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 both in summer and in winter during the period 1997-2002. A ground/boat survey double sampled 20% of the summer habitat and 5% of the winter habitat to adjust and enhance the air survey. All observations were recorded using an onboard computer which added geographic locations to the observations using coordinates from a Global Positioning System receiver. The most abundant species (corrected with visibility ratios) during the summer surveys were gull (*Larus spp.* 306,209), scoter (*Melanitta spp.*185,700), and harlequin duck (*Histrionicus histrionicus* 34,644). The most abundant species observed during the winter surveys were goldeneye (*Bucephala islandica and b. clangula spp.* 121,917), gull(105,000), mallard (*Anas platyrhynchos* 98,091), scoter(77,273), harlequin duck(54,541), northwestern crow (*Corvus caurinus* 54,427), bufflehead (*Bucephala albeola* 46,836), and merganser (*Mergus spp.* 39,939). 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 estimates without sampling error. Meaningful population values could be generated for very specific subunits selected after completion of the survey since 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, Alaska, southeast Alaska, aerial survey.

The defining characteristic of the southeastern panhandle of Alaska is its prodigious and usually 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 geese (*Branta minima)*, harlequin duck (*Histrionicus histrionicus)*, merganser (*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 fifty years (Eggeman and Johnson 1989). The coast of Denmark was systematically surveyed in the late 1980's in such a way that distribution maps could be generated for each species (Laursen et. al. 1997). The first 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 et al 1995). The second attempt was a winter aerial survey in 1996 based on 130 random plots incorporating about 5000 km of shoreline (Conant 1996 unpublished data). 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 1997-2002. Our complete shoreline coverage eliminated the serious problem of sampling error and at the same time provided accurate and thorough distribution information. We also conducted extensive boat comparison surveys to provide population correction factors. Conant et. al. (1988) calculated boat to air ratios for Port Frederick during three successive winters, 1982-1984 which helped bolster our winter correction factors.

STUDY AREA

Southeast Alaska (Figure 1) is a conglomerate of waterways and forested landscapes melded into a myriad of passages, channels, fjords, bays, lagoons and tidal flats. Steep sided and deep channeled fjords pierce into the rugged mainland mountains as well as into the ten 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 25,000km 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 as well.

Two large tides bathe the shorelines daily. The average tidal range is 5m. 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 15m in depth.

The northwest boundary was at Cape Spencer. Portland Canal on the south end 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 offset distance from shore was variable depending on the situation, but always an effort was made to give the best possible view of birds at the waters edge, or even on the rocks or beach. When conditions allowed, this was usually about 50m from shore. 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 400m from shore. Exceptions were made for scoters and sea otters. If either of these two species were outside the 400m 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 35m was preferred except when turbulence or terrain dictated the need for a higher safe altitude.

The survey was conducted over a five year period (1997-2002) 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 years 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 two weeks 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 percent 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 two crew members. The aircraft's GPS location was also saved with each observation. The two computers were specially made to slide into the radio rack of the aircraft's instrument panel. Each computer had a small, high resolution screen mounted on the front. The computer in front of the pilot-observer was zoomed in to show intricate shoreline features, while the observer's computer displayed a larger area to help with flight planning. The displayed airplane track made it easy to assure we had complete coverage without overlap.

The air crew did not classify scoters, goldeneyes, mergansers, cormorants, shorebirds or gulls to species. Loons were not classified to species in winter. Black oystercatchers were the only shorebird that was adequately surveyed. Bald eagles were not counted because of the potential for diverting the observer's view from the water and shoreline habitats into the upland habitats.

During post processing of the data, observations of the same species which were within 0.3 nautical miles of each other were lumped together. This allowed us to unite observations of one large flock which may 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. Two observers with binoculars rode in stable skiffs with outboard motors. The boat crew recorded observations to the same 400m 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, housed in protected cases, 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 three days of the air surveys over the same shorelines. The winter visibility correction ratio was an average of ratios computed from the widespread shoreline surveys (1997-2002) and the specific shoreline surveys in Port Frederick (1982-1984, Conant et al. 1988). If less than 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 nautical miles 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 percent of the open water on each plot, or 4 percent of all the open water in southeast Alaska. Additionally, a total of 196 major tide flats were pre-selected and surveyed in their entirety for both mallards (*Anas platyrhynchos*) and Canada Geese. Mallards and geese counts for these flats were combined with expanded sample estimates of mallards and geese seen within the sampled plots but outside the pre-selected tide flats.

We used data from Agler et al. (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 NM in length and were oriented east and west.

Definitions

The *pilot-observer* was pilot of the airplane and also served as observer on the left side. The *observer* sat in the right front seat and did not have piloting duties. *Shoreline water* was the water within 400 meters of any land, island or rock. *Open water* was as the inland waters beyond 400 meters of any land, island or rock.

RESULTS

Visibility correction factors were calculated using ground surveys conducted by boat along a suite of selected shoreline units (Figure 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 data more than doubled the sample sizes for many groups of species, adding precision and accuracy to the estimates. Only scoters (*Melanitta spp.)*, harlequin ducks (*Histrionicus histrionicus)* and goldeneyes (Bucephala clangula and b. islandica) showed nearly identical correction factors between the studies. We averaged the two study estimates to give equal weight to the different survey crews.

Winter and summer population estimates for the complete shoreline survey are presented in Table 2. Scoters were much more abundant in summer (185,700) than in winter (77,273). Goldeneyes and bufflehead (Bucephala albeola) were not present in summer. Mallards were far more abundant in winter than summer, while Canada geese showed little change between the two seasons.

Tables 3 and 4 combine the winter and summer shoreline counts with the best available estimates for the open water components. These give more inclusive total population totals for those species often found offshore, i.e. loon (*Gavia spp.)*, cormorant (*Phalacrocorax spp.)*, long-tailed duck (*Clangula clangula)*, guls (*Larus spp.)*, grebe (P*odiceps spp.*), pigeon guillemot (*Cepphus Columba*) and common murre (*Uria aalge*).

Distribution maps for all shoreline observations in winter and in summer for 12 species are displayed in Figure 2. 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 locals 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. Goldeneye and bufflehead were ubiquitous in winter. Rhinoceros auklets (*Cerorhinca monocerata)* were only found in the southwestern portion of the study area.

The winter survey of random plots in 1996 estimated the mallard population at 52,790 (CV = .05) and the Canada goose population at 24,318 (CV = .06).

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. There was no sampling error associated with the observed counts. Geographic locations tagged to every observation provide completed distribution data without gaps.

We were surprised by the previously undocumented abundance of scoters in summer (estimated 185,700), three times as many as were 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 percent 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 one kilometer 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 percent of the scoters in the 400m strip adjacent to shore. Judging from the many large flocks which we encountered that extended beyond the 400m shoreline strip, we felt we accounted for most of the potential 37 percent 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 400m from shore were difficult for us to locate. Therefore our sea otter estimates should be considered as minimum values. We estimated virtually the same number in winter (3,740) as in summer (3,874). Agler et al. (1996) estimated 8,180 +/- 6,286 (95% confidence limits). Sea otters were introduced at two locations on the outside coast of southeast Alaska in 1968–1971. Their expansion into the inside waters is thus far limited. That could change in the future. Prince William Sound had 150 otters in 1951 and by 1985 the numbered almost 5,000 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 therefore 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.

The estimates for mallards in 1996 and in the 1997 – 2002 surveys were extremely close, 52,790 and 51,900 respectively. The estimates for Canada geese were not close, 24,218 and 16,194 respectively. It is doubtful that observers were to blame for goose flock estimation differences because the mallard estimates were similar between the two surveys. It is more likely the geese were better surveyed on the 1996 survey when the aircraft was flown directly to all of the major tide flat areas. Geese usually flushed well in advance of the plane. The complete shoreline survey in 1997 – 2002 may have missed some geese because the aircraft was meandering along the shoreline, allowing some of the geese to react to the plane and leave the area prior to being observed.

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 fiords 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 deHaviland turbine 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 are 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, even when the observations are singles, pairs and very small flocks. The number of individual observations was not reported here because we often lumped small groups with larger nearby groups of animals. We can not guarantee that the boat observed 100 percent 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, could be very misleading for murrelets in southeast Alaska. Aerial surveys for murrelets are possible, but strict survey criteria of no wind would be required.

Some species were difficult to observe if they were on shore and did not flush or move. These included harlequin duck, merganser (*Mergus spp.*), great blue heron (*Ardea herodias*) and black oystercatcher (*Haematopus bachmani)*. 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 et. al. 1988). Equal weight was given to the Port Frederick data even though it represented only one 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.

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

FIGURE 2: Complete aerial shoreline survey, progressive 1997 through 2002. Summer survey period July 24 to August 14. Winter survey period February 15 to March 15.

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			Average	1997 to 2002 Selected Areas		Ratio
Species	Boat	Air	Ratio	Boat	Air	Ratio	Ratio	Boat	Air	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
Unidentified Scoter	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	
Guillemots	173	14					12.36	1405	245	5.73
Rhinoceros Auklet	0	0						3098	2141	1.45
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

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 - 2002.

	Winter Survey			Summer Survey		
	Observed	Visibility Correction Ratio	Expanded Estimate	Observed	Visibility Correction Ratio	Expanded Estimate
Loon	1,265	1.87	2,366	1,159	2.40	2,782
Grebe Spp. *	574	10.33	5,931	28	10.33	289
Cormorant Spp.	8,043	2.72	21,877	3,862	3.55	13,707
Great Blue Heron *	150	1.87	281	206	1.87	386
Trumpeter Swan *	229	1.62	371	1		
Canada Goose	16,194	1.54	24,939	4,026	4.98	20,049
Pacific Brant	0			9		
Mallard	51,900	1.89	98,091	1,179	4.14	4,881
Green-winged Teal	38					
Gadwall	26					
American Wigeon	556					
Northern Pintail	683					
Scaup Spp. *	2,330	2.84	6,617	19	2.62	50
Scoter Spp. **	44,410	1.74	77,273	132,643	1.40	185,700
Harlequin Duck	18,060	3.02	54,541	15,965	2.17	34,644
Long-tailed Duck *	4,719	3.46	16,328	8		
Goldeneye Spp. *	76,198	1.60	121,917	102	1.63	166
Bufflehead	14,367	3.26	46,836	0		
Merganser Spp.	27,544	1.45	39,939	14,462	1.04	15,040
Black Oystercatcher *	211	8.66	1,827	376	8.66	3,255
Gulls	64,814	1.62	104,999	266,269	1.15	306,209
Guillemot *	211	6.09	1,286	1,776	6.09	10,816
Rhinocerus Auklet *	386	1.45	559	13,750	1.45	19,896
Common Murre *	1,109	1.42	1,577	3,047	1.42	4,327
Puffin *	0			319	6.40	2,040
Common Raven *	249	5.02	1,249	210	5.02	1,054
Northwestern Crow	37,025	1.47	54,427	16,352	1.77	28,943
Sea Otter * **	2,226	1.68	3,740	2,306	1.68	3,874
Harbor Seal	5,871	3.45	20,255	12,662	1.72	21,779

* 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.

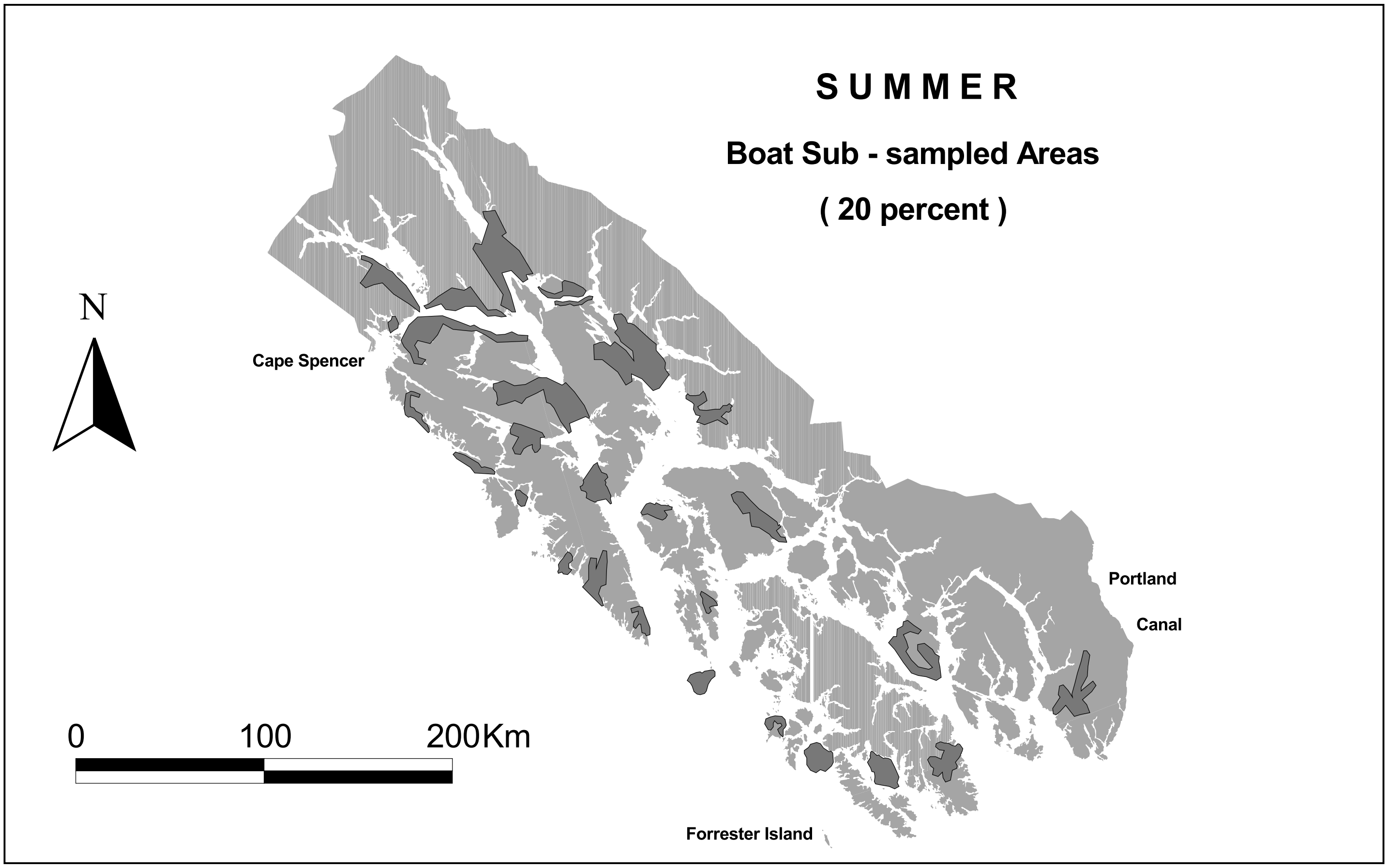
Table 3. Combined shoreline and open water estimates in winter for southeast Alaska. The same visibility corrections from Table 1 were used for both shoreline and open water. Omitted species had negligible observations. Scoters are not shown because they were not separated into shoreline and open water categories.

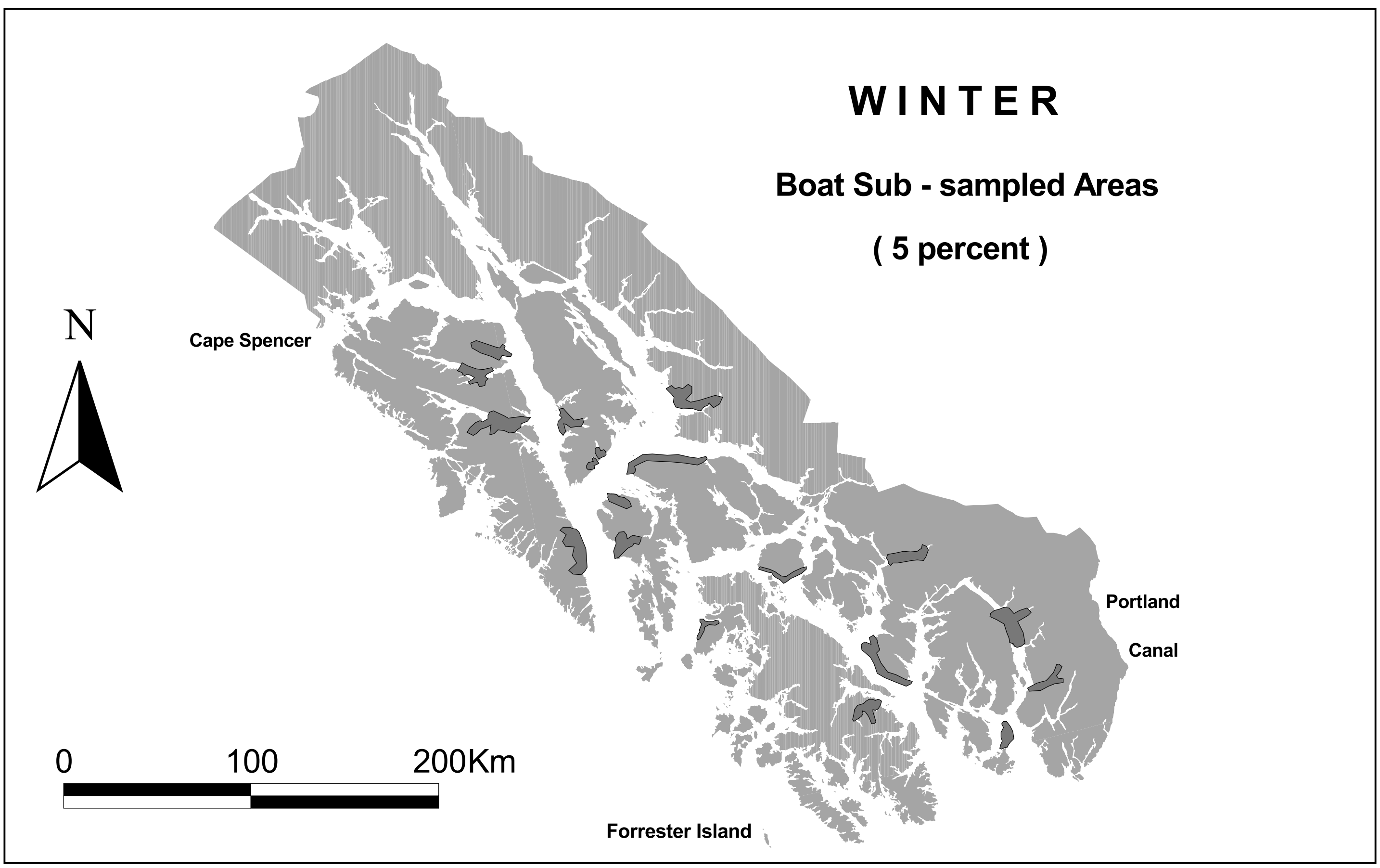
	Winter Shoreline Complete coverage 1997 - 2002	Winter Open Water 130 Random Plots 1996		
Species	Corrected Estimate	Expanded Estimate	Standard Error	Grand Total
Loons Spp.	2,366	9,316	2,676	11,682
Western Grebe	0	13,511	5,292	13,511
Other Grebe	5,931	14,446	4,361	20,377
Cormorant Spp.	21,877	9,515	1,790	31,392
Harlequin Duck	54,541	1,972	815	56,513
Long-tailed Duck	16,328	136,736	83,120	153,063
Goldeneye Spp.	121,917	10,232	5,310	132,149
Bufflehead	46,836	1,552	1,043	48,388
Merganser Spp.	39,939	10,179	3,283	50,118
Gull Spp.	104,999	116,209	22,281	221,208
Pigeon Guillemot	1,286	8,926	4,947	10,211
Common Murre	1,577	71,416	13,854	72,993

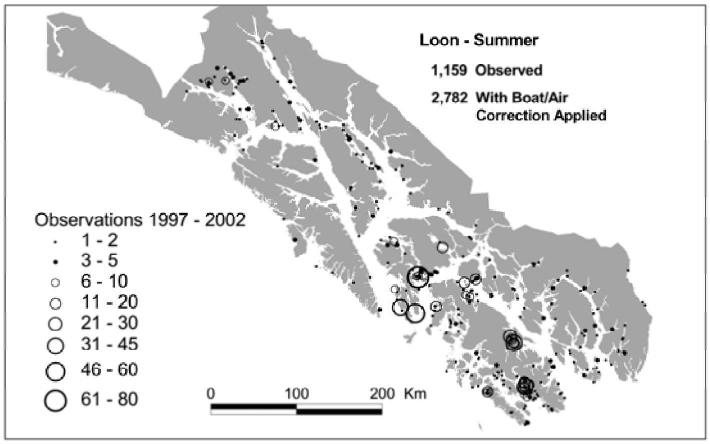
Table 4. Combined shoreline and open water estimates in summer for southeast Alaska. The small percentage of birds in the 200m to 400m section from shore was included in both surveys and therefore double counted in the grand total. There is no sampling variance for the complete shoreline survey, thus the standard error of the open water transects also apply to the grand total values.

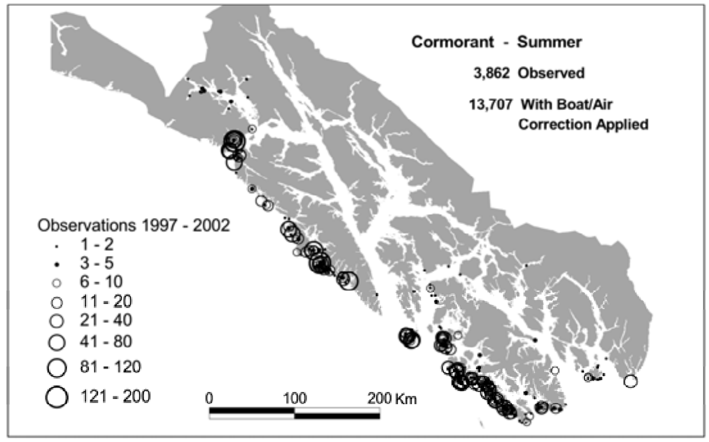
	Summer Shoreline Complete coverage 1997 - 2002	Summer Open Water (Agler et al. 1995) 440 Short Transects 1994		
	Corrected Estimate	Expanded Estimate	Standard Error	Grand Total
Loon Spp.	2,782	3,715	1,058	6,497
Cormorant Spp.	13,707	52,837	30,405	66,544
Harlequin Duck	34,644	8,462	4,440	43,106
Long-tailed Duck	24	619	452	643
Goldeneye Spp.	166	0	0	166
Bufflehead	0	0	0	0
Merganser Spp.	15,040	206	202	15,246
Gull Spp.	306,209	146,333	26,103	452,542
Pigeon Guillemot	10,816	19,401	5,236	30,217
Common Murre	4,327	134,775	38,666	139,102

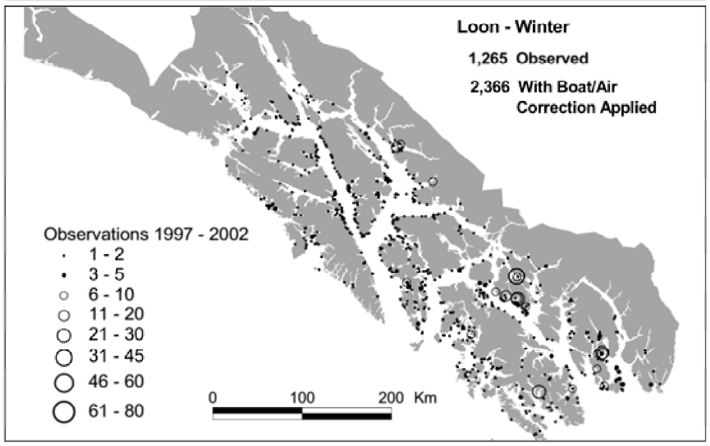
Figure 1. Southeast Alaska shoreline with boat sub-sampled areas highlighted.

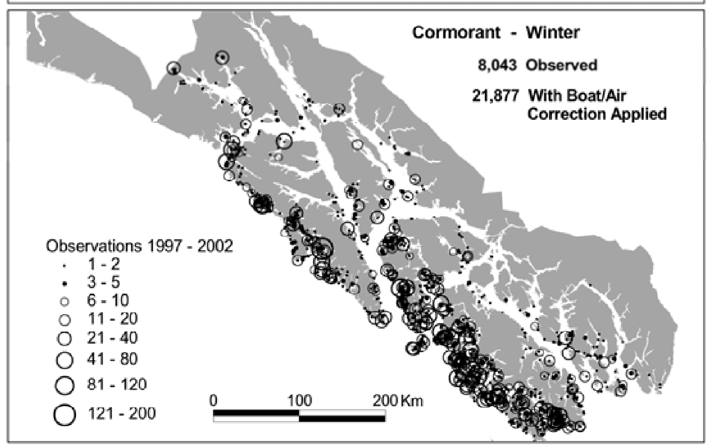


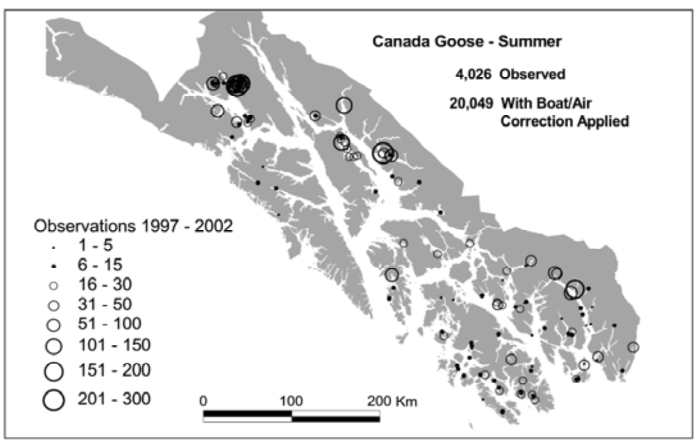


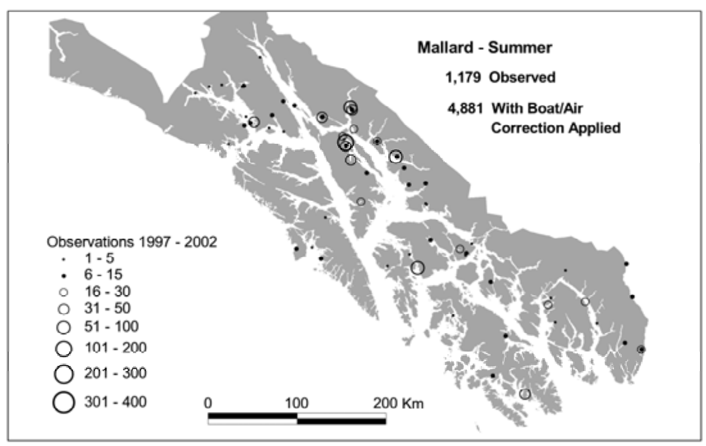

Loon - Summer
1,159 Observed
2,782 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 30
31 - 45
46 - 60
61 - 80
0 100 200 Km

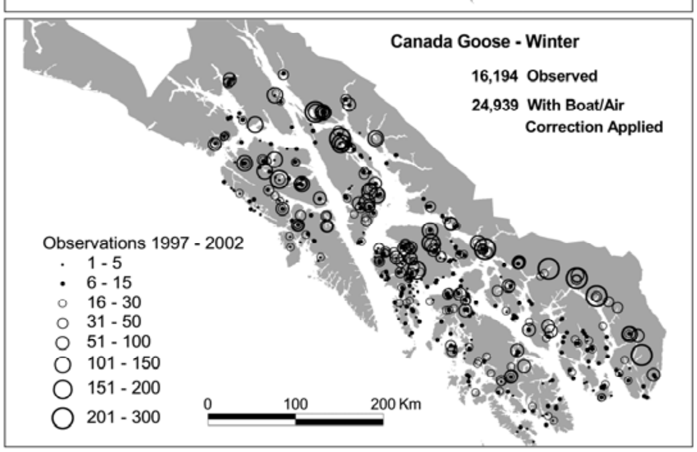

Cormorant - Summer
3,862 Observed
13,707 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 40
41 - 80
81 - 120
121 - 200
0 100 200 Km

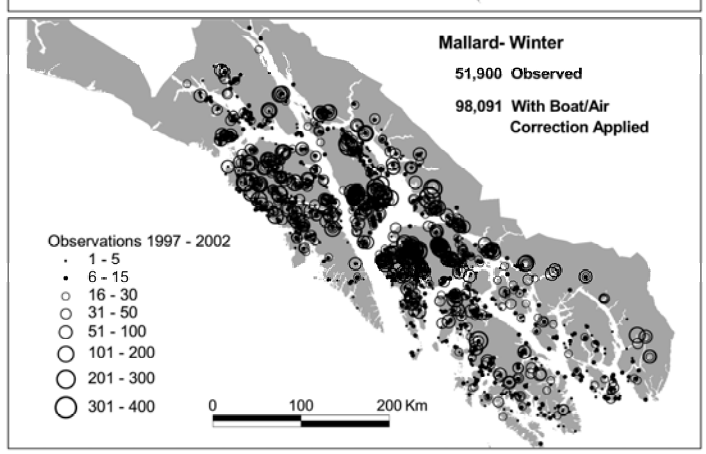

Loon - Winter
1,265 Observed
2,366 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 30
31 - 45
46 - 60
61 - 80
0 100 200 Km

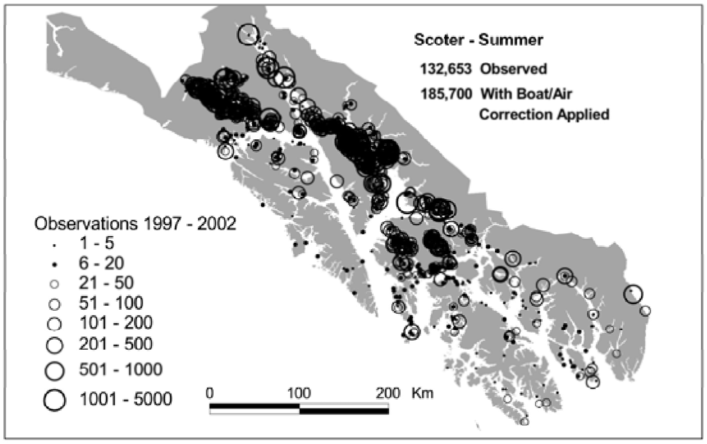

Cormorant - Winter
8,043 Observed
21,877 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 40
41 - 80
81 - 120
121 - 200
0 100 200 Km

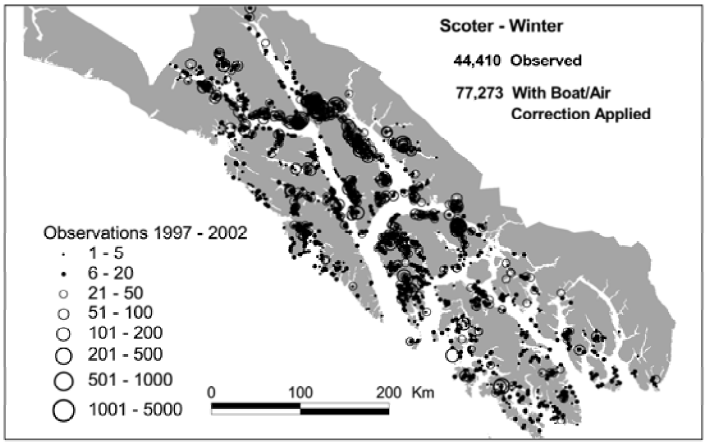

Canada Goose - Summer
4,026 Observed
20,049 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 150
151 - 200
201 - 300
0 100 200 Km

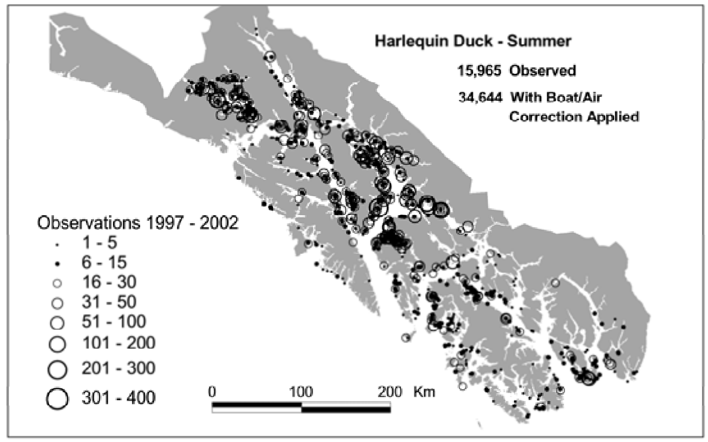

Mallard - Summer
1,179 Observed
4,881 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0 100 200 Km

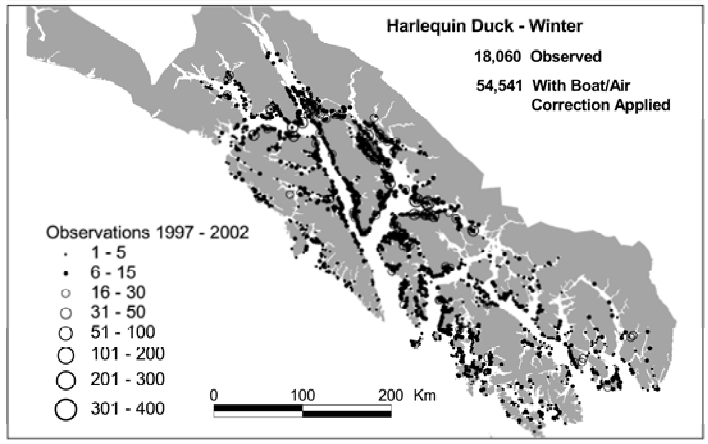

Canada Goose - Winter
16,194 Observed
24,939 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 150
151 - 200
201 - 300
0 100 200 Km

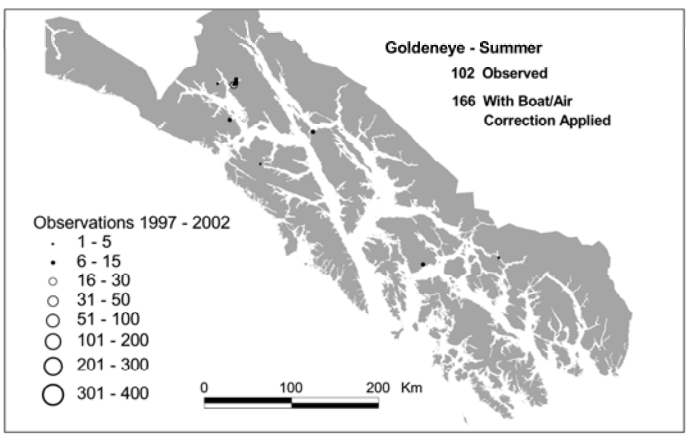

Mallard- Winter
51,900 Observed
98,091 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0 100 200 Km

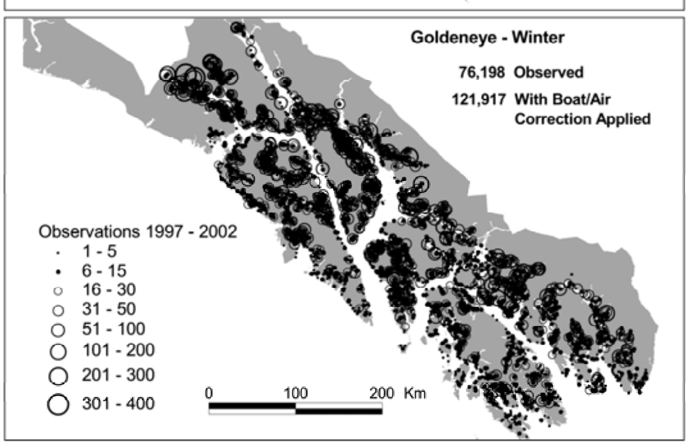

Scoter - Summer
132,653 Observed
185,700 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 20
21 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
1001 - 5000
0
100
200 Km

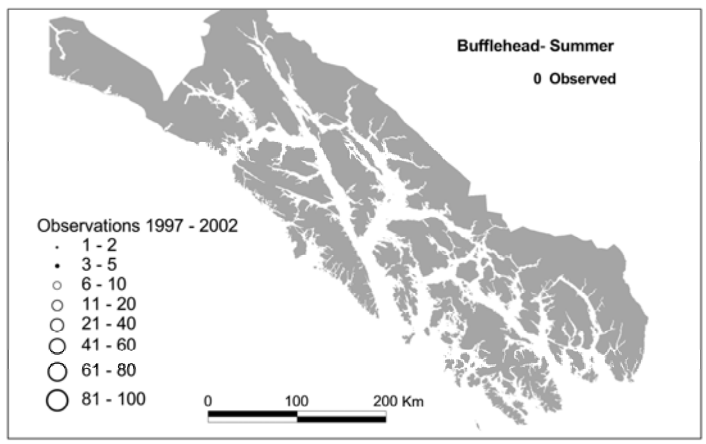

Scoter - Winter
44,410 Observed
77,273 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 20
21 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
1001 - 5000
0
100
200 Km

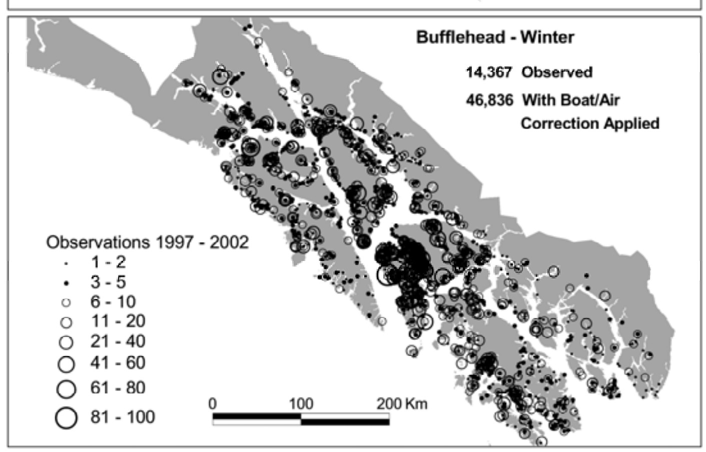

Harlequin Duck - Summer
15,965 Observed
34,644 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0
100
200 Km

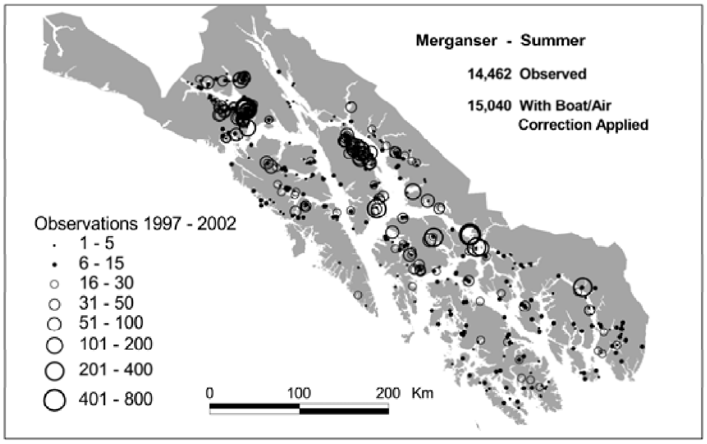

Harlequin Duck - Winter
18,060 Observed
54,541 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0
100
200 Km

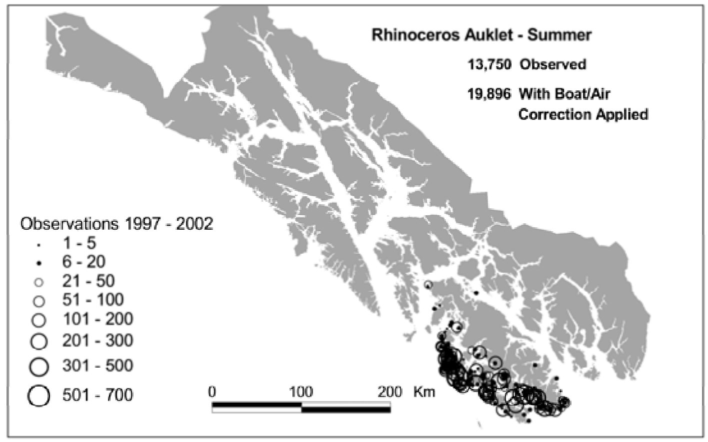

Goldeneye - Summer
102 Observed
166 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0
100
200 Km

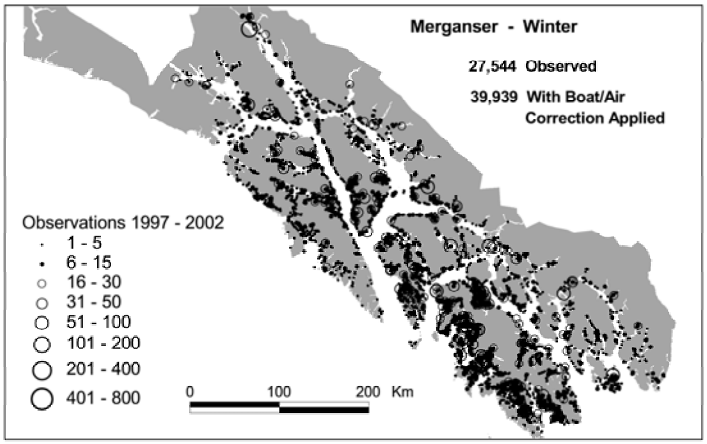

Goldeneye - Winter
76,198 Observed
121,917 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 300
301 - 400
0
100
200 Km

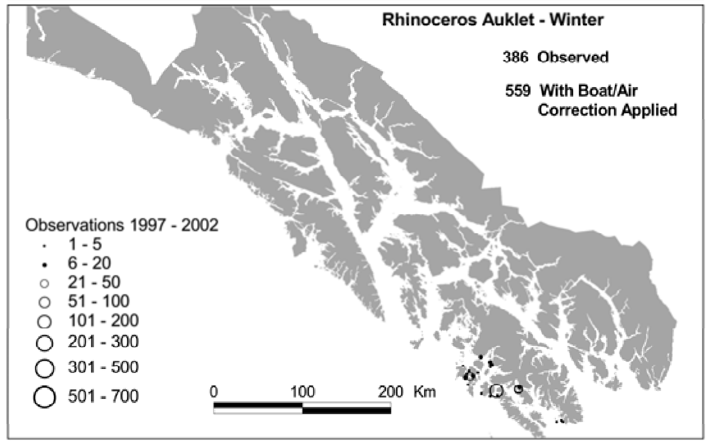

Bufflehead- Summer
0 Observed
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 40
41 - 60
61 - 80
81 - 100
0
100
200 Km

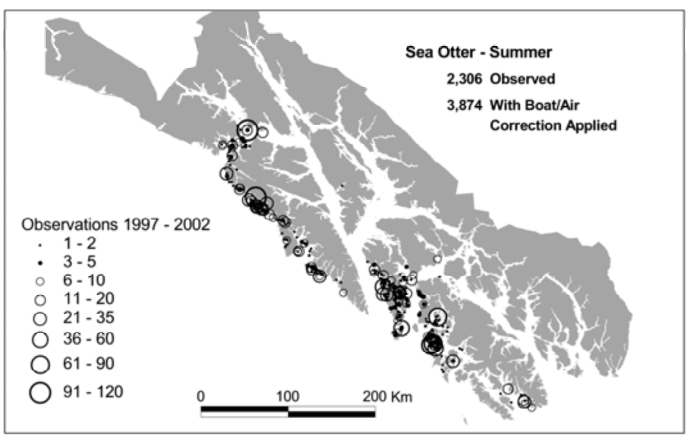

Bufflehead - Winter
14,367 Observed
46,836 With Boat/Air Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 40
41 - 60
61 - 80
81 - 100
0
100
200 Km

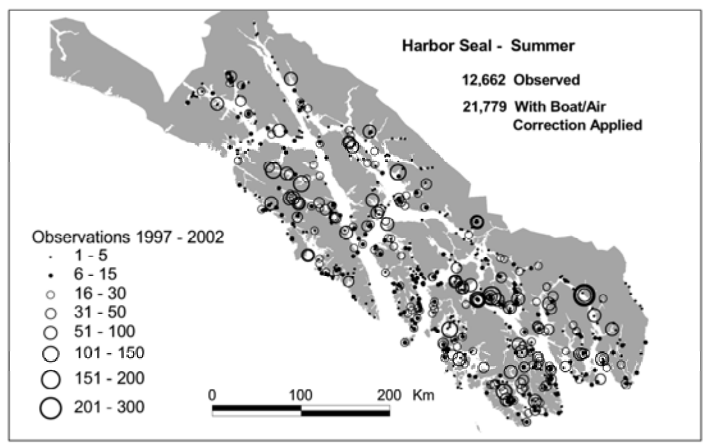

Merganser - Summer
14,462 Observed
15,040 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 400
401 - 800
0
100
200 Km

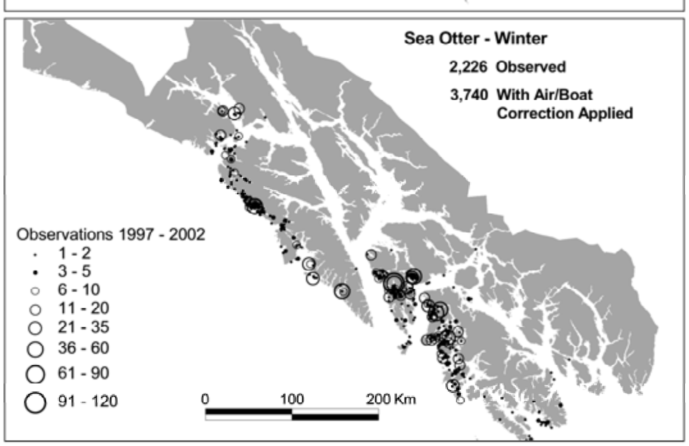

Rhinoceros Auklet - Summer
13,750 Observed
19,896 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 20
21 - 50
51 - 100
101 - 200
201 - 300
301 - 500
501 - 700
0
100
200 Km

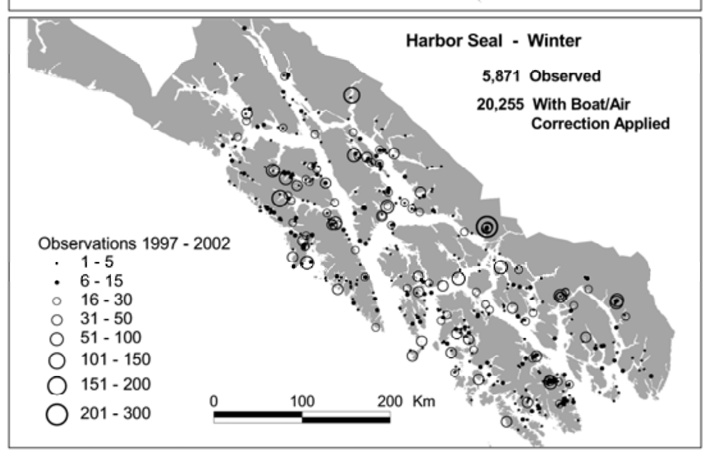

Merganser - Winter
27,544 Observed
39,939 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 200
201 - 400
401 - 800
0
100
200 Km


Rhinoceros Auklet - Winter
386 Observed
559 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 20
21 - 50
51 - 100
101 - 200
201 - 300
301 - 500
501 - 700
0
100
200 Km


Sea Otter - Summer
2,306 Observed
3,874 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 35
36 - 60
61 - 90
91 - 120
0
100
200 Km


Harbor Seal - Summer
12,662 Observed
21,779 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 150
151 - 200
201 - 300
0
100
200 Km


Sea Otter - Winter
2,226 Observed
3,740 With Air/Boat
Correction Applied
Observations 1997 - 2002
1 - 2
3 - 5
6 - 10
11 - 20
21 - 35
36 - 60
61 - 90
91 - 120
0
100
200 Km


Harbor Seal - Winter
5,871 Observed
20,255 With Boat/Air
Correction Applied
Observations 1997 - 2002
1 - 5
6 - 15
16 - 30
31 - 50
51 - 100
101 - 150
151 - 200
201 - 300
0
100
200 Km