing 95% ethyl alcohol (ETOH) from all chicks at age 15 days \((n = 3)\), as well as onto filter paper \((n = 3)\). Chicks that died at the nest were collected and preserved in 95% ETOH \((n = 7)\) after stomach contents were inspected. Of eggs that failed to hatch and could be recovered, egg shells and membranes were dried and stored \((n = 2)\) and the dead embryo (non-hatching egg) was preserved in 95% ETOH \((n = 2)\). We collected adult body feathers \((n = 9\) nests) from nest scrapes.

Nestling Diet and Adult Provisioning Patterns

Adult attendance was most common during dawn \((07:00-09:00)\) and dusk \((22:00-24:00)\), but visits occurred throughout the day. No adults were observed feeding chicks between \((01:00-06:00)\). All food loads consisted of single fish carried crosswise in the adults’ bill. Two fishes were collected from separate nest sites: one juvenile rockfish \((Sebastes\ sp.;\ total\ length: 65\ mm)\) and one sand lance \((Ammodytes\ hexagrammos;\ total\ length: 95\ mm)\). Photos will be examined to identify specific prey items brought to nestlings by adults (R. Kaler, USFWS, J. Piatt and M. Arimitsu, USGS).

Time-lapse cameras were deployed at five nests, of which only three survived \(\geq 3\) days. Average number of nest visits by adults per nest ranged from 2.5 to 9.3 visits per day. The total number of days which a nest was monitored by camera ranged from 2 to 29 days (Table 1). Nest attendance patterns at nest with \(>9\) visits were evenly distributed between adults (Table 2).

<table>
<thead>
<tr>
<th>Nest</th>
<th>Average visits per day</th>
<th>SD</th>
<th>Range of visit/day</th>
<th>Total visits during nesting period</th>
<th>Total days monitored</th>
</tr>
</thead>
<tbody>
<tr>
<td>09KIMU 13</td>
<td>9.3</td>
<td>4.0</td>
<td>4 - 18</td>
<td>270</td>
<td>29</td>
</tr>
<tr>
<td>09KIMU 14</td>
<td>4.7</td>
<td>2.0</td>
<td>2 - 7</td>
<td>33</td>
<td>7</td>
</tr>
<tr>
<td>09KIMU 05</td>
<td>3.3</td>
<td>1.7</td>
<td>1 - 5</td>
<td>13</td>
<td>4</td>
</tr>
<tr>
<td>09KIMU 08</td>
<td>2.5</td>
<td>0.7</td>
<td>2 - 3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>09KIMU 01</td>
<td>2.5</td>
<td>0.7</td>
<td>2 - 3</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 2. Individual feeding rates of adult Kittlitz's murrelets from time-lapse images collected at murrelet nests during the brood-rearing period at Agattu Island, Alaska, July to August 2009.

<table>
<thead>
<tr>
<th>Nest</th>
<th>Adult</th>
<th>Total nest visits</th>
<th>% of nest attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>09KIMU 13</td>
<td>Dark adult</td>
<td>120</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Light adult</td>
<td>110</td>
<td>40</td>
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<tr>
<td></td>
<td>Unknown adult</td>
<td>46</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total visits</td>
<td>276</td>
<td>100</td>
</tr>
<tr>
<td>09KIMU 14</td>
<td>Dark adult</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Light adult</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Unknown adult</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total visits</td>
<td>38</td>
<td>100</td>
</tr>
<tr>
<td>09KIMU 05</td>
<td>Dark adult</td>
<td>9</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Light adult</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>Unknown adult</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Total visits</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>09KIMU 08</td>
<td>Dark adult</td>
<td>5</td>
<td>56</td>
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<td></td>
<td>Light adult</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Unknown adult</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Total visits</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>09KIMU 01</td>
<td>Dark adult</td>
<td>2</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Light adult</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Unknown adult</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total visits</td>
<td>6</td>
<td>100</td>
</tr>
</tbody>
</table>
Average duration of a nest visit ranged from 9 to 20 minutes for the five nests with cameras (Table 3). At two nests, adults brooded young from 1.5 to 8.25 hours (data not shown); while these were also provisioning trips, we excluded them from our analysis of provisioning visit duration. One outlier, an adult that remained at the nest while holding a fish for 2 hours and 6 minutes, appeared to be due to the first adult waiting for the mate to arrive at the nest. Once the mate arrived, both adults fed the chick and departed from the nest site (Table 3; 09KIMU 05). The minimum and maximum duration of time between visits for a single adult was 12 minutes and 38 hours, respectively (data not shown).

Table 3. Duration of provisioning visits of adult Kittlitz's murrelets at Agattu Island, Alaska, July to August 2009. Time lapse images were recorded every 2-minutes for 24 hours per day during the brood-rearing period at murrelet nests. Values are presented as minutes.

<table>
<thead>
<tr>
<th>Nest</th>
<th>n</th>
<th>Average</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>09KIMU 13</td>
<td>276</td>
<td>0:09</td>
<td>0:06</td>
<td>0:02 - 1:32</td>
</tr>
<tr>
<td>09KIMU 14</td>
<td>38</td>
<td>0:11</td>
<td>0:05</td>
<td>0:02 - 0:28</td>
</tr>
<tr>
<td>09KIMU 08</td>
<td>9</td>
<td>0:06</td>
<td>0:05</td>
<td>0:02 - 0:18</td>
</tr>
<tr>
<td>09KIMU 05</td>
<td>9</td>
<td>0:20</td>
<td>0:39</td>
<td>0:04 - 2:06</td>
</tr>
<tr>
<td>09KIMU 01</td>
<td>5</td>
<td>0:14</td>
<td>0:02</td>
<td>0:10 - 0:18</td>
</tr>
</tbody>
</table>

**Breeding Success**

Of the 14 nests monitored at Agattu in 2009, we have known-fates for 13 nests; we departed the island prior to the failure or fledging of one nest. Thirteen murrelet nests were located during the incubation period and one was found at day five of the nestling period. Of the 13 nests found during incubation, we treated all as first nest attempts because there appeared to be no synchronized nesting and instead the nest initiation period was protracted. Daily nest survival during the incubation stage was 0.989 ± 0.030 (three losses per 262 exposure days, \(n = 13\)), and the probability an egg would survive the 30 d incubation period was 0.708 ± 0.126. Daily nest survival for the nestling stage was 0.932 ± 0.080 (eight losses per 117 exposure days, \(n = 10\)), and the probability of a chick surviving the 30 d brood-rearing period was 0.119 ± 0.103. Overall, nest survival from clutch initiation to fledging, calculated as the product of the stage-specific rates over the incubation and nestling periods, was 0.085 ± 0.077.

The only cause of nest failure during the incubation stage was abandonment by adults after eggs failed to hatch (23%, three of 13 eggs). No nests were lost due to predation of the
eggs. The remaining ten eggs hatched successfully. The main cause of nest failure during the
nestling period was either exposure to inclement weather or starvation (70%, seven of ten chicks
were found dead at the nest). Of the other three chicks, one (10%; 1 control) was depredated
early in the brood-rearing period (<3 d post-hatching), and two (20%; 1 control, 1 disturbed)
fledged from the nest at day 29 and day 38, respectively.

2009 SUMMARY AND RECOMMENDATIONS

In 2009, we located and monitored 14 Kittlitz’s murrelet nests at Agattu Island. Stage-
specific Mayfield estimates of daily nest survival were only slightly higher in 2009 than values
reported in 2008 (Table 4). More specifically, single stage estimates of survival rates during the
incubation stage increased in 2009, but decreased during the brood-rearing period (Table 4). In
both years, 70% of nests with known fates resulted in chick death due to exposure/starvation
(Fig. 6). Most chicks found dead in the nest were in an opisthotonos posture, with their heads
back and their wings drooped at their sides, similar to a “starvation posture” seen at nests of
passerines that failed due to abandonment/starvation of the young (R. Kaler, pers. obs.). We
cannot definitively assign the cause of mortality to exposure or starvation. Indeed, the high rate
of chick mortality at the nest is likely a result of multiple factors, including diet, weather, and
provisioning rates by adults.

Table 4. Mayfield nest survival estimates (± SE) for Kittlitz’s murrelets at Agattu Island,
Alaska 2008-2009. Number of nests is in parentheses.

<table>
<thead>
<tr>
<th>Estimate Type</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-stage estimates^a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incubation</td>
<td>0.318 ± 0.129 (13)</td>
<td>0.708 ± 0.126 (13)</td>
</tr>
<tr>
<td>Brood-rearing</td>
<td>0.190 ± 0.139 (8)</td>
<td>0.119 ± 0.103 (10)</td>
</tr>
<tr>
<td>Stage-specific estimates^b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage specific</td>
<td>0.060 ± 0.060 (16)</td>
<td>0.085 ± 0.077 (13)</td>
</tr>
</tbody>
</table>

^a Survival for a single stage (incubation or brood-rearing) = (Daily Survival Rate)^d, where d
is 30 d.
^b Calculated at the product of stage-specific survival of the incubation and brood-rearing
periods.
^c Kaler et al. 2008.
Figure 6. Nest fates of Kittlitz’s murrelet nests during the incubation and brood-rearing period at Agattu Island, Alaska, 2008-2009.

RECOMMENDATIONS

We recommend continued monitoring of nests at Agattu using remote, time lapse field cameras to monitor parental provisioning rates and nestling diets. Cameras had no apparent affect on daily nest survival rates or parental attendance during the chick-rearing period, although our small sample sizes preclude testing this statistically. Deployment of cameras during the incubation period merits consideration for the 2010 field season. The continued use of the control/disturbed study design will help address concerns over observer impacts on nest success. Researchers should continue to practice extreme caution while in the vicinity of active
murrelet nests in order to reduce drawing attention by predators. Field personnel should wear camouflage clothing and backpacks, as well carefully camouflage cameras deployed at nests.

Identifying 25 non-active nests based on presence of vegetation is an exciting discovery at Agattu and likely could be used to delineate the breeding range of *Brachyramphus* murrelets throughout the Aleutian Islands. If the high rate of area fidelity (not nest site fidelity) observed at Agattu is a common aspect of murrelet breeding behavior, then locating non-use nests will expedite the process of finding active nests. In some instances, a coarse estimate of year of breeding attempt can be inferred based upon appearance of egg shell fragments, as well as extant of nest survival (i.e., chick remains, lush vegetation = thicker fecal rings, later stage of brood-rearing period). While the use of vegetation cues may not work elsewhere in their breeding range, we believe it has great utility in the Aleutian Islands.

Searching murrelet habitat for both active, as well as non-active nests in the Aleutian Islands provides a new tool to aid researchers in confirming breeding by *Brachyramphus* murrelets. In 2009, we found that nest sites used by *Brachyramphus* murrelets (presumably Kittlitz’s murrelets) in previous years could be located during area searches conducted in suitable murrelet nesting habitat at Agattu Island. Using key features such as typical nest placement, vegetative cover, and presence of egg shell fragments, the breeding range of Kittlitz’s murrelets could be delineated with finer resolution throughout its range.

**CONCLUSION**

Information regarding the breeding ecology of Kittlitz’s murrelet was very limited until the discovery of a breeding population at Agattu Island in 2005. Since then, we have monitored 43 nests and contributed important information to our understanding of breeding success, chick diet, parental behavior, and nest site selection in the western Aleutian Islands. The Aleutian population of Kittlitz’s murrelets, estimated to compose ~18% of the Alaskan population, helps provide basic information on natural history and an excellent point of contrast to aid in recovery planning for this candidate species for listing under the Endangered Species Act. We recommend continued monitoring of nests using remote, time lapse field cameras to elucidate parental provisioning rates and nestling diets. The high rate of nest failure due to chick mortalities at Agattu, either as a result of exposure or starvation, warrants an increased focus on this aspect of murrelet breeding ecology.
ACKNOWLEDGMENTS

This work would not have been possible without the hard work and dedication of the staff at the Alaska Maritime National Wildlife Refuge. We thank the crew of the M/V Tiglax for providing safe passage to the outer Aleutians and for help establishing the Agattu field camp. We are grateful for the help of Erica Madison in logistics and obtaining field equipment. We thank Google Earth for their detailed images of Agattu Island. A Challenge Cost-Share Grant awarded by the US Fish and Wildlife Service provided additional funding for this research.

LITERATURE CITED


Nests contained a minimum of murrelet egg shell fragments; three nests contained feathers and bones of murrelet chicks which failed to fledge.
APPENDIX B - Annotated list of species observed at Agattu Island, Alaska, 1 June to 24 August, 2009.

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

Birds

Red-throated loon (*Gavia stellata*).--Uncommon breeder. A pair was observed nesting on a small lake south of the Binnacle Bay camp. Adults were heard or seen flying between this site and Binnacle Bay on 80 days from 1 June-25 August. On 10 July, one hatching-year bird was observed at the lake nest site.

Arctic loon (*Gavia arctica*).--Rare. One individual in non-breeding plumage was observed at Binnacle Bay on 19 August.

Common loon (*Gavia immer*).--Uncommon. Birds were observed on 39 days from 1 June-24 August. Single pairs were observed on multiple lakes on the south and west sides of the mountains at Agattu.

Shearwater spp. (*Puffinus* spp.).--Rare. Several unidentified shearwaters were observed foraging ~2 km offshore from Binnacle Bay on 20 June.

Fork-tailed storm-petrel (*Oceanodroma furcata*).--Common breeder. Birds were regularly heard at night at Binnacle Bay from 1 June-24 August for a total of 70 days detected. Multiple colonies were encountered and elevation of colonies ranged from 150 to 500 m above sea level. Colonies were located in either boulder fields covered with a dense *Sphagnum* moss or ericaceous dwarf shrub mat or in exposed boulders with no vegetative cover. Adults were commonly heard calling from boulder crevices during the day. One hatched egg shell of a storm-petrel (species unknown) was seen at the entrance of a crevice on 4 July. Common ravens were frequently observed at colonies, presumably excavating for adults, young, and eggs.

Leach’s storm-petrel (*Oceanodroma leucorhoa*).--Common breeder. Birds were regularly heard at night at Binnacle Bay from 2 June-24 August for a total of 67 days detected. Multiple colonies were encountered and elevations ranged from 150 to 500 m above sea level.

Red-faced cormorant (*Phalacrocorax urile*).--Uncommon breeder. Observed at Binnacle Bay on 25 days from 1 June-5 August. One observed on 5 July attending a nest on the east side of Binnacle Bay. A single non-breeding (second-year bird?) was observed on four occasions perched on an exposed soil bluff above the Binnacle Bay stream, approximately 2 km inland. The bird appeared to be excavating in the undercut bank of the stream.
Pelagic cormorant (*Phalacorcorax pelagicus*).--Uncommon breeder. Observed at Binnacle Bay on 21 days from 21 June-9 August. Individuals were seen foraging near the mouth of Binnacle stream or in the middle of the bay. A small colony of red-faced and pelagic cormorants breeds at Aga Cove on the east side of the island.

Unidentified cormorant spp. (*Phalacorcorax* spp.).--Unidentified cormorants were seen at Binnacle Bay from 3 June-10 August on 28 occasions.

Aleutian cackling goose (*Branta hutchinsii leucopareia*).--Abundant breeder. Geese were one of the most frequently encountered breeding birds at Agattu and were observed on 75 days from 1 June-24 August. The first goslings were observed on 19 June. Geese were commonly encountered at both low and high elevations, especially during the brood-rearing period (several nests were found above 250 masl).

Emperor goose (*Chen canagica*).--Rare. One adult seen at Binnacle Bay on 14 June.

Mallard (*Anas platyrhynchos*).--Rare. Females were observed on 6 days from 7 June-21 August at inland lakes.

Eurasian green-winged teal (*Anas crecca crecca*).--Uncommon breeder. This species was seen on 57 days from 5 June-21 August. Two females and a brood of six young were seen in the ephemeral wetland area near the Binnacle Bay camp site on 1 July. A female and young were frequently heard at night from 1 July to 18 August in the wetland area.

Eurasian wigeon (*Anas penelope*).--Rare. One pair was observed for three consecutive days from 4 June to 6 June at Binnacle Bay.

Greater scaup (*Aythya marila*).--Rare breeder. This species was seen on 5 days from 11 June-15 August. A female with young was observed on an inland lake on 14 August.

Harlequin duck (*Histrionicus histrionicus*).--Uncommon. A group of 2-5 individuals were observed on 23 occasions from 3 June-23 July. Birds were generally observed foraging at the mouth of Binnacle stream and occasionally seen loafing on rocks.

Common eider (*Somateria mollissima*).--Abundant breeder. Eiders were one of the most frequently observed species at Binnacle Bay and were seen on 84 days from 1 June-24 August. The first hatching-year young were seen on 2 July at Binnacle Bay. Females with ducklings would congregate in groups of 2-8 individuals and fiercely protect the young from Glaucous-winged gulls. Male eiders generally foraged and loafed singly or in small groups with other males or females after chicks hatched.

Red-breasted Merganser (*Mergus serrator*).--Uncommon. This species was observed on 17 days from 2 June-6 August. Pairs were seen on inland lakes, but more commonly they were observed at Binnacle Bay during early July.

Peregrine falcon (*Falco peregrinus*).--Uncommon breeder. This species was seen on 50 days from 3 June-24 August. On 4 July, we observed nest defense by both the male and female as we traveled along the beach along the east side of Binnacle Bay. On 17 July, we observed the first hatching year bird.

Rock ptarmigan (*Lagopus muta evermannii*).--Uncommon breeder. Rock ptarmigan were observed on 47 days ranging from 2 June-23 August. One nest was found during the laying period on 2 June. Using broadcast surveys to determine population size at Agattu, we counted 26 territorial males.

Rock sandpiper (*Calidris ptilocnemis*).--Common breeder. Sandpipers were observed on 71 days from 2 June-21 August. The first nest was discovered on 5 June and contained 4 eggs.
Gray-tailed tattler (*Heteroscelus brevipes*).--Rare. One adult was observed on 18 August at an inland lake. Vocalization of the bird confirmed species identification.

Parasitic jaeger (*Stercorarius parasiticus*).--Uncommon breeder. Primarily dark morph parasitic jaegers were observed on 32 days from 5 June to 21 August. Adults were generally observed in upland habitat singly or in pairs. Jaegers were observed quartering low above hillsides at high elevation.

Glaucous-winged gull (*Larus glaucescens*).--Abundant breeder. Gulls were observed on a total of 85 days from 1 June-24 August. Two nests, each containing 3 eggs, were discovered on the east side of Binnacle Bay stream along the beach and one nest with two eggs was discovered on the west side of Binnacle stream. Of these two nests, one chick was found dead in the nests, and one chick fledged. The other eggs did not hatch. In general, it appeared to be a poor breeding year for gulls based upon the low number of hatching-year young observed at Binnacle Bay (~ 2 young).

Slaty-backed gull (*Larus schistisagus*).--Rare. One individual was seen at Binnacle Bay on 31 May.

Common murre (*Uria aalge*).--Uncommon breeder. One to four adults were seen foraging at Binnacle Bay on 19 days from 5 July-24 August.

Thick-billed murre (*Uria lomvia*).--Uncommon breeder. One to two adults were seen foraging at Binnacle Bay on 10 days from 16 June-8 August.

Pigeon guillemot (*Cepphus columba*).--Common breeder. Four to 9 individuals were observed on 78 days from 1 June-24 August. Guillemots were concentrated mostly along the east side of Binnacle Bay. Birds were seen foraging near shore and fish holders were observed in the bay beginning 9 August. One hatching-year young was observed on 9 July. Guillemots were commonly observed foraging among tufted and horned puffins.

Kittlitz’s murrelet (*Brachyramphus brevirostris*).--Uncommon breeder. Fourteen nests were discovered in upland habitat during the field season. Chicks and adults were only seen inland at nests. No adults or fledged young were observed at Binnacle Bay.

Ancient murrelet (*Synthliboramphus antiquus*).--Rare. On the evening of 4, 5, and 6 June ancient murrelets were heard vocalizing near the east side of Binnacle Bay with fork-tailed and Leach’s storm petrels. On 12 June, 6 individual were seen at Binnacle Bay. Additionally, remained of ancient murrelets were found in snowy owl pellets.

Horned puffin (*Fratercula corniculata*).--Common breeder. Horned puffins were observed on 54 days from 1 June-24 August. Groups of 10-15 individuals were commonly observed foraging on the east side of Binnacle Bay, or resting on the water at the opening of the bay.

Tufted puffin (*Fratercula cirrhata*).--Common breeder. This species was observed on 82 days from 1 June-24 August. Puffins were usually observed foraging or resting on the water on the eastern side of Binnacle Bay.

Snowy owl (*Bubo scandiacus*).--Rare. Only one owl was seen 1 June; however, fresh pellets and feathers were collected at Agattu for an analysis of their diets.

Common raven (*Corus corax*).--Uncommon. Up to six individuals were seen on 71 days from 2 June-24 August. It was common to see ravens in small groups (3-6 individuals) doing synchronized flights and exchanging loud vocalizations. Ravens were frequently observed in upland habitat and in Rampart and Binnacle valley. Additionally, ravens were observed at storm-petrel colonies where they excavate the burrows and consume adults, young, and presumably eggs.
Eye-browed thrush (*Turdus obscurus*).--Rare. One male was seen and heard singing on 11 June on the south side of the westernmost mountain.

Winter wren (*Troglydotes troglodytes*).--Common breeder. Birds were observed on 58 days from 2 June-24 August, most commonly in dense forbs along the beach. On four separate occasions, an adult was found exploring the inside of our weatherport. Wrens were rarely encountered at inland sites. Young were first seen 24 July.

Gray-crowned rosy finch (*Leucosticte tephrocotis*).--Uncommon breeder. Observed on 46 days from 2 June-19 August. Birds were seen from low to high elevation. Young were first seen 15 June.

Song sparrow (*Melospiza melodia*).--Common breeder. Birds were observed on 85 days from 1 June-24 August, mostly along the beaches and in dense forbs near the beach. A nesting pair was observed at camp from 27 May-26 August. This pair likely produced three clutches based on behavioral observations of adults carrying food, removing fecal sacs, and attending to recently fledged young. Fledglings were first observed on 3 July.

Lapland longspur (*Calcarius lapponicus*).--Abundant breeder. Birds were observed along grassy slopes throughout the island. Observations were made on 81 days from 1 June-24 August. Young were first seen 4 July.

Snow bunting (*Plectrophenax nivalis*).--Fairly common breeder. Individuals were observed on 63 days from 1 June-23 August. Young were first seen 18 June.

**Mammals**

Sea otter (*Enhydra lutris*).--Rare. Otters were observed at Binnacle Bay on 13 days from 5 June-13 August. On 5 July, female with a pup was seen at Binnacle Bay.

Harbor seal (*Phoca vitulina*).--Uncommon. Seals were seen at Binnacle Bay on 80 days from 1 June-24 August. On 24 June, one recently born pup was observed with a female. On 15 July, two adult seals exchanged aggressive bites for >2 hours in the area of shore from the Binnacle Bay stream. Harbor seals were frequently seen hauled-out on rocks on the west side of Binnacle Bay.

Humpback Whale (*Megaptera novaeangliae*).--Rare. Two individuals were seen during the *Brachyramphus* surveys on 29 July ~1 nautical mile offshore of Agattu’s east side.
### APPENDIX C - Breeding status and abundance of birds observed at Agattu Island, Alaska, 2009.

<table>
<thead>
<tr>
<th>Species</th>
<th>Date First Observed</th>
<th>Date last Observed</th>
<th>No. Days Observed</th>
<th>Breeding Status</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red-throated loon</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>80</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Arctic loon</td>
<td>19-Aug</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Common loon</td>
<td>5-Jun</td>
<td>24-Aug</td>
<td>39</td>
<td>O</td>
<td>Observed on inland lakes</td>
</tr>
<tr>
<td>Shearwater spp.</td>
<td>20-Jun</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>Observed off shore near Binnacle Bay</td>
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<tr>
<td>Fork-tailed storm-petrel</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>70</td>
<td>CE</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Leach's storm-petrel</td>
<td>2-Jun</td>
<td>24-Aug</td>
<td>67</td>
<td>CE</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Red-faced comorant</td>
<td>1-Jun</td>
<td>5-Aug</td>
<td>25</td>
<td>PN</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Pelagic cormorant</td>
<td>21-Jun</td>
<td>9-Aug</td>
<td>21</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Unspecified cormorant</td>
<td>3-Jun</td>
<td>10-Aug</td>
<td>28</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Aleutian Canada goose</td>
<td>2-Jun</td>
<td>24-Aug</td>
<td>75</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Emperor goose</td>
<td>14-Jun</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>One adult observed in Binnacle Bay</td>
</tr>
<tr>
<td>Mallard</td>
<td>7-Jun</td>
<td>21-Aug</td>
<td>6</td>
<td>PO</td>
<td>Observed on ephemeral lake on west side of Island</td>
</tr>
<tr>
<td>Green-winged teal</td>
<td>5-Jun</td>
<td>21-Aug</td>
<td>57</td>
<td>CG</td>
<td>Observed at camp</td>
</tr>
<tr>
<td>Eurasian wigeon</td>
<td>4-Jun</td>
<td>6-Jun</td>
<td>3</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Greater scaup</td>
<td>11-Jun</td>
<td>15-Aug</td>
<td>5</td>
<td>CG</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Common Eider</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>84</td>
<td>CE</td>
<td>Common in Binnacle Bay</td>
</tr>
<tr>
<td>Harlequin duck</td>
<td>3-Jun</td>
<td>23-Jul</td>
<td>23</td>
<td>PO</td>
<td>Common at mouth of Binnacle Stream</td>
</tr>
<tr>
<td>Red-breasted merganser</td>
<td>2-Jun</td>
<td>6-Aug</td>
<td>17</td>
<td>PO</td>
<td>Pair observed at lakes on south side of island</td>
</tr>
<tr>
<td>Peregrine falcon</td>
<td>3-Jun</td>
<td>24-Aug</td>
<td>50</td>
<td>CR</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Rock ptarmigan</td>
<td>2-Jun</td>
<td>23-Aug</td>
<td>47</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Gray-tailed Tattler</td>
<td>18-Aug</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>One adult observed up stream from Binnacle Bay</td>
</tr>
<tr>
<td>Rock sandpiper</td>
<td>2-Jun</td>
<td>21-Aug</td>
<td>71</td>
<td>CE</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Parasitic jaeger</td>
<td>5-Jun</td>
<td>21-Aug</td>
<td>32</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Glaucous-winged gull</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>85</td>
<td>CE</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Slaty-backed gull</td>
<td>31-May</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Black-legged kittiwake</td>
<td>28-Jul</td>
<td>24-Aug</td>
<td>13</td>
<td>CN</td>
<td>Breeding colony in Aga Cove</td>
</tr>
<tr>
<td>Common murre</td>
<td>5-Jul</td>
<td>24-Aug</td>
<td>19</td>
<td>CN</td>
<td>Observed in Binnacle Bay: breeding colony in Aga Cove</td>
</tr>
<tr>
<td>Thick-billed murre</td>
<td>16-Jun</td>
<td>8-Aug</td>
<td>10</td>
<td>O</td>
<td>Observed in Binnacle Bay: breeding colony in Aga Cove</td>
</tr>
<tr>
<td>Pigeon guillemot</td>
<td>27-May</td>
<td>24-Aug</td>
<td>78</td>
<td>CR</td>
<td>Abundant on multiple days in Binnacle Bay</td>
</tr>
<tr>
<td>Kittlitz's murrelet</td>
<td>12-Jun</td>
<td>23-Aug</td>
<td>41</td>
<td>CE</td>
<td>Only observed in the Mountains</td>
</tr>
<tr>
<td>Ancient murrelet</td>
<td>4-Jun</td>
<td>12-Jun</td>
<td>4</td>
<td>O</td>
<td>Observed in Binnacle Bay</td>
</tr>
<tr>
<td>Horned puffin</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>54</td>
<td>CF</td>
<td>Abundant on multiple days in Binnacle Bay</td>
</tr>
<tr>
<td>Tufted puffin</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>82</td>
<td>CF</td>
<td>Abundant on multiple days in Binnacle Bay</td>
</tr>
<tr>
<td>Snowy owl</td>
<td>1-Jun</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>Rare</td>
</tr>
<tr>
<td>Common raven</td>
<td>2-Jun</td>
<td>24-Aug</td>
<td>71</td>
<td>O</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Eye-browed thrush</td>
<td>11-Jun</td>
<td>.</td>
<td>1</td>
<td>O</td>
<td>Rare</td>
</tr>
<tr>
<td>Winter wren</td>
<td>2-Jun</td>
<td>24-Aug</td>
<td>58</td>
<td>CR</td>
<td>Common on multiple days</td>
</tr>
<tr>
<td>Gray-crowned rosy-finch</td>
<td>2-Jun</td>
<td>19-Aug</td>
<td>46</td>
<td>CR</td>
<td>Common on multiple days</td>
</tr>
<tr>
<td>Song sparrow</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>85</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Lapland longspur</td>
<td>1-Jun</td>
<td>24-Aug</td>
<td>81</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
<tr>
<td>Snow bunting</td>
<td>1-Jun</td>
<td>23-Aug</td>
<td>63</td>
<td>CR</td>
<td>Abundant on multiple days</td>
</tr>
</tbody>
</table>

**Key:**
- O = Observed/non-breeding
- P = Nest-site Visitations
- X = Observed in breeding habitat
- PO = Pair observed
- PC = Courtship
- PA = Agitated behavior
- PY = Nest with Young
- CE = Nest with Eggs
- CN = Carrying Nest Material
- CA = Carrying Food
- CO = Occupied Nest
- CR = Recently Fledged Young
- CI = Feeding Recently Fledged Young
- CT = Confirmed

<table>
<thead>
<tr>
<th>Family</th>
<th>Scientific Name</th>
<th>First Bloom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apiaceae</td>
<td><em>Angelica lucidia</em></td>
<td>20-Jul</td>
</tr>
<tr>
<td></td>
<td><em>Heracleum lanatum</em></td>
<td>25-Jul</td>
</tr>
<tr>
<td></td>
<td><em>Conioselinum chinense</em></td>
<td>25-Jul</td>
</tr>
<tr>
<td></td>
<td><em>Ligusticum scoticum subsp. hultenii</em></td>
<td>16-Jul</td>
</tr>
<tr>
<td>Asteraceae</td>
<td><em>Achillea borealis</em></td>
<td>24-Jul</td>
</tr>
<tr>
<td></td>
<td><em>Anaphalis margaritaceae</em></td>
<td>19-Jul</td>
</tr>
<tr>
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<td><em>Antennaria dioica</em></td>
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<td>1-Aug</td>
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<td><em>Artemisia arctica</em></td>
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<td><em>Cacalia auriculata subsp. kamtschatica</em></td>
<td>16-Jul</td>
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<td><em>Arunucus sylvester</em></td>
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