

British Columbia Coastal Waterbird Survey

An Evaluation of Survey Power and Species Trends after Five Years of Monitoring



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Introduction

Project rationale

Coastal areas of British Columbia are recognized for their regional and international importance for numerous species of coastal waterbirds, including species of loon, grebe, cormorant, heron, waterfowl, shorebirds, gulls, terns, and alcids (Butler and Vermeer 1994). During the wintering season, waterbirds are attracted to British Columbia's relatively moderate climate, extensive estuaries, tidal flats, and numerous near-shore protected habitats (Butler and Campbell 1987, Butler and Cannings 1989, Butler and Vermeer 1994). The Strait of Georgia contains several smaller internationally recognized Important Bird Areas each of which reflect the diversity of habitats and associated bird populations wintering in British Columbia (Butler and Vermeer 1994).

Waterbirds in the Georgia Basin are subject to many anthropogenic influences including recreation, seaside industry, shipping/boating traffic, and the associated possible negative effects, such as disturbance, effluent discharges from industry, sewage overflow, and oil spills from ships (Vermeer 1994). There are several internationally Important Bird Areas in the Strait of Georgia close to major population centers that have much industry and shipping activity (e.g., the Fraser River delta including Boundary Bay and the Roberts and Sturgeon Banks and the Burrard Inlet near the city of Vancouver). Further, all waterbird populations in the Strait of Georgia (and other coastal areas of British Columbia) are adjacent to major oil shipping lanes and may be subject to disruptive and potentially harmful anthropogenic activities.

The proximity and interaction of waterbirds and humans in coastal areas of British Columbia highlights the importance and need for a long-term monitoring program to determine annual population sizes, distributions, and temporal change in these population parameters. Such information is critical for monitoring natural changes and fluctuations in waterbird populations. Broad scale, long-term monitoring programs also provide baseline population data that could be used to assess impacts of human induced environmental perturbations.

British Columbia Coastal Waterbird Survey background

In response to the need for data on coastal waterbird populations in British Columbia, Bird Studies Canada, with additional support from the Canadian Wildlife Service (CWS), initiated the

British Columbia Coastal Waterbird Survey (BCCWS). This program was established as a volunteer based survey to monitor coastal waterbird populations and their distributions throughout British Columbia, with a focus on the more populated areas of the lower mainland and island areas associated with the Strait of Georgia.

The BCCWS began in the winter of 1999/2000 as a five-year pilot project using survey protocols developed by BSC, CWS, British Trust for Ornithology scientists, university researchers, and local naturalists at a workshop held in July 1999. All individuals involved with the establishment of the survey protocols were familiar with coastal waterbird ecology and many have extensive expertise with survey design and implementation of long-term waterbird population studies. Presently, five seasons of data have been received from volunteers and entered into the BCCWS database (winters 1999/2000, 2000/2001, 2001/2002, 2002/2003, and 2003/2004). Thus, it is prudent at this time to present an updated analysis of survey power and to present seasonal estimates of relative abundance (population) indices, associated trends, and geographic distributions of waterbirds resulting from this survey.

Scope of the evaluation

The main goal of this report is to assess trends in numbers, and distribution of coastal waterbirds. This report also includes a brief review of the BCCWS objectives and survey protocols, including any improvements made since the first scientific evaluation of the program (see Badzinski 2003). This evaluation includes an assessment of the rigor of the information currently collected by volunteers of the survey. A major part of this report deals with an evaluation of the current sample sizes (number of BCCWS sites) and the resulting power the survey has to detect annual and longer-term changes in waterbird populations. Preliminary estimates of seasonal abundance indices and linear trends over the first five winters of the survey are presented. Relative abundances and distributions of waterbirds also are presented based on maximum numbers of individuals recorded at BCCWS sites (within species-specific survey windows) during the first five years of the survey. Data used in most statistical analyses were restricted to those collected only from Georgia Basin sites and from within species-specific survey windows (i.e., months where species numbers are thought to be “stable” throughout winter). Several statistical analyses and major data summarizations are included as appendices to improve the readability of the document.

BCCWS Project Design

Survey protocol

The BCCWS is based on coordinated, volunteer counts of waterbirds conducted on the 2nd Sunday of the month (“or as close to that date as possible”) from September through April (i.e., 8 monthly visits per winter). Waterbirds, for the purpose of the BCCWS, include loons, grebes, cormorants, herons, waterfowl, shorebirds, gulls, terns, and alcids. Volunteer surveyors must be comfortable identifying all waterbird species that regularly occur in their survey area and at their specific survey site. All surveyors are required to use either a pair of binoculars and/or spotting scope that enables them to identify birds out to a distance of at least 500m. Surveys are to be conducted only on days with reasonable weather conditions (relatively calm seas, at least 500m visibility), during the period beginning 2 hours before high tide of the day until 2 hours after high tide of the day. Prior to participating in their first BCCWS all volunteers were provided with a “Survey Protocol” booklet that outlines the mandated survey protocols and contains standardized data recording forms.

Volunteers recorded birds in four general “habitats” during surveys, including inland, near-shore, off-shore, and unknown categories. “Inland” refers to all birds on shore, in fields, or on inland bodies of water that are visible from their vantage point. “Near-shore” refers to birds observed from the high tide mark of the shoreline to 500m out onto the water. “Off-shore” refers to birds in the area from 500m off shore to as far as an observer can see waterbirds during each visit. At some sites where birds can be seen more than 500m away but obviously are not in offshore habitats (e.g., estuaries or narrow inlets), observers are asked to place counts of birds in the most appropriate habitat class. Whenever observers are not entirely sure of which habitat class to use they are asked to place the birds into the “unknown” habitat category. Observers also recorded data on weather conditions, sea conditions, visibility, tide stage, optics, human activity, and birds of prey.

Survey site designation and selection

During a protocol workshop, the BC Coastline was divided into survey sites approximately 1-2 km long and designated with a site code. 1:250,000 scale topographic maps with designated site boundaries are housed in the BSC BC Projects Coordinator office. Sites may be relatively

linear stretches of shoreline or they may be a cove, bay, inlet, or some other indentation in a section of shoreline. During each survey volunteers record total counts of all waterbirds observed at their survey site (by habitat class, see above) and should be surveyed within 2-4 hours.

Because many coastal sites along the British Columbia coastline are inaccessible, survey sites were not selected at random. Many sites are selected by volunteers with guidance and input from BSC's BC coordinator based mostly on volunteer interest in conducting a monthly survey at a particular location. Volunteers generally live in relatively close proximity to their survey sites, which should facilitate obtaining consistent monthly waterbird counts. Efforts are made to include sites of varying habitats, such as estuarine, rocky intertidal, and sandy beach (but this information currently is not recorded on data sheets or contained in the data base).

Upon their establishment, sites are mapped on GIS-derived topographic maps (1:250,000 scale). Many survey sites share common starting and ending boundaries and some sites are on opposite sides of water-bodies of varying width. In these situations, the probability for multiple counts of the same birds is higher than at relatively isolated, non-adjointing, sites. Some of these more problematic survey sites were/are monitored by organized and coordinated groups of volunteers belonging to naturalist or birding groups or organizations.

Counting waterbirds

No standardized protocol has been developed for observers to use while at sites counting birds. Because of the diverse nature of survey sites and their habitats, coupled with issues of accessibility to coastline areas, counting techniques are determined by the volunteer conducting the survey. Some volunteers count from one or several fixed points within their survey sites, while others walk the entire section of shoreline counting as they travel. Some volunteers count birds from the waters edge, while others count from more considerable distances. These variable survey techniques introduce considerable variation in surveyor effort and detection of some species of coastal waterbirds. This also makes counts difficult to compare, both within and among sites.

Volunteer and data management

Volunteer participation and information

Individual surveyor participation has been good over the first five years of the survey. The number of sites surveyed each year ranged from 171 to 207 and over all five winters volunteers surveyed a total of 260 sites (Figure 1) and submitted 6343 completed survey forms (Table 1). Bird Studies Canada is very grateful to the dedicated surveyors involved, many of whom have submitted 5 years of data and continue to survey their sites (see Appendix 1 for volunteer names and years of service).

Table 1. Total numbers of sites surveyed and forms received each winter

Winter	# Sites surveyed	# Forms received
1999/2000	195	1204
2000/2001	207	1423
2001/2002	183	1318
2002/2003	171	1138
2003/2004	190	1260
1999 - 2004 (complete set of sites in program)	260	6343

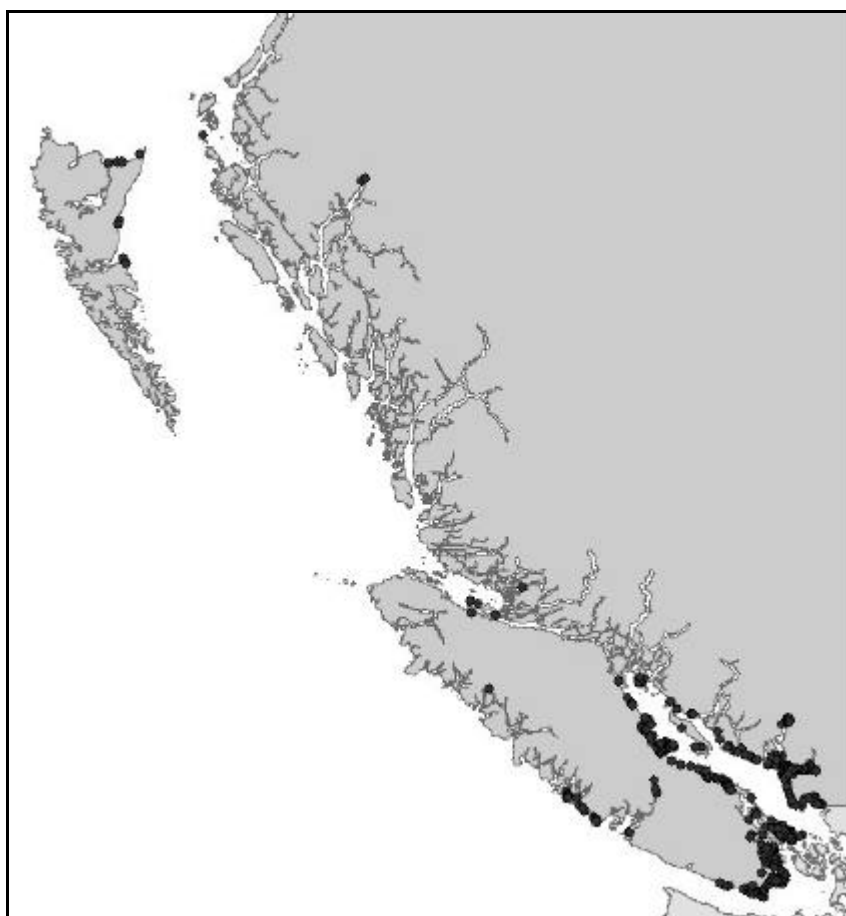


Figure 1. Total BCCWS sites in British Columbia, Canada

Several naturalist groups have numerous members that participate in the BCCWS. Currently, there are about six naturalist groups that have been or are involved in the survey. Often the group members conduct their surveys together, but in many cases individuals from the group conduct their survey independently. Naturalist groups that have coordinated survey efforts are: The Squamish Estuary Conservation Society (Squamish, 20 sites), Arrowsmith Naturalists (Parksville, 9 sites), Malaspina Naturalists (Powell River, 3 sites), Mayne Island Naturalists (Mayne Island, entire island perimeter), Nanaimo Field Naturalists (Nanaimo, 15 sites), Comox Valley Naturalists Society (Comox, 15 sites), and Bowen Nature Club (Bowen Island, 10 sites). In a few other regions volunteers conducted surveys together and had a “regional coordinator”, but were not necessarily part of a formal naturalist group (e.g., Denman Island [11 sites] and Hornby Island [21 sites]).

Database structure and management

The deadline for participants to mail BCCWS data recording forms to the BC coordinator is May of each year, but most volunteers send data as it is collected throughout the winter season. Data entry begins at the end of May and is completed by the end of June. Data are error-checked and then entered into a Microsoft Access Database maintained, housed, and managed by BSC's coordinator in British Columbia. New site locations and boundaries are digitized from topographic maps (1:50,000 to 1:250,000 scale) returned by volunteers. Geo-referenced locations are subsequently added to the existing BCCWS GIS data file/theme layer.

The BCCWS Microsoft Access database currently contains six tables. The ‘observer’ table includes the surveyors’ name, surveyor code, address, phone number, and e-mail address. The ‘regions’ table has information on the area (i.e., GI for gulf islands) and the region (i.e., Salt Spring Island) where surveys are undertaken with the region code (i.e., GISS). More specific site information is housed in the ‘sites’ table where the area-region combination is provided with a specific site number (i.e., GISS1 = Gulf Islands, Salt Spring Island, Goat Island, Ganges Inner Harbour). The ‘species’ table lists species likely to be observed during the survey and the species code (i.e., MALL = Mallard (scientific names Appendix 8)). The ‘survey’ table shows date of survey, survey site name and code, start and end time, weather conditions, sea state, tide state, tide movement, visibility, survey equipment used, and level of human activity observed during the survey. ‘Census’ is the table where the data on the species observed is recorded and

this includes where the species was observed (inland, near-shore, off-shore, unknown) and how many of each species were observed.

Methods

Species-specific survey windows

Survey windows were developed for the BCCWS to ensure that data used for developing measures of waterbird abundance indices and trends was most representative of the biological time frame of interest. Because the main focus of this survey is to monitor numbers of wintering waterbirds, the survey window specified for most species included the period from December, January, and February. However, several other survey windows were specified for species that were largely migratory transients through BC. Survey windows for each species ultimately were based on published (Butler and Cannings 1989, Butler and Vermeer 1994) and expert knowledge (R. Butler, Canadian Wildlife Service and R.J. Cannings, Bird Studies Canada, personal observations) of migration chronology and/or winter residency of waterbirds in British Columbia. Reductions in the total number of survey months included in analyses (i.e., not using all surveys from September – April) also increases number of sites that can be included in analyses each winter because sites missing a required month's data were excluded. Appendix 2 contains the survey windows specified for each species included in this report.

Analysis metric

In this report, counts were summed over all habitat categories to produce a total count of each species for each survey. The mean total count (within a survey window) of each species at a survey site each winter was chosen as the basic statistical unit for most statistical analyses. As such, these data also were used to develop relative abundance indices for trend analyses and in determining initial variance estimates for power analyses. Only sites with 100% monthly coverage of a survey window were included in analyses. Preliminary comparisons showed that using annual, site-specific mean counts as the analysis metric consistently provided slightly more power to detect annual changes in abundances of most species than using a maximum count (Appendix 3).

Power and trends

The ability of the BCCWS to meet its population monitoring objectives depends on the adequacy of the survey design, volunteer adherence to survey protocols, inherent limitations within the data, and the statistical power of the survey (Badzinski 2003). The estimated power of a survey also depends partly on the appropriateness of statistical methods used in analyses of data. Data used in the analyses that follow met, at least approximately, all the assumptions of the models employed and the underlying distributions used to generate parameter or variance estimates. It also must be remembered that power cannot be measured, only estimated. Thus, if only a small sample is available to generate a variance for a specific species, the estimate will not be very precise and may change dramatically once more data is collected. However, for the purpose of this evaluation, we assume that variance estimates are representative after 5 years of data collection and provide a reasonably reliable indication of the potential power of the BCCWS.

For determining power to detect temporal changes in waterbird populations, variance estimates were derived from statistical models employing a “route-regression” technique to analyze long-term population trends. This method has been used extensively in trend analyses of Breeding Bird Survey data (Link and Sauer 1997a, b) and other large-scale population monitoring programs developed and/or administered by Bird Studies Canada (e.g., Weeber and Vallianatos 2000). This method of evaluating trends within count data uses a log-linear regression to estimate changes in relative abundance over time while accounting for variation and changes occurring at individual survey locations (i.e., sites for the BCCWS). Long-term trends of waterbird abundances monitored by the BCCWS also will be evaluated using this statistical technique (see below).

Power analyses

Count data collected by volunteers of the BCCWS most closely approximated a Poisson distribution, so variance estimates were derived from species specific, regression models ($Y =$ BCCWS site [class variable], Winter period [class]) for each pair of winters (e.g., 1999/2000 vs. 2000/2001, etc.). Site-specific counts of species were included in analyses only if survey sites were visited in consecutive winters and at least one individual of a species was counted during each winter (see Appendix 4 for sample sizes). Further, because there were some problems with

calculating percentage changes within sites using only 2 winters (1 winter-pair) of data (e.g., the percentage change is undefined if the count is 0 the first year), a combined ratio estimator was used to determine percentage change from the observed data. A combined ratio estimator essentially is the mean value in winter x divided by the mean value in winter $x + 1$. Poisson regression models were iterated 1000 times in order to obtain estimates of species-specific variances for each winter-pair period; error distributions for many species were not perfectly Poisson distributed, so variance estimates were also corrected for overdispersion (PROC GENMOD, DIST=POISSON, PSCALE option; SAS Institute Inc. 1989). Winter-pair period specific variances were summed and averaged over all winter-periods to obtain the final variance estimates for each species; subsequently, these estimates were weighted by the total number of sites detecting each species over all 4 winter-pair periods. Monte Carlo simulations and other analytical techniques were then used to estimate the relationships between variance after 5 (6 surveys) and 10 (11 surveys) winter-intervals. These simulations were done assuming log-linear relationships and a uniform, consistent population change across all sites and winters. The magnitude of annual change that could be detected based on these variance estimates with 80% power ($\beta = 0.8$) and 95% confidence ($\alpha = 0.05$) was determined from formulas in Snedecor and Cochran (1967:113). Final power estimates have been adjusted to account for the proportion (average over all 5-winters) of BCCWS sites that actually detected each species.

It is important to note that the power of the BCCWS may be somewhat over-estimated because the rate of population change may vary among sites. For example, if populations on some routes are increasing by 5% while others are decreasing by 10% such that the overall effect is a net decline of 5% per year, it will take more sites to detect that magnitude of change than if all routes are declining by 5% per year (which is an assumption of these analyses).

Annual abundance indices and trend analyses

The number of BCCWS sites included in trend analyses for each species varied from year to year (Appendix 5). Appendix 6 shows a 5-year summary of the number of different sites that detected at least 1 individual of each species and numbers of site-winters for each species. Because data used in most statistical analyses were restricted to those collected only from Georgia Basin sites, sample sizes may be less than the total sites surveyed for the entire province (Table 1). Poisson regression models (PROC GENMOD; SAS Institute Inc. 1990) were

employed to generate annual abundance indices for each species deemed of interest. For calculation of relative abundance indices, species-specific regression models were designated as follows:

$$\text{Mean count [over survey window] (Y) = Winter period (class), Site (class)}$$

Regression models were iteratively run (1000 times) to stabilize variances and to obtain annual/seasonal abundance (parameter) estimates for each species. Prior to significance testing and calculating abundance indices, estimates of variance (and its derivatives) were corrected for overdispersion (PROC GENMOD, PSCALE option; SAS Institute Inc. 1990). Annual estimated species counts were converted into relative abundance indices using the following formula:

$$(1) \text{ Annual abundance index} = e^{A \cdot M}$$

where:

$e = 2.7183$, the base of the natural logarithm

A = species-specific annual estimate (i.e., “Winter period” class coefficients from regression models)

M = mean number of individuals of a species over all sites in the final survey year

This transformation allows determination of relative (percent) annual differences in bird abundances scaled to the average value for the most recent survey year. These annual winter estimates are presented in figures along with their associated upper and lower 95% confidence limits.

Linear trends in relative abundance of species monitored by the BCCWS from the first five winters (i.e., 1999/2000 – 2003/2004) were evaluated for statistical significance and reliability using Generalized Linear Models (PROC GENMOD; SAS Institute Inc. 1990). The same input data, error distribution, and regression modeling structures and procedures as described above for calculating abundance indices were used for these analyses, except that “Winter period” was included as a continuous variable to provide a linear estimated rate of change in each species abundance through time. Species-specific parameter (slope) estimates and measures of variability (corrected for overdispersion) from Poisson regression models were converted into relative indices of change (abundance trends) by using the following formula:

$$(2) \text{ Abundance trend} = 100 \cdot (e^B - 1)$$

where:

$e = 2.7183$, the base of the natural logarithm

β = “Winter period” coefficient from species-specific regression models

This transformation allowed determination of percent annual change (and associated 95% confidence limits) in bird abundance indices over the time. Likelihood ratio tests were used to calculate the probability that the addition of “winter period” effects into statistical models provided better fit to these data than did models not including such effects (Collett 1994). To do this, differences in deviance between models with and without year effects were calculated and those values were then used to obtain probabilities from a chi-square distribution that were subsequently converted (1 - chi-square probability) into p -values. Seasonal trends in species relative abundances (and our confidence in those estimates) are presented in Appendix 7.

Geographic distribution

For each species, distributions were mapped based on their relative abundances at each site over the five survey seasons. For each site, mean counts per year were calculated within each species’ survey window (survey windows in Appendix 2) and these yearly means were averaged to produce the overall 5-season mean count plotted at each site. Mean counts were mapped only for sites for which each month in the survey window was surveyed at least once over all five survey seasons. Sites that did not meet these criteria were considered to have insufficient data at the time of analysis.

For each species, four different sizes of circles show relative abundances at sites across the BC coast. The number of birds represented by each circle varies for each species, and the natural breaks between abundances were determined using Jenks method. Sites with insufficient data or where zero birds were observed were also mapped to be able to distinguish between the absence of a species and the lack of data on that species at a particular site. ArcMap desktop mapping software was used to create maps.

Results / Discussion

Power analysis

The estimated power of the BCCWS to detect annual changes in relative abundances of wintering bird species are presented in Table 2. This table shows the annual percentage change

in relative abundance that could be detected by monitoring 160, 180, and 200 sites (i.e., the approximate number of sites presently active or potentially could be active in future years) after 5 (6 surveys) and 10 (11 surveys) year-intervals of monitoring.

Although a standard has not yet been determined, a 3% annual trend is considered by many bird monitoring specialists as a reasonable criterion for adequate resolution of bird trends (Weeber and Vallianatos 2000). Based on this criterion and assuming that about 180 BCCWS sites are consistently surveyed for 5 winter-intervals (6-winters), adequate trend resolution is expected for 8 of 58 species commonly recorded at BCCWS sites, including Bufflehead, Common Goldeneye, Harlequin Duck, Mallard, Double-crested Cormorant, Common Loon, Horned Grebe, and Bald Eagle (Table 2). However, after 10 winter-intervals (11 winters), surveying 180 sites should allow good trend resolution for 33 of 58 species commonly recorded during BCCWS; trends for many other species also are approaching an acceptable resolution after that amount of time (Table 2). These extrapolations suggest that presently the BCCWS results probably can be considered reliable for relatively few species, but the survey has a good potential to detect meaningful changes in several different species abundances over longer periods of time (10+ years). These calculations also show the importance of retaining high levels of volunteer participation and annual coverage of existing BCCWS sites, with optimal benefits resulting from maximizing both survey longevity and the number of available survey sites run annually.

Table 2. Percent annual change (% change per winter) in species-specific abundance indices that can be detected by monitoring 160, 180, and 200 BCCWS sites after 5 and 10 winter-intervals (species' scientific names Appendix 8).

Group/species	Adjust ^b	Routes / winter ^a					
		160		180		200	
		5	10	5	10	5	10
Waterfowl							
American Wigeon	0.83	3.4	1.4	3.2	1.3	3.0	1.2
Barrow's Goldeneye	0.68	3.9	1.6	3.7	1.5	3.5	1.4
Black Scoter	0.45	6.1	2.5	5.8	2.3	5.5	2.2
Brant	0.25	10.2	4.2	9.7	3.9	9.3	3.8
Bufflehead	0.94	2.1	0.8	2.0	0.8	1.9	0.7
Canada Goose	0.70	4.6	1.9	4.4	1.8	4.2	1.7
Canvasback	0.09	14.9	6.0	14.1	5.7	13.4	5.5
Common Goldeneye	0.88	3.0	1.2	2.8	1.1	2.7	1.1
Common Merganser	0.81	3.6	1.4	3.4	1.4	3.2	1.3
Eurasian Wigeon	0.33	6.5	2.6	6.2	2.5	5.9	2.4
Gadwall	0.12	9.0	3.7	8.5	3.5	8.1	3.3
Greater Scaup	0.38	8.8	3.6	8.4	3.4	8.0	3.2
Green-winged Teal	0.34	5.5	2.2	5.2	2.1	5.0	2.0
Harlequin Duck	0.57	2.6	1.1	2.5	1.0	2.4	1.0
Lesser Scaup	0.23	8.0	3.2	7.6	3.1	7.3	2.9
Long-tailed Duck	0.39	5.3	2.1	5.0	2.0	4.8	1.9
Mallard	0.87	2.6	1.0	2.4	1.0	2.3	0.9
Mute Swan	0.08	18.5	7.5	17.6	7.2	16.8	6.8
Hooded Merganser	0.60	4.3	1.7	4.1	1.6	3.9	1.6
Northern Pintail	0.30	5.0	2.0	4.7	1.9	4.5	1.8
Red-breasted Merganser	0.73	3.7	1.5	3.5	1.4	3.3	1.3
Ring-necked Duck	0.10	10.6	4.3	10.0	4.1	9.5	3.9
Surf Scoter	0.77	4.2	1.7	4.0	1.6	3.8	1.5
Snow Goose	0.09	10.0	4.1	9.5	3.8	9.0	3.6
Trumpeter Swan	0.27	6.9	2.8	6.5	2.6	6.2	2.5
White-winged Scoter	0.55	3.8	1.5	3.6	1.4	3.4	1.4

Table 2. Continued.

Group/species	Adjust ^a	Routes / winter					
		160		180		200	
		5	10	5	10	5	10
Cormorants							
Brandt's Cormorant	0.18	9.5	3.8	9.0	3.6	8.6	3.5
Double-crested Cormorant	0.87	2.8	1.1	2.7	1.1	2.6	1.0
Pelagic Cormorant	0.70	3.9	1.6	3.7	1.5	3.5	1.4
Hérons							
Great Blue Heron	0.90	3.0	1.2	2.8	1.1	2.7	1.1
Loons							
Common Loon	0.77	2.7	1.1	2.5	1.0	2.4	1.0
Pacific Loon	0.61	6.3	2.5	5.9	2.4	5.6	2.3
Red-throated Loon	0.40	6.7	2.7	6.3	2.6	6.0	2.4
Grebes							
Horned Grebe	0.80	3.2	1.3	3.0	1.2	2.8	1.1
Red-necked Grebe	0.60	4.1	1.6	3.9	1.6	3.7	1.5
Western Grebe	0.52	7.0	2.8	6.6	2.7	6.3	2.5
Seabirds							
Common Murre	0.28	8.2	3.3	7.8	3.2	7.4	3.0
Marbled Murrelet	0.18	11.3	4.6	10.7	4.3	10.2	4.1
Pigeon Guillemot	0.25	8.9	3.6	8.4	3.4	8.0	3.3
Gulls							
Bonaparte's Gull	0.29	12.5	5.1	11.9	4.8	11.4	4.6
California Gull	0.29	11.9	4.8	11.3	4.6	10.8	4.4
Glaucous-winged Gull	0.97	3.7	1.5	3.5	1.4	3.3	1.3
Herring Gull	0.41	8.6	3.5	8.1	3.3	7.8	3.1
Mew Gull	0.82	3.7	1.5	3.5	1.4	3.3	1.3
Ring-billed Gull	0.26	8.0	3.2	7.6	3.1	7.2	2.9
Thayer's Gull	0.52	5.9	2.4	5.6	2.2	5.3	2.1

Table 2. Continued.

Group/species	Adjust ^a	Routes / winter					
		160		180		200	
		5	10	5	10	5	10
Shorebirds							
Black-bellied Plover	0.20	9.7	3.9	9.2	3.7	8.8	3.6
Black Oystercatcher	0.43	6.3	2.5	6.0	2.4	5.7	2.3
Black Turnstone	0.39	7.6	3.1	7.2	2.9	6.9	2.8
Dunlin	0.32	7.5	3.0	7.1	2.9	6.8	2.7
Greater Yellowlegs	0.22	10.3	4.2	9.8	4.0	9.4	3.8
Killdeer	0.34	8.7	3.5	8.3	3.3	7.9	3.2
Sanderling	0.16	11.6	4.7	11.1	4.5	10.6	4.3
Surfbird	0.16	14.3	5.8	13.6	5.5	13.0	5.3
Raptors							
Bald Eagle	0.94	3.0	1.2	2.9	1.1	2.7	1.1
Northern Harrier	0.10	9.7	3.9	9.1	3.7	8.7	3.5
Peregrine Falcon	0.11	15.0	6.1	14.2	5.8	13.6	5.5
Red-tailed Hawk	0.30	9.5	3.8	9.0	3.6	8.6	3.5

^a Number of sites active during each winter are as follows: 1999/2000 = 196, 2000/2001 = 206, 2001/2002 = 183, 2002/2003 = 164, 2003/2004 = 178.

^b Average proportion of sites that detected each species; these values were used to adjust power estimates.

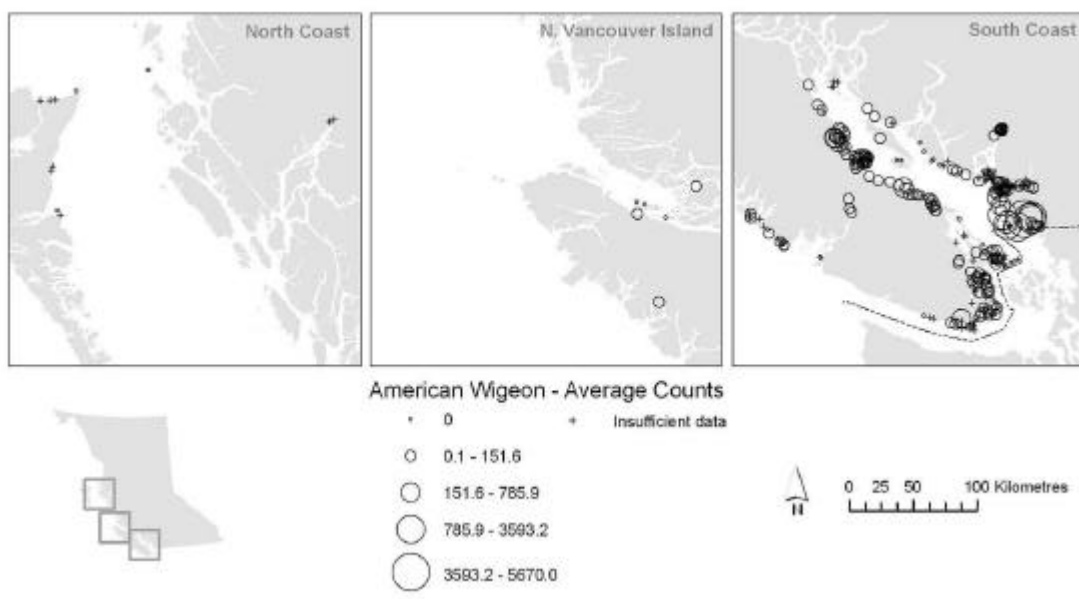
Species trends and distributions

Although surveyors recorded a total of 154 species over all seasons (waterbirds, raptors & corvids, Appendix 8), we report species trends and distributions only for the 58 species that were commonly recorded at BCCWS sites. Annual winter estimates are presented along with their associated upper and lower 95% confidence limits in Figure 2. The following are species summaries and distribution maps for the 58 species of interest:

Waterfowl

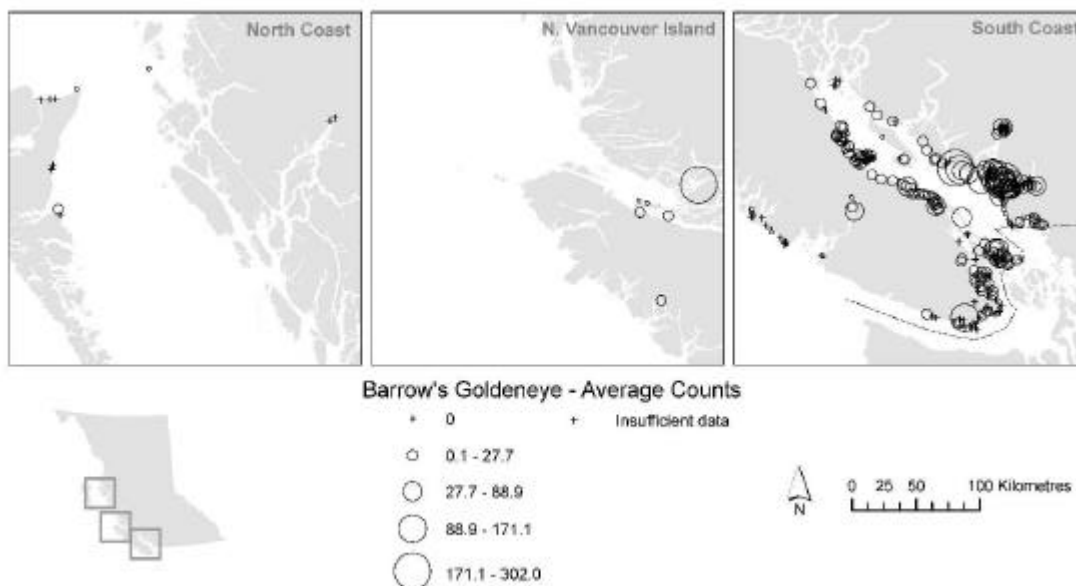
American Wigeon

Wigeons are clearly concentrated in the Fraser Delta, particularly in Boundary Bay, where tens of thousands are present each winter. The data show a significant increasing trend over the survey period, but it is by no means a smooth curve.



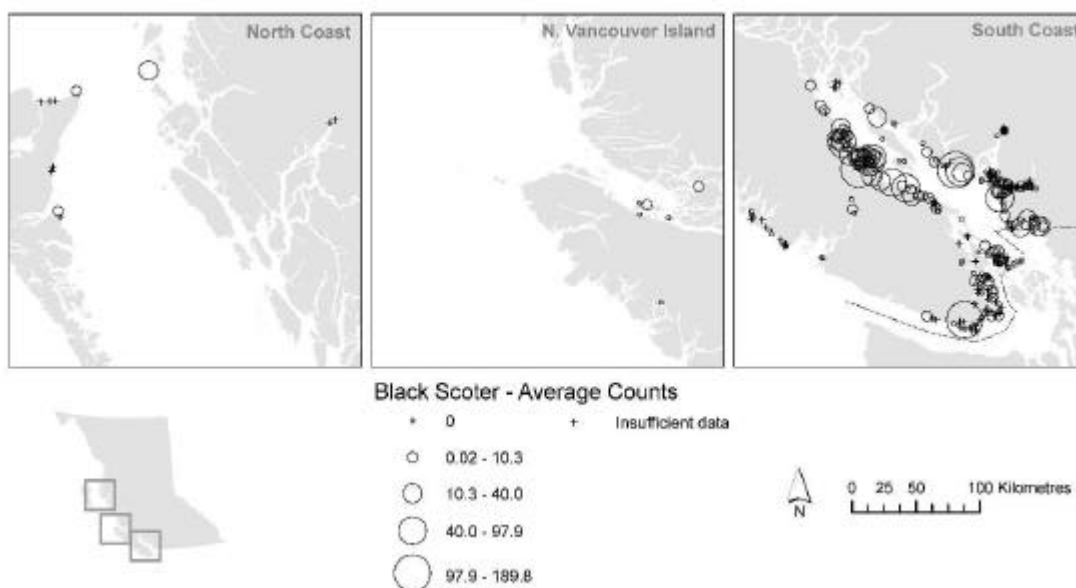
Barrow's Goldeneye

Barrow's Goldeneyes are clearly concentrated along rocky shores in the Vancouver area, where they are feeding on mussels. The population index shows a significant downward trend over the last four years, but this may be simply a return to normal levels after particularly high numbers were seen in 2001. The maximum number was from West Vancouver (2012).



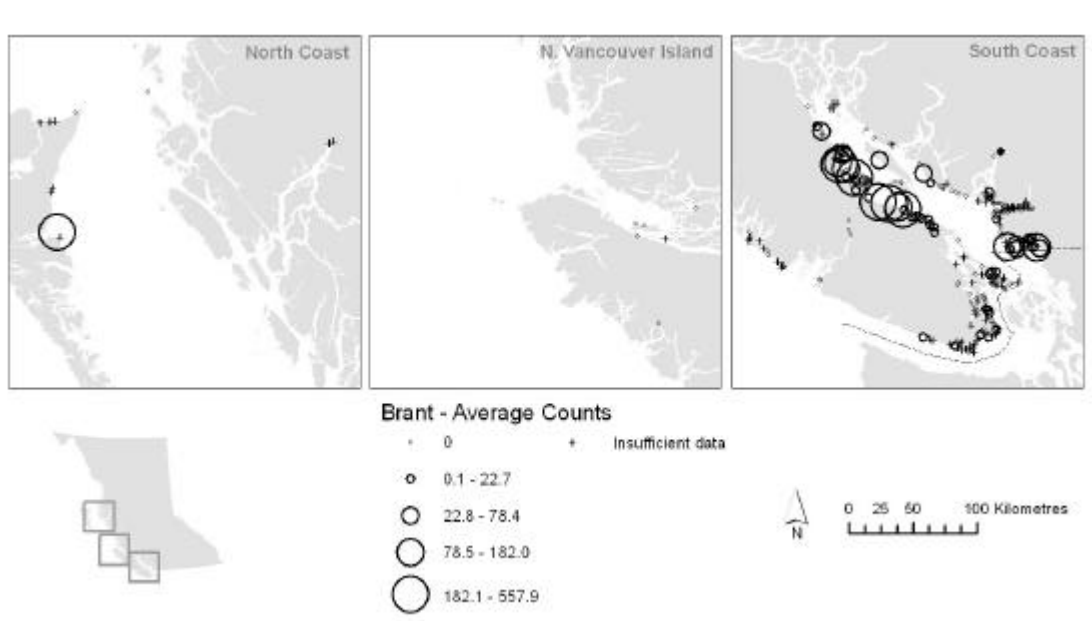
Black Scoter

Black Scoters are locally common along the British Columbia coast, especially where sandy and gravelly bottoms hold clams and other bivalves. There is no clear population trend; highest numbers were at Icarus Point, Nanaimo (2700), Roberts Creek north (1130) and Iona Island (1006).



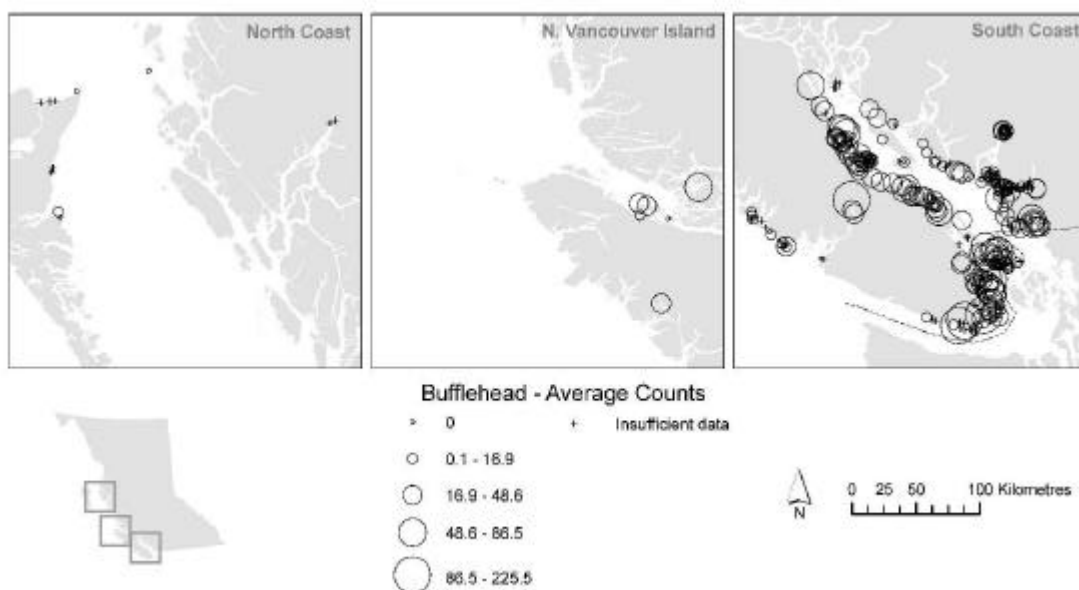
Brant

Some Brant winter in the Boundary Bay area and around Skidegate Inlet, but most are seen during spring migration on the eelgrass beds along the east shore of Vancouver Island. High counts are 7200 between French Creek and Eaglecrest Beach (Qualicum) and 2375 at the Little Qualicum River estuary. There is a steep decline in the population index over the last five years, but this may be an artefact of the survey design, which does not perform well for species that are primarily migrants rather than winter residents.



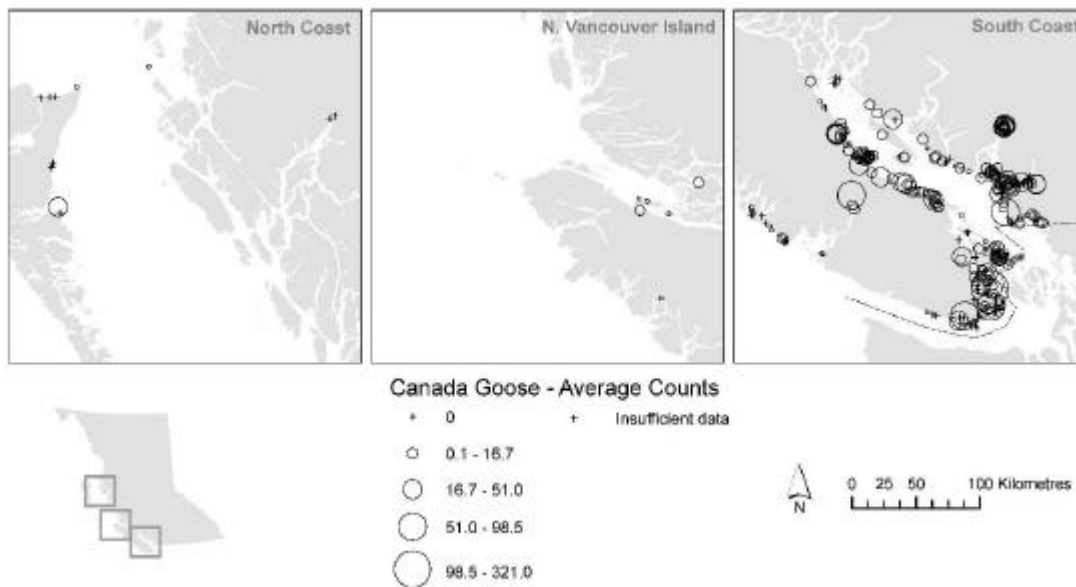
Bufflehead

Buffleheads are common up and down the coast with no obvious concentrations. The three highest counts were all from Fillongley Prov. Park, Denman Island, the maximum being 839. There was a significant increasing trend in the population index even though values fell in the final year of the survey.



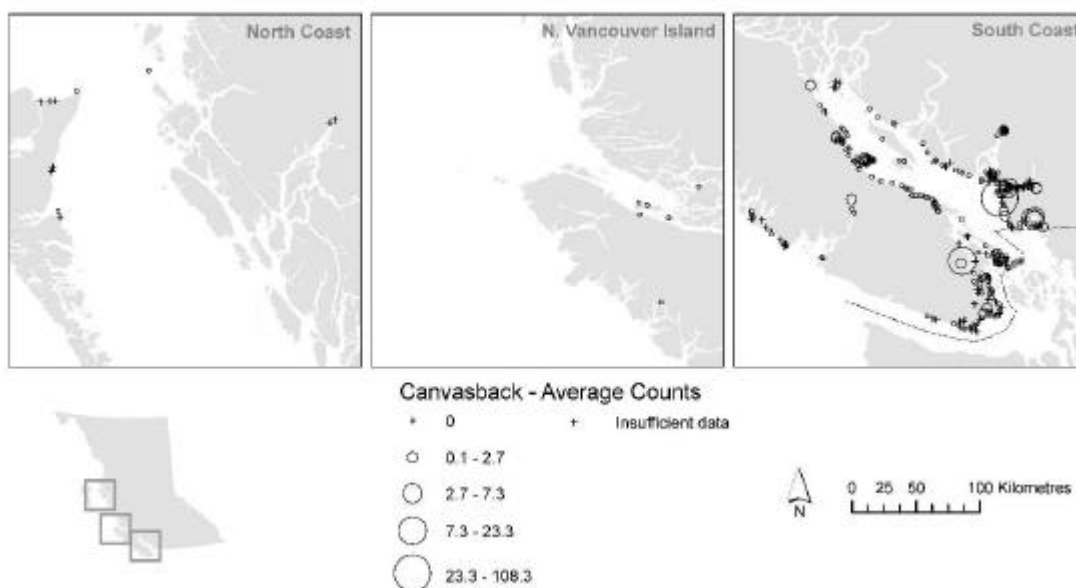
Canada Goose

Canada Geese are common all along the coast; there is no significant population trend. High counts were from Halfmoon Bay (600) and the Campbell River estuary (510). This survey is perhaps inappropriate for geese, since it concentrates on birds on the water, while geese spend most of their time grazing inland.



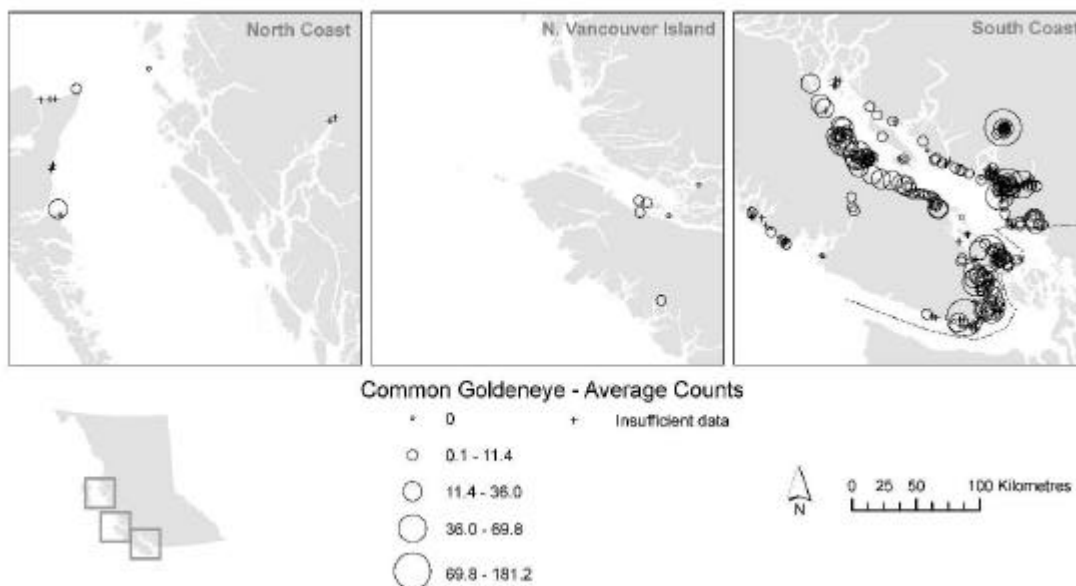
Canvasback

Canvasbacks are uncommon ducks along the coast except around the Fraser Delta. There is a significant decreasing population trend, resulting entirely from low counts in the last year of the survey. Highest counts were at Lost Lagoon (510) and Iona Island (334).



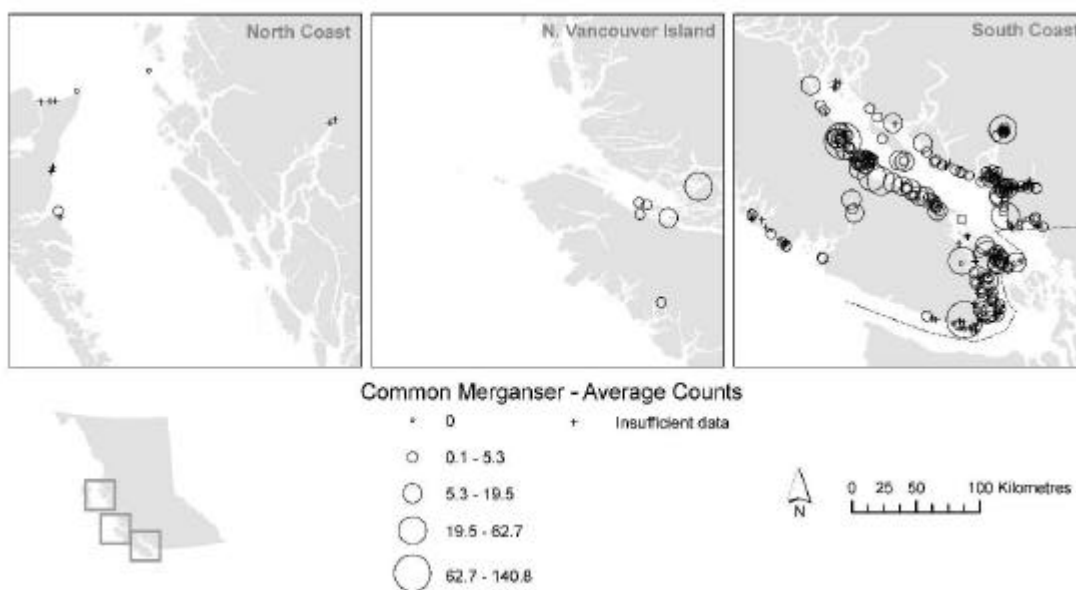
Common Goldeneye

Common Goldeneyes are found all along the coast with concentrations at river estuaries such as the Big Qualicum, Nanoose, Viner and Squamish. The population indices have been flat over the last 5 years. High counts were at the Big Qualicum River estuary (780) and Fillongley Prov. Park, Denman Island (670).



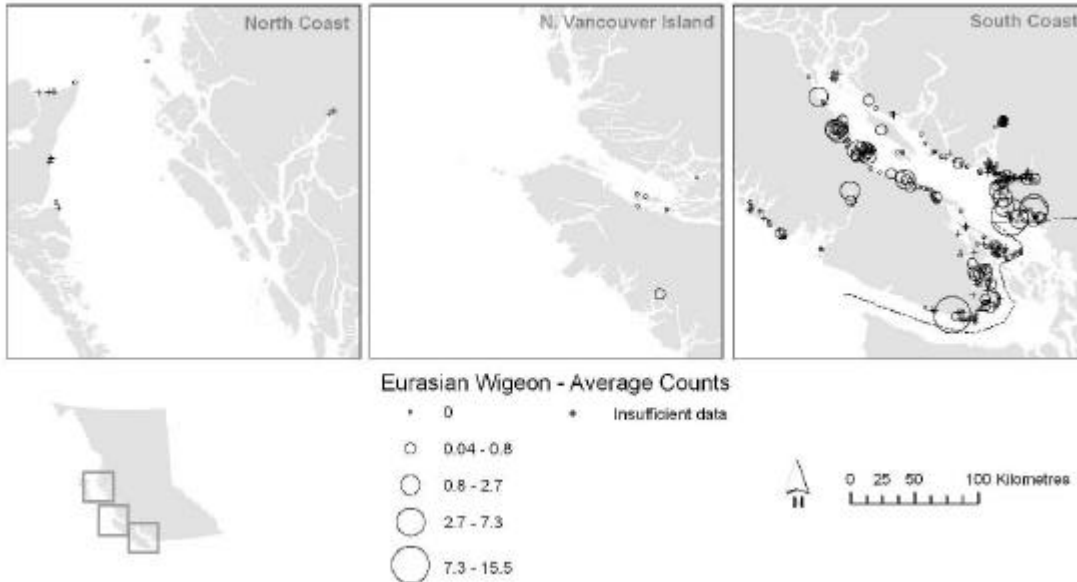
Common Merganser

Common Mergansers are found all along the coast. The largest concentrations are on freshwater lakes which are not well covered by this survey, but the species is also common in estuaries and protected basins. Highest numbers were reported from Quamachan Lake (1950) with other good totals from the Squamish delta, Victoria waterfront, Sooke Basin and Comox Bay Farm. There is no significant population trend.



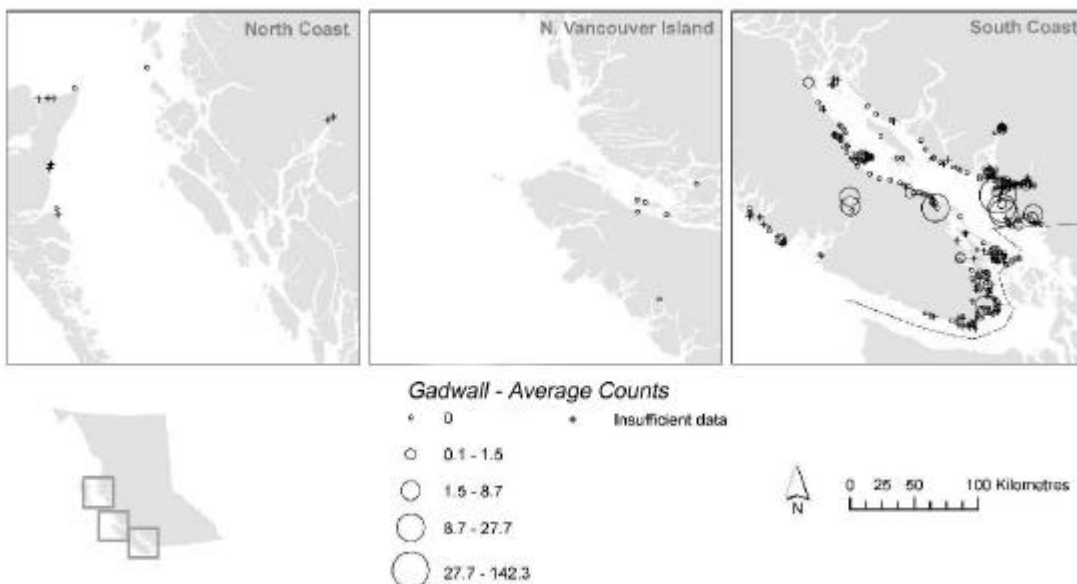
Eurasian Wigeon

Eurasian Wigeon are generally found with large flocks of American Wigeon, so the distribution maps look very similar. There was a significant increasing trend in the population index.



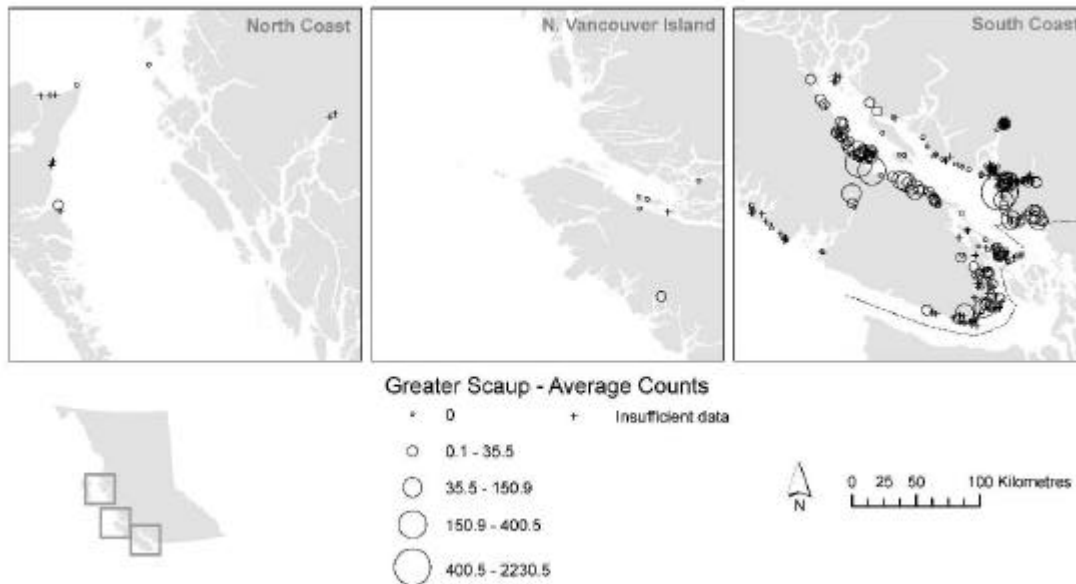
Gadwall

Gadwall are highly concentrated at the mouth of the Fraser River. With the exception of a one-time high count of 2400 on Boundary Bay between 12th and 64th Streets, the highest numbers have been on Lulu Island South (700) and Iona Island (340). The Nanaimo River estuary also has good numbers in winter. Survey data show a significant increase.



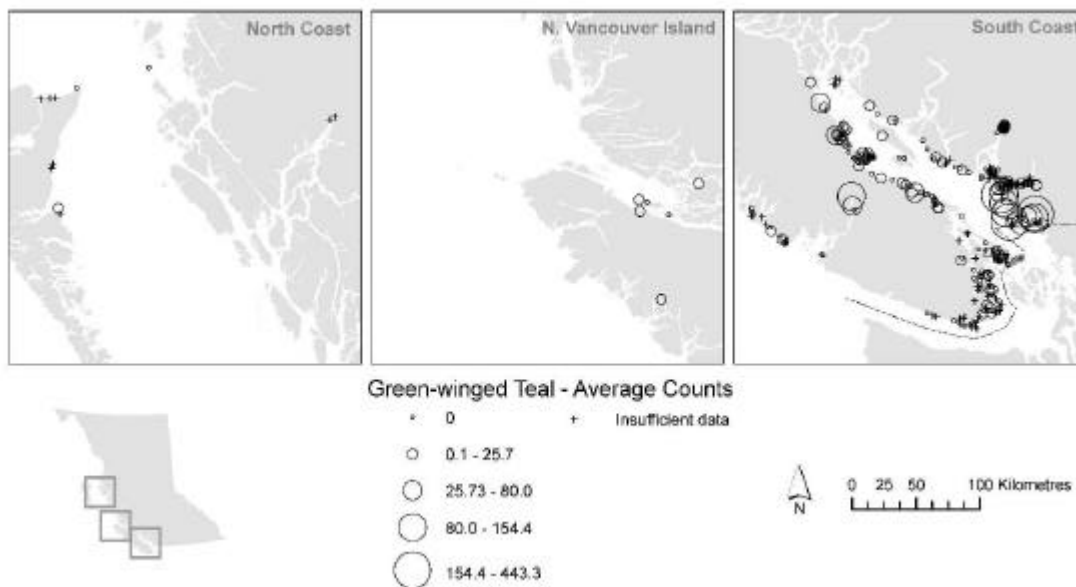
Greater Scaup

Greater Scaup are concentrated along the east coast of Vancouver Island and around the Fraser Delta. Populations of scaup have been decreasing throughout North America, and data from this survey show a significant decline over the past five years. The highest count was 6900 seen at Iona, though usual numbers at that site are about one-tenth that. Other good sites are Nanoose Bay, Deep Bay and the Big Qualicum River estuary.



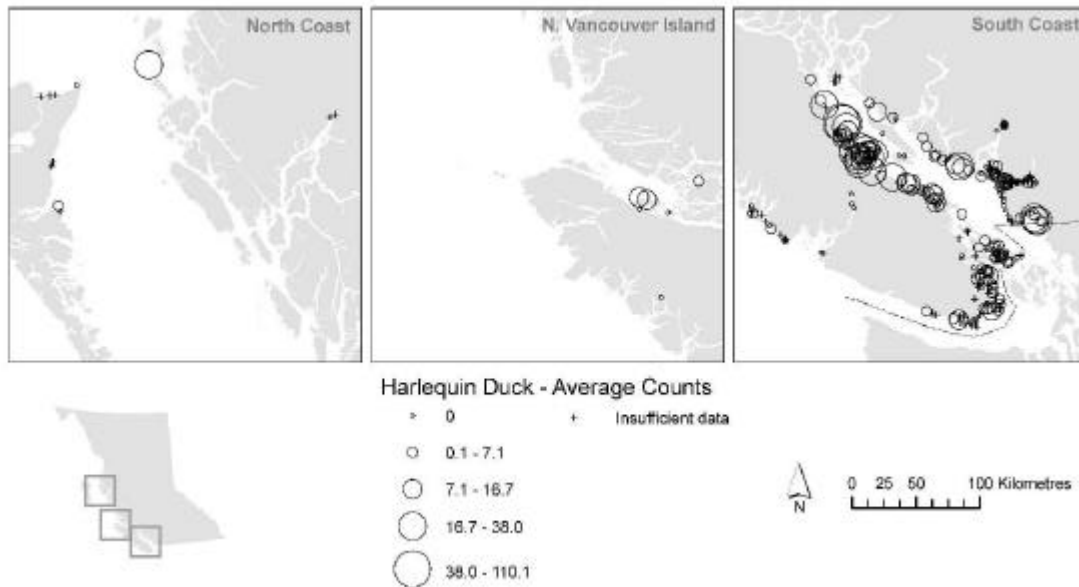
Green-winged Teal

Like most dabbling ducks, Green-winged Teal flock to the Fraser Delta and Boundary Bay. There is no significant population trend. The highest number reported was 10,000 at Iona Island.



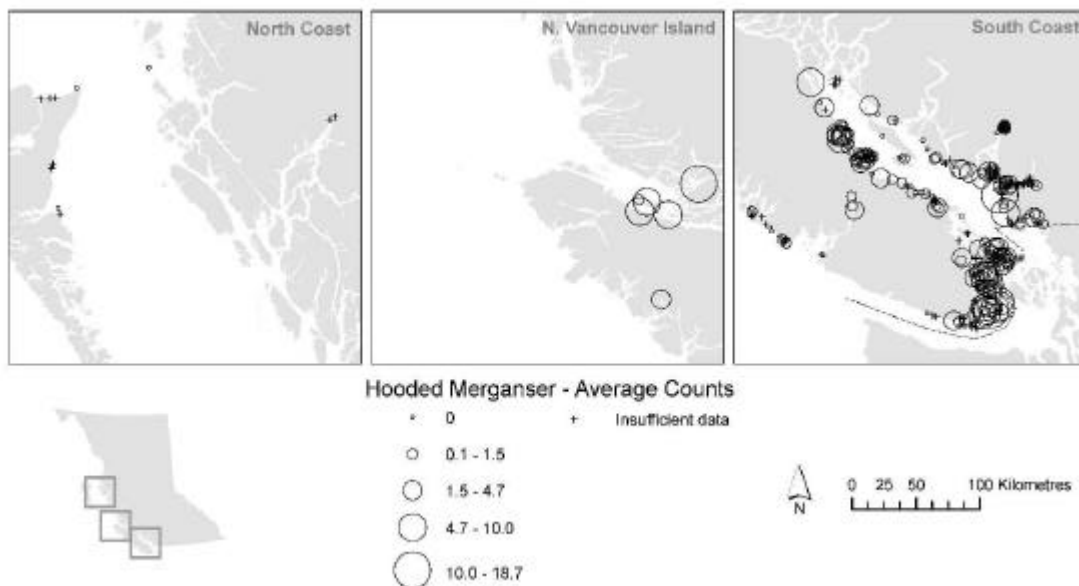
Harlequin Duck

While Harlequins are found all along the coast, their highest numbers are clearly on the central part of the east coast of Vancouver Island. The population index is steady. Highest numbers are from Fillongley Prov. Park, Denman Island (871) and Middle Bay, Hornby Island (750).



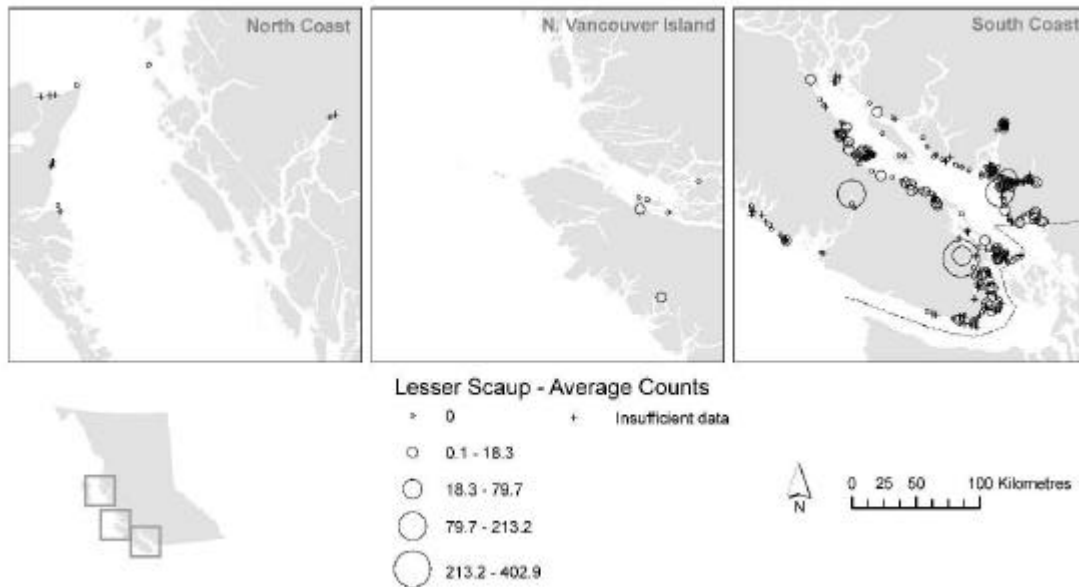
Hooded Merganser

Small numbers are scattered along the coast, but there are almost no records from the north coast. Highest numbers are on the east coast of Vancouver Island, where 245 were seen on Quamachan Lake. There is no significant population trend.



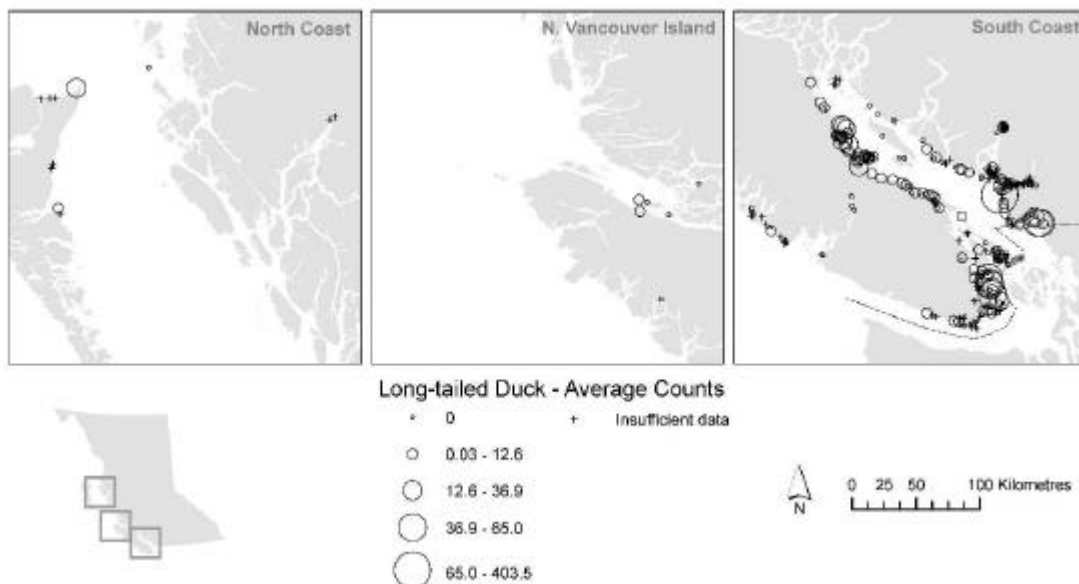
Lesser Scaup

This species is found on salt water much less often than the Greater Scaup. Highest numbers on this survey were on the Duncan Sewage Lagoons (1686), White Rock, West Promenade to 131st Street (900) and Iona Island (616). There is no significant population trend in the data.



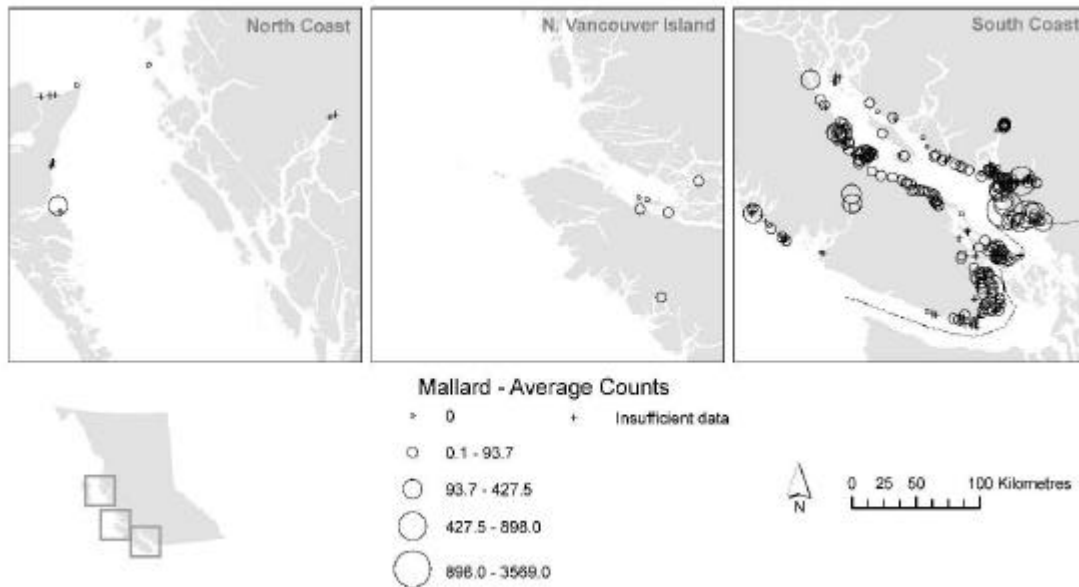
Long-tailed Duck

Numbers of wintering Long-tailed Duck show one of the strongest declining population trends of any species detected in this survey. High counts were from Iona Island (6121) and Deep Bay (3003).



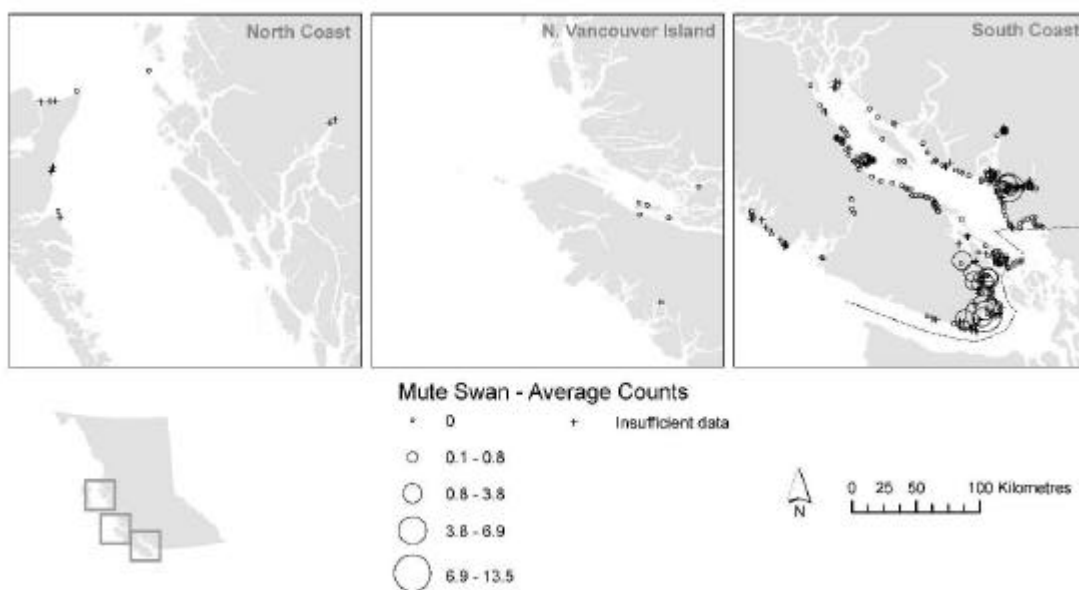
Mallard

Numbers of Mallards are highest in the Fraser Delta area although they are found almost everywhere along the coast. Numbers peaked in 2002 and then declined; there is no significant population trend. Highest numbers were at Reifel (10,600) and Iona Island (9196).



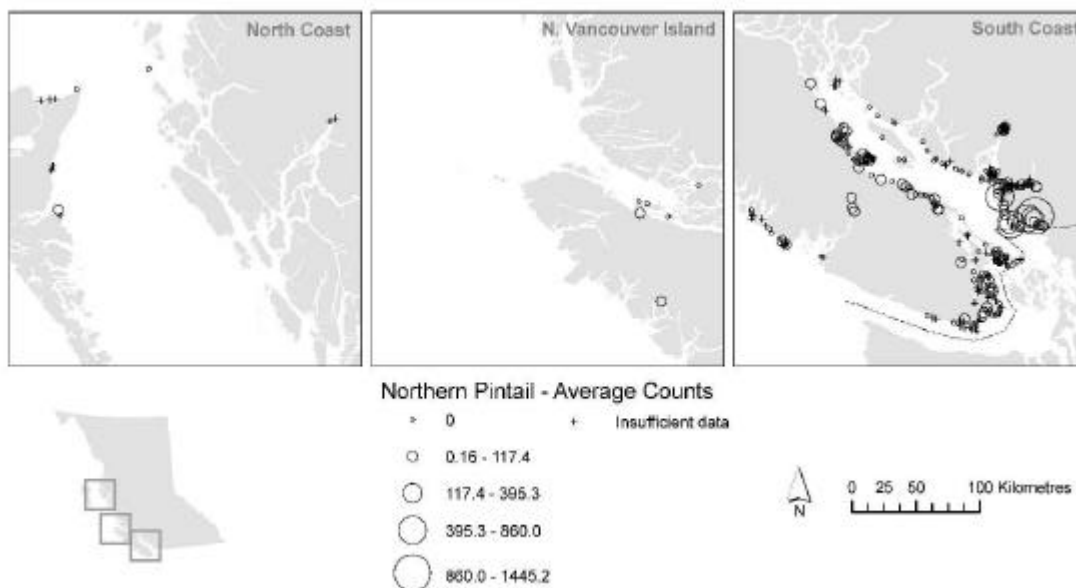
Mute Swan

In the survey region, Mute Swans are only found on south-eastern Vancouver Island and the Fraser Delta. High numbers were at Quamachan Lake (42), Esquimalt Lagoon (21) and Lost Lagoon (13). The latter birds are obviously of captive origin. There are no significant population trends.



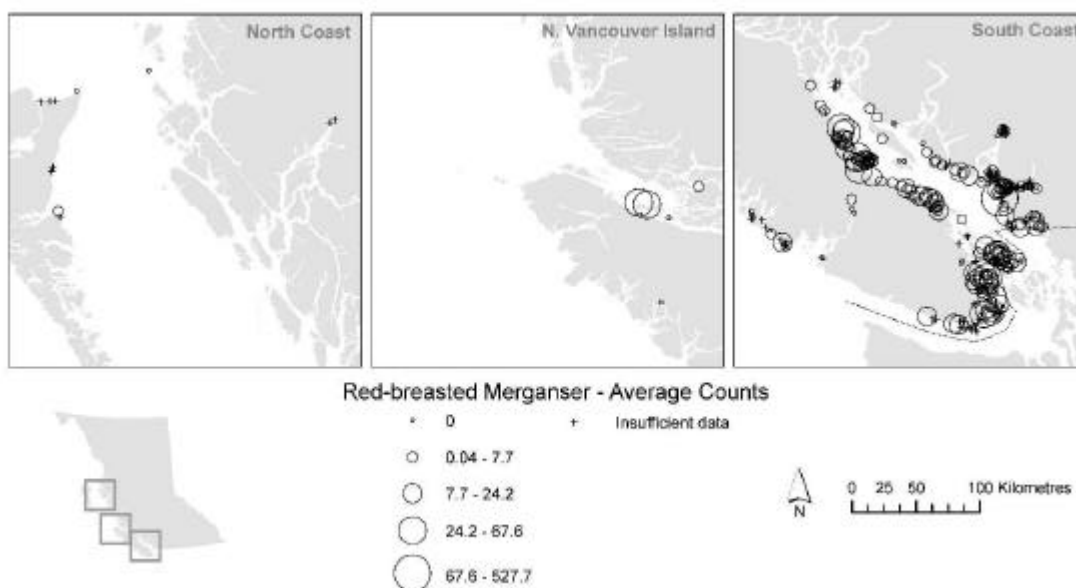
Northern Pintail

Pintail graze on mudflats in winter, so are concentrated with many other dabbling ducks in the Fraser Delta-Boundary Bay area. There is a significant increasing trend in the population index. Highest numbers were at 12th St to 64th St, Boundary Bay (31,600) and Iona Island (13,621).



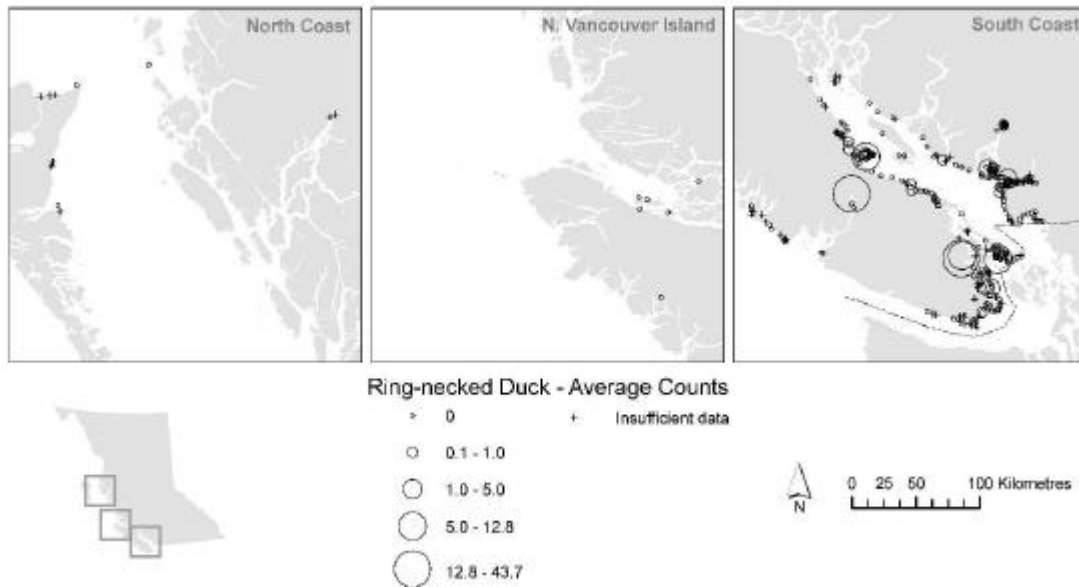
Red-breasted Merganser

Red-breasted Mergansers have much more affinity to salt water in winter than do Common Mergansers. They are found all along the coast, more commonly in the south and with a distinct concentration at the mouth of the Fraser River. The highest peak count was at Iona Island (6700). There is no significant population trend.



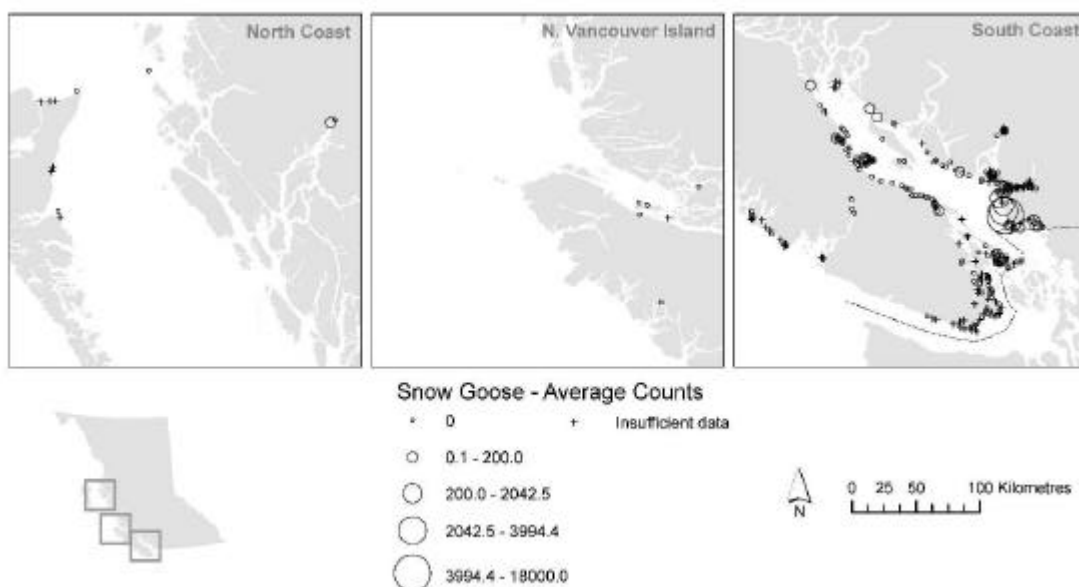
Ring-necked Duck

The Ring-necked Duck is primarily a freshwater species; highest count from the survey was at Quamachan Lake (221). Other important sites were the Somas Estuary, Port Alberni and Beaver Lake, Hornby Island. There is no significant population trend.



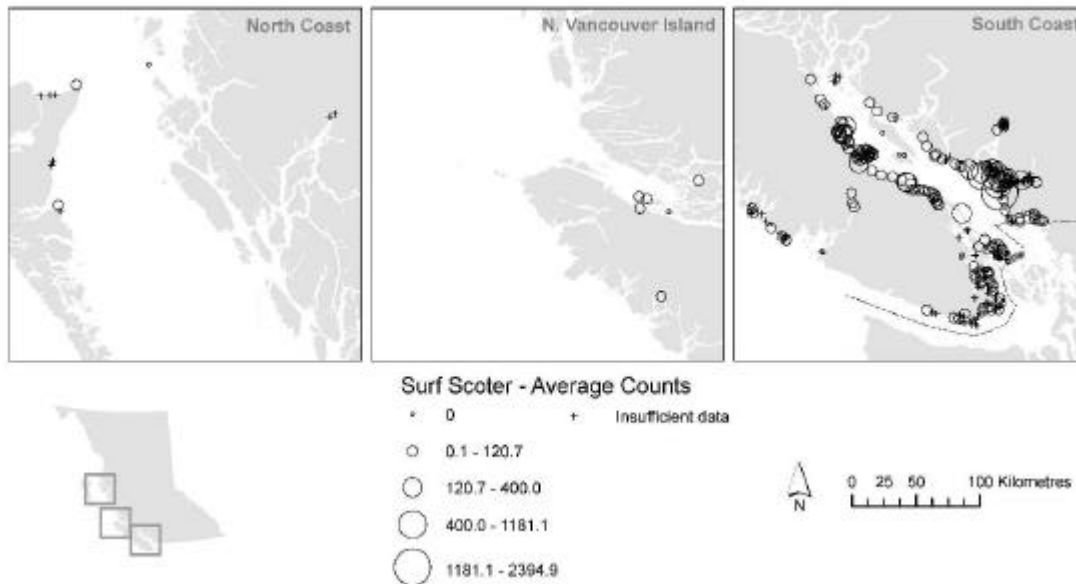
Snow Goose

There is only one significant concentration of Snow Geese on the coast—the Fraser Delta. That population arrives in the fall and usually leaves in mid-winter to return again in spring. All high counts came from the Fraser Delta, with the highest number being 30,000 at Reifel. There is no significant population trend in the survey data, but this survey is not the best way to sample such a concentrated and mobile population that is often feeding inland outside normal survey boundaries.



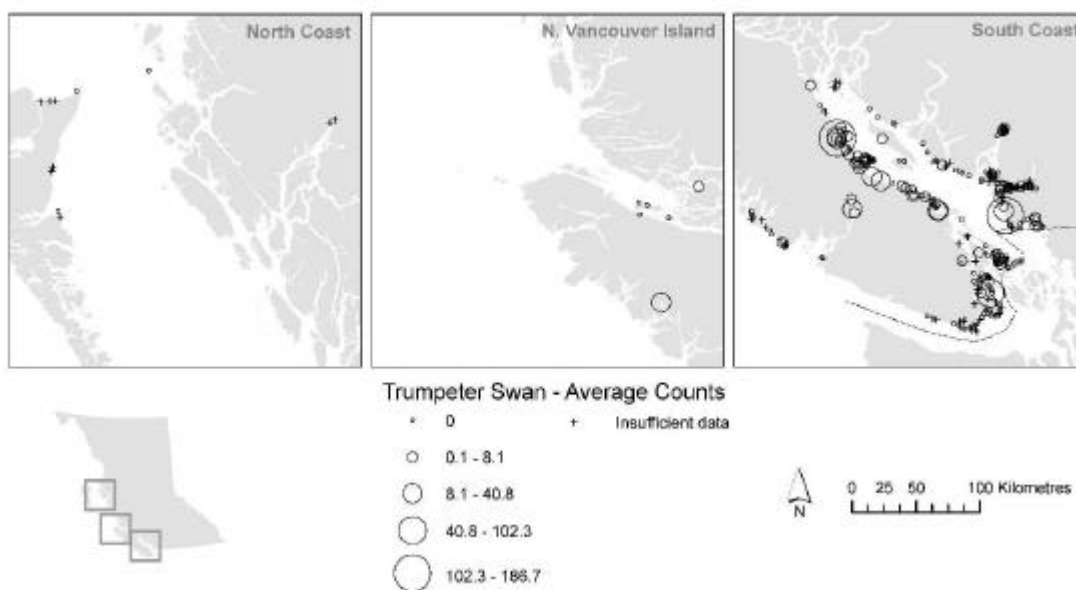
Surf Scoter

Surf Scoters associate with Barrow's Goldeneyes on the coast since they are both feeding in the same habitat on the same item—mussels on rocky shores. They also gather at herring spawn in spring and can sometimes be seen in immense flocks in that season. Peak counts were obviously of migrant flocks—90,012 at Iona Island; 28,048 at the Englishman River estuary; 16,775 in Nanoose Bay; 15,000 at Deep Bay. There is no significant population trend.



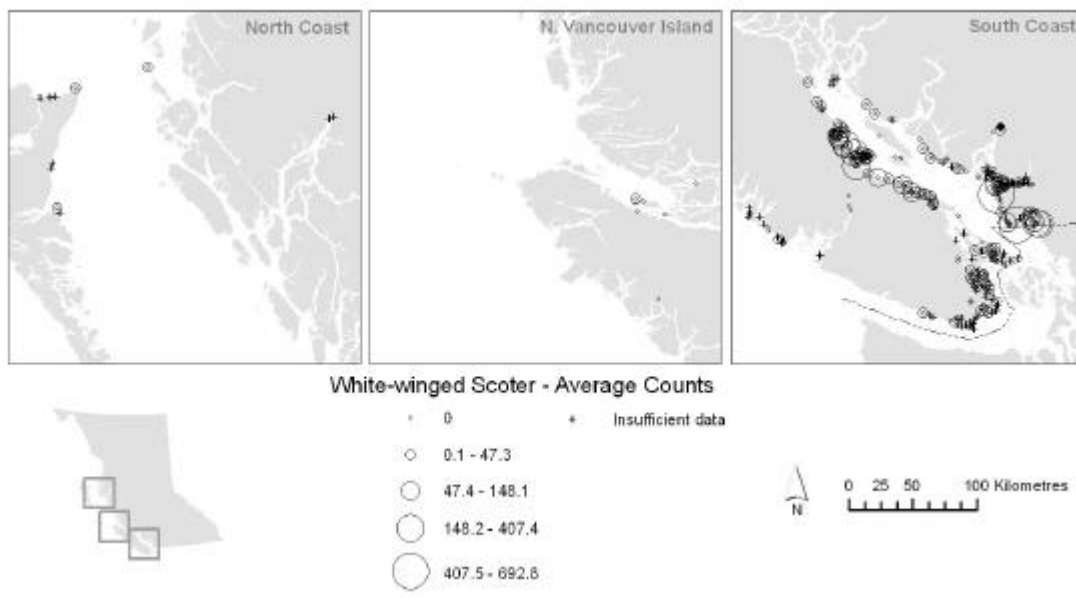
Trumpeter Swan

Trumpeter Swans winter in estuaries, particularly those with associated agricultural land. The Comox Valley has long been the site of the most significant wintering flock in the world. The highest count came from Dyke Road, Comox (910); other significant sites include Reifel Refuge, Delta (260) and Comox Bay Farm (210). There is no significant population trend.



White-winged Scoter

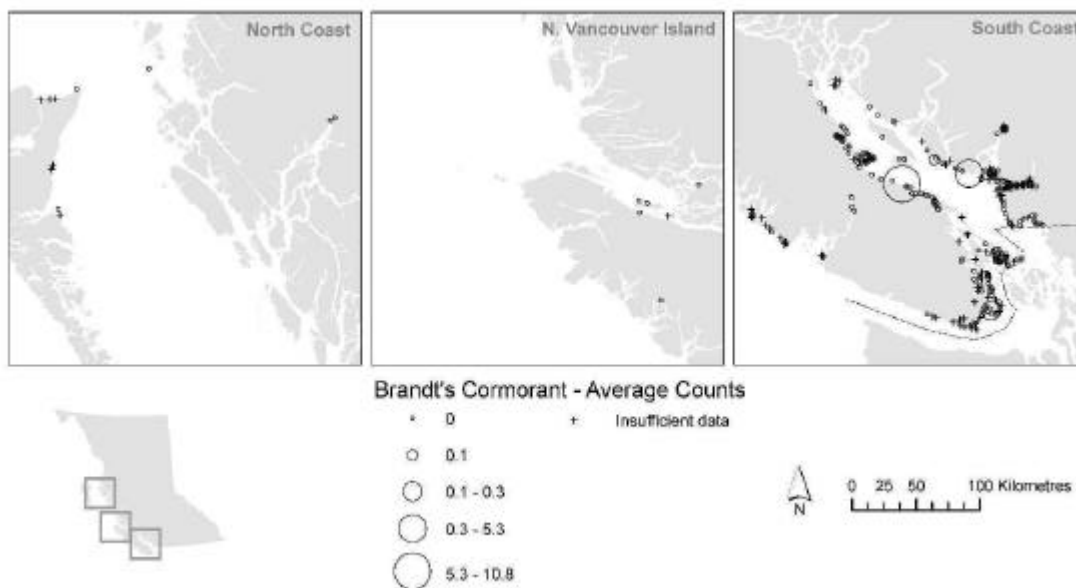
White-winged Scoters are generally found in sandy or gravelly bottomed bays. They also migrate in large flocks, often appearing at herring spawn sites with other species. The highest counts are from Iona Island and are obviously migrating flocks—12,111 and 10,020. Longbeak Point on Denman Island had consistently high numbers. There is no significant population trend.



Cormorants

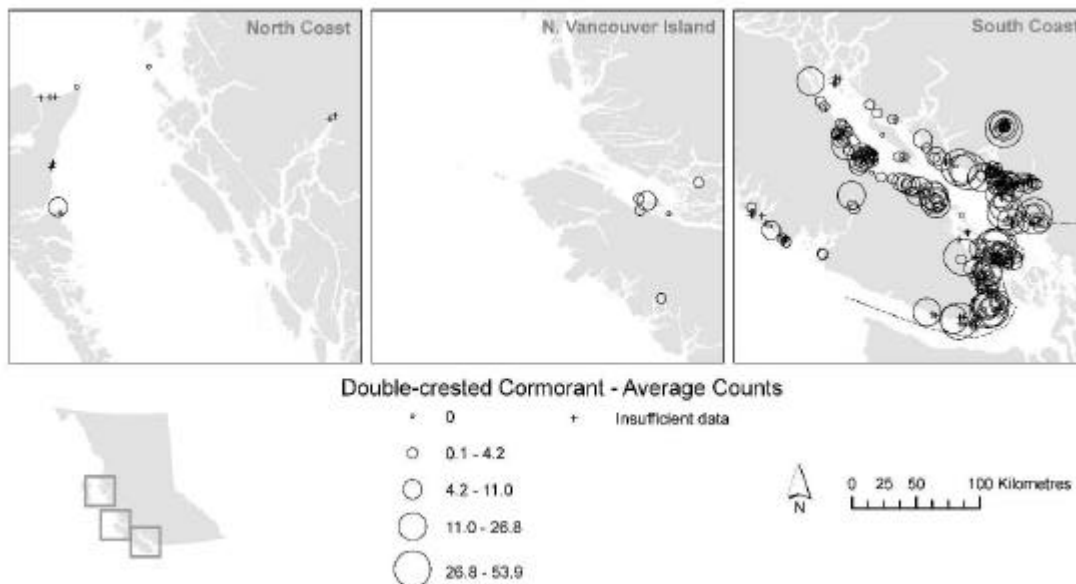
Brandt's Cormorant

This species formerly occurred in large numbers in channels with high tidal action such as Active Pass, but this survey did not pick up many large flocks. There is no significant population trend. High counts were from Page Lagoon, Nanaimo (524), Ogden Point to Clover Point, Victoria (350) and Ford Cove, Hornby Island (330).



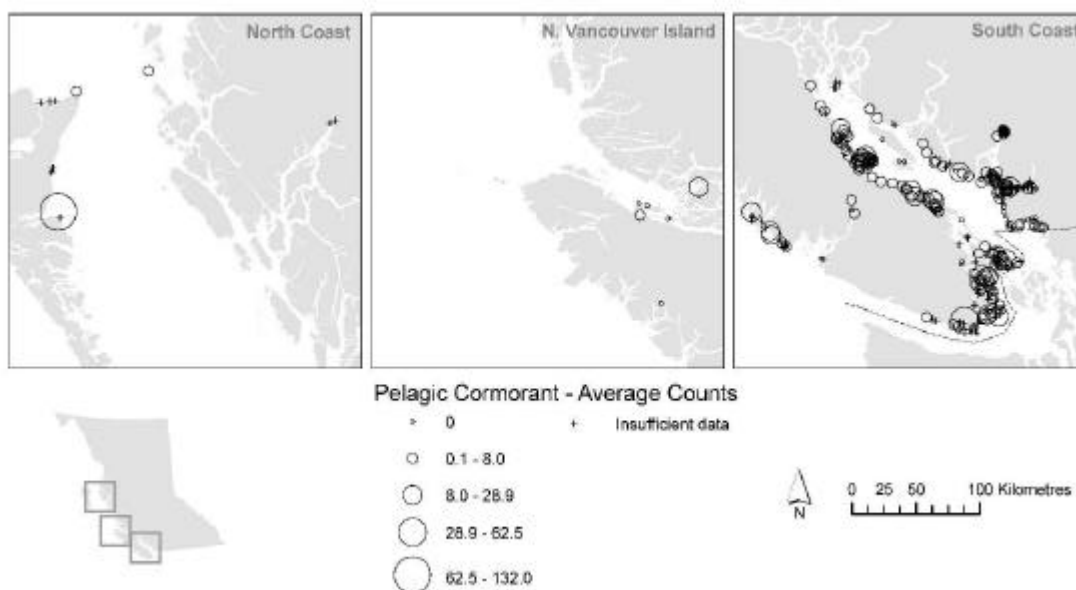
Double-crested Cormorant

Double-crested Cormorants are common in the Strait of Georgia, but decidedly uncommon off north Vancouver Island and the north coast. This species increased significantly in the Strait of Georgia from 1959 to 1987, but then decreased significantly until 1999. Data from this survey indicate an increasing wintering population over the last 5 years. Highest numbers were reported in Victoria (Saxe Point to Macaulay Point, 412; Whiffin Spit, 335) and the mouth of the Fraser River (Lulu Island South, 315; Reifel, 268).



Pelagic Cormorant

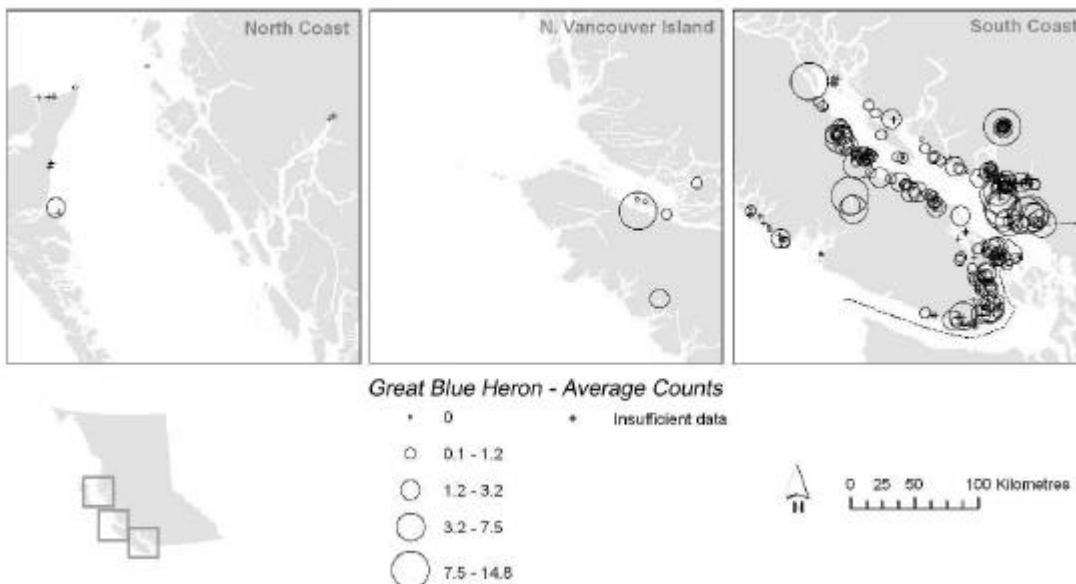
Pelagic Cormorants prefer rockier shores and more saline waters than Double-crested Cormorants. Like the Double-crested, Pelagic Cormorant breeding numbers declined in the 1990s along the east coast of Vancouver Islands. Interestingly, there is a significant increasing trend to the population index in this survey. Highest peak counts were at Grassy Point, Hornby Island (400) and Page Lagoon, Nanaimo (268).



Hérons

Great Blue Heron

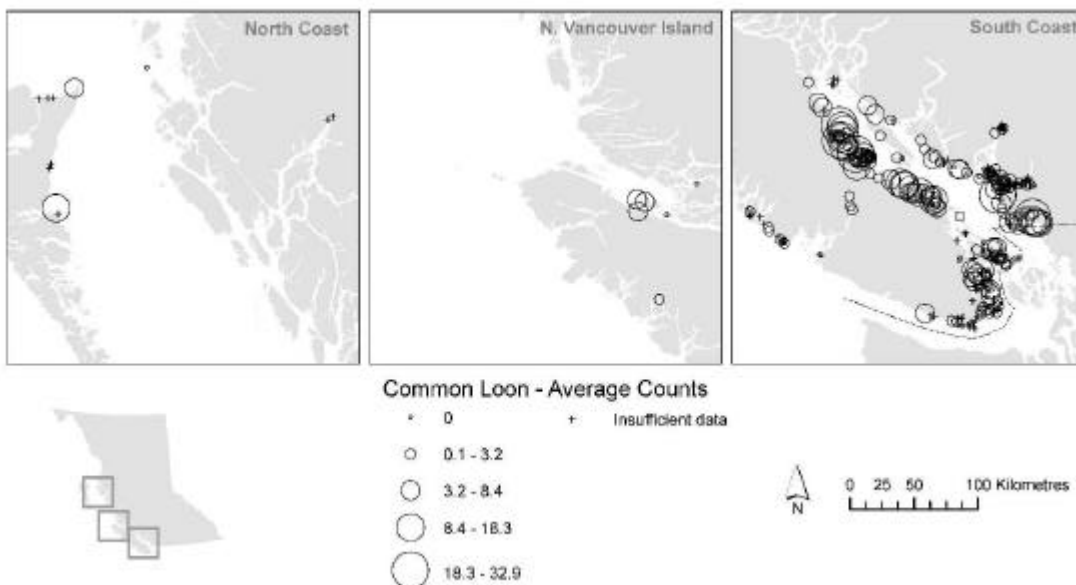
Hérons are found all along the coast, but numbers are generally low on the north coast and a distinct concentration occurs in the Fraser Delta and Boundary Bay. This is listed as a species of Special Concern by COSEWIC. High counts are from Blackie Spit, Crescent Beach (86). The population index shows a significant increase.



Loons

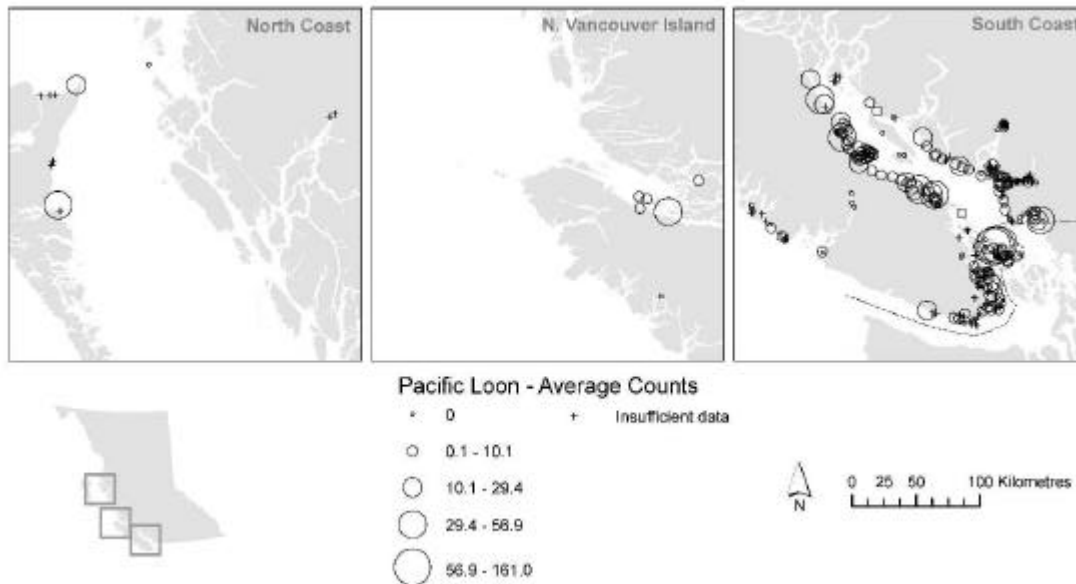
Common Loon

Common Loons are found all along the coast, with highest numbers on the east coast of Vancouver Island and the Fraser Delta. There is no significant population trend. Highest numbers were at Blackie Spit, South Surrey (277) and Saanichton Bay (212).



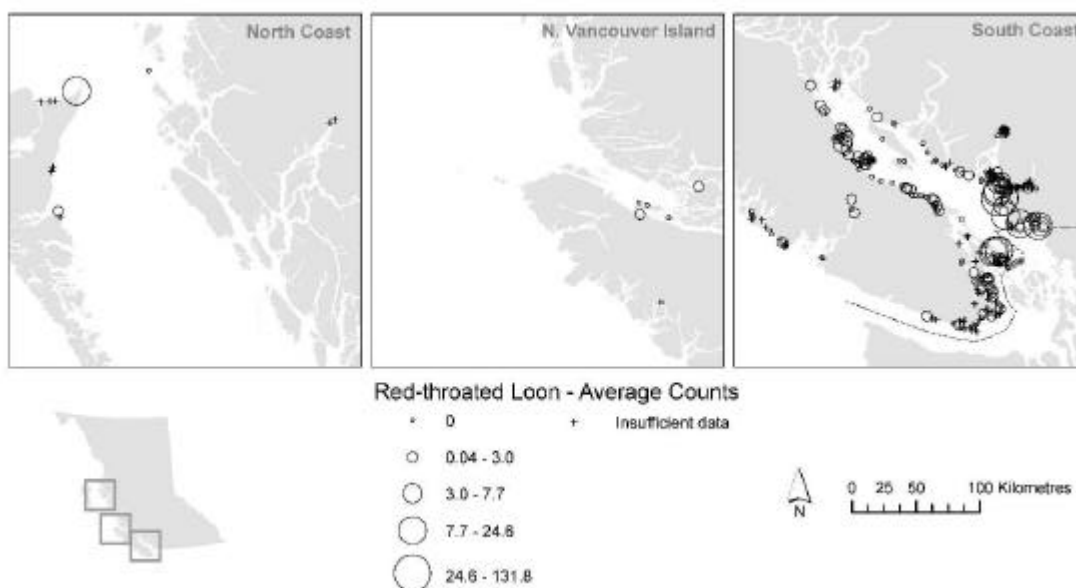
Pacific Loon

Pacific Loons concentrate in flocks at sites where strong tidal currents create high zooplankton and schooling fish numbers. Perhaps the best known of these sites in British Columbia is Active Pass between Mayne and Galiano Islands. They also gather at herring spawn in the spring. Highest numbers were at Oyster Bay (3411) and Middlepoint Bight, Sunshine Coast (3003). There is a significant increasing trend in the population index.



Red-throated Loon

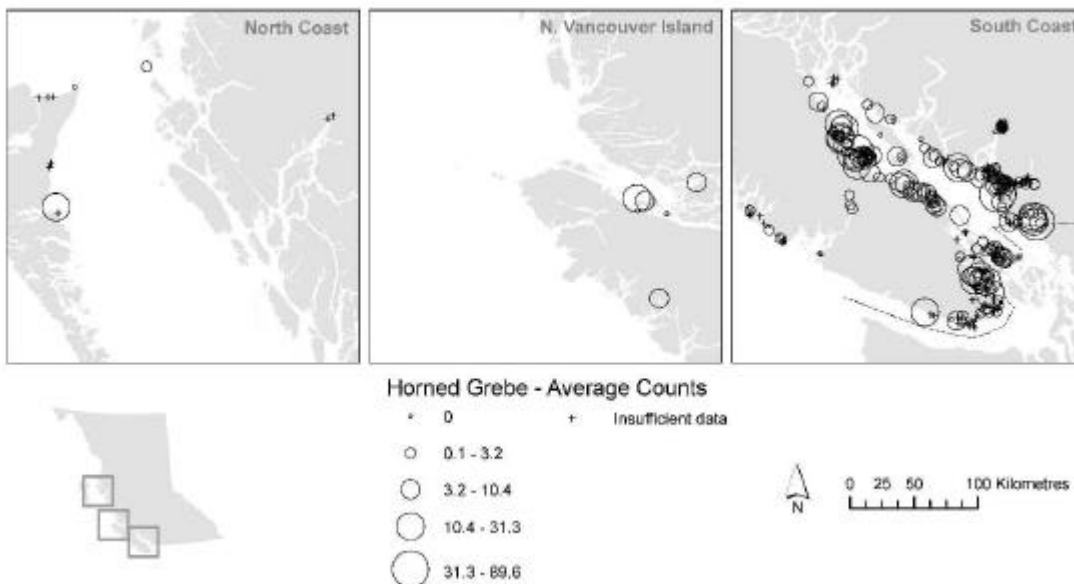
Red-throated Loons winter all along the coast, with highest numbers around the Fraser Delta. Highest peak number was 7000 at Iona Island, a remarkable concentration; other high numbers were less than one-tenth that figure. There is no significant population trend.



Grebes

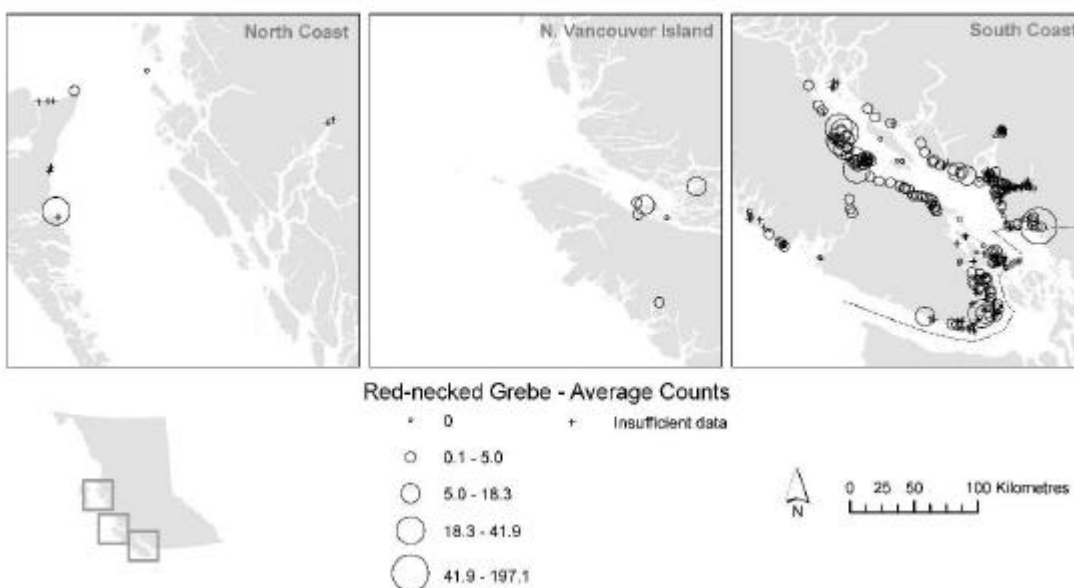
Horned Grebe

Found in small numbers all along coast, with no significant population trend. Highest numbers were all from Iona Island (650) and White Rock, West Promenade to 131st Street (364).



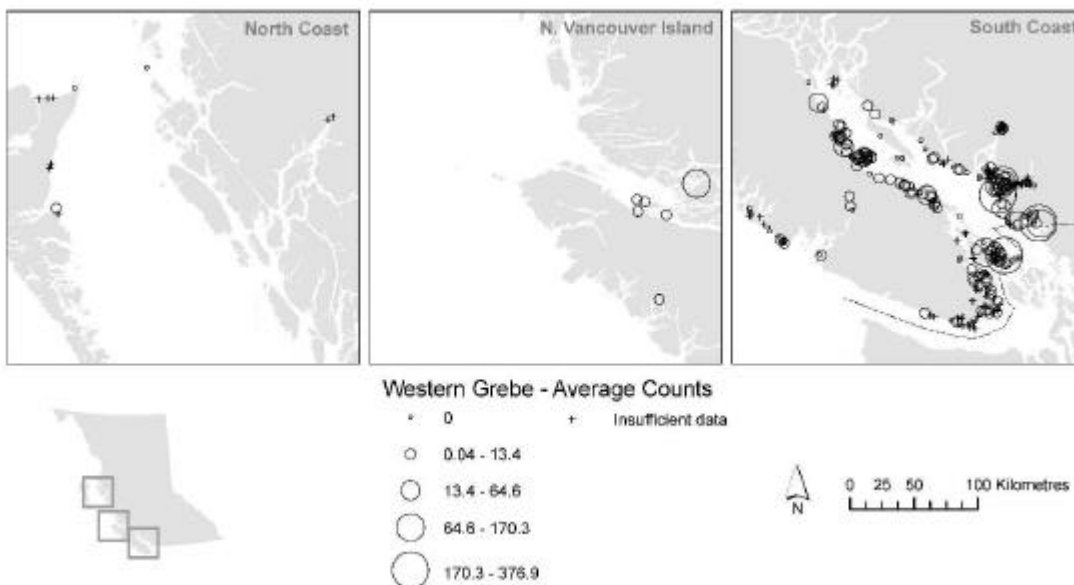
Red-necked Grebe

Red-necked Grebes winter along the length of the coast, but have only one distinct concentration—the White Rock-South Surrey area on the eastern shores of Boundary Bay. The highest counts there were: East Pier to West Promenade (2716), 1001 Steps to Beecher Street (1000), Blackie Spit (780). There is a significant downward trend in the population index.



Western Grebe

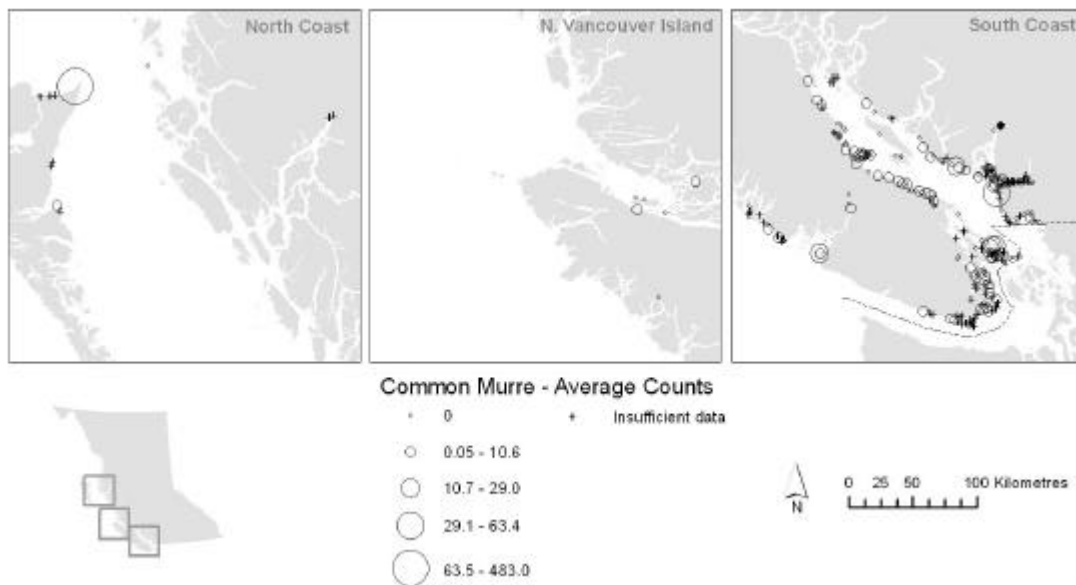
Western Grebes are a species of great concern on the British Columbia coast. Over the past 30 years, numbers on Christmas Bird Counts have declined by 90 to 95 per cent. Unfortunately, all of that decline occurred before this survey began. The population has been steady at a low level for the past five years with the exception of 2003 when a significant increase occurred (reflected in Christmas count data as well). This peak in 2003 creates a significant increasing population trend for the species over five years, but since the population dropped in 2004 it likely is not meaningful in the long term. Peak counts were at the Oyster River estuary (8000) and Iona Island (7273).



Alcids

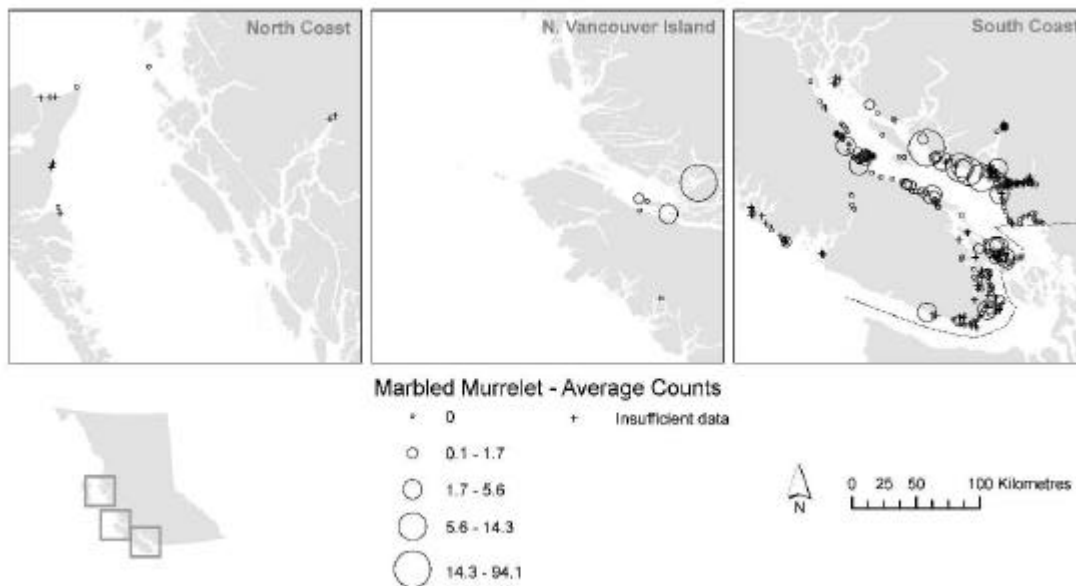
Common Murre

Common Murres nest at Cape St. James on the southern tip of the Queen Charlottes, on Triangle Island off the northern end of Vancouver Island and on rocky islets off the Olympic Peninsula. After breeding they swim to the Strait of Georgia and feed in nutrient-rich areas with strong currents. Two sites had single sightings of large flocks: Mayne Island (503) and Rose Spit, Queen Charlotte Islands (483). There is a decreasing population trend, generated by a high index during the first survey year.



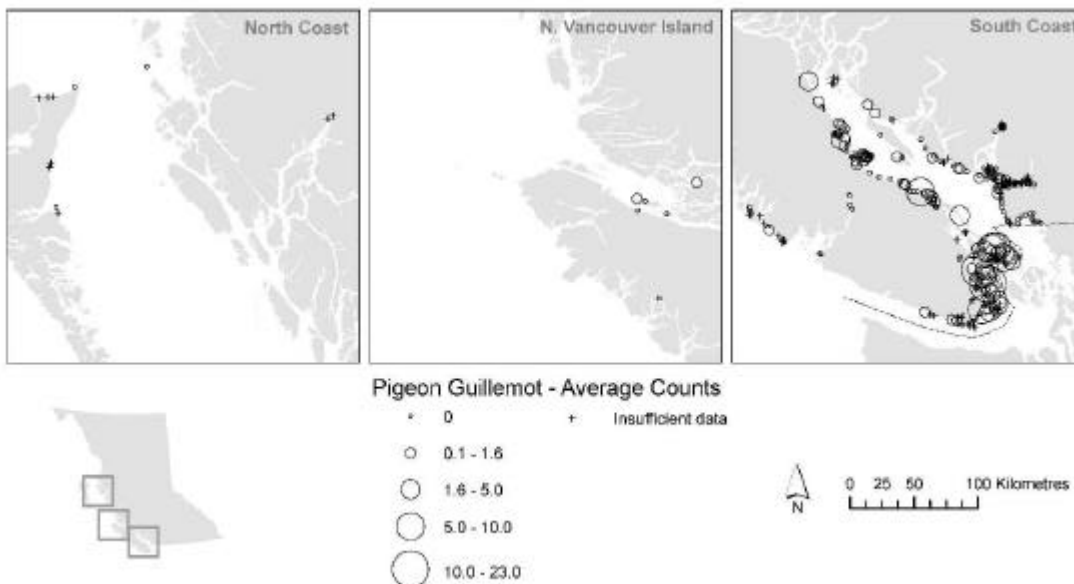
Marbled Murrelet

Numbers are concentrated along the Sunshine Coast and in Johnstone Strait. There is no significant population trend. High numbers were at Middlepoint Bight, Sunshine Coast (604) and at the Viner River estuary, off Queen Charlotte Strait (247). This species is listed as Threatened by COSEWIC because of the continued loss of nesting habitat -old growth forests- as well as mortality from fishery bycatch.



Pigeon Guillemot

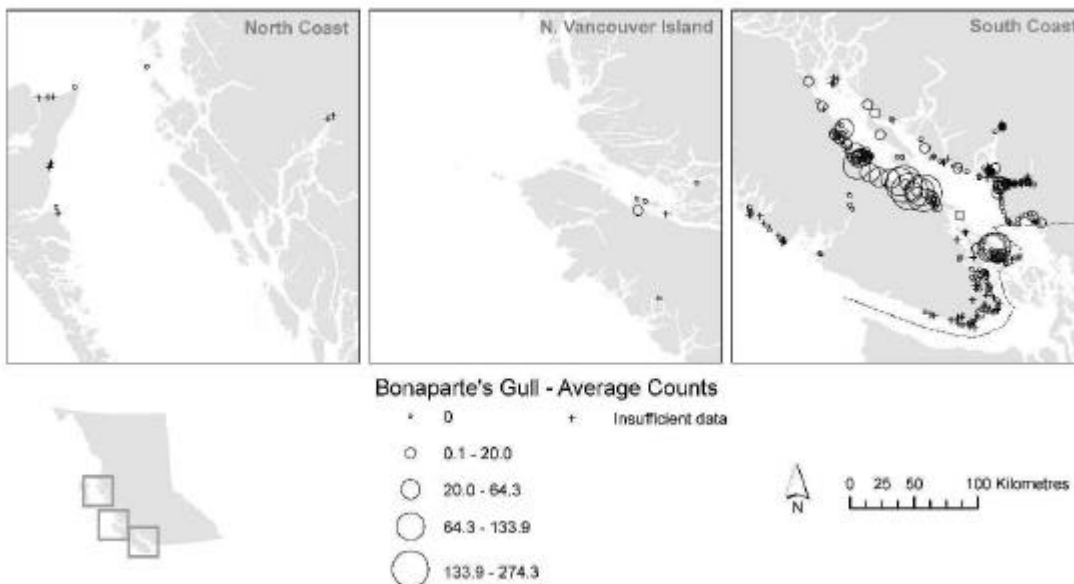
Guillemots forage along rocky shores; numbers are highest in the Gulf Islands and southern Vancouver Island. There is no significant population trend. Highest numbers were reported from Island View Beach (156), Saanichton Bay (141), Blunden Point, Nanaimo (120) and Gordon Head, Victoria (113).



Gulls

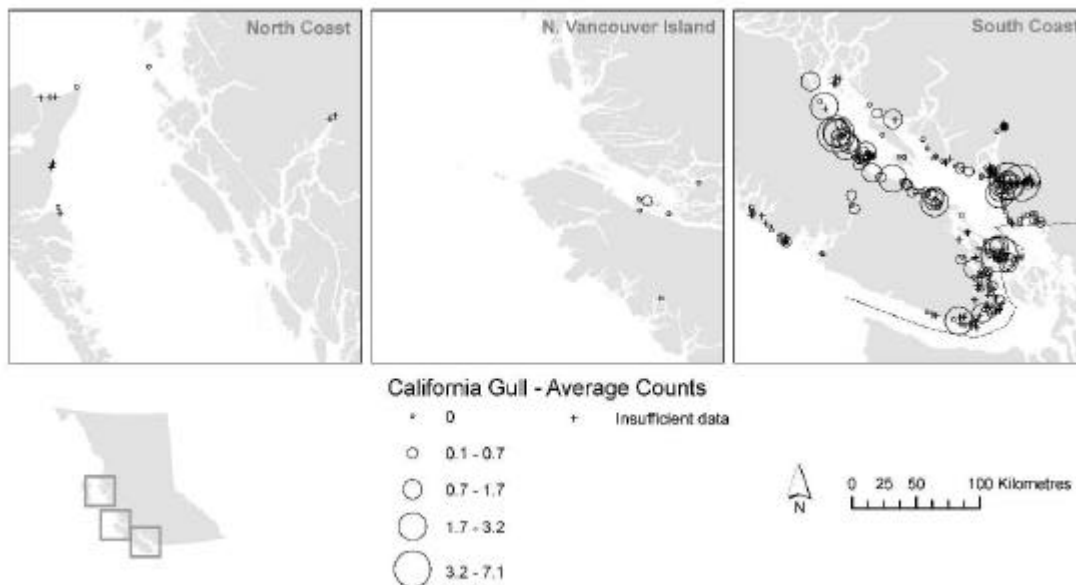
Bonaparte's Gull

Bonaparte's Gulls migrate along the coast in spring and fall, relatively few spend the winter. There is no significant population trend. However, migration peaks are in late April and mid-September, so this once-monthly survey from September through April is not ideal for monitoring the species. Numbers are clearly concentrated where strong tidal currents produce a rich crop of zooplankton; areas such as Active Pass and along eastern Vancouver Island. High counts included 2200 at Neck Point, Nanaimo, 1912 at the Nanoose Estuary and 1900 at Active Pass, Mayne Island.



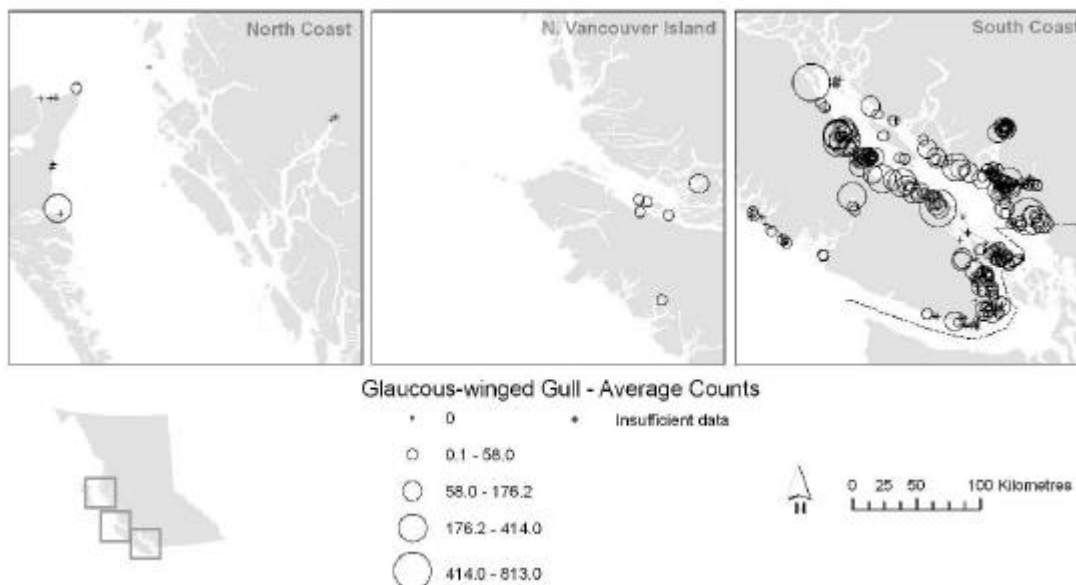
California Gull

California Gulls are primarily migrants on the coast, and thus may be missed as this survey concentrates on winter months. There is no significant population trend; variances are very high due to the flocking and migratory behaviour of the species. The highest count (more than twice as high as any other) was at Gartley Beach, Comox (1500).



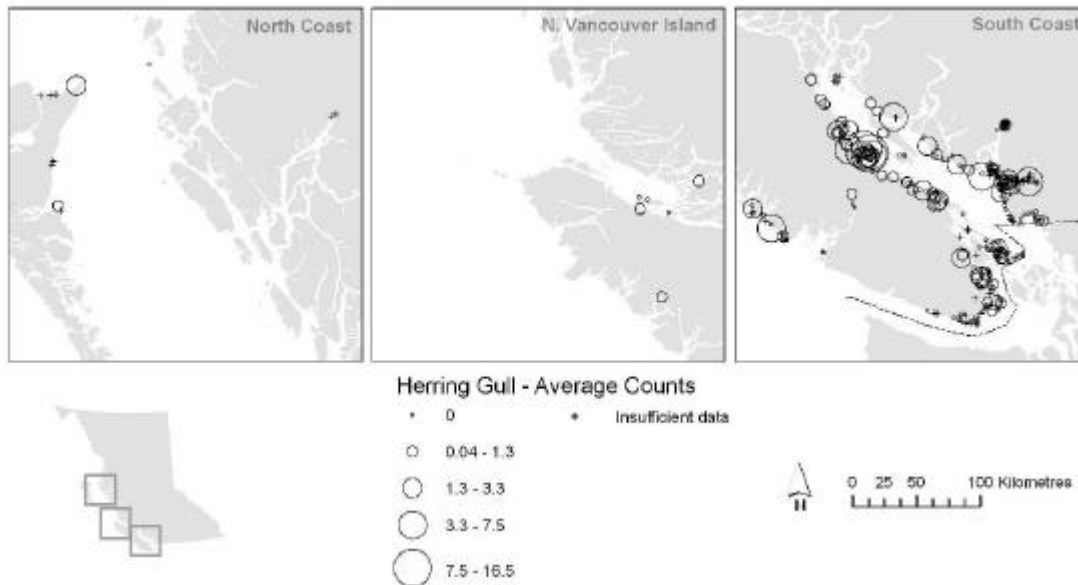
Glaucous-winged Gull

Glaucous-winged Gulls are common all along the coast but are obviously in higher numbers in the Strait of Georgia. There is no significant population trend. Peak numbers all come from the east coast of Vancouver Island; the highest is from Gartley Beach, Comox (8000).



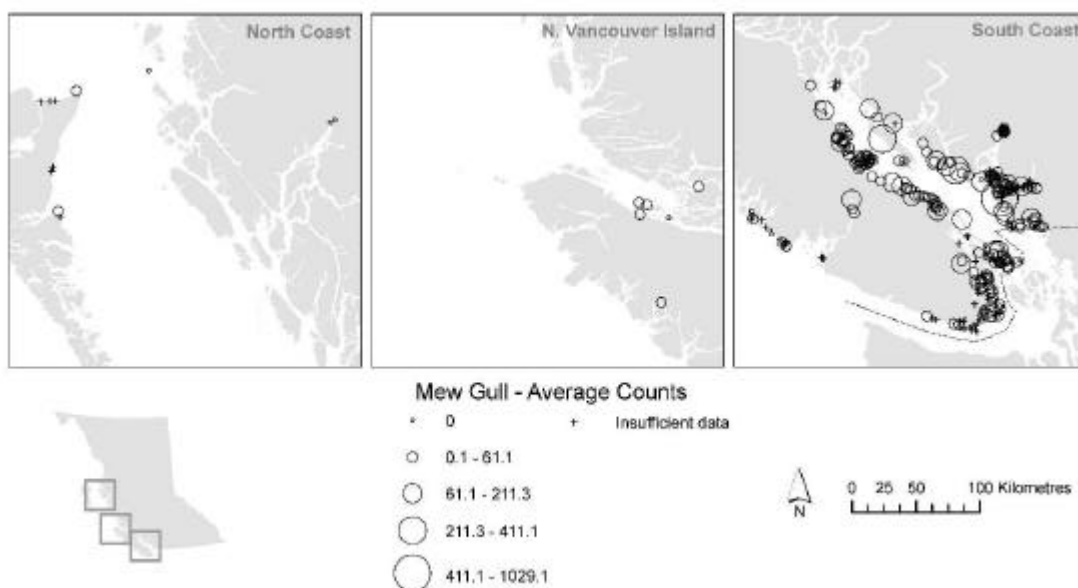
Herring Gull

Herring Gulls are one of the more uncommon gulls in the Strait of Georgia in winter. Records are scattered up and down the coast and there is no significant population trend. This gull is often misidentified, or rather other gulls, especially distant Mew and Thayer's Gulls, are often misidentified as Herrings.



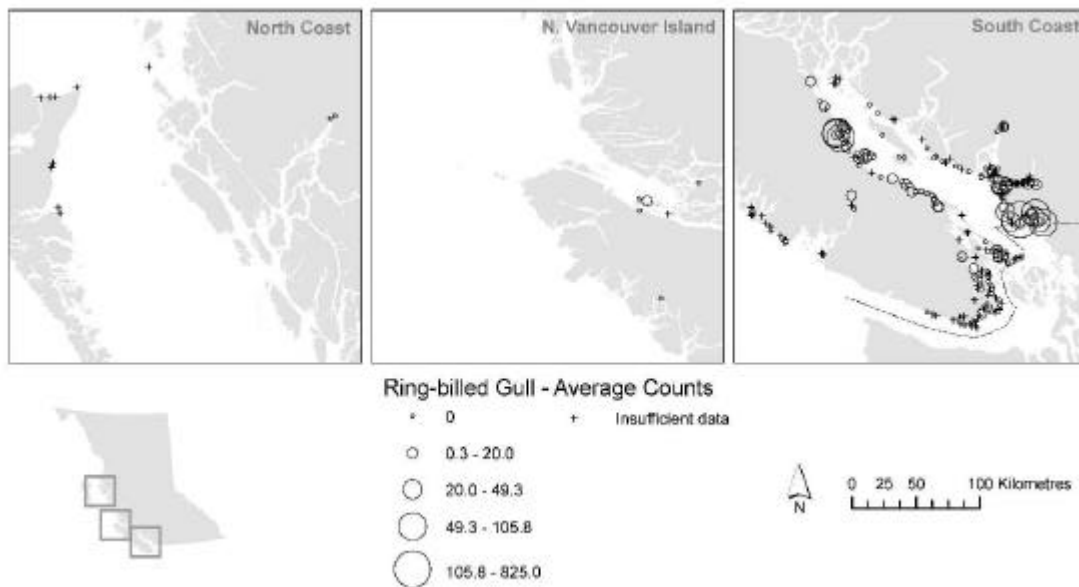
Mew Gull

Mew Gulls are common throughout the Strait of Georgia, but are less common on the central and north coast. There is a significant increasing trend in the population index over the five years of the survey. Highest peak numbers were reported at Gartley Beach, Comox (9000) and Iona Island (5910).



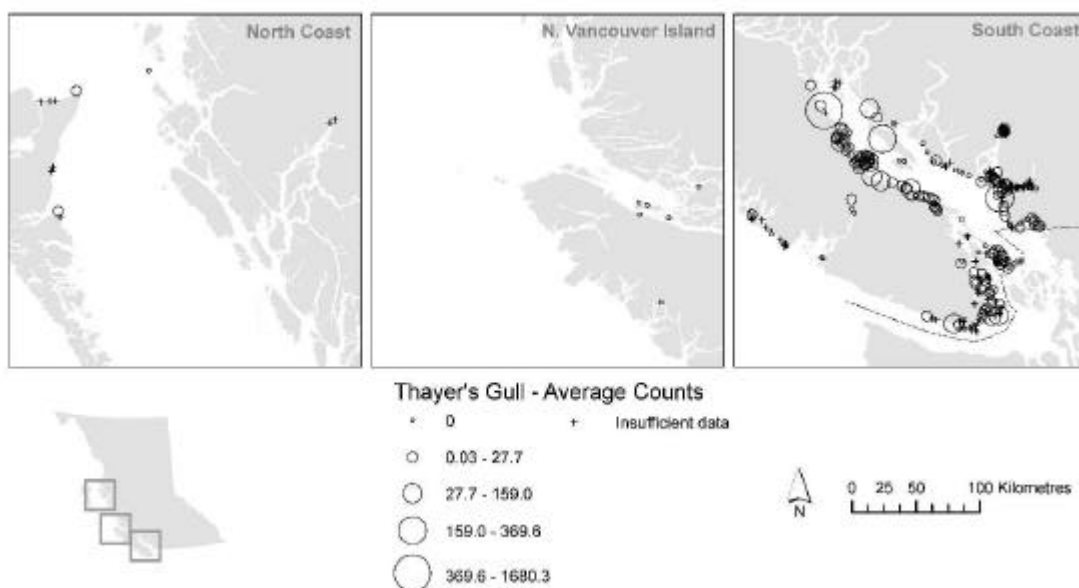
Ring-billed Gull

Ring-billed Gulls have been increasing in numbers as wintering birds along the coast, so it is surprising to see a significant downward trend to the population index. This may result from high variance in the first year of data. Highest numbers were in the Boundary Bay area; the peak number was 1360 between 12th and 64th Streets in Delta.



Thayer's Gull

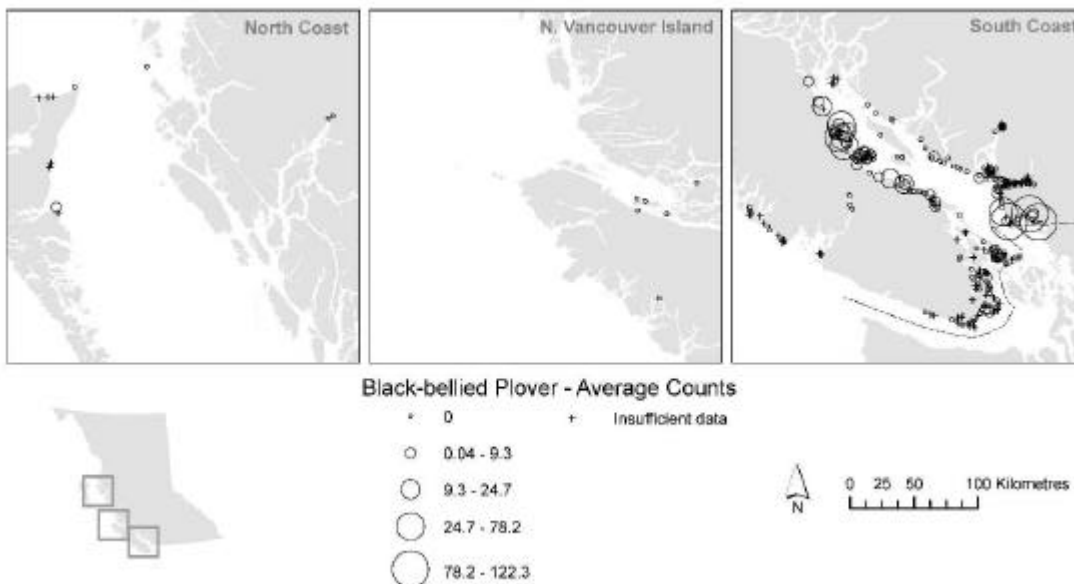
Thayer's Gulls winter commonly around the shores of the Strait of Georgia and are decidedly uncommon on northern Vancouver Island and the north coast. The Oyster River estuary consistently reported the highest counts, including a peak of 3500. There is no significant population trend.



Shorebirds

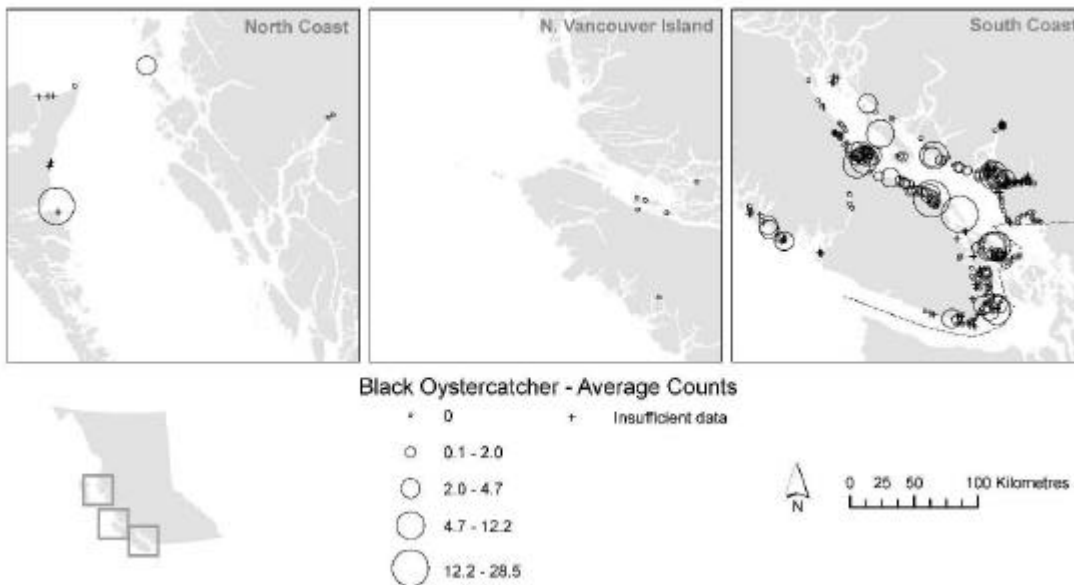
Black-bellied Plover

Black-bellied Plovers are clearly concentrated on the mudflats of Boundary Bay. There is no significant trend to the population index, though it seems to be declining after a high point in 2001. Highest numbers were at Blackie Spit, White Rock (8000).



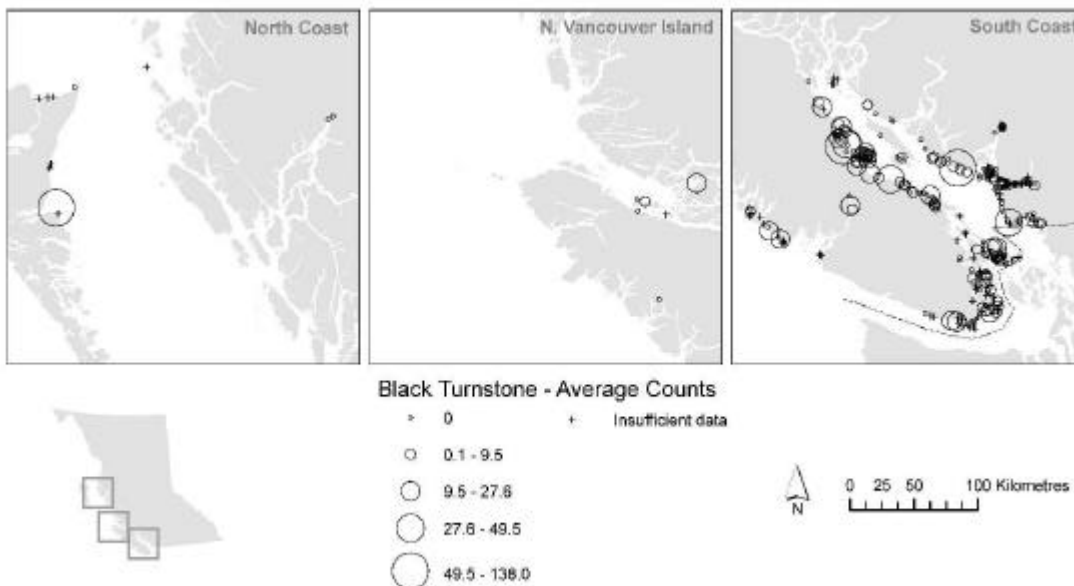
Black Oystercatcher

Oystercatchers are concentrated in eastern Vancouver Island and the Skidegate Inlet area. The population trend is essentially flat, although this species certainly increased in numbers in the Georgia Strait area before the survey began. Highest numbers were at Departure Bay (65) and Sandspit (57).



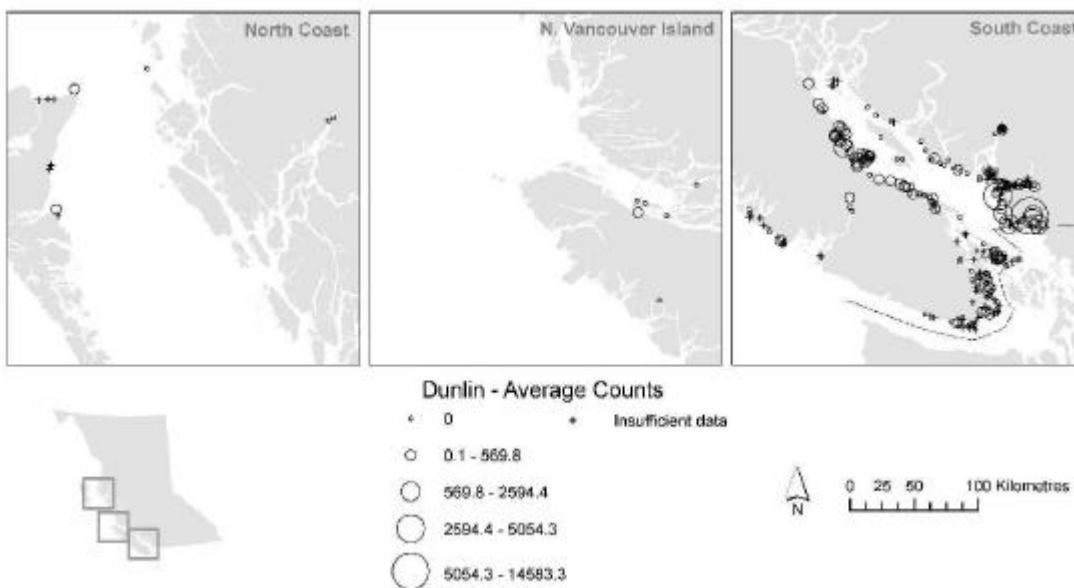
Black Turnstone

Black Turnstones winter on rocky shores all along the coast, they also commonly roost on log booms. There is no clear population trend; high numbers were at Roberts Creek (778), Longbeak Point, Denman Island (400) and Union Bay (362).



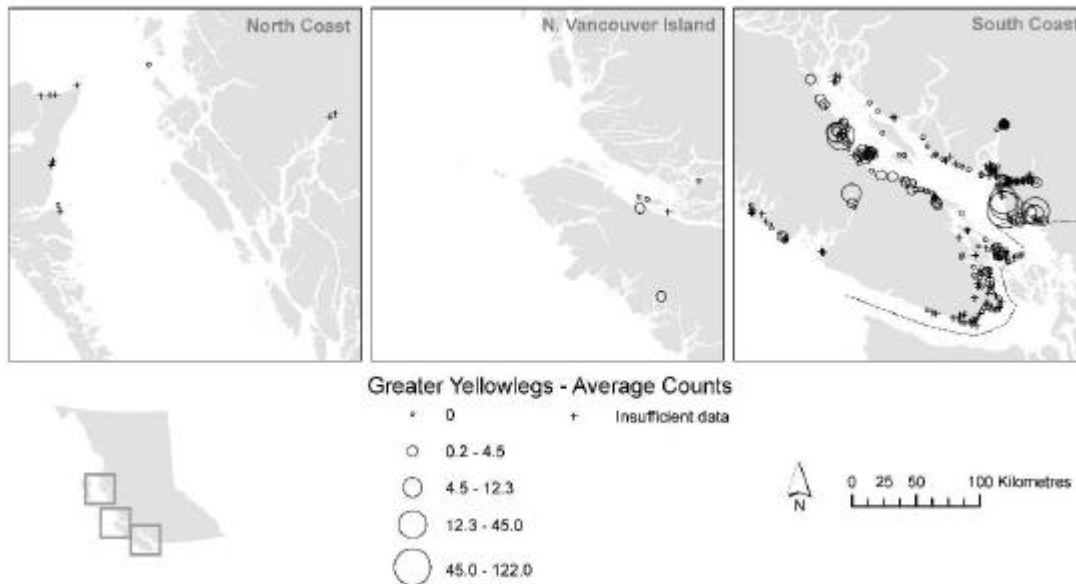
Dunlin

Dunlin are clearly concentrated on the Fraser Delta, especially in Boundary Bay. There are no significant population trends; the population index peaked in the third year of the survey. The highest numbers were at 12th St to 64th St, Boundary Bay (60,000), and near 112th St., Boundary Bay (30,000).



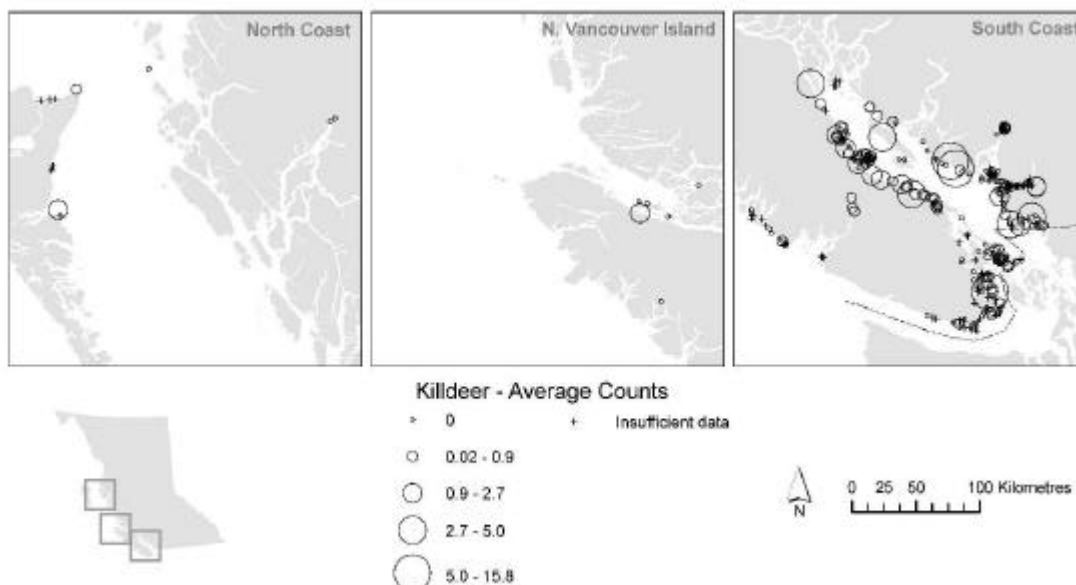
Greater Yellowlegs

Like most mud-loving shorebirds, yellowlegs concentrate on the Fraser Delta and Boundary Bay. Survey data show a significant increasing trend. However, this species winters in low numbers, so populations are not particularly well monitored by a survey such as this that could miss significant numbers of migrants. Highest numbers were at Reifel (238), Blackie Spit (115) and Roberts Creek North (115).



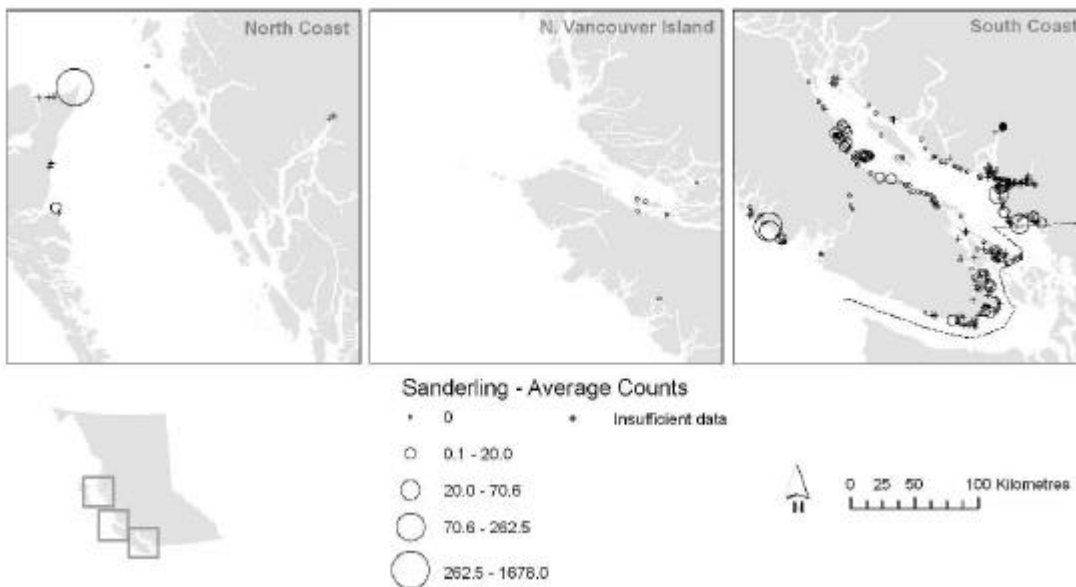
Killdeer

Small numbers are scattered along the coast. Not surprisingly the highest numbers by far come from one of the few inland survey sites, Martindale Flats, on the Saanich Peninsula (62). Numbers show a significant downward trend, which is similar to results from the Breeding Bird Survey.



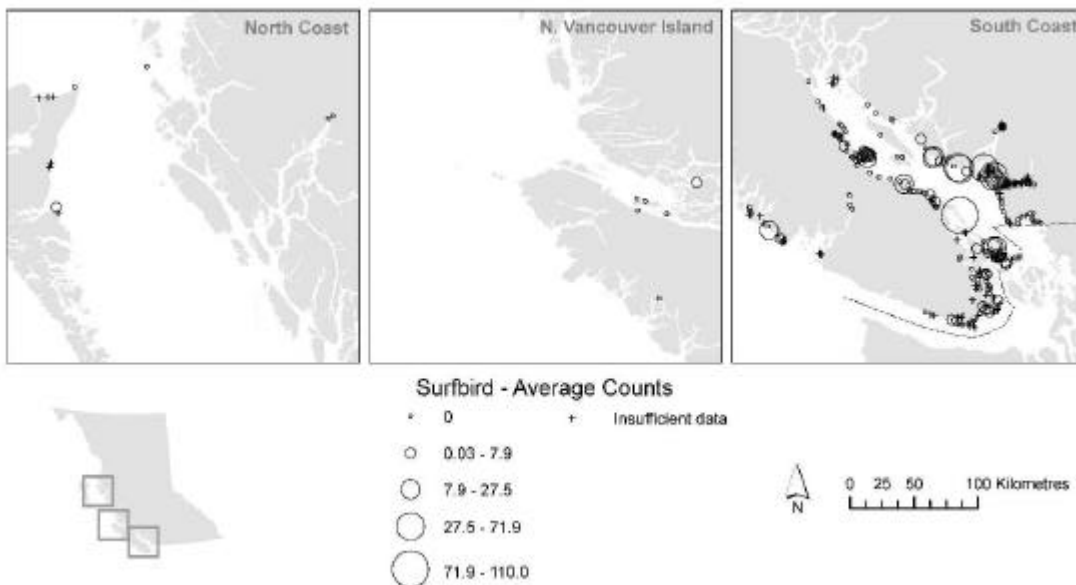
Sanderling

As their name suggests, Sanderlings prefer sandy beaches as wintering sites. The highest consistent numbers are from Rose Spit on the Queen Charlotte Islands, with a peak of 1678. Other Canadian surveys show a serious population decline for Sanderlings, but there is no significant trend in the data from this survey.



Surfbird

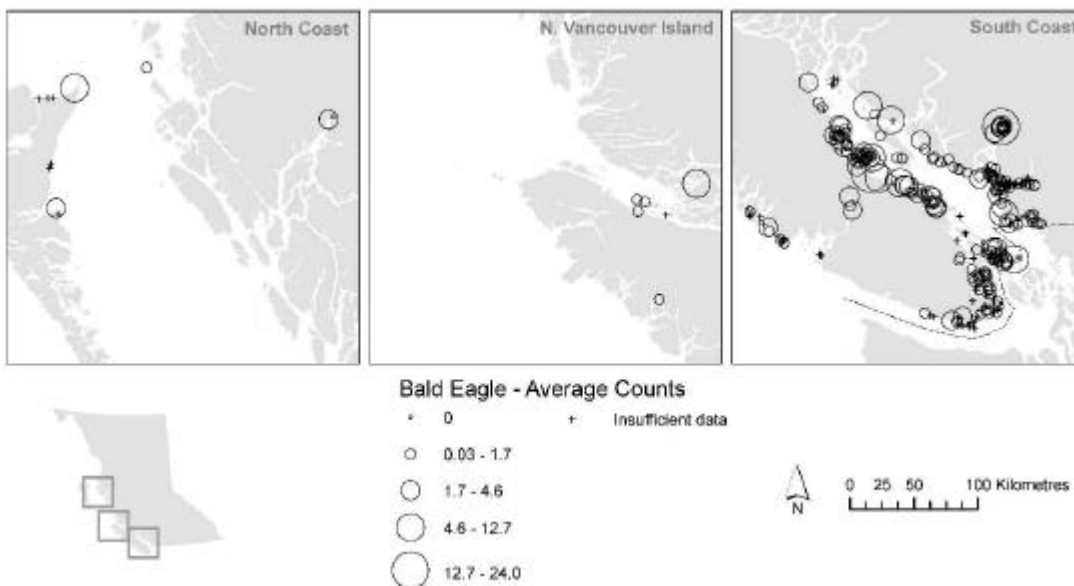
Surfbirds winter along rocky shores with Black Turnstones and Rock Sandpipers. Roberts Cr ek North was the most consistent site for large numbers of Surfbirds in this survey and had the highest peak count (554). There is no significant population trend.



Raptors

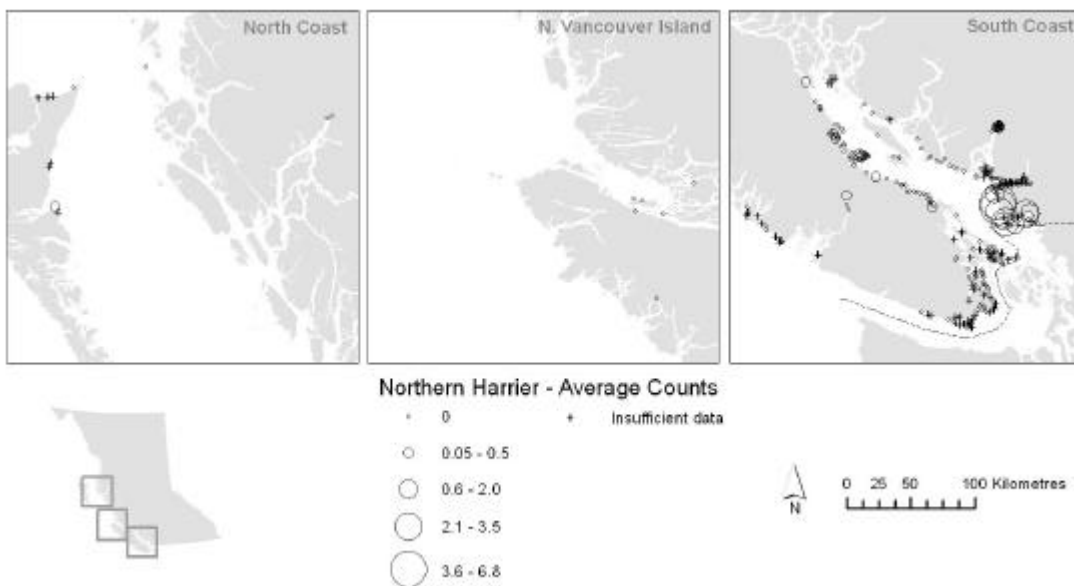
Bald Eagle

Bald Eagles are common throughout the survey area, with concentrations in the Squamish estuary, where they feed on salmon carcasses through the winter, and the east coast of Vancouver Island, where they likely gather at herring spawn sites. The data show a surprising significant downward trend that goes against other current survey data. While conventional wisdom says that this species is steadily increasing in the Strait of Georgia in winter, Christmas Bird Count data also point to a decline over the last 10 years, though not as clearly as these data do. Maximum counts were at Squamish River (161), Big Qualicum Estuary (100) and Helliwell Park, Hornby Island (100).



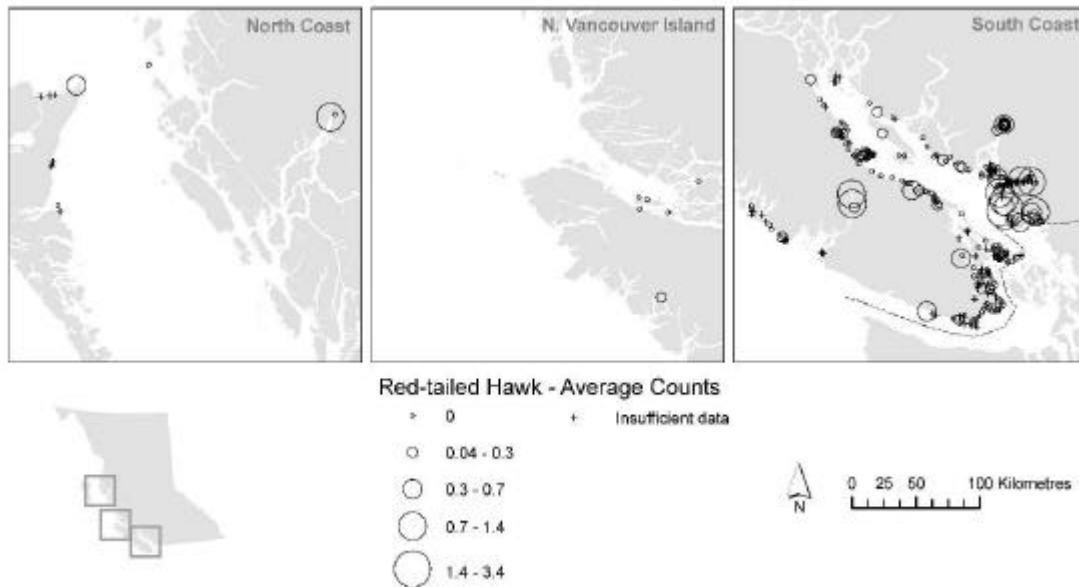
Northern Harrier

These graceful hawks are strongly tied to old field habitats of the Fraser Delta; they are common there and decidedly uncommon elsewhere along the coast. Harriers were common all along the Fraser Delta foreshore and the Boundary Bay dykes, but the northern part of Lulu Island consistently reported the most, with a high of 11 birds and a mean of 8. There was no significant population trend.



Red-tailed Hawk

Red-tailed Hawks winter around old-field habitats on the coast, especially those on the Fraser Delta. Highest peak number was 12 at Iona Island. There is a significant downward trend in the population index.



Peregrine Falcon

Peregrine Falcons winter where the food is, and on the winter coasts of British Columbia that means the Fraser Delta and Boundary Bay. Numbers are low and no population trend is evident from the data.

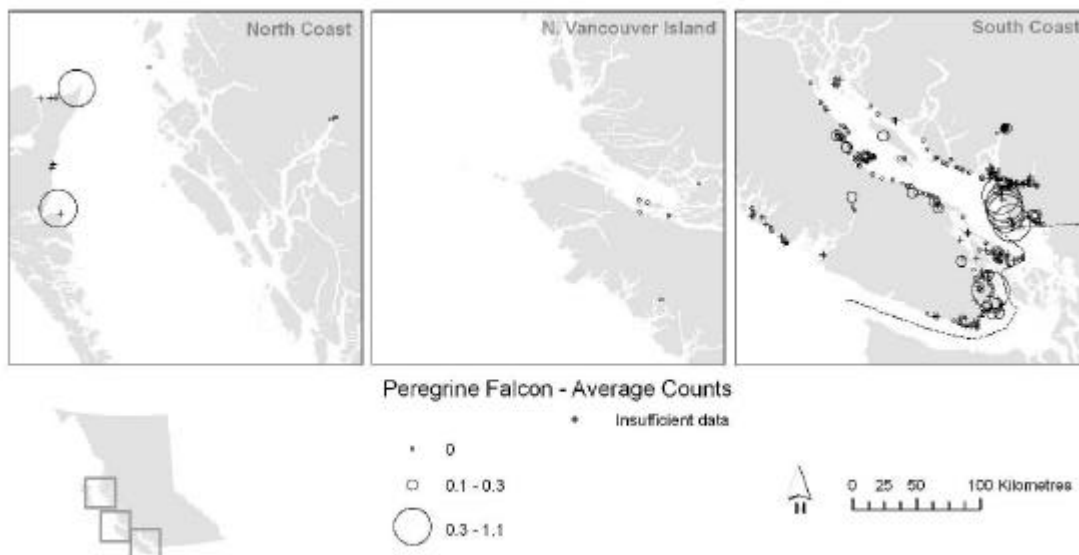
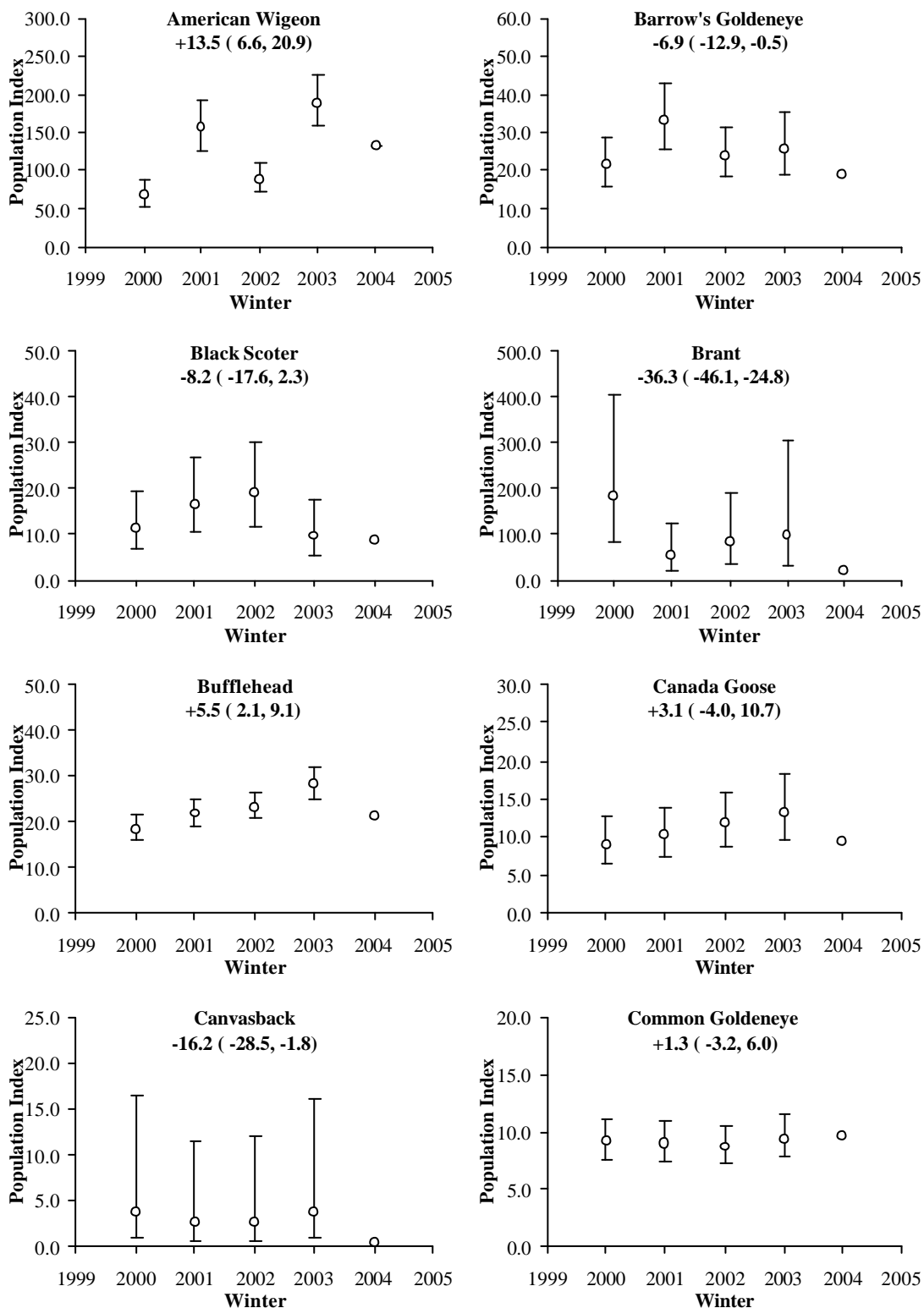
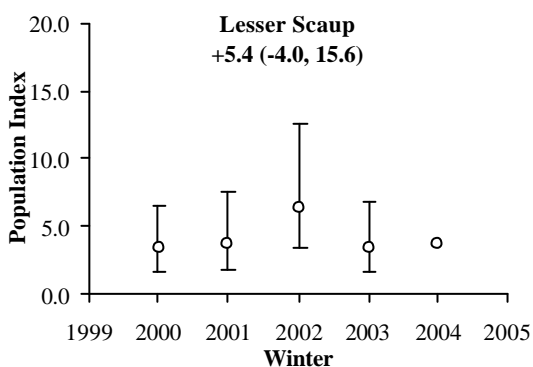
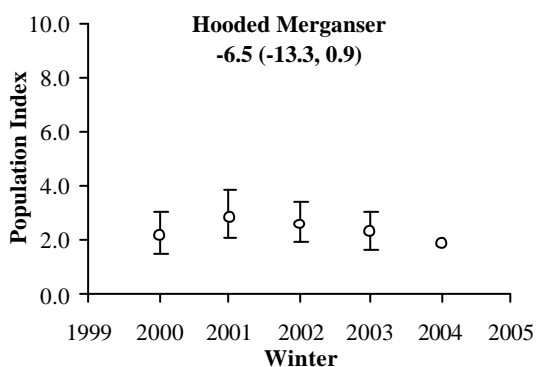
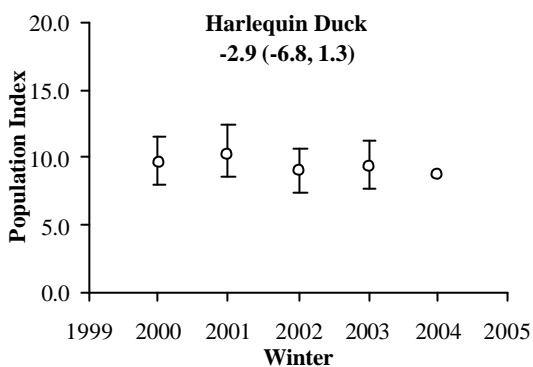
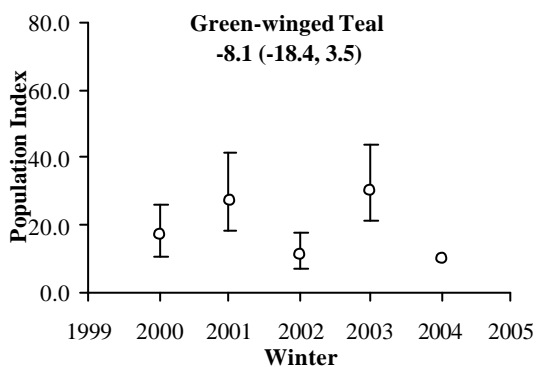
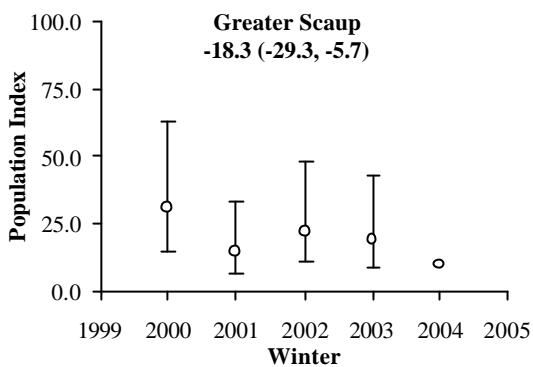
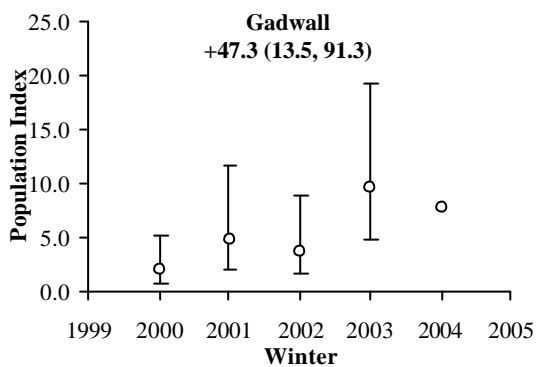
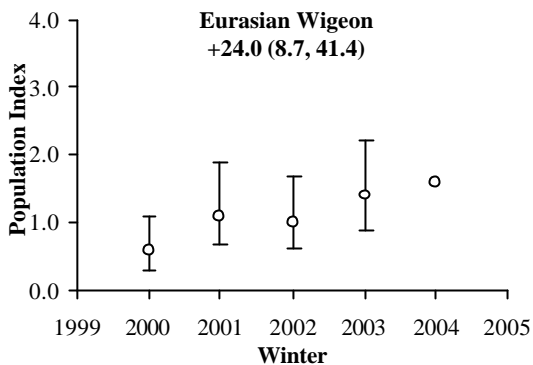
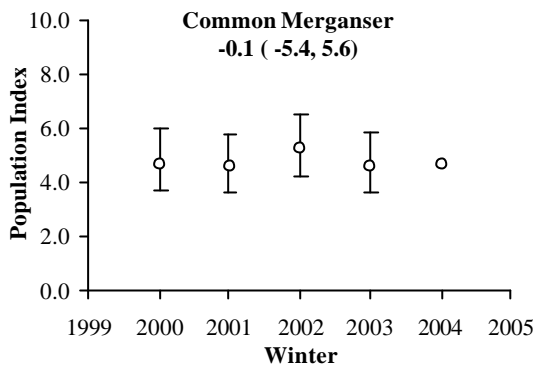
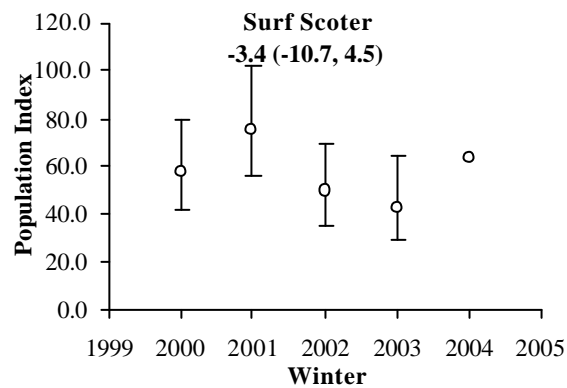
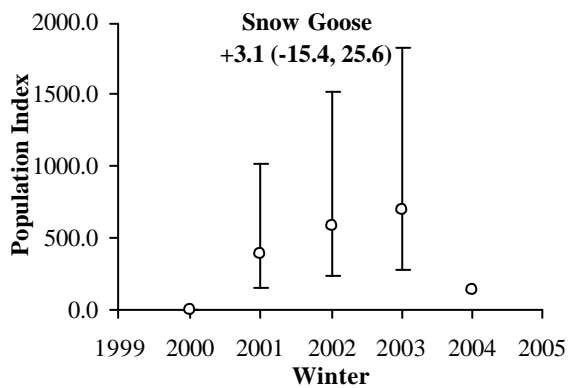
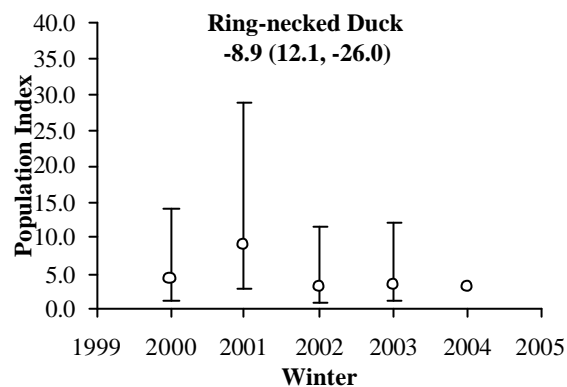
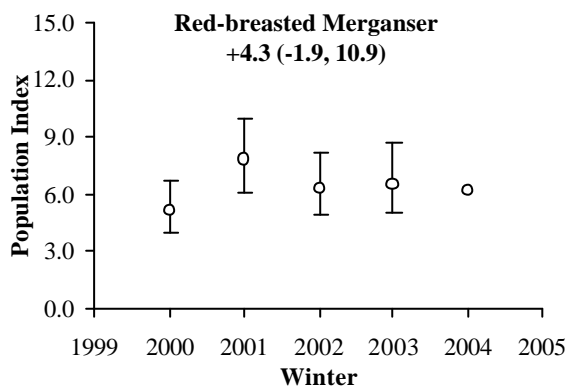
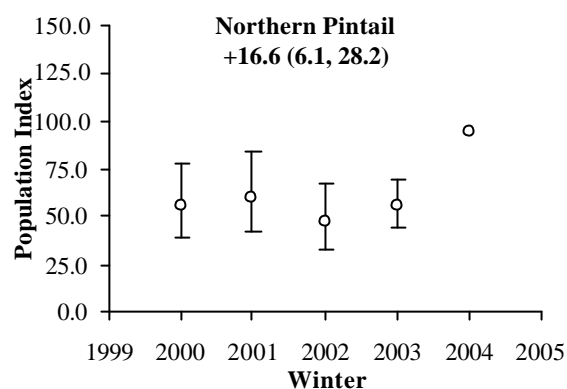
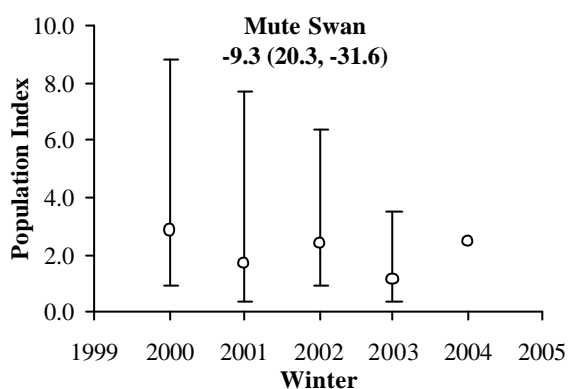
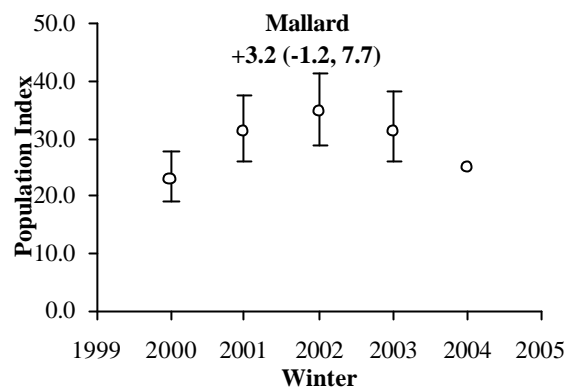
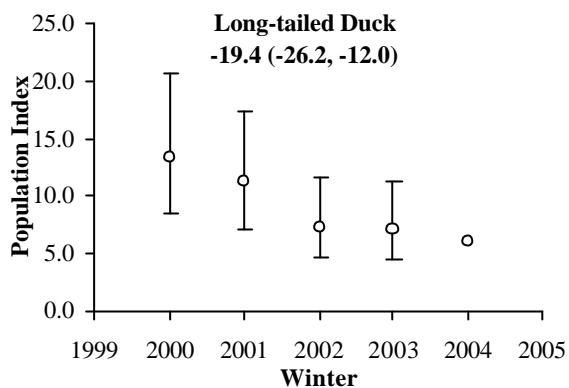
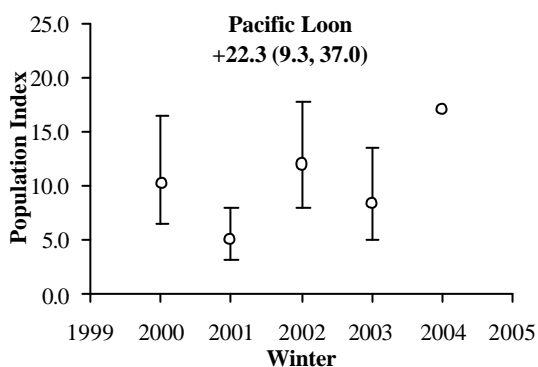
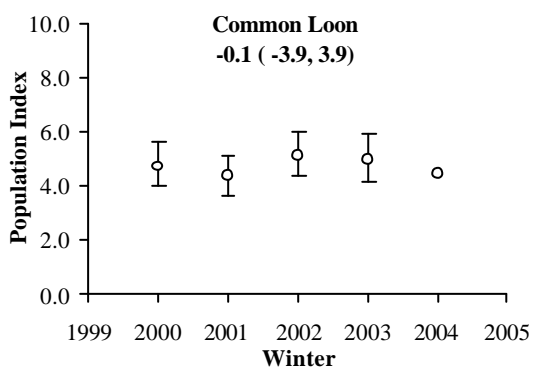
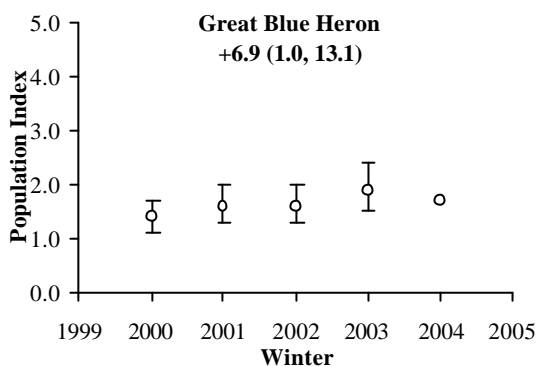
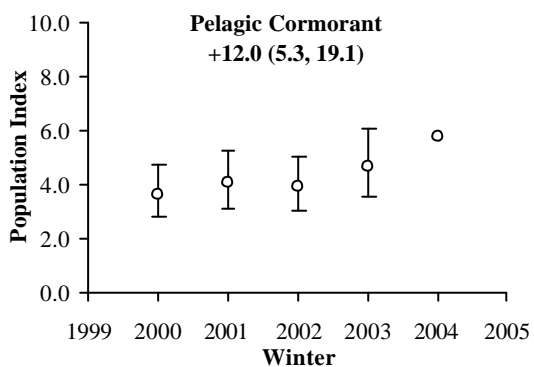
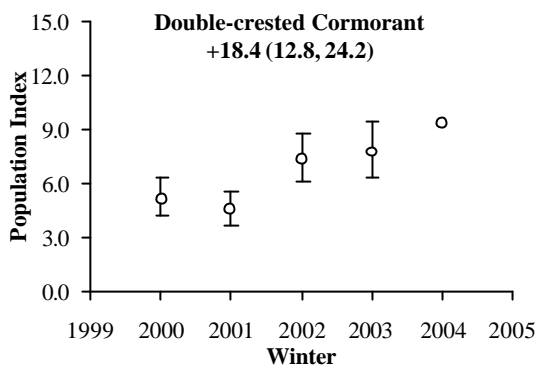
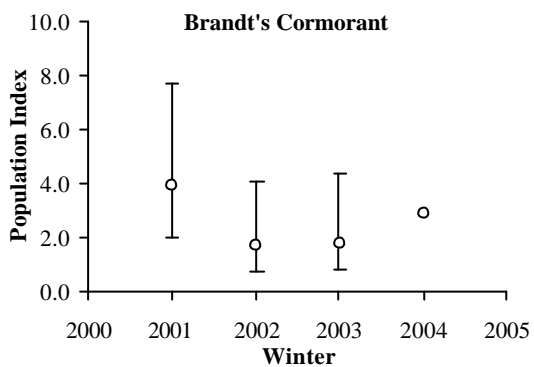
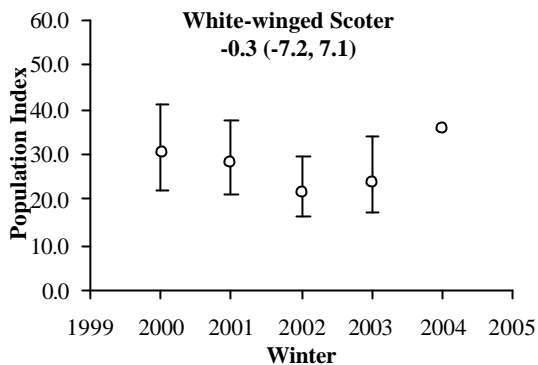
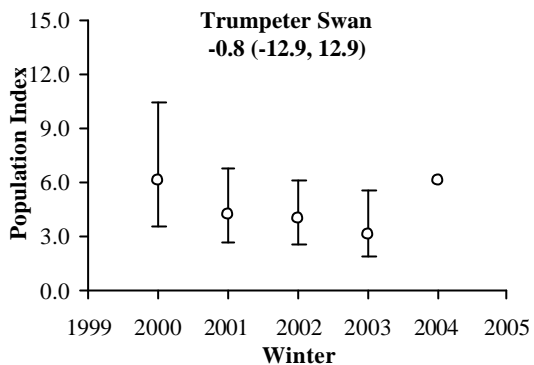


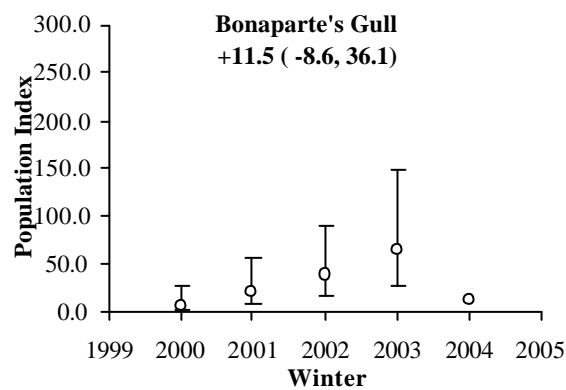
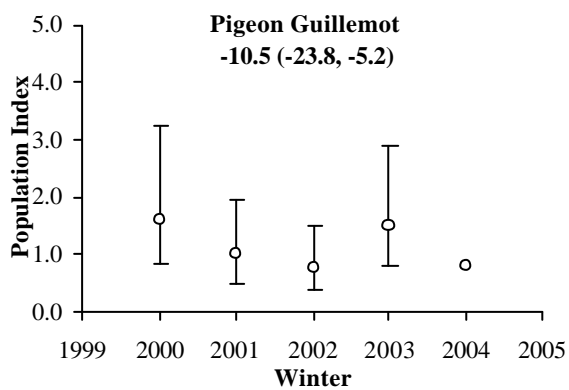
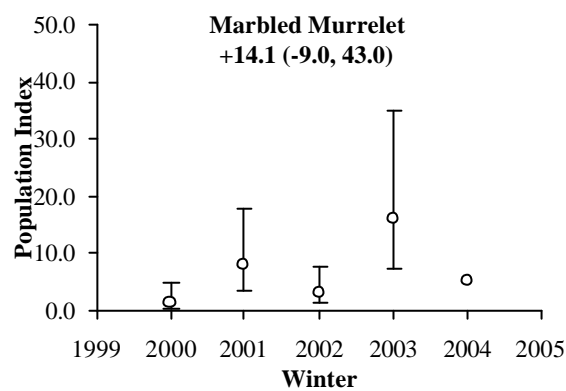
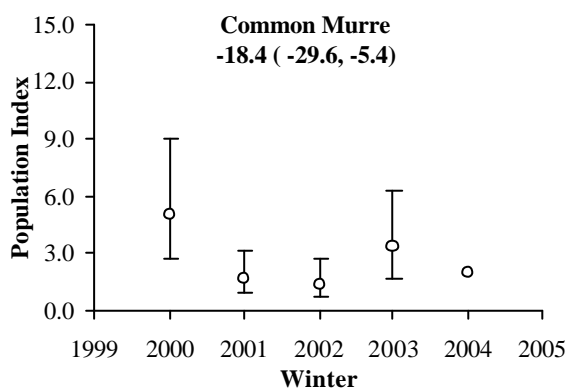
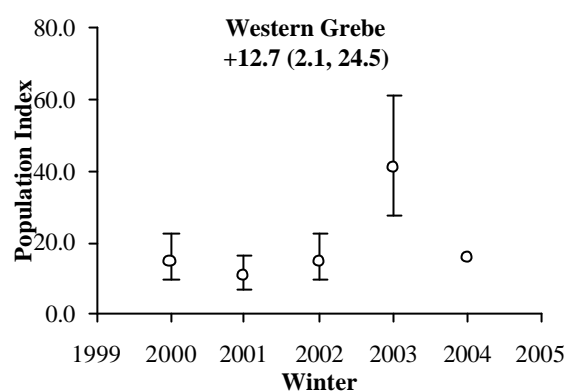
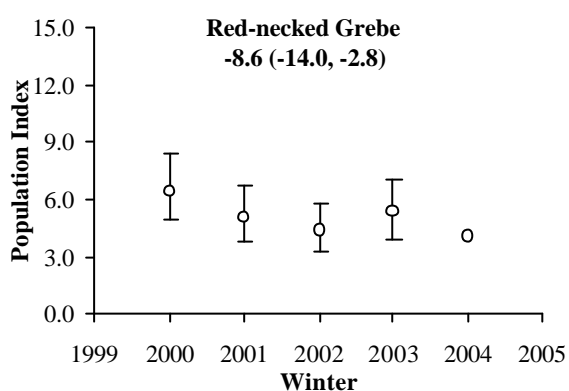
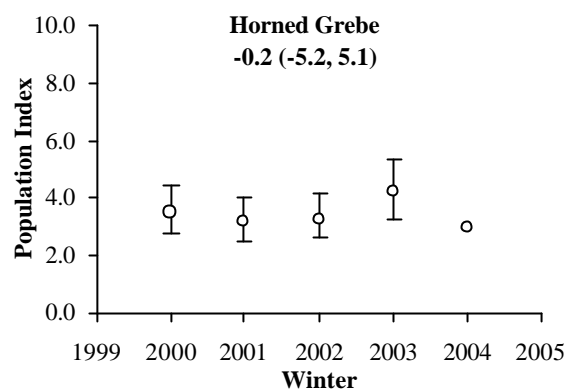
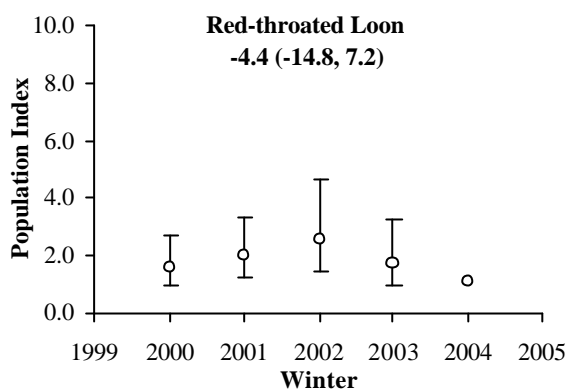
Figure 2. Annual relative abundance indices for waterbirds monitored at BCCWS sites from winter 1999/2000 (2000) through winter 2003/2004 (2004) in the Georgia Basin, British Columbia. Abundance indices are based on mean counts of individuals inside BCCWS site boundaries (during species specific survey windows) and are defined relative to winter 2004 values; vertical bars indicate 95% confidence intervals around annual indices. The estimated % annual change (linear trend) is shown for each species and the associated lower and upper extremes of 95% confidence intervals are shown in parentheses.

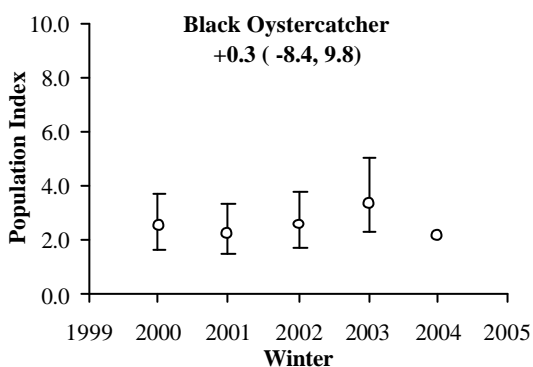
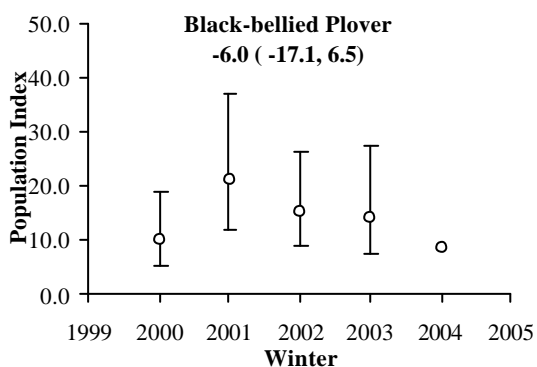
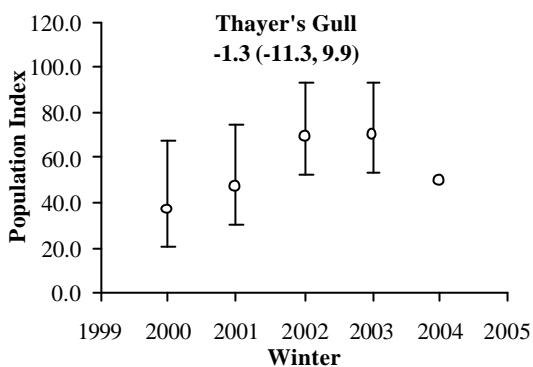
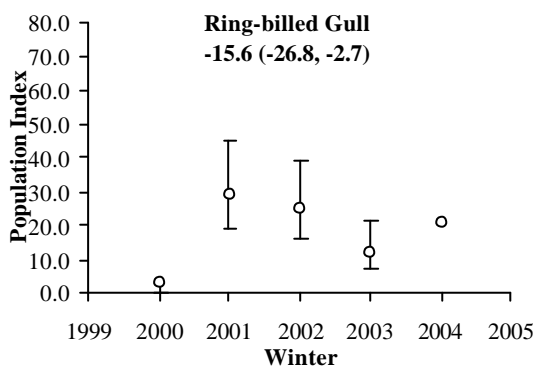
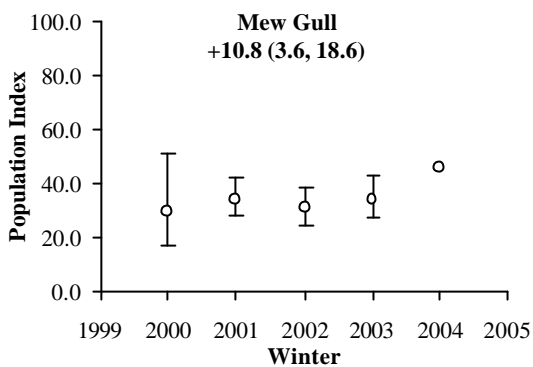
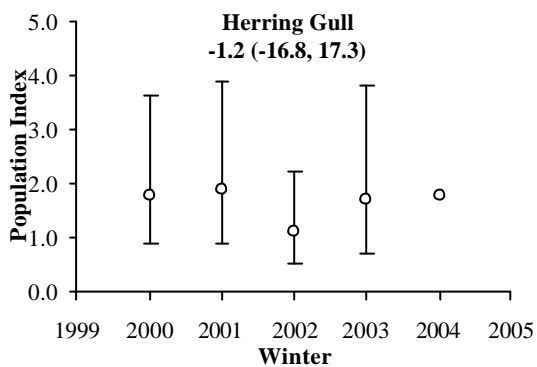
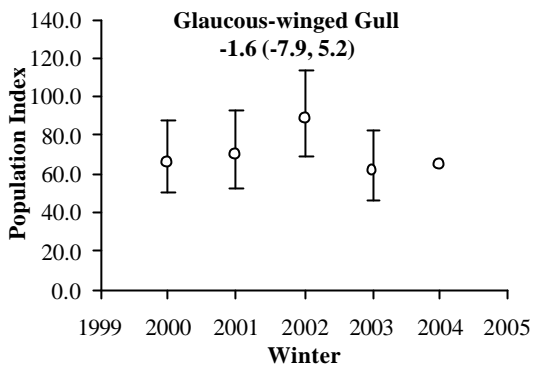
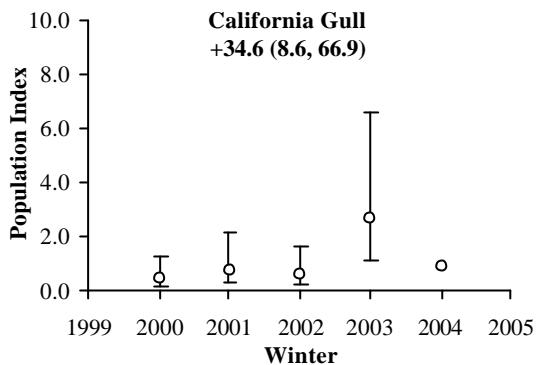


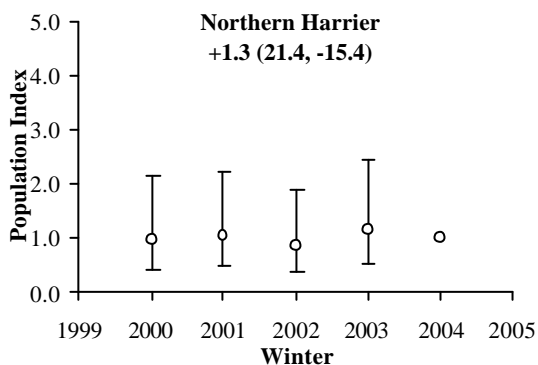
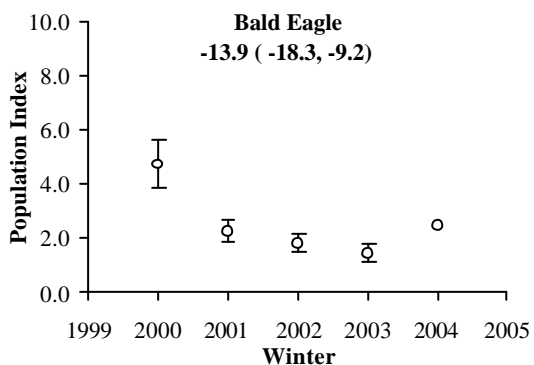
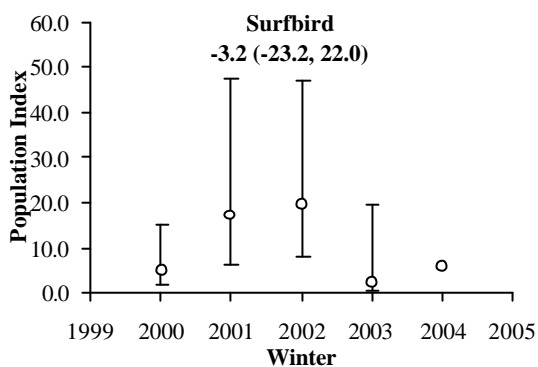
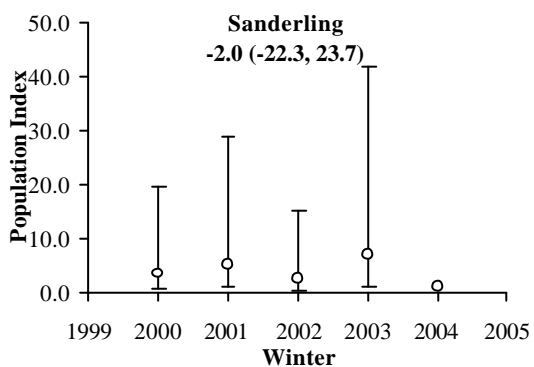
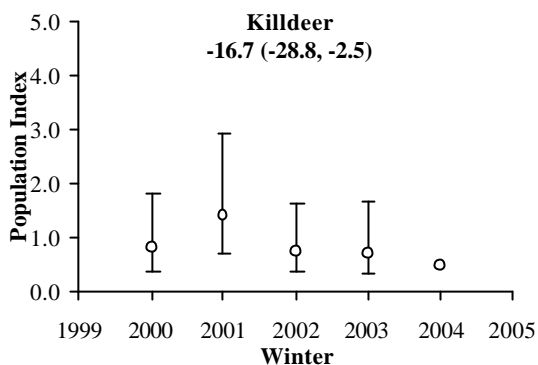
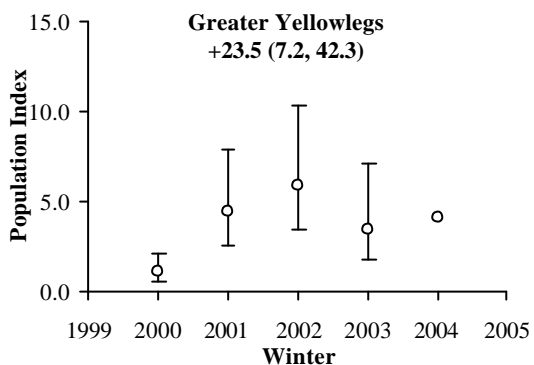
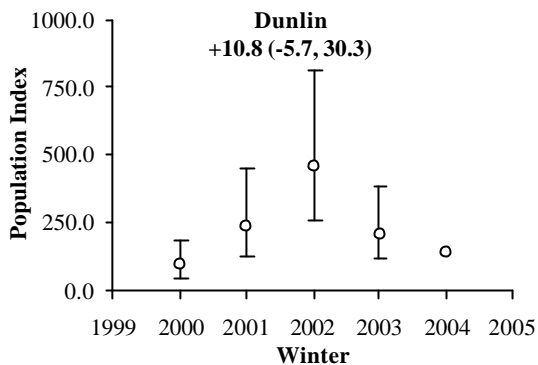
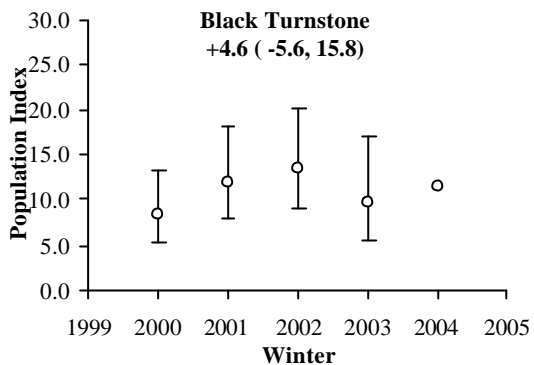


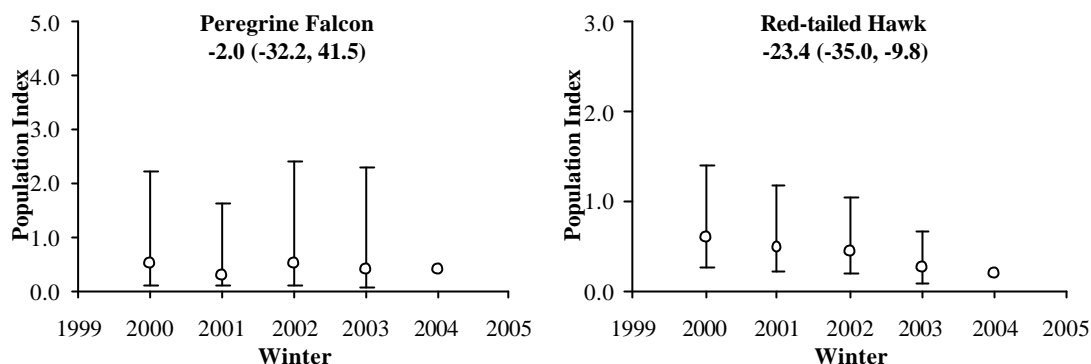












Conclusions

These trends are based on only five years of data and should be interpreted with caution. Five years is a very short period and as waterbird populations can fluctuate widely (Wilkins and Otto 2003), the trends based on this short period may not reflect the overall population status for a particular species. For example, BCCWS data show a significant increase in Western Grebes although they have declined by 90 to 95 percent over the last 30 years. In addition, because there are currently so few data points, exclusion of the one high count in winter 2003 would result in a largely stable trend, rather than a positive trend. The protocol is also designed to monitor populations of winter residents and does not work well with species that are purely migrants. These migrants tend to move through in large numbers over short periods of time and are detected irregularly on counts that only occur once per month.

The ability of the BCCWS to assess trends and distribution of waterbirds is related to how sites are selected and whether they are representative of a spatial scale larger than that of a 1-km section of shoreline. Ideally, sites would be selected at random, stratified by habitat (or by some other important strata), and have adequate spatial replication at the geographic scale(s) of interest. Doing this would improve the ability to generalize and draw inferences and extrapolate site level information to larger spatial scales, especially if data were available on habitat availability. However, given that much of the BC coastline is not easily accessible to volunteers, this type of sampling scheme is not realistic.

With these caveats in mind, for summarizing waterbird trends the 58 species of interest can be divided into 9 species groups: waterfowl, cormorants, herons, loons, grebes, seabirds, gulls,

shorebirds, and raptors. There appear to be no obvious general patterns for any particular group of waterbirds monitored in the BCCWS survey. Almost every group contains both species that show increasing trends and species that show decreasing trends (Appendix 7). For each species group, the following paragraphs summarize the numbers of species with increasing or decreasing trends. Numbers of species without significant trends are not listed.

Over the 26 species of waterfowl covered in this report, 5 species show a decreasing trend and 5 species show an increasing trend. Within the group of waterfowl, seaducks in particular have generated considerable interest because of large declines of Scoters and Long-tailed ducks over the last 30 years (Anon 1999). BCCWS data show a decreasing trend for three seaduck species (Barrow's Goldeneye, Greater Scaup, and Long-tailed Duck), and an increasing trend for only one species (Bufflehead).

Data for two of three species of cormorants show increasing trends (Double-crested Cormorant, Pelagic Cormorant). Both these species have shown significant declines in numbers at breeding colonies on the British Columbia coast between 1980 and 2000, so the results from this survey may indicate a stabilizing trend but further monitoring is clearly needed. Brandt's Cormorants, which occur primarily as a non breeding species, show no clear population trend over the past 5 years.

The only heron covered in the report, the Great Blue Heron, shows an increasing trend, and data for only one of 3 species of loons show an increasing trend (Pacific Loon). Out of the 3 species of grebes covered in the report, data for the Red-necked Grebe show a downward trend and data for the Western Grebe show an increasing trend. One of 3 species of alcids shows a decreasing trend (Common Murre). Within the 7 species of gulls, data for two species show an increasing trend (California Gull, Mew Gull) while data for Ring-billed Gulls show a downward trend. Of the 8 species of shorebird in the report, data for Greater Yellowlegs show an increasing trend while data for Killdeer show a decreasing trend. Data for two of 4 species of raptors show downward trends (Bald Eagle, Red-tailed Hawk).

It is difficult to speculate on the causes of each of these trends. Some of the species have been known to be declining before the survey began (e.g. Pelagic and Double-crested Cormorants, Western Grebes) and the increasing trends generated by this survey may indicate a stabilization in those populations. The data for Great Blue Heron is similar; this species has shown a steady decline from 1975 to 2000 based on Christmas Bird Count (CBC) data but a

distinct increase in the last five years, similar to data from this study. Similarly, the decline noted in Bald Eagle numbers was initially surprising since wintering numbers of this species have been dramatically increasing in British Columbia since 1970 based on CBC data. However, CBC data over the past year show a short-term decrease, perhaps suggesting that numbers of wintering eagles are stabilizing.

The species distribution maps draw attention to two high bird use areas: the Fraser Delta, including Boundary Bay and Roberts Bank; and the east coast of Vancouver Island from Nanoose Bay north to the Comox estuary. These areas are under significant pressure from increasing residential and industrial development. Similarly, Rose Spit at the northeastern tip of the Queen Charlotte Islands has produced some spectacular waterbird concentrations, including high counts in this survey for Sanderling and Common Murre. Rose Spit is a candidate site for a major wind power generating project. The results from waterbird surveys from these sites will be closely watched over the next few years as the British Columbia Coastal Waterbird Survey continues to provide valuable data for biologists and planners.

Acknowledgements

Bird Studies Canada would first like to thank all the skilled and enthusiastic volunteers who have contributed the data for this report. We are especially grateful to those surveyors who have made a commitment to long term data collection and thus have provided extremely valuable information on waterbird trends (see Appendix 1 for volunteer names and years of service). We would like to thank Robert Butler of the Canadian Wildlife Service for editorial comments on this manuscript. Funding for the writing of the report was provided by Environment Canada through the Georgia Basin Action Plan. Additional program funding was provided by Environment Canada through the Canadian Wildlife Service, by Ducks Unlimited and by the British Columbia Field Ornithologists.

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Appendix 1. Volunteer surveyors' years of service.

	5 years	4 years	3 years	2 years	1 year	New surveyors	
David Allinson	Hue & Jo Ann	Dave Aldcroft	Jean Allen	Chris Bibby	Sylvian Abduraman	David Lumley	Michelle Butler
Gladys & Jerry Anderson	MacKenzie John & Lois MacKenzie	Jlonka Bally-Brown Barb Beasley	Jenny Balke Ron Beal	Jim Bodkin Liz Bredberg	Liz & Roland Bamford	Carolyn MacDonald Alan MacLeod	Neil & Patricia Boyle
Steve Baillie	May Mackenzie	Susan Bell	Lyn Carmichael	Sheila Calvert	Alice & Bob Bandoni	Ann Macintosh	Maggie Cumming
Donna Baker	Frances & Torbin	Maija Bismanis	Joan Cartwright	Steve & Hazel	George Bangham	Joe Mater	Rian Dickson
Ron Barre	Madsen	Carol Davies	Ed Dahl	Cannings	Gene Barker	Golo Maurer	Graeme Dinsdale
Lonny & Geoff Bate	Diana Maloff	Janice Brown	Michael Dunn	Alice Cassidy	Jur & Rina Bekker	Zoe McDonell	Tannis Falkenberg
Margaret	Jeanette Martinolich	Lynda Colbeck	Bob Dyer	Peter Clarkson	Monica Belko	Mike McGrenere	Dave Fraser
Beswetherick	Derrick Marven	Liz Fitch	Chris Ferris	Thomas & Evelyn Constable	Kevin Bell	Marilyn Miller	Bryan Gates
Jan Bevan	Yvonne Maximchuk	Jeremy Gatten	Jennifer & John Fletcher	Fred Cooke	Mary & Ted Bentley	Art Morgon	Janet Gifford-Brown
Don Blood	Tiu McCormick	Jim Goodman	Larry Golden	Sue Couch	Linda Bernard	Marilyn & Ashton Mullan	Janet Gray Rich Green
Neil Bourne	Margaret McDonnell	David & Pam Helem	Billie Gowans	John Coulson	Borrowman	Jessica Murray	Roy & Shirley Hill
Edna Bowen	Nelson McInnes	Jean Hudson	John Graham	Geoffrey & Karen Cowper	Peter Candido	John Nicholson	Liam Hughes
John Brighton	Jack & Jean McLeod	Bert & Daphne Jervis	John Graham	Lea Haggert	Dannie Carsen	Paul deNiverville	Neil Hughes
Betty Brooks	Anne McNeill	Fran Johnson	Lea Haggert	Joyce Craig	Ele Clarke	Monica Nugent	Len Jellicoe
Bev Bullen	Sandy McRuer	Terri Kerr	Jack Hammonds	Chris Dale	Paul Clemens	Ivan	Jean Juhas
John & Lynda Butterworth	John Mills Glen & Judy Moores	Pat Levitt Monica Mather	John Ireland Allan & Sandra Kokorudz	Chris Dale Daryl Dancer-Wade	Paul Clemens Jim Clelland	Nygaard-Petersen	Deborah Lacroix
Mikell Callahan	Mike Morrell	Patti Moreland	David Lassman	Sue & Paul Fast	Bob Conkey	Phyllis Ogis	Marilyn Lambert
Douglas & Sheila Carrick	Norma Morton Heather & John Neville	Bev O'Sullivan Karin Ristau	Eric LoFröth	Dennis Forsyth Shirley Fyles	John Cooper Sean Cullen	Viveka Ohman Jason Osterhold	April Macleod Michelle Masselink
Bob Chappell	John Newell	Mary Roddick	Allan Milligan	Jeff Gaskin	Warren Drinnan	Bonnie Parks	Lynda Melney
Carole Chambers	Rosemary Nixon	Alan Shatwell	Erik Milton	Jack Hansed	Phillinda Dunne	Carlo Pavan	Bob Morford
John Chandler	G. Allen & Helen Poynter	Ron Speller Ken Walker	Guy Monty Fran Newson	Sherri Hannay Nathan Hentze	Michael Edgell Phil Edgell	Chris Pielou Barry Price	Dianna O'Brien Marian Porter
Trudy Chatwin	Bill Proctor	Chris Weixelbaumer	Wolf Rautenberg	Rob Johnson	Valerie Elliott	Sheila & Doug Rogers	Carol Rennie Dennis Rose
Vi Chungranes	Gareth Pugh	Alan Whitehead	Gloria Read	Pam & Harvey Janszen	Roger Elliott	Rick Schortinghuis	Ruth Rutledge
Paul Colton	Tony & Carol Quin	Jim Wisnia	Murray & Penny Robertson	Krista Kaptein Gail & Rex Kenner	Barry Gatten Calvin Gehlen	Grant Scott	Faith Takishita
Marian Coope	Ilze Raudzins	Janet Russwurm	Janet Russwurm	Jan Kirkby	Bonny Glambeck	Bob Simons	Joanna Smith
Bruce Cousens	John Rawsthorne	Sheila Ray	Ron Satterfield	Rhonda Korol	Kate Grauer	Joanna Smith	Jodi Sniders
Rela Cripps	Sheila Ray	Geoff Robins	Fred Simpson	Gail Loughridge	Tony Greenfield	Daphne Solecki	Daphne Solecki
John Dove	Neil Robins	Donald Ross	Joan Sommer	Yolanda Morbey	Denise Gubersky	Bonnie Stout	Chris Thompson
Yorke Edwards	Donald Ross	Rand Rudlund	Ken Summers	Jim Phillips	Donald Gunn	Chris Thompson	Peter Thompson
Kyle Elliott	Harriet Rueggeberg	Blake Fougere	Derek Sutton	Russell Prediger	Brent Gurd	Sheila Haggerstone	Peter Thompson
Patrick Fawkes	Harriet Rueggeberg	Pierre Geoffray	Jack & Bev Temp	Wendy Prothero	Keith Riding	Peter Hamel	Valerie Tinney
Kerry Finley	Brian Scott	Betty Goodman	Michael & Marilyn Whipps	Michael & Marilyn Whipps	Bernard & Herbie Rochet	Joann Harrison	Scott Wallace
Blake Fougere	Barbara Sedgwick	Pam Gordon	Julie Wright	Julie Wright	Margo Hearne	John Henigman	Alison Watt
Pierre Geoffray	Ed & Thelma Silkens	Barbara & Bob Graves	Brian Slater	Brian Slater	John Henigman	Audrey Henry	Sandra Webster
Betty Goodman	Bernie & Bernie Spitmann	Liz Hammond- Kaarremaa	Spitmann	June Ryder	Audrey Henry	C.P. Ilsley	Greg Weller
Pam Gordon	Al Storey	Barbara & Bob Graves	Al Storey	Bernard Schroeder	C.P. Ilsley	Dave Ingram	Marja deJong Westman
Barbara & Bob Graves	Doreen Tamboline	Liz Hammond- Kaarremaa	Doreen Tamboline	Derek Shaw	Dave Ingram	Doug & Marian	Bruce Whittington
Liz Hammond- Kaarremaa	Russ Tkachuk	Vicki Hansen	Russ Tkachuk	Arnold Skei	Doug & Marian	Innes	Robin Whittington
Vicki Hansen	Tauno & Cathy Tuominen	Heather Harbord	Tauno & Cathy Tuominen	Dave Spalding	Innes	Bob Johnson	Christine Woolcott
Heather Harbord	Audrey Viken	Amanda Heath	Audrey Viken	Jan Steen	Bob Johnson	Daryl Johnson	Daryl Johnson
Amanda Heath	Sally Wait	Bill Heidrick	Sally Wait	Dave Stirling	Daryl Johnson	Susan Jones	Susan Jones
Bill Heidrick	Sue Wheeler	Bill Heybroek	Sue Wheeler	Rosemary Talbot	Susan Jones	Trevor Jones	Trevor Jones
Bill Heybroek	Ken Wright	Frank Hovenden	Ken Wright	Marti Tilley	Trevor Jones	Christina Kereki	Christina Kereki
Frank Hovenden	Arlene Yaworsky	Dale Jenson	Arlene Yaworsky	Rick Toochin	Christina Kereki	Bill Kinkaid	Bill Kinkaid
Dale Jenson	Ann Zielinski	Paul Jones	Ann Zielinski	Hank Vanderpol	Bill Kinkaid	Andrew Lang	Andrew Lang
Paul Jones		Ruth Keogh		Judith & Rozi Walmsley	Andrew Lang	Reina LeBaron	Reina LeBaron
Ruth Keogh		Anne Knowles		Alice Whiting	Reina LeBaron	Will Lemmon	Will Lemmon
Anne Knowles		Charlene Lee		Diane Webster	Will Lemmon	Dan Lewis	Dan Lewis
Charlene Lee		Bev Lownie		Willi Wilson	Dan Lewis	Terry Ludwar	Terry Ludwar
Bev Lownie		Betty & Jim Lunam		Jean Woodley	Terry Ludwar		
Betty & Jim Lunam				Colin & Georgene Wykes			

Appendix 2. Species-specific survey windows used in power and trend analyses for the British Columbia Coastal Waterbird Survey.

Group/species	Survey months							
	Sept- ember	Oct- ober	Nov- ember	Dec- ember	Jan- uary	Feb- ruary	March	April
Waterfowl								
American Wigeon				X	X	X		
Barrow's Goldeneye				X	X	X		
Black Scoter				X	X	X		
Brant						X	X	X
Bufflehead				X	X	X		
Canada Goose				X	X	X		
Canvasback				X	X	X		
Common Goldeneye				X	X	X		
Common Merganser				X	X	X		
Eurasian Wigeon				X	X	X		
Gadwall				X	X	X		
Greater Scaup							X	X
Green-winged Teal				X	X	X		
Harlequin Duck				X	X	X		
Hooded Merganser				X	X	X		
Lesser Scaup				X	X	X		
Long-tailed Duck				X	X	X		
Mallard				X	X	X		
Mute Swan				X	X	X		
Northern Pintail				X	X	X		
Red-breasted Merganser				X	X	X		
Ring-necked Duck				X	X	X		
Snow Goose		X	X					
Surf Scoter				X	X	X		
Trumpeter Swan				X	X	X		
White-winged Scoter				X	X	X		

Appendix 2. Continued.

Group/species	Survey months						March	April
	Sept- ember	Oct- ober	Nov- ember	Dec- ember	Jan- uary	Feb- ruary		
Cormorants								
Brandt's Cormorant	x	x						
Double-crested Cormorant				x	x	x		
Pelagic Cormorant				x	x	x		
Hérons								
Great Blue Heron				x	x	x		
Loons								
Common Loon				x	x	x		
Pacific Loon				x	x	x		
Red-throated Loon				x	x	x		
Grebes								
Horned Grebe				x	x	x		
Red-necked Grebe				x	x	x		
Western Grebe				x	x	x		
Seabirds								
Common Murre				x	x	x		
Marbled Murrelet				x	x			
Pigeon Guillemot				x	x	x		
Gulls								
Bonaparte's Gull							x	x
California Gull				x	x	x		
Glaucous-winged Gull				x	x	x		
Herring Gull				x	x	x		
Mew Gull		x	x	x	x			
Ring-billed Gull	x							
Thayer's Gull				x	x	x		

Appendix 2. Continued.

Group/species	Survey months						March	April
	Sept- ember	Oct- ober	Nov- ember	Dec- ember	Jan- uary	Feb- ruary		
Shorebirds								
Black-bellied Plover			x	x	x			
Black Oystercatcher			x	x	x			
Black Turnstone			x	x				
Dunlin			x	x	x			
Greater Yellowlegs								x
Killdeer			x	x	x			
Sanderling			x	x	x			
Surfbird			x	x	x			
Raptors								
Bald Eagle		x	x	x				
Northern Harrier			x	x	x			
Peregrine Falcon			x	x	x			
Red-tailed Hawk			x	x	x			

Appendix 3. Comparisons of percent annual change able to be detected by surveying 200 BCCWS sites after 10 year-intervals (11 years) using mean counts of individual over survey windows and maximum count of individuals over survey windows as input data for power and trend analyses.

Group/species	Site-pairs	Percent (%) annual change		
		detectable using:		Difference (%)
		Mean count	Max count	(Mean – Max)
Waterfowl				
American Wigeon	231	3.1	3.3	-0.2
Barrow's Goldeneye	178	3.5	4.3	-0.8
Black Scoter	134	5.5	5.9	-0.4
Brant	57	9.3	9.7	-0.4
Bufflehead	308	1.9	2.1	-0.2
Canada Goose	208	4.2	4.3	-0.1
Common Goldeneye	251	2.7	3.0	-0.4
Common Merganser	239	3.2	3.6	-0.4
Eurasian Wigeon	72	7.5	8.2	-0.6
Gadwall	25	8.1	7.9	0.2
Greater Scaup	99	8.0	8.1	-0.1
Green-winged Teal	87	5.0	5.4	-0.5
Harlequin Duck	183	2.4	2.8	-0.4
Hooded Merganser	155	3.9	4.1	-0.2
Lesser Scaup	59	7.3	8.0	-0.7
Long-tailed Duck	109	4.8	4.8	0.0
Mallard	279	2.3	2.6	-0.3
Northern Pintail	84	4.5	5.0	-0.5
Red-breasted Merganser	226	3.3	3.7	-0.4
Surf Scoter	225	3.8	3.9	-0.1
Trumpeter Swan	78	6.2	6.8	-0.6
White-winged Scoter	148	3.4	3.6	-0.2

Appendix 3. Continued.

Group/species	Site-pairs	Percent (%) annual change		Difference (%) (Mean – Max)
		Mean count	Max count	
Cormorants				
Brandt's Cormorant	26	8.6	9.4	-0.9
Double-crested Cormorant	262	2.6	2.8	-0.2
Pelagic Cormorant	202	3.5	3.7	-0.3
Hérons				
Great Blue Heron	250	2.9	3.2	-0.3
Loons				
Common Loon	236	2.4	2.8	-0.4
Pacific Loon	169	5.6	6.1	-0.4
Red-throated Loon	107	6.0	6.2	-0.2
Grebes				
Horned Grebe	226	2.8	3.2	-0.4
Red-necked Grebe	157	3.7	4.0	-0.3
Western Grebe	137	6.3	6.6	-0.3
Seabirds				
Common Murre	62	7.4	7.2	0.3
Marbled Murrelet	48	10.2	10.9	-0.7
Pigeon Guillemot	62	8.0	8.5	-0.5
Gulls				
Bonaparte's Gull	86	11.4	11.5	-0.1
California Gull	58	10.8	11.9	-1.1
Glaucous-winged Gull	309	3.4	3.6	-0.2
Herring Gull	81	9.1	8.5	0.6
Mew Gull	173	3.3	3.7	-0.4
Ring-billed Gull	43	7.2	7.2	0.0
Thayer's Gull	133	5.3	5.5	-0.2

Appendix 3. Continued.

Group/species	Site-pairs	Percent (%) annual change		
		Mean count	Max count	Difference (%) (Mean – Max)
Shorebirds				
Black-bellied Plover	59	8.8	9.0	-0.2
Black Oystercatcher	119	5.7	6.0	-0.3
Black Turnstone	120	6.9	7.0	-0.1
Dunlin	84	6.8	7.5	-0.7
Greater Yellowlegs	73	9.4	9.4	0.0
Killdeer	85	7.9	8.0	-0.1
Sanderling	29	11.4	10.9	0.5
Surfbird	37	13.0	12.8	0.1
Raptors				
Bald Eagle	263	2.7	3.0	-0.3
Red-tailed Hawk	76	8.6	8.6	0.0

Appendix 4. Number of sites (detecting at least one individual of a species during each pair of winters) used to calculate per-site and overall (weighted) variance estimates for species-specific power analyses for the BCCWS.

Group/species	Winter pairs / number of sites				Total sites
	2000/01	2001/02	2002/03	2003/04	
Waterfowl					
American Wigeon	45	50	50	41	186
Barrow's Goldeneye	43	54	47	34	178
Black Scoter	36	38	37	23	134
Brant	15	14	13	15	57
Bufflehead	75	86	83	64	308
Canada Goose	51	62	52	43	208
Canvasback	4	5	5	2	16
Common Goldeneye	66	67	65	53	251
Common Merganser	58	71	60	50	239
Eurasian Wigeon	17	19	14	14	64
Gadwall	8	8	5	4	25
Greater Scaup	27	22	21	29	99
Green-winged Teal	24	20	22	21	87
Harlequin Duck	47	52	48	36	183
Hooded Merganser	37	48	41	29	155
Lesser Scaup	11	15	17	16	59
Long-tailed Duck	30	30	28	21	109
Mallard	69	78	72	60	279
Mute Swan	3	3	4	4	14
Northern Pintail	22	24	18	20	84
Red-breasted Merganser	58	64	59	45	226
Ring-necked Duck	3	2			5
Snow Goose		6	5	4	15
Surf Scoter	60	63	58	44	225
Trumpeter Swan	20	24	19	15	78
White-winged Scoter	44	42	36	26	148

Appendix 4. Continued.

Group/species	Winter pairs / number of sites				Total sites
	2000/01	2001/02	2002/03	2003/04	
Cormorants					
Brandt's Cormorant		10	7	9	26
Double-crested Cormorant	55	77	74	56	262
Pelagic Cormorant	50	56	54	42	202
Hérons					
Great Blue Heron	46	52	53	40	191
Loons					
Common Loon	62	68	61	45	236
Pacific Loon	40	51	44	34	169
Red-throated Loon	25	27	31	24	107
Grebes					
Horned Grebe	63	66	55	42	226
Red-necked Grebe	49	41	40	27	157
Western Grebe	38	40	36	23	137
Seabirds					
Common Murre	20	17	12	13	62
Marbled Murrelet	13	16	12	7	48
Pigeon Guillemot	15	15	19	13	62
Gulls					
Bonaparte's Gull	24	23	19	20	86
California Gull	15	17	15	11	58
Glaucous-winged Gull	53	62	63	50	228
Herring Gull	18	15	15	13	61
Mew Gull	16	65	47	45	173
Ring-billed Gull	2	20	10	11	43
Thayer's Gull	39	34	32	28	133

Appendix 4. Continued.

Group/species	Winter pairs / number of sites				Total sites
	2000/01	2001/02	2002/03	2003/04	
Shorebirds					
Black-bellied Plover	14	18	14	13	59
Black Oystercatcher	25	37	33	24	119
Black Turnstone	33	34	29	24	120
Dunlin	27	21	20	16	84
Greater Yellowlegs	20	19	16	18	73
Killdeer	22	24	20	19	85
Sanderling	9	10	5	3	27
Surfbird	9	14	7	7	37
Raptors					
Bald Eagle	44	85	69	65	263
Northern Harrier	7	7	6	6	26
Peregrine Falcon	8	2	3	3	16
Red-tailed Hawk	27	23	17	9	76

Appendix 5. Number of BCCWS sites included in trend analyses during each winter of the British Columbia Coastal Waterbird Survey.

Group/species	Number of sites				
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Waterfowl					
American Wigeon	63	75	83	63	65
Barrow's Goldeneye	73	81	92	61	64
Black Scoter	53	56	59	43	43
Brant	29	26	29	25	31
Bufflehead	100	114	125	90	96
Canada Goose	78	89	97	70	74
Canvasback	10	10	10	8	7
Common Goldeneye	95	104	114	80	87
Common Merganser	84	98	107	76	83
Eurasian Wigeon	30	32	30	22	24
Gadwall	12	14	13	13	11
Greater Scaup	51	50	46	40	49
Green-winged Teal	35	39	44	33	39
Harlequin Duck	62	68	76	53	57
Hooded Merganser	60	74	81	56	58
Lesser Scaup	25	27	34	26	26
Long-tailed Duck	45	48	50	36	33
Mallard	92	108	114	82	93
Mute Swan	8	6	10	7	4
Red-breasted Merganser	76	91	94	70	77
Ring-necked Duck	13	11	13	11	6
Northern Pintail	33	36	40	30	31
Surf Scoter	84	92	100	68	70
Snow Goose	2	12	10	9	9
Trumpeter Swan	31	34	37	27	27
White-winged Scoter	64	68	69	45	50

Appendix 5. Continued.

Group/species	Number of sites				
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Cormorants					
Brandt's Cormorant		19	16	14	17
Double-crested Cormorant	88	104	117	83	89
Pelagic Cormorant	76	83	92	63	73
Hérons					
Great Blue Heron	70	82	91	71	71
Loons					
Common Loon	82	93	98	70	75
Pacific Loon	65	76	81	55	59
Red-throated Loon	47	48	54	41	41
Grebes					
Horned Grebe	89	96	108	72	80
Red-necked Grebe	66	72	77	55	60
Western Grebe	62	66	66	47	57
Seabirds					
Common Murre	31	34	37	24	25
Marbled Murrelet	18	26	24	16	18
Pigeon Guillemot	29	28	33	24	27
Gulls					
Bonaparte's Gull	37	35	38	31	38
California Gull	33	31	41	28	28
Glaucous-winged Gull	76	86	101	74	75
Herring Gull	43	48	49	38	38
Mew Gull	17	82	84	61	73
Ring-billed Gull	2	30	27	20	27
Thayer's Gull	63	63	71	51	51

Appendix 5. Continued.

Group/species	Number of sites				
	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Shorebirds					
Black-bellied Plover	21	24	30	20	21
Black Oystercatcher	41	52	57	42	46
Black Turnstone	47	53	58	41	51
Dunlin	38	39	40	30	32
Greater Yellowlegs	36	34	31	30	32
Killdeer	40	44	46	33	38
Sanderling	15	16	16	9	11
Surfbird	18	19	24	16	19
Raptors					
Bald Eagle	56	114	115	86	102
Northern Harrier	15	13	16	13	12
Peregrine Falcon	11	10	9	5	7
Red-tailed Hawk	42	39	41	33	32

Appendix 6. Number of sites monitored, number of sites that had at least one individual of a species present, total number of site-winters, and number of site-winters with species present for the BCCWS.

Group/species	Sites		Site-winters	
	Total	Species present	Total	Species present
Waterfowl				
American Wigeon	166	110	553	349
Barrow's Goldeneye	166	113	553	371
Black Scoter	166	74	553	254
Brant	155	38	525	140
Bufflehead	166	156	553	525
Canada Goose	166	116	553	408
Canvasback	166	15	533	45
Common Goldeneye	166	146	553	480
Common Merganser	166	134	553	448
Eurasian Wigeon	166	44	553	138
Gadwall	166	20	553	63
Greater Scaup	170	64	584	236
Green-winged Teal	166	57	553	190
Harlequin Duck	166	94	553	316
Hooded Merganser	166	99	553	329
Lesser Scaup	166	39	553	138
Long-tailed Duck	166	64	553	212
Mallard	166	144	553	489
Mute Swan	166	13	553	35
Red-breasted Merganser	166	121	553	408
Ring-necked Duck	166	16	553	54
Northern Pintail	166	50	553	170
Snow Goose	150	14	481	42
Surf Scoter	166	127	553	414
Trumpeter Swan	166	45	553	156
White-winged Scoter	166	91	553	296

Appendix 6. Continued.

Group/species	Sites		Site-winters	
	Total	Species present	Total	Species present
Cormorants				
Brandt's Cormorant	125	22	383	66
Double-crested Cormorant	166	144	553	481
Pelagic Cormorant	166	116	553	387
Hérons				
Great Blue Heron	166	120	553	385
Loons				
Common Loon	166	128	553	418
Pacific Loon	166	101	553	336
Red-throated Loon	166	67	553	231
Grebes				
Horned Grebe	166	132	553	445
Red-necked Grebe	166	100	553	330
Western Grebe	166	87	553	298
Seabirds				
Common Murre	166	47	553	151
Marbled Murrelet	181	32	620	102
Pigeon Guillemot	166	42	553	141
Gulls				
Bonaparte's Gull	170	49	584	179
California Gull	166	48	553	161
Glaucous-winged Gull	166	130	553	412
Herring Gull	166	54	553	174
Mew Gull	125	103	382	317
Ring-billed Gull	134	35	424	106
Thayer's Gull	166	86	553	299

Appendix 6. Continued.

Group/species	Sites		Site-winters	
	Total	Species present	Total	Species present
Shorebirds				
Black-bellied Plover	166	33	553	116
Black Oystercatcher	166	72	553	238
Black Turnstone	181	71	620	250
Dunlin	166	53	553	179
Greater Yellowlegs	184	40	667	163
Killdeer	166	56	553	201
Sanderling	166	21	553	67
Surfbird	166	27	553	96
Raptors				
Bald Eagle	156	146	498	473
Northern Harrier	166	16	553	56
Peregrine Falcon	166	14	533	42
Red-tailed Hawk	166	50	553	187

Appendix 7. Estimated linear rate of change (% / winter) in abundances of birds counted at BCCWS sites from winter 1999/2000 to 2003/2004.

Group/species	Rate (% / winter)	Upper 95% CL	Lower 95% CL	<i>P</i> ^a
Waterfowl				
American Wigeon	13.5	20.9	6.6	< 0.0001
Barrow's Goldeneye	-6.9	-0.5	-12.9	0.0275
Black Scoter	-8.2	2.3	-17.6	0.1038
Brant	-36.3	-24.8	-46.1	< 0.0001
Bufflehead	5.5	9.1	2.1	0.0008
Canada Goose	3.1	10.7	-4.0	0.4025
Canvasback	-16.2	-28.5	-1.8	0.0166
Common Goldeneye	1.3	6.0	-3.2	0.5686
Common Merganser	-0.1	5.6	-5.4	0.9730
Eurasian Wigeon	24.0	41.4	8.7	0.0010
Gadwall	47.3	91.3	13.5	0.0007
Greater Scaup	-18.3	-5.7	-29.3	0.0065
Hooded Merganser	-6.5	0.9	-13.3	0.0819
Green-winged Teal	-8.1	3.5	-18.4	0.0845
Harlequin Duck	-2.9	1.3	-6.8	0.1728
Lesser Scaup	5.4	15.6	-4.0	0.2249
Long-tailed Duck	-19.4	-12.0	-26.2	< 0.0001
Mallard	3.2	7.7	-1.2	0.1410
Mute Swan	-9.3	-31.6	20.3	0.4949
Northern Pintail	16.6	28.2	6.1	0.0007
Red-breasted Merganser	4.3	10.9	-1.9	0.1678
Ring-necked Duck	-8.9	-26.0	12.1	0.3717
Snow Goose	3.1	-15.4	25.6	0.7386
Surf Scoter	-3.4	4.5	-10.7	0.3714
Trumpeter Swan	-0.8	12.9	-12.9	0.8992
White-winged Scoter	-0.3	7.1	-7.2	0.9284

Appendix 7. Continued.

Group/species	Rate (% / winter)	Upper 95% CL	Lower 95% CL	<i>P</i>
Cormorants				
Brandt's Cormorant	-12.5%	-31.1	12.9	0.2705
Double-crested Cormorant	18.4	24.2	12.8	< 0.0001
Pelagic Cormorant	12.0	19.1	5.3	0.0003
Hérons				
Great Blue Heron	6.9	13.1	1.0	0.0216
Loons				
Common Loon	-0.1	3.9	-3.9	0.9632
Pacific Loon	22.3	37.0	9.3	0.0002
Red-throated Loon	-4.4	7.2	-14.8	0.4335
Grebes				
Horned Grebe	-0.2	5.1	-5.2	0.9317
Red-necked Grebe	-8.6	-2.8	-14.0	0.0038
Western Grebe	12.7	24.5	2.1	0.0112
Seabirds				
Common Murre	-18.4	-5.4	-29.6	0.0025
Marbled Murrelet	14.1	43.0	-9.0	0.1894
Pigeon Guillemot	-10.5	5.2	-23.8	0.1704
Gulls				
Bonaparte's Gull	11.5	36.1	-8.6	0.2513
California Gull	34.6	66.9	8.6	0.0061
Glaucous-winged Gull	-1.6	5.2	-7.9	0.6316
Herring Gull	-1.2	17.3	-16.8	0.8855
Mew Gull	10.8	18.6	3.6	0.0025
Ring-billed Gull	-15.6	-2.7	-26.8	0.0197
Thayer's Gull	-1.3	9.9	-11.3	0.8054

Appendix 7. Continued.

Group/species	Rate (% / winter)	Upper 95% CL	Lower 95% CL	<i>P</i>
Shorebirds				
Black-bellied Plover	-6.0	6.5	-17.1	0.3203
Black Oystercatcher	0.3	9.8	-8.4	0.9456
Black Turnstone	4.6	15.8	-5.6	0.3901
Dunlin	10.8	30.3	-5.7	0.1372
Greater Yellowlegs	23.5	42.3	7.2	0.0022
Killdeer	-16.7	-2.5	-28.8	0.0216
Sanderling	-2.0	23.7	-22.3	0.8655
Surfbird	-3.2	22.0	-23.2	0.7532
Raptors				
Bald Eagle	-13.9	-9.2	-18.3	< 0.0001
Northern Harrier	1.3	-15.4	21.4	0.8903
Peregrine Falcon	-2.0	41.5	-32.2	0.9162
Red-tailed Hawk	-23.4	-9.8	-35.0	0.0013

^a*P*-values indicate models including the variable “Winter period” fit the data distribution better than models that did not include the variable.

Appendix 8. Complete species list for the BC Coastal Waterbird Survey -1999 to 2004.

Greylag goose (domestic) <i>Anser anser</i>	Pelagic Cormorant <i>Phalacrocorax pelagicus</i>
Greater White-fronted Goose <i>Anser albifrons</i>	American Bittern <i>Botaurus lentiginosus</i>
Snow Goose <i>Chen caerulescens</i>	Great Blue Heron <i>Ardea herodias</i>
Brant <i>Branta bernicla</i>	Great Egret <i>Ardea alba</i>
Canada Goose <i>Branta canadensis</i>	Green Heron <i>Butorides virescens</i>
Mute Swan <i>Cygnus olor</i>	Black-crowned Night-Heron <i>Nycticorax nycticorax</i>
Trumpeter Swan <i>Cygnus buccinator</i>	Turkey Vulture <i>Cathartes aura</i>
Tundra Swan <i>Cygnus columbianus</i>	Osprey <i>Pandion haliaetus</i>
Muscovy Duck (domestic) <i>Cairina moschata</i>	Bald Eagle <i>Haliaeetus leucocephalus</i>
Wood Duck <i>Aix sponsa</i>	Northern Harrier <i>Circus cyaneus</i>
Gadwall <i>Anas strepera</i>	Sharp-shinned Hawk <i>Accipiter striatus</i>
Eurasian Wigeon <i>Anas penelope</i>	Cooper's Hawk <i>Accipiter cooperii</i>
American Wigeon <i>Anas americana</i>	Northern Goshawk <i>Accipiter gentilis</i>
Eurasian X American Wigeon Hybrid	Red-tailed Hawk <i>Buteo jamaicensis</i>
American Black Duck <i>Anas rubripes</i>	Ferruginous Hawk <i>Buteo regalis</i>
Mallard <i>Anas platyrhynchos</i>	Rough-legged Hawk <i>Buteo lagopus</i>
Blue-winged Teal <i>Anas discors</i>	Golden Eagle <i>Aquila chrysaetos</i>
Cinnamon Teal <i>Anas cyanoptera</i>	American Kestrel <i>Falco sparverius</i>
Northern Shoveler <i>Anas clypeata</i>	Merlin <i>Falco columbarius</i>
Northern Pintail <i>Anas acuta</i>	Gyr Falcon <i>Falco rusticolus</i>
Green-winged Teal <i>Anas crecca</i>	Peregrine Falcon <i>Falco peregrinus</i>
Green-winged (Eurasian) Teal	Virginia Rail <i>Rallus limicola</i>
Canvasback <i>Aythya valisineria</i>	Sora <i>Porzana carolina</i>
Redhead <i>Aythya americana</i>	American Coot <i>Fulica americana</i>
Ring-necked Duck <i>Aythya collaris</i>	Sandhill Crane <i>Grus canadensis</i>
Greater Scaup <i>Aythya marila</i>	Black-bellied Plover <i>Pluvialis squatarola</i>
Lesser Scaup <i>Aythya affinis</i>	American Golden-Plover <i>Pluvialis dominica</i>
King Eider <i>Somateria spectabilis</i>	Pacific Golden-Plover <i>Pluvialis fulva</i>
Harlequin Duck <i>Histrionicus histrionicus</i>	Semipalmated Plover <i>Charadrius semipalmatus</i>
Surf Scoter <i>Melanitta perspicillata</i>	Killdeer <i>Charadrius vociferus</i>
White-winged Scoter <i>Melanitta fusca</i>	Black Oystercatcher <i>Haematopus bachmani</i>
Black Scoter <i>Melanitta nigra</i>	American Avocet <i>Recurvirostra americana</i>
Long-tailed Duck <i>Clangula hyemalis</i>	Greater Yellowlegs <i>Tringa melanoleuca</i>
Bufflehead <i>Bucephala albeola</i>	Lesser Yellowlegs <i>Tringa flavipes</i>
Common Goldeneye <i>Bucephala clangula</i>	Solitary Sandpiper <i>Tringa solitaria</i>
Barrow's Goldeneye <i>Bucephala islandica</i>	Willet <i>Catoptrophorus semipalmatus</i>
Hooded Merganser <i>Lophodytes cucullatus</i>	Wandering Tattler <i>Heteroscelus incanus</i>
Common Merganser <i>Mergus merganser</i>	Spotted Sandpiper <i>Actitis macularius</i>
Red-breasted Merganser <i>Mergus serrator</i>	Whimbrel <i>Numenius phaeopus</i>
Ruddy Duck <i>Oxyura jamaicensis</i>	Long-billed Curlew <i>Numenius americanus</i>
Red-throated Loon <i>Gavia stellata</i>	Hudsonian Godwit <i>Limosa haemastica</i>
Pacific Loon <i>Gavia pacifica</i>	Marbled Godwit <i>Limosa fedoa</i>
Common Loon <i>Gavia immer</i>	Ruddy Turnstone <i>Arenaria interpres</i>
Yellow-billed Loon <i>Gavia adamsii</i>	Black Turnstone <i>Arenaria melanocephala</i>
Pied-billed Grebe <i>Podilymbus podiceps</i>	Surfbird <i>Aphriza virgata</i>
Horned Grebe <i>Podiceps auritus</i>	Red Knot <i>Calidris canutus</i>
Red-necked Grebe <i>Podiceps grisegena</i>	Sanderling <i>Calidris alba</i>
Eared Grebe <i>Podiceps nigricollis</i>	Semipalmated Sandpiper <i>Calidris pusilla</i>
Western Grebe <i>Aechmophorus occidentalis</i>	Western Sandpiper <i>Calidris mauri</i>
Clark's Grebe <i>Aechmophorus clarkii</i>	Red-necked Stint <i>Calidris ruficollis</i>
Black-footed Albatross <i>Phoebastria nigripes</i>	Least Sandpiper <i>Calidris minutilla</i>
Northern Fulmar <i>Fulmarus glacialis</i>	Baird's Sandpiper <i>Calidris bairdii</i>
Sooty Shearwater <i>Puffinus griseus</i>	Pectoral Sandpiper <i>Calidris melanotos</i>
Short-tailed Shearwater <i>Puffinus tenuirostris</i>	Sharp-tailed Sandpiper <i>Calidris acuminata</i>
Brandt's Cormorant <i>Phalacrocorax penicillatus</i>	Rock Sandpiper <i>Calidris ptilocnemis</i>
Double-crested Cormorant <i>Phalacrocorax auritus</i>	Dunlin <i>Calidris alpina</i>

Appendix 8 Continued.

Stilt Sandpiper <i>Calidris himantopus</i>	Glaucous-winged X Western Gull Hybrid
Short-billed Dowitcher <i>Limnodromus griseus</i>	Glaucous Gull <i>Larus hyperboreus</i>
Long-billed Dowitcher <i>Limnodromus scolopaceus</i>	Great Black-backed Gull <i>Larus marinus</i>
Wilson's Snipe <i>Gallinago delicata</i>	Black-legged Kittiwake <i>Rissa tridactyla</i>
Red-necked Phalarope <i>Phalaropus lobatus</i>	Caspian Tern <i>Sterna caspia</i>
Red Phalarope <i>Phalaropus fulicarius</i>	Common Tern <i>Sterna hirundo</i>
Pomarine Jaeger <i>Stercorarius pomarinus</i>	Black Tern <i>Chlidonias niger</i>
Parasitic Jaeger <i>Stercorarius parastiticus</i>	Common Murre <i>Uria aalge</i>
Franklin's Gull <i>Larus pipixcan</i>	Pigeon Guillemot <i>Cepphus columba</i>
Little Gull <i>Larus minutus</i>	Marbled Murrelet <i>Brachyramphus marmoratus</i>
Black-headed Gull <i>Larus ridibundus</i>	Ancient Murrelet <i>Synthliboramphus antiquus</i>
Bonaparte's Gull <i>Larus philadelphia</i>	Cassin's Auklet <i>Ptychoramphus aleuticus</i>
Heermann's Gull <i>Larus heermanni</i>	Rhinoceros Auklet <i>Cerorhinca monocerata</i>
Mew Gull <i>Larus canus</i>	Great Horned Owl <i>Bubo virginianus</i>
Ring-billed Gull <i>Larus delawarensis</i>	Snowy Owl <i>Bubo scandiacus</i>
California Gull <i>Larus californicus</i>	Barred Owl <i>Strix varia</i>
Herring Gull <i>Larus argentatus</i>	Long-eared Owl <i>Asio otus</i>
Thayer's Gull <i>Larus thayeri</i>	Short-eared Owl <i>Asio flammeus</i>
Iceland Gull <i>Larus glaucoides</i>	Northern Saw-whet Owl <i>Aegolius acadicus</i>
Slaty-backed Gull <i>Larus schistisagus</i>	Belted Kingfisher <i>Ceryle alcyon</i>
Western Gull <i>Larus occidentalis</i>	Northwestern Crow <i>Corvus caurinus</i>
Glaucous-winged Gull <i>Larus glaucescens</i>	Common Raven <i>Corvus corax</i>
	American Dipper <i>Cinclus mexicanus</i>