DISTRIBUTION AND ABUNDANCE OF WATERBIRDS NEAR SHORE IN SOUTHEAST ALASKA, 1997–2002

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ABSTRACT—The 25,000 km of shoreline in southeast Alaska was surveyed for waterbirds by fixed-wing aircraft in summer and winter during the period 1997 to 2002. A ground/boat survey double sampled 20% of the summer habitat and 5% of the winter habitat to adjust and enhance the air survey. The most abundant species during the summer surveys, with visibility correction factors applied, were gulls (*Larus* spp.; 306,200, CV = 0.004), scoters (*Melanitta* spp.; 185,700, CV = 0.004), and Harlequin Duck (*Histrionicus histrionicus*; 34,640, CV = 0.03). The most abundant species observed during the winter surveys were goldeneyes (*Bucephala islandica* and *B. clangula*; 121,920, CV = 0.01), gulls (105,000, CV = 0.01), Mallard (*Anas platyrhynchos*; 98,090, CV = 0.01), scoters (77,300, CV = 0.01), Harlequin Duck (54,540, CV = 0.02), Bufflehead (*Bucephala albeola*; 46,840, CV = 0.03), and mergansers (*Mergus* spp.; 39,940, CV = 0.02). The variance estimates did not include uncertainty about the visibility correction factors. We observed 2.4 times as many scoters in summer as in winter and surmise they were sub-adults, failed breeders, and adult males which had deserted females on the breeding grounds. Complete shoreline coverage provided precise estimates for the abundant species. Meaningful population values could be generated for very specific subunits selected after completion of the survey because all shoreline was covered and all observations were tied to a geographic location.

Key words: waterfowl, sea bird, loon, cormorant, Sea Otter, seal, distribution, abundance, shoreline, southeast Alaska, aerial survey.

The defining characteristic of the southeastern panhandle of Alaska is its prodigious and complex shoreline which serves as a major focal point for an abundance of waterbirds and marine mammals. It is the closest ice-free marine environment to a vast region of western Canada in which many of the diving ducks and loons nest. Resident populations of Canada Goose (*Branta minima*), Harlequin Duck (*Histrionicus histrionicus*), mergansers (*Mergus* spp.), Sea Otter (*Enhydra lutris*), and Harbor Seal (*Phoca vitulina*) also concentrate along the shorelines.

Wintering waterbirds on the east coast of the United States have been counted from airplanes for the past 50 y (Eggeman and Johnson 1989). The coast of Denmark was systematically surveyed in the late 1980s (Laursen and others 1997). The 1st attempt to estimate the entire shoreline populations of waterbirds in southeast Alaska was a summer boat survey in 1994, based on a sampling design of 191 random shoreline segments totaling 764 km (Agler and others 1995). The 2nd attempt was a winter aerial survey in 1996 based on 130 random plots incorporating about 5000 km of shoreline (Anonymous 1996). Estimates from these sampling designs suffered from high variances for most species.

We conducted aerial surveys of the distribution and abundance of waterbirds along all shorelines in southeast Alaska from 1997 to 2002. Our complete shoreline coverage eliminated the serious sampling problems associated with uneven distribution of birds and at the same time provided accurate and thorough distribution information. We also conducted extensive boat comparison surveys to provide population correction factors. Conant and others (1988) calculated boat to air ratios for Port Frederick during 3 successive winters, 1982 to 1984, which helped bolster our winter correction factors.

STUDY AREA

Southeast Alaska (Fig. 1) is a conglomerate of waterways and forested landscapes melded into a myriad of passages, channels, fjords,

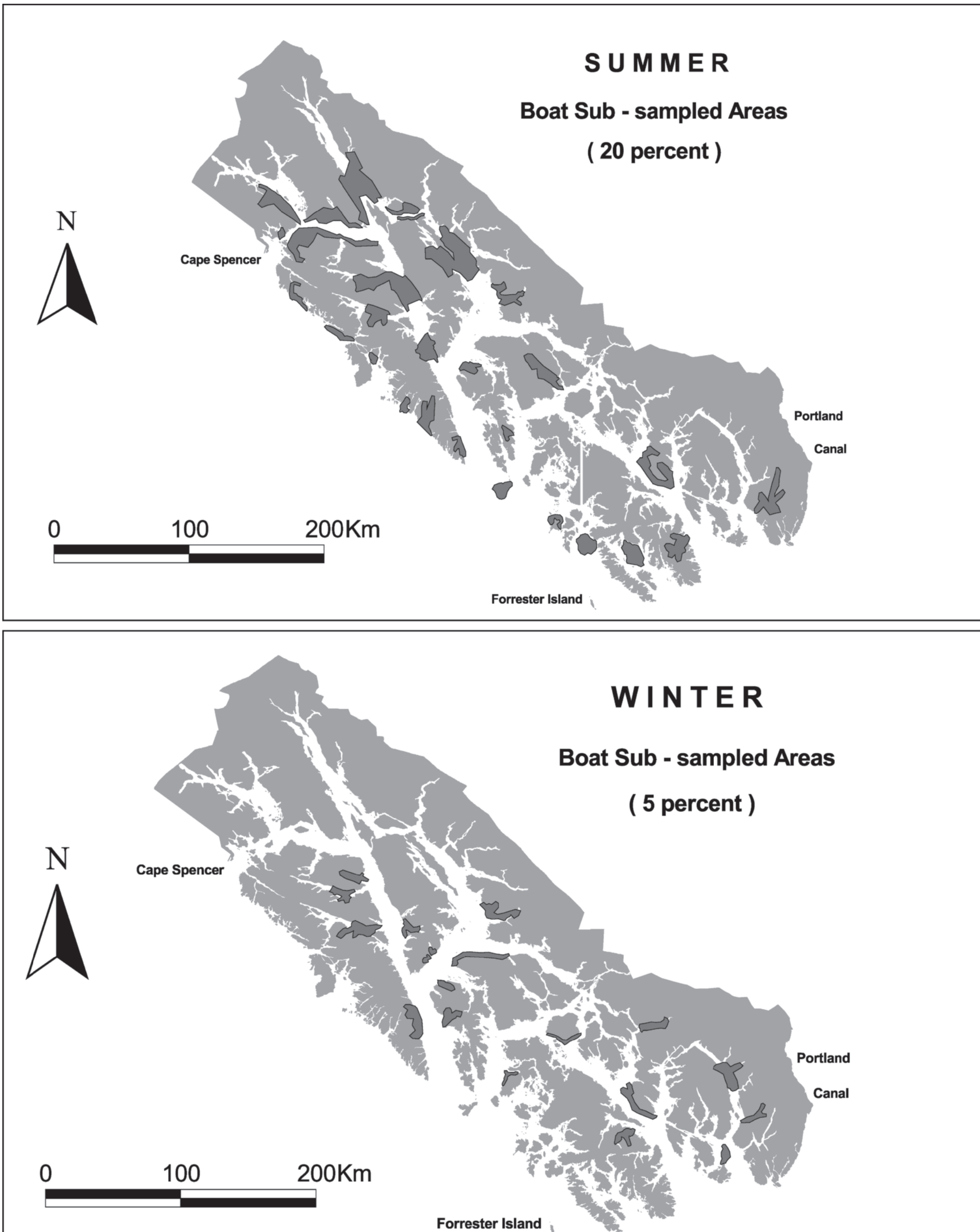

FIGURE 1. Southeast Alaska aerial survey includes shoreline from Cape Spencer to Portland Canal. Areas sub-sampled by boat are highlighted.

bays, lagoons, and tidal flats. Steep-sided and deep-channeled fjords pierce into the rugged mainland mountains as well as into the 10 largest islands. At the other extreme are areas characterized by low relief islands and islets with convoluted shorelines and intricate patterns of small waterways and shoals. Intermediate combinations of mountains and water complete the archipelago which encompasses 25,000 km of shoreline. Large mainland rivers are fed by silt laden tributaries originating from the multitude of glaciers. These rivers terminate in large tide flats or deltas with marsh habitat spread across the elevated portions. Smaller rivers and streams flow out from the island mountain ranges and often form tidal deltas.

Two large tides bathe the shorelines daily. The average tidal range is 5 m. This creates broad flushing through the large channels. The heads of deep bays and fjords often have a large influx of fresh water which may greatly reduce the salinity, especially on the water's surface. Those areas are usually frozen during the coldest winter months.

The intertidal habitats are rich with marine fauna within or attached to the substrate. Multiple species of kelp cover portions of the exposed intertidal margin as well as the adjacent shallow water areas less than 15 m in depth.

The northwest boundary of the study area was Cape Spencer. Portland Canal at the southern boundary was flown on the summer survey but was excluded on the winter survey. Forrester Island was not surveyed in winter or summer.

METHODS

The aerial surveys were conducted using fixed-wing aircraft that were flown parallel to all shores. Rocks and reefs were circled. The transect width was 400 m from any land, islet or rock. The offset distance of the aircraft from shore was generally 50 m. Greater offset distances were necessary when passing a sharp indentation of the shoreline. The crew member facing away from shore attempted to count all birds seen to 400 m from shore. Exceptions were made for scoters and Sea Otters. If either of these 2 species were outside the 400-m limit but within view, the aircraft was diverted to count all of the animals in the aggregation. Usually the shoreline was on the right side of the plane, except when it was convenient to circle islets to the left or when the observer needed a respite from the concentration of shoreline searching. An altitude of 35 m was preferred except when turbulence or terrain dictated the need for a higher safe altitude.

The survey was conducted over a 5-y period (1997 to 2002), in which successive blocks of shoreline were sequentially flown until all of southeast Alaska was completely covered. The progression was north to south. Winter surveys occurred in 1997, 2000, 2001, and 2002. Summer surveys occurred in 1997, 1998, 1999, 2001, and 2002. The summer portion was flown during the last week of July or the first 2 wk of August. The winter portion was flown between mid-February and mid-March. A specially modified turbine powered DeHaviland Beaver on amphibious floats was used for all of the summer surveys and 92% of the winter surveys. A Cessna 206 on amphibious floats was used for the balance of the winter surveys.

All voice observations were digitally recorded into separate computers for each of the 2 crew members. The aircraft's GPS location also was saved with each observation. Each computer had a small, high resolution screen mounted on the front. The pilot-observer served as observer on the left-side of the aircraft. The computer in front of the pilot-observer was zoomed in to show intricate shoreline features, while the right seat observer's computer displayed a larger area to help with flight planning. The displayed track of the aircraft made it easy to assure we had complete coverage without overlap.

The air crew did not classify scoters (*Melanitta* spp.), goldeneyes (*Bucephala clangula* and *B. islandica*), mergansers, cormorants (*Phalacrocorax* spp.), shorebirds, or gulls (*Larus* spp.) to species. Loons were not classified to species in winter. Black Oystercatchers (*Haematopus bachmani*) were the only shorebird that was adequately surveyed. Bald Eagles (*Haliaeetus leucocephalus*) were not counted because of the potential for diverting the observer's view from the water and shoreline habitats into the upland habitats.

For the purpose of plotting observations on maps, observations of the same species which were within 0.3 nautical miles (nmi) of each other were lumped together. This allowed us to unite observations of 1 large flock which may

TABLE 1. Boat to air comparisons by species for sub-sampled shoreline areas using actual birds observed. Ratios served as visibility correction factors for estimating actual totals. The boat observations alone served as measures of species composition.

	Winter							Summer		
	1982 to 1984 Selected Areas			1982 to 1984 Port Frederick				1997 to 2002 Selected Areas		
Species	Boat	Air	Ratio	Boat	Air	Ratio	Average Ratio	Boat	Air	Ratio Boat/Air
Red-throated Loon								62	17	
Pacific Loon	27	0						50	2	
Common Loon	48	0						135	31	
Yellow-billed Loon	8	0						1	0	
Loon spp.	64	112						30	66	
Total Loons	147	112	1.31	254	105	2.42	1.87	278	116	2.40
Red-necked Grebe	180	1						4	0	
Horned Grebe	448	0						7	0	
Western Grebe	1	1						0	0	
Grebe spp.	60	62						13	5	
Total Grebe	689	64	10.77				10.77	24	5	4.80
Double-crested Cormorant	57	0						7	0	
Pelagic Cormorant	464	0						2099	0	
Cormorant spp.	406	261						438	717	
Total Cormorant	927	261	3.55	287	152	1.89	2.72	2544	717	3.55
Great Blue Heron	22	5	4.40				4.40	51	34	1.50
Trumpeter Swan	59	36	1.64				1.64	1	1	1.00
Canada Goose	1920	1414	1.36	1829	1064	1.72	1.54	1408	283	4.98
Pacific Brant	1	0						0	0	
Mallard	6038	3576	1.69	9590	4578	2.09	1.89	455	110	4.14
Green-winged Teal								67	0	
American Wigeon	7	34						39	0	
Northern Pintail								1	0	
Scaup spp.	410	156	2.63	1383	452	3.06	2.84	32	0	
White-winged Scoter	2021	260						4251	423	10.05
Black Scoter	70	3						2	5	
Surf Scoter	2590	412						32590	3872	8.42
Scoter spp.	357	2338						11828	30431	
Total Scoter	5038	3013	1.67	12343	6846	1.80	1.74	48671	34731	1.40
Harlequin Duck	4948	1673	2.96	1898	614	3.09	3.02	8742	4031	2.17
Long-tailed Duck	532	172	3.09	1399	366	3.82	3.46	12	2	
Barrow's Goldeneye	6816	0						0	0	
Common Goldeneye	123	0						0	0	
Goldeneye spp.	1959	5683						176	9	
Total Goldeneye	8898	5683	1.57	6716	4100	1.64	1.60	176	9	19.56
Bufflehead	3031	1018	2.98	2370	670	3.54	3.26	0	0	
Red-breasted Merganser	1045	0						61	0	
Common Merganser	753	0						61	0	
Hooded Merganser	41	0						0	0	
Merganser spp.	353	2008						4000	3965	
Total Merganser	2192	2008	1.09	585	323	1.81	1.45	4122	3965	1.04
Black Oystercatcher	82	12					6.83	221	23	9.61
Glaucous-Winged Gull	3093	0						8992	0	
Herring Gull	34	0						2787	0	
Mew Gull	1645	0						34813	0	
Bonaparte's Gull	0	0						7607	0	
Black-legged Kittiwake	1	0						9229	0	
Gull spp.	15	2510						4591	59192	
Total Gull	4788	2510	1.91	2691	2021	1.33	1.62	68019	59192	1.15
Arctic Tern	0	0						277	0	
Caspian Tern	0	0						10	0	
Pigeon Guillemot	173	14					12.36	1405	245	5.73
Rhinoceros Auklet	0	0						3098	2141	1.45

TABLE 1. Continued.

Species	Winter: 1982 to 1984 Selected Areas			Winter: 1982 to 1984 Port Frederick			Winter	Summer: 1997 to 2002 Selected Areas		Summer
	Boat	Air	Ratio	Boat	Air	Ratio	Average Ratio	Boat	Air	Ratio Boat/Air
Common Murre	122	18					6.78	1808	1339	1.35
Tufted Puffin	0	0						187	0	
Horned Puffin	0	0						120	0	
Total Puffin	0	0						307	48	6.40
Common Raven	114	20					5.70	182	39	4.67
Northwestern Crow	2789	1903					1.47	7065	3999	1.77
Sea Otter	135	53					2.55	725	460	1.58
Harbor Seal	1121	325					3.45	2543	1480	1.72

have been split between the left and right sides of the aircraft.

Visibility correction ratios were calculated by double sampling subjectively selected areas by boat for comparison with the aerial data. Areas were selected to be representative of all habitat types and logistically plausible for the boat effort. The areas were large and contiguous to reduce the chance of birds moving into or out of the areas during the time between the air and boat surveys. Movements of birds into or out of the 400-m shoreline strip were assumed to offset each other over the large area sampled. Two observers with binoculars rode in stable skiffs with outboard motors. The boat crew recorded observations to the same 400-m limit from shore as the air crew. The boat crew used the same rules as the air crew for scoters and Sea Otters that were >400 m from shore. The boat crew always classified birds to species. Laptop computers allowed GPS locations to be tagged with each observation. It was assumed that the boat estimates portrayed the actual number of birds. The evasive behavior of the birds was carefully monitored, and the path of the skiff adjusted, to help prevent roll up of flocks ahead of the skiff, which could result in double counting. Boat surveys were always conducted within 3 d of the air surveys over the same shorelines. The winter visibility correction ratio was an average of ratios computed from the double sampled shoreline surveys (1997 to 2002) reported here, and the specific shoreline surveys in Port Frederick (1982 to 1984, Conant and others 1988). If <100 individuals of a species were seen from the air in the comparison study areas during either the summer or winter periods, a weighted average of the summer and winter data was used to calculate the visibility correction ratio.

To estimate wintering bird numbers in the open water, beyond 400 m from shore, we conducted an aerial survey in 1996 of 130 random plots out of a possible 650 total plots. Each plot was one quarter section of a USGS 1:63,360 topographic map. All plots were 7.5 nmi north to south. In areas >400 m from shore, we flew 7 systematic east-west lines within each plot, located on integer minutes of latitude which amounted to 20% of the open water on each plot, or 4% of all the open water in southeast Alaska. Variance was estimated with standard stratified random sampling procedures.

We used data from Agler and others (1995) to estimate the open water component of birds in summer. They surveyed 440 randomly located short transects beyond 200 m from shore. Transects averaged 0.9 nmi in length and were oriented east and west.

Variance Estimation

Even though we had complete shoreline coverage, there was still some variance associated with our counts because we did not see every bird and flock. Detection probabilities for a flock were highly dependent on flock size. We made the assumption that flocks of 50 or more birds had a 100% probability of detection. We assigned a detection probability $p =$ (Visibility Correction Factor)$^{-1}$ to all remaining sightings. We assumed that the number of those sightings, n, would follow a binomial distribution. The mean number of birds in these sightings was $\bar{X}$ with a standard error of $S_{\bar{X}}$. The variance estimate for n was $S_n^2 = (n/p) \cdot (p) \cdot (1 - p)$. The number of birds observed was $n \cdot \bar{X}$ with an estimated variance of $(n^2 \cdot S_{\bar{X}}^2) + (\bar{X}^2 \cdot S_n^2) + (S_{\bar{X}}^2 \cdot S_n^2)$ (Goodman 1960).

Results

Visibility correction factors were calculated using water surveys conducted by boat along a suite of selected shoreline units (Fig. 1, Table 1). As expected, in all cases the boat survey crews found more individuals than the air survey crews. Inclusion of the Port Frederick wintering data more than doubled the sample sizes for many groups of species. We gave equal weight to both surveys and averaged their estimates. Scoters, Harlequin Ducks, and goldeneyes showed nearly identical correction factors between the 2 studies.

Winter and summer population estimates for the complete shoreline survey are presented in Table 2. Scoters were much more abundant in summer (185,700, CV = 0.004) than in winter (77,300, CV = 0.01). Goldeneyes and Bufflehead (*Bucephala albeola*) were not present in summer. Mallards (*Anas platyrhynchos*) were far more abundant in winter than summer, while Canada Geese showed little change between the 2 seasons.

Winter and summer shoreline counts were combined with the best available estimates for the open water component (Table 3, Table 4) to estimate total population values for southeast Alaska. The inclusion of open water counts was particularly important for those species often found offshore, such as loons, cormorants, Long-tailed Duck (*Clangula clangula*), gulls, grebe (*Podiceps* spp.), Pigeon Guillemot (*Cepphus columba*), and Common Murre (*Uria aalge*).

TABLE 2. Southeast Alaska shoreline aerial survey including observed animals and population estimates corrected with visibility factors. The entire shoreline was systematically covered during the period 1997 to 2002.

	Winter Survey			Summer Survey		
	Observed	Visibility Correction Ratio	Expanded Estimate	Observed	Visibility Correction Ratio	Expanded Estimate
Loon	1265	1.87	2370	1159	2.40	2780
Grebe spp.*	574	10.33	5930	28	10.33	290
Cormorant spp.	8043	2.72	21,880	3862	3.55	13,700
Great Blue Heron*	150	1.87	280	206	1.87	390
Trumpeter Swan*	229	1.62	370	1		
Canada Goose	16,194	1.54	24,940	4026	4.98	20,050
Pacific Brant	0			9		
Mallard	51,900	1.89	98,090	1179	4.14	4880
Green-winged Teal	38					
Gadwall	26					
American Wigeon	556					
Northern Pintail	683					
Scaup spp.*	2330	2.84	6620	19	2.62	50
Scoter spp.**	44,410	1.74	77,300	132,643	1.40	185,700
Harlequin Duck	18,060	3.02	54,540	15,965	2.17	34,640
Long-tailed Duck*	4719	3.46	16,330	8		
Goldeneye spp.*	76,198	1.60	121,920	102	1.63	170
Bufflehead	14,367	3.26	46,840	0		
Merganser spp.	27,544	1.45	39,940	14,462	1.04	15,040
Black Oystercatcher*	211	8.66	1830	376	8.66	3260
Gull spp.	64,814	1.62	105,000	266,269	1.15	306,200
Pigeon Guillemot*	211	6.09	1290	1776	6.09	10,800
Rhinocerus Auklet*	386	1.45	560	13,750	1.45	19,900
Common Murre*	1109	1.42	1580	3047	1.42	4330
Puffin spp.*	0			319	6.40	2040
Common Raven*	249	5.02	1250	210	5.02	1050
Northwestern Crow	37,025	1.47	54,430	16,352	1.77	28,940
Sea Otter*,**	2226	1.68	3740	2306	1.68	3870
Harbor Seal	5871	3.45	20,260	12,662	1.72	21,780

* For these species, the number of individuals seen from the aircraft was less than 100 for either winter or summer and the visibility correction ratio is a combination of summer and winter data.

** All visible scoters and sea otters were counted from the aircraft or boat regardless of distance from shore.

TABLE 3. Winter estimates of marine waterbirds in southeast Alaska, including shoreline and open water. The same visibility corrections from Table 1 were used for both shoreline and open water. Omitted species had negligible observations. The visibility correction factors were assumed to be constants.

	Winter						
	Shoreline Complete Coverage 1997–2002			Open Water 130 Random Plots 1996			
Species	No. of Sightings	Corrected Estimate	CV	Corrected Estimate	CV	Grand Total	CV
Loon spp.	807	2370	0.06	9300	0.29	11,670	0.23
Western Grebe	0	0	0	13,500	0.39	13,500	0.39
Other Grebe	343	5930	0.07	14,400	0.30	20,330	0.21
Cormorant spp.	1540	21,880	0.04	9500	0.19	31,380	0.06
Canada Goose	774	24,940	0.02	0	0	24,940	0.02
Mallard	2990	98,090	0.01	0	0	98,090	0.01
Scoter spp.	3450	77,300	0.01	-	-	77,300	0.01
Harlequin Duck	3393	54,540	0.02	2000	0.41	56,540	0.02
Long-tailed Duck	622	16,330	0.04	136,700	0.61	153,030	0.54
Goldeneye spp.	8460	121,920	0.01	10,200	0.52	132,120	0.04
Bufflehead	2648	46,840	0.03	1600	0.67	48,440	0.04
Merganser spp.	6059	39,940	0.02	10,200	0.32	50,140	0.07
Gull spp.	9666	105,000	0.01	116,200	0.19	221,200	0.10
Pigeon Guillemot	107	1290	0.14	8900	0.55	10,190	0.48
Common Murre	124	1580	0.08	71,400	0.19	72,980	0.19

Distribution maps for all shoreline observations in winter and summer for 12 species are displayed in Fig. 2, 3, and 4. Cormorants were found primarily on the exposed outside coast in summer, whereas in winter they were found on the major waterways within 50 km of the coast. Canada Geese were distributed throughout southeast Alaska in winter, but were confined to specific locales in summer. Mallards were abundant throughout in winter and very sparse in summer. Scoters and mergansers were highly concentrated in Glacier Bay and the east side of Admiralty Island in summer, and far less so in winter. Goldeneyes and Bufflehead were ubiquitous in winter. Rhinoceros Auklets (*Cerorhinca monocerata*) were only

TABLE 4. Summer estimates of marine waterbirds in southeast Alaska, including shoreline and open water. The small percentage of birds in the 200-m to 400-m section from shore was included in both surveys and therefore double counted in the grand total. The same visibility corrections from Table 1 were used for the shoreline. Omitted species had negligible observations. The visibility correction factors were assumed to be constants.

	Summer						
	Shoreline Complete Coverage 1997–2002			Open Water (From Agler and others 1995) 440 Short Transects 1994			
Species	No. of Sightings	Corrected Estimate	CV	Expanded Estimate	CV	Grand Total	CV
Loon spp.	205	2780	0.08	3700	0.28	6480	0.16
Cormorant spp.	345	13,700	0.05	52,800	0.58	66,500	0.46
Canada Goose	191	20,050	0.05	0	0	20,050	0.05
Mallard	81	4880	0.10	0	0	4880	0.10
Scoter spp.	1670	185,700	0.004	-	-	185,700	0.004
Harlequin Duck	1194	34,640	0.03	8500	0.52	43,140	0.11
Merganser spp.	623	15,040	0.02	206	0.98	15,250	0.02
Gull spp.	10,620	306,200	0.004	146,300	0.18	452,500	0.06
Pigeon Guillemot	435	10,800	0.08	19,400	0.27	30,200	0.18
Rhinoceros Auklet	343	19,900	0.01	196,300	0.28	216,200	0.25
Common Murre	122	4330	0.04	134,800	0.29	139,130	0.28

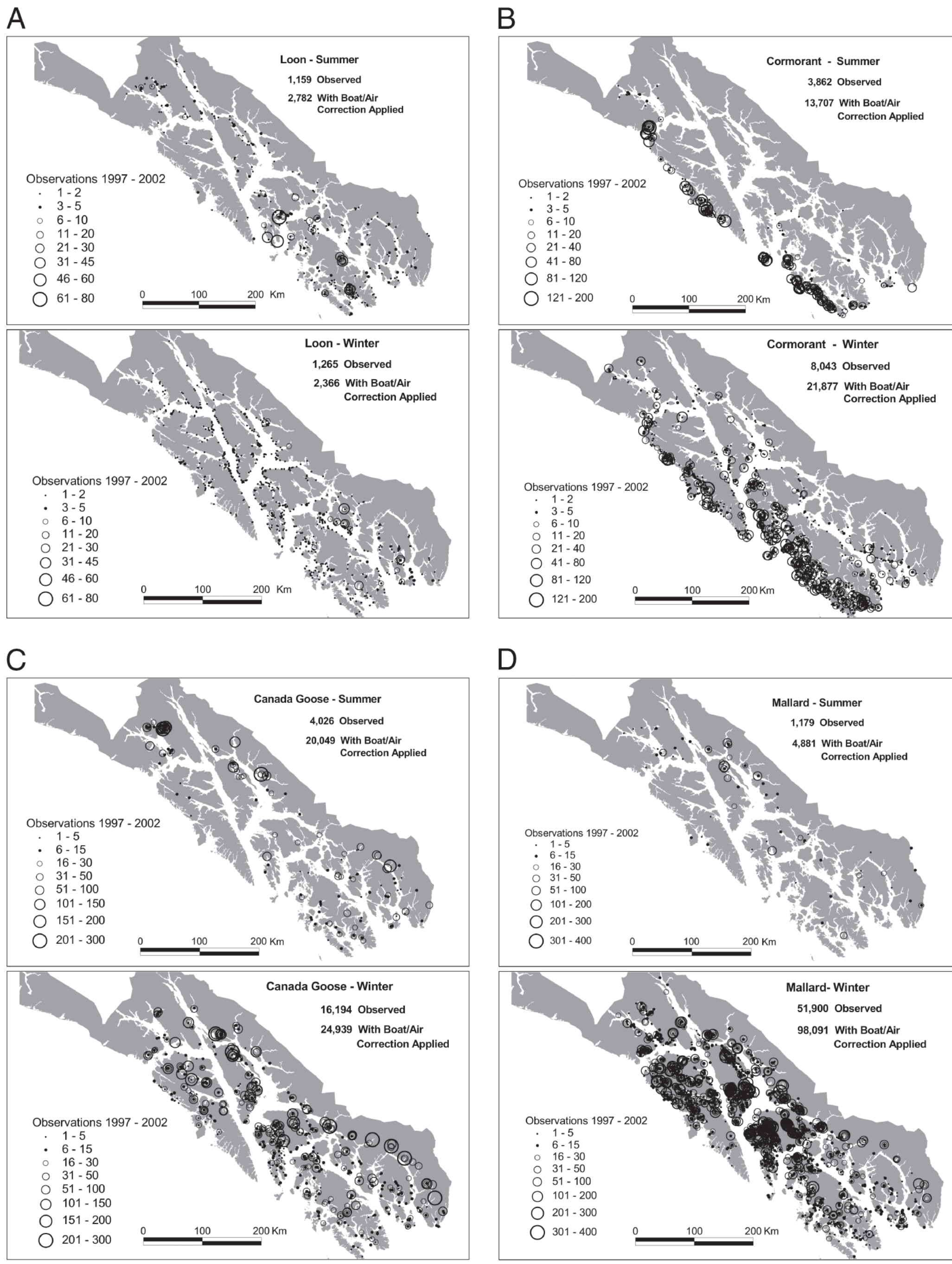

FIGURE 2. Complete aerial shoreline survey, 1997 through 2002: loons, cormorants, Canada Goose, and Mallard. Summer survey period was 24 July to 14 August. Winter survey period was 15 February to 15 March.

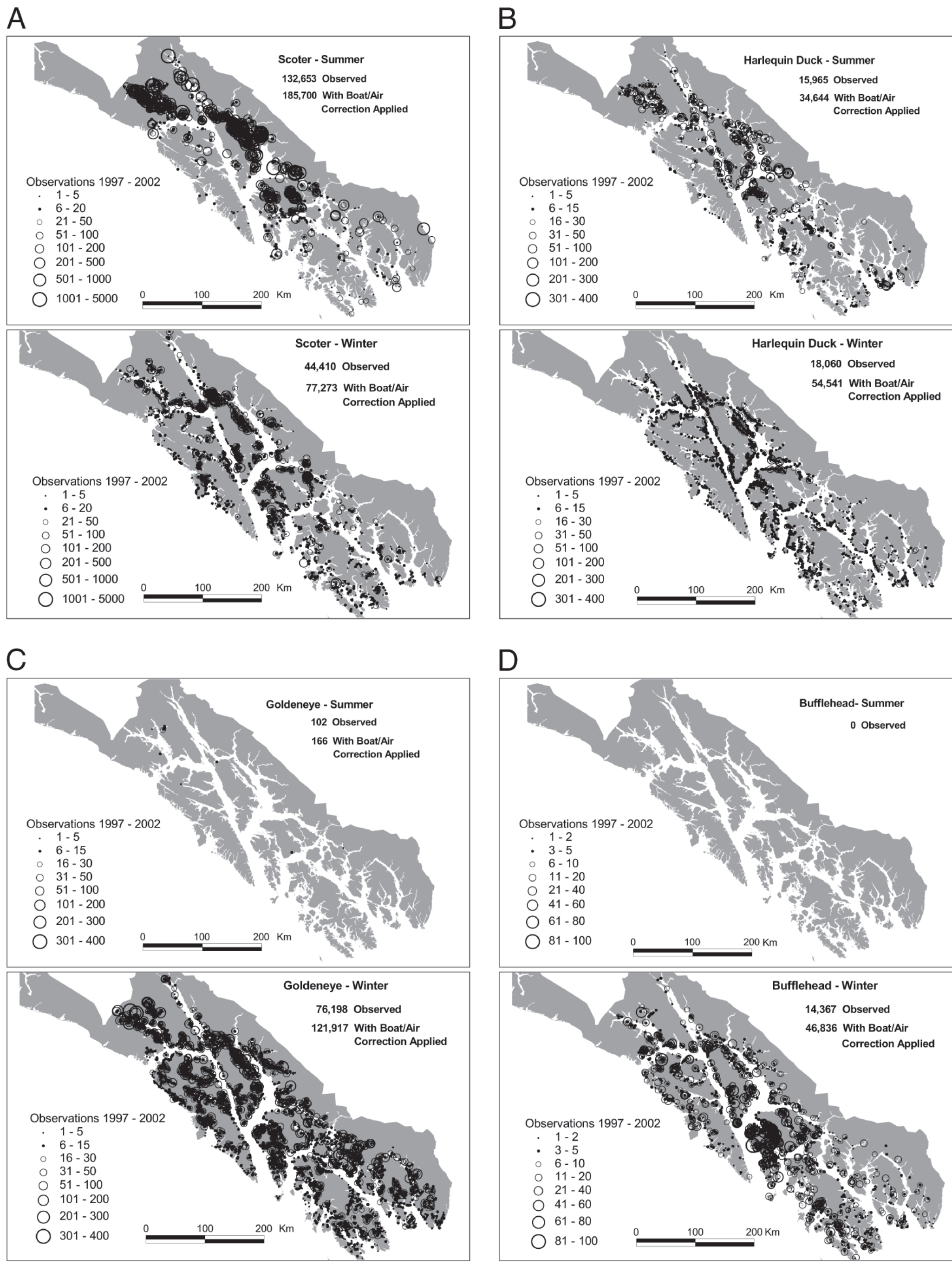

FIGURE 3. Complete aerial shoreline survey, 1997 through 2002: scoters, Harlequin Duck, goldeneyes, and Bufflehead. Summer survey period was 24 July to 14 August. Winter survey period was 15 February to 15 March.

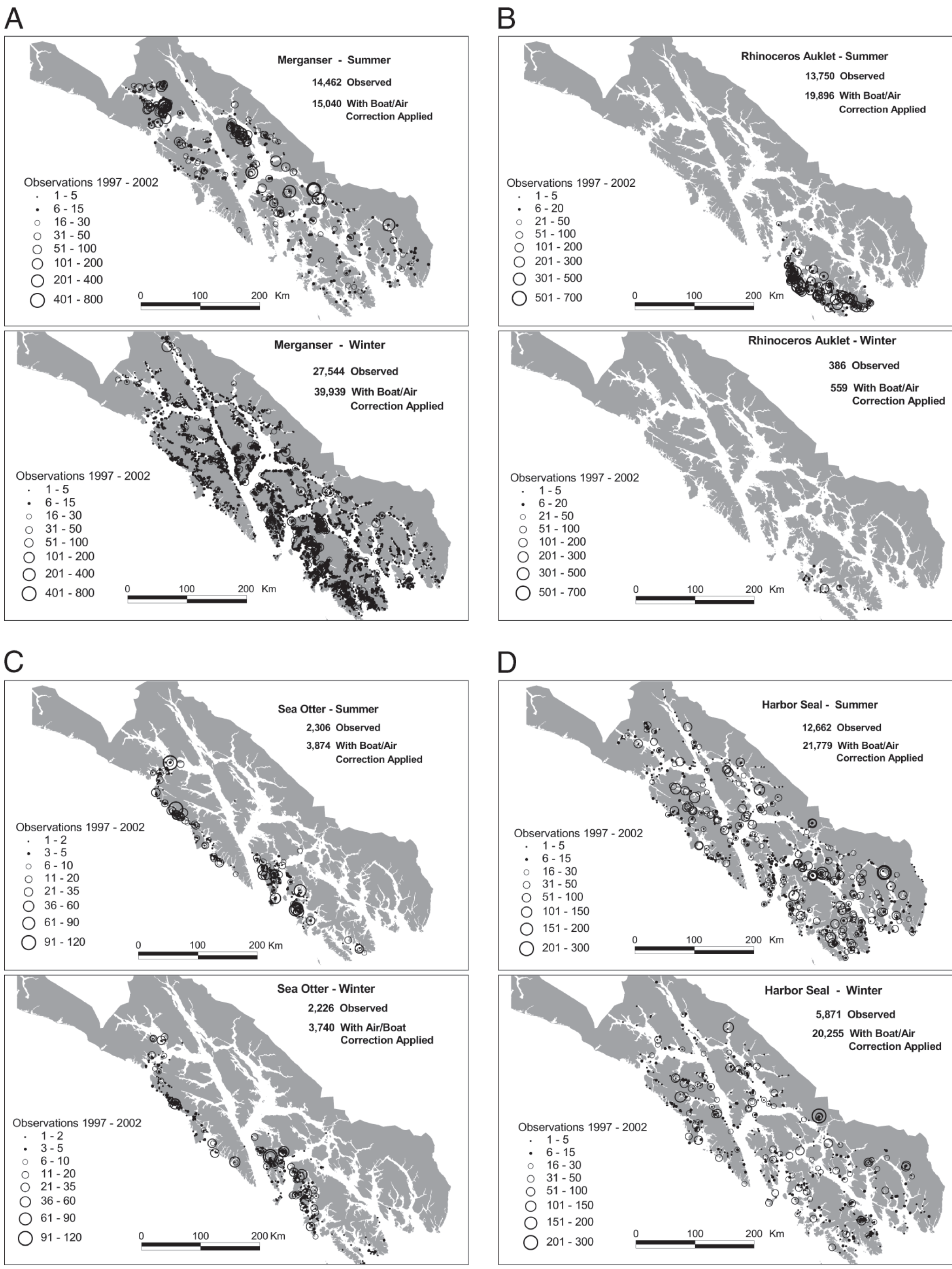

FIGURE 4. Complete aerial shoreline survey, 1997 through 2002: Merganser, Rhinoceros Auklet, Sea Otter, and Harbor Seal. Summer survey period was 24 July to 14 August. Winter survey period was 15 February to 15 March.

found in the southwestern portion of the study area.

DISCUSSION

Complete shoreline survey coverage of a large region such as southeast Alaska provided a valuable data set with benefits over surveys which utilized a sampling design. Any subset of the whole could be chosen and the data could stand alone. Geographic locations tagged to every observation provided complete distribution data without gaps.

We were surprised by the previously undocumented abundance of scoters in summer, which was 3 times greater than the scoter abundance estimated in winter. We speculate that these were non-breeding young birds, failed breeders, or adult males using the portions of southeast Alaska closest to their interior breeding grounds in Canada. This represents 20% of the estimated North American breeding population.

Scoters presented a challenge to the shoreline strip survey method. Their flocks were often large and often extended from near shore to 1 km offshore. We chose to address this situation by circling all large flocks to obtain a good ocular count. Large flocks were usually highly visible up to a mile or more, so we felt we would see a very high proportion of the scoter flocks. The 1996 winter aerial survey found 63% of the scoters in the 400-m strip adjacent to shore. Judging from the many large flocks which we encountered that extended beyond the 400-m shoreline strip, we felt we accounted for most of the potential 37% scoters in the open water section. Since scoters were similarly distributed in summer, we can assume we accounted for the large majority of the scoters in summer as well.

Sea Otters that were alone or in small groups in the open water beyond 400 m from shore were difficult for us to locate. Therefore our Sea Otter estimates should be considered as minimum values. We estimated similar numbers in winter (3740) as in summer (3874). Agler and others (1996) estimated 8180 ± 6286 (95% confidence limits). Sea Otters were introduced at 2 locations on the outside coast of southeast Alaska in 1968 to 1971. Their expansion into the inside waters is thus far limited, but this could change in the future. Prince William Sound had 150 Sea Otters in 1951, and by 1985 they numbered almost 5000 and were distributed throughout the inside waters. The presence of Sea Otters directly influences kelp communities. Sea Otters reduce the abundance of urchins which allows kelp forests to flourish. In this way Sea Otters influence the habitats for sea ducks and many sea birds.

Other species which rarely stray from the shorelines include Harlequin Duck, goldeneye, Bufflehead, Mallard, and Canada Goose. A very high percentage of these birds would have been available to our survey path.

Sources of Error

The distribution of birds we observed was only representative of the time frames of our surveys, late winter and late summer. We assume there were no major shifts in distribution and abundance of animals between the survey years. We recognize that we may have observed some localized concentration areas that may not remain unchanged over a period of many years. Frozen bays and fjords completely displaced birds but attracted seals in some cases.

The comparability of a future repeated survey to our results will depend upon the use of an aircraft with similar flight performance as the turbine powered DeHaviland Beaver, similar skill level of the pilot-observer, strict adherence to the survey methods, and equally trained observers. Nonetheless, the broad scale distribution patterns of animals should be valid in the face of these survey factors.

The accuracy of expanded population estimates were affected by potential sources of error in the visibility correction ratios. Sample sizes for many species in the double sampled areas were inadequate. When dealing with large and variable flock sizes, there is a need for large samples of observations from both the air and the boat. Smith (1995) recommends a minimum sample size of at least 40 observations for each type of craft, even when the observations are singles, pairs, and very small flocks. We can not guarantee that the boat observed 100% of the animals. Compromising factors included variable sea conditions, variable observer experience and levels of interest, low tides restricting access to large tidal zones, and movements of animals between the air and boat surveys.

Murrelets (*Brachyramphus* spp.) were often seen but they were not reported here because they were almost impossible to observe from the air when the water surface was at all choppy. Our data, if presented, would be very misleading for murrelets in southeast Alaska. Aerial surveys for murrelets are possible, but the strict survey criterion of no wind is an absolute requirement which was not adhered to in this survey.

Some species were difficult to observe if they were on shore and did not flush or move. These included Harlequin Duck, mergansers, Great Blue Heron (*Ardea herodias*), and Black Oystercatcher. Canada Geese on the other hand sometimes flushed far in advance of the airplane and may have flown out of view before we had a chance to see them. Sun glare was another problem, occurring more frequently during the winter survey when the sun was close to the horizon most of the day.

The calculated ratio of boat to air for the winter surveys was a combination of data from our survey and the previous intensive effort in Port Frederick (Conant and others 1988). Equal weight was given to the Port Frederick data even though it represented only 1 relatively small area in southeast Alaska.

Applicability of Results

The geographic data base generated for the entire shoreline of southeast Alaska allows the user to pick and choose any region for analysis. This helps with developing oil spill contingency plans, responding to actual oil spills, selecting areas of special concern, and providing the basis for designing future more detailed studies of selected species.

The data provide a basis with which to compare future species abundance studies for any portion of the area. The distribution information is complete and therefore may be used to focus interest in concentration areas. Future studies could attempt to explain the distributional patterns with information about intertidal substrate, water quality, and hydrographic variables. These data may be obtained from the US Fish and Wildlife Service, Division of Migratory Bird Management, Alaska Region.

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