Population Size and Production of Geese and Eiders Nesting on the Yukon-Kuskokwim Delta, Alaska in 1998

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INTRODUCTION:

Annual assessment of nesting populations of geese on the Yukon-Kuskokwim Delta (YKD) provides information for biologists, participants in cooperative goose management plans, and Pacific Flyway technical committees. A ground-based sampling procedure has been used since 1986 to estimate the number of total nests, active nests, and eggs for cackling Canada geese (Branta canadensis minima), emperor geese (Chen canagica), greater white-fronted geese (Anser albifrons frontalis), and spectacled eiders (Somateria fischeri). Annual information on the size of the nesting population and potential number of young produced contributes long term data needed to understand goose and eider population ecology and better manage these species.

Highlights of the 1998 season included: 1) late nesting chronology relative to the previous 5 years; 2) increases in nest numbers from 1997 for spectacled eider, swan, crane, and all geese; and 3) highest recorded number of cackler and white-fronted goose nests since surveys began in 1986.

METHODS:

The ground-based sampling for nests provides a general, long-term monitoring procedure for most of the medium and high density spectacled eider and goose nesting habitat on the coast of the Yukon-Kuskokwim delta.

Boundaries of the sampled area included all refuge-owned lands containing medium and high densities of aerial observations or nests for spectacled eiders. Density data included both air and ground samples from 1985 to 1997. We excluded some high density nesting habitat near Kokechik Bay, 2 patches on South Nelson Island, and several tracts around Hazen Bay because the land was owned by native corporations and in those areas permission to sample plots every year was not assured. The remaining areas formed 1 stratum totaling 683 km^2, or 5.3% of the total coastal zone (Figs. 1 and 2). The coastal zone outside of the ground-sampled stratum was sampled only by aerial transects.

The 1998 design differed from the 1995-97 single stratum design with minor adjustment of boundaries and the addition of a low density stratum between the Aphrewn and Kashunuk Rivers that extended south through the Opagyrak Peninsula to include an upland ridge (Fig. 1). It was included to test the assumption that aerial survey-based expansion factors (i.e., nest/observed birds ratios) are constant among strata within a given year. Additionally, Kigigak Island, with high densities of eiders, was sampled more intensively (4 additional plots for a total of 6 plots). Concurrently, aerial survey transects (see below) were

expanded in 1998 to include more intense coverage in the low density stratum and Kigigak Island. The total area sampled (E3, low density, and Kigigak Island strata) was 854 km^2.

The ground plot survey is linked to an aerial transect survey of the Yukon-Kuskokwim delta, which has been conducted by USFWS, Migratory Bird Management Project, Anchorage, since 1985 (Butler et al. 1988). A pilot and an observer recorded singles, pairs, and flocks of geese, brant, swans, and cranes along approximately 100 systematic transects. Beginning in 1988, a rear-seat observer recorded eiders, other ducks, loons, and gulls. This has provided a precise index to total waterfowl populations on the coastal YKD. Aerial survey data were used to expand the ground-based estimates of nests, active nests, and eggs from the ground-sampled strata to the entire YKD coastal region. The expansion factor was the ratio of the aerial survey breeding population index found in the 12,852 km^2 entire coastal area to the aerial index within the 854 km^2 sampled by ground plots. The breeding population index for most species was based on the number of singles plus number of pairs observed. Single geese observed are assumed to be the mates of unobserved incubating females on nests. For brant and gulls, the total number of birds observed was used, and for swans, half the number of singles plus the number of pairs observed was used as the index to breeding population size to calculate the expansion factor.

Ground plots were 400 x 800 m (0.32 km^2) around a randomly located center point. Plot size was identical to plots searched from 1986-94 and 1997. We used PC ARC/INFO and custom-written TrueBASIC computer programs to randomly select and draw plot boundaries directly onto 1:63,360 scale topographic maps. Even if most or all of a plot was within a river or a large lake, it was still included in the sample. Plot boundaries were transferred to color Xerox copies of color infrared aerial photographs (1:15,000 or 1:10,000). These provided useful field maps to aid in finding plots, searching for nests, and determining exact plot boundaries.

Each plot was searched by 2 biologists who were transported either by Cessna 185 float-equipped aircraft or by motorboat. One of the boat crews worked the lower Aphrewn/Opagyrak River area; the other boat crew worked the Naskonat Peninsula. Most plots were within 2 km walking distance from a river or lake suitable for landing aircraft. All sites dry enough for a nest, particularly lake shores and islands, were examined for all active and destroyed goose, brant, eider, swan, crane, loon, and gull nests. Nests of other species were recorded as encountered but most shorebird, passerine, and duck nests were missed.

We recorded species, nest site, number of eggs, evidence of predation, and other pertinent data on a card for each nest. A few eggs in many clutches were floated to determine the approximate stage of incubation. Even if the adult birds were not observed at the nest, nearly all nests could be identified to species based on down or contour feathers in the nest bowl. Nest cards were tabulated, edited, and sorted using Excel, and data were summarized using TrueBASIC programs.

The estimated total number of nests measured the effective breeding population size (i.e., the number of pairs with nests). The estimated total number of viable eggs found at mid- to late-incubation directly measured the number of young that could potentially augment the fall population if they survived. The mean and variance of the number of nests or eggs per plot was based on a simple random sample of plots within each stratum. The proportion of nests remaining active when the plots were searched was an index to nesting success; the

actual proportion of nests that produced young is lower because of nest loss after the plot search. Also, because the detection rate is lower for nests that fail during laying or early incubation, the nest success index is an overestimate of the proportion surviving even to mid-incubation. The number of eggs per active nest (effective clutch size) and average predicted date of hatch were based on all active nests found on random plots.

Several plots were targeted for double-searches, which was intended to estimate detection rates for spectacled eiders and other waterfowl. Nests on plots designated for double searches were marked with uniquely labeled tongue depressors during the initial search, and recorded as found during the second search by a different crew. Data for detection rates are not yet analyzed and will be reported separate from this report.

RESULTS:

We searched 72 plots from 7-21 June 1998 (Fig. 1). Three crews plus a pilot at the YDNWR Kanagayak field camp searched 25 plots and double-searched 2 plots. YDNWR, USGS/BRD, and University of Alaska Fairbanks biologists from Kigigak Island, Aknerkochik, Manokinak, Hock Slough, Tutakoke, Big Slough, and Opagyrak field camps searched 24 plots, and 2 crews of 2 biologists each operating by motorboat searched 24 plots and double-searched 2 plots. Training and previous field experience varied among participants and was comparable to previous years. Weather was generally cool and breezy, with moderate precipitation.

Search of 72 plots yielded 3,324 nests: 1,602 cackling Canada goose, 281 emperor goose, 392 white-fronted goose, 488 brant, and 68 spectacled eider nests, plus 493 nests of other species. One Steller's eider nest was found. Total estimated nest populations were 103,528 cacklers, 26,799 emperors, 86,466 white-fronts, and 3,624 spectacled eiders (Table 1). Number of nests increased from 1997 (a poor production year due to flooding) for all species, although differences were not significant. Numbers of cackler and white-fronted goose nests are now the highest since nest surveys were begun in 1986 (Table 1, Fig. 3).

A late spring breakup made nest sites available in late May. In 1998, average hatch dates (predicted by egg float angles) were later than the previous 5 years, but about average for 1986-97 for all geese, eiders, cranes, and swans (Table 2, Fig. 4).

Mean active clutch sizes in 1998 was average for most species, although emperor geese seem to exhibit decreasing clutch size over the past 13 years (Fig. 4). The proportions of nests active when found remained high again in 1998 for all species (Fig. 4).

Coefficients of variation (SE/mean) for 1998 nest estimates were lower than the previous 12-year average CV's for all species.

DISCUSSION:

One of the principal objectives of this survey is to precisely estimate the nesting population of spectacled eiders on the YKD. The single stratum design used since 1995 was intended to improve precision of estimates by limiting sampling to high and medium density spectacled eider habitat. Coefficients of variation from 1995-97 (mean = 0.195) are indeed lower than those obtained previously (mean = 0.230 for 1986-94) using different stratification. However, we believe that precision can be further improved by a re-analysis of these data, and possibly a modification of the sampling design. Re-analysis may involve

post-classification based on nest densities, vegetative communities or other topographic features. Additional precision can be obtained by expanding the ground sampled area into Kokechik Bay or other native-owned lands (now excluded from sampled area) with high densities of eiders, thereby reducing the geographic expansion factor and its associated variance.

A primary advantage of the ground plot random sampling procedure over intensive local studies was that it assured applicability to the entire population within the sampled area and not just the immediate areas around intensive biological study camps. The expansion of the ground sample to the entire coastal YKD based on aerial survey data assumed that the ratios of nests to observed single-pairs were the same in the ground plot sampled and unsampled areas. The proportion of nests that remained active and average number of eggs per active nest were also assumed to be the same. The aerial survey-based expansion factors do not require that nest:air observation ratios were the same among years, only that they were constant among strata within a given year. This assumption needs to be investigated further.

Annual changes in nest population size are less informative than long term trends because of sampling error, changes in observers, distribution of plots, and small sample size for some less common species. Only several years of consistent declines or increases are likely to indicate a true population change. We believe that a graphical presentation (Figure 3) enables better interpretation of data than analysis of year-to-year changes in population size. Large annual changes in population size probably reflect sampling error rather than a dramatic, or real, population change. One example is the apparent large increase in spectacled eiders in 1998; although we can not rule out the possibility that the increase was real, the increase could also be explained in part by the high number of plots that by chance were located in high density eider habitat (e.g., lower Kashunuk River). A similar argument could be made for cacklers and white-fronts although it is not unexpected that their populations have truly increased.

This survey is not designed to accurately estimate species with clumped, or colonial, distributions, such as brant and gulls. Consequently, large annual fluctuations and poor precision in annual estimates of population size for these species are likely, although long term averages should be accurate.

Nest plot data show increasing red-throated loon and decreasing Pacific loon populations. These trends are incongruous to those shown from aerial surveys (Groves et al. 1996). We believe species population trends generated using nest plot data may be influenced by unequal attention given to finding loon nests among years and perhaps by incorrect species identification in recent years. However, the trend for both species combined still indicates a 12% average annual decrease since 1989. Eggs and nests of red-throated and Pacific loons are almost impossible to distinguish, and adults usually flush at large distances away from searchers. Species designation based on pond size or whether adults were seen flying over a plot is not reliable. Preliminary data for loons on the Colville River Delta (S. Earnst, pers. comm.) suggest the 2 species may be distinguished by egg size. We intend to measure all loon eggs in the future to help differentiate species, but species-specific trends will probably be dubious for a number of years because of past misidentification problems.

SUGGESTIONS FOR 1999 NEST PLOT WORK

1. Continue with 2 boat and 3 air crews originating from Kanagayak camp.
2. Continue double-searching effort on a limited basis to increase precision of nest detection rates for all species and nest fates (destroyed versus active), especially for spectacled eiders. It is important that as many crews as possible participate in the double-searching effort to ensure applicability of the pooled detection rate to the "average observer or crew".

3. Emphasize training and improve accuracy of species identification by providing searchers with a weatherproof, easy-to-use guide to nests and eggs.

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Table 1. Annual estimates of density and population size of nests in a single stratum of 952 km^2 (1986-1994) or 670 km^2 (1995-97), or 3 strata totalling 854 km^2 (1998) sampled by random plots. The expanded nest population size was determined by the proportion of the aerial observations within the sampled strata compared to the entire coastal YKD survey area of 12,786 km^2. Aerial population indices were based on numbers of singles and pairs, except for black brant, glaucous gull, and mew gull where total birds observed was used, and tundra swan where half the number of singles plus the number of pairs was used.

	Ground plot sampled area:										Expanded to entire coast		
Year	No. plots	Area (km2)	Nests /km2	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Proportion of aerial observations in sampled area of YKD	total nests	active nests	active eggs
Cackling Canada Goose													
86	24	956.1	12.04	11465	1649	0.144	7628	35332	0.665	0.578	19851	13207	61175
87	33	956.1	13.27	12640	1727	0.137	11823	60366	0.935	0.522	24194	22630	115544
88	41	956.1	9.57	9118	1753	0.192	6623	30749	0.726	0.560	16277	11823	54892
89	32	956.1	19.62	18686	3821	0.204	15073	72616	0.807	0.588	31770	25627	123463
90	44	956.1	21.12	20117	2557	0.127	15329	71738	0.762	0.569	35384	26962	126181
91	53	956.1	23.79	22653	2593	0.114	19690	94559	0.869	0.541	41877	36400	174806
92	52	956.1	31.38	29890	3906	0.131	26237	125760	0.878	0.564	52955	46483	222803
93	56	956.1	27.05	25766	3197	0.124	23496	107522	0.912	0.610	42270	38546	176392
94	61	956.1	33.36	31776	2746	0.086	26070	118764	0.820	0.588	54058	44350	202042
95	50	669.7	61.08	40903	5052	0.124	35649	159960	0.872	0.477	85751	74736	335346
96	54	669.7	55.50	37171	4515	0.121	33933	154024	0.913	0.491	75705	69110	313695
97	75	669.7	50.45	33784	4122	0.122	27910	112660	0.826	0.468	72219	59662	240829
98	72	856.6	59.15	50749	5064	0.100	47270	215373	0.931	0.490	103528	96431	439361
						0.133			0.840	0.542			
Emperor Goose													
86	24	956.1	10.10	9619	1548	0.161	7270	38426	0.756	0.388	24777	18726	98979
87	33	956.1	11.82	11259	1368	0.122	10562	53093	0.938	0.366	30758	28854	145042
88	41	956.1	9.08	8643	1306	0.151	7548	37726	0.873	0.365	23656	20659	103258
89	32	956.1	16.86	16058	1803	0.112	14896	76235	0.928	0.405	39661	36791	188291
90	44	956.1	12.32	11729	1296	0.11	10158	50963	0.866	0.396	29582	25620	128534
91	53	956.1	15.78	15033	1772	0.118	14638	73501	0.974	0.421	35746	34807	174773
92	52	956.1	14.57	13876	1479	0.107	13349	67208	0.962	0.434	31984	30769	154912
93	56	956.1	12.75	12144	1335	0.11	11468	54964	0.944	0.460	26384	24915	119414
94	61	956.1	17.21	16389	1525	0.093	15378	75606	0.938	0.439	37324	35021	172182
95	50	669.7	13.61	9113	1059	0.116	8816	42980	0.977	0.302	30175	29192	142318
96	54	669.7	15.43	10335	1033	0.1	9749	49952	0.943	0.334	30943	29189	149557
97	75	669.7	9.88	6619	677	0.102	6343	30309	0.958	0.311	21269	20382	97394
98	72	856.6	11.65	9996	1041	0.104	9485	44317	0.949	0.373	26799	25429	118814
						0.116			0.924	0.384			
White-fronted Goose													
86	24	956.1	5.03	4786	1039	0.217	4688	20103	0.980	0.239	20008	19598	84042
87	33	956.1	5.32	5063	869	0.172	4944	23286	0.977	0.174	29064	28381	133674
88	41	956.1	4.36	4152	744	0.179	4101	18000	0.988	0.237	17544	17328	76057
89	32	956.1	6.42	6116	1413	0.231	6050	28373	0.989	0.209	29278	28962	135825
90	44	956.1	8.87	8450	1033	0.122	7982	36406	0.945	0.215	39346	37167	169517
91	53	956.1	10.99	10463	1111	0.106	9970	46436	0.953	0.206	50782	48389	225375
92	52	956.1	12.70	12100	1168	0.097	11860	52901	0.980	0.272	44466	43584	194404
93	56	956.1	9.68	9215	1080	0.117	8770	37349	0.952	0.257	35862	34130	145350
94	61	956.1	11.52	10975	1059	0.096	10701	46616	0.975	0.222	49518	48282	210326
95	50	669.7	13.96	9350	1025	0.11	9083	38380	0.975	0.162	57716	56068	236914
96	54	669.7	17.95	12023	1218	0.101	11575	52088	0.963	0.175	68585	66030	297136
97	75	669.7	15.15	10149	1053	0.104	9984	42913	0.984	0.162	62532	61516	264405
98	72	856.6	16.95	14538	1336	0.092	14154	60969	0.974	0.168	86466	84182	362619
						0.134			0.972	0.208			
Black Brant													

	Ground plot sampled area:										Expanded to entire coast		
Year	No. plots	Area (km2)	Nests /km2	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Proportion of aerial observations in sampled area of YKD	total nests	active nests	active eggs
86	24	956.1	4.62	4399	3202	0.728	3562	14718	0.810				
87	33	956.1	6.76	6434	1695	0.263	5567	21523	0.865	0.541	11895	10292	39791
88	41	956.1	4.05	3861	1937	0.502	3159	11881	0.818	0.504	7662	6269	23577
89	32	956.1	24.83	23651	19125	0.809	21456	85143	0.907	0.492	48102	43638	173167
90	44	956.1	10.83	10315	4824	0.468	6416	21446	0.622	0.438	23560	14654	48983
91	53	956.1	13.25	12615	5762	0.457	11453	41220	0.908	0.531	23772	21582	77675
92	52	956.1	28.08	26742	11345	0.424	25790	101505	0.964	0.482	55432	53459	210405
93	56	956.1	16.88	16081	6621	0.412	13583	46818	0.845	0.463	34705	29314	101039
94	61	956.1	17.72	16875	4277	0.253	15472	60296	0.917	0.497	33968	31144	121371
95	50	669.7	8.69	5818	2917	0.501	4185	15019	0.719	0.299	19458	13997	50231
96	54	669.7	5.66	3789	1890	0.499	3307	12402	0.873	0.197	19204	16761	62859
97	75	669.7	5.11	3420	1278	0.374	3227	11390	0.944	0.343	9985	9422	33255
98	72	856.6	17.73	15213	5482	0.360	13025	47508	0.856	0.319	47703	40842	148971
						0.465			0.850	0.425			
Tundra Swan													
86	24	956.1	1.19	1130	288	0.255	1130	3812	1.000	0.176	6437	6437	21713
87	33	956.1	1.23	1173	323	0.275	1173	4267	1.000	0.182	6448	6448	23455
88	41	956.1	1.47	1400	321	0.229	1400	6490	1.000	0.199	7044	7044	32655
89	32	956.1	1.22	1166	336	0.288	1166	5268	1.000	0.174	6683	6683	30193
90	44	956.1	1.48	1408	250	0.178	1375	5886	0.977	0.165	8525	8325	35638
91	53	956.1	0.97	922	196	0.213	873	3411	0.947	0.174	5307	5025	19635
92	52	956.1	1.46	1392	173	0.124	1392	5266	1.000	0.158	8831	8831	33408
93	56	956.1	1.42	1351	258	0.191	1333	5288	0.987	0.165	8164	8055	31953
94	61	956.1	1.40	1335	258	0.193	1335	5786	1.000	0.161	8300	8300	35971
95	50	669.7	1.02	683	127	0.186	623	2345	0.912	0.117	5838	5325	20043
96	54	669.7	1.59	1068	165	0.154	1033	5064	0.968	0.099	10766	10413	51048
97	75	669.7	1.44	965	141	0.146	910	3833	0.943	0.098	9857	9295	39152
98	72	856.6	1.98	1697	207	0.122	1606	5346	0.946	0.124	13647	12915	42991
						0.196			0.975	0.153			
Sandhill Crane													
86	24	956.1	0.67	641	243	0.379	641	879	1.000				
87	33	956.1	0.93	884	312	0.353	766	1353	0.867	0.123	7190	6230	11005
88	41	956.1	1.64	1563	319	0.204	1563	3030	1.000	0.146	10709	10709	20759
89	32	956.1	0.70	668	223	0.334	566	1132	0.847	0.108	6198	5252	10504
90	44	956.1	1.98	1886	312	0.165	1837	3254	0.974	0.110	17153	16708	29596
91	53	956.1	1.75	1669	378	0.226	1669	3122	1.000	0.114	14583	14583	27279
92	52	956.1	1.55	1474	285	0.193	1416	2474	0.961	0.137	10752	10329	18047
93	56	956.1	1.25	1195	294	0.246	1071	1641	0.896	0.126	9513	8526	13064
94	61	956.1	1.63	1555	256	0.165	1555	2797	1.000	0.152	10260	10260	18455
95	50	669.7	1.37	920	144	0.157	861	1633	0.967	0.097	9485	8876	16835
96	54	669.7	1.90	1275	199	0.156	1240	2343	0.973	0.097	13185	12823	24230
97	75	669.7	1.40	938	169	0.18	938	1737	1.000	0.110	8551	8551	15834
98	72	856.6	1.50	1287	203	0.158	1287	2267	1.000	0.095	13552	13552	23872
						0.224			0.960	0.118			
Spectacled Eider													
86	24	956.1	3.06	2915	828	0.284	1867	8307	0.640				
87	33	956.1	2.41	2299	439	0.191	1684	8545	0.732				
88	41	956.1	2.33	2220	676	0.305	2072	10044	0.933	0.421	5273	4922	23858
89	32	956.1	2.20	2095	485	0.232	1861	8994	0.888	0.377	5563	4942	23882
90	44	956.1	2.12	2021	415	0.205	1838	9899	0.909	0.452	4473	4068	21911
91	53	956.1	1.58	1502	362	0.241	1315	6905	0.876	0.636	2360	2066	10851
92	52	956.1	1.38	1318	283	0.215	1127	6168	0.855	0.678	1943	1662	9094
93	56	956.1	1.50	1425	327	0.229	1216	5293	0.853	0.802	1777	1517	6602
94	61	956.1	1.84	1752	298	0.17	1290	6233	0.736	0.685	2559	1884	9105
95	50	669.7	2.93	1959	390	0.199	1573	7925	0.803	0.665	2946	2365	11917

				Ground plot sampled area:							Expanded to entire coast		
Year	No. plots	Area (km2)	Nests /km2	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Proportion of aerial observations in sampled area of YKD	total nests	active nests	active eggs
96	54	669.7	2.78	1860	353	0.19	1516	7682	0.815	0.604	3080	2511	12723
97	75	669.7	2.35	1572	363	0.231	1407	6178	0.897	0.626	2511	2247	9867
98	72	856.6	2.67	2293	364	0.159	2168	10519	0.945	0.633	3624	3426	16623
						0.219			0.837	0.598			
Common Eider													
86	24	956.1	0.05	49	49	1	0	0	0.000				
87	33	956.1	0.29	279	149	0.534	160	991	0.573				
88	41	956.1	0.36	347	172	0.496	347	1736	1.000	0.429	810	810	4051
89	32	956.1	1.37	1309	528	0.403	1309	7220	1.000	0.000			
90	44	956.1	0.31	293	118	0.403	198	873	0.676	0.000			
91	53	956.1	0.70	671	308	0.459	597	2818	0.890	0.142	4725	4204	19843
92	52	956.1	0.95	903	439	0.486	883	4539	0.978	0.000			
93	56	956.1	0.46	436	188	0.431	259	1337	0.594	0.402	1086	645	3329
94	61	956.1	0.69	659	262	0.398	579	2465	0.879	0.720	915	804	3422
95	50	669.7	0.75	505	231	0.457	475	2404	0.941	0.442	1143	1075	5439
96	54	669.7	1.08	723	254	0.351	689	3652	0.952	0.377	1916	1826	9679
97	75	669.7	0.99	662	256	0.387	607	2758	0.917	0.330	2006	1839	8358
98	72	856.6	1.01	868	223	0.257	677	3340	0.780	0.373	2326	1814	8952
						0.466			0.783	0.292			
Pacific Loon													
86	24	956.1	1.89	1802	479	0.266	1218	1575	0.676				
87	33	956.1	2.35	2235	547	0.245	2204	3992	0.986				
88	41	956.1	1.42	1348	303	0.225	1297	2349	0.962				
89	32	956.1	1.95	1857	513	0.276	1857	3596	1.000	0.043	43404	43404	84049
90	44	956.1	2.28	2173	294	0.135	2014	3764	0.927	0.097	22434	20792	38859
91	53	956.1	2.83	2694	373	0.138	2535	4551	0.941	0.104	25986	24452	43898
92	52	956.1	1.72	1634	319	0.195	1570	2682	0.961	0.067	24287	23336	39864
93	56	956.1	1.49	1417	327	0.231	1417	2609	1.000	0.122	11650	11650	21451
94	61	956.1	1.14	1088	252	0.232	1088	2045	1.000	0.090	12054	12054	22657
95	50	669.7	1.06	712	188	0.264	712	1217	1.000	0.041	17366	17366	29683
96	54	669.7	0.26	172	88	0.512	172	241	1.000	0.040	4354	4354	6101
97	75	669.7	0.62	414	109	0.263	386	717	0.933	0.067	6188	5770	10717
98	72	856.6	1.42	1212	220	0.182	1103	1898	0.910	0.074	16310	14843	25541
						0.243			0.946	0.074			
Red-throated Loon													
86	24	956.1	0.41	392	130	0.332	392	442	1.000				
87	33	956.1	0.07	63	62	0.984	63	126	1.000				
88	41	956.1	0.00	0	0		0	0					
89	32	956.1	0.13	122	86	0.705	122	188	1.000	0.080	1516	1516	2336
90	44	956.1	0.75	719	234	0.325	719	1141	1.000	0.170	4222	4222	6700
91	53	956.1	0.36	341	142	0.416	281	489	0.824	0.250	1364	1124	1956
92	52	956.1	0.51	486	146	0.3	422	780	0.868	0.104	4686	4069	7520
93	56	956.1	0.39	373	156	0.418	335	669	0.898	0.205	1819	1634	3263
94	61	956.1	0.34	322	139	0.432	322	592	1.000	0.164	1969	1969	3620
95	50	669.7	0.89	594	156	0.263	594	1128	1.000	0.124	4790	4790	9097
96	54	669.7	0.62	413	151	0.366	413	758	1.000	0.092	4499	4499	8257
97	75	669.7	0.74	496	158	0.319	496	965	1.000	0.100	4985	4985	9698
98	72	856.6	0.68	587	227	0.387	550	1064	0.937	0.219	2677	2508	4853
						0.437			0.961	0.151			
Glaucous Gull													
86	24	956.1	1.97	1873	486	0.259	1257	2351	0.671				
87	33	956.1	1.66	1580	504	0.319	1580	3884	1.000				

	Ground plot sampled area:										Expanded to entire coast		
Year	No. plots	Area (km2)	Nests /km2	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Proportion of aerial observations in sampled area of YKD	total nests	active nests	active eggs
88	41	956.1	2.46	2343	908	0.388	2190	5507	0.935				
89	32	956.1	1.97	1873	735	0.392	1761	4520	0.940				
90	44	956.1	3.41	3249	528	0.163	2576	6900	0.793				
91	53	956.1	2.82	2689	787	0.293	2235	6107	0.831				
92	52	956.1	3.56	3391	1169	0.345	3153	8542	0.930	0.420	8070	7504	20328
93	56	956.1	2.34	2231	563	0.252	2163	5581	0.970	0.224	9946	9643	24881
94	61	956.1	3.79	3610	432	0.12	3547	10004	0.983	0.182	19815	19469	54911
95	50	669.7	3.15	2107	601	0.285	2107	5462	1.000	0.163	12926	12926	33509
96	54	669.7	1.34	896	260	0.29	896	2239	1.000	0.154	5803	5803	14501
97	75	669.7	3.42	2289	1066	0.466	2261	5654	0.988	0.226	10151	10027	25073
98	72	856.6	4.38	3760	1820	0.484	3687	9761	0.981	0.146	25717	25217	66760
						0.312			0.925	0.217			
Mew Gull													
86	24	956.1	0.75	711	349	0.491	711	1446	1.000				
87	33	956.1	0.60	575	303	0.527	575	1090	1.000				
88	41	956.1	2.95	2814	2502	0.889	2764	7326	0.982				
89	32	956.1	1.66	1583	541	0.342	1481	3699	0.936				
90	44	956.1	1.32	1257	614	0.488	1207	2891	0.960				
91	53	956.1	0.89	846	328	0.388	736	1783	0.870				
92	52	956.1	1.93	1835	500	0.272	1687	4257	0.919	0.156	11797	10846	27368
93	56	956.1	2.13	2033	1122	0.552	2033	5586	1.000	0.246	8257	8257	22688
94	61	956.1	1.85	1762	212	0.12	1722	4429	0.977	0.368	4792	4683	12045
95	50	669.7	1.95	1306	377	0.289	1306	3384	1.000	0.210	6219	6219	16114
96	54	669.7	1.08	723	219	0.303	723	1929	1.000	0.185	3917	3917	10450
97	75	669.7	0.37	248	77	0.31	248	607	1.000	0.323	767	767	1877
98	72	856.6	1.52	1308	453	0.346	1308	3130	1.000	0.179	7318	7318	17511
						0.409			0.973	0.238			

Table 2. Annual proportion of nests remaining active at first plot search, mean clutch size of apparently viable eggs found in actively incubated nests, and predicted mean date of hatch based on egg float angles. Means are calculated considering each nest found on a random ground plot as a sample unit rather than using cluster sampling or stratification.

	Proportion of Nests Active		Clutch Size (Active Nests)		Predicted Hatch Date (June1=601, July1=701)			
year	prop.	n	eggs	n	avg.	min	max	n
Cackling Canada Goose								
86	0.589	265	4.82	156	629.6	614	713	144
87	0.907	270	5.08	245	628.7	621	718	83
88	0.769	281	4.59	215	623.8	613	710	68
89	0.853	434	4.84	370	629.9	621	710	53
90	0.742	512	4.58	380	623.3	612	706	175
91	0.857	669	4.66	573	622.2	611	703	351
92	0.895	669	4.75	599	629.6	620	718	390
93	0.885	705	4.51	624	623.8	609	706	359
94	0.814	625	4.59	509	618.8	609	709	411
95	0.872	1378	4.49	1201	619.8	611	703	721
96	0.913	1079	4.54	985	616.9	608	703	754
97	0.826	1225	4.04	1012	616.5	604	704	812
98	0.936	1603	4.54	1482	625.2	612	639	888
86	0.684	158	5.40	108	627.0	91	709	98
87	0.914	232	5.19	212	627.1	619	707	90
88	0.889	217	5.10	193	621.0	616	704	66
89	0.916	322	5.12	295	630.0	619	707	63
90	0.863	336	4.95	290	620.3	610	630	88
91	0.947	380	4.97	360	619.2	611	702	256
92	0.959	270	5.02	259	628.3	620	709	181
93	0.954	306	4.86	292	621.2	612	705	139
94	0.939	328	4.92	308	618.6	611	630	192
95	0.967	307	4.88	297	617.7	611	706	187
96	0.943	300	5.12	283	615.4	605	623	186
97	0.958	240	4.78	230	614.7	607	630	153
98	0.954	281	4.70	380	624.0	616	703	215
White-fronted Goose								
86	0.937	63	4.17	59	626.9	622	712	54
87	0.930	86	4.55	80	626.6	620	702	39
88	0.963	82	4.45	79	621.9	615	703	31
89	0.991	112	4.52	111	627.4	621	704	21
90	0.936	173	4.60	162	621.5	610	629	52
91	0.935	214	4.65	200	621.0	611	703	138
92	0.971	204	4.48	198	629.0	619	708	110
93	0.970	199	4.31	193	623.3	617	706	84
94	0.973	222	4.36	216	618.6	610	629	129
95	0.972	316	4.22	307	620.7	609	701	178
96	0.963	349	4.50	336	617.9	608	701	143
97	0.984	368	4.30	362	617.5	606	629	184
98	0.974	392	4.32	380	625.3	617	706	261
Black Brant								
86	0.631	111	4.14	70	625.9	622	629	6
87	0.933	313	4.39	292	625.9	622	701	18
88	0.644	222	3.41	143	618.9	613	703	36
89	0.929	1011	3.76	939	626.7	620	706	40
90	0.710	428	3.26	304	619.1	615	627	50
91	0.867	542	3.70	470	618.4	613	701	184
92	0.963	898	3.95	865	626.0	619	706	152
93	0.852	562	3.54	479	620.6	613	628	107
94	0.883	274	3.86	242	616.2	610	628	93
95	0.719	196	3.59	141	618.1	612	701	44
96	0.873	110	3.75	96	616.7	611	626	44
97	0.944	124	3.50	117	614.1	604	624	100
98	0.875	488	3.66	427	623.3	616	704	260

Table 2. (Continued) Annual proportion of active nests, mean clutch size, and predicted mean date of hatch.

year	Proportion of Nests Active: prop.	n	Clutch Size (Active Nests): eggs	n	Predicted Hatch Date (June1=601, July1=701): avg.	min	max	n
Tundra Swan								
86	1.000	14	3.89	14	627.8	624	701	9
87	1.000	17	3.79	17	627.7	621	702	8
88	1.000	24	4.60	24	626.5	617	705	4
89	1.000	24	4.29	24	630.7	627	703	4
90	0.964	28	4.09	27	623.9	620	626	4
91	0.926	27	4.20	25	624.1	617	708	12
92	1.000	20	3.80	20	630.0	624	708	8
93	0.964	28	4.04	27	626.0	619	702	6
94	1.000	27	4.33	27	621.3	611	630	9
95	0.913	23	3.76	21	625.2	621	702	9
96	0.968	31	4.90	30	619.1	611	629	9
97	0.943	35	4.21	33	614.3	610	626	8
98	0.952	42	3.32	38	630.4	623	712	20
Sandhill Crane								
86	0.938	16	1.67	15	627.2	616	710	11
87	0.958	24	1.63	23	625.2	618	710	10
88	1.000	34	1.94	34	619.1	618	624	6
89	0.850	20	1.88	17	619.8	617	622	2
90	0.979	47	1.75	46	617.9	615	622	9
91	0.980	50	1.95	49	616.4	610	628	25
92	0.967	30	1.83	29	629.2	625	705	9
93	0.943	35	1.67	33	619.0	614	629	14
94	1.000	32	1.80	32	613.6	611	615	5
95	0.935	31	1.90	29	617.5	612	630	10
96	0.973	37	1.89	36	614.1	609	625	14
97	1.000	34	1.84	34	614.3	610	626	8
98	1.000	35	1.77	35	620.6	615	626	19
Spectacled Eider								
86	0.658	38	4.34	25	702.2	624	710	15
87	0.831	65	5.03	54	628.7	623	706	16
88	0.731	67	4.98	49	626.6	619	702	17
89	0.927	41	5.05	38	702.1	622	707	5
90	0.927	41	5.26	38	623.0	618	627	15
91	0.875	40	5.43	35	621.3	615	710	25
92	0.889	27	5.63	24	702.4	625	714	17
93	0.868	38	4.43	33	624.5	616	709	18
94	0.714	35	4.80	25	622.0	611	706	14
95	0.803	66	5.04	53	623.6	613	704	44
96	0.815	54	5.07	44	618.2	612	702	33
97	0.895	57	4.39	51	619.0	610	630	39
98	0.941	68	4.84	64	627.9	617	707	52
Common Eider								
86	0.500	4	3.50	2				
87	0.857	14	5.83	12	701.0	628	708	4
88	0.704	27	4.61	18				
89	1.000	31	5.52	31	702.0	629	708	4
90	0.929	14	5.31	13	621.5	620	623	2
91	0.865	37	5.00	32	626.4	618	705	27
92	0.941	17	5.25	16	702.2	626	706	12
93	0.600	15	5.11	9	623.7	617	627	5
94	0.857	14	4.24	12	623.4	615	704	9
95	0.941	17	5.06	16	623.4	614	702	13
96	0.952	21	5.30	20	618.4	611	702	14
97	0.917	24	4.55	22	619.4	609	701	14
98	0.781	32	5.00	25	628.0	620	704	18

Table 2. (Continued) Annual proportion of active nests, mean clutch size, and predicted mean date of hatch.

	Proportion of Nests Active		Clutch Size (Active Nests)		Predicted Hatch Date (June1=601, July1=701)			
year	prop.	n	eggs	n	avg.	min	max	n
Pacific Loon								
86	0.900	30	1.58	26	705.7	701	725	19
87	0.930	43	1.85	40	704.3	627	712	23
88	0.860	43	1.75	37	629.3	623	705	4
89	0.977	43	1.81	42	704.5	627	715	4
90	0.912	34	1.90	31	630.2	624	709	8
91	0.929	56	1.87	52	624.8	616	630	15
92	0.935	31	1.79	29	706.5	629	718	9
93	1.000	35	1.82	35	624.4	617	630	9
94	1.000	22	1.86	22	626.1	622	629	4
95	1.000	24	1.71	24	626.3	620	701	7
96	1.000	5	1.40	5	623.6	621	701	4
97	0.933	15	1.86	14	623.5	619	630	8
98	0.919	37	1.76	34	702.9	625	714	20
Red-throated Loon								
86	0.600	5	1.33	3	713.0	720	720	1
87	1.000	5	1.80	5	629.1	629	630	2
88	0.778	9	1.57	7	616.0	616	616	1
89	1.000	2	1.50	2	622.0	622	622	1
90	0.923	13	1.58	12	701.7	629	704	3
91	0.909	11	1.70	10	700.1	627	704	6
92	0.900	10	1.89	9	704.1	703	705	3
93	0.917	12	2.00	11	627.0	624	704	3
94	1.000	7	1.86	7	619.5	618	621	2
95	1.000	20	1.90	20	623.9	622	627	3
96	1.000	12	1.83	12	621.0	616	626	5
97	1.000	18	1.94	18	620.1	616	627	9
98	0.947	19	1.94	18	627.3	620	708	17
Glaucous Gull								
86	0.800	30	2.22	24	625.8	622	705	10
87	1.000	49	2.33	49	628.2	621	710	16
88	0.932	74	2.44	69	624.8	615	708	9
89	0.894	47	2.49	42	622.4	622	623	3
90	0.839	56	2.64	47	617.0	617	617	2
91	0.826	92	2.75	76	617.7	612	703	26
92	0.947	75	2.75	71	626.1	622	704	23
93	0.983	59	2.64	58	619.2	615	707	11
94	0.981	54	2.77	53	616.4	611	627	17
95	1.000	71	2.59	71	617.4	614	626	18
96	1.000	26	2.50	26	614.1	611	620	15
97	0.988	83	2.47	82	616.4	609	629	19
98	0.983	116	2.67	114	621.6	615	639	64
Mew Gull								
86	0.923	13	2.25	12	703.5	622	712	10
87	1.000	19	2.29	19	627.1	621	704	5
88	0.977	43	2.68	41	618.0	614	624	4
89	0.918	49	2.58	45	622.0	622	622	1
90	0.960	25	2.54	24	621.4	617	626	2
91	0.857	42	2.58	36	619.4	614	702	8
92	0.941	34	2.56	32	627.0	623	704	10
93	1.000	92	2.76	92	624.1	617	702	7
94	0.963	27	2.54	26	614.4	610	621	8
95	1.000	44	2.59	44	617.6	615	622	16
96	1.000	21	2.67	21	613.5	608	620	10
97	1.000	9	2.44	9	618.8	615	627	8
98	1.000	40	2.42	40	623.8	619	704	19