An Evaluation of Breeding Bird Resources near Hooper Bay, Alaska, 2009

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ABSTRACT: In 2009, Yukon Delta National Wildlife Refuge and Sea Lion Corporation cooperated to conduct bird surveys in the areas proposed as Hooper Bay airport relocation alternatives by the Alaska Department of Transportation and Public Facilities. Breeding season bird surveys were conducted on most proposed primary and cross runways, as well as in the runway protection zones for each of the four alternatives. In addition, the four proposed borrow sites, plus four auxiliary areas of nesting bird habitat, were all surveyed at least once during the breeding season. We conducted a total of 32 area searches within 12 survey zones between 27 May and 24 June. We detected 81 species during our field work, and found 198 nests of 18 species. An analysis of species richness and nest numbers revealed that among the four airport relocation alternatives, Alternative 2 ranked highest, and Alternative 1 ranked lowest, in terms of bird resources; Alternative 3 may have had the highest overall nest densities. Among the proposed borrow sites and auxiliary areas, the proposed Dall Point borrow site ranked highest overall for bird resources, and Nuok Spit appeared to support the highest overall nest density. The Red Phalarope, a focal species for a new oil spill restoration project on Sea Lion Corporation lands, was very scarce in the vicinity of Hooper Bay. Finally, there were very few observations of threatened eiders; the areas we searched in the immediate vicinity of Hooper Bay do not appear to currently support breeding populations of either Spectacled or Steller's eiders.

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COVER PHOTO: Female Red Phalarope (*Phalaropus fulicarius*); photo by Theodor Swem.

EXECUTIVE SUMMARY

In May and June, 2009, the U. S. Fish and Wildlife Service (USFWS) and Sea Lion Corporation (SLC) cooperated to conduct bird surveys in the areas proposed as Hooper Bay airport relocation alternatives by the Alaska Department of Transportation and Public Facilities (DOTPF). The Refuge provided one permanent staff member to coordinate the surveys, and hired two Alaska Native Science and Engineering Program (ANSEP) students enrolled at University of Alaska—Fairbanks to serve as technicians. Sea Lion Corporation hired three local high school students as interns to assist the USFWS bird survey team.

We evaluated the four airport relocation alternatives proposed by DOTPF as of 8 December 2008. Three of these included dune and wetland habitats south or southeast of the current Hooper Bay airport. The fourth alternative is in the upland tundra north of the village, a short distance beyond the northern terminus of the village's hardened ATV trail. For each alternative, there is a primary runway, a crosswind runway, and four runway protection zones (RPZs, one at each end of each of the two runways). We did area searches and nest searches along the proposed runways and in the RPZs. We recorded the date and time of each survey, as well as every bird species detected. In addition, we recorded one of 14 status codes for each species, to reflect its use of the surveyed area. For analysis, these 14 were collapsed into three increasingly restrictive categories: 1) occurrence (all birds detected, including those just flying by), 2) use (either foraging or breeding evidence), or 3) breeding. We also conducted nest searches in each of the surveyed areas, recording for each nest the species, the nest contents (number of eggs or young), and the parental care status (adult on nest or not, and sex of incubating adult).

Similar protocols were implemented in the four proposed borrow sites, each of which was visited at least once. Because of their large size, we attempted to visit borrow sites on more than one occasion when possible. In addition, we surveyed four auxiliary areas near Hooper Bay (three wetland basins plus the hardened trail corridor) to search for focal species (threatened eiders and phalaropes) and to compare overall species richness and nest abundance with the borrow sites. Through these comparisons, we were able to consider the importance of the borrow sites (as bird habitat) in a broader ecological and spatial context.

Because of variation in both the amount of time spent on surveys, and the seasonal probability of detecting species and nests, we controlled for these variables by a) generating rates of species accumulation and nest detection, and b) limiting comparisons of nest detection to surveys conducted during that interval of the season when most nests were active. Measures of species richness and nest-finding rates were used in comparisons among surveyed areas.

We conducted 32 area searches within 12 survey zones between 27 May and 24 June, and discovered 198 nests of 18 species. We completed six runway surveys and 13 RPZ surveys. For Alternative 1 (modification and expansion of existing runway complex), we did not survey the current airport or its RPZs. For Alternative 3, we did not complete the north RPZ on the crosswind runway, and for Alternative 4, we completed a nest search on the crosswind runway, but the area search data were not recorded. These data gaps were controlled for when comparing the various airport alternatives. We also completed at least one area search

in each of the four borrow areas (Dall Point – one search, Alternative #4 uplands – one, South Airport Road – three, and Nuok Spit – two). At Dall Point, we only surveyed the southern half of the proposed borrow area, and at Nuok Spit, we only surveyed the northwestern half of the proposed borrow area. Searches in these two areas were limited so as to avoid disturbing subsistence users who were in those areas on the days of our surveys. Finally, we conducted at least one area search in each of four additional areas: 1) Napareayak Slough, 2) wetlands due north of the village-airport road, 3) wetlands northwest of the estuary that drains the tundra immediately north-northwest of the village, and 4) the hardened trail corridor.

Our surveys indicated that Airport Alternative #2 ranked highest in terms of bird resources, and Alternative # 1 (expansion of current runway with added crosswind runway) ranked the lowest. Alternatives #3 and #4 were intermediate overall, although Alternative #3 did have a considerably higher nest detection rate than any of the other alternatives. Among the four proposed borrow areas and four additional areas surveyed, the Dall Point borrow area was clearly the most important, ranking highest in five of 10 variables describing patterns of species richness, habitat use, and nest density. For example, among 23 waterfowl nests discovered during our field work, over half were found in or around the Dall Point borrow area (nine in the proposed borrow area and three others in the nearby uplands). The upland borrow area (i.e., north of Alternative #4) ranked lowest among the eight areas, but its low scores may have been due at least in part to the early timing of the survey there. The Nuok Spit borrow area was very important for nesting birds, particularly shorebirds. Nest detection rates at Nuok Spit were 133% higher than the mean among all eight areas, and 20% higher than the next highest area (the hardened trail corridor).

Red Phalaropes were considered a focal species during our 2009 surveys because of the initiation of a new collaborative project between USFWS and SLC. This 10-year project to protect nesting bird habitat on SLC lands was one of 14 projects selected to make restoration for damages to marine birds (including phalaropes) resulting from oil spilled from the *S. S. Luckenbach* along the coast of central California between 1992 and 2003. Red Phalaropes were among the species most severely impacted by the spill. To evaluate the feasibility of management efforts to protect phalarope nesting habitat, it is necessary to document their current status and habitat preferences on SLC lands. Red Phalaropes were among the rarest shorebirds detected during our field work near Hooper Bay in 2009. The presence of a few pairs suggested that breeding may have occurred, but no nests were found despite our targeted efforts to search wetlands in which pairs were detected, and no broods, fledged juveniles, or post-breeding adults were detected during our field work in late July and early August.

Spectacled and Steller's Eiders are protected as threatened species under the Endangered Species Act. Although the Sea Lion Corporation lands surveyed during this study are not designated as Critical Habitat for either species, we did keep track of all of our observations of those two species. Only two Spectacled Eiders were seen in or over our survey areas. A male was seen on 15 June in a wetland near the southeast end of the Alternative #3 primary runway, and a second lone bird flew over the South Airport Road borrow site on 22 June. No Steller's Eiders were observed during our field work. It does not appear that either species of threatened eider is currently breeding on Sea Lion Corporation lands within our 2009 study area in the immediate vicinity of Hooper Bay.

TABLE OF CONTENTS

INTRODUCTION

For much of the last decade, the community of Hooper Bay and its Native village corporation, Sea Lion Corporation (SLC), have worked to reduce human disturbance in important bird-nesting habitats. Their efforts have included 1) posting signs on corporation lands, 2) creating locally-developed outreach products encouraging habitat protection, 3) annually staffing and maintaining an information and education camp on the bluff above Kokechik Bay (with partial funding assistance from the USFWS), and 4) working with partners (e.g., U. S. Natural Resources Conservation Service, U. S. National Park Service) to create a hardened all-terrain vehicle (ATV) trail north of the village to allow for the protection and recovery of adjacent habitats that have been damaged by ATV use.

During 2008, the State of Alaska's Department of Transportation and Public Facilities (DOTPF) and the village of Hooper Bay considered options for either improving the existing airport runway or building a new runway complex somewhere else near the village. In December 2008, DOTPF formally provided four alternatives for runway construction and four alternatives for borrow sites to support the construction of the runways, aprons, and associated roads. Within the context of protecting important bird habitat, SLC asked the USFWS to evaluate the breeding bird resources in those areas during the 2009 nesting season. Yukon Delta National Wildlife Refuge (YDNWR) agreed to coordinate and fund this effort.

This project coincided with the initiation of a 10-year cooperative project between USFWS and the Sea Lion Corporation. In 2009, they were awarded funding by the Luckenbach Trustee Council (LTC) to protect bird nesting habitat on corporation lands. The LTC oversees the use of oil spill restoration money to mitigate the effects of chronic oil spills that occurred along the coast of central California between 1992 and 2003. The oil originated from the wreck of the *S. S. Luckenbach*, which sank off the coast of San Francisco in 1953. Estimates of bird mortality from those spills exceeded 51,000, including thousands of individuals of species known to breed near Hooper Bay, such as Pacific Loons and Red Phalaropes (Luckenbach Trustee Council 2006). Because restoration efforts would be very difficult to implement in the marine habitats where the spill occurred, the LTC solicited proposals for restoration projects on the breeding grounds of the affected species. Among the 14 projects selected was one to protect nesting bird habitat on SLC lands. This restoration project has four objectives: 1) to develop habitat management guidelines to protect nesting bird habitat on corporations lands, 2) to continue to support SLCs annual information and education camp, 3) to collaboratively develop outreach tools explaining the damage ATVs cause to wildlife habitat, and 4) to monitor the effectiveness of project implementation. Because new airport development will impact bird nesting habitat near Hooper Bay, regardless of which alternative is selected, a small portion of the *Luckenbach* project funding augmented the 2009 survey work at the very end of the field season.

The 2009 field work was undertaken with the following primary objectives: 1) evaluate the avian resources of the various DOTPF airport alternatives during the breeding season, 2) determine the status of Red Phalaropes, a focal species for the *Luckenbach* project, in the vicinity of Hooper Bay, and 3) determine the status of threatened eiders on, and in the vicinity of, the various DOT airport alternatives to determine whether potential new airport developments might impacts breeding eiders. In addition to providing and interpreting data relative to these three objectives, this report also provides a preliminary ecological overview of the 2009 spring season at Hooper Bay.

METHODS

Field work was conducted in the vicinity of Hooper Bay, Alaska (61^{o} 31’ 51.87” N, 166^{o} 05’ 47.80” W; Fig. 1, 2), from 19 May through 24 June, and from 21 July through 5 August, 2009. Our primary sampling was designed to evaluate the four airport relocation alternatives (ARAs) and the four borrow sites proposed by DOTPF as of 8 December 2008. Three of the ARAs included dune and wetland habitats south or southeast of the current Hooper Bay airport (Fig. 3-5). The fourth was in the upland tundra north of the village, just a short distance beyond the current northern terminus of the village’s hardened ATV trail (Fig. 6). For each alternative, there is a primary runway, a crosswind runway, and four runway protection zones (RPZs, one at each end of each of the two runways). The four proposed borrow sites are located, from north to south, at Dall Point, north of ARA 4’s primary runway, south of the Hooper Bay airport road, and at Nuok Spit (Fig. 6).

In addition, we surveyed four additional areas (“auxiliary areas”) near Hooper Bay (Fig. 7) in search of Red Phalaropes and threatened eiders. These auxiliary areas included 1) Napareayak Slough, 2) North Airport wetlands (wetlands due north of the village-airport road), 3) Northwest Estuary (wetlands northwest of estuary north-northwest of the village), and 4) Hardened Trail (corridor 25 m wide on either side of hardened ATV trail from the wind turbines to the trail’s northern terminus). By comparing results from these surveys with those of the borrow sites, we were able to consider the relative importance of the borrow sites (as bird habitat) in a broader ecological context. Overall, we considered the four airport alternatives, four proposed borrow sites, and four auxiliary areas to represent 12 survey “zones.” Multiple surveys were conducted within each of the ARAs (i.e., runways and RPZs were each surveyed separately), and some of the borrow sites and auxiliary areas were surveyed on multiple days (see details below). As a result the total number of surveys exceeded the number of survey zones.

A number of approaches have been used in recent years to determine either relative or absolute abundance of breeding birds in northern habitats. Among the most frequently used are distance sampling and plot-based double-sampling. Distance sampling, however, was inappropriate for our study because numerically, small shorebirds were the most important element of the avian community around Hooper Bay. One of the three primary assumptions of distance sampling is that objects are detected at their initial locations (Buckland et al. 1993). My observations over many years indicate that this assumption is routinely violated among small shorebirds, many of which move either toward or away from an observer prior to detection; distance estimates recorded after such movements result in biased estimates of density.

Plot-based sampling is central to the protocols for arctic PRISM (Program for Regional and International Shorebird Monitoring; Bart and Earnst 2002, Bart and Earnst 2005, Bart et al. 2005), but requires that a subset of plots (“intensive” plots) be visited repeatedly over the course of the season to ascertain "true" densities for comparison with plots visited only once ("rapid" plots). At Hooper Bay, however, scheduling and staffing precluded multiple visits to intensive plots. Therefore, I opted to evaluate the bird resources of the DOTPF airport alternatives with area searches *sensu* Andres et al. (1999). In area searches, field crew members walked zigzag paths across the plot of interest (e.g., proposed runways and RPZs), detouring when necessary to focus on specific potential nesting habitat such as wetland margins, thickets, and dune cut banks. For proposed runways and RPZs, crew members ensured that they approached to within 25 m of all points within the surveyed plots. Because of their large size, however, the borrow sites and auxiliary areas were too large for us to guarantee that we approached within 25 m of all points on a single visit. Therefore, we attempted to visit borrow areas on more than one occasion when possible for more thorough coverage, but we never assumed that we had met the coverage standard that we met for the runways and RPZs.

During area searches, observers recorded the date and time of each survey, as well as every bird species detected. In addition, we recorded one of 14 status codes for each species, to reflect its use of the surveyed area (see Appendix 1). For analysis, these 14 were collapsed into three increasingly restricted categories: 1) occurrence (i.e., all species detected on or over study plot, to include birds just flying by), 2) use (foraging or breeding on plot), or 3) breeding. We chose to include birds just flying over the survey area in our data collection specifically because we wanted to evaluate the potential impacts of airport runway development; even though some species may not have used the terrestrial or aquatic habitats in a survey area, their presence in flight has potential implications for airport site selection. During a single area search, if different individuals, or the same individuals at different times, were recorded exhibiting different behaviors during the course of the survey, that species was ultimately coded with the behavior that indicated the greatest level of site attachment to the area (i.e., occurrence < use < breeding). For example, if a Western Sandpiper was observed flying over the plot, and a second was found on a nest, the behavioral code for that species would be N (nest observed), and it would be tallied as a breeding species for that plot.

We also conducted nest searches in each of the surveyed areas, recording for each nest the species, the nest contents (number of eggs or young), the parental care status (adult on nest or not, and sex of incubating adult, when it could be determined), and GPS coordinates. Nest searches were conducted either during the course of area searches or separately by rope-dragging. In the latter approach, a 30-m rope was dragged just above the ground to flush nesting birds. So that the rope itself did not snag, disturb and/or destroy nesting habitat, 0.67 m long strips of heavy clear plastic were attached to 0.33 m rope streamers, which were in turn attached to the main ropes at 0.6 m intervals. Thus, the main rope could be kept above ground levels while the rope and plastic streamers were pulled smoothly across the ground. Previous work on the Yukon-Kuskokwim Delta and elsewhere (Smith et al. 2009) suggested that rope-dragging might not significantly enhance nest-searching efforts, but I specifically incorporated it into our 2009 field work in order to give our student employees (two ANSEP students and three high school interns) experience with another type of field protocol.

Although area searching and nest searching provided information about the presence and absence of bird species on surveyed plots, they did not yield density estimates *per se*. Because the amount of time spent on a plot varied as a function of several variables such as plot size (e.g., runways vs. RPZs), the number of wetlands, and nest density, simple comparisons of the raw data among airport alternatives could be misleading. We used regression analyses to determine if the time spent surveying affected the number of nests or number of species whose nests were found on a plot. Where appropriate, rates of nest discovery and species accumulation were used as comparative indices of density and richness, respectively.

The number of nests found can also vary seasonally, thus affecting the results of area and nest searches. Plots visited early in the season may be surveyed before most of the nesting species have arrived and/or initiated nesting; plots visited too late in the season may be surveyed after significant numbers of nests have hatched or been depredated. Under both scenarios, detections of individuals and, particularly, nests, may be much lower than the number that actually nested there. To look for such patterns, I conducted regression analyses to determine if plots surveyed early or late should be excluded from the comparisons among alternatives. For all statistical tests, $P < 0.05$ was considered significant; $0.05 < P < 0.10$ was considered marginally significant.

In addition to quantitative data collection, we kept track of all bird and mammal species seen during our field work by compiling a daily checklist. We maintained a camp journal where noteworthy observations of birds, mammals, weather, and seasonal phenology were recorded and transcribed each evening after our day's field work was completed. We also recorded detailed observations of focal species (including Red Phalaropes and threatened eiders) in the camp journal. This allowed all observations of the focal species to be considered, rather than just those made during the course of formal sampling. Red Phalaropes were a focal species because they were one of the species incurring the highest mortality as a result of the *Luckenbach* oil spill (Luckenbach Trustee Council 2006). Spectacled and Steller's eiders were focal species because they are threatened species; their presence in an area proposed for development might merit specific mitigation efforts. The common and scientific names of all bird species detected during our field work are listed in Appendix 2.

RESULTS AND DISCUSSION

Ecological Overview

Rodent Population High – Receding snow during May revealed local concentrations of microtine rodents, primarily Tundra Voles (*Microtus oeconomus*). They were particularly abundant in the village, the coastal sand dunes south of the airport, and along the south side of the road to the airport. For example, during a reconnaissance visit to Hooper Bay on 6 May, I hiked along the 2-km airport road from the village, across a few hundred m of dunes to the beach, and then across ~200 m of tundra just inland of the dunes. Without specifically looking for voles, I spotted 57 along the road, 13 in the dunes, and 10 on the upland tundra. On 22 May, two crew-members spotted 28 along the airport road. The concentration of rodents at Hooper Bay was apparently associated with a regional vole population high that was unprecedented relative to recent years (Fisher et al. 2009).

At Hooper Bay in 2009, however, these rodent concentrations were limited in space and time. Once snow-melt was completed, we saw very little evidence of rodents (e.g., fecal piles, winter nests, clippings, tunnels) away from those areas where we detected them early in the season in the first areas free of snow, and even in those areas, far fewer voles were seen. After the count of 28 on 22 May, voles were detected on all seven field days during the rest of the month, but never more than seven in a day, with an average of only 4.3/day. Detections were even less frequent in June, with voles recorded on only 10 of 16 field days, and an average of only 1.3/day. During our 32 area searches (see Survey Results, below), only eight voles (in four areas) and five winter nests (in three areas) were detected. During 13 field days in July and August, only two voles were detected.

This paucity of voles following the local spring concentrations was reflected by the relative scarcity of vole predators. Although both Snowy Owls (*Bubo scandiacus*) and Pomarine Jaegers (*Stercorarius pomarinus*) nested around Hooper Bay during a massive rodent population high in 1924 (Brandt 1943), we saw none in 2009. Most other rodent predators were seen only infrequently. We saw Least Weasels (*Mustela nivosa*) on only two days—one on 26 May and two on 3 June. Single Red Foxes (*Vulpes vulpes*) were seen on 3 June, 15 June, and 3 August; Arctic Foxes (*Alopex lagopus*) were not seen at all. Short-eared Owls were seen throughout May and June (six and eight days, respectively), suggesting that local nesting may have been attempted, but other than their presence during this period, we observed no evidence of breeding.

Spring phenology – The second noteworthy aspect of the 2009 spring was that it was a relatively late year in terms of temperature and snowmelt. May temperatures recorded at several stations along the coast of the Yukon-Kuskokwim Delta were a few degrees below average (Fisher et al. 2009). At Hooper Bay specifically, May temperatures were also below average, and consistent temperatures above freezing did not occur until 30 May, which is about three weeks later than average (Platte and Stehn 2009). Snow cover was < 20% in the Hooper Bay region by the last week of May. This was consistent with observations across the entire coastal Yukon-Kuskokwim Delta which indicated that snowmelt in spring 2009 was later than six of the other nine years this decade, (Platte and Stehn 2009). The slightly late spring resulted in waterfowl along the central coast of the Yukon-Kuskokwim Delta initiating nests a few days later than the long-term averages (Fisher et al. 2009).

Timing of nesting and its effect on surveying – In addition to its ecological implications, understanding spring phenology is important because of its effect on survey timing and effectiveness (Meltofte 2001, Nebel and McCaffery 2003). Our goal was to begin formal surveys once most species, particularly the shorebirds, had initiated nesting. By the time we arrived in Hooper Bay on 19 May, all of the common locally breeding shorebird and waterfowl species had already arrived; within a few days, most had dispersed into nesting habitat. Only a few species of migrant songbirds (e.g., Tree Swallow, Bank Swallow, and Eastern Yellow Wagtail) apparently arrived after we did. Based on the amount of snow cover, and thus the amount of snow-free habitat available for nesting, we assumed that starting surveys in late May would be appropriate, particularly in the upland habitats where snow melts and water drains earlier. Such timing was consistent with the typical timing of shorebird breeding elsewhere on the coastal Yukon Delta (e.g., Ruthrauff 2002, Nebel and McCaffery 2003, McCaffery et al. 2004, Johnson et al. 2005, McCaffery 2005, Johnson et al. 2009, Fisher et al. 2009,). Our earliest nest observations in 2009 corroborated this assessment. Some bird species began nesting late in the third week of May or shortly thereafter. The first nest discovered was a 1-egg Green-winged Teal clutch on 25 May. On 26 May, we found two Northern Pintail nests (5 and 6 eggs, respectively). On 28 May, we found nests of Green-winged Teal (9 eggs), Willow Ptarmigan (8 eggs), and Long-tailed Jaeger (1 egg). Because the onset of shorebird nesting usually coincides with initiation in these and related species, we expected our survey starting date of 27 May to be suitable.

Despite these efforts to initiate surveys so as to coincide with the onset of shorebird nesting, however, our earliest surveys were too early. Shorebirds did not begin nesting until the first week of June. Among the five most commonly nesting species, the first nests discovered for Western Sandpiper and Dunlin had incomplete clutches, which allowed us to estimate the initiation date by back-dating (assuming that the freshest egg in the clutch had been laid on the day of discovery, and that one day is required to produce each egg in the clutch). For example, a 2-egg clutch discovered on 2 June would have an estimated clutch initiation date of 1 June. For Black Turnstone, Semipalmated Sandpiper, and Red-necked Phalarope, however, the first nests found were already complete (i.e., 4-egg clutches). Theoretically, these nests could have been initiated well before they were discovered.

In many shorebird studies, the eggs from clutches of unknown age are floated to estimate their age (Liebezeit et al. 2007); in other studies, laying dates are estimated by back-dating (based on species-specific incubation periods) from known hatching dates. Our study, however, was the first year of a project specifically intended to reduce human disturbance to nesting birds. Therefore, we did not mark nests, float eggs, or re-check nests after discovery, which precluded empirically estimating the age of complete clutches.

Without these types of data, the probability that a newly-discovered shorebird clutch with four eggs has been only recently completed depends on the extent and effectiveness of prior nest-searching. Concerted efforts to find the earliest nesting shorebirds are generally successful, particularly for turnstones, *Calidri*s sandpipers, and phalaropes (B. J. McCaffery, unpubl. data). After the first few days of nest-searching conducted on a daily or near-daily basis, it is very unusual to find nests which were actually initiated earlier than the first nests found (see also Smith et al. 2009).

At Hooper Bay, we were searching in appropriate nesting habitat for one, two, and 17 days before finding nests of Black Turnstones, Semipalmated Sandpipers, and Red-necked Phalarope, respectively. In addition, 1) after the first turnstone nest was found, no others were found for another three days, after which time they were easy to find, and 2) Semipalmated Sandpiper nests (both incomplete and complete) were found easily on days after the first had been found. Given the intensity of our search effort, and the time frame over which subsequent nests were found, I assume that the earliest nests we found were at least among the very earliest initiated in the shorebird populations we were studying. Specifically for the purposes of dating clutch initiation, I assumed that when the first nest of a species was found with four eggs, the clutch had been completed on the day of discovery; I then back-dated accordingly to generate the earliest initiation date for that species.

Given those assumptions, 2009 was the latest year for shorebird nest initiation among those years for which there are records (Table 1). Initiation dates among the five most common species ranged from 2-6 days later than the previous latest date on record. For Semipalmated Sandpiper, we had only one other estimate of first clutch initiation date (Brandt 1943). For the other four species, we had between four and 13 additional years of data for comparison. The estimated first clutch initiation dates in 2009 were 12.5, 12, 12, and 16 days later than the previous mean initiation dates for Black Turnstone, Western Sandpiper, Dunlin, and Red-necked Phalarope, respectively.

The very late nesting of Red-necked Phalaropes may have been related to another unusual phenomenon. We consistently observed large flocks of Red-necked Phalaropes (including dozens to > 100 individuals) foraging in particular wetlands throughout the pre-laying interval. Typically, phalaropes arrive in smaller flocks, and birds then disperse onto wetlands as they become ice-free over the next week or so. Even when multiple individuals are using the same wetlands during the pre-laying period, they do not typically gather in large flocks. Instead, groups begin to break up as females fight over mates, and pairs quickly begin to separate themselves from congeners. At Hooper Bay in 2009, however, phalaropes were present when we arrived on 20 May, and the large flocks were present well into the third week of June. I've never previously seen such persistent (or large) flocks of pre-breeding phalaropes on the breeding grounds on either the North Slope or the Yukon-Kuskokwim Delta. Whatever precluded earlier nesting may also have delayed pairing and/or dispersal into breeding habitat. Whether this phenomenon is typical at Hooper Bay, or unique to the late nesting season in 2009, remains to be determined.

Given the time lag between the onset of our surveys and the onset of shorebird egg-laying, I tested whether the date of the survey affected nest-finding rates. Julian date significantly predicted the overall nest-finding rate (nests/hr), and was described by the quadratic equation: $\hat{y} = -7.7675 + 0.0964\ x_i - 0.0003\ x_i^2$ ($r^2 = 0.426$, $F = 10.74$, $P < 0.001$). In other words, nest-finding rate was very low both early and late in the four-week nest-searching season. Nest-finding rates (nests found/hour) were 0.2, 3.9, 4.7, and 1.9 in weeks one, two, three, and four, respectively. These rates were significantly different from one another (Kruskal-Wallis $\chi^2 = 12.69$, df = 3, $P = 0.005$). I therefore limited comparisons of nest-finding rates among airport alternatives to those surveys conducted during the second and third week of nest-searching (i.e., 3-16 June); by the fourth week of June, nests again became more difficult to find because increasing proportions had already hatched or been depredated.

Survey Results

Overview – Within the 12 survey zones, we conducted a total of 32 area searches between 27 May and 24 June. We completed six runway surveys and 13 RPZ surveys. For Alternative 1 (modification and expansion of existing runway complex), we did not survey the current airport or its RPZs, because our intent was to evaluate the potential impacts of new development. For Alternative 3, we did not complete the north RPZ on the crosswind runway, and for Alternative 4, we completed a nest search on the crosswind runway, but the area search data were not recorded. These data gaps were controlled for when comparing the various airport alternatives, by evaluating species richness and nests found per runway or RPZ surveyed. We also completed at least one area search in each of the four borrow areas (Dall Point – one, Alternative #4 uplands – one, South Airport Road – three, and Nuok Spit – two). At Dall Point, we were only able to survey the southern half of the proposed borrow area, and at Nuok Spit, we only surveyed the northwestern half of the proposed borrow area. Searches in these two areas were limited so as to avoid disturbing subsistence users who were in those areas on the days of our surveys. Finally, among the auxiliary area, we conducted three surveys of the Napareayak Slough wetlands, and one survey each in the North Airport, Northwest Estuary, and Hardened Trail areas.

We detected 81 species during our field work at Hooper Bay in 2009 (Appendix 2). Of these, a total of 41 species were detected in the four airport relocation alternatives (Appendix 3), 44 species were detected in the four proposed borrow sites (Appendix 4), and 36 species were detected in the four auxiliary areas (Appendix 5). We discovered 198 nests of 18 species (Table 2).

Because our nest-searching was not targeting particular species, and because we were simply trying to cover areas as thoroughly as possible, the number of nests of each species may serve as a rough index of relative abundance. Shorebird nests numerically dominated the total. In fact, five species of shorebirds (Black Turnstone, Semipalmated Sandpiper, Western Sandpiper, Dunlin, and Red-necked Phalarope) accounted for just over 75% of all nests found (Table 2). The only other species with $\geq$ 10 nests was the Lapland Longspur.

Some nests, however, are more cryptic than others. As a result, the nests of some species are simply more difficult to find than others, so even nest-searching efforts that do not target particular species may still not detect nests in proportion to their actual occurrence in the habitat. Therefore, the number of nests detected per species is not a sufficient index of relative abundance. A supplementary metric, one that incorporates some measure of relative abundance as well as local spatial distribution, is the frequency of species occurrence within the 12 survey zones. Species found in more of the zones may be more abundant and/or more broadly distributed in the Hooper Bay region. Fifty-two species were detected in at least one of the 12 survey zones (Table3). Only a single species was detected in all 12 zones, the Lapland Longspur. Eight other species were detected in at least 10 zones, including Green-winged Teal, five species of shorebirds, Arctic Tern, and Long-tailed Jaeger. We detected evidence for possible breeding within survey zones in 35 species (Table 4). Only four species were classified as breeding in $\geq$ 10 zones, including the Semipalmated Sandpiper, Dunlin, Red-necked Phalarope, and Lapland Longspur. Even these metrics of relative abundance, however, have their limitations. Comparisons are probably most robust within taxa that have relatively similar nesting habitats, nest types, and/or behavior around nests (i.e., comparing frequency of occurrence among ducks, among shorebirds, or among songbirds, rather than across taxa).

Survey duration – Because the amount of time spent surveying varied among plots, it was important to determine if this affected either the total number of nests found or the number of species found nesting. Among all areas surveyed, the number of minutes spent surveying did predict both the total number of nests (F = 7.819, adj. r^2 = 0.264, P = 0.012) and the number of species whose nests were found (F = 11.36, adj. r^2 = 0.353, P = 0.003). For the proposed borrow sites and auxiliary area, the relationships were significant (total nests: F = 5.860, adj. r^2 = 0.288, P = 0.034; species nesting: F = 6.49, adj. r^2 = 0.314, P = 0.027). Where searches covered the entire survey plot on a single day (e.g., the runway and RPZ alternatives), these relationships were marginally significant (total nests: F = 5.707, adj. r^2 = 0.440, P = 0.062; species nesting: F = 4.908, adj. r^2 = 0.394, P = 0.078).

Time spent surveying affected, not only nest numbers, but also measures of species richness on the proposed borrow pits and additional wetlands. Total species (F = 59.12, adj. r^2 = 0.829, P < 0.001), foraging or breeding species (F = 17.09, adj. r^2 = 0.573, P = 0.02), and breeding species only (F = 15.58, adj. r^2 = 0.549, P = 0.002) were all predicted by the amount of time spent surveying. Because of these relationships between survey time and survey results, raw data were converted to rates to facilitate comparisons among surveyed areas.

Airport Relocation Alternatives – The number of species detected (i.e., species richness) varied among ARAs (Table 5). Total species detected, as well as species either foraging or breeding, on the surveyed areas were similar among alternatives 2, 3, and 4; ARA 4 was the highest in each case, and ARA 1 was markedly lower than the other three in each case. There was more variation when considering only species for which we detected breeding evidence, but again, ARA 1 was the lowest.

As noted previously, however, we did not always survey the same number of runways or RPZs for each alternative (see also Table 5). This could bias the species richness values. For example, Alternative 4 might have had the lowest values for species richness simply because we only surveyed one runway and two RPZs for Alternative 4, versus the maximum of two runways and four RPZs for Alternative 2. To control for this variation in sampling, I calculated mean species richness for the runways and RPZs surveyed in each alternative (Table 6). By controlling for effort in this way, Alternative 2 ranked out the highest for species richness, while Alternative 1 remained the lowest.

We also evaluated nest-finding rates among the ARAs. First, we considered whether or not rope-dragging significantly enhanced nest-finding success by comparing runways searched by rope-dragging with those searched without rope-dragging. All six runway surveys were conducted during the same nine-day period (3-11 June), which was within the two-week period when we detected relatively high and consistent numbers of nests (see above). On three proposed runways with rope-dragging, nine nests were discovered, four of which were detected when the rope flushed the incubating bird. On the three runways surveyed without rope-dragging, 11 nests were discovered. Because there was no obvious effect of rope-dragging, we included all areas nest-searched in our analysis, regardless of whether or not rope-dragging was conducted.

Alternative 3 had the highest nest finding rate (4.77 nests/hr), nearly 50% higher than Alternative 2, the alternative with the next highest value (3.21 nests/hr). Alternative 1 ranked third (3.06 nests/hr), while Alternative 4 was the lowest (2.95 nests/hr).

Borrow Sites and Auxiliary Areas – Among the four proposed borrow sites, Dall Point ranked first in two of three measures of species richness, in total nests, and in nesting species richness; it ranked second in total species richness, just one behind the wetlands portion of the South Airport Road (SAR) borrow site (Table 7). The proposed borrow site in the uplands north of ARA 4 ranked lowest in all five measures. This was at least in part due to the early date on which it was surveyed (28 May). The first search of the SAR site on 30 May yielded a similar paucity of nests, although the SAR site had conspicuously higher measures for total species richness and richness of foraging or breeding species even on that early date. These data, plus my own experience elsewhere on the Delta comparing similar habitats, suggest that the upland borrow site did support fewer species overall than the other proposed sites. Considering only surveys conducted during June (i.e., Julian dates 164-174), the SAR dunes ranked lowest in every category.

Among surveys conducted during June in proposed borrow sites, Dall Point also ranked highest in all four categories based on the *rate* of species detection, while the two Nuok Spit surveys tied for the highest rate of nest detection (Table 8). A consideration of all of the data from the proposed borrow sites indicates that they should be ranked in the following order in terms of their value for birds during the breeding season (from most to least valuable): Dall Point, Nuok Spit, South Airport Road, ARA 4 Uplands.

The auxiliary areas (three wetland basins plus the hardened trail corridor) were more difficult to rank. The first survey in the Napareayak Slough watershed was conducted on 29 May, too early to document most of the nesting activity there. All other surveys in these areas, however, were conducted within a one-week period between 18 and 24 June. Among these five later surveys, the North Airport wetlands or the Northwest Estuary wetlands ranked either first or second eight out of ten times across the five comparisons of species richness and nest numbers (Table 9). When *rates* of nest and new species detections were calculated, however, the 20 June Napareayak Slough survey and the hardened trail corridor ranked first or second all ten times across the five comparisons (Table 10).

Despite the difficulties in assigning ranks to these surveyed areas, they do serve to highlight the importance of the Dall Point area. When the borrow site data are considered along with the data from the auxiliary survey areas, Dall Point still stands out. In fact, Dall Point had the highest or second-highest score in eight of ten categories (Tables 7-10). In addition, nine of the 23 waterfowl nests that we discovered were within the Dall Point borrow site, and four more were in the adjacent uplands. Finally, among the combined data sets, the two Nuok Spit surveys still had the highest overall rate of nest finding.

Additional considerations – Several factors should be kept in mind when evaluating the data presented here. First, comparisons among all 12 survey zones may not be straightforward because the areas are not completely independent. Three of the survey zones (ARAs 1-3) are all in the same general area and ARAs 1 and 2 in particular include a roughly comparable range of habitats (ARA 3 shares both dune and wetland habitat with the other two, but it extends farther into the very low, tidally-influenced graminoid meadows near Hooper Bay). Each of the five newly proposed runways in these three RPZs (i.e., not including the existing runway) intersects at least one other proposed runway, and the westernmost RPZs in all three alternatives virtually overlap. In addition, two proposed runways skirt the western and northern edge, respectively of the South Airport Road borrow site. Despite this degree of overlap, however, some conspicuous differences did emerge among these closely situated survey zones. If warranted, however, additional analyses could be conducted that could compare this area of overlapping survey zones with the other eight survey zones.

A second factor limiting the strength of inference possible from the data is that each of the runways and RPZs surveyed was only surveyed once. Surveys could potentially differ significantly from day to day (e.g., because of weather, previous disturbance, etc.) or over the course of the season. For example, species just flying by or foraging on one day may actually settle and exhibit breeding behaviors on a subsequent day. Ideally, one might conduct replicates over several consecutive days or at various times over the course of the season. Logistical constraints precluded such an effort in 2009. Although a few of the borrow sites and auxiliary areas were surveyed on multiple days, temporal variation among counts was confounded by variation in the specific areas searched within those areas on the different days (with the exception of the first survey on the South Airport Road borrow site [Tables 7-8], which was clearly surveyed too early in the year for finding nests). Thus, the data we collected do not shed light on the potential limitations of one-time surveys.

The nest-finding and new species accumulation rates used for comparing the various ARAs are relatively crude surrogates for more quantitative estimates of nest density and species richness. The latter metric particularly is potentially quite problematic if the rate at which new species are detected (i.e., total species detected/time spent surveying) asymptotes at a survey duration shorter than the time spent surveying in some areas. For example, if a crew could detect all the species that might occur on a plot in two hours, but they spent a total of four hours on the plot, the new species rate generated by their effort would be biased low. An examination of our data detected no such asymptote, however, and the numbers of species detected continued to show a linear increase across the entire range of survey durations.

It is important to note that any index of nest abundance (including the nest-finding rate used in this study) is just a surrogate for the true metric of interest, productivity. Ideally, one would want to estimate how many young were actually produced (i.e., fledged and departed the breeding area) in a given patch of habitat in order to evaluate its true value for the bird populations of interest. Number of nests is just an interim metric, because the number of young produced also depends on hatching and fledging success. For a single year study, however, that interim metric may actually be preferable, because hatching and fledging success probably show more annual variation than the number of nests. Thus, to provide a quick snapshot regarding the relative value of an area for nesting birds, a metric of nest abundance may be suitable.

Finally, a comment on breeding status is appropriate. As noted previously, species were classified as “Breeding” if they were recorded with any of the status codes from A through Y in Appendix 1. Such a decision rule yields a very liberal definition of breeding, with the minimum threshold being simply the presence of the species in suitable nesting habitat at the right time of year. Progressively more stringent definitions (i.e., using increasingly small subsets of the status codes) could be applied to cover a spectrum of breeding probabilities ranging from "possible" through "probable" to "confirmed." In this report, for example, the latter case is represented by those species listed in Appendices 3-5 with an "N" (i.e., nest found) designation. For the purposes of this study, however, we wanted as inclusive a list of "breeders" as possible to reflect the potential of the various surveyed areas.

Red Phalarope observations

Red Phalaropes were among the rarest shorebirds detected during our field work near Hooper Bay in 2009. Among 12 shorebird species expected to be breeding in the Hooper Bay area, only the Ruddy Turnstone was detected on fewer dates. Red Phalaropes were noted in only four of the 12 survey zones. Similarly, among 11 species of shorebirds detected during our 32 area searches, Red Phalaropes were detected on the fewest (Table 11). Overall, we made only 14 observations of Red Phalaropes, with no more than five birds seen in any one observation (Appendix 6). Although the presence of a few pairs suggested that breeding may have occurred, no nests were found despite our targeted efforts to search wetlands in which pairs were detected, and no broods, fledged juveniles, or post-breeding adults were detected during our field work in late July and early August.

Threatened eider observations

Spectacled Eiders were detected on four dates during our field work. Observations on two of the four days were over the Bering Sea. On 23 May, six pairs (three separate pairs, plus a flock of three pairs) were seen flying down the coast near the south edge of Nuok Spit. On 13 June, a pair and a single female flew south down the coast and then landed in the waters within a few hundred meters of shore at Dall Point.

Two Spectacled Eiders were seen away from the ocean. The first was a single male observed in the wetlands south of the airport road on 15 June. He was observed in a wetland near the southeast end of the Alternative #3 primary runway. Because no female accompanied him, and because of the late date (i.e., after the nest initiation period for the species in the coastal Yukon-Kuskokwim Delta), I suspect that this male was probably just passing through the vicinity of Hooper Bay while dispersing from a breeding area beyond our study area en route to the marine habitats used by males before and during their post-breeding wing molt. The second was a lone bird (sex not recorded on data form) flying over the South Airport Road borrow site on 22 June.

No Steller's Eiders were observed during our field work. Based on the absence of observations of this species, and the paucity of observations of Spectacled Eiders (as well as the behavior and timing of the only two eiders actually seen in or over our surveyed areas), it does not appear that either species of threatened eider is currently breeding on Sea Lion Corporation lands within our 2009 study area in the immediate vicinity of Hooper Bay.

CONCLUSIONS

The data presented here provide some insight and perspective for evaluating the potential impacts of the various Hooper Bay airport relocation alternatives developed by the Alaska DOTPF. Despite the limitations of the data set, the results should inform discussions and deliberations by the involved stake-holders. In particular, the proposed Dall Point borrow site was an area of conspicuously rich bird habitat, and the northern portion of the proposed Nuok Spit borrow site supported very high densities of nesting shorebirds. This study was limited, however, to an evaluation of potential impacts to the bird resources in our study area. Additional factors must certainly be considered in coming to a decision about future Hooper Bay airport development. Birds are not the only subsistence resources in the vicinity of the village. Berries, fishes, and greens are all harvested locally, and areas not necessarily preferred by nesting birds may be important harvest areas for these other resources. Very practical considerations such as costs, construction logistics, and maintenance feasibility will all have to be evaluated as well.

Finally, in the face of ongoing climate change and habitat alterations on the outer coast of the central Yukon-Kuskokwim Delta, runway, road, and (particularly) borrow site developments should be considered in light of their potential impact on erosion, sedimentation, and hydrology. Needless to say, such impacts go well beyond their effects on Hooper Bay's bird resources. The potential for significant disturbance to the protective line of dunes and/or the insulating tundra layer overlying local beds of permafrost, respectively, should be very carefully and professionally evaluated prior to airport development. This will ensure that whatever alternative is selected will minimize the impacts to the broad range of subsistence resources in terrestrial, fresh-water, intertidal, and marine habitats of the Hooper Bay area. Without such considerations, development could easily lead to damaging levels of either coastal or thermokarst (i.e., permafrost) erosion, along with associated changes to the area's natural tidal patterns and hydrology.

ACKNOWLEDGMENTS

I would like to thank William Naneng of Sea Lion Corporation for inviting USFWS to partner with SLC on this project. Without his enthusiastic support, encouragement, and guidance, the 2009 field effort would never have come to fruition. Through a Challenge Cost Share grant with USFWS, Sea Lion Corporation also provided funding for field crew housing in Hooper Bay and student intern salaries. I thank Hooper Bay School site administrator Scott Ballard, HBS staff members Gene Armstrong, Chuck Matoush and Grant Funk, and Robert Sundown (USFWS) for their assistance and guidance in selecting and preparing the local high school interns, and I thank the interns themselves (Tom Ballard, Walter Naneng, and Minnie Simon) for their contribution to the project. The hospitality of Chuck Matoush, as well as of Gene and Nemy Armstrong, was very much appreciated during my visits to Hooper Bay, and I am particularly grateful to the Armstrong's for making their home available to my crew during the entire field season. Carolyn Marn and Janet Whitlock (USFWS) were both helpful and patient as we developed budgets and began implementation of the *Luckenbach* project at Hooper Bay. Finally, I wish to acknowledge the contribution of my two field assistants, University of Alaska—Fairbanks ANSEP students Eddie Corp and Derek Evon. Their keen interest in and knowledge of the natural world, their conscientious work ethic, and their good-natured, consistently positive approach to field work under occasionally difficult conditions were invaluable and contributed significantly to the success of this project.

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LIST OF FIGURES

Fig. 1. Hooper Bay and surrounding area. “A” marks denote 250 m grid points used for reference during 2009 field season.

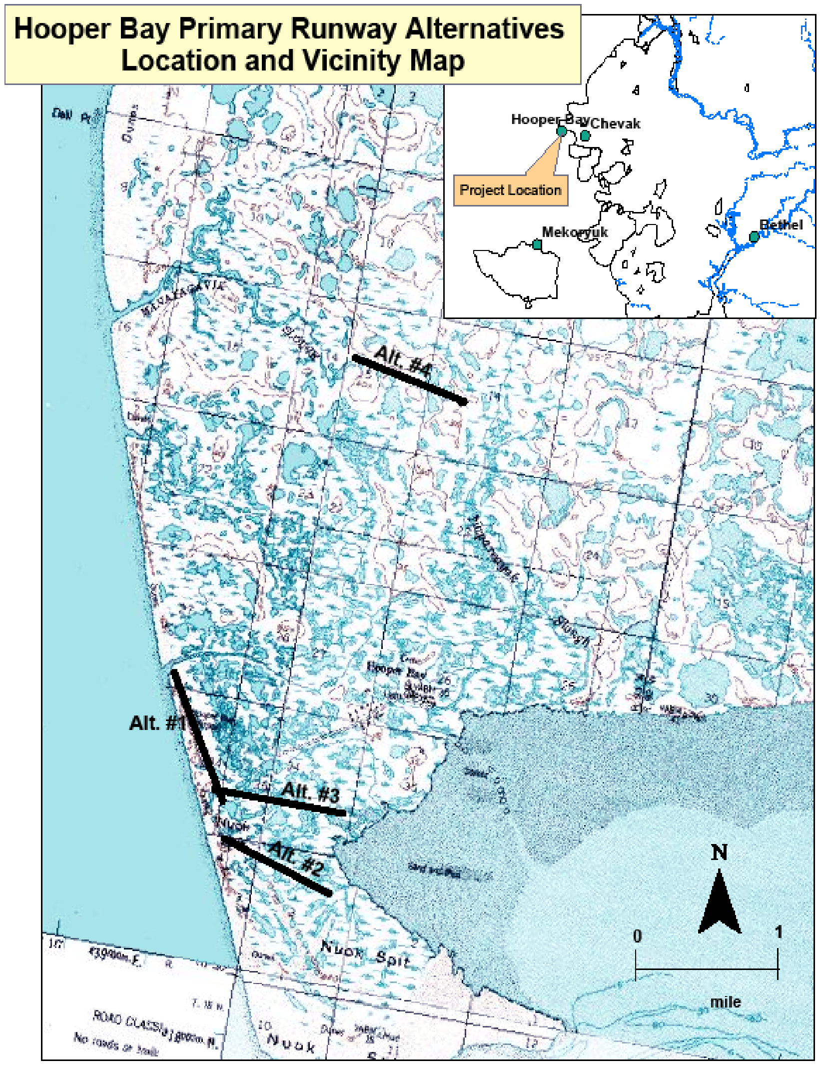

Fig. 2. U.S.G.S. topographic map of Hooper Bay region, with 4 primary runway alternatives depicted (proposed cross-runway locations not shown). Image prepared by Alaska Department of Transportation and Public Facilities, and provided as a link in public scoping letter of 30 December 2008 describing airport improvement options.

Fig 3. Airport Relocation Alternative 1 (with South Airport Road and Nuok Spit borrow sites shown). Image prepared by Alaska Department of Transportation and Public Facilities, and provided as a link in scoping letter of 30 December 2008 describing airport improvement options.

Fig 4. Airport Relocation Alternative 2 (with South Airport Road and Nuok Spit borrow sites shown). Image prepared by Alaska Department of Transportation and Public Facilities, and provided as a link in scoping letter of 30 December 2008 describing airport improvement options.

Fig 5. Airport Relocation Alternative 3 (with South Airport Road and Nuok Spit borrow sites shown). Image prepared by Alaska Department of Transportation and Public Facilities, and provided as a link in scoping letter of 30 December 2008 describing airport improvement options.

Fig 6. Airport Relocation Alternative 4 (with Dall Point, ARA 4 Upland, South Airport Road and Nuok Spit borrow sites shown). Image prepared by Alaska Department of Transportation and Public Facilities, and provided as a link in letter of 30 December 2008 describing airport improvement options. Borrow pit designations added.

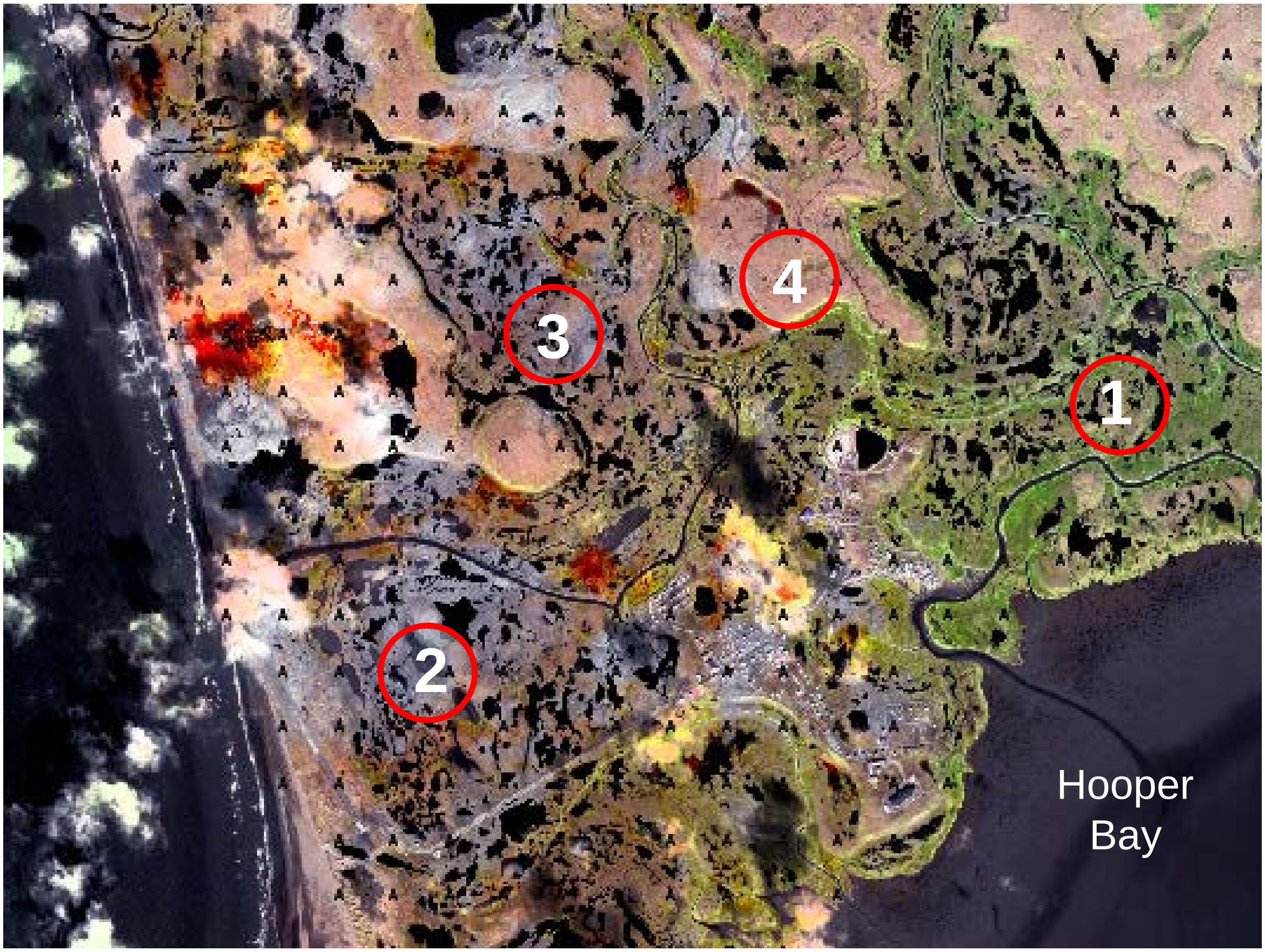

Fig. 7. Auxiliary survey areas, including 1) Napareayak Slough wetlands, 2) North Airport wetlands (wetlands due north of the village-airport road), 3) Northwest Estuary (wetlands northwest of estuary north-northwest of the village), and 4) Hardened Trail (corridor 25 m wide on either side of hardened ATV trail from the wind turbines to the trail's northern terminus).

LIST OF TABLES

Table 1. Estimated first clutch initiation dates for five shorebird species on outer central Yukon-Kuskokwim Delta.

	Species[1]	BLTU	WESA	SESA	DUNL	RNPH
Year	Location					
1924	Hooper Bay[2]	26 May	23 May	2 June	25 May	25 May
1966	Kolomak River[3]		27-28 May		29 May	
1967	Kolomak River[3]		19-20 May		21 May	
1968	Kolomak River[3]		19-20 May		21 May	
1978	Tutakoke River[4]	15 May				
1979	Tutakoke River[4]	19 May				
1980	Tutakoke River[4]	3 June				
1998	Kanaryarmiut Field Station[5]		21 May			26 May
1999	Kanaryarmiut Field Station[5]		19 May			26 May
2000	Kanaryarmiut Field Station[5]		21 May			27 May
2001	Kanaryarmiut Field Station[5]		25 May			4 June
2002	Kanaryarmiut Field Station[5]		18 May			26 May
2003	Kanaryarmiut Field Station[5]		10 May			22 May
2004	Kanaryarmiut Field Station[5]		12 May		13 May	19 May
2005	Kanaryarmiut Field Station[5]		15 May		18 May	21 May
2006	Kanaryarmiut Field Station[5]		30 May		29 May	26 May
2004	Old Chevak Field Station[6]					15 May
2005	Old Chevak Field Station[6]					30 May
2008	Old Chevak Field Station[6]					23 May
2009	Hooper Bay[7]	5 June[8]	1 June	5 June[8]	2 June	10 June[8]

1. BLTU = Black Turnstone, WESA = Western Sandpiper, SESA = Semipalmated Sandpiper, DUNL = Dunlin, RNPH = Red-necked Phalarope.
2. Brandt 1943
3. Holmes 1971, 1972
4. Handel and Gill 2000, Handel and Gill 2001
5. Ruthrauff 2002, Johnson 2006, Jamieson 2009, B. J. McCaffery (unpubl. data)
6. B. J. McCaffery, unpublished data.
7. This study.
8. First clutch found was complete.

Table 2. Nests located during study at Hooper Bay, 2009.

Species	**Nests Located**
Greater White-fronted Goose	6
Emperor Goose	1
Northern Shoveler	2
Northern Pintail	5
Green-winged Teal	7
Greater Scaup	2
Semipalmated Plover	1
Black Turnstone	11
Semipalmated Sandpiper	32
Western Sandpiper	52
Dunlin	35
Calidris sandpiper, sp.?	1
Wilson's Snipe	1
Red-necked Phalarope	20
Arctic Tern	4
Long-tailed Jaeger	1
Savannah Sparrow	2
Lapland Longspur	10
Hoary Redpoll	1
redpoll, sp.?	3
passerine, sp.?	1
Total = 18 species	**198 nests**

Table 3. Number of 12 survey zones in which each species was detected.

Species	Zones	Species	Zones
Greater White-fronted Goose	7	Dunlin	11
Emperor Goose	8	Long-billed Dowitcher	10
Brant	7	Wilson's Snipe	7
Cackling Goose	4	Red-necked Phalarope	11
Tundra Swan	8	Red Phalarope	4
Gadwall	1	Sabine's Gull	3
American Wigeon	3	Mew Gull	4
Mallard	6	Glaucous Gull	4
Northern Shoveler	5	Aleutian Tern	8
Northern Pintail	8	Arctic Tern	10
Green-winged Teal	11	Parasitic Jaeger	8
Canvasback	1	Long-tailed Jaeger	10
Greater Scaup	8	Short-eared Owl	2
Spectacled Eider	1	Common Raven	2
King Eider	1	Tree Swallow	1
Black Scoter	3	Bank Swallow	4
Long-tailed Duck	6	Eastern Yellow Wagtail	8
Willow Ptarmigan	4	Wilson's Warbler	1
Red-throated Loon	2	American Tree Sparrow	1
Pacific Loon	7	Savannah Sparrow	9
Sandhill Crane	1	Fox Sparrow	1
Black-bellied Plover	5	Golden-crowned Sparrow	1
Semipalmated Plover	3	Lapland Longspur	12
Bar-tailed Godwit	4	Common Redpoll	1
Black Turnstone	9	Hoary Redpoll	3
Semipalmated Sandpiper	11	redpoll, sp.?	3
Western Sandpiper	10	total redpolls	6

Table 4. Number of 12 survey zones in which breeding evidence for each species was detected.

Species	Zones	Species	Zones
Greater White-fronted Goose	2	Wilson's Snipe	7
Emperor Goose	2	Red-necked Phalarope	10
Tundra Swan	2	Red Phalarope	3
Mallard	3	Mew Gull	1
Northern Shoveler	2	Aleutian Tern	2
Northern Pintail	7	Arctic Tern	5
Green-winged Teal	8	Parasitic Jaeger	2
Greater Scaup	3	Long-tailed Jaeger	3
Long-tailed Duck	3	Bank Swallow	1
Willow Ptarmigan	4	Eastern Yellow Wagtail	6
Pacific Loon	3	Wilson's Warbler	1
Black-bellied Plover	5	American Tree Sparrow	1
Semipalmated Plover	2	Savannah Sparrow	7
Bar-tailed Godwit	2	Lapland Longspur	11
Black Turnstone	8	Common Redpoll	1
Semipalmated Sandpiper	10	Hoary Redpoll	3
Western Sandpiper	9	redpoll, sp.?	2
Dunlin	11	total redpolls	5
Long-billed Dowitcher	5		

Table 5. Summary statistics comparing species richness among four Airport Relocation Alternatives (ARAs).

	ARA 1	ARA 2	ARA 3	ARA 4
Runways Surveyed[1]	1	2	2	1
RPZs[2] Surveyed[3]	2	4	3	4
Species occurring[4] – combined[5]	19	29	28	31
Species occurring – runways	7	20	18	16
Species occurring– RPZs	18	21	21	27
Species using[6] – combined	17	22	22	23
Species using – runways	7	15	17	12
Species using – RPZs	15	15	15	15
Species breeding[7] – combined	14	22	20	17
Species breeding – runways	7	15	16	11
Species breeding – RPZs	12	15	13	11

1. Maximum of two possible per ARA (except for Alternative 1; see text).
2. RPZ = Runway Protection Zone.
3. Maximum of four possible per ARA (except for Alternative 1; see text).
4. Includes all species detected on or flying over plot during survey period.
5. Includes all species detected on runway(s) or RPZs for given alternative.
6. Includes species detected foraging or with evidence for on-site breeding.
7. Includes only species with some evidence for on-site breeding (see Appendix 1).

Table 6. Comparison of mean species richness among four Airport Relocation Alternatives (ARAs).

	ARA 1	ARA 2	ARA 3	ARA 4
Mean Total Species[1]/Runway	7.0	13.5	13.5	16.0
Mean Total Species/RPZ[2]	12.0	12.5	10.7	11.0
Mean Foraging or Breeding Species/Runway	7.0	11.0	11.5	13.0
Mean Foraging or Breeding Species/RPZ	9.0	8.3	7.7	6.8
Mean Breeding Species/Runway	7.0	11.0	11.0	11.0
Mean Breeding Species/RPZ	7.5	7.8	7.0	4.8
Score[3]	7	14	9	10

1. Total species include all species detected on or flying over plot during survey period.
2. RPZ = Runway Protection Zone.
3. Score calculated by assigning ranks of 1-4 to each ARA in each category, with ranks of 1, 2, 3, and 4 earning scores of 3, 2, 1, and 0, respectively; scores then summed among categories within each ARA to generate species richness score for each alternative.

Table 7. Summary statistics for species richness and nest numbers among four proposed borrow pit areas.

	ARA 4[1]	DP[2]	NS NW[3]	NS SE[4]	SAR N[5]	SAR Wetl.[6]	SAR Dune[7]
Julian Date	148	164	166	167	150	173	174
Total Species	7	28	14	13	16	29	12
Foraging or Breeding	4	24	11	7	8	11	6
Breeding Only	3	22	11	7	3	5	4
Total Nests	1	30	28	22	0	26	4
Species Nesting	1	10	5	6	0	6	3

1. Airport Relocation Alternative 4 Uplands
2. Dall Point (southern half only)
3. Nuok Spit Northwest (northwest portion of northwestern half)
4. Nuok Spit Southeast (southeast portion of northwestern half)
5. South Airport Road (northern portion)
6. South Airport Road (wetlands only)
7. South Airport Road (dunes only)

Table 8. Comparison of rates of new species and nest detections among four proposed borrow pit areas.

	ARA 4[1]	DP[2]	NS NW[3]	NS SE[4]	SAR N[5]	SAR Wetl.[6]	SAR Dune[7]
Julian Date	148	164	166	167	150	173	174
New Spp./hr	5.6	5.1	3.3	3.9	6.4	4.8	3.9
New Foraging or Breed. Spp./hr.	3.2	4.4	2.6	2.1	3.2	1.8	2
New Breeding Spp. Only/hr.	2.4	4	2.6	2.1	1.2	0.8	1.3
Nests/hr.	0.8	5.5	6.6	6.6	0.0	4.3	1.3
Nesting Spp./ hr.	0.8	1.8	1.2	1.8	0.0	1.0	1.0

1. Airport Relocation Alternative 4 Uplands
2. Dall Point (southern half only)
3. Nuok Spit Northwest (northwest portion of northwestern half)
4. Nuok Spit Southeast (southeast portion of northwestern half)
5. South Airport Road (northern portion)
6. South Airport Road (wetlands only)
7. South Airport Road (dunes only)

Table 9. Summary statistics for species richness and nest numbers among four auxiliary areas.

	NS[1]	NS[1]	NS[1]	NA[2]	NWE[3]	HT[4]
Julian Date	149	171	175	169	170	173
Total Species	18	15	13	25	29	8
Foraging or Breeding	11	9	9	18	24	8
Breeding Only	1	6	3	12	16	4
Total Nests	0	7	1	9	5	8
Species Nesting	0	4	1	4	3	3

1. Napareayak Slough
2. North Airport wetland (wetlands due north of the village-airport road)
3. Northwest Estuary (wetlands northwest of estuary north-northwest of the village)
4. Hardened Trail (corridor 25 m wide on either side of hardened ATV trail)

Table 10. Comparison of rates of new species and nest detections among four auxiliary areas.

	NS[1]	NS[1]	NS[1]	NA[2]	NWE[3]	HT[4]
Julian Date	149	171	175	169	170	173
New Spp./hr	6.8	7.1	5.3	4.6	4.9	5.5
New Foraging or Breed. Spp./hr.	4.1	4.3	3.7	3.3	4.1	5.5
New Breeding Spp. Only/hr.	0.4	2.9	1.2	2.2	2.7	2.8
Nests/hr.	0	3.3	0.4	1.7	0.9	5.5
Nesting Spp./ hr.	0	1.9	0.4	0.7	0.5	2.1

1. Napareayak Slough
2. North Airport wetland (wetlands due north of the village-airport road)
3. Northwest Estuary (wetlands northwest of estuary north-northwest of the village)
4. Hardened Trail (corridor 25 m wide on either side of hardened ATV trail)

Table 11. Days and area searches on which shorebirds were detected at Hooper Bay, Alaska, spring, 2009.

Species	Dates Detected 19 May – 23 June	Area Searches on which Detected
Black-bellied Plover	25	10
Semipalmated Plover	23	3
Bar-tailed Godwit	18	4
Ruddy Turnstone	2	0
Black Turnstone	29	15
Semipalmated Sandpiper	28	26
Western Sandpiper	28	25
Dunlin	29	27
Long-billed Dowitcher	28	13
Wilson's Snipe	17	10
Red-necked Phalarope	29	28
Red Phalarope	7	5

LIST OF APPENDICES

Appendix 1. Behavioral status codes for species detected during area searches. For analytical purposes, all codes counted as occurrence (**O**), FO (foraging) plus codes A – Y counted as use (**U**), and codes A – Y counted as evidence for breeding (**B**).

X -- Detected, no evidence of breeding
FB -- Fly-by (flew over study plot, but did not land; for exception, see FO)
M -- Apparent migratory over-flight (northbound flights by flocked birds in spring)
FO -- Foraging (includes jaegers and terns obviously searching for prey from the air)
A -- Alarm call
B -- Building nest
C -- Courtship display
D -- Distraction display
F -- Adult with fecal sac or food in bill
H -- Observed in possible nesting habitat
N -- Nest observed
P -- Pair observed in suitable habitat
S -- Singing male
Y -- Downy or newly-fledged young

Appendix 2. Common and scientific names of bird species detected at Hooper Bay, 2009.

Greater White-fronted Goose *Anser albifrons*
Emperor Goose *Chen canagica*
Brant *Branta bernicla*
Cackling Goose *Branta hutchinsii*
Tundra Swan *Cygnus columbianus*
Gadwall *Anas strepera*
American Wigeon *Anas americana*
Mallard *Anas platyrhyncos*
Northern Shoveler *Anas clypeata*
Northern Pintail *Anas acuta*
Green-winged Teal *Anas crecca*
Canvasback *Aythya valisineria*
Redhead *Aythya americana*
Greater Scaup *Aythya marila*
Spectacled Eider *Somateria fischeri*
King Eider *Somateria spectabilis*
Common Eider *Somateria mollissima*
Harlequin Duck *Histrionicus histrionicus*
Surf Scoter *Melanitta perspicillata*
White-winged Scoter *Melanitta fusca*
Black Scoter *Melanitta nigra*
Long-tailed Duck *Clangula hyemalis*
Red-breasted Merganser *Mergus serrator*
Willow Ptarmigan *Lagopus lagopus*
Red-throated Loon *Gavia stellata*
Pacific Loon *Gavia pacifica*
Common Loon *Gavia immer*
Yellow-billed Loon *Gavia adamsii*
Horned Grebe *Podiceps auritus*
Pelagic Cormorant *Phalacrocorax pelagicus*
Merlin *Falco columbarius*
Peregrine Falcon *Falco peregrinus*
Sandhill Crane *Grus canadensis*
Black-bellied Plover *Pluvialis squatarola*
Pacific Golden-Plover *Pluvialis fulva*
Semipalmated Plover *Charadrius semipalmatus*
Spotted Sandpiper *Actitis macularius*
Whimbrel *Numenius phaeopus*
Bristle-thighed Curlew *Numenius tahitiensis*
Hudsonian Godwit *Limosa haemastica*
Bar-tailed Godwit *Limosa lapponica*
Ruddy Turnstone *Arenaria interpres*
Black Turnstone *Arenaria melanocephala*
Red Knot *Calidris canutus*
Semipalmated Sandpiper *Calidris pusilla*
Western Sandpiper *Calidris mauri*
Least Sandpiper *Calidris minutilla*
Pectoral Sandpiper *Calidris melanotos*
Dunlin *Calidris alpina*
Long-billed Dowitcher *Limnodromus scolopaceus*
Wilson's Snipe *Gallinago delicata*
Red-necked Phalarope *Phalaropus lobatus*
Red Phalarope *Phalaropus fulicarius*
Black-legged Kittiwake *Rissa tridactyla*
Sabine's Gull *Xema sabini*
Mew Gull *Larus canus*
Herring Gull *Larus argentatus*
Slaty-backed Gull *Larus schistisagus*
Glaucous-winged Gull *Larus glaucescens*
Glaucous Gull *Larus hyperboreus*
Aleutian Tern *Onychoprion aleuticus*
Arctic Tern *Sterna paradisaea*
Parasitic Jaeger *Stercorarius parasiticus*
Long-tailed Jaeger *Stercorarius longicaudus*
Short-eared Owl *Asio flammeus*
Common Raven *Corvus corax*
Tree Swallow *Tachycineta bicolor*
Bank Swallow *Riparia riparia*
Gray-cheeked Thrush *Catharus minimus*
Varied Thrush *Ixoreus naevius*
Eastern Yellow Wagtail *Motacilla tschutschensis*
American Pipit *Anthus rubescens*
Wilson's Warbler *Wilsonia pusilla*
American Tree Sparrow *Spizella arborea*
Savannah Sparrow *Passerculus sandwichensis*
Fox Sparrow *Passerella iliaca*
Golden-crowned Sparrow *Zontotrichia atricapilla*
Dark-eyed Junco *Junco hyemalis*
Lapland Longspur *Calcarius lapponicus*
Common Redpoll *Acanthis flammea*
Hoary Redpoll *Acanthis hornemanni*
redpoll, sp.? *Acanthis,* spp.?

Appendix 3. Species detected on Airport Relocation Alternatives. O = occurrence, U = Use, B = Breeding (for definitions, see Methods). N = nest found.

Species	ARA 1	ARA 2	ARA 3	ARA 4
Greater White-fronted Goose	O		O	B-N
Emperor Goose		B		U
Brant		O	O	
Cackling Goose		O		
Tundra Swan	O	O		
Gadwall				O
Mallard		B	O	B
Northern Shoveler			B	O
Northern Pintail		B	B	B
Green-winged Teal	B	B-N	B	B
Greater Scaup			B	O
Black Scoter		O		
Long-tailed Duck	B			U
Willow Ptarmigan	B	B		B
Red-throated Loon				O
Pacific Loon		O	B	O
Black-bellied Plover		B	B	B
Semipalmated Plover		B		O
Black Turnstone	B-N	B	B-N	B
Semipalmated Sandpiper	B-N	B-N	B-N	B
Western Sandpiper	B-N	B-N	B-N	B
Dunlin	B-N	B-N	B-N	B
Long-billed Dowitcher	B	B	B	B
Wilson’s Snipe	B	B	B-N	B
Red-necked Phalarope	B	B	B	B
Red Phalarope		B	B	
Sabine’s Gull			O	U
Mew Gull				O
Glaucous Gull		O		
Aleutian Tern		O	U	O
Arctic Tern	U	B	B-N	U
Parasitic Jaeger		B	O	U
Long-tailed Jaeger	U		B	B
Short-eared Owl				U
Tree Swallow			O	
Bank Swallow	U	B	U	
Eastern Yellow Wagtail	B	B	B	B
Savannah Sparrow	B	B	B	B-N
Lapland Longspur	B-N	B-N	B-N	B
Common Redpoll			B	
Hoary Redpoll	B	B		
redpoll, sp.?		B		

Appendix 4. Species detected on proposed Borrow Sites. O = occurrence, U = Use, B = Breeding (for definitions and area descriptions, see Methods). N = nest found.

Species	Dall Point	Uplands	SAR	Nuok S.
Greater White-fronted Goose	B-N		O	
Emperor Goose		O	O	O
Brant	O		O	O
Cackling Goose			O	
Tundra Swan	B		B	O
American Wigeon	O			
Mallard			O	
Northern Shoveler	B-N		O	
Northern Pintail	B-N		O	
Green-winged Teal	B-N		U	B
Greater Scaup		O	U	B
Spectacled Eider			O	
King Eider	O			
Black Scoter			O	
Long-tailed Duck			O	
Willow Ptarmigan	B			
Pacific Loon			O	
Sandhill Crane			O	
Black-bellied Plover	B		B	
Semipalmated Plover	B-N			
Bar-tailed Godwit	B	U		
Black Turnstone			O	B-N
Semipalmated Sandpiper	B-N		B-N	B-N
Western Sandpiper	B-N		B-N	B-N
Dunlin	B		B-N	B-N
Long-billed Dowitcher		O	U	B
Wilson’s Snipe	B		B	B
Red-necked Phalarope	B-N		B-N	B-N
Mew Gull			O	
Glaucous Gull			O	
Aleutian Tern	B-N		O	O
Arctic Tern	B-N		O	O
Parasitic Jaeger			O	O
Long-tailed Jaeger	U	B-N	O	O
Common Raven	U			
Bank Swallow			O	
Eastern Yellow Wagtail	B		O	B
Wilson’s Warbler	B			
American Tree Sparrow	B			
Fox Sparrow	O			
Golden-crowned Sparrow	B			

Appendix 4 (cont'd.). Species detected on proposed Borrow Sites. O = occurrence, U = Use, B = Breeding (for definitions, see Methods). N = nest found.

Species	Dall Point	Uplands	SAR	Nuok S.
Savannah Sparrow			B-N	
Lapland Longspur	B-N	B	B-N	B-N
Hoary Redpoll	B-N			
redpoll, sp.?			B-N	O

Appendix 5. Species detected in auxiliary survey areas. O = occurrence, U = Use, B = Breeding (for definitions and area descriptions, see Methods).

Species	Napareayak	N. Airport	NW Estuary	H. Trail
Greater White-fronted Goose	U		U	
Emperor Goose	B-N	O	U	
Brant	U	O		
Cackling Goose	U		O	
Tundra Swan	O	U	U	
American Wigeon		U	U	
Mallard	U		B	
Northern Shoveler			U	
Northern Pintail	B-N	B	B-N	
Green-winged Teal	U	B	B	U
Canvasback		U		
Greater Scaup	U	U	B-N	
Black Scoter	O			
Long-tailed Duck	B	B	U	
Red-throated Loon	O			
Pacific Loon	U	B	B	
Bar-tailed Godwit	O		B	
Black Turnstone	B	B-N	B	
Semipalmated Sandpiper	B-N	B	B	U
Western Sandpiper	U		B-N	B-N
Dunlin	B-N	B-N	B	B-N
Long-billed Dowitcher	U	U	U	
Red-necked Phalarope	B-N	B-N	B	U
Red Phalarope		B	U	
Sabine’s Gull		O		
Mew Gull	O		B	
Glaucous Gull		O	O	
Aleutian Tern		O	B	
Arctic Tern	O	B-N	B	
Parasitic Jaeger	O	B	O	
Long-tailed Jaeger	O		O	U
Short-eared Owl			O	
Common Raven		O		
Eastern Yellow Wagtail		O		
Savannah Sparrow	U	U	B	B
Lapland Longspur	B	B	B	U

Appendix 6. Red Phalarope observations near Hooper Bay, 2009.

<u>28 May</u> -- 2 females and a male seen in the Napareayak Slough wetlands just east of the hardened trail (61 degrees, 32', 35" N, 166 degrees, 05 min, 56" W); large, mostly ice-free wetland.

<u>29 May</u> -- 2 pairs and a third male flew N over the airport runway; none seen at site of yesterday's observations.

<u>4 June</u> -- Pair seen N of village-airport road, about half-way between airport and village (61d, 31', 23" N, 166 d, 07', 33" W).

-- Pair plus one (sex not recorded) near bend in airport road just before airport at very north end of Airport Alternative 3 cross runway (within N RPZ) at 61d, (61 d, 31', 9" N, 166 d, 08', 07" W).

-- Two pairs plus one (sex not recorded) in and near wetland where first pair of morning seen north of village-airport road.

<u>8 June</u> -- Male seen in exact same portion of wetland as first observation on 4 Jun (north of village-airport road)

-- Pair in same wetland where pair plus one seen near bend in airport road on 4 June.

-- Third sighting involved a fly-by on main runway of Airport Alternative 3.

<u>9 June</u> -- A “breeping” female flew E near N end of Alt 2 cross runway; one (sex unknown) seen just N of the north RPZ of AA2 cross runway (same bird?); site very close to area of first observation on 4 and 8 June.

<u>18 June</u> -- The wetlands north of the airport road were searched today specifically to look for red phalarope nests in the vicinity of the 4 and 8 June sightings. None were found. A female was seen 400 m north of the road; she called, but no nest found. A male was spotted 200 m from female. Another male flew by about 500 m north of pair.

<u>19 June</u> -- A single male seen in the marshes north of the estuary that flows into the Bering Sea just north of the current runway.