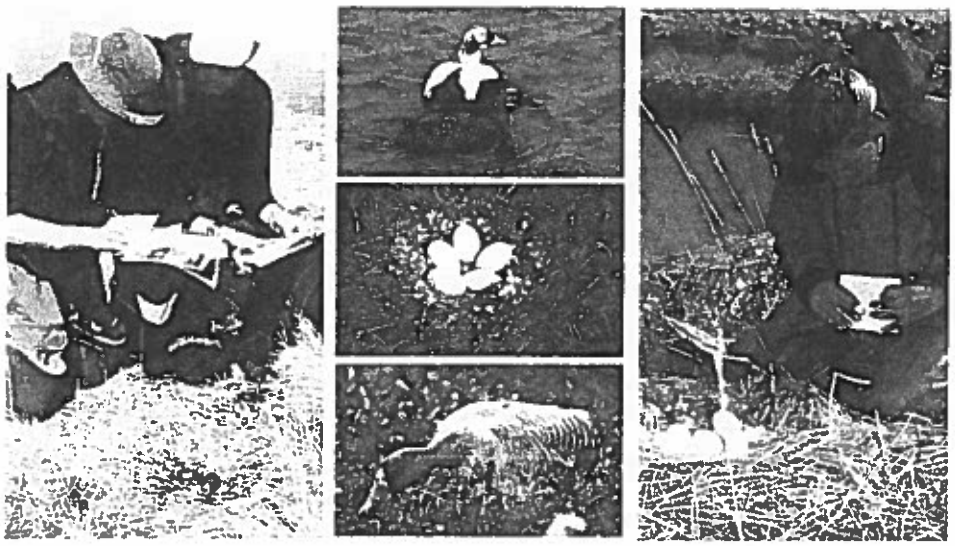
Population Size and Production of Geese and Eiders Nesting on the Yukon-Kuskokwim Delta, Alaska in 2000



Field Report: 13 December, 2000

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HIGHLIGHTS OF THE 2000 SURVEY: Numbers of nests were high for most species of geese. Number of eider nests was down. Clutch sizes and nest success were higher than long term averages for most species. Tundra voles were unusually abundant for the first time in many years.

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.

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 716 km^2, or 5.6% 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 2000 design was nearly identical to the 1995-97 design, with minor boundary changes to simplify analysis among air and ground surveys. The low density stratum between the Aphrewn and Kashunuk Rivers sampled in 1998-99 was dropped, and Kigigak Island, considered a separate stratum in 1998-99, was sampled as part of the single stratum design in 2000.

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 (Eldridge et al. 2000, 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 716 km^2 sampled by ground plots. The breeding population index for most species was based on twice the number of singles plus number of birds in pairs observed because 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, the number of singles plus the number of birds in pairs observed was used as the index to breeding population size to calculate the expansion factor. The 1999 population estimates for all species have changed slightly from those reported in last year's report, which was prepared before 1999 expansion factors were available.

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 1997-99. 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.

Most plots were searched by 2 biologists who were transported either by Cessna 185 float-equipped aircraft or by motorboat. Two boat crews originated from the Kanagayak camp; one worked areas around the lower Manokinak/Aknerkochik Rivers; the other 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.

RESULTS:

We searched 80 plots from 8-19 June 2000 (Fig. 1). Four crews plus a pilot at the YDNWR Kanagayak field camp searched 40 plots. YDNWR, USGS/BRD, and University of Alaska Fairbanks biologists from Kigigak Island, Aknerkochik, Hock Slough, Tutakoke, and Big Slough field camps searched 15 plots, and 2 crews of 2 biologists each operating by motorboat searched 25 plots. Training and previous field experience varied among participants and was comparable to previous years. Weather was generally sunny and warm, with little precipitation.

Search of 80 plots yielded 3,708 nests: 1,672 cackling Canada goose, 351 emperor goose, 493 white-fronted goose, 547 brant, 71 spectacled eider, and 574 nests of other species. Total estimated nest populations were 104,307 cacklers, 34,700 emperors, 98,456 white-fronts, and 2,898 spectacled eiders (Table 1). Cacklers and white-front nest populations are the highest recorded since these surveys were begun in 1986. Numbers of nests for most species similar or greater than in 1999; spectacled eiders were the only notable exception (Table 1, Fig. 3).

Ice breakup was similar to the long term average and nest sites were available in late May. In 2000, average hatch dates for geese (predicted by egg float angles) were about 3 days earlier than 1999 but similar to the 1986-99 average (Table 2. Fig. 4). Spectacled eider nesting chronology was similar to 1999 and the 1986-99 average.

Mean active clutch sizes of all goose species and spectacled eiders were higher than in previous years, but clutch sizes of other species were similar to long term averages. The proportions of nests active when found remained high again in 2000 for all species (Fig. 4).

Coefficients of variation (SE/mean) for 2000 nest estimates were lower than the previous 14-year average CV's for all species except spectacled eiders and sandhill cranes.

Tundra voles were abundant this year, probably due to the lack of a spring flood tide that presumably usually drowns a high proportion of the population. In response to vole abundance, short-eared owls nested in abundance. Furthermore, nest predation was generally low, possibly due to the abundance of alternate prey for foxes, jaegers, and gulls. The combination of high nest numbers, increased clutch size, and high nest success for most species suggests potential for excellent production in 2000.

DISCUSSION:

We searched a record number of plots in 2000 due to several factors: 1) great weather and no foul-weather days, 2) good logistical planning and air support by YDNWR and charter Beaver aircraft, 3) an excellent field crew and pilots, and 4) discontinuation of double-searching effort this year. A photographic field guide to nests and eggs was provided to nest searchers. This guide proved extremely useful to all participants; species identification and overall data quality seemed to improve. The guide will be revised in the future.

One of the principal objectives of this survey is to precisely estimate the nesting population of spectacled eiders on the YKD. The sampling 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 1995-99 (mean = 0.204) 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.

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.

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 4) 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.

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.

Lastly, we have not reported estimates of nest abundance for loons for the second year in a row, pending further analyses. Nest plot data from 1986-98 show increasing red-throated loon and decreasing Pacific loon populations, although 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 by incorrect species identification. Eggs and nests of red-throated and Pacific loons are almost impossible to distinguish, and adults usually flush at large distances away from searchers. Further analyses will break out loon nest populations by species based on the species ratio seen during the breeding pair aerial survey in the same areas.

SUGGESTIONS FOR 2001 NEST PLOT WORK

1. Ship all gear and nonperishable food to Kanagayak in late April to minimize the "bottleneck" effect that occurs each year with the arrival of a large crew and massive amounts of gear and food.
2.. Consider a "camping air crew" in lieu of a third boat crew. This crew would stay at overnight spike camps for several days where they can walk to several plots with difficult access by float plane or boat.

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Table 1. Annual estimates of density and population size of nests in a single stratum of 956 km² (1986-1994), 670 km² (1995-97), 716 km² (2000) or 3 strata totalling 857 km² (1998-99) 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 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:										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	59.20	50713	5065	0.100	47270	215373	0.932	0.490	103455	96469	439537
99	59	856.6	50.7	43427	5385	0.124	37685	154243	0.868	0.464	93593	81218	332420
'00	80	715.7	64.67	46281	3884	0.084	43983	207987	0.950	0.444	104307	99128	468756
					Average	0.129			0.840	0.538			
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	118812
99	59	856.6	11.47	9822	807	0.082	9065	40128	0.923	0.313	31380	28962	128204
'00	80	715.7	13.58	9716	929	0.096	9577	47748	0.986	0.280	34700	34204	170529
						0.112			0.928	0.373			
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	86536	84250	362911
99	59	856.6	13.87	11881	1237	0.104	11242	46994	0.946	0.157	75675	71605	299325
'00	80	715.7	19.07	13646	1258	0.092	13342	59401	0.978	0.139	98456	96263	428579
						0.129			0.970	0.200			

	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
Black Brant													
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	47690	40831	148928
99	59	856.6	5.85	5012	1446	0.289	3978	12756	0.794	0.256	19586	15545	49848
'00	80	715.7	21.16	15141	5069	0.335	13508	50959	0.892	0.292	51924	46324	174757
						0.445			0.849	0.404			
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	13685	12952	43113
99	59	856.6	1.06	907	172	0.190	816	3021	0.900	0.120	7558	6800	25175
'00	80	715.7	1.28	913	153	0.168	858	3211	0.940	0.102	8995	8453	31635
						0.194			0.968	0.148			
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	13547	13547	23863
99	59	856.6	0.85	728	183	0.252	636	1090	0.874	0.110	6618	5782	9909
'00	80	715.7	1.35	969	139	0.143	941	1716	0.971	0.072	13384	12997	23702
						0.221			0.965	0.114			

	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
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
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	2.72	2330	369	0.158	2168	10519	0.930	0.633	3624	3425	16618
99	59	856.6	2.8	2401	578	0.241	2173	10704	0.905	0.612	3921	3549	17482
'00	80	715.7	2.75	1965	295	0.150	1827	9771	0.930	0.678	2898	2695	14412
						0.216			0.848	0.605			
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	2327	1815	8954
99	59	856.6	0.55	470	167	0.354	318	1547	0.677	0.615	764	517	2515
'00	80	715.7	1.08	775	212	0.274	747	3654	0.964	0.587	1321	1273	6229
						0.406			0.844	0.340			

	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
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				
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	25753	25253	66856
99	59	856.6	1.83	1564	397	0.254	1472	3991	0.941	0.225	6954	6545	17746
'00	80	715.7	5.18	3709	974	0.262	3626	9550	0.978	0.246	15077	14740	38821
						0.305			0.929	0.221			
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	7307	7307	17486
99	59	856.6	1.59	1365	394	0.289	1320	3379	0.967	0.263	5188	5017	12843
'00	80	715.7	1.43	1024	189	0.185	969	2547	0.946	0.201	5087	4814	12653
						0.386			0.971	0.237			

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
99	0.869	1113	4.07	931	626.9	617	716	772
00	0.950	1672	4.73	1509	624.3	614	710	1014
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
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	268	624.0	616	703	215
99	0.919	247	4.51	224	627.0	617	706	188
00	0.986	351	4.99	344	623.1	613	708	280
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
99	0.947	263	4.18	246	627.3	619	710	208
00	0.978	493	4.46	478	624.6	614	709	334
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
99	0.821	156	3.19	126	625.6	617	707	108
00	0.892	547	3.73	372	623.1	616	703	216

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
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
99	0.900	20	3.67	18	701.3	624	709	14
00	0.939	33	3.73	30	625.5	618	705	22
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
99	0.875	16	1.71	14	622.8	619	628	12
00	0.971	35	1.82	34	619.2	613	629	22
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
99	0.911	56	4.94	51	628.2	618	709	51
00	0.930	71	5.35	66	627.6	618	709	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
99	0.765	17	4.46	13	630.2	622	709	12
00	0.964	28	4.89	27	628.7	624	705	23

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
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
99	0.949	39	2.73	37	626.5	619	707	25
00	0.978	134	2.62	124	622.2	612	709	72
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
99	0.972	36	2.54	35	625.1	621	709	25
00	0.946	37	2.63	35	625.2	617	705	17

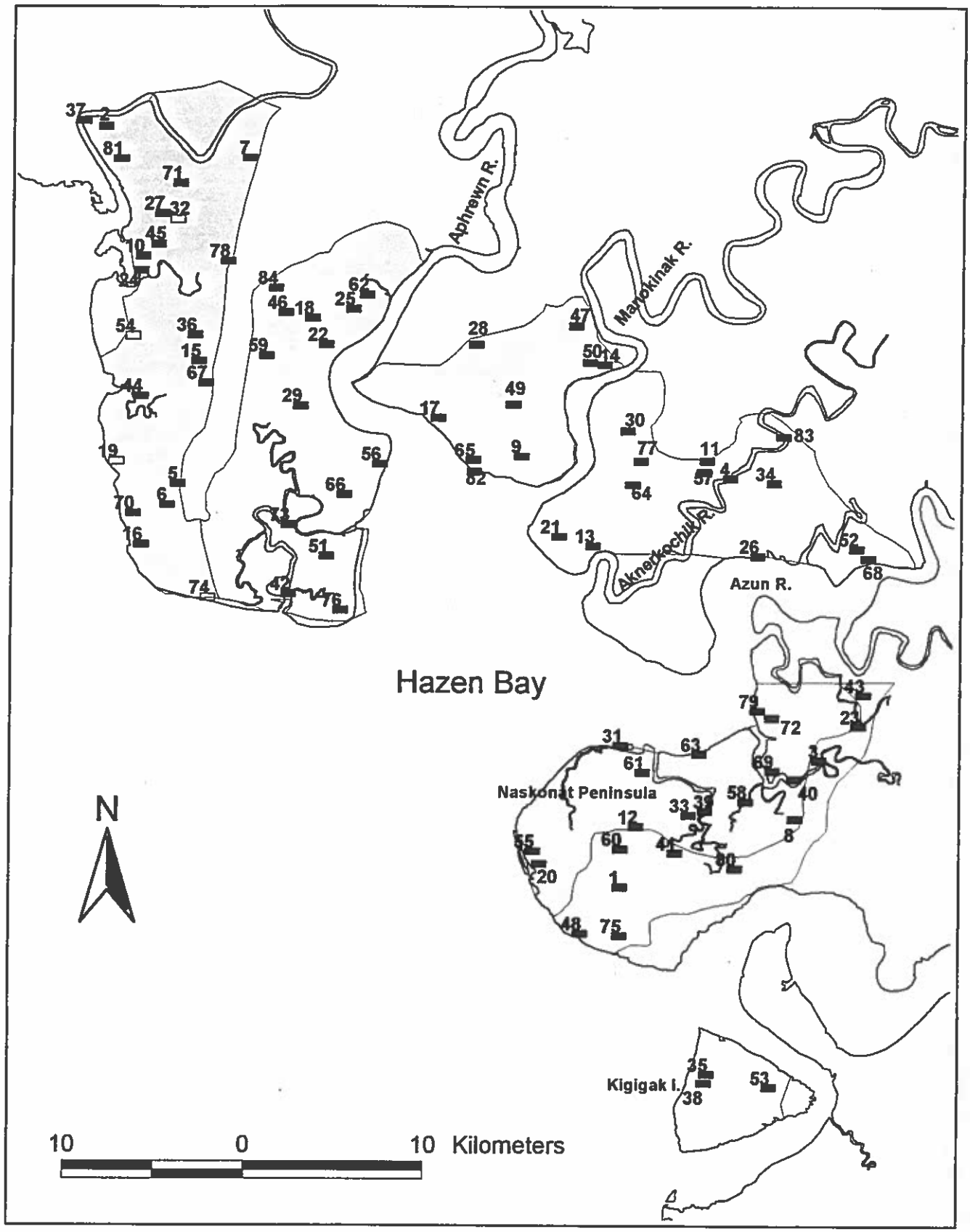

Figure 1. Study area (shaded) sampled by nest plots in 2000 on the Yukon-Kuskokwim delta, Alaska. Plots searched for nests are indicated by solid rectangles and plots randomly selected but not searched are indicated by open rectangles.

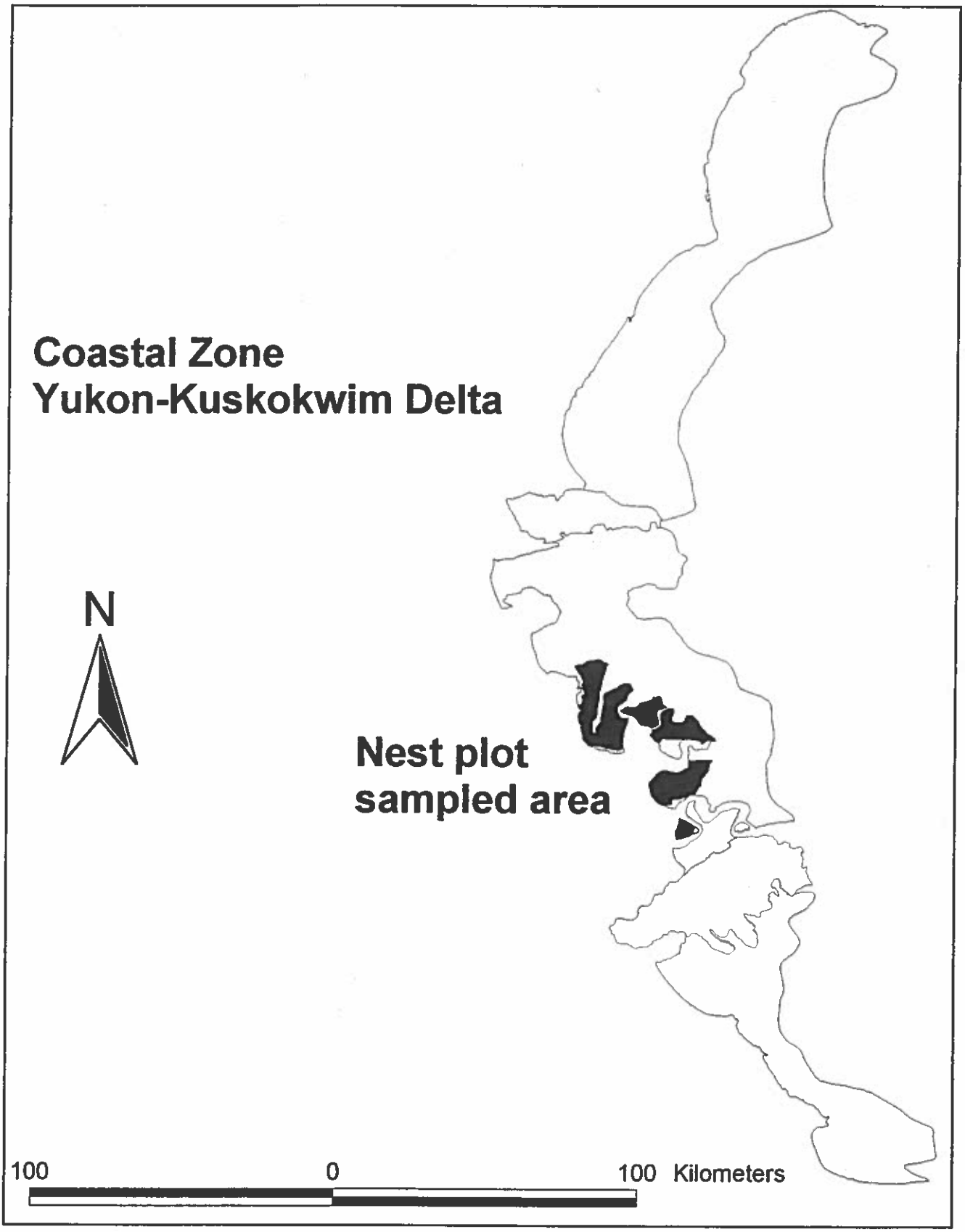

Figure 2. Location of nest plot sampled area in the coastal zone of the Yukon-Kuskokwim delta, 2000.

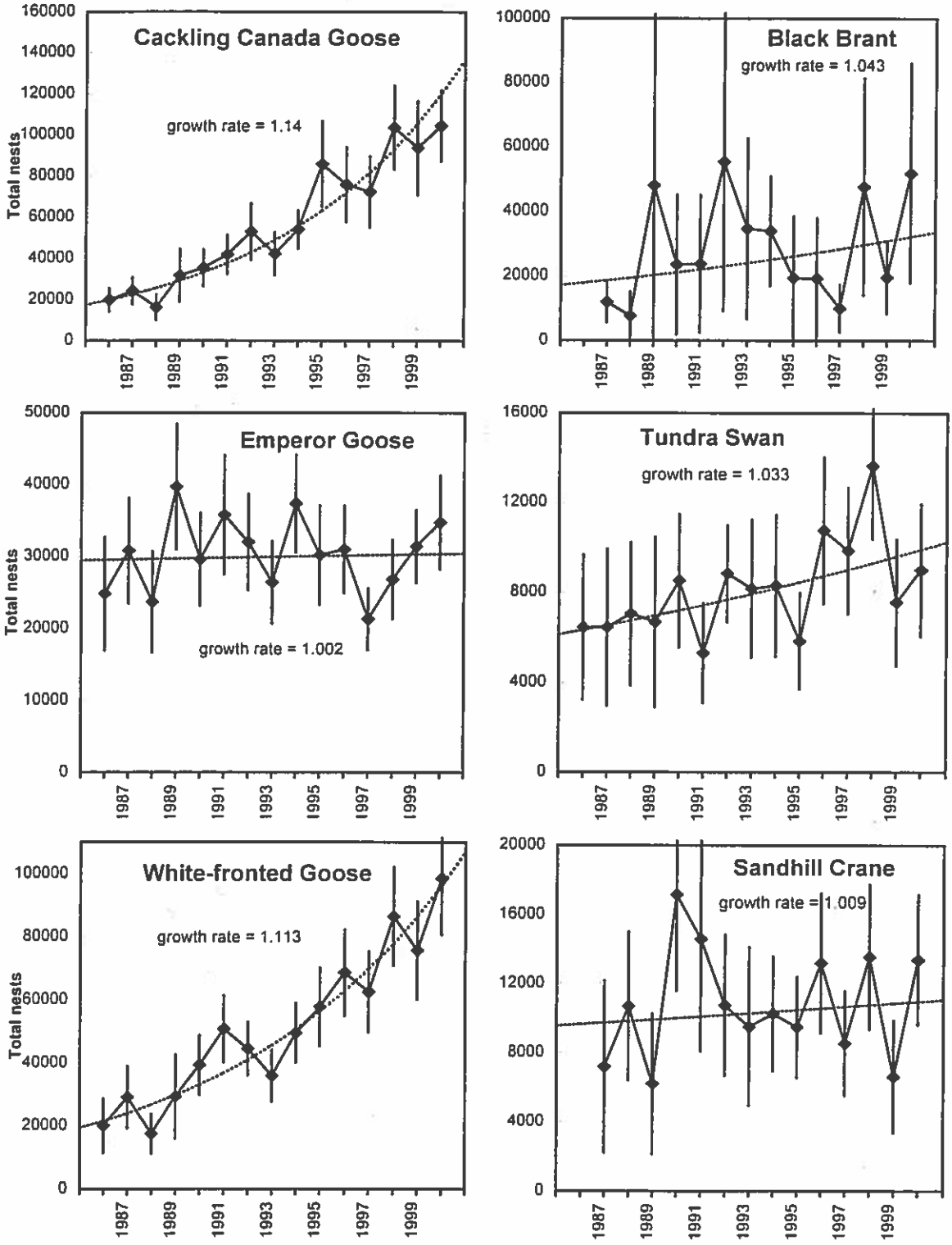

Figure 3. Estimated total nest population sizes on the Yukon-Kuskokwim Delta, Alaska. Vertical lines indicate 95% confidence intervals. Log-linear regression estimates the average annual growth rates of the expanded nest populations.

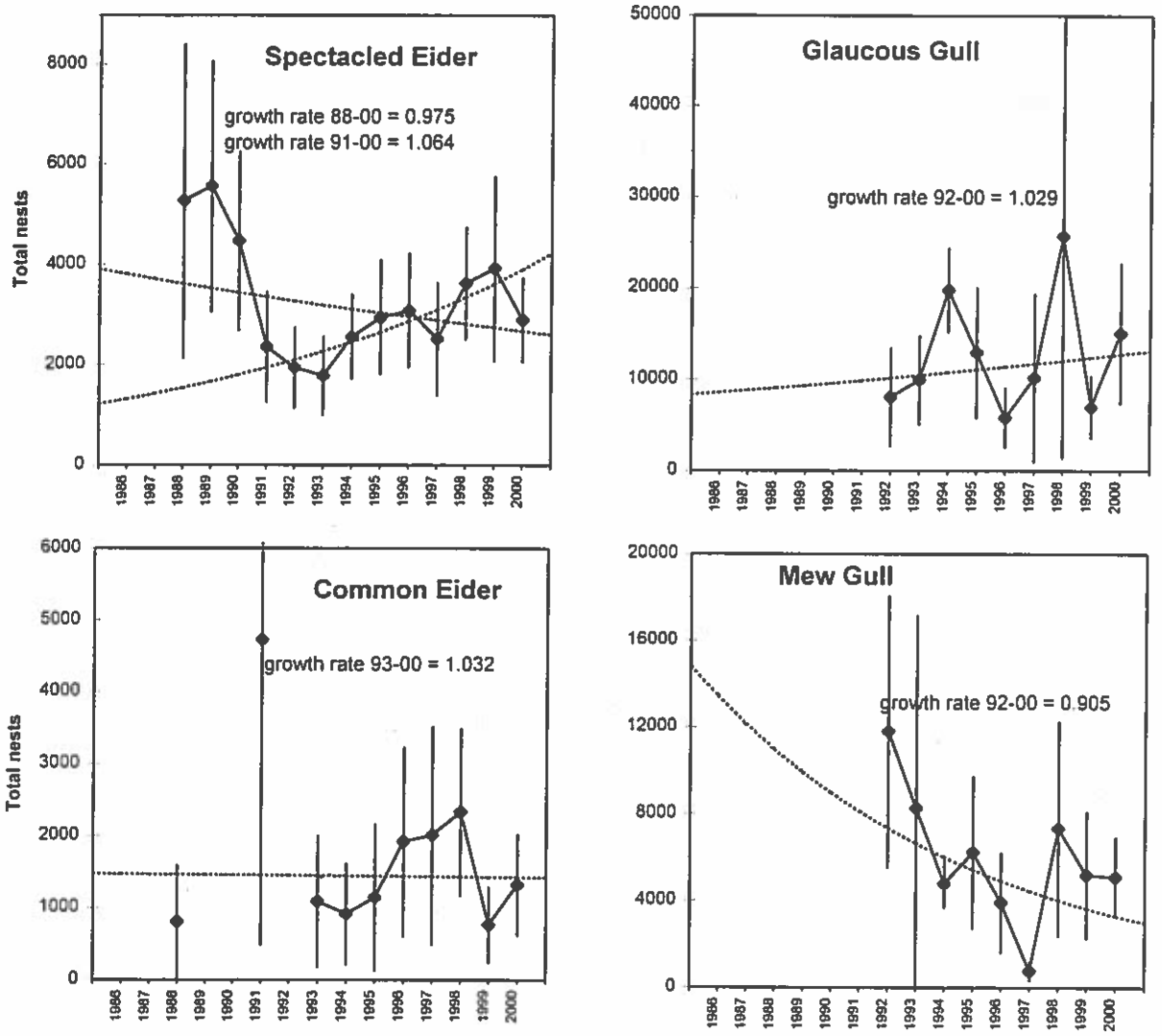

Figure 3 (continued). Estimated total nest population sizes on the Yukon-Kuskokwim Delta, Alaska. Vertical lines indicate 95% confidence intervals. Log-linear regression estimates the average annual growth rates of the expanded nest populations.

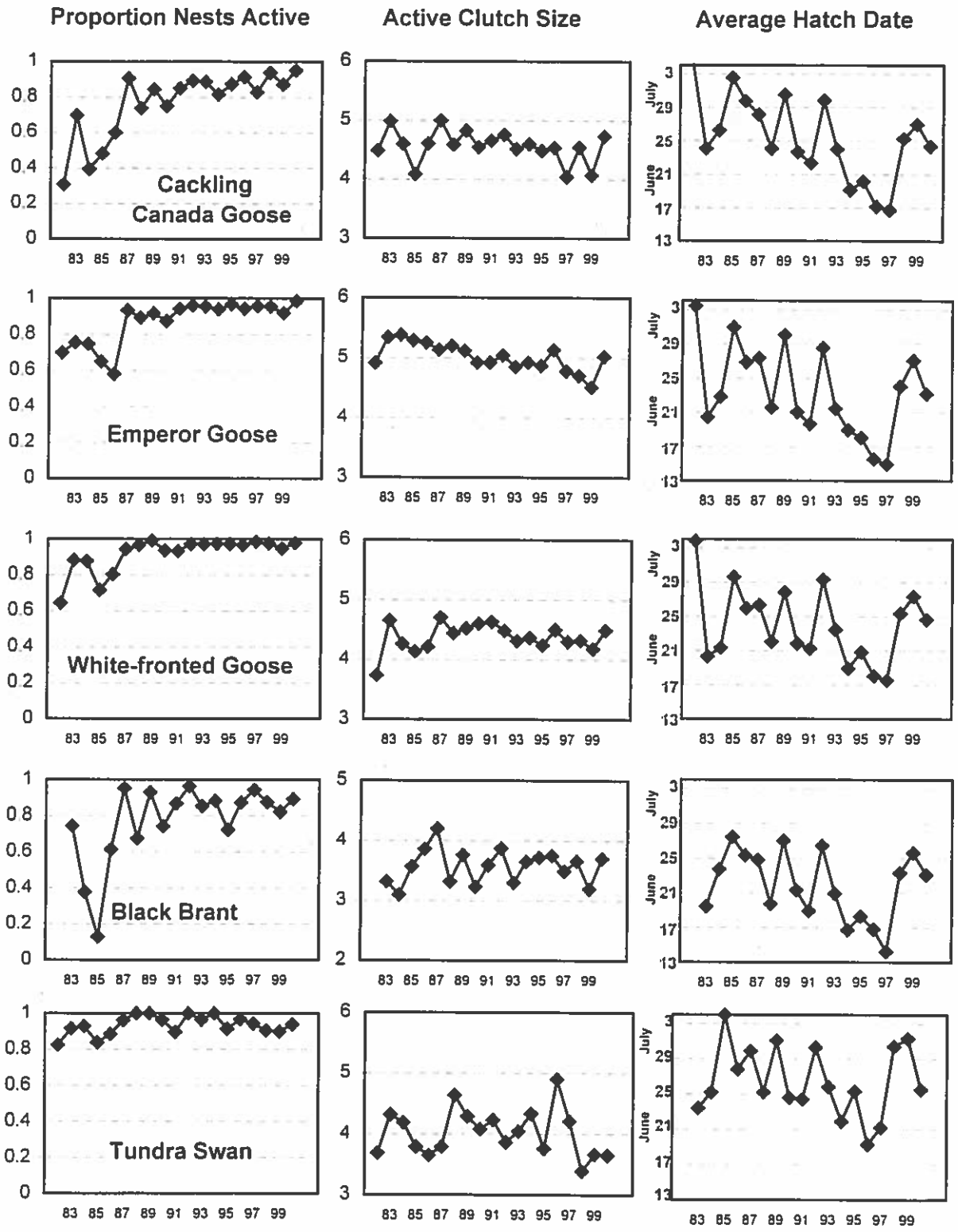

Figure 4. Proportion of nests active when found, average clutch size of apparently viable eggs, and average hatch date predicted by egg float angles from all nests and plots searched on the coast of the Yukon-Kuskokwim Delta from 1982-2000.

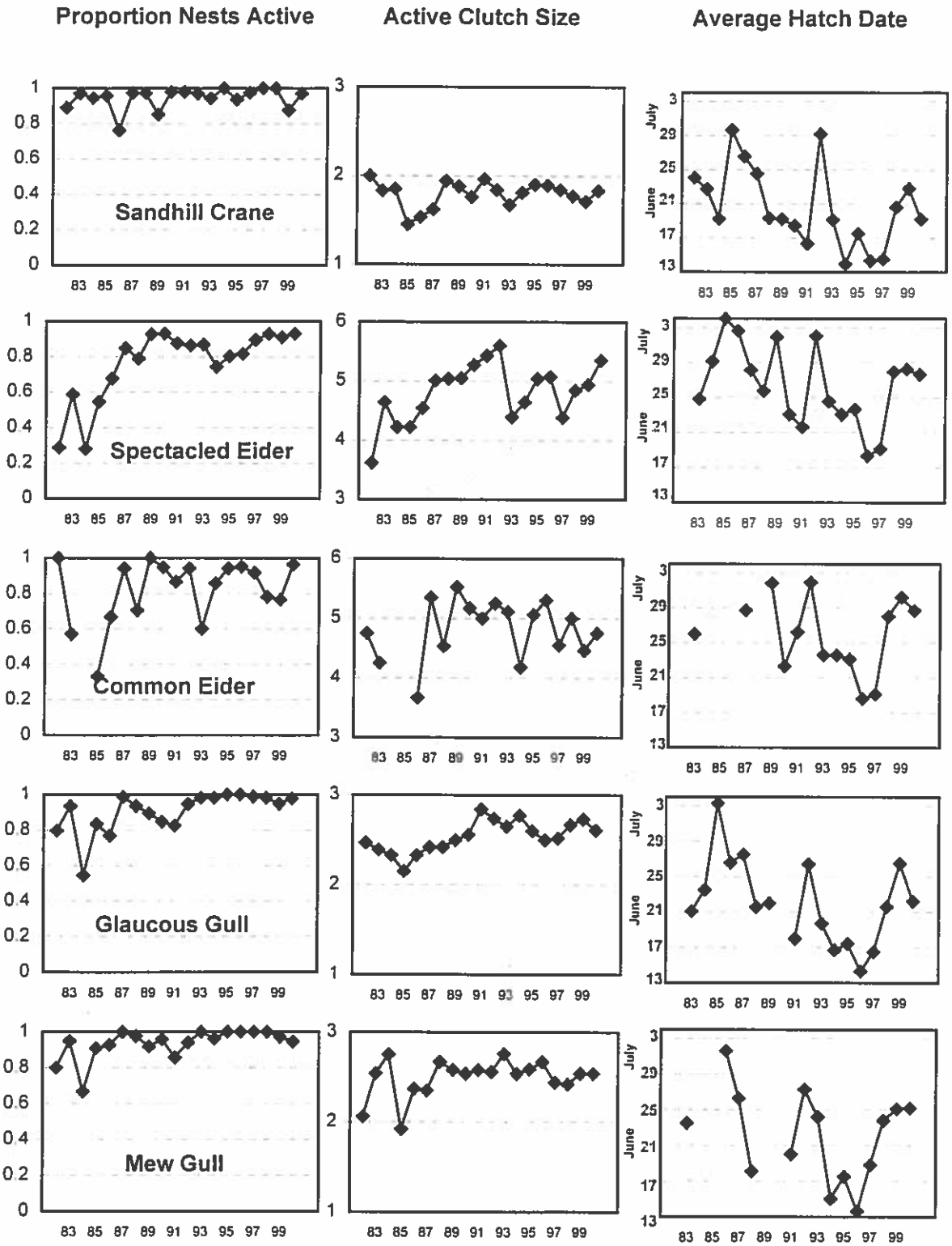

Figure 4. (continued) Proportion of nests active when found, average clutch size of apparently viable eggs, and average hatch date predicted by egg float angles from all nests and plots searched on the coast of the Yukon-Kuskokwim Delta from 1982-2000.