TUNDRA SWAN POPULATION SURVEY IN BRISTOL BAY, NORTHERN ALASKA PENINSULA, 2003 and 2008

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ABSTRACT
Tundra swan (*Cygnus columbianus*) population surveys were conducted in spring and late summer of 2003 and 2008 according to the schedule established in the Alaska Peninsula/Becharof NWR (Refuge) draft Wildlife Inventory Plan (WIP). In 2003 WIP procedures were followed with two observers. Prior to the 2008 survey year, a series of questions were asked about survey design and sample size resulting in modified survey methods, data collection, and management; the 2008 survey included three observers who mapped all observations. This report outlines the survey methods and preliminary results from each survey.

INTRODUCTION
The Alaska Peninsula, primarily on the Bristol Bay Coastal Plain, is home to 15 – 20% of Alaska's tundra swans and approximately the same percentage of the Pacific Flyway population; it provides the southern-most breeding range for tundra swans in North America. The more southerly location and maritime influences along both coasts of the Alaska Peninsula open nesting habitat earlier in the spring than in other regions of Alaska, allowing for an early and longer nesting season. The Alaska Peninsula/Becharof NWR spans the eastern side of the Alaska Peninsula and the conservation of migratory birds is named as a purpose for both the Alaska Peninsula and Becharof National Wildlife Refuges. Although most of the Bristol Bay Coastal Plain and tundra swan habitat is off the Refuge, the cooperating factors of conservation purposes of the Refuge and USFWS Migratory Bird Management (MBM), the proximity to the refuge boundary, and interest among other refuge biologists (e.g., Dau at Izembek) led to intensive study during the first years of Refuge establishment (Wilk 1987, 1988).

During the 1980s, the tundra swan population appeared to be increasing, and with the subsequent T/V Exxon Valdez oil spill on the Pacific coast, Refuge interests turned elsewhere; there was no monitoring done in the 1990s by Refuge biologists. Swans have been monitored annually during the spring Breeding Pairs survey since 1964. In addition, the Region 7 (Alaska) MBM office conducted one survey during the 1990s, shifting the perceived management responsibility to the regional office. However, Refuge Wildlife Biologist Wilk expressed concern that MBM may overestimate tundra swans in the Bristol Bay stratum during the Breeding Pairs survey because he felt they applied an estimate gained from survey of higher density habitats to the entire study area (Wilk 1987).

The tundra swan is often referenced as an indicator species of wetland and waterfowl habitat health. Because wetland habitat may be altered as a result of climate change, continued monitoring of this species will assist biologists in understanding the ramifications of climate change to this, and other wetland species. As the Alaska Peninsula is the southern-most stronghold for tundra swan populations, it may be the first to show an impact from climate change. Harvest may also be increasing for tundra swans due to the legalization of spring waterfowl hunting for Alaska rural residents starting in spring of 2003. As many Alaska Peninsula nesting swans stage in spring along the Naknek River where most of the human population on the northern Alaska Peninsula is concentrated, hunting pressure and/or disturbance from hunting during pre-breeding energy accumulation could be significant to their population. Another factor affecting tundra swans may be the increasing population of trumpeter swans (Conant et al. 2007). Waterfowl biologists (Conant et al. 2007) believe their habitats do not

generally overlap as trumpeter swans are found primarily in boreal forest and south coastal areas. In 2004 for the first time, and every spring since, trumpeter swans have been observed on the Naknek River. Since current methods of aerial survey do not differentiate the species, it will be difficult to detect any displacement of tundra swans by trumpeter swans unless supplemental ground or helicopter studies are employed.

It is convenient that a key species of interest is also thought to be easy to survey because of their relatively large size, white color, and habitat preferences of open tundra, wetlands, or water bodies. It is the practice of MBM to apply a sightability factor of one to tundra swans (i.e., implies 100% detection) during breeding pairs surveys. Sightability (AKA detection) may be highly variable between observers; Refuge surveys dependent on novice observers may miss an unknown number of birds, thus leading to underestimates in population estimates. Understanding this important parameter and its impacts on population estimates is key to improving monitoring of Refuge/Service trust species.

Brief History of Swan Surveys in Alaska

King was the first to describe tundra swan populations from Alaska's Arctic north and to describe methods for surveying swans using aircraft in the 1970s (King 1970, 1973). Swans were further studied on the Yukon Delta (Lensink 1973, Dau 1981, King and Hodges 1981) and on the Arctic National Wildlife Refuge (Garner & Reynolds 1986)[1]. Wilk initiated swan studies in 1984 on the Alaska Peninsula with the intent to document numbers, distribution, and productivity (Wilk 1987). Migratory Bird Management conducted a survey of swans in 1991 on the Alaska Peninsula (USFWS-MBM 1991). Through the 1990s no further tundra swan specific work was conducted on the Alaska Peninsula, although swans continued to be included as part of the Alaska-wide Breeding Pairs survey every May (stratum 8 on the northern Alaska Peninsula, Mallek & Groves 2009). The population index of the Western population of tundra swans is increasing (1949 – 2001; Pacific Flyway Council 2001). In the early 2000s, Refuge biologists and management determined tundra swans should be monitored periodically; therefore a pilot study was conducted in 2002 (Doster 2002). Objectives included estimating tundra swan population and productivity and tracking long-term population trends for the Northern Alaska Peninsula. Monitoring swan habitat and use patterns was also a long-term objective.

Many other refuges in Alaska have Wildlife Inventory Plans which include some level of population or productivity monitoring of tundra or trumpeter swan populations (Kenai, Selawik, Koyukuk/Nowitna, and Tetlin). Although no formal plan is in place, it has been the established tradition of USFWS to survey "White Swans" (primarily targeting trumpeter swans) in the Interior and SE Alaska every five years; several refuges (Kanuti, Kenai, Koyukuk/Nowitna, Tetlin) work with MBM on this survey. In general, these surveys follow a "Trumpeter and Tundra Swan Survey Protocol" that was established in the 1980s and updated in 1995 and 2005 (Conant et al. 2007).

[1] This information was summarized from Wilk (1987).

New Objectives for 2008

In addition to the original objective of estimating populations, productivity, and long-term trends of Alaska Peninsula tundra swans, several issues regarding methodology arose prior to the 2008 survey. Increasing emphasis on estimating detection probabilitys for all types of surveys called for addressing the issue with this species. 2During the 1980s, Wilk flew smaller plots at two altitudes to calculate a sightability index (Gasaway et al. 1986). We attempted to do this in 2003; however I felt we double counted birds, especially at the lower altitude, and did not analyze the data. In 2008, we used slightly different data collection methods so we could estimate detection rates and correct for any double detection of swans on the return transect line (observing swans more than half the distance to the next transect). The use of double observer and line transect methods has recently been explored by others (Quang and Becker 1997, Borchers et al. 2006, Koneff et al. 2008, Buckland et al. 2010). This increased complexity of data analysis led the Refuge to enter into a statistical contract with TerraStat Consulting Group/Alice Shelly to further analyze methods, estimate detection, evaluate sample size, and conduct a power analysis resulting in recommendations for future surveys. This report will not cover those results in detail, but will provide background for that work and results from data analysis comparable to past years.

STUDY AREA

As defined by Wilk (1987), the study area encompasses the northern two-thirds of the Alaska Peninsula from where it adjoins the mainland (latitude 59°20'N, longitude 155°30' W) to Port Moller, a distance of approximately 480 km (Figure 1). The Aleutian Mountain Range bounds the south and east; the Kvichak River bounds the north. The area north and west of the mountains is referred to as the Bristol Bay Coastal Plain (Plain). The Alaska Peninsula has a moderate polar-maritime climate typified by high winds, frequent precipitation, cloud cover, and mild temperatures. Local weather is affected by the Bering Sea and Pacific Ocean (USFWS 2005) which provide moisture laden winds resulting in frequent fog and precipitation. Federal lands with Native inholdings dominate land ownership in the mountains and along the Gulf of Alaska coast, while State of Alaska and Native Corporations and villages own most of the Plain.

Potential swan habitat is generally found below 150 m elevation and excludes the large lakes (Naknek, Becharof, and Ugashik Lakes). The Plain is dominated by low and dwarf shrub communities, tundra, and a variety of wetland types. Broad, meandering rivers cross the landscape, creating diverse wetland habitat separated by gently rolling uplands. The Plain is dotted with ponds and lakes of various sizes and depths. Some are connected by creeks and rivers; others are isolated. Tundra swans are primarily found in moist and wet tundra dominated by mosses, sedges, grasses, and ericaceous shrubs, and in lakes and ponds with emergent vegetation (primarily *Potamogeton* spp., *Myriophyllum* spp., and *Sparganium hyperboreum*).

Wilk established 186 sample units (SU) over a study area of 18,009 km^2 of potential swan habitat (Figure 2). Each SU was a quarter section of 1:63,360 scale U. S. Geological Survey

[2] The issue of detection addresses the observer's ability to see every object of interest; if it is not perfect, the survey will underestimate the number of objects.

Figure 1. Study area for the Alaska Peninsula tundra swan population and productivity surveys includes the beige-colored lowlands draining into Bristol Bay from Kvichak River to Port Moller.

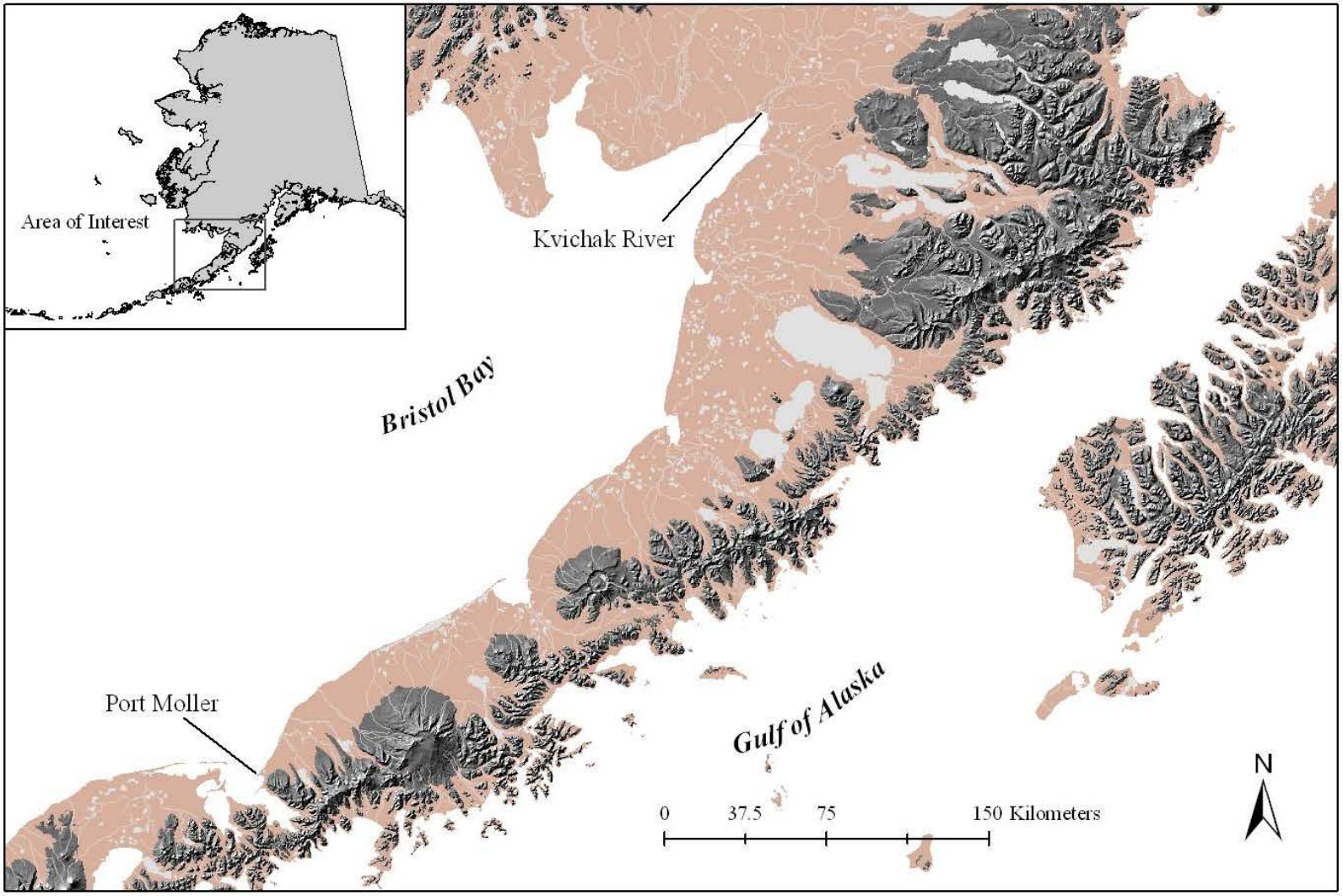
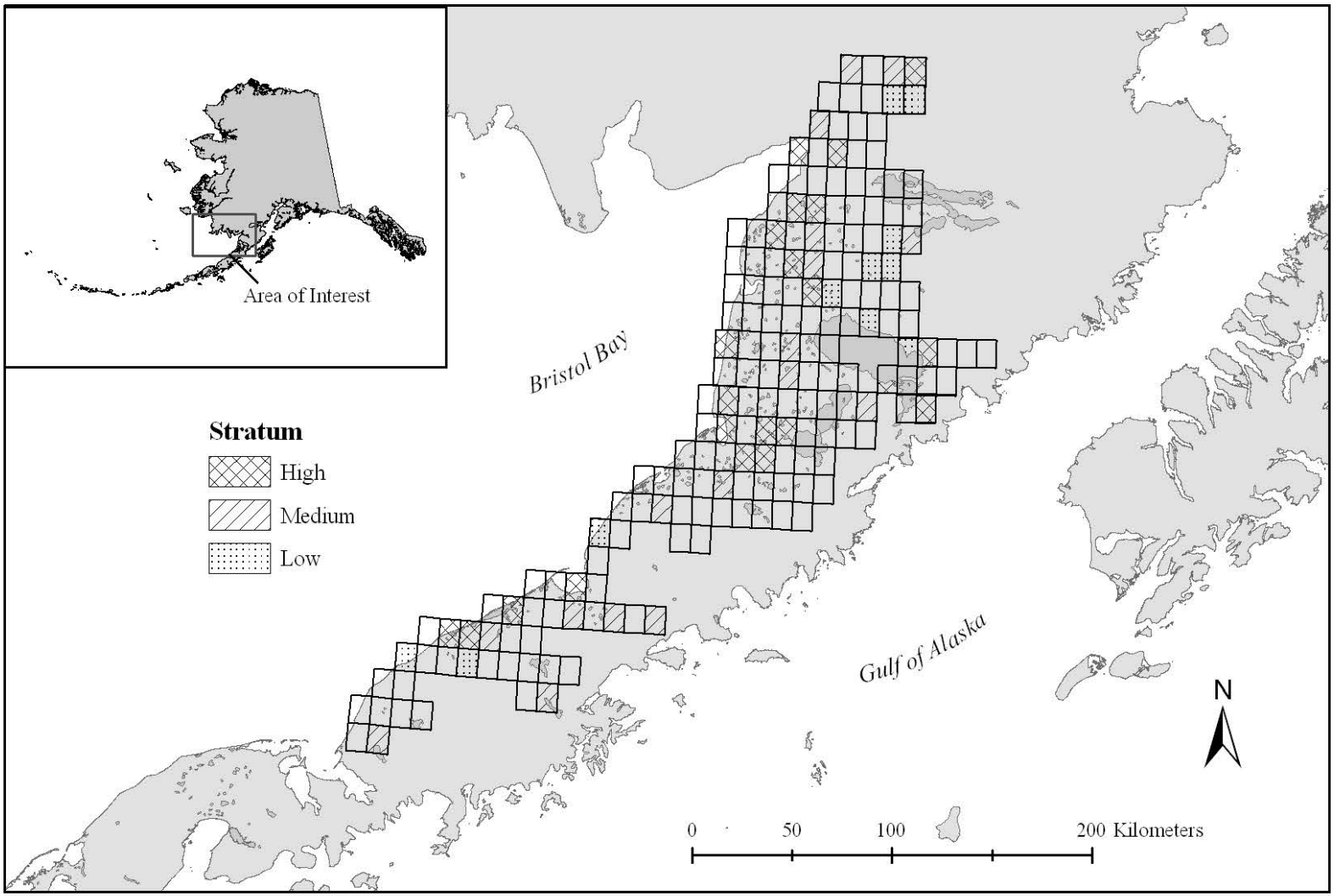


Figure 2. Sampling universe of 186 quarter 15 minute map quad plots with 2003 and 2008 sample indicated by stratum for the Northern Alaska Peninsula tundra swan population survey.



map and is labeled using the USGS map name row letter, column number, and a value 1-4 indicating which quarter (starting in upper left and numbering clockwise). Using topographic maps (most from the 1950s-1963 with minor revisions in the 1970s and 1980s), planimeter, and notes from aerial surveys, Wilk determined the amount of potential swan habitat within each SU[3]. Wilk also assigned a stratum value based on combined survey data from all years with density of breeding adults assigned as follows: low (0-0.1 swans/km2, N=68 plots), medium (0.10 – 0.20 swans/ km2, N=58 plots), high (0.20-0.60 swans/km2, N=60 plots).

METHOD

Field Procedures - 2003

The general aerial survey method is outlined in the Draft WIP- *Tundra Swan Population and Productivity Monitoring* (USFWS 2004). We selected 39 of 40 plots (including 11 low, 17 medium and 11 high stratum; one plot was excluded accidentally) used in 1991 by MBM to allow for paired comparisons. Using optimal allocation and variance data from Wilk (1987), we determined that more high stratum plots were needed (optimal selection was 10 low, 14 medium and 26 high). We randomly selected 11 more high stratum plots for a total of 50 (Doster 2002 Table 1 Revised; Cochran 1963, Siniff and Skoog 1964). During the spring survey, we determined that Ugashik B3_1 only had 5 km of potential habitat, and being mountainous, was extremely difficult and unsafe to fly. We did not revisit this plot in late summer, giving us a completed sample of 49 plots.

We conducted the spring survey from 28 May to 10 June and the late summer from 6 to 16 August. Total flight time for the survey was 88 hours. All flights were conducted with the Refuge's Cessna 206 on wheels piloted by Refuge Operations Specialist Cox. Alaska Wildlife Protection officers allowed us to use the fuel cache at Pumice Creek. Biological Technician Meixell manned the front right observer seat and operated the computer while the author observed from the left rear seat.

Prior to the pilot survey in 2002, we generated a model for the boundaries of each SU, and the north-south survey lines were spaced approximately one mile (1.6 km) apart and one half-mile (0.8 km) from each plot boundary. The model resulted in a file that could be displayed in the navigating and data recording program *Moving Maps* (Hodges 2000). A Dell laptop computer was held on Meixell's lap and turned so the pilot could watch the survey lines while Meixell used the voice record program to collect observations and plot data. Alternately a Fujitsu 51873 lap top was used to display the lines for the pilot while the Dell was used to collect data. Voice recording of data minimizes the need to look away from the survey area to record data. Meixell recorded both the front and back seat observations using coding that indicating if the swans were on the right or left side of the aircraft. The program was only used to show the approximate north-south position of the observation along the transect, and no indication of distance from the transect was given. We attempted to limit our distance observed to one half-mile from the aircraft (half the distance to the next transect line or the plot boundary). Paper maps were carried and occasionally used for navigation when the computer failed; notes were taken on paper in those few instances of computer failure. Swans were noted as single, pairs, with nest, with

[3] Defined as all wetland and adjacent terrestrial lowland and upland habitat generally below 150 m elevation.

cygnets (with count), and flocks (with count). Note that the 2003 and 2008 surveys used North American Datum 83 for latitude and longitude; this will differ by approximately 120 m to the east and 80 m north of the latitude and longitude boundaries on paper maps used by Wilk in the 1980s (NAD 27). We transcribed data after the survey by listening to the voice file of *Moving Maps* for the observations, transcribing onto paper and entering into Microsoft Excel files; the *Moving Maps* generated dbf files of location were then merged with the observations in Excel.

Deviations from protocol included flying the survey at 500' rather than 150 m (492') above ground level, flying during conditions where winds exceeded 12 knots, and flying into the early evening when glare was sometimes a problem.

Field Procedure – 2008

We used the same 49 plots used in 2003 and added one more low stratum plot (Chignik B5_1) to replace the plot excluded in 2003 from that stratum. The spring survey was flown from 27 May to 6 June; the late summer dates were 1 to 7 August. As in 2003, we were allowed to use the fuel cache at Pumice Creek. The aircraft used in spring was the Refuge's Found Bushhawk (N794) on wheels piloted by Refuge Operations Specialist Cox; in late summer we used the Region's Found Bushhawk (N706M) on wheels piloted by Regional Aviation Manager Fox. On the last day of survey we used a Cessna 185 on wheels piloted by Schuman to complete the last five plots because Fox was no longer available. The author manned the front right seat and operated the computer. In the rear seats, spring observers included Biological Volunteers Redding and Deutsch; and in late summer, Redding and Supervisory Wildlife Biologist Britton. The rear seat observers switched sides from day to day. We used the same Dell lap top as in 2003 with *Moving Maps* for navigation in spring, and to record the actual flight line, and when we started and ended each transect. In the late summer, we uploaded the same coordinates to the aircraft GPS, and the pilot used the GPS to navigate. The same file was used to navigate transects as in 2003, with the addition of transects for the one new plot.

To meet the new objectives, observers were coached to keep the principles of distance observation in mind: that the most important observations are those closest to the observer. Observations were mapped on paper maps by each observer so distance from the transect line could be estimated. Paper maps (6.5″ x 8.25″ on 8.5″ x 11″ paper) were made for each observer prior to the survey[4]. The scale of the paper maps was approximately 1:76,700; a dot of size 1 mm is equal to approximately 80 m on the ground. Each observation was numbered on the map; in the map margin a corresponding number with the swan or other observation was noted (Conant et al 1997, Conant et al. 2007). The lack of perfect detection on the inner edge of the transect strip was also addressed by having two observers on the right side. Observers were instructed to look forward and not directly perpendicular or behind their seat. The right side observers were instructed to withhold calling out their observation until it had passed the wing

[4] In spring I forced the projection to concur with the paper NAD27 datum so the plot boundaries lined up with NAD27 Lat/Long on the paper maps. We discovered they did not concur with the flight track in *Moving Maps* which was NAD83. The paper map plot boundaries and transect lines were drawn approximately 120 m west of the lines as navigated from *Moving Maps*. We were aware of the problem and ignored the line on paper when mapping the birds. The August maps were corrected to agree with NAD83 and what was flown from *Moving Maps* or the aircraft GPS.

(perpendicular to the aircraft); then the observers would confirm if the front, rear, or both observers had seen the swan(s). The front and rear right side coordinated numbers so their observations could later be linked. One of the rear seat observers also kept general notes as to when each plot was started and finished, weather conditions, and who was in each seat. We also noted if we thought an observation was more than one half-mile from the transect (observers look back on their last transect after every other transect flown).

In the spring of 2009 an exercise was completed to estimate the blind strip underneath the Found Bushhawk. To accomplish this, Refuge Wildlife Specialist/Pilot Finley, Wildlife Biologist Watts, and the author traveled to the airstrip at Egegik. We set up a series of cones on the ramp at measured distances perpendicular to a flight line down the edge of the airstrip. We then flew the flight line, tracking our flight using *Moving Maps,* and determining which cones were visible from the front and rear seat. After returning to the office and plotting the flight lines, the visible distances were transmitted to the statisticians for use in the distance estimation. These data will not be further discussed in this paper.

After the spring survey and again after the late summer survey, the Biological Interns used ArcGIS 9.1 to digitize observation number (coded map name, side, and observation number, e.g., BBA1_2_R1) and location from the maps. They created a shape file for each season and for each side of the aircraft. The NPS extension *Alaska Pak* was used to add the latitude and longitude for each digitized point. In Excel, they stored the corresponding Unique Observation number, the observation, any counts (e.g., number of cygnets, number in flock); and for the right side, who observed (front, rear, both). Later, date, plot, transect line number (numbered from east to west), data for left observer, observer's initials, if the observer was looking east or west, and notes were added to the file. Eventually a complex system of coding was developed to mark any birds seen twice (from two transects) and for observations seen by both right seat observers that were not mapped in the same location (a judgment call by the author was made as to which location was more likely).

To obtain the distance of each observation from the track line, we used the track file created by *Moving Maps*. *Moving Maps* creates a separate file for each day, so these had to be merged into one file. Since the track file was active even when we were not surveying, there was much extra data in this file, which was edited using the incidental data regarding start and finish time of plots, then clipped to the plot boundaries shape file (Plot_sample). Any other flight lines that were not flown transects were then edited out by hand. We used *Hawth's Tools*[5] to connect the transect point track file into lines. The shape file was projected from geographic coordinates to Alaska Albers projection. Using the *Near* tool in *ArcToolbox*, distance was measured between each observation and the transect line and added to the attribute table of the shape file. Some manual editing had to be done to this file especially for "seen twice" observations. This information was all exported to the Excel file. A "Readme" worksheet was added to each Excel file to explain all of the coding for the data sheet.

[5] With ArcGIS 9.3.

Data Analysis

I included information useful to future project managers, which will be presented as simple tables or appendices of information (e.g., project costs, incidental observations). I present summary information generated in 2008 addressing observations beyond the ½ mile transect width and due to the double observers on the right side of the aircraft. Monthly weather data were obtained from the National Weather Service web site for the King Salmon Station (http://www.wrcc.dri.edu/summary/Climsmak.html).

I summarized data by swan age or group status to be comparable to the tables as commonly reported in MBM reports; adults and subadults as singles, in pairs[6], in flocks; number of nests or broods, total cygnets; and various totals. For 2008, I report data only from two observers (front right and rear left) to be comparable to the 2003 survey; I excluded any observations thought to be duplicates (i.e., "seen twice").

I calculated a population estimate by the named swan ages/groups using stratified sampling estimate based on proportions within each strata (Appendix I). A finite population correction was applied. Average brood sizes, percent juvenile, and broods per pair were calculated using a combined ratio estimate (Appendix I). All population estimates are presented as means $\pm$ 95% confidence interval.

Because each plot is not of equal area and does not contain an equal amount of potential swan habitat, Wilk and others have used a ratio estimator to estimate swan populations and standard errors. I used Wilk's potential areas for each plot surveyed and total potential area in each stratum, and using stratified random sampling, applied a ratio estimator[7] (Appendix I) for breeding adults (singles + pairs), flocked birds, and cygnets (late summer only) so population data could be compared to Wilk (1987). Note that neither population estimate corrects for birds that could not be detected because they were below the aircraft.

I used a paired t-test on the stratified sample to test for differences between the years 2003 and 2008, limiting the test to the 49 plots common to both years and significance levels of $\alpha = 0.05$ and 0.1. I also applied paired t-tests between historical data and 2008 using the year/season with the greatest number of plots in common to the 2008 data set. For spring this was the 1984 data set (n=38) and for late summer the 1991 data set (n=39). Comparisons were made between years and seasons for breeding adults (singles + pairs), total adults (breeding adults + flocks), cygnets, and total swans (includes cygnets in the late summer value) where appropriate.

Plot density was calculated using a mean of the spring and late summer breeding adults (single and paired swans) for each survey year. These were then scored according to the criteria used in Wilk for each stratum. The new stratum designation was compared against the established stratum as an indication of changing local swan density and to evaluate the constancy of the stratified random sampling regime over time.

[6] Number of singles plus two times the number of pairs (equal "in pairs") are referred to as breeding adults.
[7] Includes the finite population correction.

RESULTS and DISCUSSION

Field Methods, Effort, & Costs

The 2008 survey timing was similar to the 2003 survey timing except the 2008 late summer survey was about six days earlier than 2003. Better weather in 2008 allowed for a shorter survey window (10 and 7 days versus 13 and 10 days). Survey windows in late May/early June for the spring survey were similar to survey windows in the 1980s (Wilk); however, our late summer surveys were conducted in early to mid August, while some of Wilk's late summer surveys were conducted into early September. In both 2003 and 2008, 88 hours were needed to complete the spring and late summer surveys although the actual totals varied slightly between seasons within years. Where data are available, the mean time spent on plot was 27 (spring 2003, n=47), 26 (late summer 2003, n=48), 28 (spring 2008, n=50), and 30 (late summer 2008, n=50) minutes. Time spent on plot will vary with aircraft speed and wind conditions. In the 1980s some surveys were conducted using the meandering method and some systematically (transects); in the 2000s, all surveys were flown following north-south transects with one exception – one plot was surveyed with east-west transects (2003) due to weather. A Cessna 180 with pilot and two observers or a Piper PA-18 with pilot and one observer mapping onto paper topographic maps was used in the 1980s, while we used a Cessna 206 on wheels in 2003 and a Found Bushhawk on wheels in 2008. We calculated numbers of birds and not numbers of pairs as sometimes is used in MBM or Refuge reports. In any survey to date on the Alaska Peninsula, surveyors did not attempt to distinguish lone subadults that were not established on territories from single breeding adults; because of this, "breeding adults" may be overestimated.

Costs were calculated for the 2003 and 2008 surveys (Appendix I). These are estimated costs based on average salaries at each grade level (Step 5 used for permanent employees and Step 1 used for seasonal employees). In 2008 we used two interns on the spring survey and one intern and one supervisory biologist as observers on the late summer survey. Intern costs would have been lower than a GS-5 biological technician, but the supervisory biologist would have been much higher, probably averaging out the costs. Note that the hourly rate for the Refuge aircraft had not changed much between years, but fuel costs have increased by over $2 per gallon.

Weather

Notable weather during the 2003 and 2008 survey years included higher than average rain in May, June, and August and unseasonably warm temperatures in April of 2003, contrasted by dryer than average conditions in May and August and unseasonably cold temperatures of April, June, and July in 2008 (Table 1). As reported (Wilk 1987) and demonstrated in this table, 1985 was an exceptionally cold spring; in contrast, 1983 was exceptionally warm through the spring and early summer, and 1983 and 1984 were unusually dry years.

Population Estimates

To compare the 2003 and 2008 years, an estimate was generated from a stratified random sample (Table 2)[8]. The estimate of breeding adults increased from spring to late summer and was larger

[8] To allow for reexamination of these data, plot counts of breeding adults, flocks, broods, cygnets, and associated sums are presented in Appendix III.

Table 1. Total monthly precipitation and average monthly temperature for King Salmon, Alaska during the years of the Alaska Peninsula Tundra Swan Surveys, 1983-1987, 2003, 2008.

Total Monthly Precipitation (cm)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1983	1.07	0.63	0.56	5.63	3.48	3.05	3.88	5.91	5.99	7.16	2.49	1.22	41.07
1984	2.99	1.40	1.12	1.09	2.74	4.04	3.30	6.12	2.26	1.45	2.54	4.54	33.58
1985	2.41	1.85	3.22	0.86	2.94	3.12	3.32	8.22	6.70	5.81	8.50	4.01	50.99
1986	3.38	0.48	0.61	2.49	2.56	2.36	6.19	8.17	10.23	6.35	4.85	1.65	49.31
2003	1.17	3.48	0.38	2.36	4.67	5.84	6.22	11.50	3.98	4.75	9.87	1.95	56.17
2008	3.20	0.96	1.95	2.77	1.52	3.40	6.42	4.11	8.38	6.85	1.88	4.29	45.74
MEAN	2.54	1.95	2.23	2.56	3.30	4.06	5.71	7.59	7.72	5.30	3.71	3.17	49.82
Number of Years	55	55	55	55	54	53	54	55	55	55	55	55	52

Average Monthly Temperature (°C)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1983	-11.18	-7.42	0.66	2.48	8.09	12.12	14.08	12.26	7.49	-1.80	-1.08	-2.72	2.75
1984	-8.13	-18.96	2.40	-1.54	6.08	11.29	12.03	11.93	8.87	-1.05	-5.29	-4.08	1.13
1985	0.33	-11.88	-5.23	-6.21	4.39	8.54	12.41	11.33	8.54	-2.97	-3.83	1.21	1.38
1986	-8.39	-5.53	-5.82	-2.19	5.61	9.94	12.03	11.24	9.32	2.25	-3.21	-0.76	2.04
2003	-1.92	2.01	-6.73	3.17	6.83	11.32	13.82	13.68	7.69	2.79	-3.15	-11.34	3.18
2008	-14.16	-12.86	-4.78	-1.85	5.89	9.17	11.43	12.15	8.82	-1.96	-9.56	-6.26	-0.33
MEAN	-9.57	-8.27	-5.51	0.31	6.27	10.44	12.84	12.37	8.51	0.65	-5.17	-9.07	1.24
Number of Years	55	55	55	55	54	53	54	55	55	55	55	55	52

Table 2. Populations estimates generated with Stratified Random Sampling based on proportions, Alaska Peninsula Tundra Swan Survey, 2003 and 2008. (N=186, in 2003 n=49 and in 2008 n=50)

	Spring							Late Summer										
2003	Singles	In Pairs	Single + Pairs	in Flocks	Total AD	Nests		Singles	In Pairs	Single + Pairs	in Flocks	Total AD	Broods	Cygnets	All	Avg Brood	BR/PR	% Juv
Total	828	2,741	3,568	633	4,201	810		597	3,146	3,743	1,492	5,235	243	473	5,708	1.94	0.15	8.3
CI [1]	178	411	510	573	810	137		119	496	582	607	1,023	62	131	1,086	0.19	0.04	2.0
CI Percent	0.21	0.15	0.14	0.91	0.19	0.17		0.20	0.16	0.16	0.41	0.20	0.26	0.28	0.19	0.10	0.27	0.24
2008																		
Total	1,141	1,779	2,920	1,337	4,257	519		492	2,796	3,287	1,470	4,758	347	686	5,444	1.98	0.25	12.6
CI	190	309	447	1,648	1,726	101		91	459	516	563	892	89	215	1,005	0.25	0.09	3.2
CI Percent	0.17	0.17	0.15	1.23	0.41	0.19		0.18	0.16	0.16	0.38	0.19	0.26	0.31	0.18	0.13	0.34	0.25

[1] Confidence Interval for Average Brood Size, Broods/Pair and % Juvenile approximate using 2 standard errors.

in 2003 (3,568 CI ± 510 in spring, 3,743 CI ± 582 in late summer) than 2008 (2,920 CI ± 449 in spring, 3,287 CI ± 521 in late summer). More birds were in flocks in the spring of 2008 (633 CI ± 573 in 2003 vs. 1,337 CI ± 1,648 in 2008), and the estimates had wide confidence intervals; the flock estimates were similar in late summer between years (1,492 CI ± 607 in 2003 vs. 1,470 CI ± 563 in 2008) with a narrower confidence interval. All confidence intervals for the stratified random sample for breeding adult birds and total adults ranged from 14-21% of the mean except total adults in spring 2008 (41%). Confidence intervals for flocks, broods, and cygnets were much wider, ranging from 26-123% of the mean.

Lower total cygnet counts in the 2000s are reflected in the derived productivity measures (average brood size, broods/pair, and percent juvenile). Calculated mean brood size was similar in 2003 and 2008 at 1.94 (CI ± 0.19) and 1.98 (CI ± 0.25) cygnets per brood. However, the number of broods per pair was much lower in 2003 versus 2008 (15% ± 4% vs. 25% ± 9%). During the 1980s, calculated mean brood size was closer to 3 (range of 2.7 – 3.6, see August values, Table 7, Wilk 1987[9]). The percentage of pairs with broods[10] was also higher during the 1980s (range of 24.7% to 55.2%; see August values, Table 6, Wilk 1987). Average brood size was reported at 2.9, and broods per pair was reported at 23% for the Bristol Bay stratum in 1999 (USFWS 1991). The high productivity noted in the 1980s may have driven the high population counts observed during that decade.

Comparisons using the 2003 and 2008 data showed several within-year and between-year differences. In general, breeding adults (singles + pairs), total adults (breeding adults + flocks), cygnets, and all swans (total adults + cygnets) were higher in late summer of both years and lower in 2008 (except cygnets). Between-year comparisons of breeding adults, total adults, cygnets, and total swans showed significant differences in spring and late summer for breeding adults only (at both the p=0.05 and 0.1 levels; Table 3). Comparing spring versus late summer within years indicated there were significantly fewer breeding adults in spring versus late summer of 2008, and significantly fewer total adults (breeding adults + birds in flocks) in spring versus late summer of 2003 (Table 3). Of note, although the data indicate there were fewer breeding adults in spring 2008 than 2003, the number of broods observed and cygnets produced was 40-45% higher than the 2003 estimate (t-test between paired plots was not significant for cygnets).

Because the plots are of unequal size and contain unequal potential swan habitat area, Wilk (1987) calculated indices from surveys, "using the ratio method for sampling unequal-sized units without replacement for each stratum" (Caughley, 1977); "the strata indices were then pooled to provide an overall index of the number of breeding swans present and the standard error" (Wilk 1987). Doster (2002) applied this estimation method, but data were only available from the high and medium strata. To compare against these previous estimates of total breeding adults, birds in flocks, and total cygnets (late summer only), a ratio estimator was applied to the 2003 and 2008 data (Table 4). I assumed that I used the same method for ratio estimation as used in Wilk

[9]Method of brood size calculation is not stated and may not be calculated using strata.
[10]Wilk's calculations may not be directly comparable as he may have defined pairs as count of pairs + ½ count of singles, while my calculations are based on pair counts only. As in footnote 7, strata also may not have been used.

Table 3. T-test results for between year and between season comparisons for tundra swan age and group totals, Alaska Peninsula Tundra Swan Survey, 2003 and 2008.

	Between Years (2003 vs 2008)							Between Seasons (Spring vs Late Summer)			
	Spring			Late Summer				2003		2008	
Paired t-test	Singles + Pairs	Subtotal Adults		Singles + Pairs	Subtotal Adults	Cygnets	Total Swans	Singles + Pairs	Subtotal Adults	Singles + Pairs	Subtotal Adults
mean deviation	-3.41	0.37		-2.28	-2.38	1.85	-1.22	0.94	5.56	1.98	2.70
std err of deviation	0.91	3.31		0.89	1.60	1.17	1.61	0.81	2.53	0.83	4.84
95% confidence interval	1.84	6.66		1.79	3.22	2.35	3.24	1.62	5.08	1.66	9.73
Significance (0.05)	Yes	No		Yes	No	No	No	No	Yes	Yes	No
90% confidence interval	1.53	5.55		1.49	2.69	1.96	2.71	1.35	4.24	1.39	8.12
Significance (0.10)	Yes	No		Yes	No	No	No	No	Yes	Yes	No

(1987). The ratio estimator method produced estimates that were slightly smaller than the stratified random sample and with larger confidence intervals except for breeding adults in August of 2008 (breeding adults: 3,379 CI $\pm$ 761 in spring 2003, 2,827 CI $\pm$ 589 in spring 2008; 3,545 CI $\pm$ 816 in fall 2003, 3,183 CI $\pm$ 443 in fall 2008). Using this larger set of years, the highest estimate of breeding adults (pairs + singles) was found in 2002 and second highest in 2003, falling in 2008 to estimates comparable to the 1980s. Note the small confidence intervals in the 1983-1985 spring surveys and 1984 July survey due to large sample sizes. Flock estimates were lower in the spring surveys of 1983, 1986, and 2003 (636 – 791), and higher in 1984 and 2008 (1,317 to 1,381). All late summer surveys had similar flock estimates (1,413 – 1,844). The number of cygnets observed in late summer was considerably less in both 2003 and 2008 (448 - 664) versus 1984-1986 (1,506 – 1,726). Paired t-tests between 1984 and 2008 spring data (breeding adults and total adults) and between 1991 and 2008 late summer data (breeding adults, total adults and total swans) found no significant differences between years (Table 5).

The Bristol Bay stratum of the annual Waterfowl Breeding Population survey (Appendix III from MBM files transmitted by Groves, also see Mallek & Groves 2009, Conant et al. 1999) shows a slow but steady increase in total swans from the early 1970s through the 1980s, and a slower increase through the 1990s and 2000; this is also demonstrated by multi-year means. The population trend of the Western Population of swans (1949 – 2001; measured by Pacific Flyway Midwinter Surveys; Pacific Flyway Council 2001) also shows a steady increase. Although not directly comparable because the Bristol Bay stratum also includes areas to the west of our study area, the high values of our 2002 and 2003 surveys and low values of 2008 coincide with highs and lows of the Breeding Population survey. These data also agree with the fact that we found no significant differences between the 1984 or 1991 surveys and the 2008 population estimates.

Table 4. Comparison of population estimates using the ratio estimator for the Alaska Peninsula Tundra Swan Survey, 1983-1986, 2002, 2003 and 2008.

		June				July			
		Pairs + Singles	Flocks	N		Pairs + Singles	Flocks	Cygnets	N
1983	Total	3,058	791	98		2,555	1,618		50
	SE	76	136			120	154		
	% SE	3	17			5	10		
	CI	152	271			3	17		
1984	Total	2,865	1,317	162		2,783	1,592	1,726	102
	SE	29	144			67	115	85	
	% SE	1	11			2	7	5	
	CI	56	283			132	226	167	
1985	Total	3,142	1,940	95		3,011	1,844	1,506	42
	SE	85	450			205	297	172	
	% SE	3	23			7	16	11	
	CI	167	887			403	585	338	
1986	Total	2,875	776	28		3,016	1,515	1,550	21
	SE	256	341			332	600	335	
	% SE	9	44			11	40	22	
	CI	526	700			682	1,233	688	
		May/June				August			
2002	Total	3,766[1]		15					
	SE	589							
	% SE	15							
	CI	1,263							
2003	Total	3,379	599	49		3,545	1,413	448	49
	SE	380	290			408	335	80	
	% SE	11	48			12	24	18	
	CI	761	580			816	669	159	
2008	Total	2,827	1,295	50		3,183	1,424	664	50
	SE	295	843			222	322	120	
	% SE	10	65			7	23	18	
	CI	589	1,685			443	644	240	

[1]This estimate did not include low stratum.

Table 5. T-test results for between year comparisons for tundra swan age and group totals, Alaska Peninsula Tundra Swan Survey, 2003 and 2008.

	1984 vs 2008			1991 vs 2008		
	Spring (n=38)			Late Summer (n=39)		
Paired t-test	Singles + Pairs	Subtotal Adults		Singles + Pairs	Subtotal Adults	All Swans
mean deviation	-0.01	5.30		-0.51	-2.50	-1.28
std err of deviation	0.86	4.89		1.31	2.12	2.44
95% confidence interval	1.74	9.89		2.66	4.30	4.94
Significance (0.05)	No	No		No	No	No
90% confidence interval	1.45	8.24		2.21	3.58	4.12
Significance (0.10)	No	No		No	No	No

Detection

In 2003, we attempted to estimate detection by flying smaller plots at two altitudes (250' vs. 500'). At the lower altitude, observers were instructed to view out only ¼ mile, and transects were spaced at ½ mile intervals. After examining the data, I felt that the observers had not been able to meet this limit and had double counted many observations; therefore the data were not further analyzed. Using this same technique (Gasaway et al. 1986), Wilk estimated a sightability correction factor of 1.375 SE $\pm$ 0.0167 for June (73% probability of detection), and in July of 1.5426 SE $\pm$ 0.1741 (64% probability of detection). Note that swans were missed more in July, although the group sizes, with cygnets, were potentially larger. Wilk mentioned increased emergent vegetation as a factor decreasing sightability later in the summer. The 2008 survey was designed to estimate detection using distance sampling (Buckland et al. 2001). This will be reported in a separate paper (Shelly and Reynolds 2010).

Group Patterns

The number of plots with flocks increased from spring to late summer (9 in spring 2003, 9 in spring 2008, 30 in late summer 2003, and 29 in late summer 2008). The largest flock encountered during each survey was 110 (spring 2003), 85 (late summer 2003), 250 (spring 2008), and 36 (late summer 2008). As mentioned above, more adults were found in flocks and fewer as breeding adults in the spring of 2008 versus the spring of 2003; by late summer flock numbers were similar between years, although breeding adults were still lower in 2008. In addition to the number of breeding adults being depressed, the 2008 spring season was unusual in that a large percentage of the breeding adults were observed as single birds (Table 2). In spring 2003, 23% of breeding adults were observed as singles, whereas in 2008, 39% were observed alone. In the late summer surveys, single adults dropped to 16% in 2003 and 18% in 2008. Perhaps the colder and drier spring in 2008 delayed vegetation growth and caused paired birds to forage separately during the day. An alternative hypothesis is that second year birds had not separated from their parents, causing a high number of 3-4 bird flocks; this was not supported by the data.

Density and Stratum Stability

Several plots were surveyed where no swans were observed (two plots spring 2003, one plot late summer 2003, five plots spring 2008, and two plots late summer 2008). Two plots (Chignik A7_2 and Karluk C6_1) had no swans on three of four surveys. Mean annual densities equal to or greater than 0.5 swans/km^2 (breeding adults) were observed on several plots in different seasons or years. Stability of density over the years is a concern with regard to survey design because stratum designations were originally assigned by calculating a mean density from the 1980s surveys. In 2003, 35 of 49 plots retained their original stratum designation, while densities increased on nine to a higher stratum and densities declined on five to a lower stratum, resulting in 27 high, 11 medium, and 11 low stratum plots (originally scored as 22 high, 17 medium, and 10 low plots; Table 6 and 7). In 2008, 32 plots of 50 retained their original designation, while seven plots moved to a higher stratum and 11 moved to a lower stratum, resulting in 22 high, 11 medium, and 17 low stratum plots (Table 6, 7). Note that all population estimates above were based on the original stratum designation. Some shift of stratum designation may be expected for plots with original densities close to the stratum breaks, but shifts from low to high or high to low are unexpected. Plots with little potential habitat were especially vulnerable to changes in swan density (e.g., Karluk C6-1, Ugashik D1-4, Naknek A2-3). One of the many implications of a change to stratum designation includes larger variances within each stratum, thus larger confidence intervals.

Survey Issues

We cannot ignore differences in survey methods when we consider differences between the 2003 and 2008 population estimates or when comparing to surveys conducted by Wilk or by MBM. In 2008, we used the Found Bushhawk for the first time. This aircraft was selected for the Alaska Peninsula/Becharof NWR with wildlife surveys in mind: the aircraft has windows down to the cabin floor in both front and rear seats to decrease observations missed under the aircraft. It also lacks struts that could impair vision. However, no direct comparison of visibility has been done between the Cessna 185, the Cessna 206, the Found, and the Beaver used by MBM; and no blind strip estimate is available for the Cessnas. In a comparison of the Aviat Husky, Piper Super Cub, and ACA Scout, Spindler et al. (2000) found differences between aircraft depended on vegetation cover. In 2008, as in the 1980s, paper maps were used to map observations, requiring observers to spend some time away from the survey window. It is possible that this could reduce the number of birds observed. Since the rear seat observers did not have access to the flight position from *Moving Maps* as the front seat observer did in 2008, mapping may have been more difficult for the rear seat observers, especially in areas of uniform terrain. Note that this report restricted 2008 observations to the front right and rear left seats to be comparable to 2003 observer position and number. If all observations were included, a higher estimate would have been obtained for 2008. Although Wilk (1987) discusses the issue of the blind area under the aircraft, it is unclear if his estimates were corrected for this unsurveyed area. The 2003 and 2008 estimates in this paper were not corrected for the blind strip.

Table 6. Comparison of the established plot stratum from 1980s and the calculated mean density/stratum for 2003 and 2008 breeding adult observations, Alaska Peninsula Tundra Swan Survey, 2003 and 2008.

PLOT	EST. POT.L HABITAT (km2)	EST. STRATA	Mean 2003 density	2003 Strata	Mean 2008 density	2008 Strata
Ugashik B4-1	140	H	0.214	H	0.211	H
Dillingham A1-2	148	H	0.220	H	0.220	H
Ugashik D5-1	86	H	0.558	H	0.221	H
Ugashik B5-2	140	H	0.361	H	0.246	H
Ugashik C4-4	138	H	0.326	H	0.257	H
Naknek B4-1	135	H	0.322	H	0.270	H
Chignik D3-3	50	H	0.310	H	0.320	H
Chignik C4-1	97	H	0.500	H	0.330	H
Naknek A3-1	136	H	0.368	H	0.346	H
Naknek C4-3	135	H	0.348	H	0.352	H
Ugashik C4-3	138	H	0.406	H	0.355	H
Naknek D3-3	134	H	0.261	H	0.358	H
Karluk D6-1	41	H	0.427	H	0.390	H
Naknek B4-3	135	H	0.319	H	0.393	H
Naknek C3-4	134	H	0.552	H	0.522	H
Naknek D4-3	18	H	0.25	H	0.528	H
Chignik C6-3	62	H	0.363	H	0.169	M
Ugashik C5-1	138	H	0.312	H	0.174	M
Chignik C5-4	125	H	0.224	H	0.180	M
Ugashik C5-4	83	H	0.261	H	0.170	M
Karluk C6-1	8	H	0.125	M	0.000	L
Ugashik D1-4	26	H	0.077	L	0.038	L
Chignik B3-4	50	M	0.100	M	0.110	M
Chignik C3-2	95	M	0.184	M	0.116	M
Ugashik D4-3	137	M	0.157	M	0.150	M
Chignik C5-3	141	M	0.191	M	0.160	M
Ugashik D4-2	137	M	0.186	M	0.190	M
Bristol Bay A1-2	139	M	0.140	M	0.079	L
Naknek B1-2	58	M	0.112	M	0.086	L
Naknek B3-4	137	M	0.197	M	0.201	H
Naknek D3-1	134	M	0.243	H	0.194	M
Naknek B3-1	137	M	0.288	H	0.208	H
Chignik C2-2	140	M	0.264	H	0.211	H
Dillingham A2-1	149	M	0.211	H	0.221	H
Chignik C1-2	50	M	0.340	H	0.230	H
Ugashik C2-2	25	M	0.220	H	0.280	H
Ugashik B5-4	140	M	0.050	L	0.075	L
Chignik A7-4	123	M	0.057	L	0.081	L
Dillingham A1-1	148	M	0.064	L	0.084	L
Chignik B7-2	34	L	0.000	L	0.015	L
Bristol Bay A2-4	93	L	0.054	L	0.027	L
Naknek B2-3	137	L	0.036	L	0.029	L
Naknek B1-1	70	L	0.064	L	0.043	L
Dillingham A1-4	148	L	0.034	L	0.047	L
Dillingham A1-3	148	L	0.024	L	0.051	L
Naknek B1-4	112	L	0.067	L	0.063	L
Chignik B5-1	25	L	Not surveyed		0.040	L
Naknek A2-3	16	L	0.250	H	0.031	L
Ugashik D1-2	28	L	0.107	M	0.036	L
Naknek A3-2	136	L	0.158	M	0.103	M

Table 7. Comparison of assigned stratum (left) to observed stratum[1] for each year (top), Alaska Peninsula Tundra Swan Survey, 2003 and 2008.

2003	H	M	L	Total
H	20	1	1	22
M	6	8	3	17
L	1	2	7	10
Total	27	11	11	49

Misclassification rate was 29%

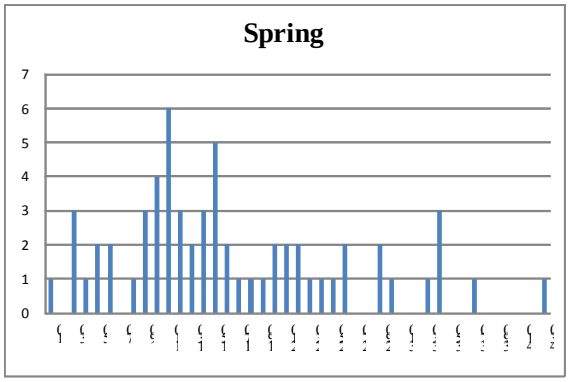
2008	H	M	L	Total
H	16	4	2	22
M	6	6	5	17
L	0	1	10	11
Total	22	11	17	50

Misclassification rate was 36%

[1]Observed stratum calculated from mean density of breeding adults for spring and late summer surveys.

Data regarding observations seen beyond the 0.5 mile viewing transect width were collected in 2008. During the spring survey, observers recorded five singles, nine pairs, one nest (with single), and two flocks from two survey lines (2% of 755 objects observed once). During the fall survey 12 singles, 33 pairs, seven broods (all with singles or pairs), and six flocks were observed from two survey lines (7% of 712 objects observed once).

Data were also collected regarding the agreement of location between the front and rear right seat observers in 2008. In the spring, of 277 observations mapped by both observers, 216 were mapped in the same location, and 61 (22%) were mapped in different locations, varying in perpendicular distance from the plane of 6 to 425 m (Figure 3a). In the late summer, 297 observations were mapped by both observers: 232 were mapped in the same location, and 65 (22%) were mapped in different locations, varying in distance from the plane of 8 to 517 m (Fig. 3b).



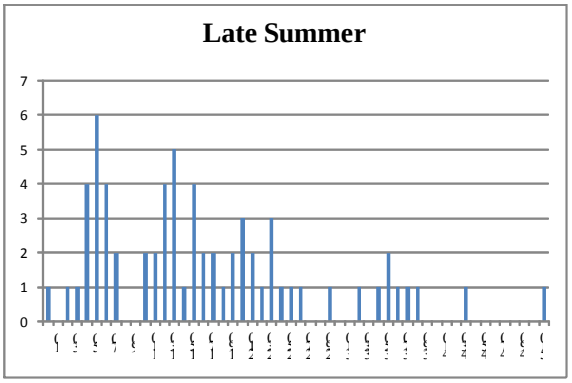


Figure 3a (Spring) and 3b (Lake Summer). Frequency of difference between mapped observations of right seat observers as measured perpendicular to the survey line.

Incidental Observations

Incidental species sightings are summarized in Appendix IV. Of the birds, individual observations of raptors and cranes dominated. These birds are large and frequently in motion which increases their detection. The 100 ptarmigan tallied were observed in one flock. During the summer months, mammals were often difficult to detect because of low contrast between their color and the background. However, it is notable that there were far fewer caribou observed in 2008 than in 2003.

CONCLUSIONS

Since detection is not addressed in this report, we should view these results as indicative of population trend rather than absolute estimates of population size. Initial questions about observer detection and power analysis of the sample stratum and sample size will be addressed in the statistical contract report for the analysis of the 2008 data (Shelly & Reynolds 2010). These data indicate Refuge level population estimates concur with trends observed during the Breeding Population (Bristol Bay stratum) estimates conducted by MBM. However, these results are more specific to the Northern Alaska Peninsula population. Since both spring and late summer data are collected during this survey, more information is available for year specific productivity. Both sets of data indicate tundra swan populations in this area are stable with no significant changes to breeding adults or total swans from the early 1980s or 1991 to 2008. It is noteworthy that the number of cygnets observed and other measures of productivity are lower than those observed in the 1980s; however, the number of young recruited into the breeding population (and not number of young produced) and adult mortality ultimately control adult population levels, and we do not have data on those parameters at the current time. Since adult mortality in this population has potentially increased with the recent legalization of the spring waterfowl hunt, continued monitoring is warranted.

The quality of the estimates is drawn into question by the lack of stability of the stratum designations. For the stratified estimate (with or without ratio estimation), using plot data that have a lower or higher density than the established stratum will increase the estimate of variance,

and therefore the confidence interval. The lack of stability of stratum and its implication for sample design will be further explored in the statistical contract report for the analysis of the 2008 data (Shelly & Reynolds. In preparation). Recommendations from that report should be followed to improve the quality of the population estimate and allow for detection of significant population changes.

The observation that plot stratum has not remained stable over the years brings into question the use of swan density to define stratum. This was initially used as a surrogate for swan habitat in the era when remotely acquired information was extremely limited. Refuge biologists should further explore the feasibility of developing a model (would require ground truthing) linking swan density with some measurable feature on remotely acquired data, and then base stratum on the habitat feature independent of swan density. Remotely sensed habitat data would have to be regularly acquired and updated to determine if stratum changes are occurring. Since we are using swans as an indicator species for other wetland-dependent species, it would be appropriate to track information directly about the habitat as well as population indices.

In future, the influx of trumpeter swans into the area may raise more survey methodology issues. To date, biologists in the state have monitored "white swans" including both species in population estimates where their distributions overlap. Obtaining better habitat information may be the most efficient way to separate the two species for population estimates.

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Appendix I. Statistical Equations Used in the Report

y_{ih}	number of swans (or other measurement) observed in plot i in strata h
x_{ih}	estimated potential habitat area (or other measurement) in plot i in strata h
$\hat{R}$	Ratio estimate
s	Standard deviation
V	Variance of parameter
N	Number of plots in sample universe
N_h	Number of plots in stratum h
n_h	Number of plots sampled in stratum h
A	Potential habitat area in sample universe

Stratified sampling estimate:

$$\overline{y}_h = \frac{\sum_{i=1}^{n_h} y_{ih}}{n_h} \text{ (average abundance in stratum h)}$$

$$\hat{T} = \sum_{h=1}^{3} \overline{y_h} \cdot N_h \text{ (total abundance estimate),}$$

$$V(\hat{T}) = \sum_{h=1}^{3} N_h^2 \cdot \left(\frac{N_h - n_h}{N_h}\right) \cdot \left(\frac{s_h^2}{n_h}\right)$$, where

s_h^2 is the sample variance of abundance in strata h.

For Ratios (i.e., ratio estimate of abundance, Mean Brood Size, Broods/Pair, and Percent Cygnets) in a stratified sample:

$$\hat{R} = \frac{\hat{T}}{\hat{X}} = \frac{\sum \overline{y_h} \cdot N_h}{\sum x_h \cdot N_h}$$, with variance:

$$V(\hat{R}) = \frac{1}{\hat{X}^2} \cdot V(\hat{T})$$

$$V(\hat{T}) = \sum_h \frac{N_h^2 (1 - \frac{n_h}{N_h})}{n_h} \cdot \left[\frac{\sum_{i=1}^{n_h} [(y_{hi} - \overline{y_h}) - \hat{R}(x_{hi} - \overline{x_h})]^2}{n_h - 1} \right].$$

Appendix II. Estimated Costs for Alaska Peninsula Tundra Swan Survey, 2003 and 2008.

	2003				2008		
Item	Hours	Hourly or Gallon Rate	Total		Hours	Hourly or Gallon Rate	Total
Spring Survey, Flight Time/Cost	46	140	6,440.00		43	145	6,275.20
August Survey, Flight Time/Cost	42	140	5,880.00		45	145/425*	8,026.20
Aircraft Fuel = 88 hr *15 gal/hr *3.50/gal		$3.50	4,620.00			$5.80	7,656.00
Total Flight Hours	88		16,940.00		88		21,957.40
Pilot, GS 12 (step 5)	88	35.08	3,087.19		88	39.18	3,447.40
Wildlife Biologist, Flight time (GS 11, step 5 + haz pay)	88	35.13	3,091.08		88	39.23	3,451.80
Wildlife Technician 1, Flight time (GS 5, step 1 + haz pay)	88	16.91	1,487.67		88	18.87	1,660.56
Wildlife Technician 2, Flight time (GS 5, step 1 + haz pay)	-	-	-		88	18.87	1,660.56
Wildlife Biologist, Preparation	8	29.27	234.17		16	32.69	523
Wildlife Technician, Data Management	40	14.09	563.51		100	15.73	1,572.50
Wildlife Biologist, Data Mgmt/Analy	-	-	-		80	32.69	2,615.00
Wildlife Biologist, Report Preparation	60	29.27	1,756.30		60	32.69	1,961.25
Total Staff Hours	372		10,219.92		608		16,892.07
Grand Total			27,159.92				38,849.47
Statistical Contract							15,000

* we had to use a contract pilot to finish the survey in this year which increased flight costs

Appendix III. Raw counts of breeding adults, flocks, broods, cygnets and associated totals, Alaska Peninsula Tundra Swan Survey, 2003 - 2008.

		May 2003					August 2003						
Plot	Strata	Singles + Pairs	# Flocks	Birds in Flocks	Total Adults		Singles + Pairs	# Flocks	Birds in Flocks	Total Adults	# Broods	# Cygnets	Total Swans
BBA1_2	M	23			23		16	2	15	31	1	1	32
BBA2_4	L	7	1	3	10		3			3			3
ChigA7_4	M	6			6		8	1	4	12			12
ChigB3_4	M	2			2		8			8	1	1	9
ChigB5_1		NS	NS	NS	NS		NS	NS	NS	NS	NS	NS	NS
ChigB7_2	L	0			0		0			0			0
ChigC1_2	M	16			16		18	1	7	25			25
ChigC2_2	M	38			38		36	4	41	77	3	3	80
ChigC3_2	M	14			14		21			21	1	1	22
ChigC4_1	H	40			40		57	2	122	179	5	12	191
ChigC5_3	M	26			26		28	1	3	31	1	1	32
ChigC5_4	H	33			33		23	1	9	32	2	4	36
ChigC6_3	H	19	1	3	22		26	3	20	46			46
ChigD3_3	H	10			10		21	3	9	30	4	8	38
DillA1_1	M	8			8		11			11	1	1	12
DillA1_2	H	37			37		28	1	4	32	3	6	38
DillA1_3	L	4			4		3			3	1	2	5
DillA1_4	L	3			3		7			7	1	3	10
DillA2_1	M	33	3	54	87		30	4	31	61			61
KarC6_1	H	0			0		2			2			2
KarD6_1	H	20			20		15			15	2	7	22
NakA2_3	L	6			6		2			2			2
NakA3_1	H	42			42		58	3	27	85	2	7	92
NakA3_2	L	21			21		22	1	6	28	1	1	29
NakB1_1	L	4			4		5	2	6	11			11
NakB1_2	M	8			8		5			5	2	6	11
NakB1_4	L	8			8		7	1	4	11	1	1	12

Appendix III, con't. Raw counts of breeding adults, flocks, broods, cygnets and associated totals, Alaska Peninsula Tundra Swan Survey, 2003 - 2008.

		May 2003					August 2003						
Plot	Strata	Singles + Pairs	# Flocks	Birds in Flocks	Total Adults		Singles + Pairs	# Flocks	Birds in Flocks	Total Adults	# Broods	# Cygnets	Total Swans
NakB2_3	L	2			2		8			8			8
NakB3_1	M	33			33		46	5	20	66	2	3	69
NakB3_4	M	32			32		22	1	3	25			25
NakB4_1	H	35			35		52	1	9	61	1	1	62
NakB4_3	H	43			43		43			43	3	6	49
NakC3_4	H	61			61		87	3	27	114	9	18	132
NakC4_3	H	55	1	4	59		39	2	10	49	5	9	58
NakD3_1	M	27	2	8	35		38	3	16	54	5	11	65
NakD3_3	H	31			31		39	1	9	48	7	17	65
NakD4_3	H	5			5		4			4	2	4	8
UgaB4_1	H	32	1	110	142		28	1	4	32	1	3	35
UgaB5_2	H	44			44		57			57	4	7	64
UgaB5_4	M	7			7		7	1	4	11			11
UgaC2_2	M	10			10		1			1			1
UgaC4_3	H	58	2	9	67		54	2	20	74	1	3	77
UgaC4_4	H	43	1	16	59		47	5	22	69	4	5	74
UgaC5_1	H	47	1	5	52		39	3	10	49			49
UgaC5_4	H	33			33		39	1	4	43	1	2	45
UgaD1_2	L	4			4		2			2			2
UgaD1_4	H	2			2		2	1	3	5			5
UgaD4_2	M	26			26		25			25			25
UgaD4_3	M	27			27		16			16			16
UgaD5/6_1	H	51			51		45	4	18	63	2	2	65
Grand Total		1136	13	212	1348		1200	64	487	1687	79	156	1843

Appendix III, con't. Raw counts of breeding adults, flocks, broods, cygnets and associated totals, Alaska Peninsula Tundra Swan Survey, 2003 - 2008.

		May 2008					August 2008						
Plot	Strata	Singles + Pairs	# Flocks	Birds in Flocks	Total Adults		Singles + Pairs	# Flocks	Birds in Flocks	Total Adults	# Broods	# Cygnets	Total Swans
BBA1_2	M	10			10		12	1	26	38	3	3	41
BBA2_4	L	3			3		2			2			2
ChigA7_4	M	9			9		11	1	3	14	2	7	21
ChigB3_4	M	6			6		5			5	1	3	8
ChigB5_1	L	2			2		0			0			0
ChigB7_2	L	0			0		1			1	1	1	2
ChigC1_2	M	12			12		11			11	1	2	13
ChigC2_2	M	27	1	3	30		32			32	7	17	49
ChigC3_2	M	8			8		14			14	1	1	15
ChigC4_1	H	31			31		33	9	110	143	2	4	147
ChigC5_3	M	19			19		26	2	21	47	4	6	53
ChigC5_4	H	35			35		10	1	6	16	3	6	22
ChigC6_3	H	13			13		8	1	3	11	3	4	15
ChigD3_3	H	10			10		22			22	2	2	24
DillA1_1	M	8			8		17			17	1	1	18
DillA1_2	H	26			26		39	3	16	55			55
DillA1_3	L	5			5		10			10	1	1	11
DillA1_4	L	10			10		4			4			4
DillA2_1	M	42	1	16	58		24	4	27	51	4	4	55
KarC6_1	H	0			0		0			0			0
KarD6_1	H	16	1	14	30		16	2	10	26	1	3	29
NakA2_3	L	0			0		1			1			1
NakA3_1	H	46	1	3	49		48	3	16	64	10	31	95
NakA3_2	L	10			10		18	1	3	21	3	5	26
NakB1_1	L	4			4		2			2			2
NakB1_2	M	4			4		6			6			6
NakB1_4	L	6			6		8			8			8

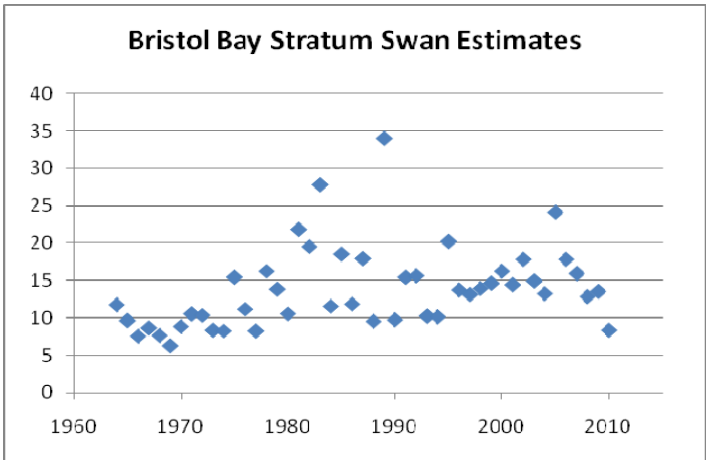
Appendix III, con't. Raw counts of breeding adults, flocks, broods, cygnets and associated totals, Alaska Peninsula Tundra Swan Survey, 2003 - 2008.

		May 2008					August 2008						
Plot	Strata	Singles + Pairs	# Flocks	Birds in Flocks	Total Adults		Singles + Pairs	# Flocks	Birds in Flocks	Total Adults	# Broods	# Cygnets	Total Swans
NakB2_3	L	5			5		3			3			3
NakB3_1	M	21			21		36	1	9	45	2	4	49
NakB3_4	M	18		0	18		37	1	4	41	5	17	58
NakB4_1	H	29		0	29		44	3	23	67	1	2	69
NakB4_3	H	52	1	9	61		54	2	7	61	6	8	69
NakC3_4	H	65	4	20	85		75	10	64	139	11	23	162
NakC4_3	H	40	1	4	44		55	4	31	86	4	10	96
NakD3_1	M	28	2	6	34		24	3	12	36	2	3	39
NakD3_3	H	46		0	46		50	4	15	65	7	17	82
NakD4_3	H	10		0	10		9	1	5	14	3	8	22
UgaB4_1	H	29	6	379	408		30	2	7	37	1	2	39
UgaB5_2	H	37		0	37		32	2	6	38	4	6	44
UgaB5_4	M	10		0	10		11	1	4	15	1	1	16
UgaC2_2	M	6		0	6		8	1	3	11			11
UgaC4_3	H	43		0	43		55	3	12	67	4	4	71
UgaC4_4	H	41		0	41		30		0	30	8	15	45
UgaC5_1	H	23		0	23		25	2	17	42			42
UgaC5_4	H	20		0	20		27		0	27	1	1	28
UgaD1_2	L	0		0	0		2		0	2			2
UgaD1_4	H	0		0	0		2		0	2			2
UgaD4_2	M	23		0	23		29	2	7	36	1	1	37
UgaD4_3	M	22		0	22		19	2	13	32			32
UgaD5/6_1	H	15	3	30	45		23	3	23	46	1	2	48
Grand Total		945	21	484	1429		1060	75	503	1563	112	225	1788

Appendix IV. Observations from the Bristol Bay stratum (23 segments) of the annual Breeding Population Survey, 1964-2010. Estimates in thousands of birds.

Survey Year	Total	Multi-year mean
1964	11.7	
1965	9.6	
1966	7.5	
1967	8.6	
1968	7.6	
1969	6.2	
1970	8.8	8.6
1971	10.5	
1972	10.3	
1973	8.3	
1974	8.2	
1975	15.4	
1976	11.1	
1977	8.2	
1978	16.2	
1979	13.8	
1980	10.5	11.3
1981	21.8	
1982	19.5	
1983	27.8	
1984	11.5	
1985	18.5	
1986	11.8	
1987	17.9	
1988	9.5	
1989	34	
1990	9.7	18.2

Survey Year	Total	Ten year mean
1991	15.4	
1992	15.6	
1993	10.2	
1994	10.1	
1995	20.2	
1996	13.7	
1997	13.1	
1998	13.9	
1999	14.6	
2000	16.2	14.3
2001	14.4	
2002	17.8	
2003	14.9	
2004	13.2	
2005	24.1	
2006	17.8	
2007	15.9	
2008	12.8	
2009	13.5	
2010	8.3	15.3



Appendix V. Observations of other animals made during the Alaska Peninsula Tundra Swan Surveys, 2003 and 2008.

Observation	Spring 2003	Lt. Summer 2003	Spring 2008	Lt Summer 2008
Birds				
Greater white-fronted geese	14	65		
Geese			4	
Willow Ptarmigan		100		
Osprey			2	
Bald Eagle	6	6	2	4
Bald Eagle, nest	3			2
Northern Harrier	1	1		2
Rough-legged Hawk			2	
Golden Eagle			1	
Peregrine Falcon				1
Raptor, Unknown		2		1
Sandhill Crane	18	46		31
Sandhill Crane PR w/ colt		1		
Gull Colony			1	
Parasitic Jaeger				1
Short-eared Owl				1
Mammals				
Bear	11	13	7	37
Bear with Cub	2	4	1	6
Bear Den	2			
Beluga	10		P	>50
Carbou w/ calf			4	
Caribou	347	768	62	10
Caribou Herd			1	
Fox			1	
Moose	1	13	17	7
Moose w/ calf	1	3	2	1
Moose, Bull		1	2	
Seal				>100
Walrus			8	
Walrus, Dead	1			
Wolf			1	3
Wolf Den?			1	