Population Size and Production of Geese and Eiders Nesting on the Yukon-Kuskokwim Delta, Alaska in 1995

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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 to the long term data needed to understand goose population ecology and better manage these species.

In 1995, changes in survey design reflected an increased priority on obtaining precise estimates of the size of the spectacled eider nesting population, with secondary emphasis on geese. Additionally, we estimated detection rates of waterfowl nests by double-searching a sample of plots, although these data will be reported separate from this report.

METHODS:

In 1995, the ground-based sampling for nests was based on a single stratum design. We reduced the size of the sampled stratum from that used in 1994 to improve sampling efficiency and the precision of estimates for spectacled eiders. The design 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.

The boundary of the single stratum used in 1995 included all areas containing medium and high densities of aerial observations or nests for spectacled eiders (Fig. 1). Density data included both air and ground samples from 1985 to 1994. We excluded 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 670 km^2 (Fig. 1), or 5.2% of the total coastal zone. Area in the coastal zone outside of the ground-sampled stratum was sampled only by aerial transects.

The ground plot survey is linked to the aerial transect survey flown since 1985 by W.I. Butler, Jr., USFWS, Migratory Bird Management Project, Anchorage. 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. Boundaries for 16 aerial sampling strata were based on physiographic regions. Features such as lake size, prevalence of ponds, homogeneous sedge meadow, and upland tundra that were visible on Landsat images at 1:250,000 scale determined the strata boundaries. The aerial data were analyzed by a 10 stratum design that grouped the original 16 strata into 8 strata based on aerial sampling intensity and subdivided 2 of these strata into regions sampled or not sampled by ground plots.

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 inverse of the proportion of the aerial breeding population index found in the stratum sampled by ground plots compared to the population index in the entire area. 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 (# breeding pairs) to calculate the expansion factor.

Ground plots were 950 m (0.57 mi) long and 475 m (0.28 mi) wide oriented east-west around a random center point. We used computer programs (PC ARC/INFO, and custom-written TrueBASIC) to randomly select plot centers 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.

Biologists who searched each plot were transported either by Cessna 185 float-equipped aircraft or by boat. Most plots were within 2 km walking distance from a lake or river suitable for landing aircraft. Each plot was completely searched on a single visit. Nest searching took 2 people 1.5-10 hours (mean = 5 hrs) depending on the complexity of the habitat and the number of nests found. All possible sites dry enough for a nest, particularly on 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. A small fraction of the goose (<1%) and loon (10%) nests were not identified to species and these unknowns were included in population estimates as cackling Canada goose, or Pacific loon. These species were more commonly found compared to other species of geese or red-throated loons. Nest cards were tabulated, edited, and sorted using dBase.

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 determined the number of young that have some potential to survive to the fall population. The mean number of nests or eggs per plot was based on a simple random sample of plots within the stratum. We also calculated the unweighted average proportion of nests remaining active when the plots were searched (an index to the weighted average for nesting success).

The number of eggs per active nest (effective clutch size) and average predicted date of hatch were based on all active nests found on the random plots. These 2 parameters considered each nest as an independent sampling unit; nests were not weighted by stratum area or population size, nor was cluster sampling by plots considered.

RESULTS:

Between 3-17 June 1995, 50 plots were searched (Fig. 2). Up to 6 biologists plus a pilot at the YDNWR Kanagayak field camp worked on 13 days to search 23 plots, research biologists from Kigigak Island, Manokinak, Hock Slough, and Old Chevak field camps searched 17 plots, and a crew of 2 biologists operating by motorboat searched 10 plots. Search of 50 plots yielded 2698 nests: 1374 cackling Canada goose, 307 emperor goose, 316 white-fronted goose, 196 brant, and 66 spectacled eider nests, plus 439 nests of other species (Table 2).

Cackling Canada and white-fronted goose nesting populations continued their upward trend and are at their highest levels since these surveys were begun in 1986. The total estimated nests were 85,751 cacklers, 29,881 emperors, 57,531 white-fronts, and 2968 spectacled eiders (Table 2). Estimates for emperor geese were lower than 1994 estimates, but similar to the average nesting population size for the previous 9 years (Table 1). Numbers of spectacled eider nests increased from 1994.

Sparse snow cover and early melting made nest sites available in mid-May. In 1995, average hatch dates (predicted by egg float angles) for cacklers, white-fronted geese, and brant were the second earliest since 1986, with 1994 the only earlier year (Table 1).

For all species of geese, clutch size was smaller in 1995 than in 1994. Mean active clutch sizes in 1995 for cacklers, emperors, whitefronts, and brant were small and ranked 10, 9, 9, and 7, respectively, out of the previous 10 years (Table 1).

Generally, indices to nest success were relatively high for most species. Nesting success in 1995 ranked 4, 1, 3, and 7 for cacklers, emperors, whitefronts, and brant, respectively, in comparison to the highest unweighted nest success indices shown in the last 10 years (Table 1). Predation by foxes and avian predators was not severe. A black

bear (Ursus americana) visited one plot near the mouth of the Tutakoke River and evidently gorged on eggs.

Coefficients of variation (SE/mean) for 1995 nest estimates were slightly higher than in 1994 (which may be biased low because plots selected in 1994 were a subset from previous years), but lower than the 10-year average CV's for all species except brant.

DISCUSSION:

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 remain active and average number of eggs per active nest are also assumed to be the same. The aerial survey based expansion factors do not require that nest:air observation ratios are the same among years, only that they are constant among strata within a given year.

Although the spectacled eider nesting population seems to have increased by 14% from 1994, we believe that the number of nests was overestimated slightly in 1995. Two areas within the strata (west bank of Aphrewn River, southeast section of Naskonat Peninsula), where past surveys have indicated lower densities of eiders, were not sampled because of difficult accessability. Consequently, areas of higher eider densities were sampled more intensively. The trajectory and magnitude of increase in nests was, however, consistent with aerial survey data, which showed a 9% increase in the number of spectacled eider breeding pairs from 1994 to 1995.

In the future, searched plots should be distributed throughout the stratum without large unsampled areas to avoid this potential bias. Continued reliance on mobile boat-based crews may enable more thorough coverage of the strata because boat crews can generally access many plots not accessable by float plane and are less inhibited by inclement weather that prevents travel by plane.

Plots took longer to search this year than they have in previous years, thus fewer plots were sampled. Several factors contributed to the increased time requirements for searching plots: 1) plots were about 40% larger than in previous years, 2) the new stratification concentrated plots in areas of high bird densities, 3) goose densities have increased on the YDNWR, and 4) extra time was spent marking nests and eggs, which was necessary to determine nest detection rates. The cumulative effect of these factors was that it was virtually impossible for a Kanagyak-based crew to search more than one plot per day.

Although the changes in design (i.e., reduction in stratum size, increased plot size) were intended to provide more precise estimates of spectacled eiders, precision was good for most other species as well. The reduction in number of plots searched (due to increased time requirements) was apparently offset by an increase in total area sampled (13% greater than in 1994) and a reduction in variance among plots. If goose populations continue to increase, plots will take even longer to search, and at some point it will no longer be practical to search high-density plots of this size in a single

day. Additional analyses are needed to determine the efficiency of different sampling designs, including: 1) random sampling versus cluster sampling, and 2) how precision is affected by sampling fewer larger plots versus many smaller plots.

Decisions about plot size and sampling design for future surveys should take into account: 1) statistical efficiency, 2) effects on geese such as disturbance and observer-caused predation, 3) pilot workload, 4) observer fatigue, 5) comparative efficiency of boat versus air-transported crews, 6) practicality and logistical constraints, 7) cost, 8) concerns of local native communities, and 9) the need for double-searching plots to estimate nest detection rates.

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Table 1. 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 Eggs		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
Emperor Goose								
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
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
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
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

Table 1. (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 Eggs eggs	n	Predicted Hatch Date (June1=601, July1=701) avg.	min	max	n
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
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	0.803 815	66	5.04	53	623.6	613	704	44
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
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
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

Table 1. (Continued) Annual proportion of active nests, mean clutch size, and predicted mean date of hatch.

	Proportion of Nests Active		Clutch Size Active Eggs		Predicted Hatch Date (June1=601, July1=701)			
year	prop.	n	eggs	n	avg.	min	max	n
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
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

Table 2. Annual estimates of density and population size of nests in a single stratum of 952 km² (1986-1994) or 670 km² (1995) stratum sampled by random plots. The expanded nest population size was determined by the proportion of the aerial observations within the sampled stratum compared to the entire coastal YKD survey area of 12786 km². 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:						Prop.	Aerial	Expanded to entire coast		
Year	No. plots	Nests /km2	total nests	SE	CV	Active nests	Active eggs	nests active	expansion factor	total nests	active nests	active eggs
Cackling Canada Goose												
86	24	12.04	11465	1649	0.144	7628	35332	0.665	0.578	19851	13207	61175
87	33	13.27	12640	1727	0.137	11823	60366	0.935	0.522	24194	22630	115544
88	41	9.57	9118	1753	0.192	6623	30749	0.726	0.560	16277	11823	54892
89	32	19.62	18686	3821	0.204	15073	72616	0.807	0.588	31770	25627	123463
90	44	21.12	20117	2557	0.127	15329	71738	0.762	0.569	35384	26962	126181
91	53	23.79	22653	2593	0.114	19690	94559	0.869	0.541	41877	36400	174806
92	52	31.38	29890	3906	0.131	26237	125760	0.878	0.564	52955	46483	222803
93	56	27.05	25766	3197	0.124	23496	107522	0.912	0.610	42270	38546	176392
94	61	33.36	31776	2746	0.086	26070	118764	0.820	0.588	54058	44350	202042
95	50	61.08	40903	5052	0.124	35649	160227	0.872	0.477	85751	74736	335906
					0.138			0.825	0.560			
Emperor Goose												
86	24	10.10	9619	1548	0.161	7270	38426	0.756	0.388	24777	18726	98979
87	33	11.82	11259	1368	0.121	10562	53093	0.938	0.366	30758	28854	145042
88	41	9.07	8643	1306	0.151	7548	37726	0.873	0.365	23656	20659	103258
89	32	16.86	16058	1803	0.112	14896	76235	0.928	0.405	39661	36791	188291
90	44	12.32	11729	1296	0.111	10158	50963	0.866	0.396	29582	25620	128534
91	53	15.78	15033	1772	0.118	14638	73501	0.974	0.421	35746	34807	174773
92	52	14.57	13876	1479	0.107	13349	67208	0.962	0.434	31984	30769	154912
93	56	12.75	12144	1335	0.110	11468	54964	0.944	0.460	26384	24915	119414
94	61	17.21	16389	1525	0.093	15378	75606	0.938	0.439	37324	35021	172182
95	50	13.47	9024	1063	0.118	8816	42980	0.977	0.302	29881	29192	142318
					0.120			0.916	0.398			
White-fronted Goose												
86	24	5.03	4786	1039	0.217	4688	20103	0.980	0.239	20008	19598	84042
87	33	5.32	5063	869	0.172	4944	23286	0.976	0.174	29064	28381	133674
88	41	4.36	4152	744	0.179	4101	18000	0.988	0.237	17544	17328	76057
89	32	6.42	6116	1413	0.231	6050	28373	0.989	0.209	29278	28962	135825
90	44	8.87	8450	1033	0.122	7982	36406	0.945	0.215	39346	37167	169517
91	53	10.99	10463	1111	0.106	9970	46436	0.953	0.206	50782	48389	225375
92	52	12.70	12100	1168	0.096	11860	52901	0.980	0.272	44466	43584	194404
93	56	9.68	9215	1080	0.117	8770	37349	0.952	0.257	35862	34130	145350
94	61	11.52	10975	1059	0.097	10701	46616	0.975	0.222	49518	48282	210326
95	50	13.92	9320	1023	0.110	9083	38380	0.975	0.162	57531	56068	236914
					0.145			0.971	0.219			
Black Brant												
86	24	4.62	4399	3202	0.728	3562	14718	0.810				
87	33	6.76	6434	1695	0.263	5567	21523	0.865	0.541	11895	10292	39791
88	41	4.05	3861	1937	0.502	3159	11881	0.818	0.504	7662	6269	23577
89	32	24.83	23651	19125	0.809	21456	85143	0.907	0.492	48102	43638	173167
90	44	10.83	10315	4824	0.468	6416	21446	0.622	0.438	23560	14654	48983
91	53	13.25	12615	5762	0.457	11453	41220	0.908	0.531	23772	21582	77675
92	52	28.08	26742	11345	0.424	25790	101505	0.964	0.482	55432	53459	210405
93	56	16.88	16081	6621	0.412	13583	46818	0.845	0.463	34705	29314	101039
94	61	17.72	16875	4277	0.253	15472	60296	0.917	0.497	33968	31144	121371
95	50	8.69	5818	2917	0.501	4185	14693	0.719	0.203	28660	20616	72379
					0.482			0.838	0.461			

Table 2. (Continued) Annual estimates of nest density and population size.

Year	N. plots	Ground plot sampled area: Nests /km²	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Aerial expansion factor	Expanded to entire coast: Total nests	Active nests	Active eggs
Tundra Swan												
86	24	1.19	1130	288	0.255	1130	3812	1.000	0.176	6437	6437	21713
87	33	1.23	1173	323	0.275	1173	4267	1.000	0.182	6448	6448	23455
88	41	1.47	1400	321	0.229	1400	6490	1.000	0.199	7044	7044	32655
89	32	1.22	1166	336	0.288	1166	5268	1.000	0.174	6683	6683	30193
90	44	1.48	1408	250	0.177	1375	5886	0.977	0.165	8525	8325	35638
91	53	0.97	922	196	0.213	873	3411	0.947	0.174	5307	5025	19635
92	52	1.46	1392	173	0.124	1392	5266	1.000	0.158	8831	8831	33408
93	56	1.42	1351	258	0.191	1333	5288	0.987	0.165	8164	8055	31953
94	61	1.40	1335	258	0.193	1335	5786	1.000	0.161	8300	8300	35971
95	50	1.02	683	127	0.186	623	2345	0.912	0.127	5378	4906	18465
					0.213			0.982	0.167			
Sandhill Crane												
86	24	0.67	641	243	0.380	641	879	1.000				
87	33	0.93	884	312	0.352	766	1353	0.867	0.123	7190	6230	11005
88	41	1.64	1563	319	0.204	1563	3030	1.000	0.146	10709	10709	20759
89	32	0.70	668	223	0.333	566	1132	0.847	0.108	6198	5252	10504
90	44	1.98	1886	312	0.165	1837	3254	0.974	0.110	17153	16708	29596
91	53	1.75	1669	378	0.226	1669	3122	1.000	0.114	14583	14583	27279
92	52	1.55	1474	285	0.193	1416	2474	0.961	0.137	10752	10329	18047
93	56	1.25	1195	294	0.246	1071	1641	0.896	0.126	9513	8526	13064
94	61	1.63	1555	256	0.165	1555	2797	1.000	0.152	10260	10260	18455
95	50	1.33	890	138	0.155	861	1633	0.967	0.097	9175	8876	16835
					0.242			0.951	0.124			
Spectacled Eider												
86	24	3.06	2915	828	0.284	1867	8307	0.640				
87	33	2.41	2299	439	0.191	1684	8545	0.732				
88	41	2.33	2220	676	0.305	2072	10044	0.933	0.421	5273	4922	23858
89	32	2.20	2095	485	0.232	1861	8994	0.888	0.377	5563	4942	23882
90	44	2.12	2021	415	0.205	1838	9899	0.909	0.452	4473	4068	21911
91	53	1.58	1502	362	0.241	1315	6905	0.875	0.636	2360	2066	10851
92	52	1.38	1318	283	0.215	1127	6168	0.855	0.678	1943	1662	9094
93	56	1.50	1425	327	0.229	1216	5293	0.853	0.802	1777	1517	6602
94	61	1.84	1752	298	0.170	1290	6233	0.736	0.685	2559	1884	9105
95	50	2.93	1959	390	0.199	1573	7925	0.803	0.664	2950	2369	11935
					0.227			0.823	0.589			
Common Eider												
86	24	0.05	49	49	0.988	0	0	0.000				
87	33	0.29	279	149	0.534	160	991	0.573				
88	41	0.36	347	172	0.496	347	1736	1.000	0.429	810	810	4051
89	32	1.37	1309	528	0.403	1309	7220	1.000	0.000			
90	44	0.31	293	118	0.401	198	873	0.676	0.000			
91	53	0.70	671	308	0.460	597	2818	0.890	0.142	4725	4204	19843
92	52	0.95	903	439	0.486	883	4539	0.978	0.000			
93	56	0.46	436	188	0.431	259	1337	0.594	0.402	1086	645	3329
94	61	0.69	659	262	0.397	579	2465	0.879	0.720	915	804	3422
95	50	0.75	505	231	0.457	475	2404	0.941	0.442	1143	1075	5439
					0.505			0.753	0.267			
Pacific Loon												
86	24	1.89	1802	479	0.266	1218	1575	0.676				
87	33	2.35	2235	547	0.245	2204	3992	0.986				
88	41	1.42	1348	303	0.225	1297	2349	0.962				
89	32	1.95	1857	513	0.277	1857	3596	1.000	0.043	43404	43404	84049
90	44	2.28	2173	294	0.135	2014	3764	0.927	0.097	22434	20792	38859
91	53	2.83	2694	373	0.138	2535	4551	0.941	0.104	25986	24452	43898
92	52	1.72	1634	319	0.195	1570	2682	0.961	0.067	24287	23336	39864
93	56	1.49	1417	327	0.231	1417	2609	1.000	0.122	11650	11650	21451
94	61	1.14	1088	252	0.231	1088	2045	1.000	0.090	12054	12054	22657
95	50	1.06	712	188	0.263	712	1217	1.000	0.041	17366	17366	29683
					0.221			0.945	0.080			

Table 2. (Continued) Annual estimates of nest density and population size.

Year	N. plots	Ground plot sampled area: Nests /km²	Total nests	SE	CV	Active nests	Active eggs	Prop. nests active	Aerial expansion factor	Expanded to entire coast: Total nests	Active nests	Active eggs
Red-throated Loon												
86	24	0.41	392	130	0.331	392	442	1.000				
87	33	0.07	63	62	0.991	63	126	1.000				
88	41	0.00	0	0	0.000	0	0					
89	32	0.13	122	86	0.702	122	188	1.000	0.080	1516	1516	2336
90	44	0.75	719	234	0.326	719	1141	1.000	0.170	4222	4222	6700
91	53	0.36	341	142	0.416	281	489	0.824	0.250	1364	1124	1956
92	52	0.51	486	146	0.300	422	780	0.868	0.104	4686	4069	7520
93	56	0.39	373	156	0.418	335	669	0.898	0.205	1819	1634	3263
94	61	0.34	322	139	0.431	322	592	1.000	0.164	1969	1969	3620
95	50	0.89	594	156	0.263	594	1128	1.000	0.124	4790	4790	9097
					0.418			0.859	0.157			
Glaucous Gull												
86	24	1.97	1873	486	0.260	1257	2351	0.671				
87	33	1.66	1580	504	0.319	1580	3884	1.000				
88	41	2.46	2343	908	0.387	2190	5507	0.935				
89	32	1.97	1873	735	0.392	1761	4520	0.940				
90	44	3.41	3249	528	0.162	2576	6900	0.793				
91	53	2.82	2689	787	0.293	2235	6107	0.831				
92	52	3.56	3391	1169	0.345	3153	8542	0.930	0.420	8070	7504	20328
93	56	2.34	2231	563	0.252	2163	5581	0.970	0.224	9946	9643	24881
94	61	3.79	3610	432	0.120	3547	10004	0.983	0.182	19815	19469	54911
95	50	3.15	2107	601	0.285	2107	5551	1.000	0.163	12926	12926	34055
					0.282			0.905	0.247			
Mew Gull												
86	24	0.75	711	349	0.491	711	1446	1.000				
87	33	0.60	575	303	0.526	575	1090	1.000				
88	41	2.95	2814	2502	0.889	2764	7326	0.982				
89	32	1.66	1583	541	0.342	1481	3699	0.936				
90	44	1.32	1257	614	0.489	1207	2891	0.960				
91	53	0.89	846	328	0.387	736	1783	0.870				
92	52	1.93	1835	500	0.273	1687	4257	0.919	0.156	11797	10846	27368
93	56	2.13	2033	1122	0.552	2033	5586	1.000	0.246	8257	8257	22688
94	61	1.85	1762	212	0.120	1722	4429	0.977	0.368	4792	4683	12045
95	50	1.95	1306	377	0.288	1306	3384	1.000	0.210	6219	6219	16114
					0.436			0.964	0.245			

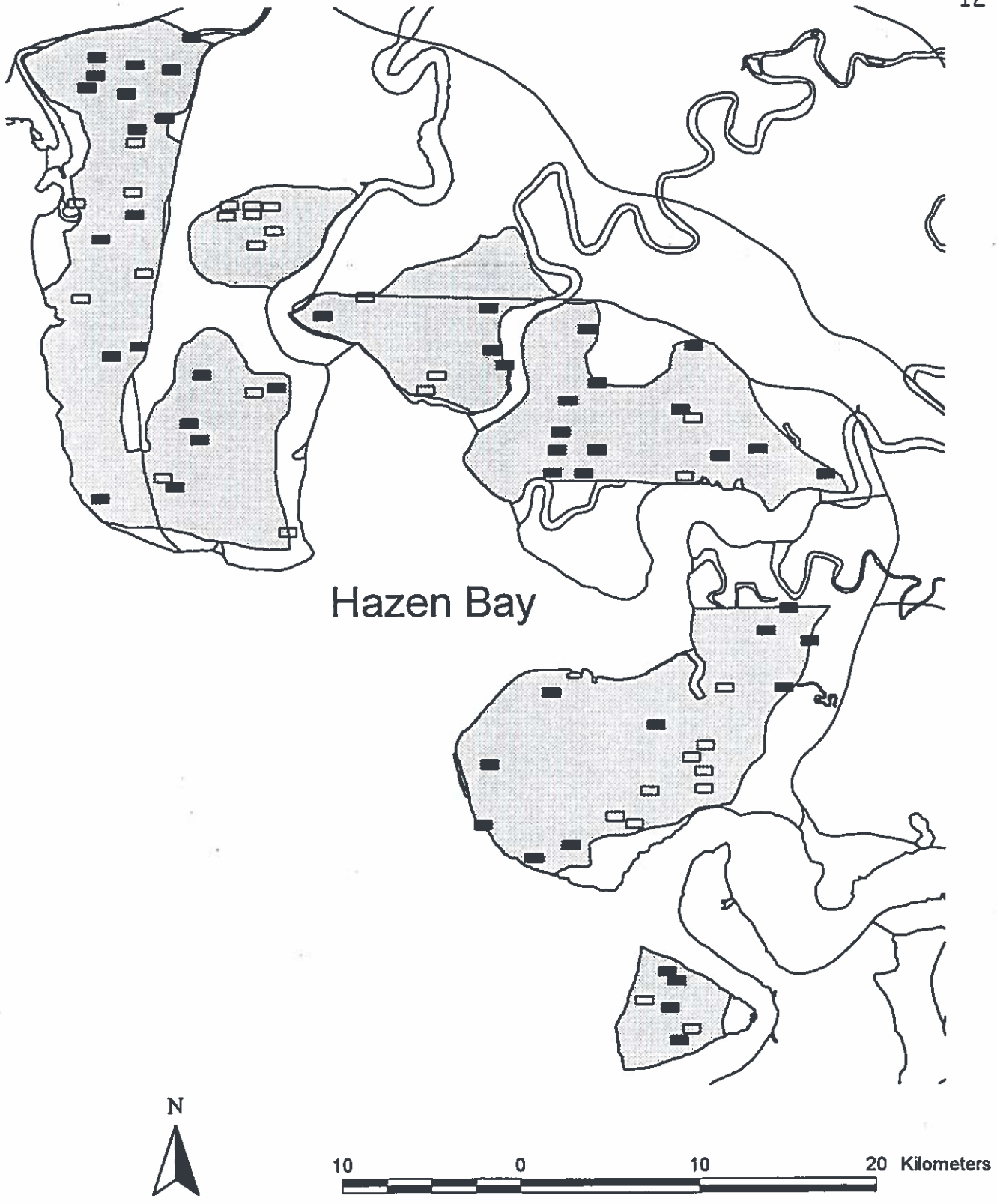

Figure 1. Study area (shaded) sampled by nest plots in 1995 on the Yukon-Kuskokwim delta, Alaska. Plots searched for nests are indicated by solid rectangles and plots randomly selected but not searched are indicated by open rectangles.

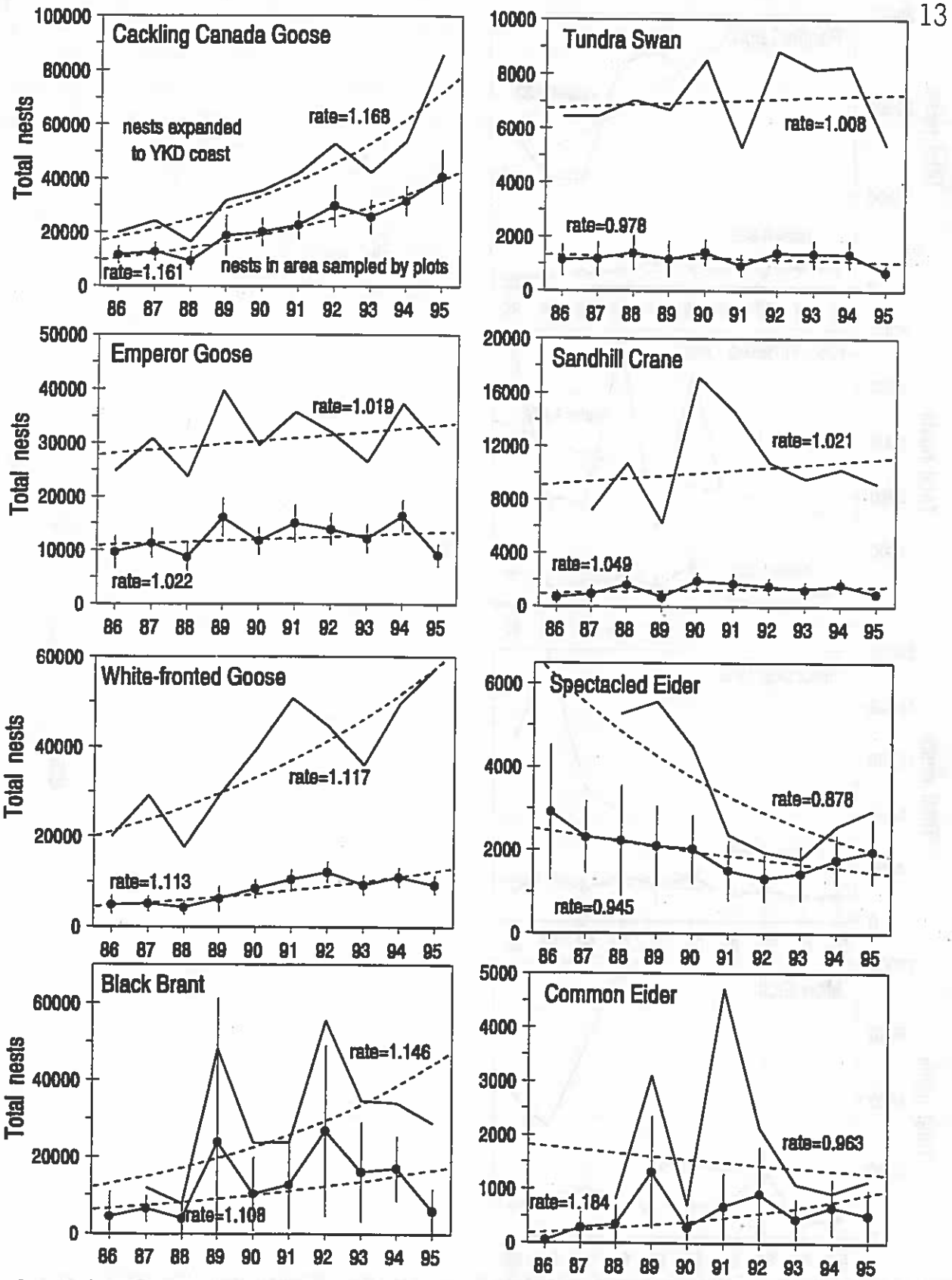

Figure 2. Estimated total nest population size for the area sampled by plots and for the entire coastal YKD area of 12786 sq.km as expanded by the inverse proportion of the aerial survey observations within the ground sampled area. Vertical lines indicate 95 % confidence intervals. Dashed line indicates the log-linear regression fit estimating the annual rate of population growth.

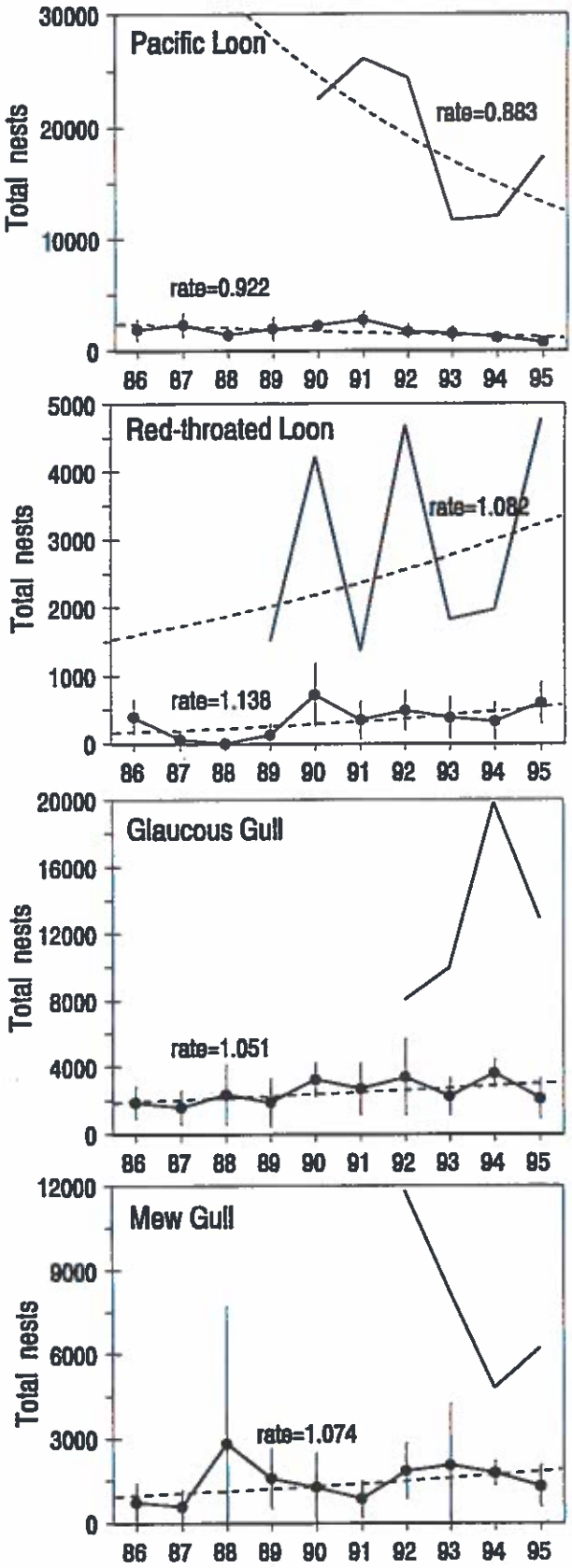

Figure 2 (continued). Estimated total nest population size for the area sampled by plots and for the entire coastal YKD area of 12786 sq.km as expanded by the inverse proportion of the aerial survey observations within the ground sampled area. Vertical lines indicate 95 % confidence intervals. Dashed line indicates the log-linear regression fit estimating the annual rate of population growth.