The British Columbia Coastal Waterbird Survey: An Evaluation of Survey Power and Species Trends After Five Years of Monitoring

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ABSTRACT

The coastal habitats of British Columbia support some of the highest densities of seabirds, waterfowl and shorebirds in the eastern North Pacific. Globally significant wintering and migratory populations of waterfowl and shorebirds use the region's productive estuarine, tidal flat, rocky and sandy shoreline and inshore aquatic habitats. Birds and their habitats in British Columbia are subject to a wide range of anthropogenic influences including recreation, industrial and residential development, and increasing shipping traffic. Several internationally recognized Important Bird Areas are immediately adjacent to major population centers, and are thus vulnerable to disturbance, habitat loss and alteration, toxic effluent discharge and chronic oil pollution. This proximity and the interaction between waterbirds and humans highlighted the need for a long-term waterbird population monitoring program, particularly one that could assess impacts of natural and human-induced environmental change. The British Columbia Coastal Waterbird Survey (BCCWS) was established in 1999 to meet this need.

The BCCWS is a volunteer-based survey administered by Bird Studies Canada (BSC) with support from the Canadian Wildlife Service (CWS), and focuses on monitoring the bird populations in and around the Strait of Georgia. CWS and BSC agreed to undertake a formal evaluation of the ability of the BCCWS to fulfil its major monitoring objectives after 5 years of data collection. The primary objectives of the survey are: 1) to assess the size of non-breeding waterbird populations in coastal areas of British Columbia, particularly those within the Georgia Basin, 2) to assess trends in numbers and distribution of coastal waterbirds, 3) to assess and monitor the importance of individual sites for waterbirds, and 4) to improve understanding of the ecology of waterbirds, including responses to natural and anthropogenic change (e.g. habitat alteration). During the first five winter survey seasons (1999/2000 to 2003/2004), over 6,300 surveys were conducted at 260 survey sites. This is an adequate dataset from which to conduct preliminary assessments of survey power, species abundance trends, and small- and large-scale geographic distributions of species.

This report provides an overview of the BCCWS protocol, database structure and management, and a more detailed appraisal of the analyses conducted to assess the survey's ability to meet its waterbird population monitoring goals. The report's primary objectives are to: 1) provide a quantitative assessment of the ability of the BCCWS to detect changes in the abundance of waterbirds (and other species of interest) in the Georgia Basin, 2) derive annual species abundance indices and assess linear trends in abundance over the first 5 years of the survey, and 3) present data summaries of species abundances and distributions at BCCWS sites. We discuss trends in species abundances and distributions, compare BCCWS results with

other published and unpublished survey data, and propose recommendations to improve the quality and utility of data collected by the BCCWS.

Retrospective power analyses, based on route regression techniques, showed that after five winter-intervals (i.e. six winters) of monitoring, the BCCWS had relatively low power to detect annual changes in abundances of bird populations. For example, assuming that 180 BCCWS sites were consistently surveyed for five winter-intervals, a 3% annual change in abundance (a widely accepted threshold for adequate trend resolution) was expected for only nine out of 58 of the most commonly recorded species at BCCWS sites. However, after monitoring the same number of sites for ten winter-intervals (i.e. 11 winters), detection of a 3% change in annual abundance was expected for 34 of the 58 species most commonly recorded during BCCWS; 14 other species also were approaching (3.9% - 3.1%) the 3% annual change detection threshold. These calculations suggest that over the short-term the BCCWS has potential to detect meaningful changes in abundance of a limited number of species. Over longer periods of time, however, the BCCWS appears to have adequate potential for monitoring annual abundance changes in a large number of species from a variety of guilds. These extrapolations emphasize the importance of securing and maintaining survey longevity over decades. Maintaining annual coverage of a large number of BCCWS sites is also important, but the differences in retaining more versus fewer sites typically only marginally improved the power of the survey to detect annual changes in species abundances.

Winter distribution maps depicting site-specific five-year mean abundances for 58 of the most commonly recorded species underscore the international importance of two high bird-use areas within the Georgia Strait, the Fraser River Delta (including Boundary Bay and Roberts Bank) and the east coast of Vancouver Island (Nanoose Bay north to the Comox estuary). Trends in abundance for these same 58 species suggest that over the first five-years of monitoring, declines may have occurred in 11 species, and increases may have occurred in 13 species. Given that only five years of data have been collected, and that power analyses suggest that this survey yields best results following longer-term monitoring, we emphasize that trends presented within this report be interpreted with caution.

RÉSUMÉ

Les milieux côtiers de la Colombie-Britannique abritent quelques-unes des plus denses populations d'oiseaux de mer, de sauvagines et d'oiseaux de rivage dans la partie est du Pacifique Nord. Dans l'ensemble, des populations hivernantes et migratoires importantes de sauvagines et d'oiseaux de rivage se servent des habitats estuariens, des battures, des habitats aquatiques riverains et côtiers, de type rocheux et sablonneux, productifs de la région. En Colombie-Britannique, les oiseaux et leurs habitats sont soumis à une grande variété d'influences anthropiques, y compris à un usage à des fins récréatives, au développement industriel et résidentiel ainsi qu'à un trafic maritime croissant. Nombre de zones importantes pour la conservation des oiseaux sont directement attenantes aux principales agglomérations et ,par conséquent, vulnérables aux perturbations, à la perte et à la dégradation des habitats, au rejet d'effluents toxiques et à la pollution chronique par hydrocarbures. Cette proximité et l'interaction entre les oiseaux aquatiques et l'homme font ressortir la nécessité d'un programme de surveillance à long terme des populations d'oiseaux aquatiques, plus précisément d'un programme qui permette d'évaluer l'incidence des changements environnementaux d'origine naturelle et de ceux causés par l'homme. Le Relevé des populations côtières d'oiseaux aquatiques en Colombie-Britannique (RPCOACB) a été mis en place en 1999 en réponse à ce besoin.

Le RPCOACB s'appuie sur des relevés faits par un réseau de bénévoles et est géré par Études d'oiseaux Canada (EOC) avec l'aide du Service canadien de la faune (SCF). Ce relevé se concentre sur la surveillance des populations d'oiseaux dans le détroit de Géorgie et ses environs. Le SCF et EOC ont convenu d'entreprendre une évaluation formelle de la capacité du RPCOACB de répondre à ses grands objectifs de surveillance après cinq ans de collecte de données. Voici les grands objectifs du relevé : 1) évaluer la taille des populations d'oiseaux aquatiques non reproducteurs vivant dans les régions côtières de la Colombie-Britannique, surtout celles qui se trouvent dans le bassin de Géorgie; 2) dégager des tendances concernant leur effectif et leur distribution; 3) déterminer l'importance de sites particuliers pour les oiseaux aquatiques; 4) mieux comprendre l'écologie des oiseaux aquatiques, dont les effets des changements naturels et anthropiques (par ex., dégradation de l'habitat). Au cours des cinq premières saisons hivernales de recensement (1999-2000 à 2003-2004), plus de 6,300 relevés ont été effectués en 260 stations. Il s'agit d'un ensemble de données adéquat permettant d'exécuter une évaluation préliminaire de la qualité du relevé, des tendances relatives à

l'abondance des espèces, et de la répartition géographique des espèces à petite et à grande échelle.

Ce rapport donne un aperçu du protocole utilisé dans le cadre du RPOACB, de la structure et de la gestion de la base de données ainsi qu'une appréciation plus détaillée des analyses visant à évaluer la capacité du relevé de répondre à ses objectifs de surveillance des oiseaux aquatiques. Les principaux objectifs du rapport sont les suivants : 1) fournir une évaluation quantitative de la capacité du RPOACB de déceler des variations dans l'abondance des oiseaux aquatiques (et autres espèces d'intérêt) vivant dans le bassin de Géorgie; 2) extraire des indices annuels d'abondance des espèces et dégager les tendances linéaires des effectifs au cours des premières années du relevé; 3) présenter des résumés des données relatives à l'abondance et à la distribution des espèces aux stations liées au RPOACB. Nous discutons des tendances en matière d'effectifs et de distribution des espèces, comparons les résultats du RPOACB aux données d'autres études publiées et non publiées et proposons des recommandations visant à améliorer la qualité et le degré d'utilité des données recueillies dans le cadre du RPOACB.

En général, après cinq périodes interhivernales (soit 6 hivers) de surveillance, la capacité du RPOACB de détecter les variations annuelles relatives à l 'abondance des populations d'oiseaux était faible. Par exemple, en partant du principe qu'environ 180 stations liées au RPOACB font l'objet de recensements réguliers pendant cinq périodes interhivernales, une variation de 3 % dans l'abondance des oiseaux aquatiques n'avait été prévue que pour neuf des 58 espèces les plus couramment recensées aux stations liées au RPOACB. Toutefois, après avoir surveillé le même nombre de stations pendant 10 périodes interhivernales (soit 11 hivers), on s'attendait à pouvoir détecter une variation annuelle de 3 % dans l'effectif chez 34 des 58 espèces recensées au cours du RPOACB; mais, on s'approchait aussi du seuil de variation annuelle détectée de 3 % (3,9 % à 3,1 %) dans le cas de14 autres espèces. Ces calculs suggèrent, au moins à court terme, que le RPOACB a la capacité de détecter des variations significatives de l'effectif chez un nombre limité d'espèces. Par ailleurs, sur de longues périodes, le RPOACB semble avoir le potentiel voulu pour surveiller les variations annuelles de l'effectif d'un grand nombre d'espèces provenant d'une variété de guildes. Ces extrapolations mettent l'accent sur l'importance de garantir et d'assurer la longévité du relevé sur des décennies. Il est aussi important de garantir la couverture annuelle d'un grand nombre de stations liées au RPOACB, mais les écarts qui existent entre recenser en général un plus grand ou un plus petit nombre de stations n'améliorera que très peu la capacité du relevé de détecter les variations annuelles dans l'effectif des diverses espèces.

Des cartes de répartition des espèces en hiver décrivant pour chacune des stations, sur une période de cinq ans, la moyenne des effectifs dans le cas des 58 des espèces les plus courantes recensées font ressortir l'importance, à l'échelle internationale, de deux zones pour la conservation des oiseaux dans le détroit de Géorgie, soit le delta du Fraser (y compris Boundary Bay et Roberts Bank) et la côte est de l'île de Vancouver (du nord de Nanoose Bay à l'estuaire de Comox). Les tendances relatives à l'abondance de ces mêmes 58 espèces suggèrent qu'au-delà des cinq premières années de surveillance, des baisses peuvent s'être produites chez 11 espèces et des hausses chez 13. Puisque la période de collecte de données ne s'est étendue que sur 5 ans, et que les analyses de capacité indiquent que ce relevé donne de meilleurs résultats après une surveillance à plus long terme, il faut interpréter ces tendances avec prudence.

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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 loons, grebes, cormorants, herons, waterfowl, shorebirds, gulls 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, Roberts and Sturgeon Banks, and 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 size indices, distributions, and temporal changes 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 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 goals of this report are to assess survey power and to determine trends in numbers and distributions 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 (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 the average 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”). To improve the readability of the document, several statistical analyses and major data summarizations are included as appendices.

PROJECT DESIGN AND METHODOLOGY

Survey protocol

The BCCWS is a citizen science survey. It involves coordinated volunteer counts, which are conducted on the 2nd Sunday of the month (or as close to that date as possible) from September through April (i.e. eight monthly site-visits per winter). Species groups surveyed are loons, grebes, cormorants, herons, waterfowl (ducks, geese and swans), shorebirds, gulls, alcids and raptors. Surveyors must be comfortable identifying all waterbird species that regularly occur in and around their survey area; if there is uncertainty over an identification, the record is assigned to the nearest identifiable taxonomic level (e.g. unidentified gull). All surveyors are required to use a pair of binoculars; some also use spotting scopes, enabling identifications and more precise counts of birds farther offshore. Surveys are conducted within two hours of the high tide on the survey day. All surveyors are equipped with a survey protocol manual prior to their first survey, which describes in detail the survey procedure and completion of standard data recording forms.

Surveyors record birds in three discrete “distance bands”: inland, near-shore and off-shore. “Inland” refers to all birds above the high water mark, e.g. upper beaches, fields and inland water bodies visible from the surveyors’ vantage point(s). “Near-shore” refers to birds observed from the high tide mark out to 500 m. “Off-shore” refers to the area beyond 500 m from the high tide mark (out to as far as an observer can see). Records are placed into an “unknown” distance band if the surveyor is uncertain which distance band to report. Birds only seen flying over are not recorded. Data on weather conditions, sea conditions, visibility, tide stage, optics used and human activity (disturbance factors) are also collected.

Survey site designation and selection

During the protocol workshop, the BC coastline was divided into survey sites approximately 1-2 km long. Topographic maps (1:250,000 scale) with designated site boundaries are housed in the BSC BC Projects office. Sites may be relatively linear stretches of shoreline or they may be a cove, bay, inlet, or some other naturally demarcated section of shoreline. During each survey volunteers record total counts by distance class of all waterbirds observed at their survey site.

Survey sites were not randomly selected because many sites along the British Columbia coastline are inaccessible. Sites away from the more heavily populated parts of the BC coast are selected by volunteers with guidance and input from BSC’s BC coordinator. Survey sites are generally chosen in relatively close proximity to the volunteer's residence to facilitate obtaining consistent monthly counts. Survey sites cover a wide range of habitats, including estuaries and intertidal mudflats, rocky shores and sandy beaches.

Survey site locations and boundaries are digitized within a GIS, from topographic maps (1:50,000 to 1:250,000 scale) returned by volunteers. Many survey sites share common boundaries, and some are situated along opposite shores of water bodies of varying width. In these situations, the probability for multiple counts of the same birds is higher than at isolated sites. Some stretches of coast with several adjacent sites were monitored by organized and coordinated groups of surveyors belonging to naturalist organisations and local birding groups.

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 further away. These variable survey techniques introduce variation in surveyor effort and detection of some species of coastal waterbirds, potentially compromising comparisons of counts 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 annually ranged from 171 to 207. 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 surveys conducted each winter period.

Winter	Sites surveyed	Surveys conducted
1999/2000	195	1,204
2000/2001	207	1,423
2001/2002	183	1,318
2002/2003	171	1,138
2003/2004	190	1,260
1999 - 2004	260	6,343

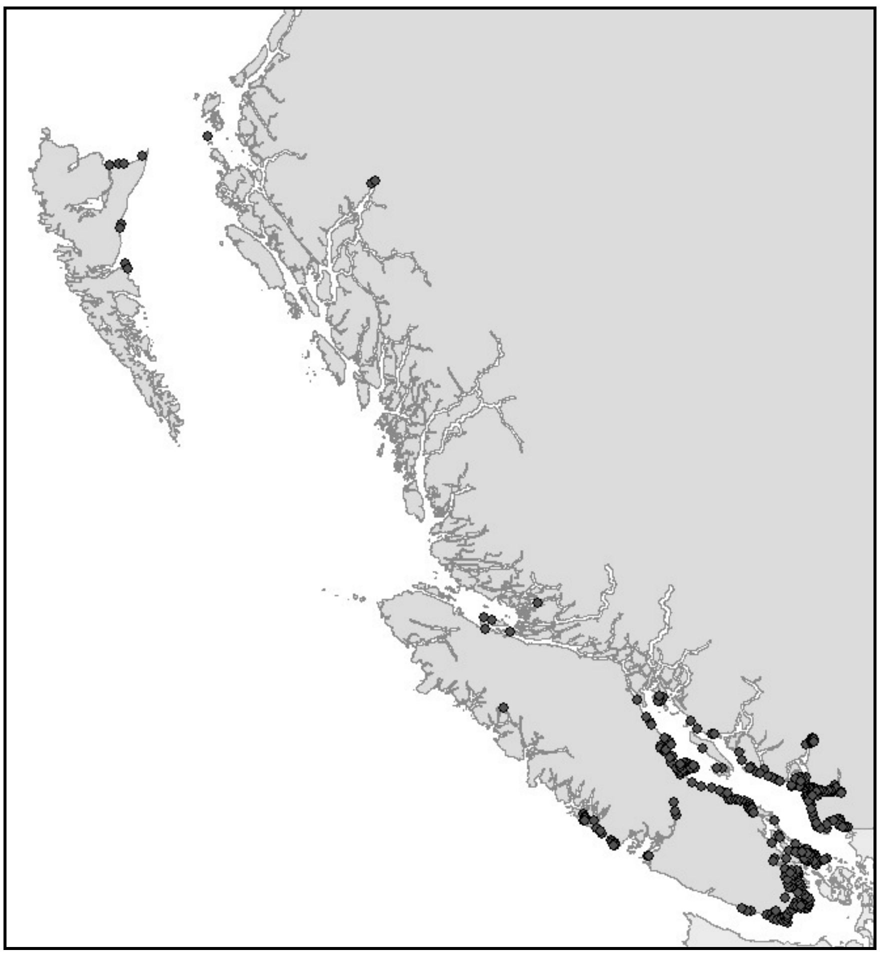


Figure 1. Geographic distribution of British Columbia Coastal Waterbird Survey sites, 1999-2004.

Several naturalist groups have members who coordinate surveys for the BCCWS: 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 groups of volunteers conduct surveys together and have one "regional coordinator" (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, which is maintained, housed, and managed by BSC. Digitised survey site polygons are stored and updated in the BCCWS GIS data file/theme layer, maintained by the BSC BC Projects office and the Canadian Wildlife Service's Pacific Wildlife Research Centre.

The BCCWS Microsoft Access Database contains all the surveyor, site and individual survey details (including individual species counts from each distance band for each site), in a series of related tables, with standard coding systems for surveyors, sites and regions.

Species-specific survey windows

Survey windows were developed to ensure that data used in statistical analyses were most representative of the biological timeframe of interest. A primary objective of the survey was to monitor wintering bird populations, and so the survey window specified for most species included the period from December, January, and February. However, different survey windows were developed for species that are largely migrants in coastal BC. Survey windows for each species ultimately were based on a combination of published data (Butler and Cannings 1989, Campbell *et al*. 1990, Butler and Vermeer 1994) and extensive personal observations (R. Butler, Canadian Wildlife Service and R.J. Cannings, Bird Studies Canada) of migration chronology and winter residency. Appendix 2 details the survey windows specified for each species.

Analysis metric

Counts from all distance bands were summed to give a total count of each species for each survey. The basic statistical unit for most analyses was the mean total count of each species at a survey site within the specified survey window of each winter season. These data were also used to determine initial variance estimates (for power analyses), annual abundance indices, and long-term trends for each species. Only sites with 100% monthly coverage within the species-specific 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, it can only be 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 after additional years of survey data are included. 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.

The statistical analyses we use and describe below for power and trend analyses are generally modeled after the "route-regression" analysis, which is a statistical technique that 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). Basically, this involves estimating changes in bird abundance over time at individual survey sites, then determining larger scale patterns by taking weighted averages of the trends at these sites. Error distributions of count data are often best approximated by a Poisson distribution (Weeber and Vallinatos 2000); count data from the BCCWS has previously been demonstrated to be distributed in such a manner (Badzinski 2003). Consequently, we have specified Poisson error distributions in all statistical models. We used the SAS analytical software package (SAS Institute 1990) to perform all data manipulations, transformations, simulations, and statistical modeling of the BCCWS data.

Power analyses

For these analyses, we only included response count data (i.e., average number of birds counted within the species-specific survey window during each survey season) for BCCWS sites that were surveyed at least two times in consecutive winters and where at least one individual of the species of interest was detected in one of those seasons. We also wanted to ensure that data from at least 2 sites were included in each model so that variance estimates could be generated. We then created a variable called winter-pair which grouped counts from consecutive winters into paired groups (e.g., winter 1999/2000 and 2000/2001 data were coded as winter-pair 1; 2000/2001 and 2001/2002 data were coded as winter-pair 2, etc.).

Subsequently, winter-pair and species were used as "by group" variables in our statistical analyses to generate species-specific variance estimates for each winter survey season. We then used Poisson regression models using a log link function (Y = Winter [class], BCCWS Site [class]), to generate species-specific variance estimates for each winter survey season. Regression models were iterated up to 1000 times in order to ensure that computation algorithms converged and thus provided estimates of species-specific variances for each winter-pair period. Because error distributions for many species were not perfectly Poisson distributed, variance estimates also were corrected for over-dispersion (PROC GENMOD, DIST=POISSON, PSCALE option; SAS Institute 1990).

Variances for species during each survey season were then used to estimate and model the power of the BCCWS. To do this, we weighted the variances by the total number of sites detecting each species during each of the survey periods. We then derived an average (weighted) variance for each species and used this estimate in all subsequent power calculations and simulations. We then used Monte Carlo simulations and other analytical techniques to estimate the percentage annual change in species abundance at different numbers (160, 180 and 200) of BCCWS sites surveyed after five and 10 winter-intervals (six and 11 survey seasons respectively). These simulations were done assuming log-linear relationships and a uniform, consistent population change across all sites and winters. We then used formulas in Snedecor and Cochrane (1967:113) to estimate the magnitude of annual change, based on these variance estimates with 80% power ($\beta = 0.8$) and 95% confidence ($\alpha = 0.05$), that could be detected after monitoring 200 BCCWS sites for 10-year intervals (a realistic long-term goal for the program). We also used this technique to compare if different count indices (i.e., using mean count of individuals or season-maximum counts) greatly affected power of the survey (see Appendix 3). All power estimates have been adjusted to account for the proportion (average over all 5-winter periods) 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 one individual of each species, and the numbers of site-winters for each species. Because data used in most statistical analyses were restricted to those collected only from BCCWS sites within the Georgia Basin, sample sizes may be less than the total sites surveyed for the entire province (Table 1). We used Poisson regression models (Mean species count over survey window [Y] = Winter Period [class], BCCWS Site [class]) that employed a log link function to obtain "Winter Period" class coefficients and standard errors for each species deemed of interest; regression models were iterated up to 1000 times to allow computation algorithms to converge upon solutions (PROC GENMOD; SAS Institute 1990). Before testing for model fit and calculating indices of relative abundance, we corrected variance estimates (and its derivatives) for over-dispersion (PROC GENMOD, PSCALE option; SAS Institute 1990). We used the following formula to convert "Winter Period" (1999/2000, 2000/2001, 2001/2002, 2002/2003, and 2003/2004) class coefficients (in natural log units due to use of the log link function) from the regression models into annual population indices for each species:

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

where:

e = 2.7183, the base of the natural logarithm

A = Winter Period class coefficients from species-specific regression models

M = average 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 (non-model based) value for the most recent survey year. These annual winter estimates are presented in figures along with their lower and upper 95% confidence limits. Regression models do not provide a specific parameter estimate and standard error for the most recent (2003/2004) survey year, so no confidence limits could be calculated and only the average number of individuals are shown in figures 2 through 59 (see also Weeber and Vallianatos 2000).

Linear trends in numbers of species monitored by the BCCWS from the first 5 winters (i.e., 1999/2000 – 2003/2004) were evaluated for statistical significance and reliability using Generalized Linear Models (PROC GENMOD; SAS Institute 1990). The same input data, error distribution (Poisson), and regression modeling structures (log link function) and procedures as described above for calculating annual 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 (in natural log units) from Poisson regression models, corrected for over-dispersion, were converted into relative indices of change (abundance trends) by using the following formula:

(2) Abundance trend = $100 \times (e^{\beta} - 1)$

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 in bird abundance indices over the time. We also calculated the lower and upper 95% confidence intervals from standard errors associated with the “Winter Period” parameter estimate. Likelihood ratio tests were used to calculate the probability that addition of “Winter Period” effects into 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 “Winter Period” effects were calculated and those values were then used to obtain probabilities from a chi-square distribution, which were subsequently converted (1 - chi-square probability) into *p*-values. Seasonal trends in species abundances (and confidence in those estimates) are presented in Appendix 7.

Species distributions

Species distributions were mapped using ArcMap desktop mapping software. For each species at each site, mean monthly counts for each winter were calculated from survey data collected within the species-specific survey window (see Appendix 2); these winter period means were summed and averaged to produce an overall five-season mean count plotted for each site. Mean counts were mapped only for sites where each month in the species-specific survey window was surveyed at least once over all five survey seasons. Sites that did not meet these criteria were excluded from the analysis. Variable diameter circles (divided into four categories, with natural breaks between abundances determined using Jenks method) were used to represent individual species relative abundance at each site. For each species, sites with insufficient data, or where zero birds were observed, were also mapped, to illustrate sites where the species was either absent or data were insufficient to derive a relative abundance.

RESULTS

Survey power: BCCWS's ability to detect trends

The estimated power of the BCCWS to detect annual changes in relative abundance of wintering bird species is presented in Table 2. Although a universally accepted standard has not yet been defined, a 3% annual change in numbers is considered by many bird monitoring specialists to be a reasonable criterion for adequate trend resolution for birds (Weeber and Vallianatos 2000). Based on this criterion, and assuming that about 180 BCCWS sites are consistently surveyed for five winter-intervals (i.e. six winters), adequate trend resolution is expected for nine of the 58 species most commonly recorded at BCCWS sites: Common Loon, Horned Grebe, Double-crested Cormorant, Great Blue Heron, Mallard, Bufflehead, Common Goldeneye, Harlequin Duck and Bald Eagle (Table 2). After 10 winter-intervals (11 winters), surveying 180 sites should allow good trend resolution for 34 of 58 species commonly recorded during BCCWS, including five dabbling duck, eleven diving duck, one goose, one swan, three shorebird, two cormorant, three loon, three grebe and three gull species. Trends for fourteen other species, spread across a variety of guilds, are also approaching (3.9-3.1%) an acceptable resolution after 10 winter-intervals (Table 2).

Trend resolution also slightly improved with an increase in the number of survey sites. For species expected to meet the 3% threshold criterion after 10 years, increasing the number of survey sites by 20 (i.e. 200 total) improved trend resolutions by only 0.1% - 0.2%.

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 five and 10 winter-intervals (species' scientific names are given in Appendix 8).

		160[a]		180		200	
Group/species	Adjust[b]	5	10	5	10	5	10
Loons							
Red-throated Loon	0.40	6.7	2.7	6.3	2.6	6.0	2.4
Pacific Loon	0.61	6.3	2.5	5.9	2.4	5.6	2.3
Common Loon	0.77	2.7	1.1	2.5	1.0	2.4	1.0
Grebes							
Red-necked Grebe	0.60	4.1	1.6	3.9	1.6	3.7	1.5
Horned Grebe	0.80	3.2	1.3	3.0	1.2	2.8	1.1
Western Grebe	0.52	7.0	2.8	6.6	2.7	6.3	2.5
Cormorants							
Double-crested Cormorant	0.87	2.8	1.1	2.7	1.1	2.6	1.0
Brandt's Cormorant	0.18	9.5	3.8	9.0	3.6	8.6	3.5
Pelagic Cormorant	0.70	3.9	1.6	3.7	1.5	3.5	1.4
Herons							
Great Blue Heron	0.90	3.0	1.2	2.8	1.1	2.7	1.1
Waterfowl							
Mute Swan	0.08	18.5	7.5	17.6	7.2	16.8	6.8
Trumpeter Swan	0.27	6.9	2.8	6.5	2.6	6.2	2.5
Canada Goose	0.70	4.6	1.9	4.4	1.8	4.2	1.7
Brant	0.25	10.2	4.2	9.7	3.9	9.3	3.8
Snow Goose	0.09	10.0	4.1	9.5	3.8	9.0	3.6
Mallard	0.87	2.6	1.0	2.4	1.0	2.3	0.9
Gadwall	0.12	9.0	3.7	8.5	3.5	8.1	3.3
Northern Pintail	0.30	5.0	2.0	4.7	1.9	4.5	1.8
American Wigeon	0.83	3.4	1.4	3.2	1.3	3.0	1.2
Eurasian Wigeon	0.33	6.5	2.6	6.2	2.5	5.9	2.4
Green-winged Teal	0.34	5.5	2.2	5.2	2.1	5.0	2.0
Canvasback	0.09	14.9	6.0	14.1	5.7	13.4	5.5
Ring-necked Duck	0.10	10.6	4.3	10.0	4.1	9.5	3.9
Greater Scaup	0.38	8.8	3.6	8.4	3.4	8.0	3.2
Lesser Scaup	0.23	8.0	3.2	7.6	3.1	7.3	2.9
Harlequin Duck	0.57	2.6	1.1	2.5	1.0	2.4	1.0

Table 2, continued

Group/species	Adjust[b]	160[a]		180		200	
		5	10	5	10	5	10
Waterfowl							
Long-tailed Duck	0.39	5.3	2.1	5.0	2.0	4.8	1.9
Surf Scoter	0.77	4.2	1.7	4.0	1.6	3.8	1.5
Black Scoter	0.45	6.1	2.5	5.8	2.3	5.5	2.2
White-winged Scoter	0.55	3.8	1.5	3.6	1.4	3.4	1.4
Common Goldeneye	0.88	3.0	1.2	2.8	1.1	2.7	1.1
Barrow's Goldeneye	0.68	3.9	1.6	3.7	1.5	3.5	1.4
Bufflehead	0.94	2.1	0.8	2.0	0.8	1.9	0.7
Hooded Merganser	0.60	4.3	1.7	4.1	1.6	3.9	1.6
Common Merganser	0.81	3.6	1.4	3.4	1.4	3.2	1.3
Red-breasted Merganser	0.73	3.7	1.5	3.5	1.4	3.3	1.3
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
Red-tailed Hawk	0.30	9.5	3.8	9.0	3.6	8.6	3.5
Peregrine Falcon	0.11	15.0	6.1	14.2	5.8	13.6	5.5
Shorebirds							
Black-bellied Plover	0.20	9.7	3.9	9.2	3.7	8.8	3.6
Killdeer	0.34	8.7	3.5	8.3	3.3	7.9	3.2
Black Oystercatcher	0.43	6.3	2.5	6.0	2.4	5.7	2.3
Greater Yellowlegs	0.22	10.3	4.2	9.8	4.0	9.4	3.8
Black Turnstone	0.39	7.6	3.1	7.2	2.9	6.9	2.8
Surfbird	0.16	14.3	5.8	13.6	5.5	13.0	5.3
Dunlin	0.32	7.5	3.0	7.1	2.9	6.8	2.7
Sanderling	0.16	11.6	4.7	11.1	4.5	10.6	4.3

Table 2, continued

Group/species	Adjust[b]	160[a]		180		200	
		5	10	5	10	5	10
Gulls							
Bonaparte's Gull	0.29	12.5	5.1	11.9	4.8	11.4	4.6
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
California Gull	0.29	11.9	4.8	11.3	4.6	10.8	4.4
Herring Gull	0.41	8.6	3.5	8.1	3.3	7.8	3.1
Thayer's Gull	0.52	5.9	2.4	5.6	2.2	5.3	2.1
Glaucous-winged Gull	0.97	3.7	1.5	3.5	1.4	3.3	1.3
Alcids							
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

[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

A total of 154 species was recorded during the first five winter seasons of the survey (Appendix 8). In addition, Eurasian Green-winged Teal, and Eurasian x American Wigeon and Glaucous-winged x Western Gull hybrids were also recorded. This section reports on species trends and distributions for the 58 species most commonly recorded at BCCWS sites, in a series of individual species accounts. Each account is accompanied by a) a distribution map illustrating the mean relative abundance of the species at all BCCWS sites, and b) a graph illustrating mean relative abundance indices in each winter period (1999/2000 is shown as 2000; 2000/1 = 2001, etc.), defined relative to winter 2004 values, together with the lower and upper 95% confidence intervals around each mean. The 2004 mean value is displayed without confidence intervals because regression models do not generate a specific parameter estimate (or standard error) for the most recent survey year.

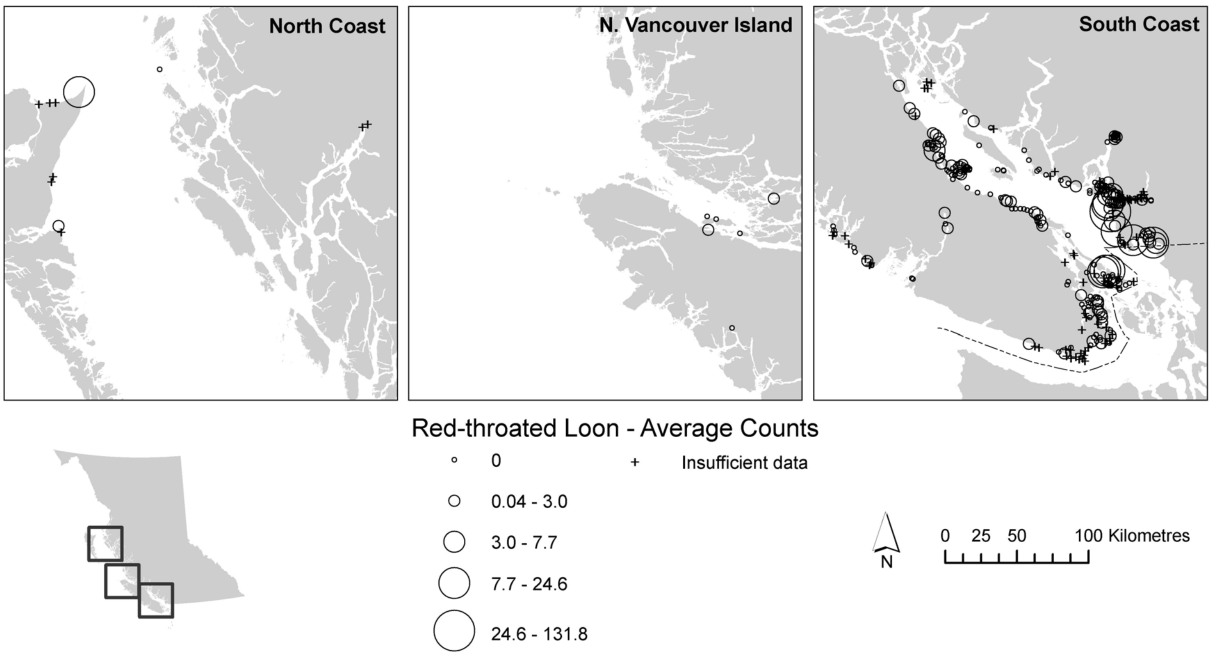
Each figure caption reports the estimated linear rate of change (percentage per year) in abundance for the species, together with the associated lower and upper 95% confidence intervals. An apparent trend (increasing or decreasing) is shown by a species when the confidence interval on the slope does not include zero; there is no trend apparent when the confidence intervals do include zero. Following this information, we provide a statistical evaluation of whether inclusion of the variable “winter period” improved ($p \leq 0.05$) model fit.

Loons

<u>Red-throated Loon</u> *Gavia stellata*

Red-throated Loons winter all along the coast, with highest numbers around the Fraser Delta. The highest count reported was 7,000 at Iona Island, a remarkable concentration. Other reported numbers were less than one-tenth that figure. There was no population trend.

a)



b)

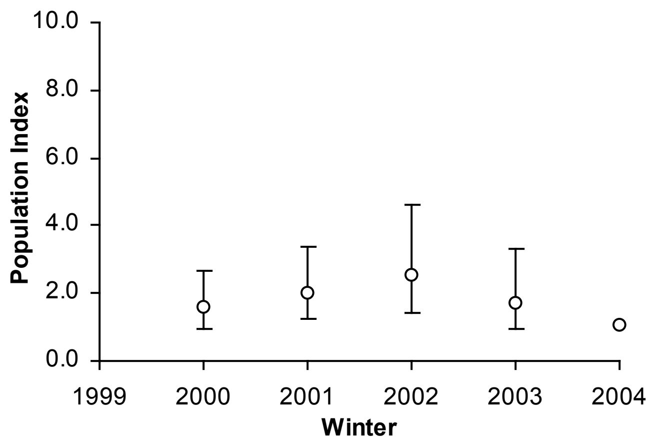


Figure 2. Red-throated Loon: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -4.4% (95% C.I. = -14.8, 7.2). Inclusion of the variable “winter period” did not improve model fit (p = 0.4335).

<u>Pacific Loon</u> *Gavia pacifica*

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 where herring spawn in the spring. Highest counts were at Oyster Bay (3,411) and Middlepoint Bight, Sunshine Coast (3,003). There was an apparent increasing trend during the first five years of this survey; the trend from Christmas Bird Counts from 1959 to 1988 in British Columbia was stable (Sauer *et al*. 1996).

a)

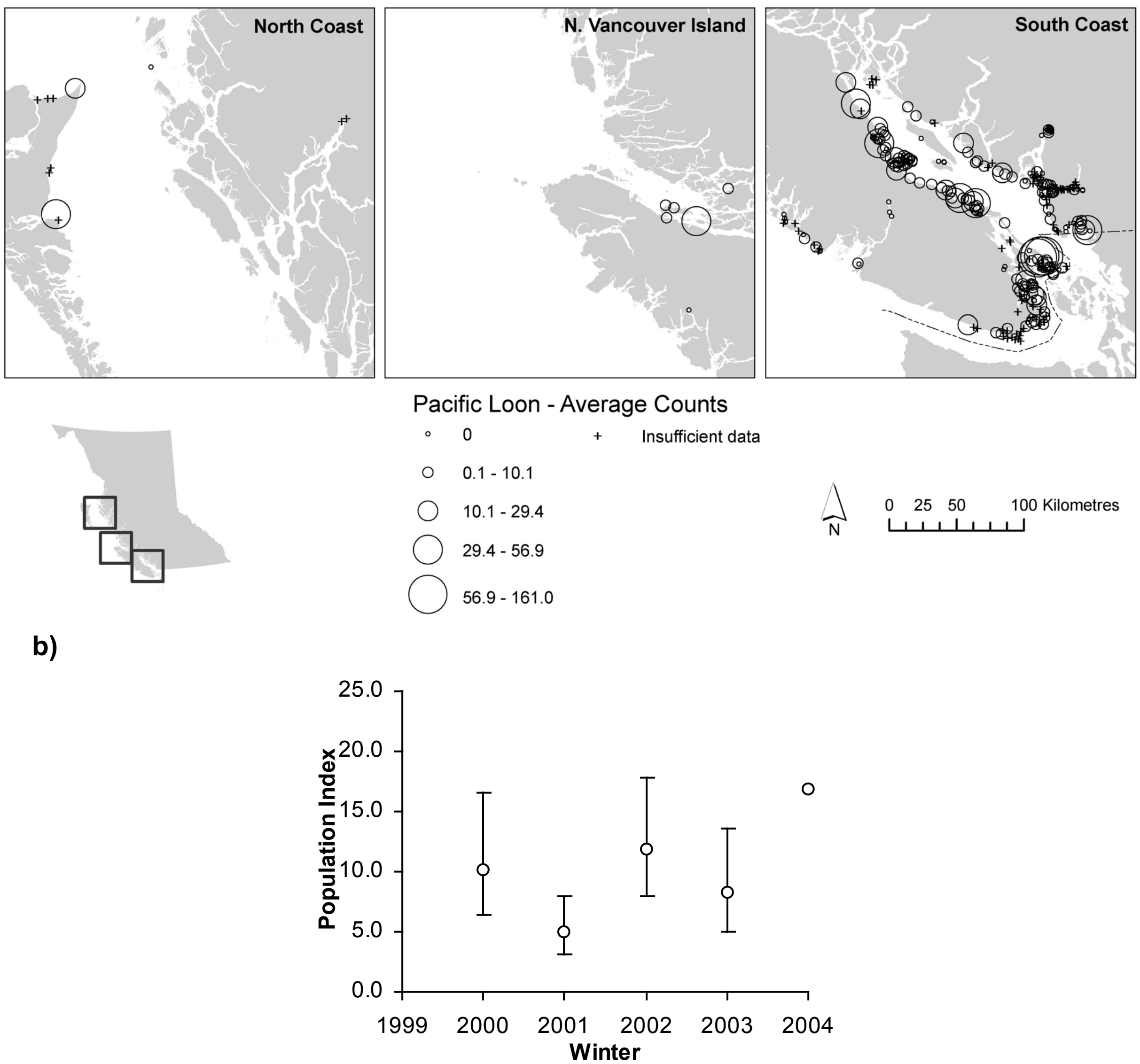
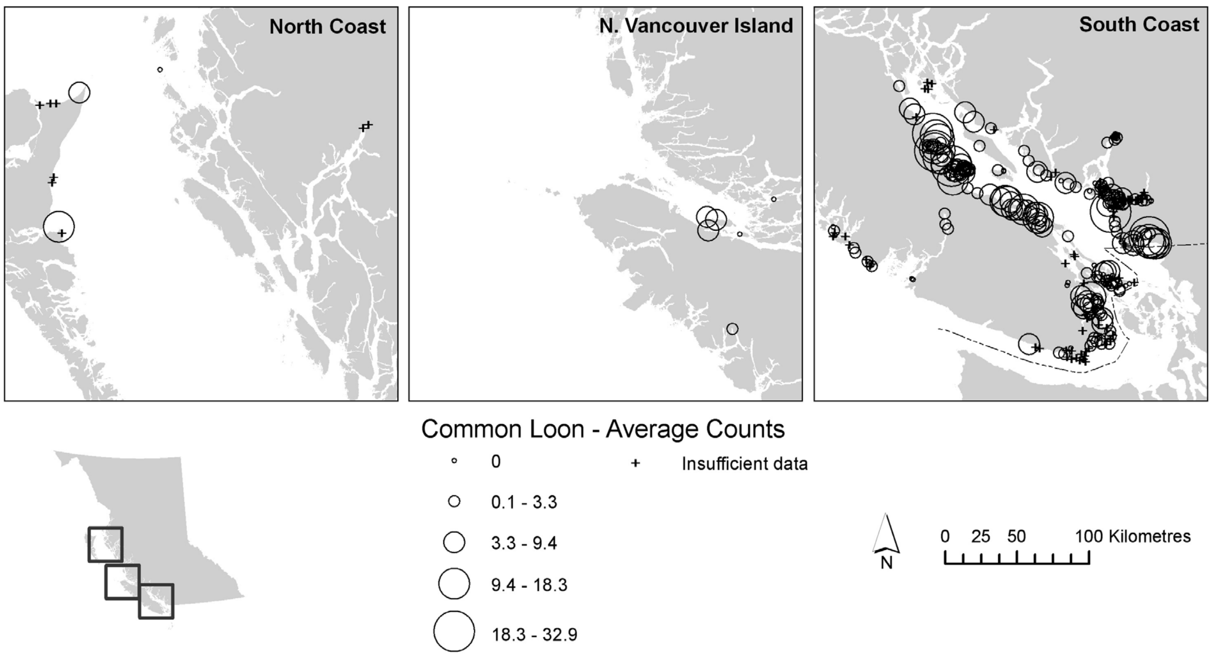


Figure 3. Pacific Loon: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear rate of change (% per winter) in abundance was 22.3% (95% C.I. = 9.3, 37.0). Inclusion of the variable "winter period" improved model fit (*p* = 0.0002).

<u>Common Loon</u> *Gavia immer*

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

a)



b)

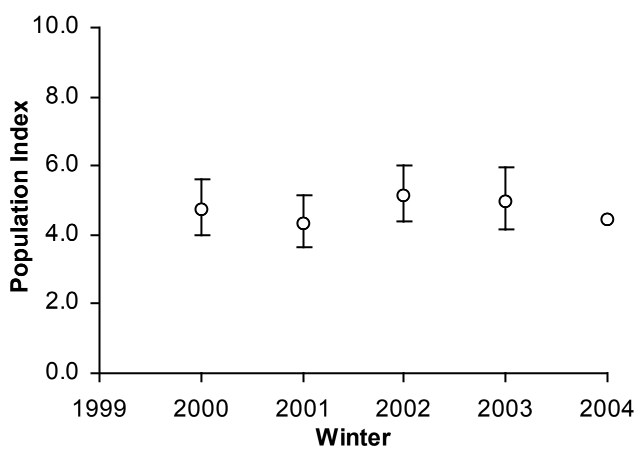


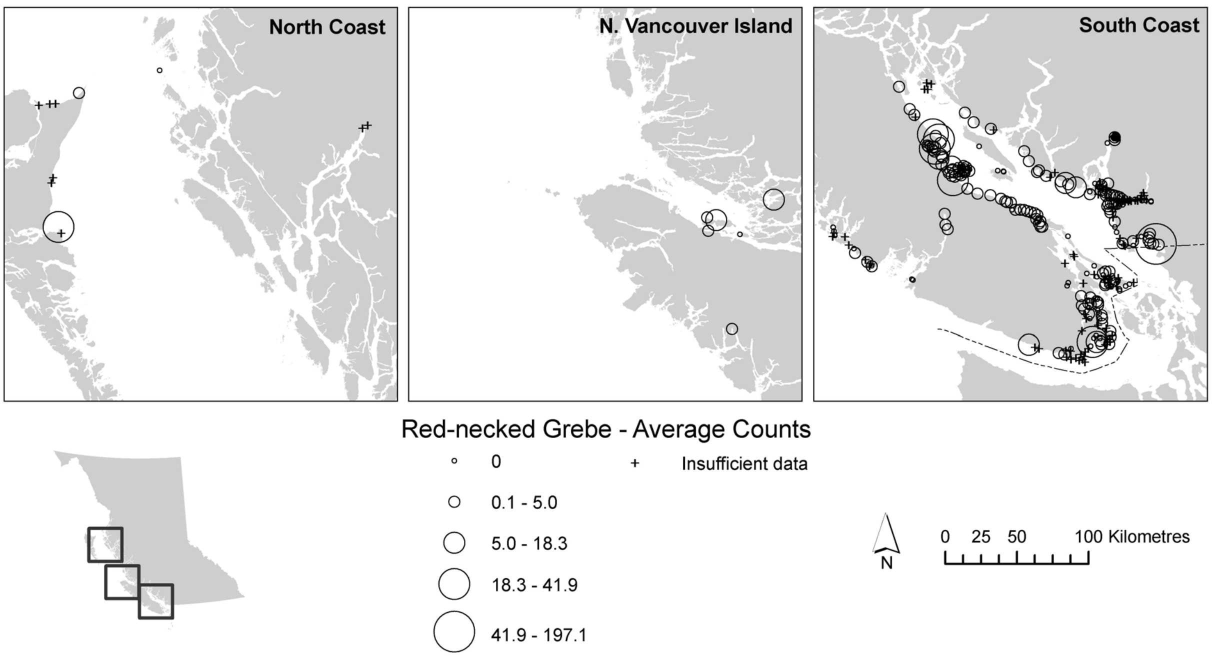
Figure 4. Common Loon: **a)** Relative abundance of Common Loon at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -0.1% (95% C.I. = -3.9, 3.9). Inclusion of the variable "winter period" did not improve model fit (*p* = 0.9632).

Grebes

Red-necked Grebe *Podiceps grisegena*

Red-necked Grebes winter along the entire length of the coast, but are concentrated in one distinct zone: the White Rock-South Surrey area on the eastern shores of Boundary Bay. Highest counts were reported from East Pier to West Promenade (2,716), 1001 Steps - Beecher Street (1,000) and Blackie Spit (780). The population index showed an apparent decline. The long-term trend from 1959 to 1988 from Christmas Bird Count data in British Columbia was stable (Sauer *et al*. 1996).

a)



b)

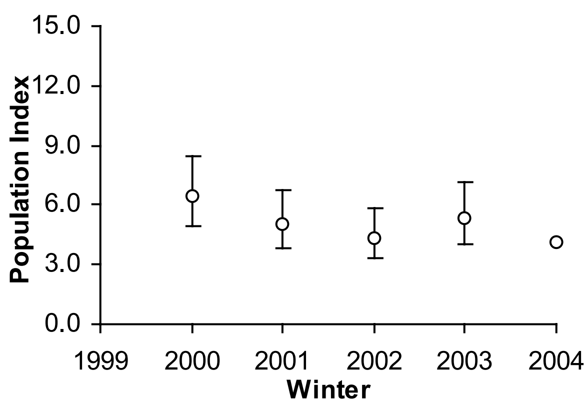
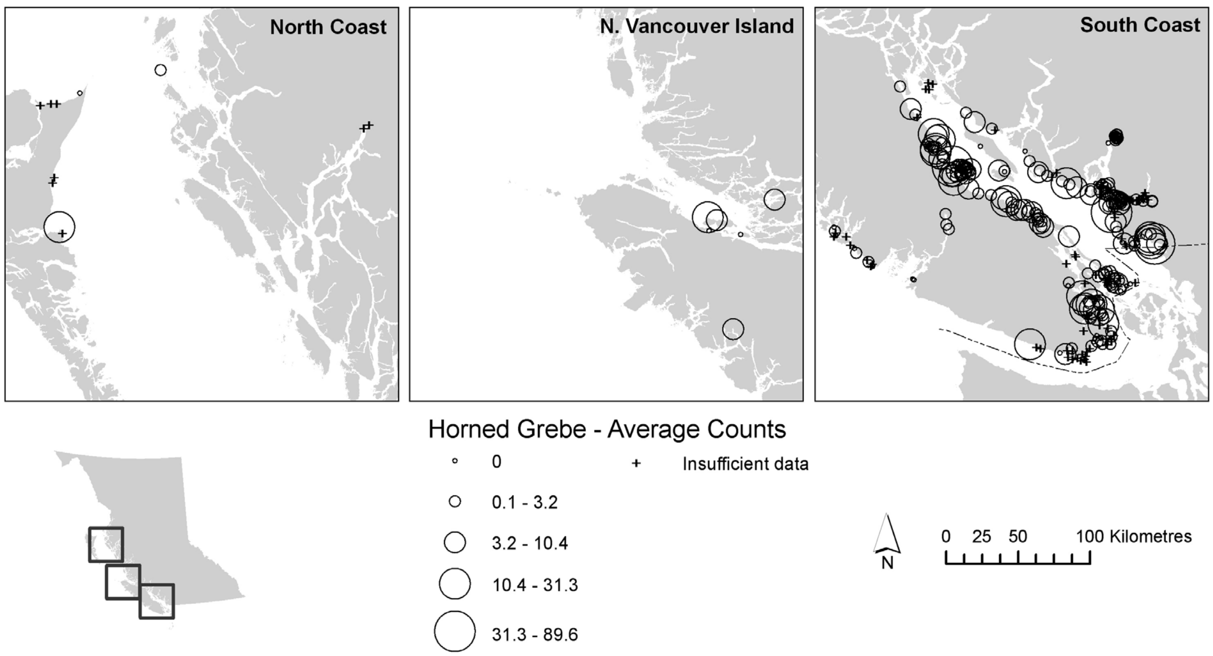


Figure 5. Red-necked Grebe: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -8.6% (95% C.I. = -14.0, -2.8). Inclusion of the variable “winter period” improved model fit (p = 0.0038).

<u>Horned Grebe</u> *Podiceps auritus*

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

a)



b)

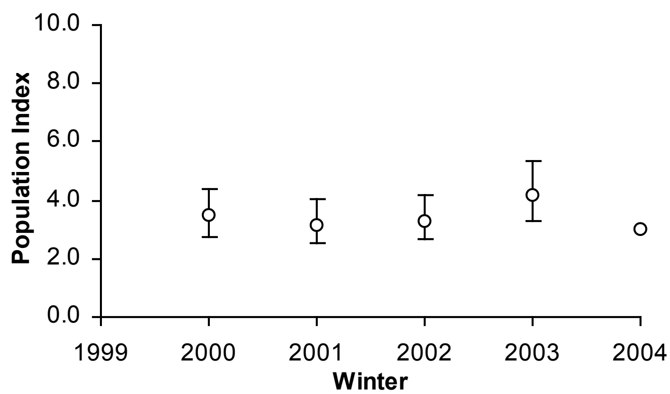
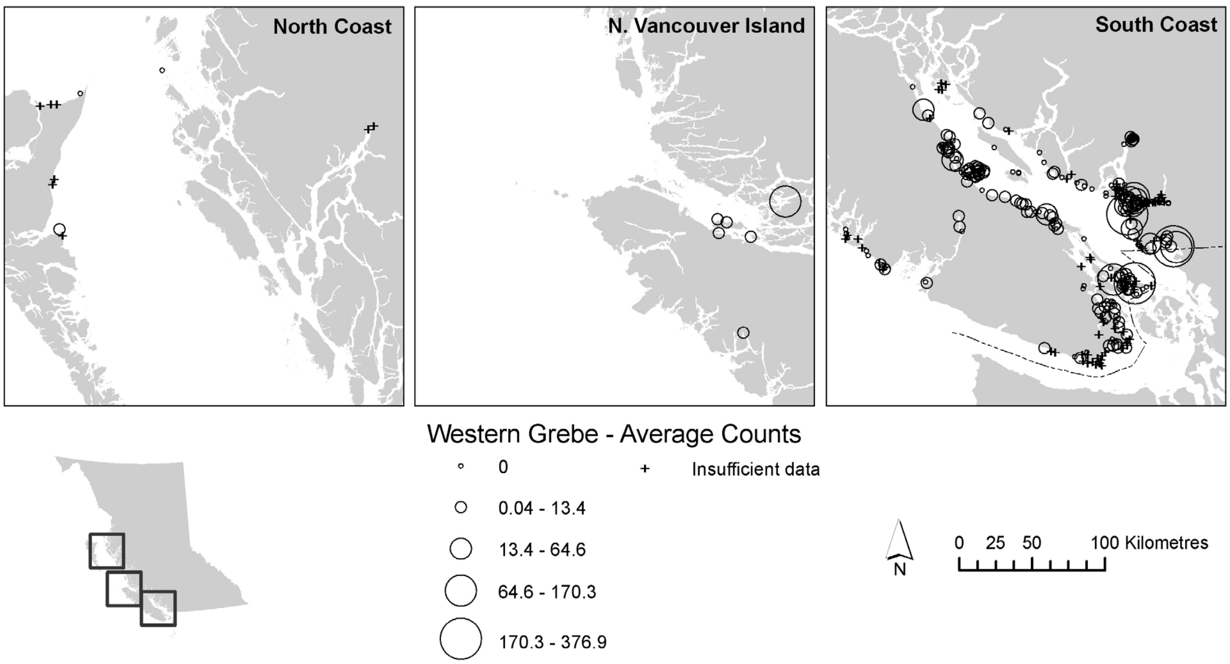


Figure 6. Horned Grebe: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -0.2% (95% C.I. = -5.2, 5.1). Inclusion of the variable “winter period” did not improve model fit (p = 0.9317).

<u>Western Grebe</u> *Aechmorphus occidentalis*

Western Grebes are of great conservation concern on the British Columbia coast: during the 30 years prior to the BCCWS, numbers on Christmas Bird Counts declined by 90-95%. Between 1999/2000 and 2003/4, the population index shows an apparent increase, caused by a spike in numbers in 2003 (reflected in Christmas count data as well). This increasing trend may be erroneous, but the population decline of the previous three decades appears to have stabilized. Peak counts were at the Oyster River estuary (8,000) and Iona Island (7,273).

a)



b)

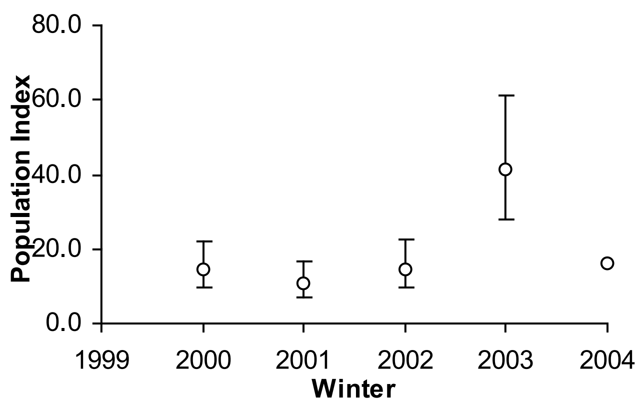


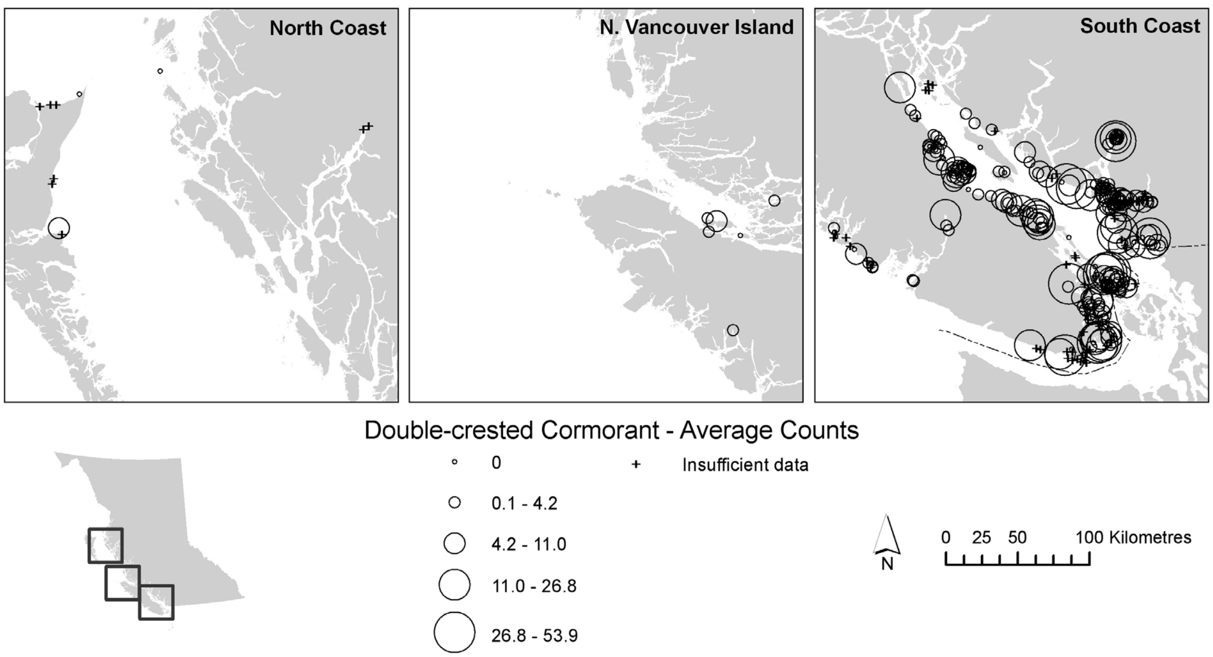
Figure 7. Western Grebe: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/4 (2004). Estimated linear trend (% per winter) in abundance was 12.7% (95% C.I. = 2.1, 24.5). Inclusion of the variable “winter period” improved model fit (p = 0.0112).

Cormorants

Double-crested Cormorant *Phalacrocorax auritus*

Common in the Strait of Georgia, but uncommon further north, numbers of this cormorant increased in the Strait of Georgia from 1959 to 1987, then decreased between 1987 and 1999. BCCWS data from 1999-2004 indicate an increasing wintering population. 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).

a)



b)

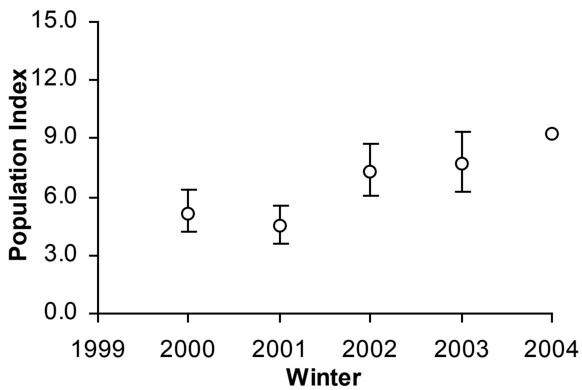
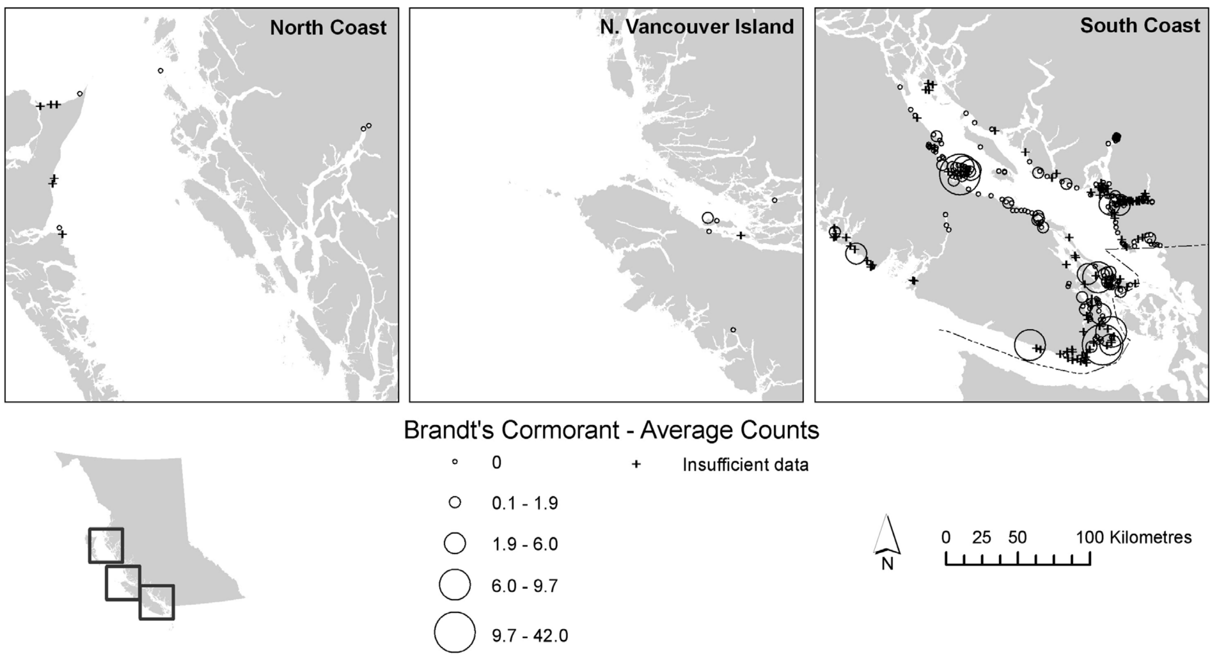


Figure 8. Double-crested Cormorant: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 18.4% (95% C.I. = 12.8, 24.2). Inclusion of the variable “winter period” improved model fit (*p* = 0.0001).

Brandt's Cormorant *Phalacrocorax penicillatus*

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

a)



b)

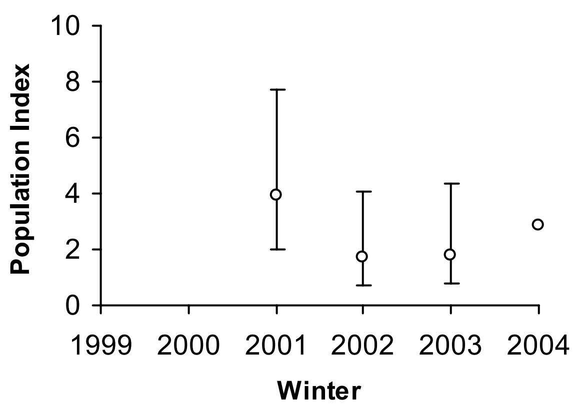
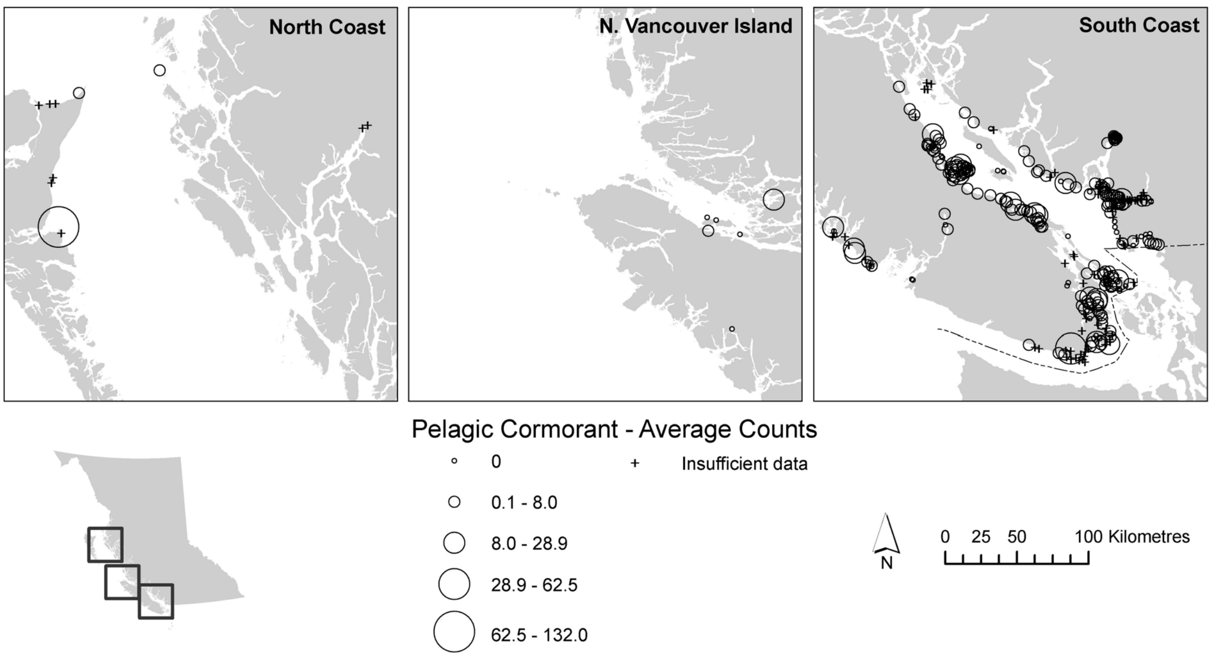


Figure 9. Brandt's Cormorant: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –12.5% (95% C.I. = -31.1, 12.9). Inclusion of the variable "winter period" did not improve model fit (p = 0.2705).

Pelagic Cormorant *Phalacrocorax pelagicus*

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 Island. 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).

a)



b)

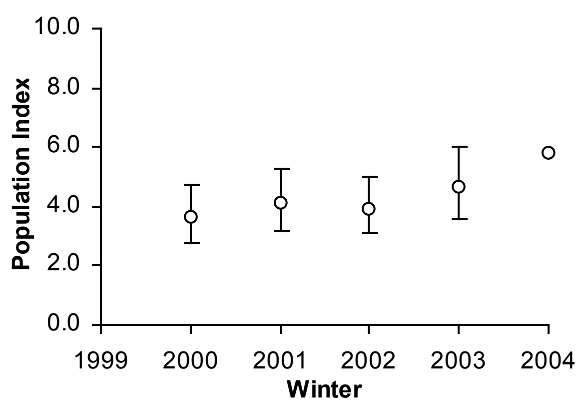


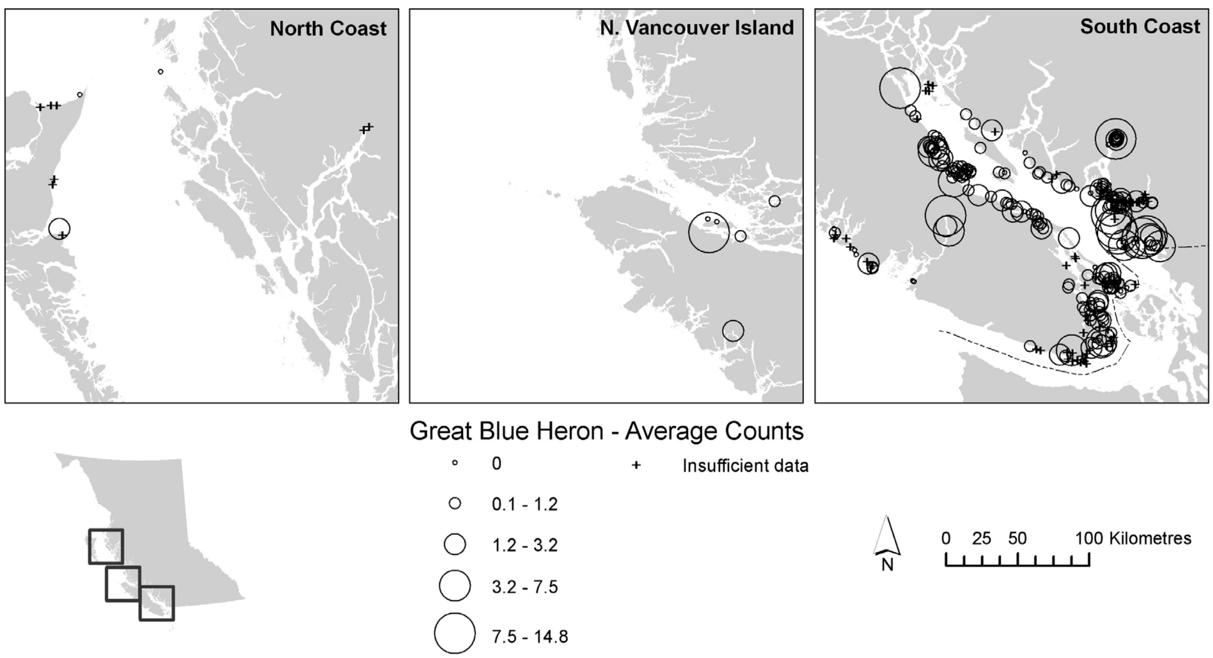
Figure 10. Pelagic Cormorant: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 12.0% (95% C.I. = 5.3, 19.1). Inclusion of the variable “winter period” improved model fit (p = 0.0003).

Herons

Great Blue Heron *Ardea herodias*

The coastal subspecies (*A.h. fannini*) is listed as a species of Special Concern by COSEWIC. It is found throughout coastal British Columbia, concentrated in the Fraser Delta and Boundary Bay, with lower numbers on the north coast. The highest count was from Blackie Spit/ Crescent Beach area, South Surrey (86). The population index shows an apparent increase.

a)



b)

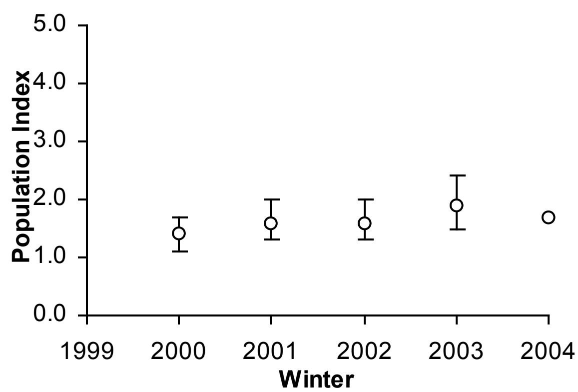


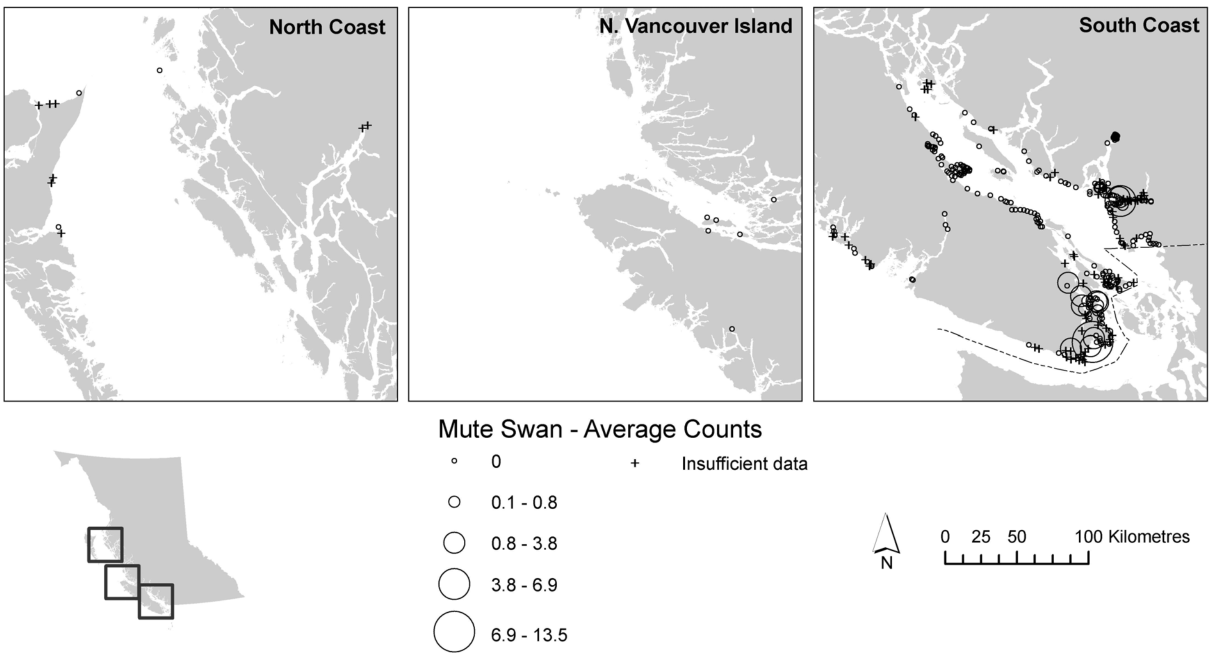
Figure 11. Great Blue Heron: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 6.9% (95% C.I. = 1.0, 13.1). Inclusion of the variable “winter period” improved model fit (p = 0.0216).

Waterfowl

Mute Swan *Cygnus olor*

Within the BCCWS survey region, Mute Swans only occur on south-eastern Vancouver Island and in the Fraser Delta. High numbers were at Quamichan Lake (42), Esquimalt Lagoon (21) and Lost Lagoon (13). The latter birds are of captive origin. There was no population trend.

a)



b)

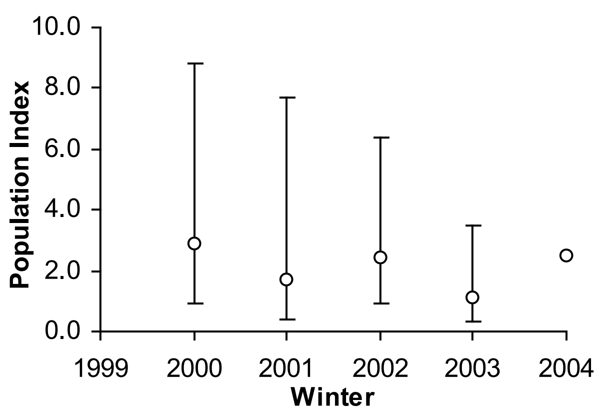
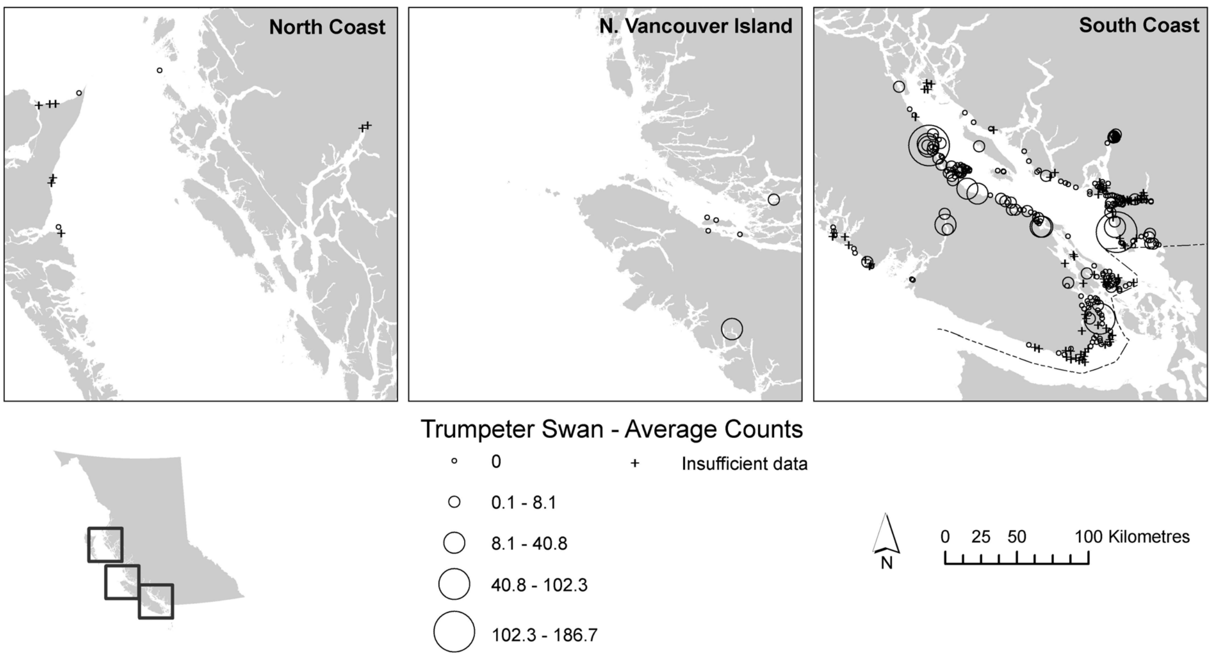


Figure 12. Mute Swan: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -9.3% (95% C.I. = -31.6, 20.3). Inclusion of the variable "winter period" did not improve model fit (p = 0.4949).

<u>Trumpeter Swan</u> *Cygnus buccinator*

Trumpeter Swans winter on 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 was no population trend. The number of wintering Trumpeter Swans in British Columbia reported on Christmas Bird Counts increased dramatically from 1959 to 1988 (mean annual increase 11.8%, Sauer *et al*. 1996).

a)



b)

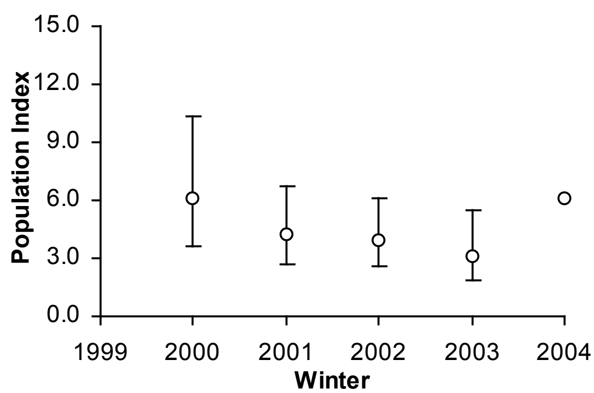
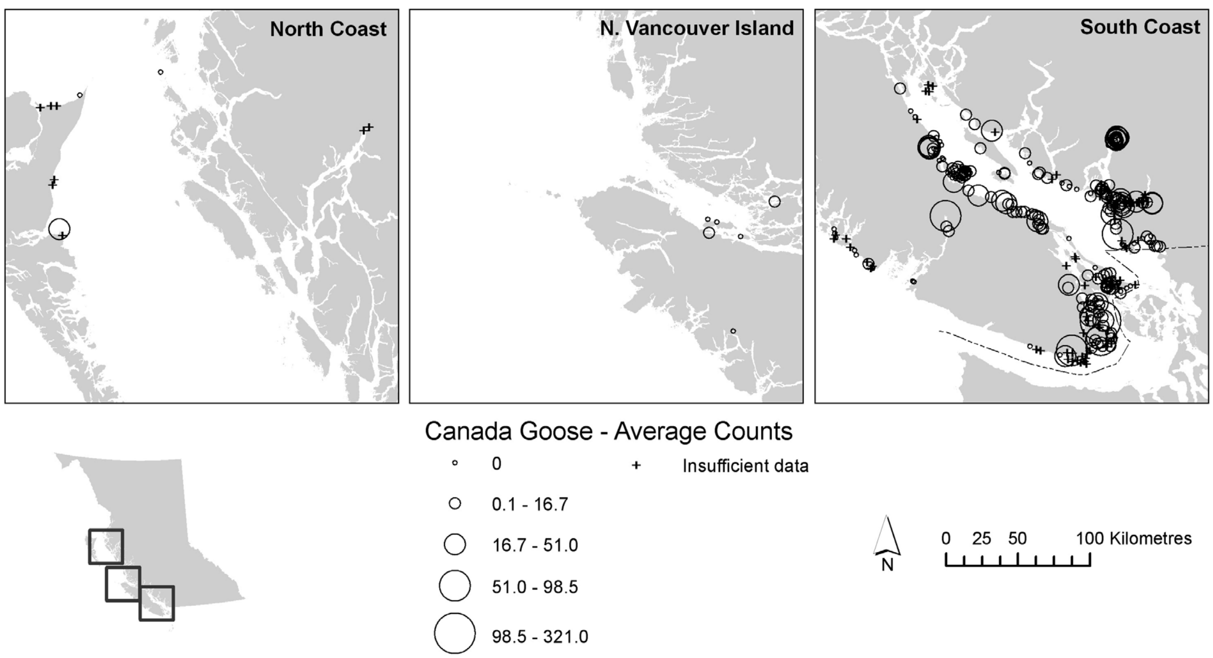


Figure 13. Trumpeter Swan: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -0.8% (95% C.I. = -12.9, 12.9). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.8992).

Canada Goose *Branta canadensis*

Canada Geese are common all along the coast; high counts came from Halfmoon Bay (600) and the Campbell River estuary (510). There was no population trend. Christmas Bird Count data showed that wintering Canada Goose numbers increased dramatically in the 1970s and 1980s, showing a province-wide 8.6% annual increase from 1959 to 1988 (Sauer *et al*. 1996), but have stabilized over the last decade. Subspecies and feral populations were not differentiated in this survey. This survey is perhaps inappropriate for geese, since it concentrates on birds on the water, while geese spend most of their time grazing inland.

a)



b)

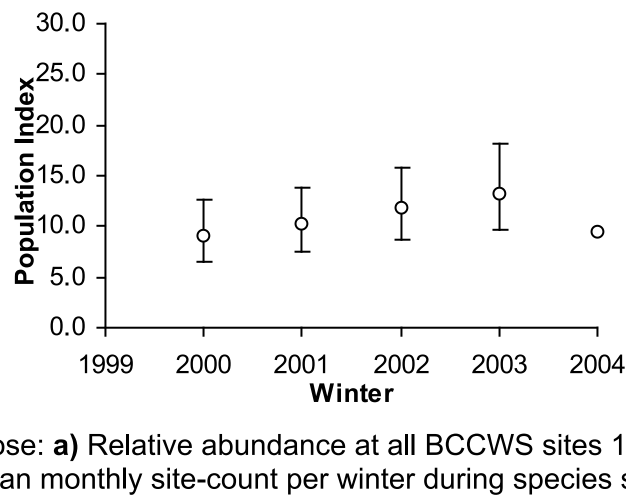
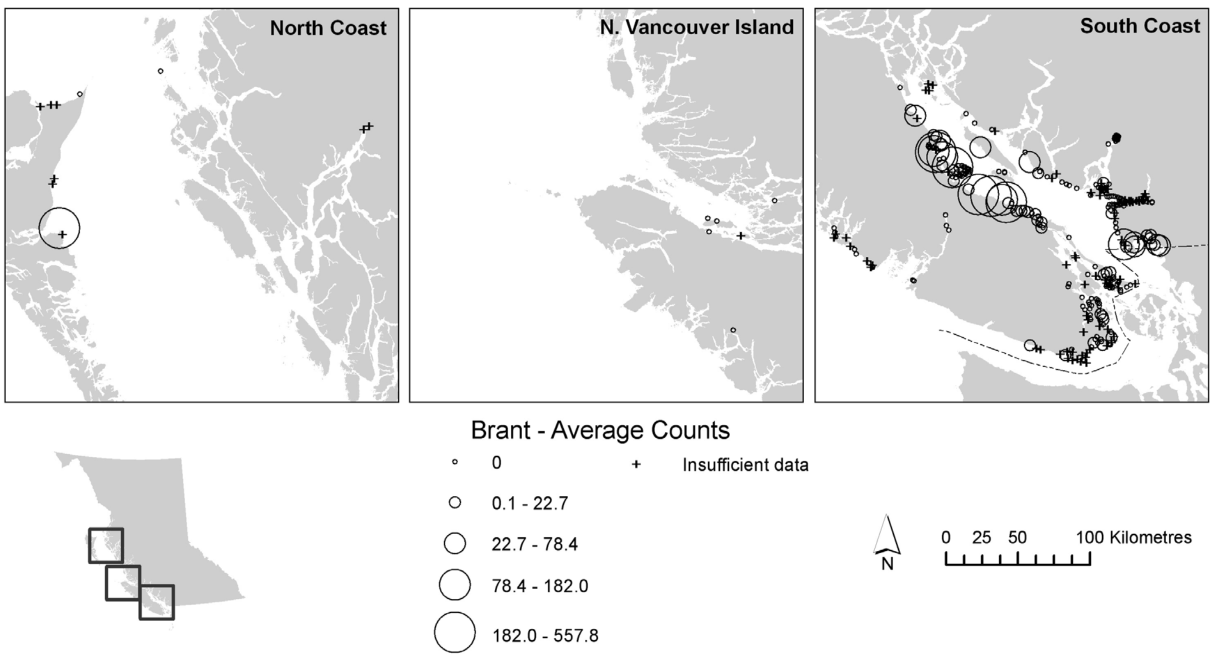


Figure 14. Canada Goose: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 3.1% (95% C.I. = -4.0, 10.7). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.4025).

Brant *Branta bernicula*

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. The highest counts were 7200 between French Creek and Eaglecrest Beach (Qualicum) and 2375 at the Little Qualicum River estuary. There is an apparent decline in the population index from 1999-2004, but this may be an artefact of the survey design, which does not perform well for species that are primarily migrants.

a)



b)

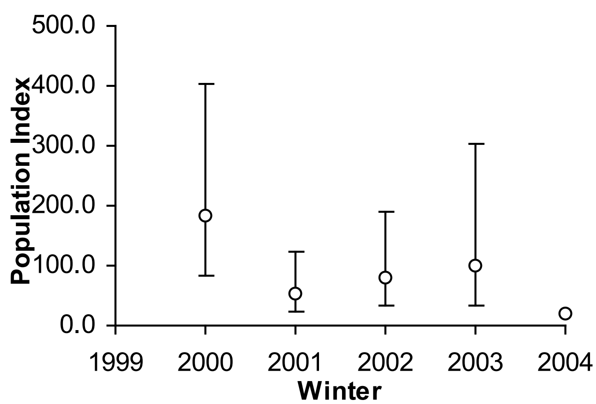
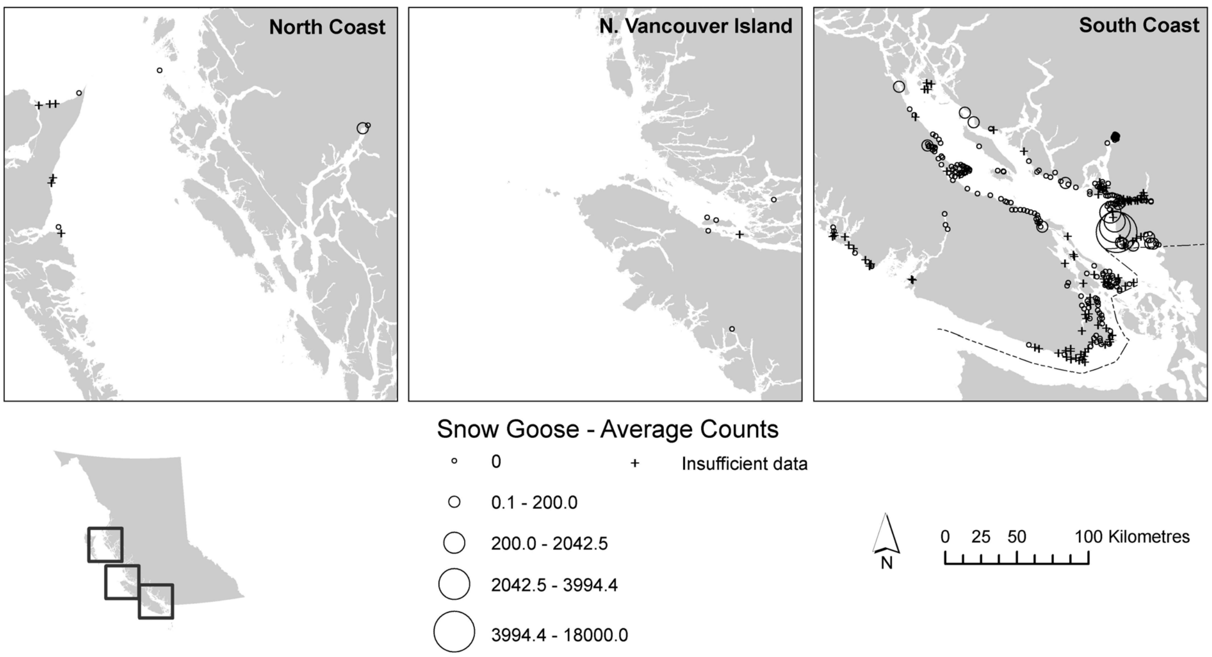


Figure 15. Brant: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -36.3% (95% C.I. = -46.1, -24.8). Inclusion of the variable “winter period” improved model fit ($p < 0.0001$).

<u>Snow Goose</u> *Chen caerulescens*

There is only one significant concentration of Snow Geese along the British Columbia coast - in 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 a high count of 30,000 at Reifel. There was no population trend, but this survey is not the best way to sample such a concentrated and mobile population that often feeds away from normal survey boundaries.

a)



b)

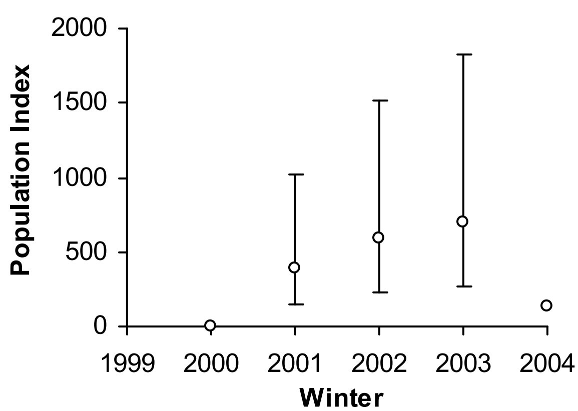
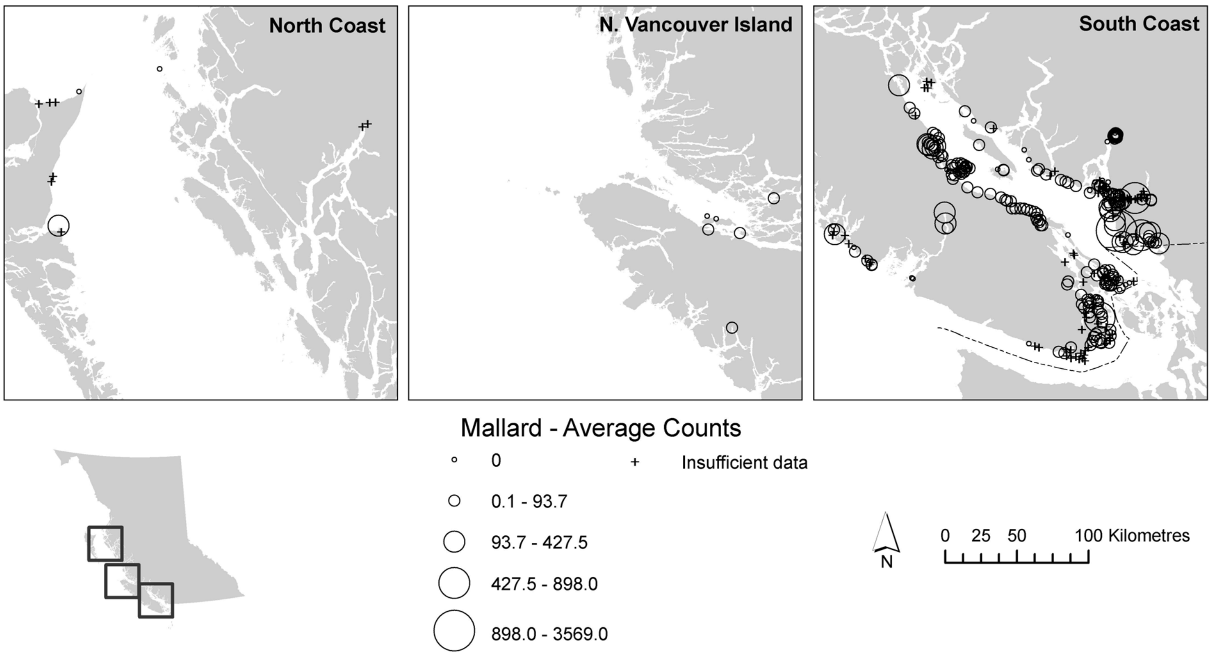


Figure 16. Snow Goose: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 3.1% (95% C.I. = -15.4, 25.6). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.7386).

Mallard *Anas platyrhynchos*

This duck is widespread along the BC coast, with the largest concentrations occurring in the Fraser Delta area. Highest numbers were at Reifel (10,600) and Iona Island (9196). There was no population trend. Christmas Bird Count data suggest a long-term increase of the wintering Mallard population in British Columbia from 1959 to 1988 (3.3% annually, Sauer *et al*. 1996).

a)



b)

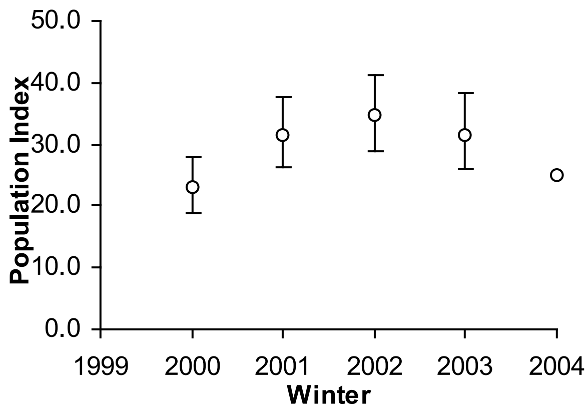
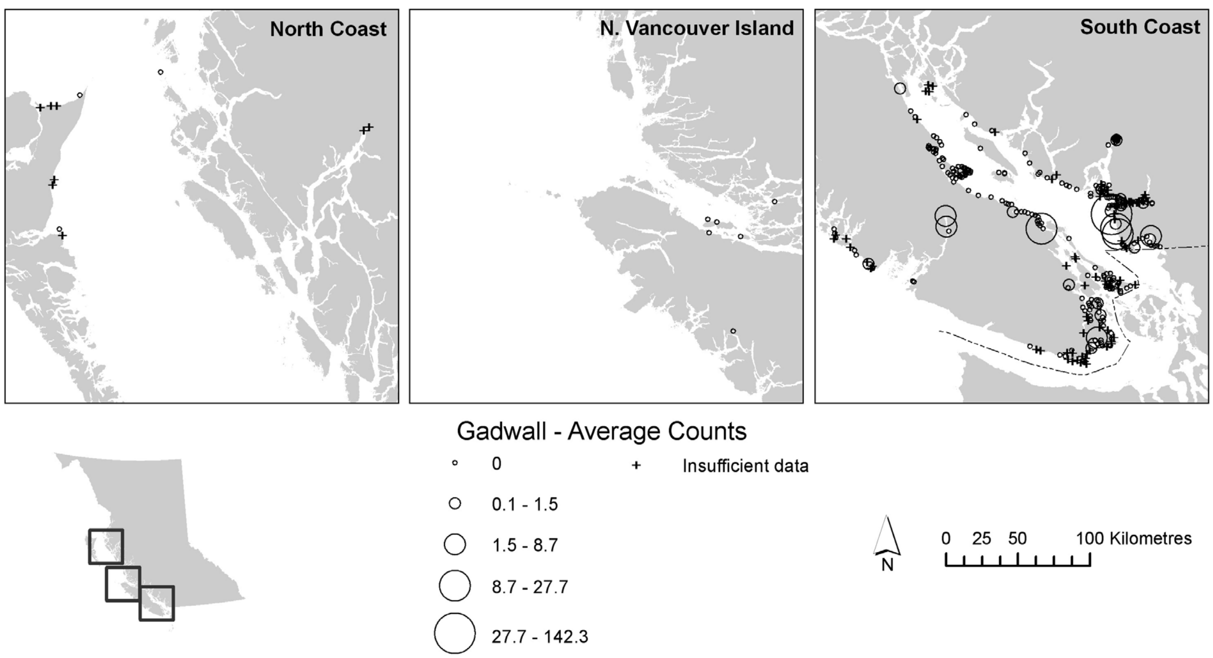


Figure 17. Mallard: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 3.2% (95% C.I. = -1.2, 7.7). Inclusion of the variable “winter period” did not improve model fit (p = 0.1410).

Gadwall *Anas strepera*

Gadwall are highly concentrated at the mouth of the Fraser River. With the exception of a one-time high count of 2,400 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 supported good numbers in winter. There was an apparent increasing population trend over the survey period. This trend may be a continuation of the long-term trend shown by British Columbia Christmas Bird Count data from 1959 to 1988, which indicated an annual increase of 5.8% (Sauer *et al*. 1996).

a)



b)

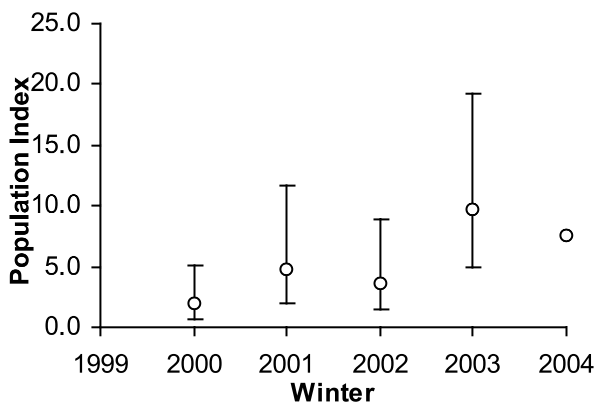
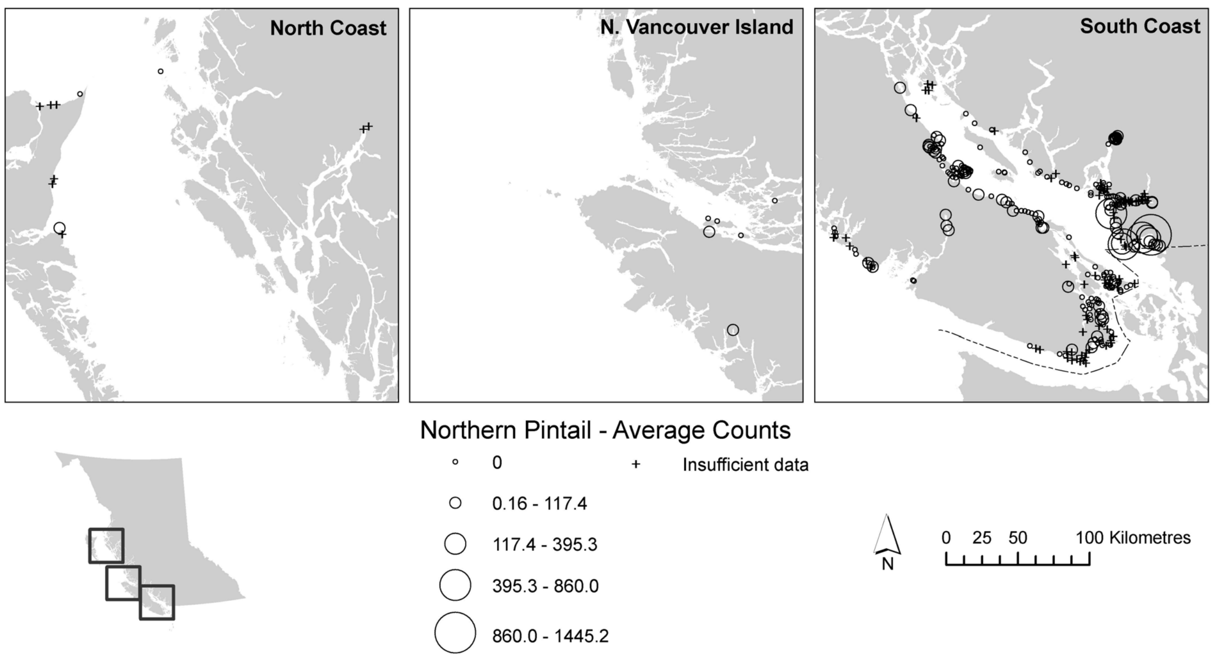


Figure 18. Gadwall: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 47.3% (95% C.I. = 13.5, 91.3). Inclusion of the variable “winter period” improved model fit (p = 0.0007).

Northern Pintail *Anas acuta*

Pintail graze on mudflats in winter, so are concentrated with many other dabbling ducks in the Fraser Delta-Boundary Bay area. Highest counts were at 12th St to 64th St, Boundary Bay (31,600) and Iona Island (13,621). There was an apparent increasing trend in the population index. Christmas Bird Count data from British Columbia suggested a stable population from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

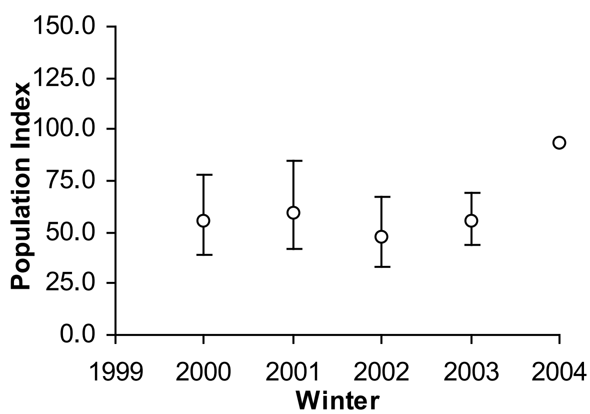
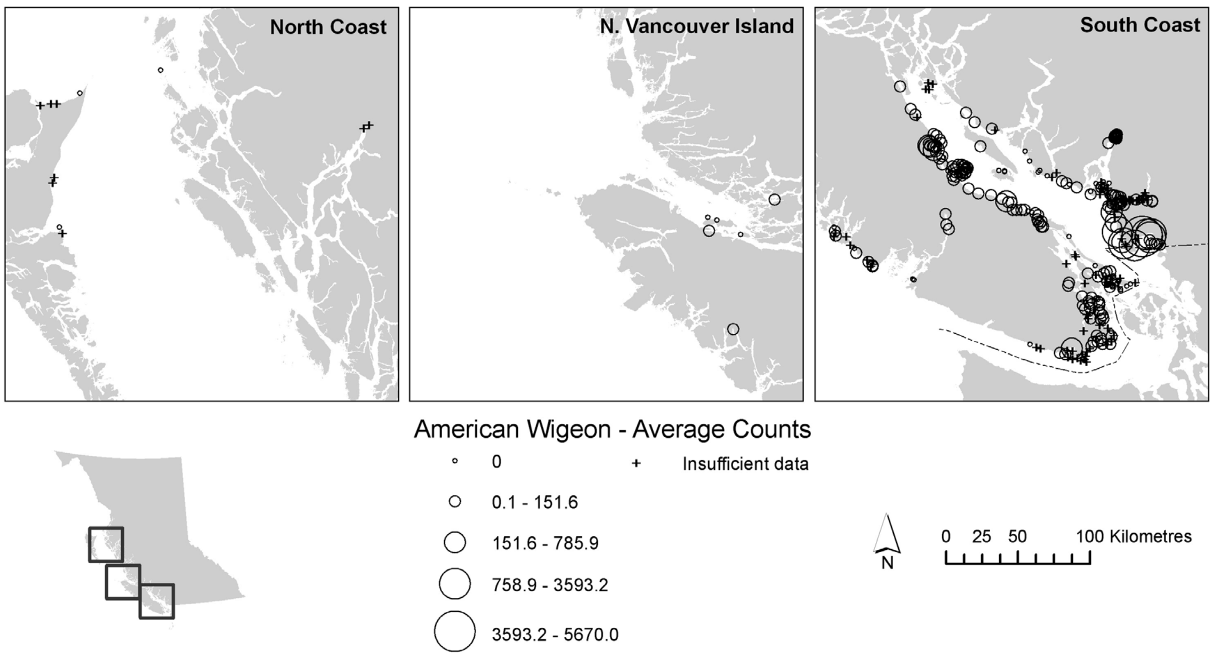


Figure 19. Northern Pintail: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 16.6% (95% C.I. = 6.1, 28.2). Inclusion of the variable “winter period” improved model fit (p = 0.0007).

American Wigeon *Anas americana*

American Wigeon are concentrated in the Fraser Delta, particularly in Boundary Bay, where tens of thousands over winter. There is an increasing trend to the population index.

a)



b)

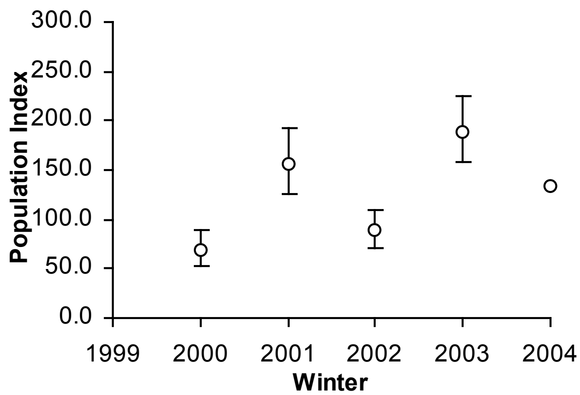
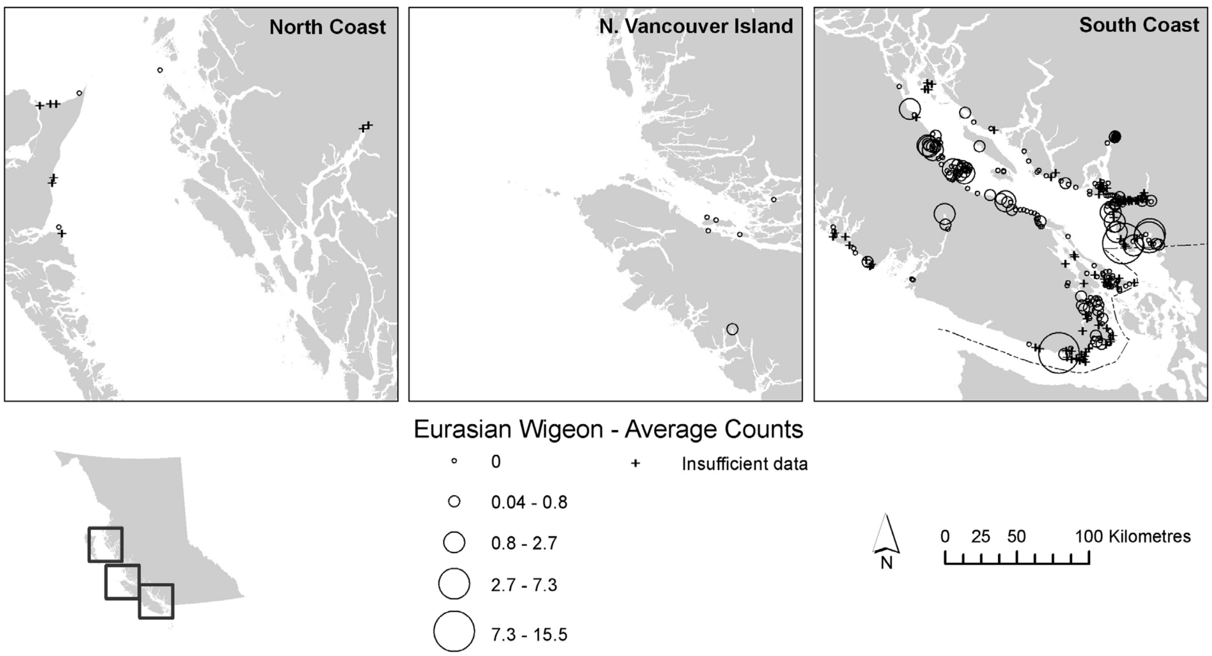


Figure 20. American Wigeon: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 13.5% (95% C.I. = 6.6, 20.9). Inclusion of the variable “winter period” improved model fit ($p < 0.0001$).

Eurasian Wigeon *Anas penelope*

Small numbers of Eurasian Wigeon are generally found with large flocks of American Wigeon, so the two species' distribution maps look very similar. There was an increasing trend in the population index, which may be a continuation of the long-term trend shown by British Columbia Christmas Bird Count data from 1959 to 1988, which indicated an annual increase of 2.9% (Sauer *et al*. 1996).

a)



b)

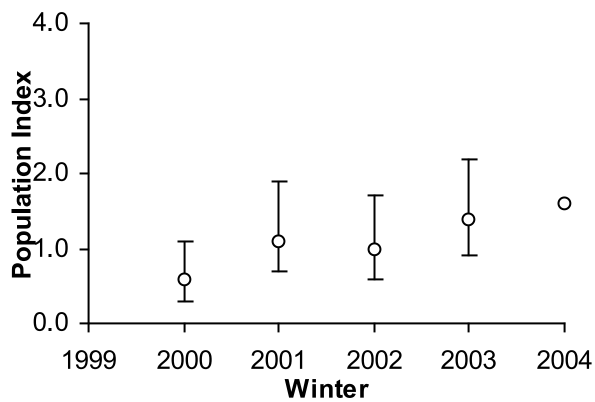
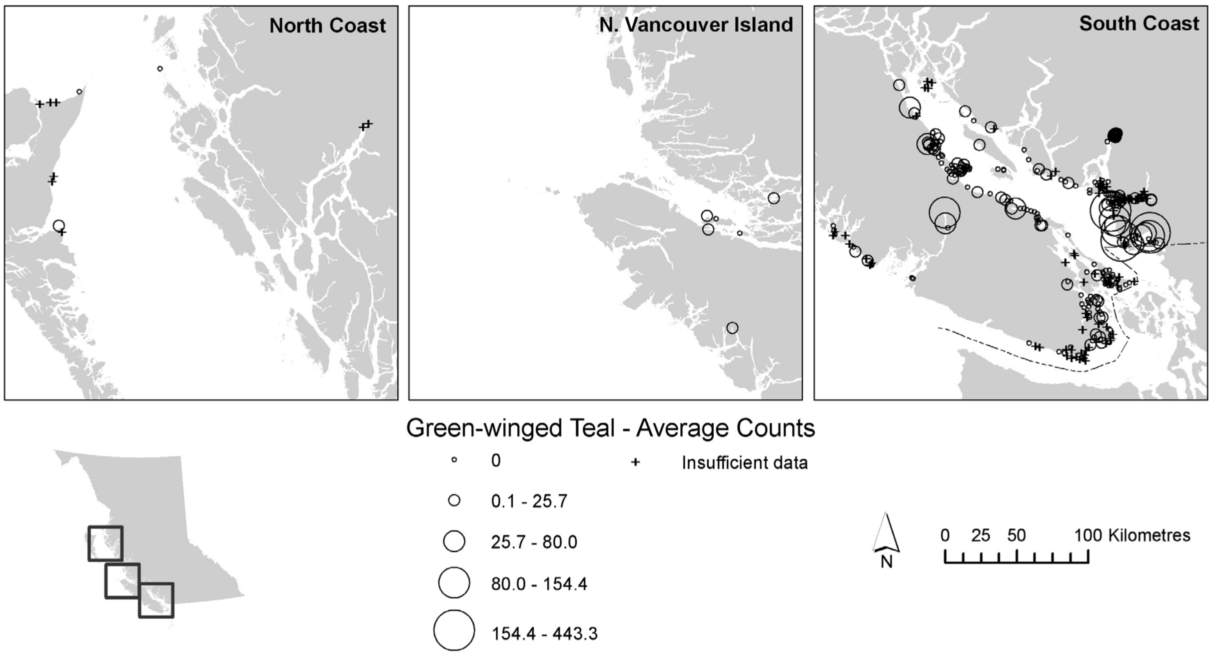


Figure 21. Eurasian Wigeon: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 24.0% (95% C.I. = 8.7, 41.4). Inclusion of the variable "winter period" improved model fit (*p* = 0.0010).

Green-winged Teal *Anas crecca*

Like most dabbling ducks, Green-winged Teal flock to the Fraser Delta and Boundary Bay. The highest number reported was 10,000 at Iona Island. There was no population trend apparent from BCCWS data. Christmas Bird Count data from British Columbia suggested an increasing trend from 1959 to 1988 (4.9% annually, Sauer *et al*. 1996).

a)



b)

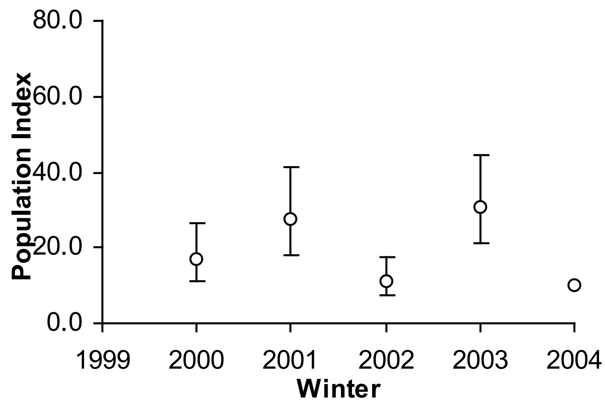
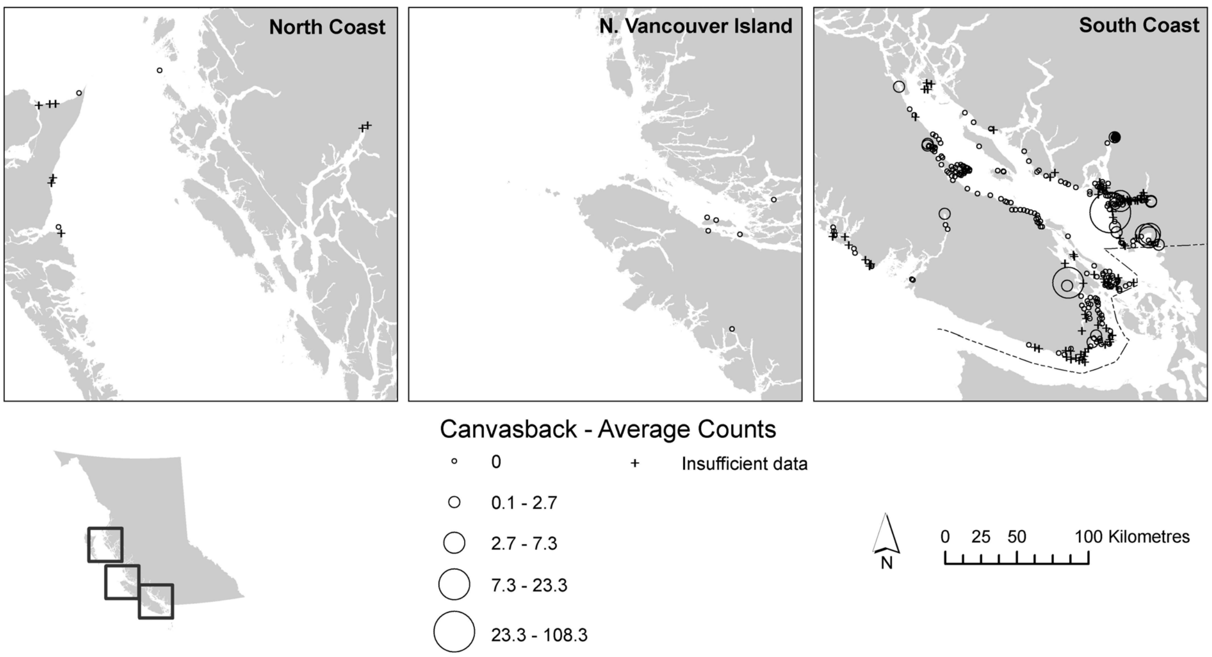


Figure 22. Green-winged Teal: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -8.1% (±95% C.I. = -18.4, 3.5). Inclusion of the variable “winter period” did not improve model fit (p = 0.0845).

Canvasback *Aythya valisineria*

Canvasbacks are uncommon ducks along the coast except around the Fraser Delta. Highest counts were at Lost Lagoon (510) and Iona Island (334). The low counts in the last year of the survey indicated a decreasing population trend for the five-year period. Long-term data from the Christmas Bird Count showed a stable wintering population in British Columbia from 1959 to 1988 (Sauer *et al*. 1996).

a)



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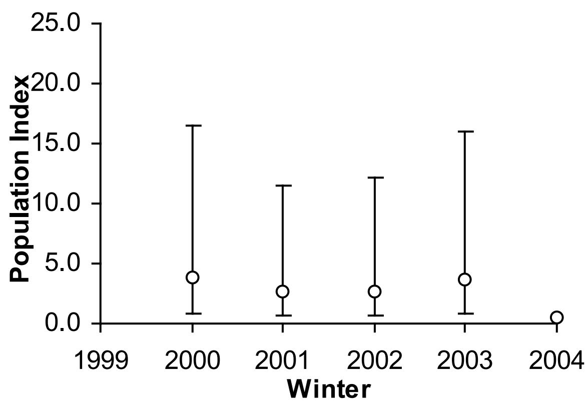
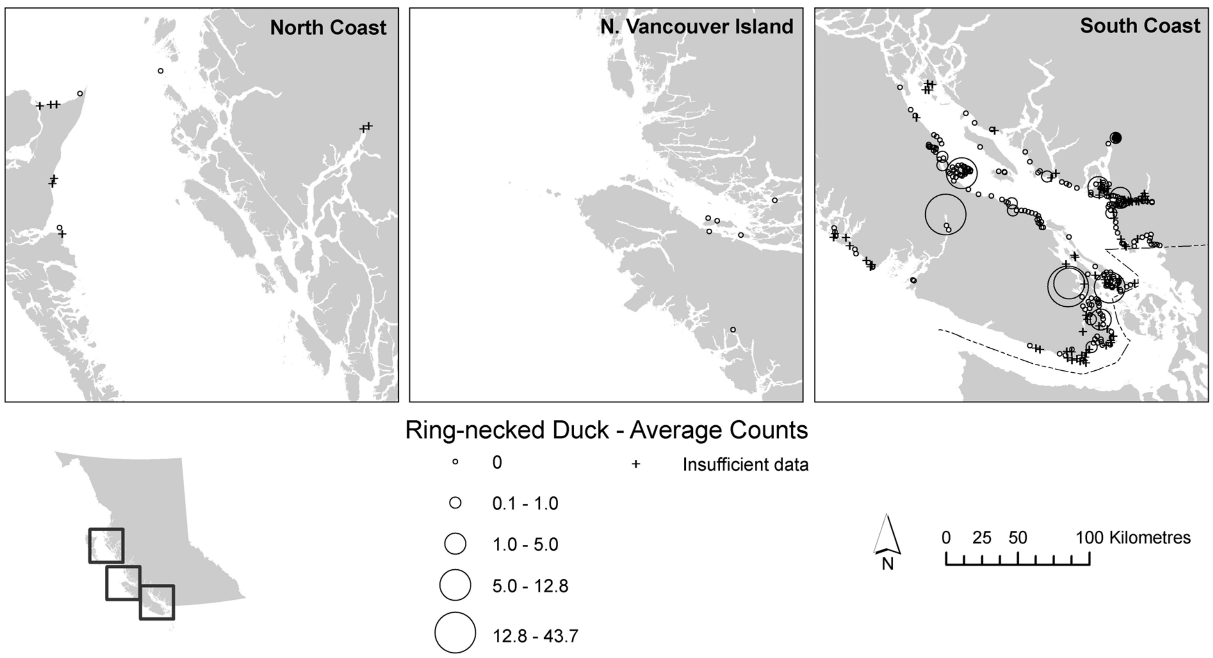


Figure 23. Canvasback: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -16.2% (95% C.I. = -28.5, -1.8). Inclusion of the variable “winter period” improved model fit (p = 0.0166).

Ring-necked Duck *Aythya fuligula*

The Ring-necked Duck is primarily a freshwater species; highest count from the survey was at Quamichan Lake (221). Other important sites were the Somass Estuary, Port Alberni and Beaver Lake, Hornby Island. There was no population trend, a result mirrored in British Columbia Christmas Bird Count data from 1959 to 1988 (Sauer *et al*. 1996).

a)



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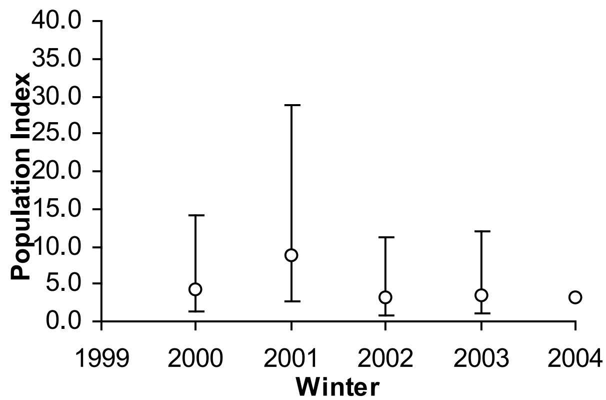
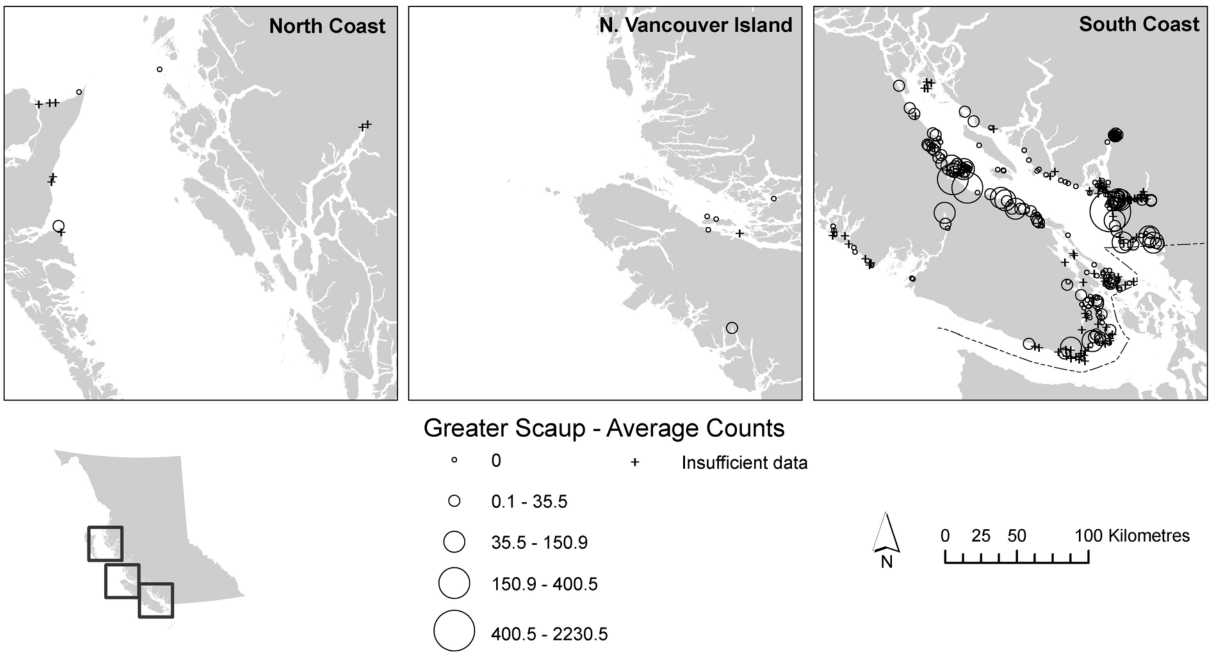


Figure 24. Ring-necked Duck: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -8.9% (95% C.I. = -26.0, 12.1). Inclusion of the variable “winter period” did not improve model fit (p = 0.3717).

<u>Greater Scaup</u> *Aythya marila*

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 decline for 1999-2004. Christmas Bird Count data from British Columbia from 1959 to 1988 also suggest a decline (4.4% annually, Sauer *et al*. 1996). The highest count was 6,900 at Iona, though usual numbers at that site are about one-tenth that. Other important sites are Nanoose Bay, Deep Bay and the Big Qualicum River estuary.

a)



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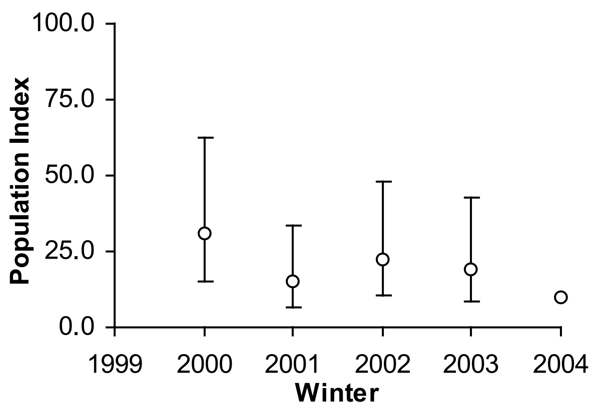
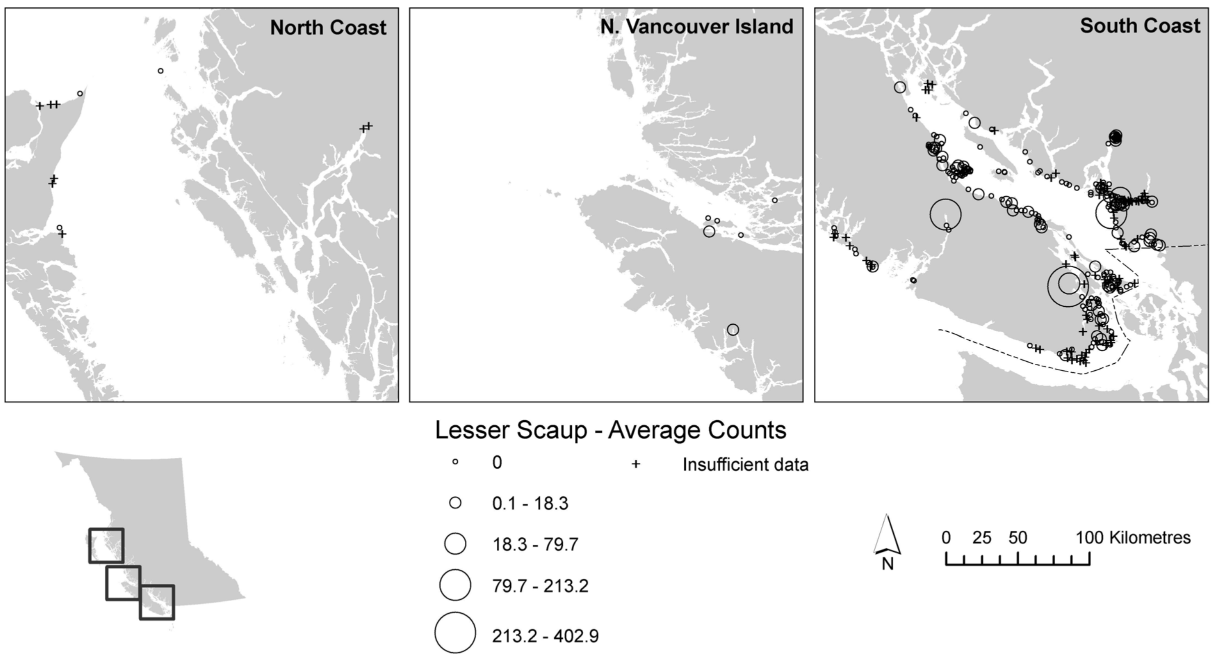


Figure 25. Greater Scaup: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -18.3% (95% C.I. = -29.3, -5.7). Inclusion of the variable “winter period” improved model fit (p = 0.0065).

Lesser Scaup *Aythya affinis*

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 (1,686), White Rock, West Promenade to 131st Street (900) and Iona Island (616). There was no population trend, and the Christmas Bird Count trend for British Columbia from 1959 to 1988 was also steady (Sauer *et al*. 1996).

a)



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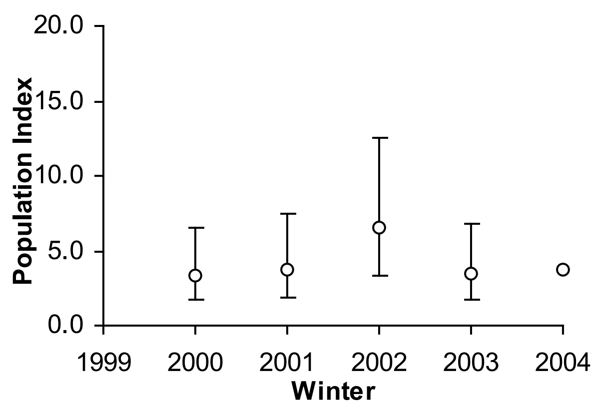


Figure 26. Lesser Scaup: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 5.4% (95% C.I. = -4.0, 15.6). Inclusion of the variable "winter period" did not improve model fit (*p* = 0.2249).

Harlequin Duck *Histrionicus histrionicus*

While Harlequins are found all along the coast, their highest numbers are clearly on the central part of the east coast of Vancouver Island. Highest numbers were recorded from Fillongley Provincial Park, Denman Island (871) and Middle Bay, Hornby Island (750). The population index apparently stable, as was the long-term Christmas Bird Count trend from 1959 to 1988 in British Columbia (Sauer *et al*. 1996).

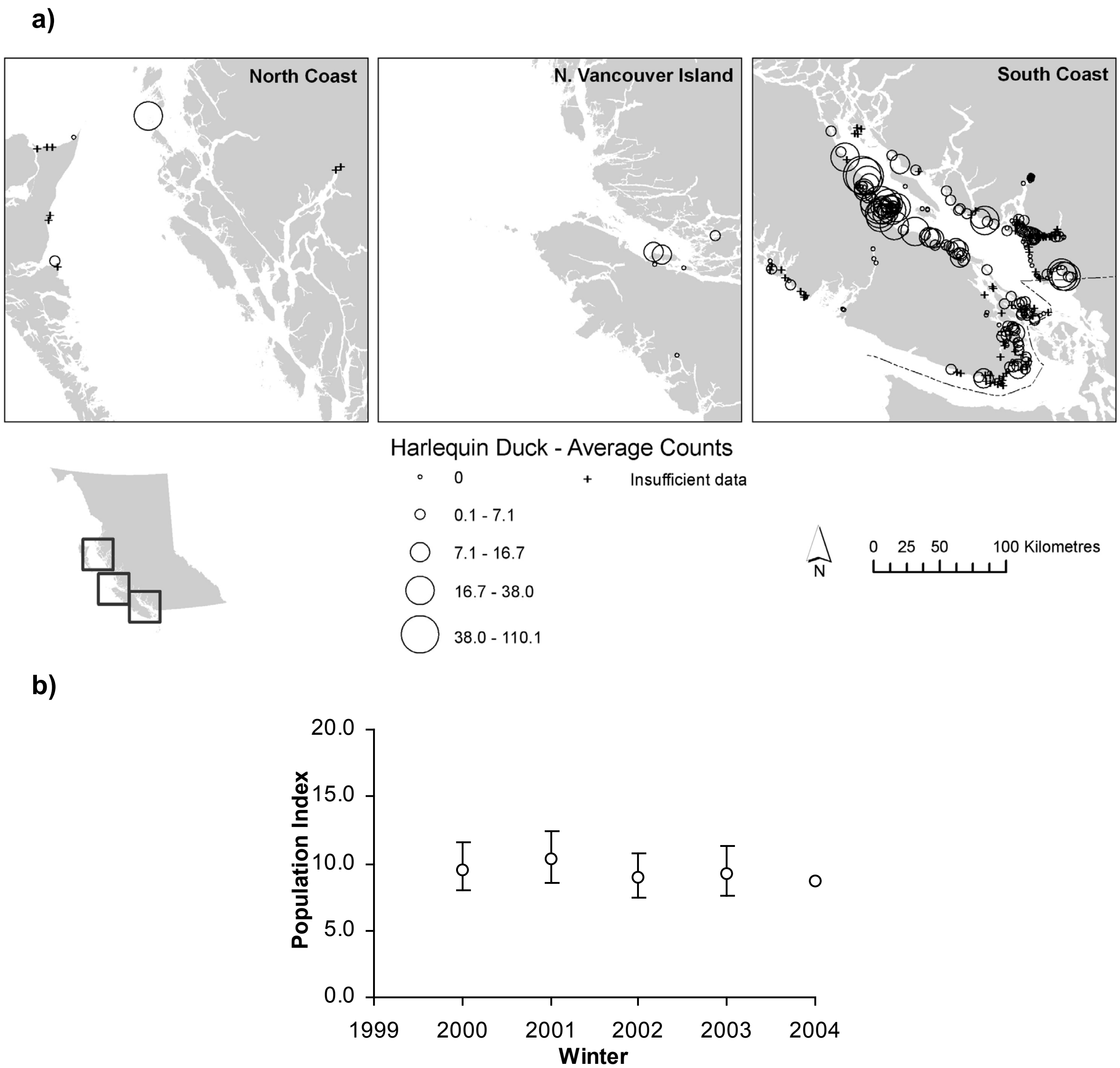
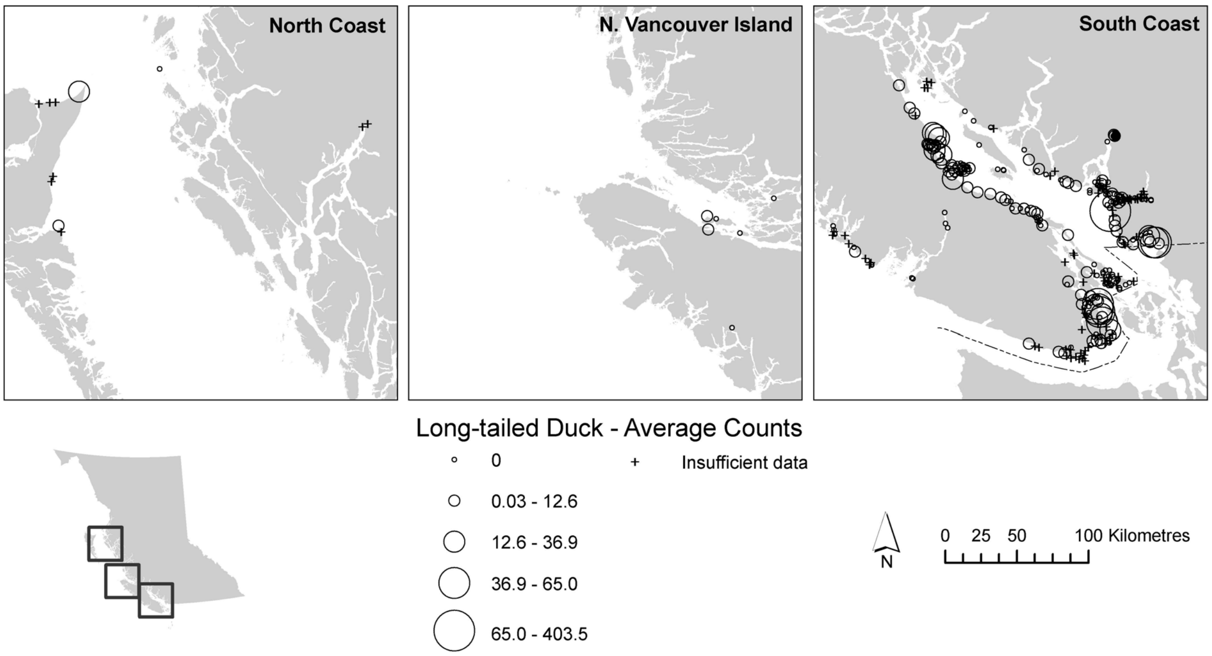


Figure 27. Harlequin Duck: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -2.9% (95% C.I. = -6.8, 1.3). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.1728).

Long-tailed Duck *Clangula hyemalis*

Numbers of wintering Long-tailed Duck show one of the strongest declining population trends of any species detected in this survey. This may be the continuation of a longer-term trend; Christmas Bird Count data from British Columbia from 1959 to 1988 show an annual decline of 4.8% (Sauer *et al*. 1996). High counts were from Iona Island (6,121) and Deep Bay (3,003).

a)



b)

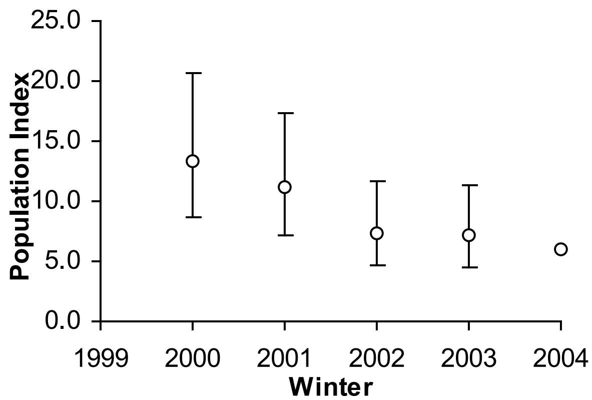
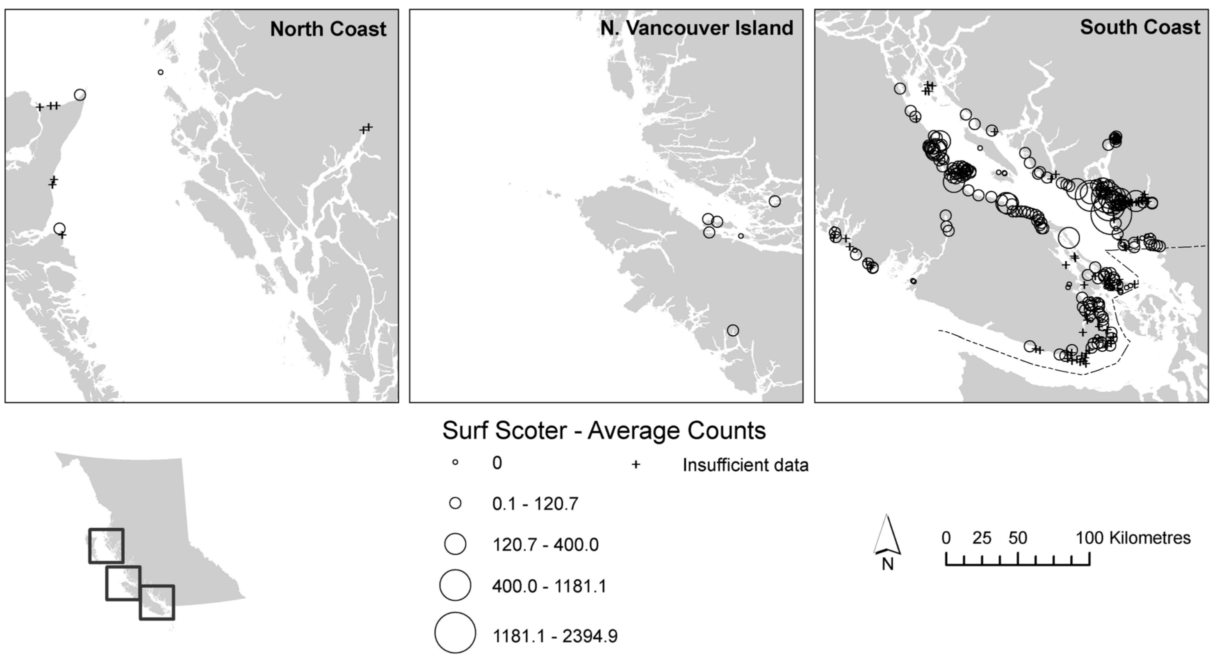


Figure 28. Long-tailed Duck: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -19.4% (95% C.I. = -26.2, -12.0). Inclusion of the variable “winter period” improved model fit ($p < 0.0001$).

Surf Scoter *Melanitta perspicillata*

Surf Scoters associate with Barrow's Goldeneyes along the British Columbia coast because both feed on mussels on rocky shores. They also gather at herring spawning sites in spring and can sometimes be seen in immense flocks in that season. Peak counts were of migrant flocks: 90,012 at Iona Island; 28,048 at the Englishman River estuary; 16,775 in Nanoose Bay; and 15,000 at Deep Bay. There was no significant population trend, although Christmas Bird Count data suggested that Surf Scoter numbers in British Columbia had previously decreased (by 2.4% annually) from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

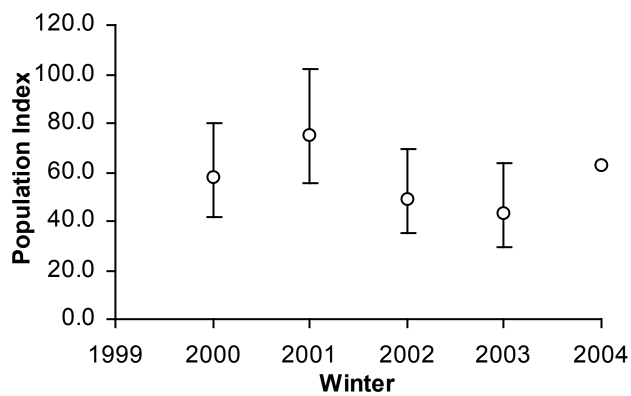
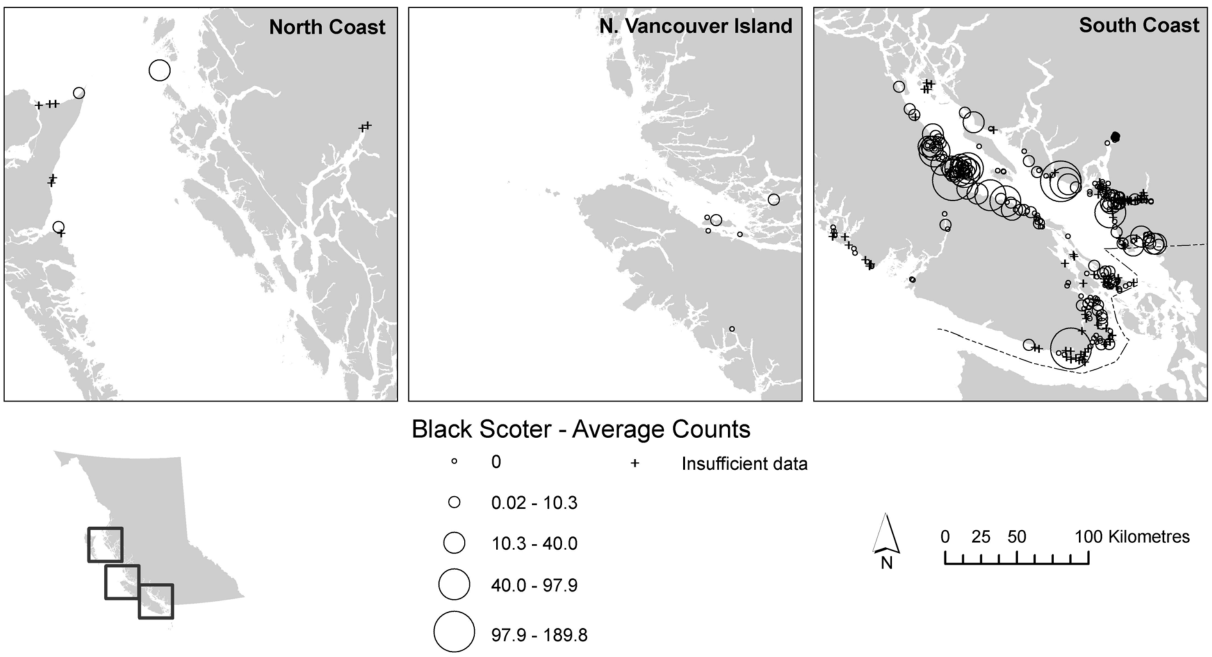


Figure 29. Surf Scoter: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -3.4% (95% C.I. = -10.7, 4.5). Inclusion of the variable "winter period" did not improve model fit (p = 0.3714).

<u>Black Scoter</u> *Melanitta nigra*

Black Scoters are locally common along the British Columbia coast, especially where sandy and gravelly bottoms hold clams and other bivalves. There was no clear population trend; highest numbers were at Icarus Point, Nanaimo (2,700), Roberts Creek north (1,130) and Iona Island (1,006). Christmas Bird Count data indicated a disturbing long-term decline in wintering Black Scoter numbers in British Columbia, with an annual decline of 3.1% between 1959 and 1988 (Sauer *et al*. 1996).

a)



b)

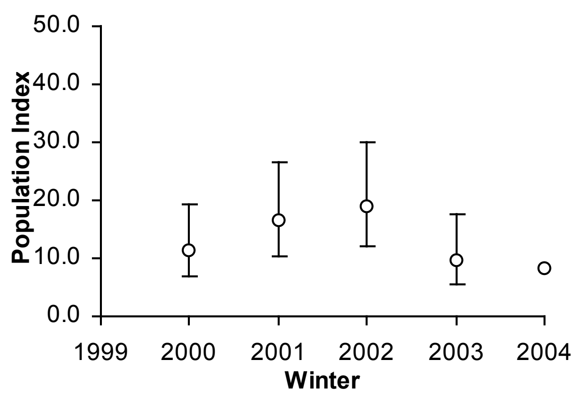
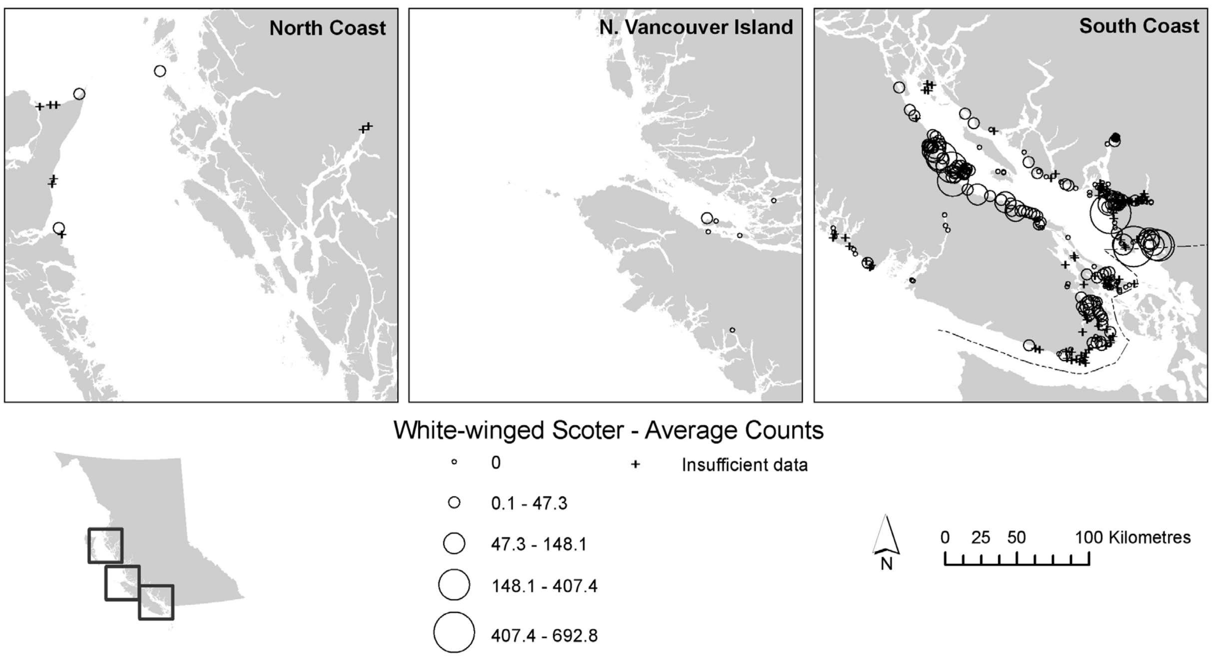


Figure 30. Black Scoter: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -8.2% (95% C.I. = -17.6, 2.3). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.1038).

White-winged Scoter *Melanitta fusca*

White-winged Scoters are generally found in sandy or gravely-bottomed bays. They migrate in large flocks, often appearing at herring spawn sites with other diving duck species. The highest counts were from Iona Island (migrating flocks): 12,111 and 10,020. Longbeak Point on Denman Island supported consistently high numbers. There was no population trend. From 1959 to 1988, Christmas Bird Count data suggested a 4.0% annual decline in White-winged Scoter numbers in British Columbia (Sauer *et al*. 1996).

a)



b)

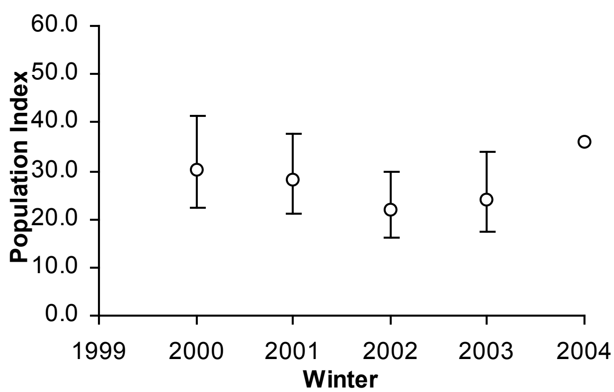
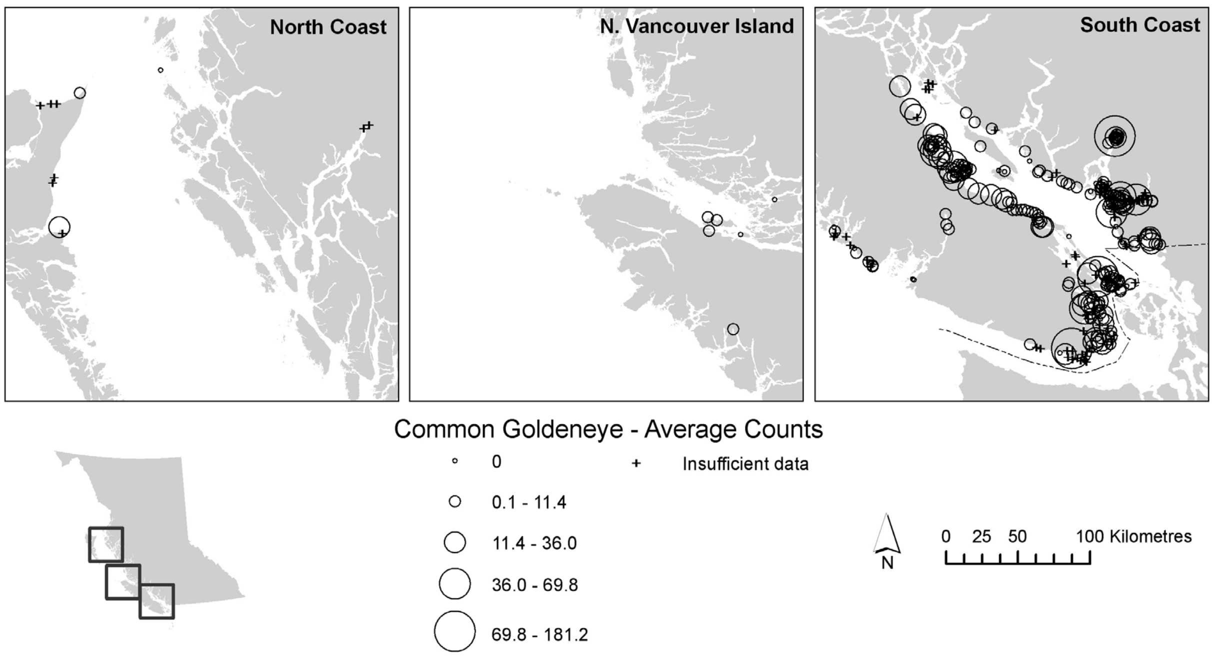


Figure 31. White-winged Scoter: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -0.3% (95% C.I. = -7.2, 7.1). Inclusion of the variable “winter period” did not improve model fit (p = 0.9284).

Common Goldeneye *Bucephala clangula*

Common Goldeneyes are found all along the coast with concentrations at river estuaries such as the Big Qualicum, Nanoose, Viner and Squamish. High counts were at the Big Qualicum River estuary (780) and Fillongley Provincial Park, Denman Island (670). There was no population trend. Christmas Bird Count data showed a significant annual decline in British Columbia of 2.4% from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

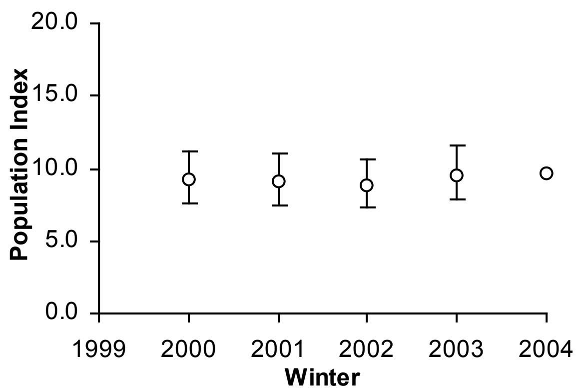
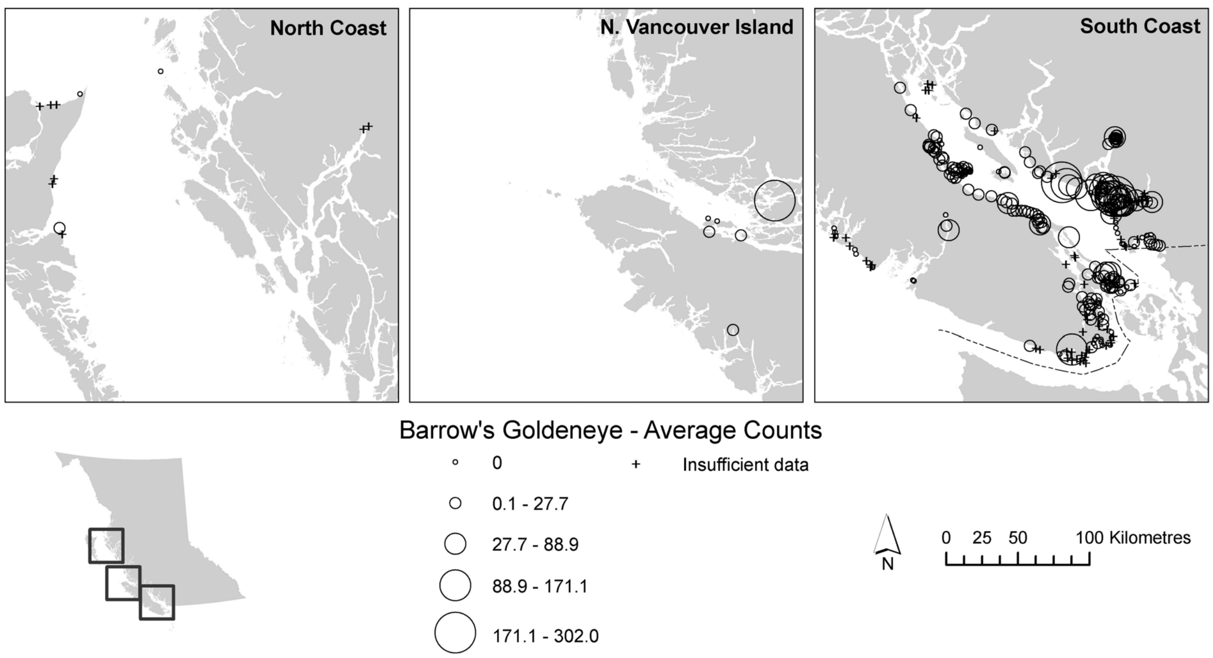


Figure 32. Common Goldeneye: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 1.3% (95% C.I. = -3.2, 6.0). Inclusion of the variable “winter period” did not improve model fit (p = 0.5686).

Barrow’s Goldeneye *Bucephala islandica*

Barrow’s Goldeneyes are concentrated along rocky shores on the mainland coast, particularly from the southern Sunshine Coast to Burrard Inlet, where they feed on mussels. The population index shows a downward trend over the five-year period, although this may be simply a return to normal levels after particularly high numbers were seen in 2001. The maximum count was from West Vancouver (2,012).

a)



b)

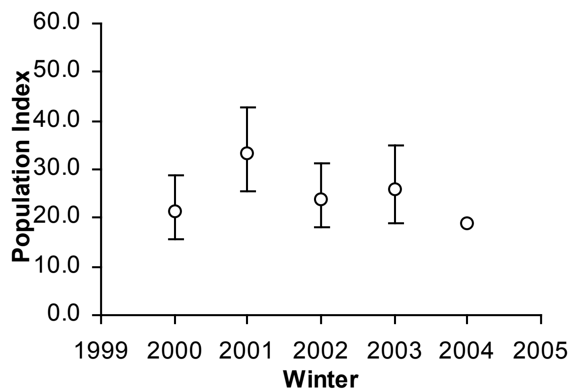
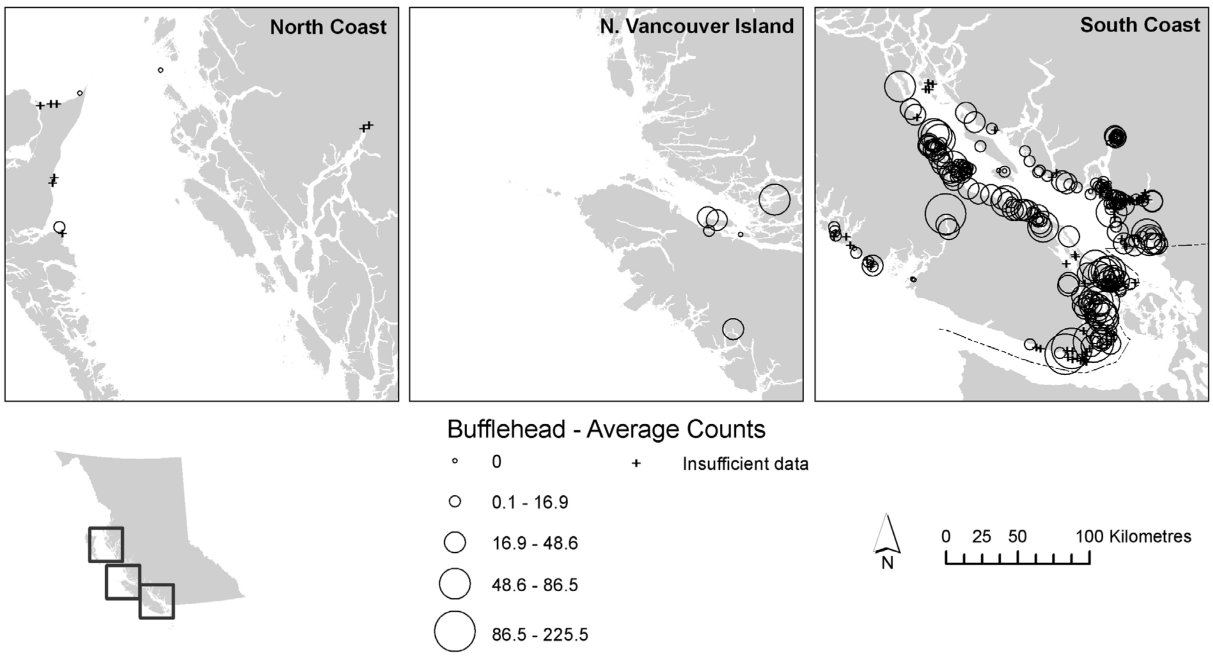


Figure 33. Barrow’s Goldeneye: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -6.9% (95% C.I. = -12.9, -0.5). Inclusion of the variable “winter period” improved model fit (p = 0.0275).

Bufflehead *Bucephala albeola*

Buffleheads are uniformly common up and down the coast with no distinct concentrations. The three highest counts were all from Fillongley Provincial Park, Denman Island, the maximum being 839. There was an increasing trend in the population index despite values falling in the final year of the five-year survey period. Christmas Bird Count results suggested a stable wintering population in British Columbia between 1959 and 1988 (Sauer *et al*. 1996).

a)



b)

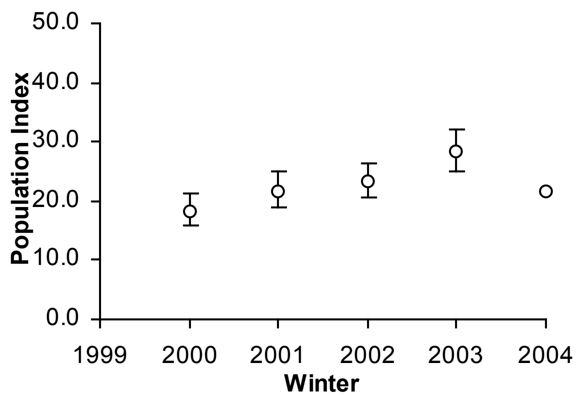
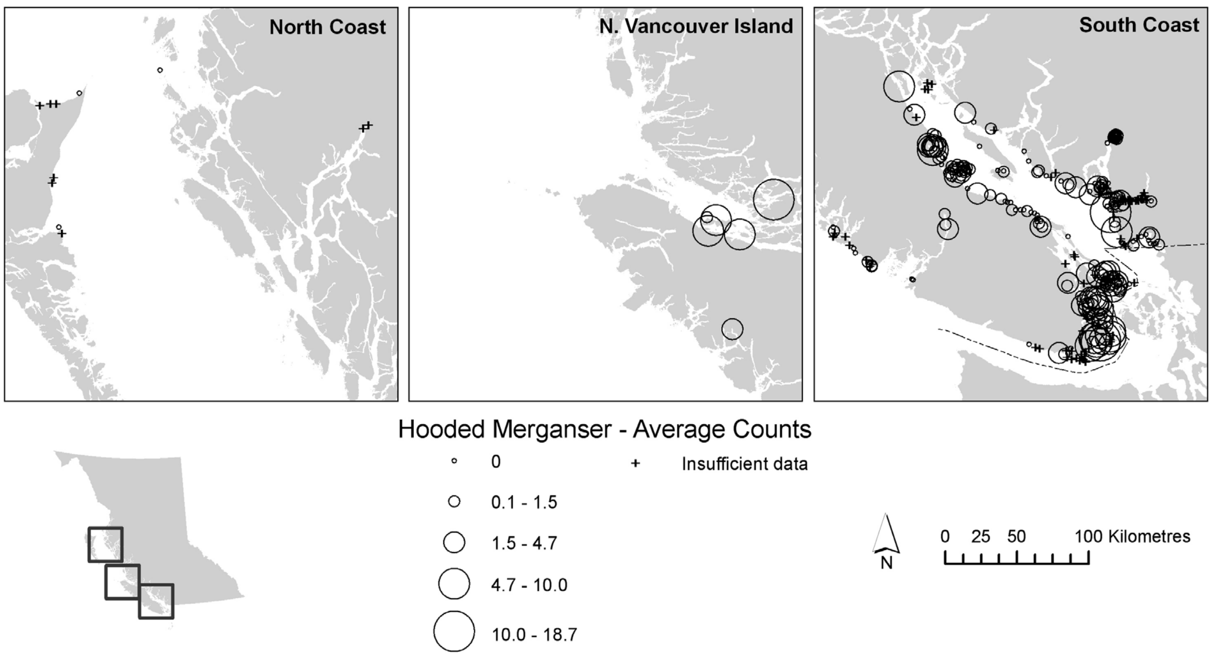


Figure 34. Bufflehead: **a)** Relative abundance of at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 5.5% (95% C.I. = 2.1, 9.1). Inclusion of the variable “winter period” improved model fit (p = 0.0008).

<u>Hooded Merganser</u> *Lophodytes cucullatus*

This species was widespread in small numbers along the South and Vancouver Island coasts, but there were almost no records from the north coast. Highest numbers were on the east coast of Vancouver Island, where 245 were seen on Quamichan Lake. There was no population trend, and the Christmas Bird Count trend for British Columbia from 1959 to 1988 was steady as well (Sauer *et al*. 1996).

a)



b)

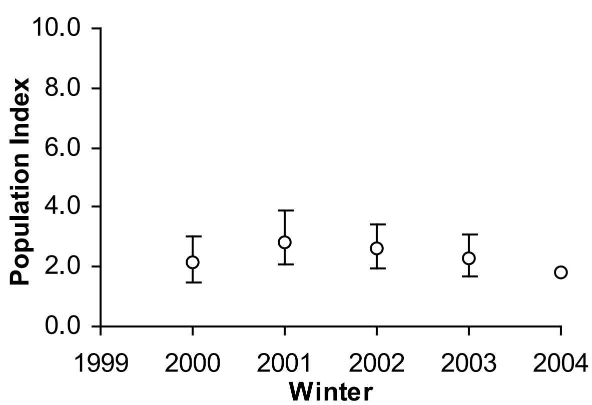
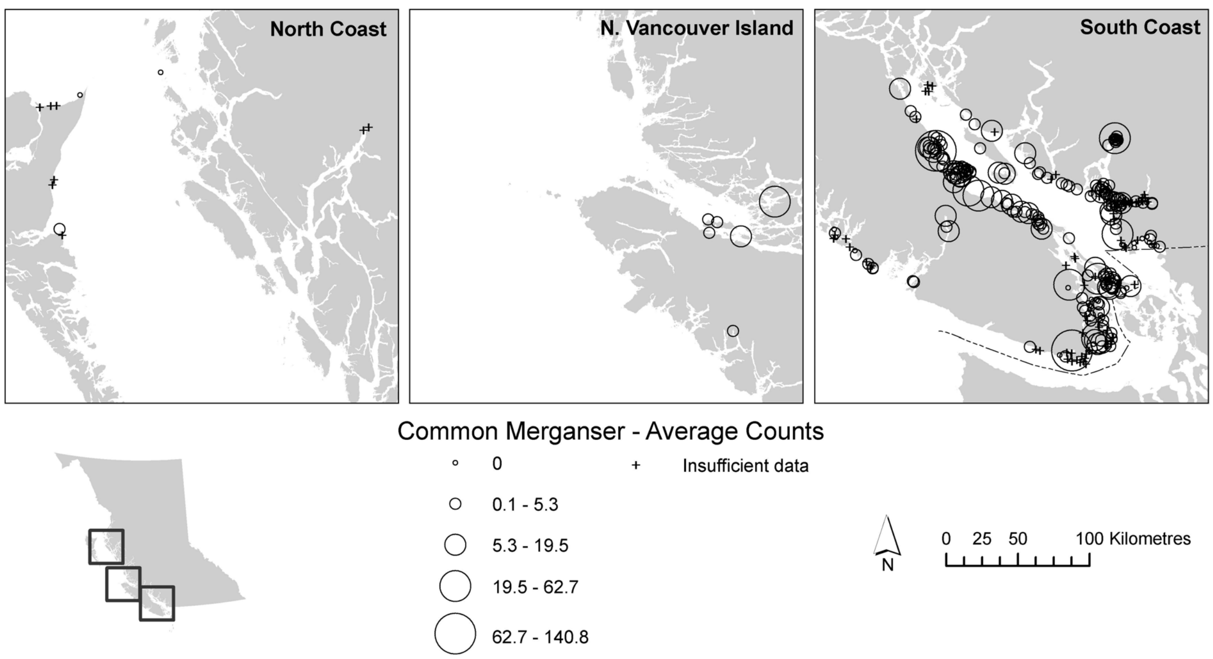


Figure 35. Hooded Merganser: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -6.5% (95% C.I. = -13.3, 0.9). Inclusion of the variable “winter period” improved model fit (p = 0.0819).

Common Merganser *Mergus merganser*

Common Mergansers were found all along the coast. The largest concentrations occur 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 Quamichan Lake (1,950) with other important concentrations in the Squamish delta, Victoria waterfront, Sooke Basin and Comox Bay Farm. There was no population trend. Long-term data from the Christmas Bird Count also showed a stable wintering population in British Columbia from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

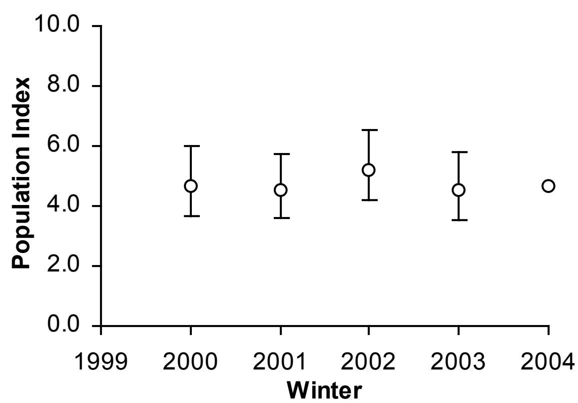
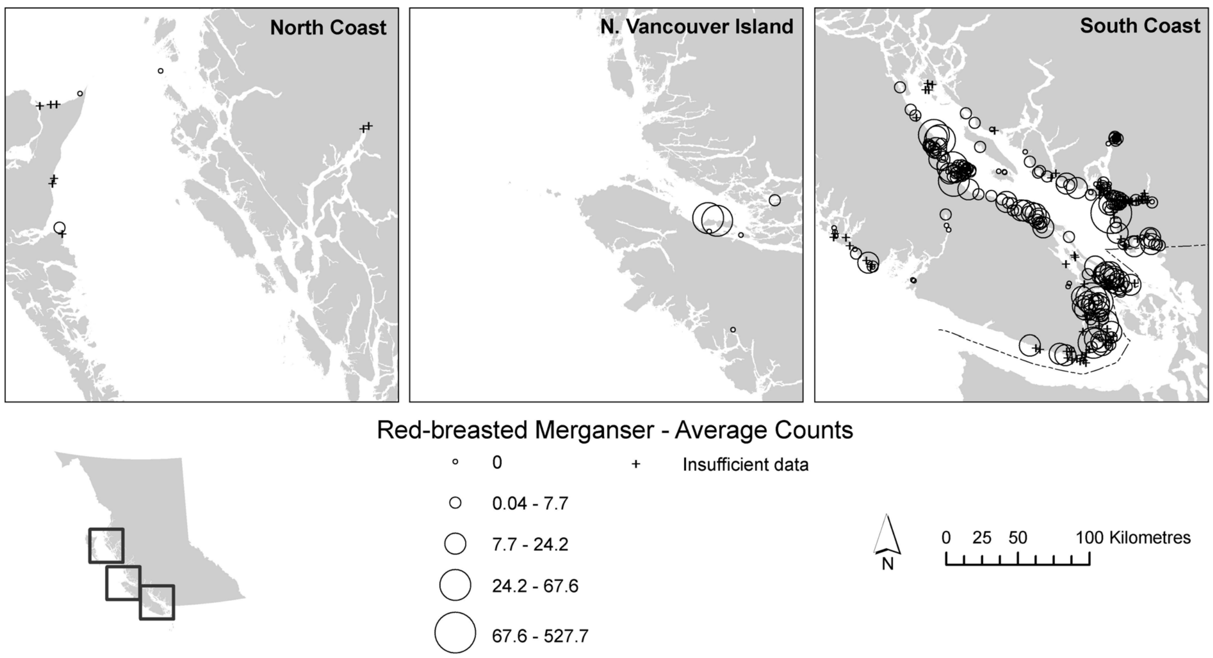


Figure 36. Common Merganser: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -0.1% (95% C.I. = -5.4, 5.6). Inclusion of the variable “winter period” did not improve model fit (p = 0.9730).

Red-breasted Merganser *Mergus serrator*

Red-breasted Mergansers have much more affinity to salt water in winter than do Common Mergansers. They occur 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 (6,700). No population trend was apparent, a result mirrored in British Columbia Christmas Bird Count data from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

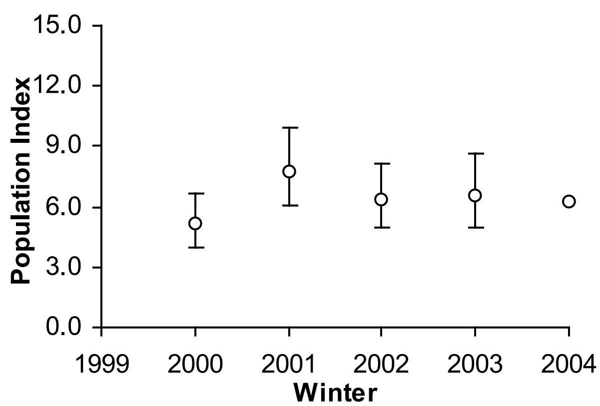


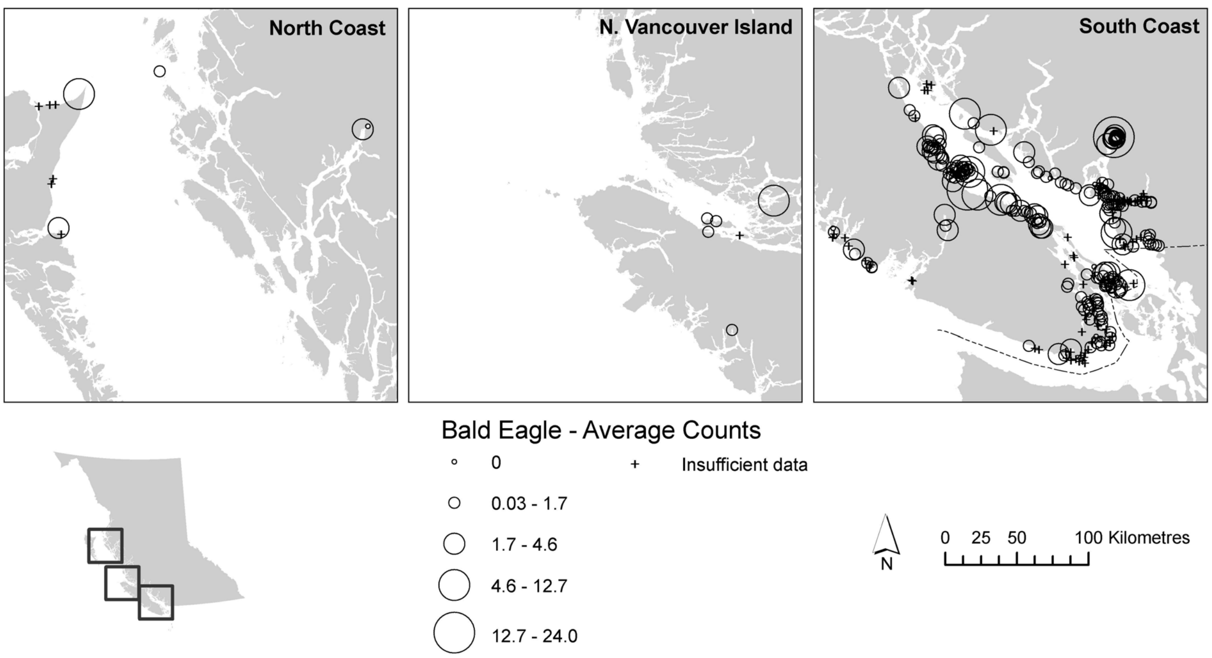
Figure 37. Red-breasted Merganser: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 4.3% (95% C.I. = -1.9, 10.9). Inclusion of the variable “winter period” did not improve model fit (p = 0.1678).

Raptors

Bald Eagle *Haliaeetus leucocephalus*

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 downward trend. While conventional wisdom says that this species was steadily increasing in the Strait of Georgia in winter, recent Christmas Bird Count point to a stabilization or possible decline over the last 10 years. Maximum counts were at Squamish River (161), Big Qualicum Estuary (100) and Helliwell Park, Hornby Island (100).

a)



b)

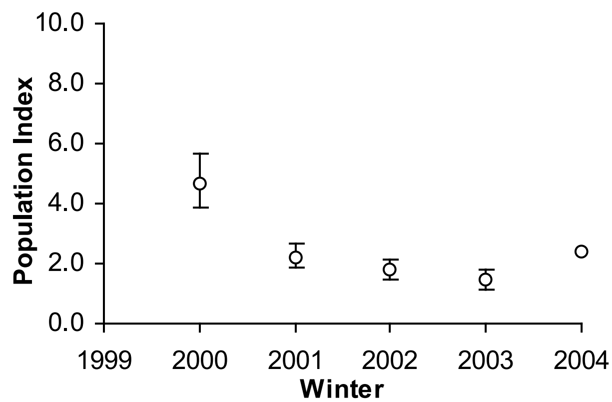
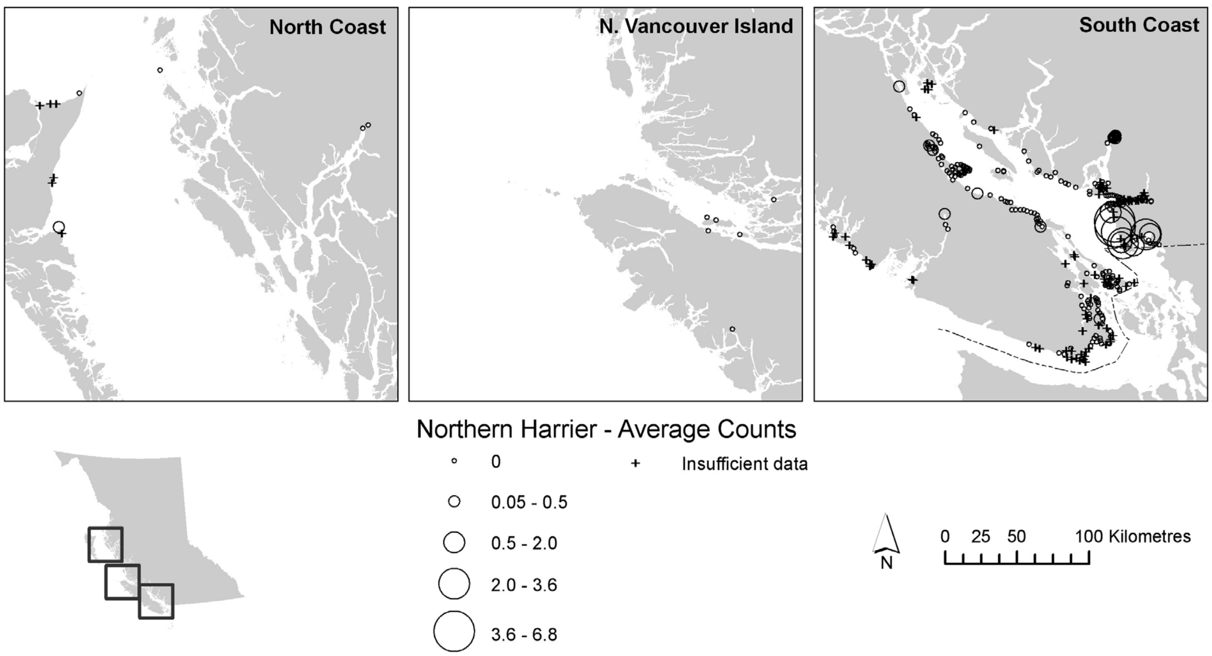


Figure 38. Bald Eagle: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -13.9% (95% C.I. = -18.3, -9.3). Inclusion of the variable “winter period” improved model fit (*p* <0.0001).

Northern Harrier *Circus cyaneus*

These graceful hawks are strongly tied to old-field habitats of the Fraser Delta, where they are common winter visitors. They are 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 count of 11 birds and a mean of 8. There was no population trend.

a)



b)

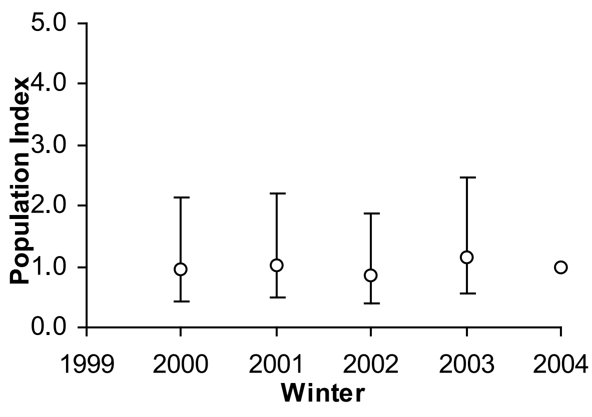
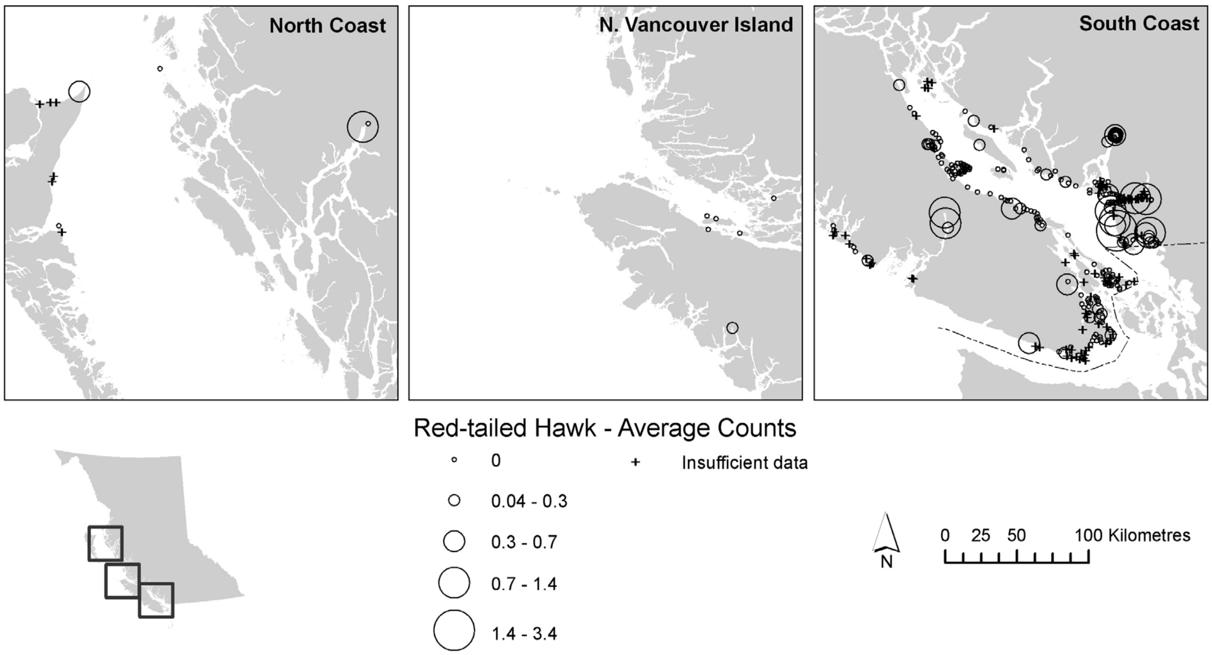


Figure 39. Northern Harrier: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 1.3% (95% C.I. = -15.4, 21.4). Inclusion of the variable "winter period" did not improve model fit (p = 0.8903).

Red-tailed Hawk *Buteo jamaicensis*

Red-tailed Hawks winter around old-field habitats on the coast, especially those on the Fraser Delta. Highest count was 12 at Iona Island. There was a downward trend in the population index. Christmas Bird Count data indicate an earlier (1959-1988) increase in wintering Red-tailed Hawks in British Columbia (4.1% annually, Sauer *et al*. 1996).

a)



b)

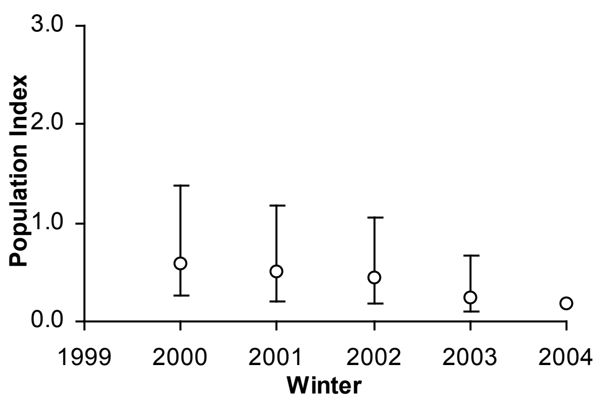


Figure 40. Red-tailed Hawk: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -23.4% (95% C.I. = -35.0, -9.8). Inclusion of the variable "winter period" improved model fit (p = 0.0013).

Peregrine Falcon *Falco peregrinus*

Peregrine Falcons winter chiefly in the Fraser Delta and Boundary Bay area, also on the east coast of Queen Charlotte Islands. Numbers were low and no population trend was evident from the data.

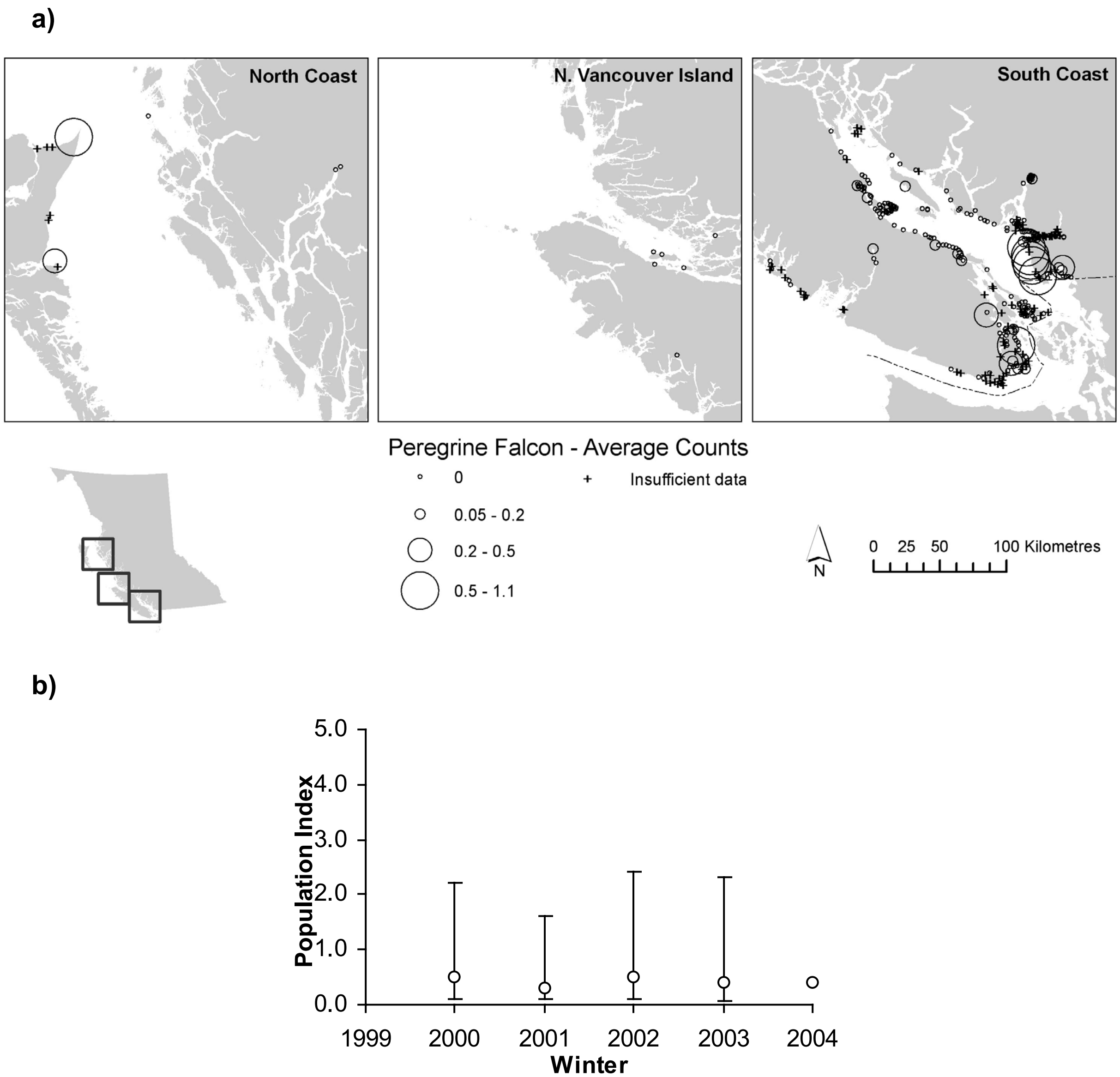


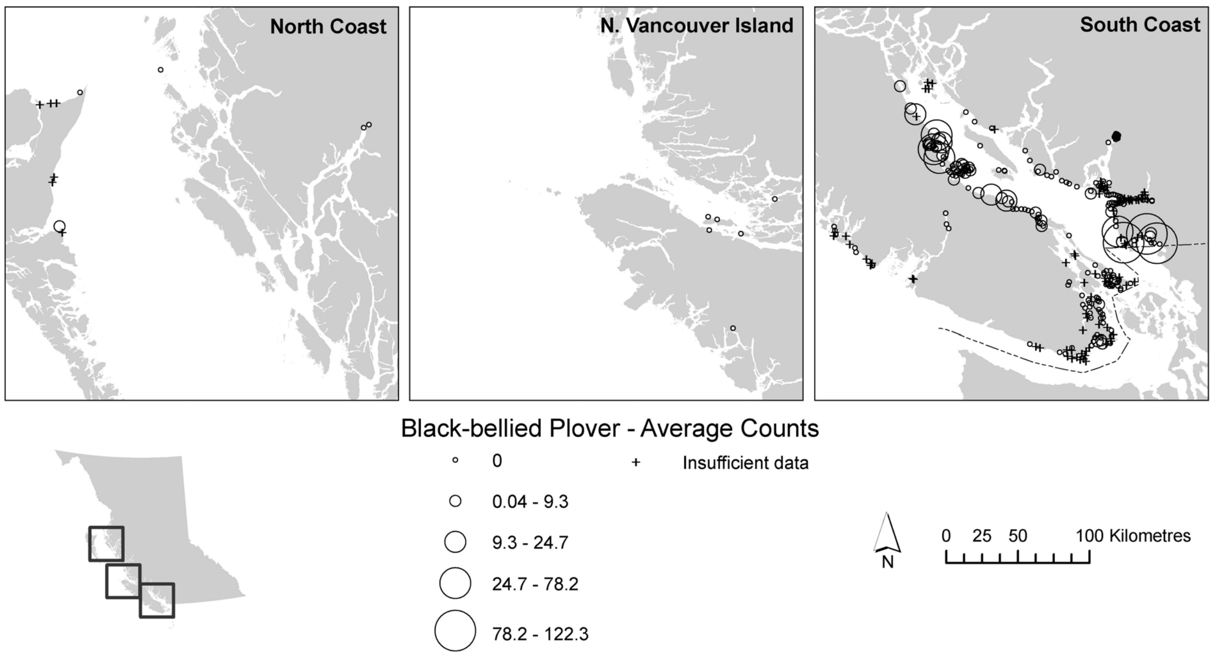
Figure 41. Peregrine Falcon: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -2.0% (95% C.I. = -32.2, 41.5). Inclusion of the variable “winter period” did not improve model fit (*p* = 0.9162).

Shorebirds

Black-bellied Plover *Pluvialis squatarola*

Black-bellied Plovers concentrated on the mudflats of Boundary Bay, although highest numbers were recorded at Blackie Spit, White Rock (8,000). There was no population trend.

a)



b)

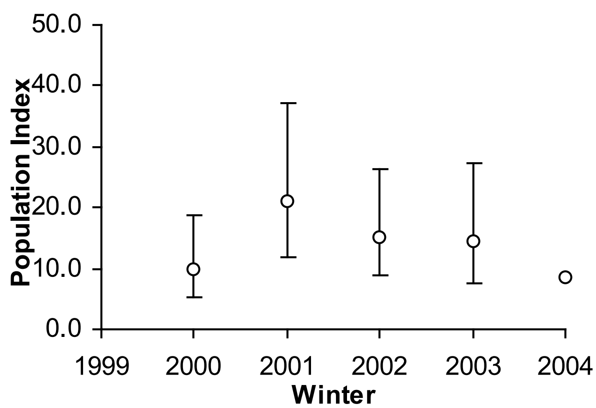
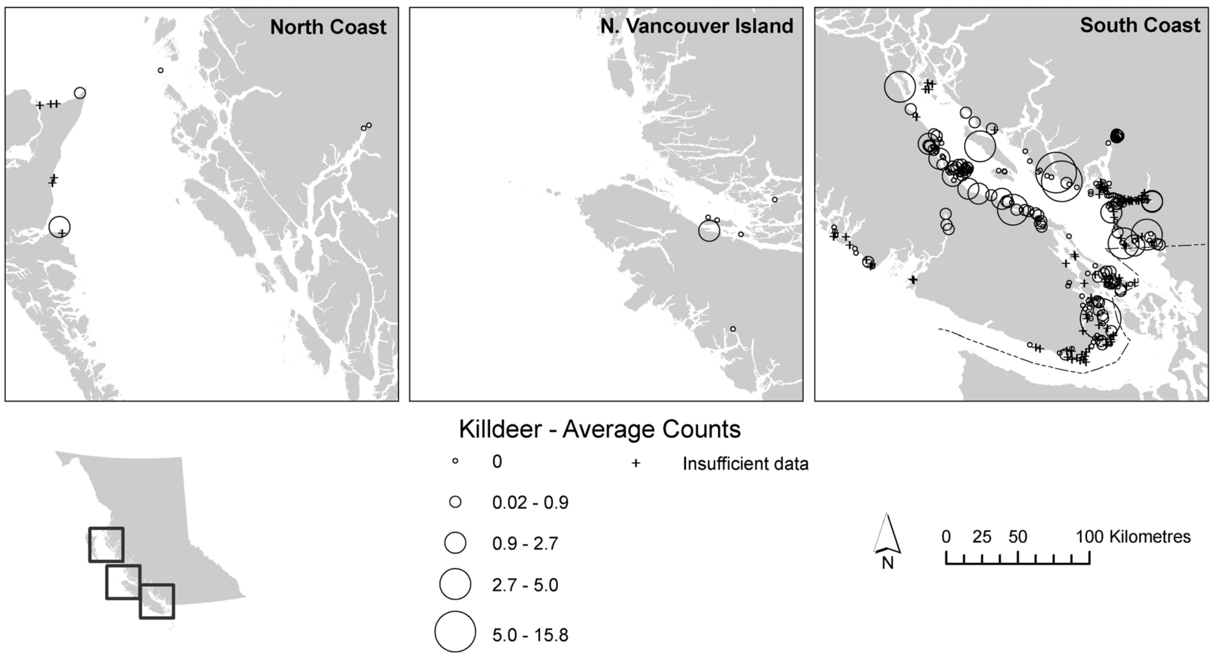


Figure 42. Black-bellied Plover: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -6.0% (95% C.I. = -17.1, 6.5). Inclusion of the variable “winter period” did not improve model fit (p = 0.3203).

<u>Killdeer</u> *Charadrius vociferus*

Widespread in small numbers up and down the coast. Highest counts came from one of the few inland survey sites, Martindale Flats, on the Saanich Peninsula (62). There was an apparent decline during the survey period, a trend mirrored by results from the Breeding Bird Survey (1999-2004 annual trend -12.8%, Downes *et al*. 2005) and the Christmas Bird Count (1959-1988, annual trend -5.6%, Sauer *et al*. 1996).

a)



b)

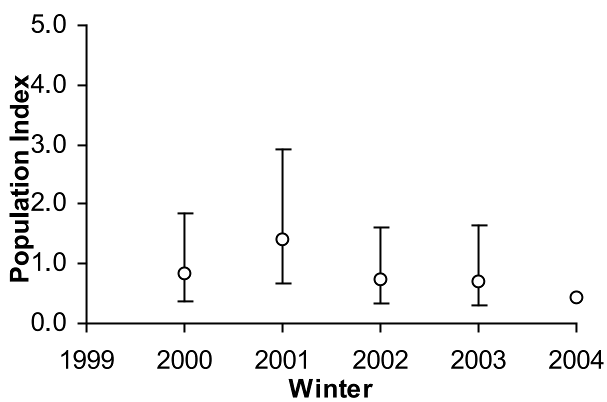
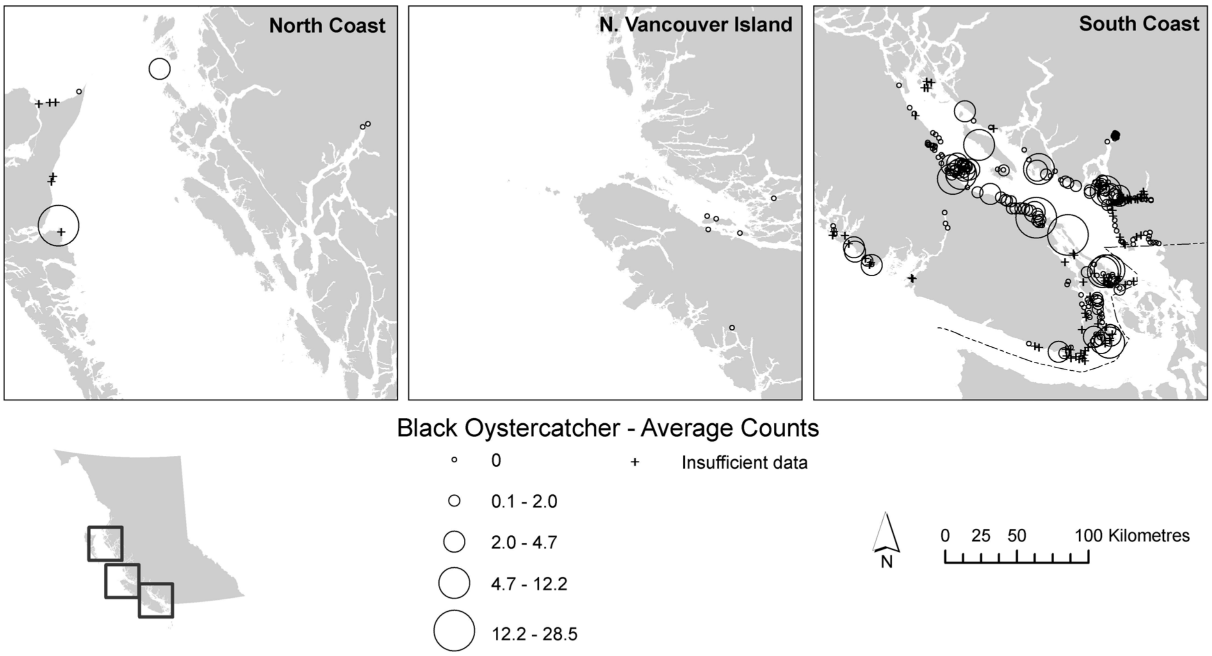


Figure 43. Killdeer: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -16.7% (95% C.I. = -28.8, -2.5). Inclusion of the variable “winter period” improved model fit (p = 0.0216).

Black Oystercatcher *Haematopus bachmani*

Oystercatchers were concentrated in eastern Vancouver Island and the Skidegate Inlet area. There was no population trend during the survey period, 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).

a)



b)

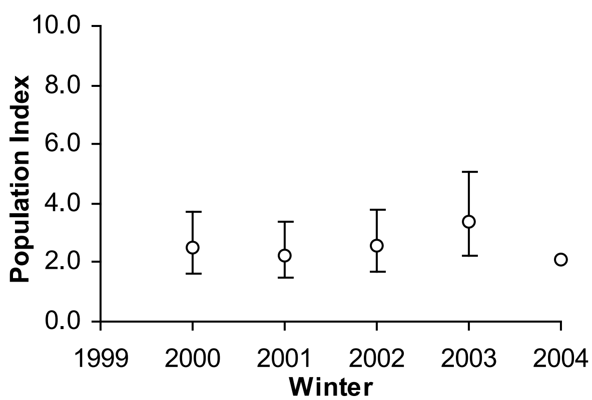
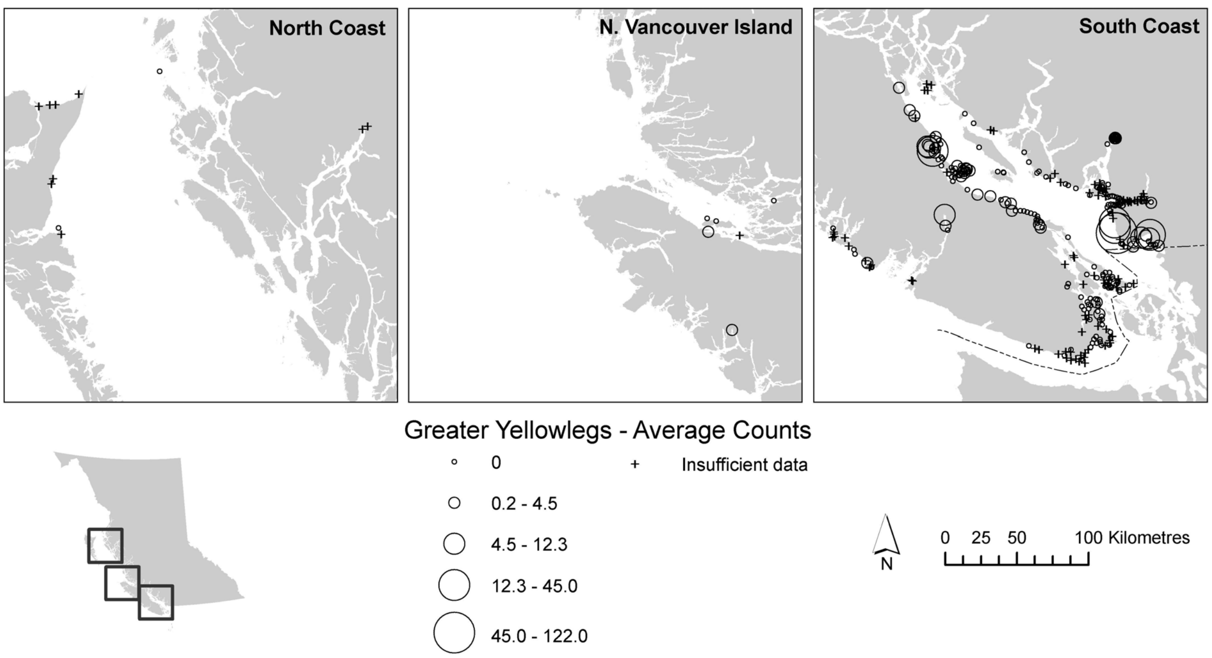


Figure 44. Black Oystercatcher: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 0.3% (95% C.I. = -8.4, 9.8). Inclusion of the variable "winter period" did not improve model fit (p = 0.9456).

Greater Yellowlegs *Tringa melanoleuca*

Like most mud-loving shorebirds, yellowlegs concentrate around the Fraser Delta and Boundary Bay. There is an apparent increasing trend. This species winters in British Columbia in low numbers, so the population as a whole, which comprises a large migratory population, may not be particularly well monitored by a survey such as this. Highest numbers were at Reifel (238), Blackie Spit (115) and Roberts Creek North (115).

a)



b)

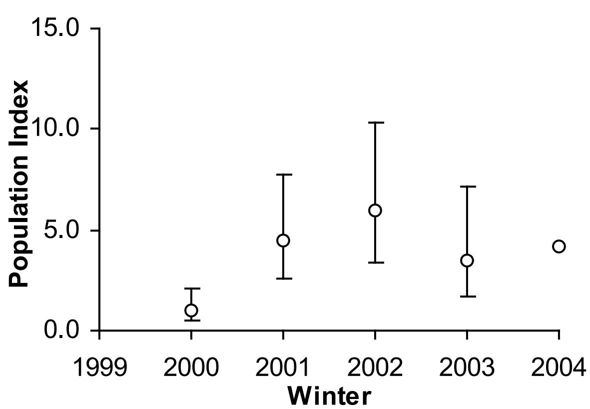
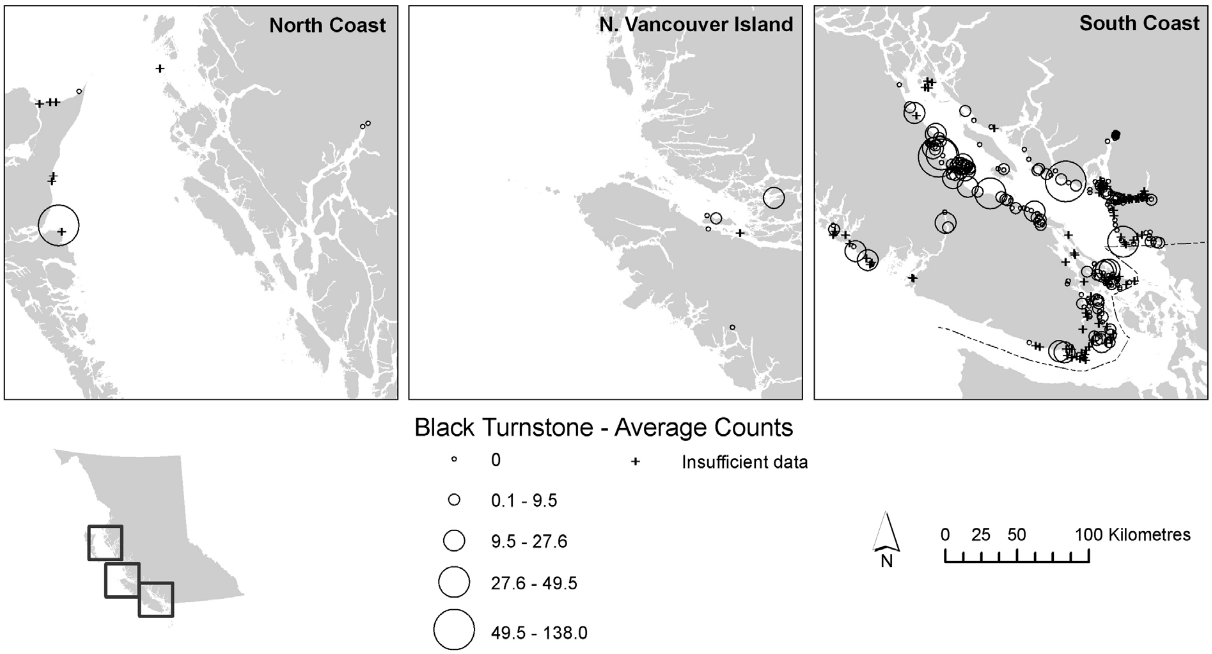


Figure 45. Greater Yellowlegs: a) Relative abundance at all BCCWS sites 1999-2004. b) Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 23.5% (95% C.I. = 7.2, 42.3). Inclusion of the variable "winter period" improved model fit (p = 0.0022).

Black Turnstone *Arenaria melanocephala*

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

a)



b)

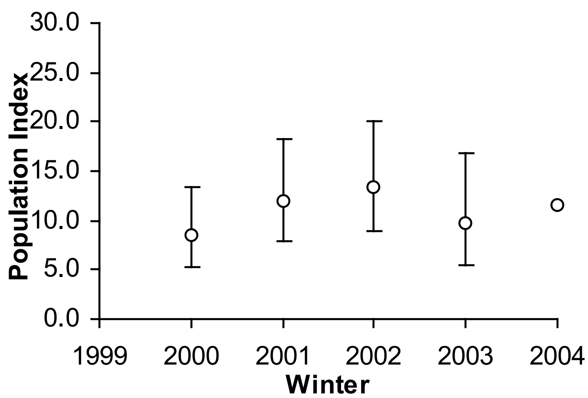
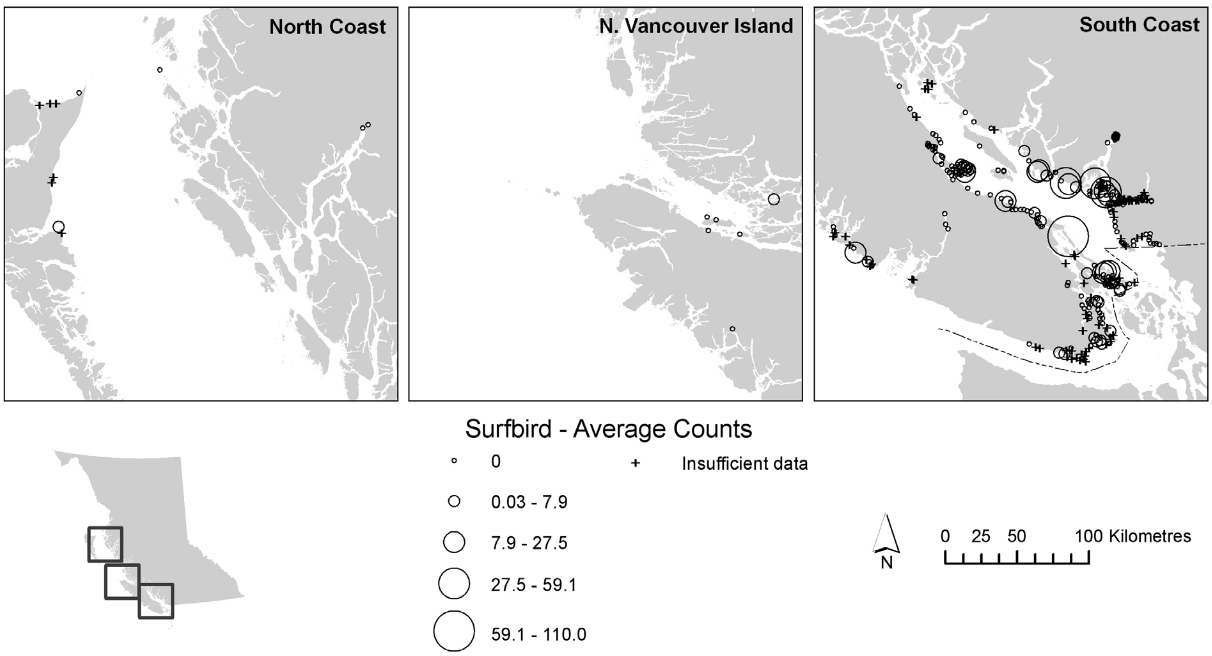


Figure 46. Black Turnstone: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 4.6% (95% C.I. = -5.6, 15.8). Inclusion of the variable “winter period” did not improve model fit (p = 0.3901).

<u>Surfbird</u> *Aphriza virgata*

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

a)



b)

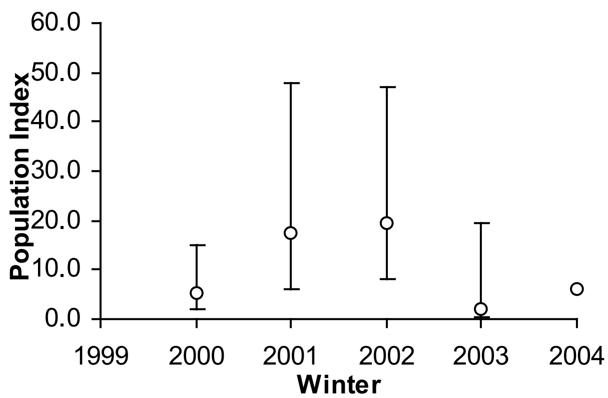
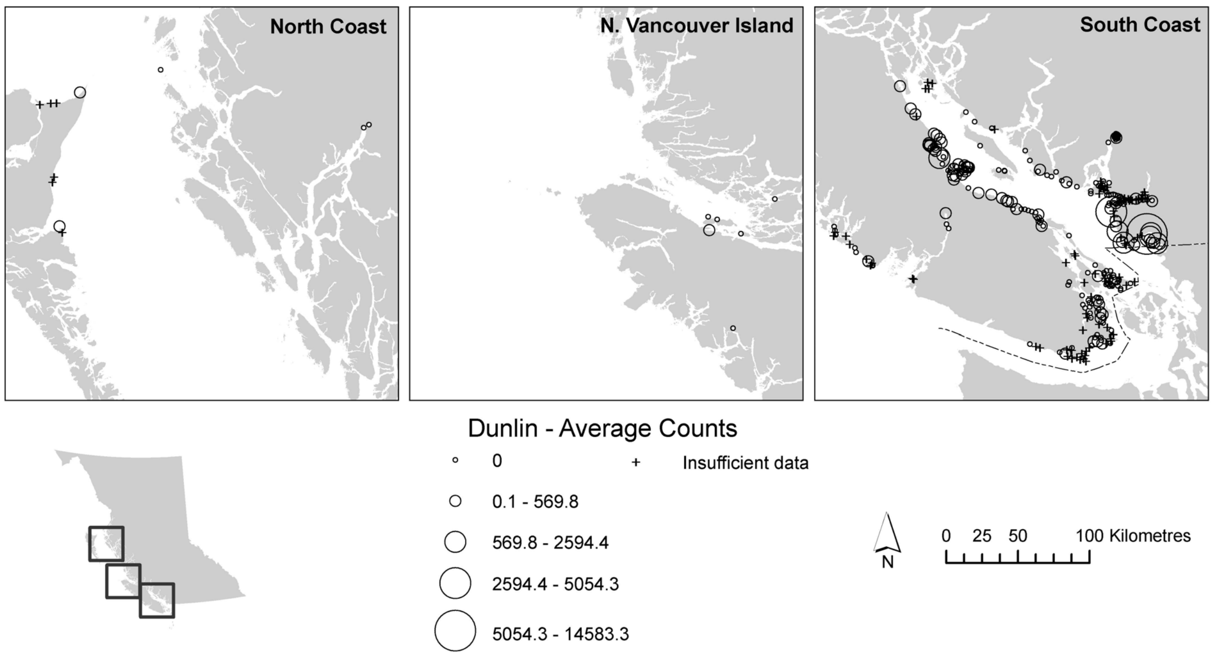


Figure 47. Surfbird: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -3.2% (95% C.I. = -23.2, 22.0). Inclusion of the variable “winter period” did not improve model fit (p = 0.7532).

Dunlin *Calidris alpina*

Dunlin were concentrated in the Fraser Delta, especially in Boundary Bay. There were no significant population trends. The highest counts were at 12th St to 64th St, Boundary Bay (60,000), and near 112th St., Boundary Bay (30,000).

a)



b)

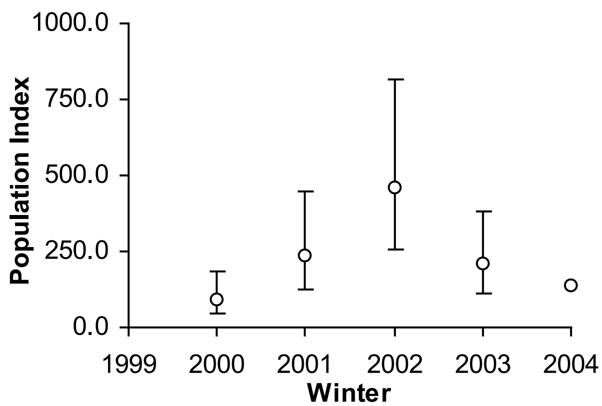


Figure 48. Dunlin: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 10.8% (95% C.I. = -5.7, 30.3). Inclusion of the variable “winter period” did not improve model fit (p = 0.1372).

Sanderling *Calidris alba*

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 1,678. Other Canadian surveys show a serious population decline for Sanderlings, but no population trend is apparent from the BCCWS survey data.

a)

b)

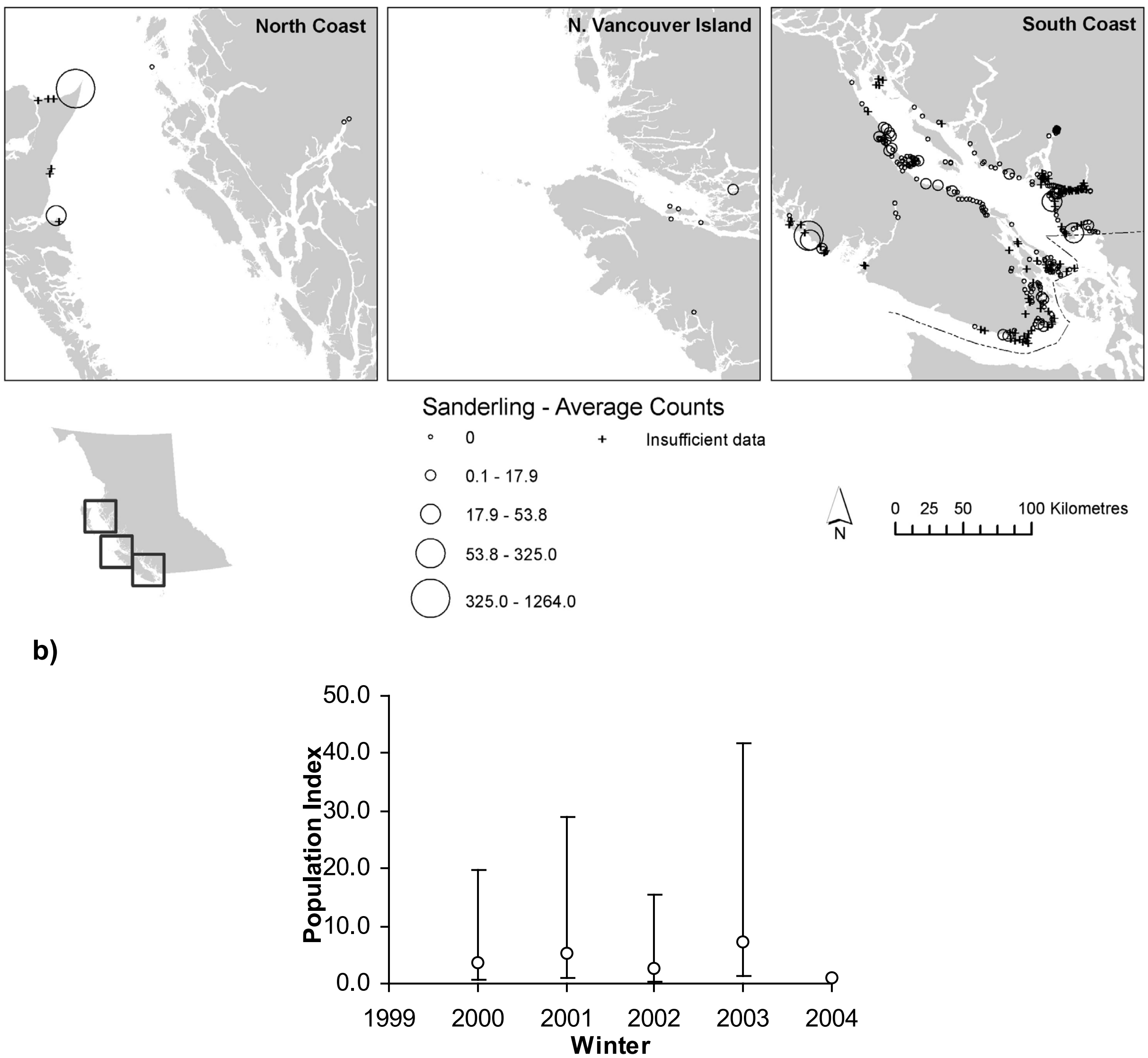


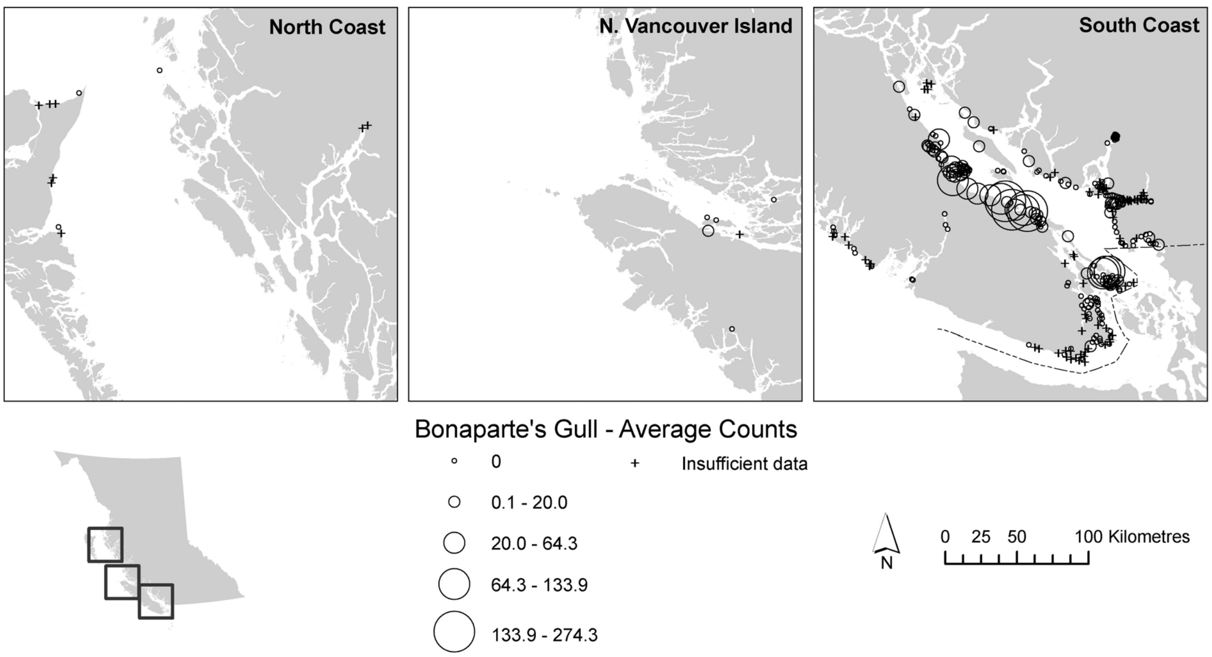
Figure 49. Sanderling: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was -2.0% (95% C.I. = -22.3, 23.7). Inclusion of the variable “winter period” did not improve model fit (p = 0.8655).

Gulls

Bonaparte's Gull *Larus philadelphia*

Bonaparte's Gull is chiefly a migrant in British Columbian coastal habitats, and relatively few over winter. Migration peaks occur in late April and mid-September, so this once-monthly survey from September through April is not well suited for monitoring the species. Numbers were concentrated where strong tidal currents produce a rich crop of zooplankton; areas such as Active Pass and along eastern Vancouver Island. High counts included 2,200 at Neck Point, Nanaimo, 1,912 at the Nanoose Estuary and 1,900 at Active Pass, Mayne Island. There was no population trend.

a)



b)

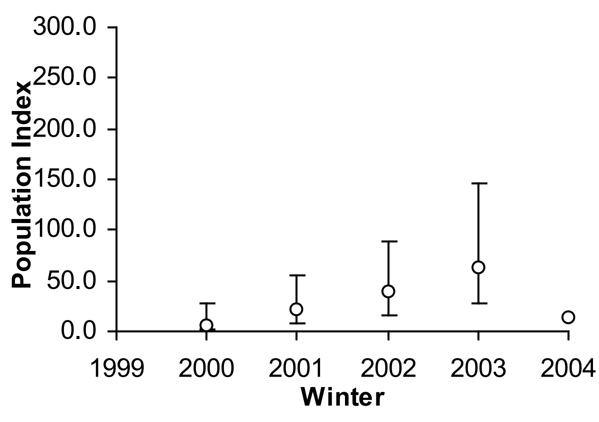
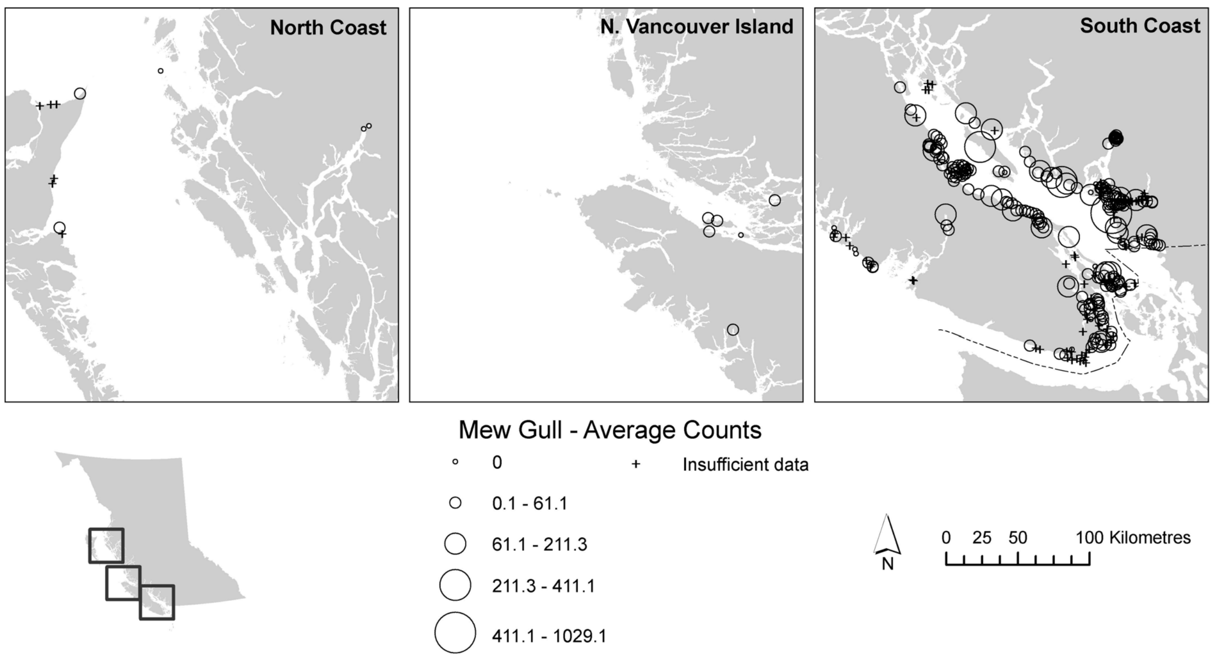


Figure 50. Bonaparte's Gull: **a)** Relative abundance at all BCCWS sites 1999-2004**. b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 11.5% (95% C.I. = -8.6, 36.1). Inclusion of the variable "winter period" did not improve model fit (*p* = 0.2513).

<u>Mew Gull</u> *Larus canus*

Mew Gulls are common throughout the Strait of Georgia, but less common along the central and northern British Columbia coast. There was an apparent increasing trend in the population index over the five years of the survey. Highest peak numbers were reported at Gartley Beach, Comox (9,000) and Iona Island (5,910).

a)



b)

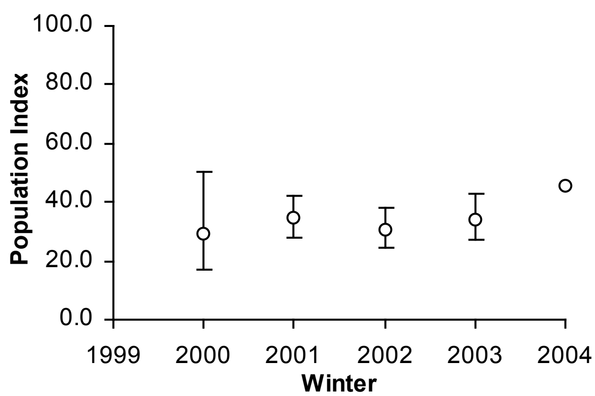
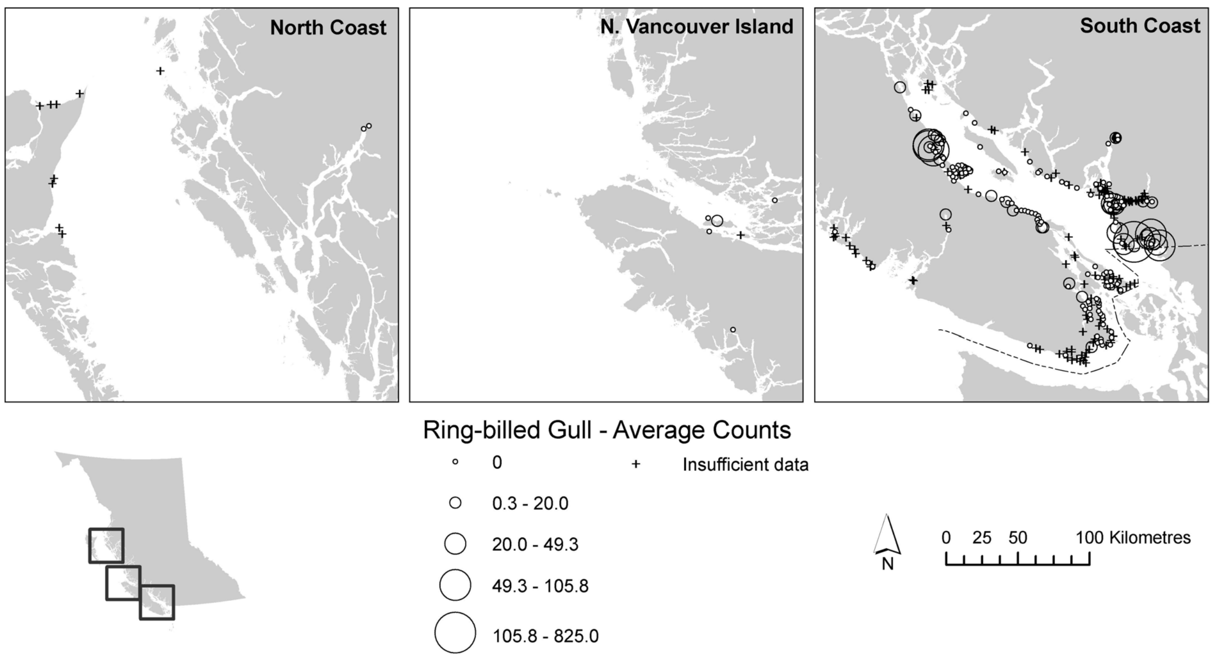


Figure 51. Mew Gull: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 10.8% (95% C.I. = 3.6, 13.6). Inclusion of the variable “winter period” improved model fit (p = 0.0025).

Ring-billed Gull *Larus delawarensis*

Ring-billed Gulls have been increasing in numbers as wintering birds along the coast, so it is surprising to see an apparent decreasing trend to the population index. High variance in the first year of data may be a contributory factor to this trend. Highest numbers were in the Boundary Bay area; the peak number was 1,360 between 12th and 64th Streets in Delta.

a)



b)

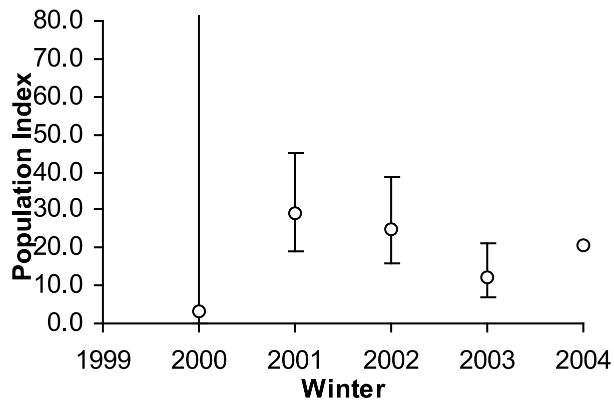
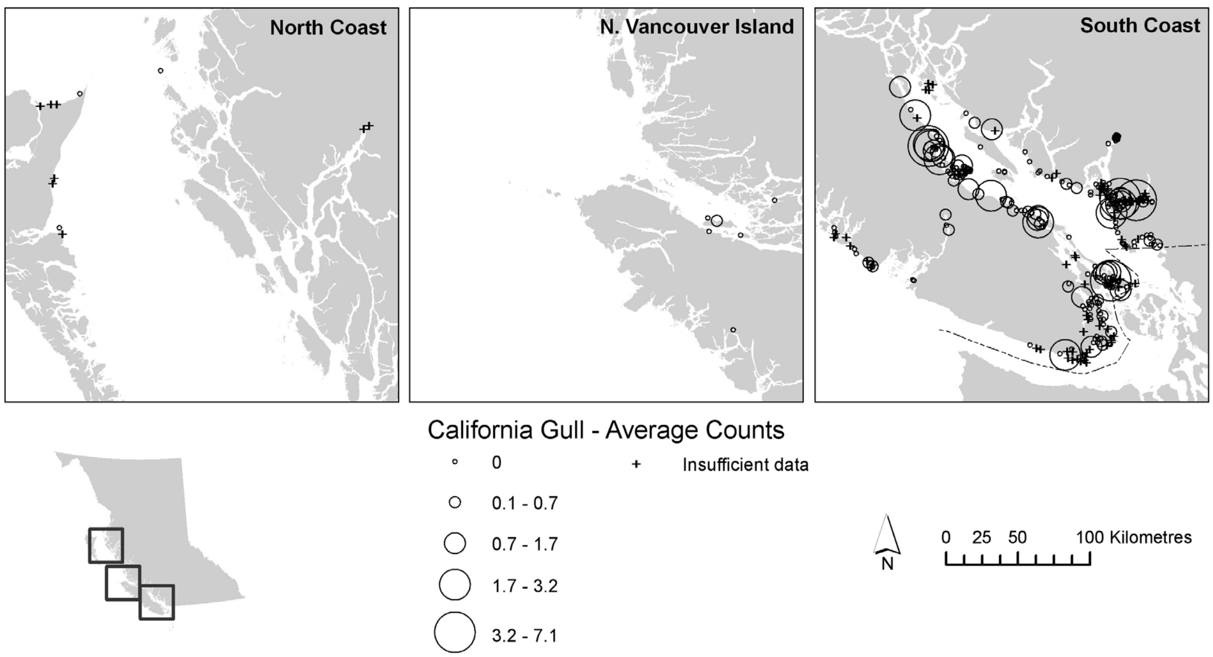


Figure 52. Ring-billed Gull: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –15.6% (95% C.I. = -26.8, -2.7). Inclusion of the variable “winter period” improved model fit (*p* = 0.0197).

California Gull *Larus californicus*

California Gulls are primarily migrants in coastal British Columbia, and may be missed as this survey concentrates on winter months. There was 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 (1,500).

a)



b)

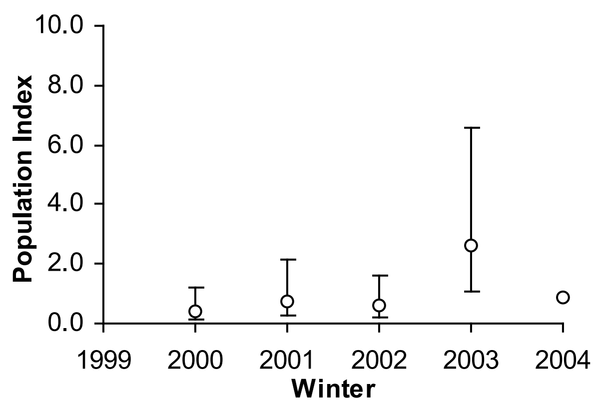
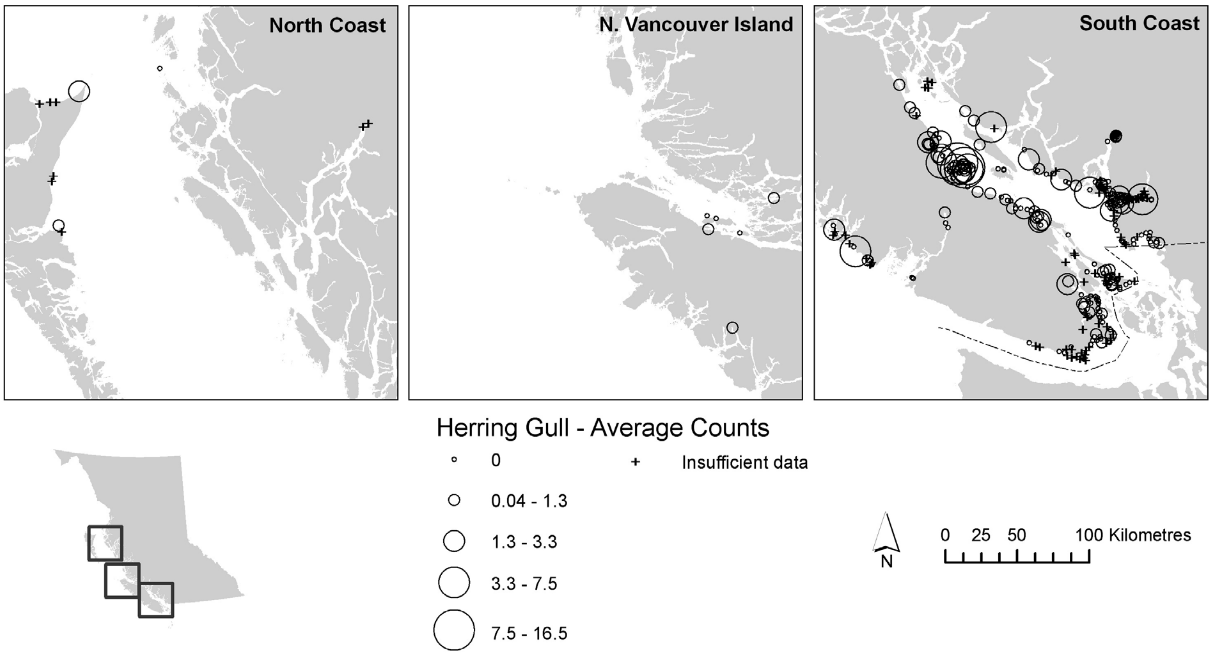


Figure 53. California Gull: **a)** Relative abundance of at all BCCWS sites 1999-2004**. b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 34.6% (95% C.I. = 8.6, 66.9). Inclusion of the variable “winter period” improved model fit (*p* = 0.0061).

Herring Gull *Larus argentatus*

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

a)



b)

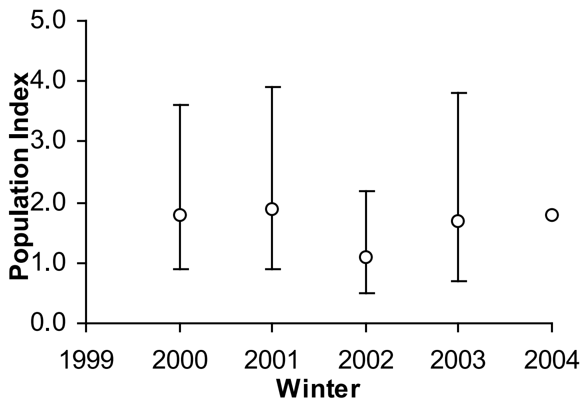
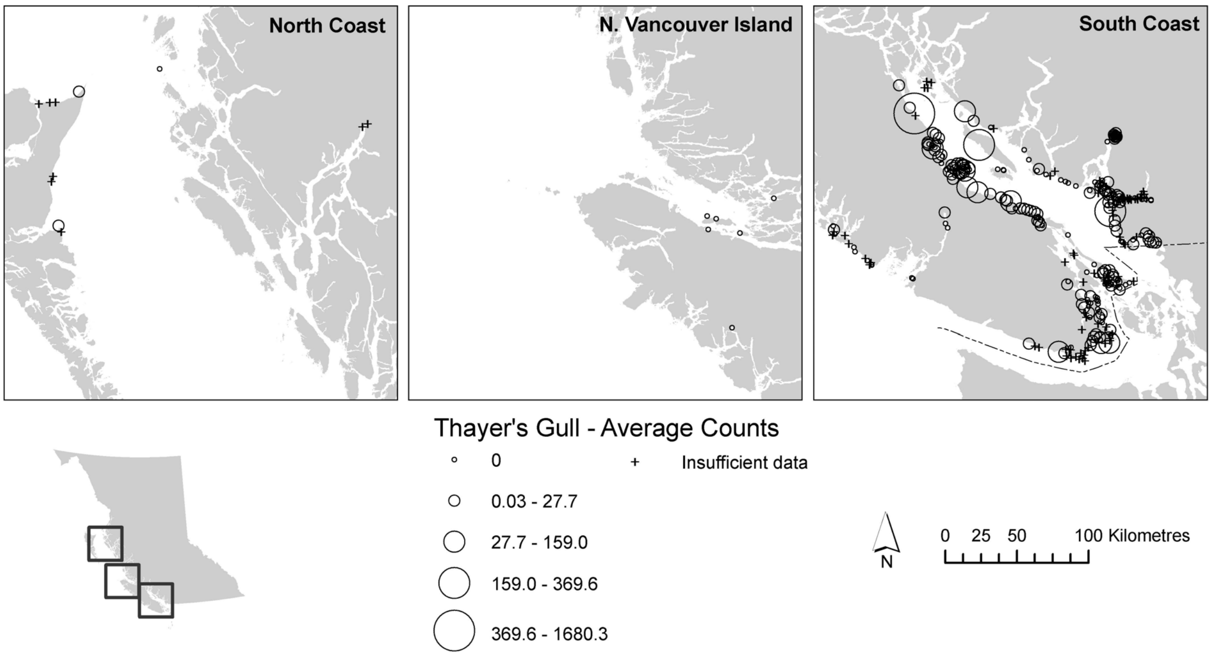


Figure 54. Herring Gull: **a)** Relative abundance at all BCCWS sites 1999-2004. b) Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –1.2% (95% C.I. = -16.8, 17.3). Inclusion of the variable "winter period" did not improve model fit (p = 0.8855).

<u>Thayer's Gull</u> *Larus thayeri*

Thayer's Gulls winter commonly around the shores of the Strait of Georgia, but are considerably less common along northern Vancouver Island and northern coasts. The Oyster River estuary consistently reported the highest counts, including a peak of 3,500. There was no population trend.

a)



b)

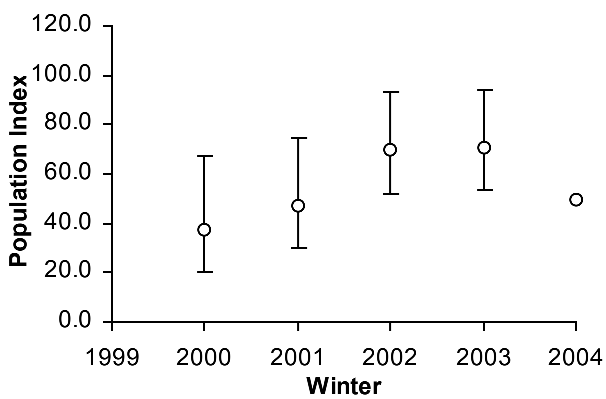
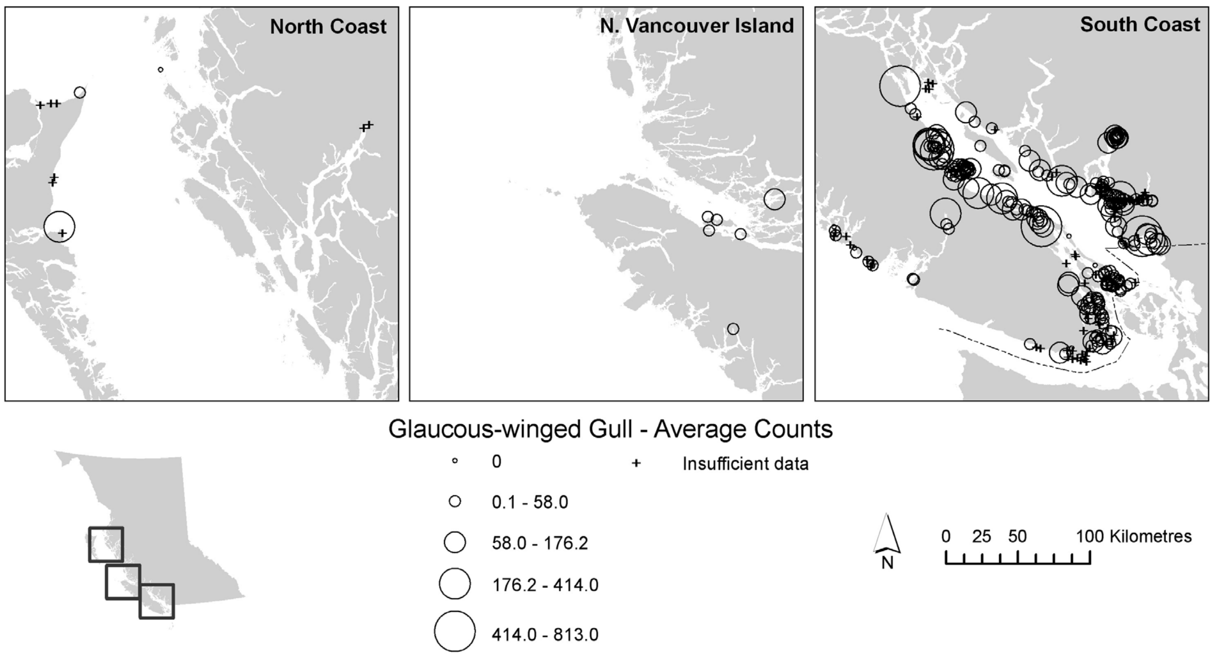


Figure 55. Thayer's Gull: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –1.3% (95% C.I. = -11.3, 9.9). Inclusion of the variable "winter period" did not improve model fit (p = 0.8054).

Glaucous-winged Gull *Larus glaucescens*

Glaucous-winged Gulls are common all along the coast, with highest numbers concentrated in the Strait of Georgia. There was no significant population trend. Peak numbers all come from the east coast of Vancouver Island; the highest is from Gartley Beach, Comox (8,000).

a)



b)

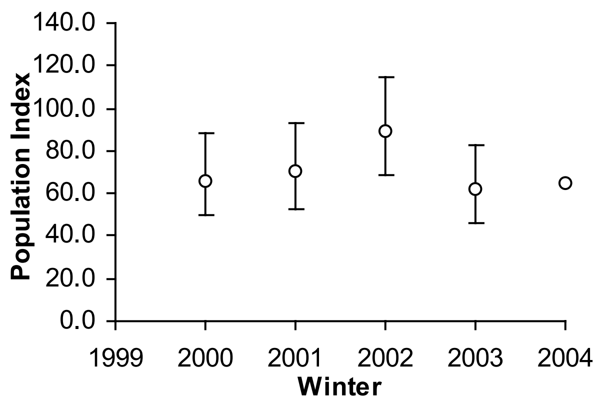


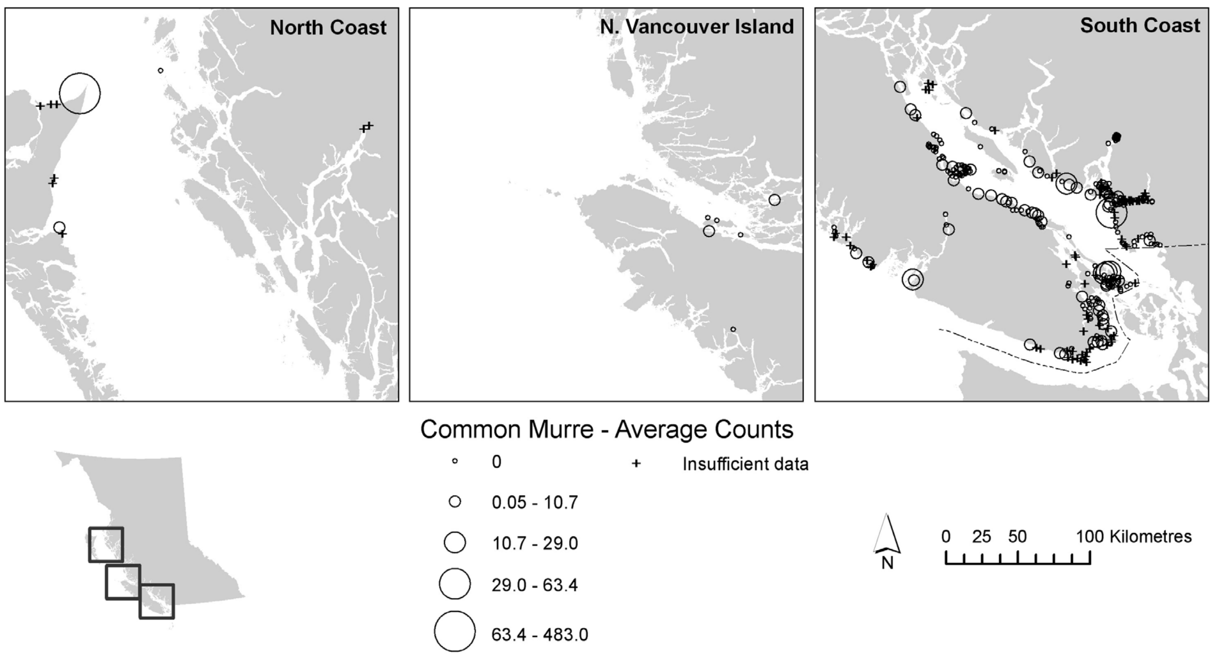
Figure 56. Glaucous-winged Gull: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –1.6% (95% C.I. = -7.9, 5.2). Inclusion of the variable “winter period” did not improve model fit (p = 0.6316).

Alcids

<u>Common Murre</u> *Uria aalge*

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 move 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 an apparent decreasing population trend, probably generated by a high index during the first survey year. The Christmas Bird Count dataset indicated a stable population wintering in British Columbia from 1959 to 1988 (Sauer *et al*. 1996).

a)



b)

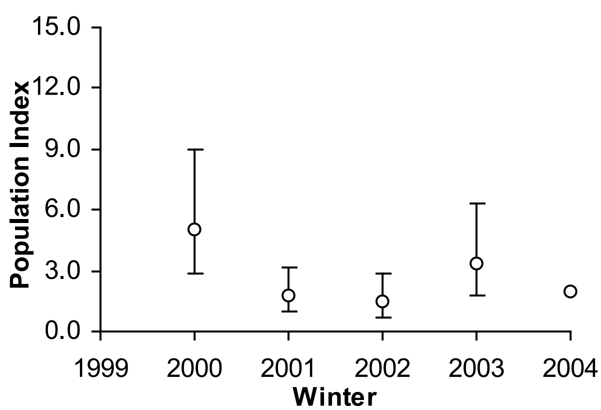
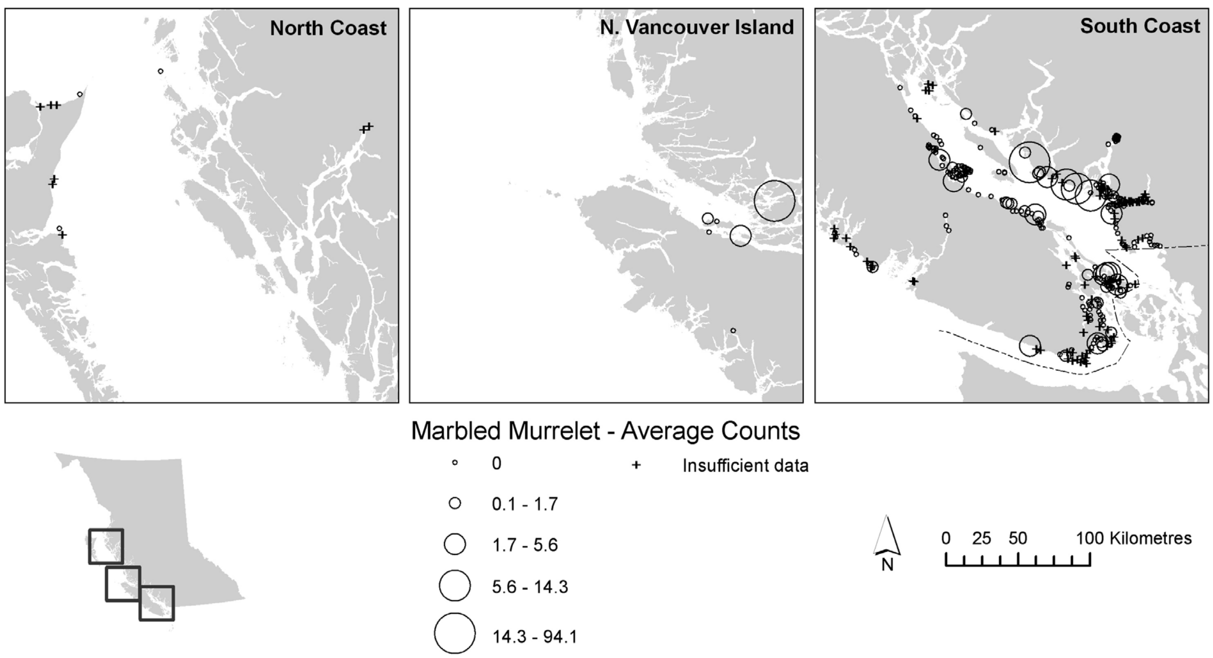


Figure 57. Common Murre: **a)** Relative abundance at all BCCWS sites 1999-2004; **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –18.4% (95% C.I. = -29.6, -5.4). Inclusion of the variable “winter period” improved model fit (*p* = 0.0025).

Marbled Murrelet *Brachyramphus marmoratus*

Numbers are concentrated along the Sunshine Coast and in Johnstone Strait. There was no population trend. High numbers were at Middlepoint Bight, Sunshine Coast (604) and at the Viner River estuary, off Queen Charlotte Strait (247). BirdLife International (2004) list this alcid as Globally Threatened (Endangered), and COSEWIC lists this species as Threatened due to continuing nesting habitat loss (old growth forests) and mortality from fisheries by-catch.

a)



b)

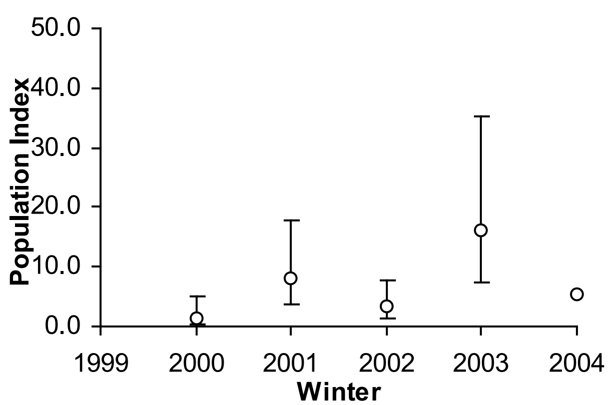
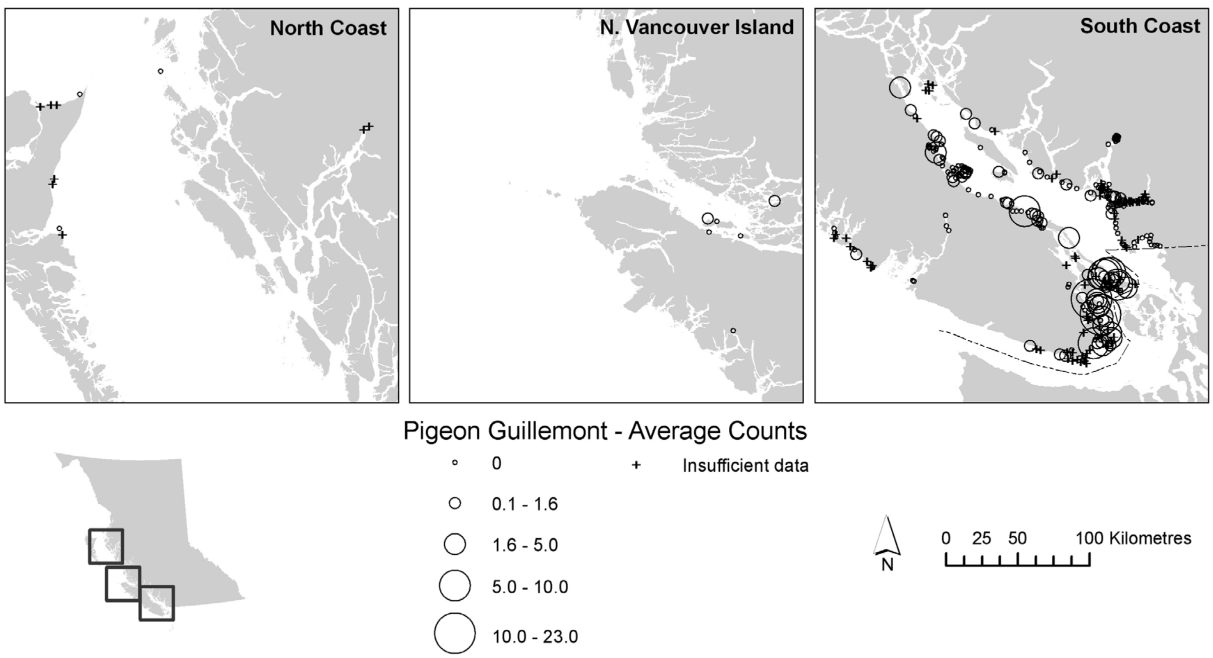


Figure 58. Marbled Murrelet: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species-specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was 14.1% (95% C.I. = -9.0, 43.0). Inclusion of the variable “winter period” did not improve model fit (p = 0.1894).

Pigeon Guillemot *Cepphus columba*

Pigeon Guillemots forage along rocky shores. Numbers are highest in the Gulf Islands and southern Vancouver Island; highest counts reported by this survey were from Island View Beach (156), Saanichton Bay (141), Blunden Point, Nanaimo (120) and Gordon Head, Victoria (113). There was no population trend, although Christmas Bird Count data from 1959 to 1988 suggested an average annual decline of 2.5% over that period (Sauer *et al.* 1996).

a)



b)

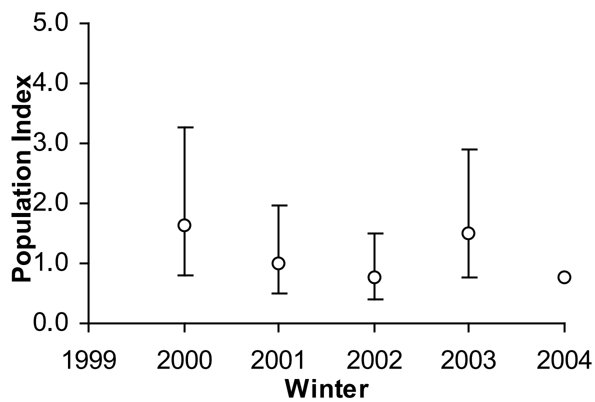


Figure 59. Pigeon Guillemot: **a)** Relative abundance at all BCCWS sites 1999-2004. **b)** Annual relative abundance (mean monthly site-count per winter during species specific survey window ±95% CI) at BCCWS sites in the Georgia Basin between winter 1999/2000 (2000) and 2003/2004 (2004). Estimated linear trend (% per winter) in abundance was –10.5% (95% C.I. = -23.8, 5.2). Inclusion of the variable "winter period" did not improve model fit (*p* = 0.1704).

DISCUSSION

Route regression analyses determined that after five winter-intervals (i.e. six winters) of monitoring, the BCCWS had relatively low power to detect annual changes in abundances of bird populations, assuming a 3% annual change in abundance as an acceptable trend resolution: only nine species of 58 of the most commonly recorded species at BCCWS sites met this threshold. However, after monitoring the same number of sites for ten winter-intervals (i.e. 11 winters), detection of a 3% change in annual abundance was expected for 34 of the 58 species most commonly recorded during BCCWS, and an additional 14 species approached (within 1% of) this 3% annual change detection threshold. These calculations indicate that the BCCWS has adequate potential to detect meaningful changes in abundance of a wide variety of species guilds over longer periods of time (10+ years), and is performing the role for which it was established. These results also underscore the importance of securing survey longevity over decades. Maintaining annual coverage of a large number of survey sites is also important, but the difference in retaining more versus fewer (e.g., 200 versus 180) sites typically will only marginally improve the power of the survey to detect annual changes in species abundance after 11 survey seasons. Optimal benefits will come from retaining high levels of volunteer participation across years and consistent coverage of the same sites over time.

Interpretation of population trends based on the survey data to 2003/4 must be made with caution. A five-year period is a relatively short time with respect to long-term population monitoring, especially given that waterbird populations are known to fluctuate widely (e.g. ducks, Wilkins and Otto 2003). Therefore, the trends presented in this report may not reflect the overall population status of a particular species. Western Grebe provides an example where BCCWS data indicate an increase, which is contrary to the 90% - 95% decline shown by Christmas Bird Count data over the past ca.30 years. There were relatively few data for Western Grebe collected by the BCCWS, and exclusion of the one high count during winter 2003 would suggest a generally stable, rather than an increasing trend.

There were no general patterns of decline or increase within any particular group of waterbirds monitored in the BCCWS survey. In fact, most groups included species that apparently showed both increasing and decreasing trends. BCCWS data further suggest that declines may have occurred in 11 species and increases may have occurred in 13 species. However, given that only five years of data have been collected, and that power analyses suggest that this survey yields best results following longer-term monitoring, these trends must be interpreted cautiously. Nonetheless, those species showing a decreasing trend should be watched closely as the survey continues, to see whether these apparent trends are real and continue to be borne out by a longer-term dataset.

Within the waterfowl, sea ducks 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 duck species that winter in coastal habitats (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 and Pelagic Cormorants). 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, although further monitoring is clearly needed. Brandt's Cormorant, which occurs primarily as a non-breeding species, shows no clear population trend over the past 5 years.

It is inappropriate at this stage to speculate on any causes of the apparent trends shown by the first five years of the BCCWS. Some of the species monitored were known to be in decline prior to the survey (e.g. Pelagic and Double-crested Cormorants, Western Grebe) and the increasing trends generated by this survey may indicate stabilization in their 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 data but an apparent increase since then, as is also suggested by the BCCWS data. Similarly, the decline noted in Bald Eagle numbers was initially unexpected because, based on Christmas Bird Count data, numbers of birds wintering in British Columbia dramatically increased since 1970 (Sauer *et al*. 1986). In recent years, however, Christmas Bird Count data suggest that eagle numbers have stabilized or may even be declining in British Columbia.

The BCCWS survey protocol is designed to monitor wintering populations that remain relatively stable over periods of three to five months. This survey does not perform well with species that are only migrants (e.g. Western Sandpiper *Calidris mauri*) because large numbers tend to move through during short periods of time, which causes irregular detection on surveys that only occur on one day each month. Other species for which the survey may not perform well include geese (e.g. Canada and Snow Geese) and other waterfowl that spend substantial time in inland habitats.

The ability of the BCCWS to assess distribution and population trends is related to how sites are selected and if they are representative of spatial scales larger than that of a 1-2 km section of shoreline (the typical length of a BCCWS site). Site selection away from the most heavily populated areas (the Lower Mainland and Victoria) may be biased towards sites that support larger numbers and/or higher species richness. These sites are likely to support the best habitats. Population declines are more likely to occur first in more marginal habitats/sites and it is thus possible that the BCCWS may be missing some real trends on a regional scale. Many sites along the Lower Mainland and Victoria coastlines abut each other; future analyses should investigate the effects of spatial autocorrelation on survey results.

Ideally, sites should 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. This would improve the ability to generalize and draw inferences, and extrapolate site level information to larger spatial scales, in relation to habitat, land-use and other relevant datasets. Given the relative inaccessibility of much of the BC coastline, this type of sampling scheme may only be realistic within the more populated areas of the Georgia Basin where survey coverage is extensive enough to allow sub-sampling.

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, industrial and recreational development. Relating the results from BCCWS surveys to habitat and land-use change, particularly in high bird-and-human-use areas such as the Fraser Delta and along the east coast of Vancouver Island, will provide a valuable resource for biologists, planners and land-use managers.

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Appendix 1 Volunteer surveyors' years of service (1999/2000 – 2003/4)

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

Appendix 2 Species-specific survey windows used in power and trend analyses for the British Columbia Coastal Waterbird Survey. Species' scientific names are given in Appendix 8.

	Survey months[a]							
Group/species	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Loons								
Red-throated Loon				x	x	x		
Pacific Loon				x	x	x		
Common Loon				x	x	x		
Grebes								
Red-necked Grebe				x	x	x		
Horned Grebe				x	x	x		
Western Grebe				x	x	x		
Cormorants								
Double-crested Cormorant				x	x	x		
Brandt's Cormorant	x	x						
Pelagic Cormorant				x	x	x		
Herons								
Great Blue Heron				x	x	x		
Waterfowl								
Mute Swan				x	x	x		
Trumpeter Swan				x	x	x		
Canada Goose				x	x	x		
Brant						x	x	x
Snow Goose		x	x					
Mallard				x	x	x		
Gadwall				x	x	x		
Northern Pintail				x	x	x		
American Wigeon				x	x	x		
Eurasian Wigeon				x	x	x		
Green-winged Teal				x	x	x		
Canvasback				x	x	x		
Ring-necked Duck				x	x	x		

Appendix 2 continued

	Survey months[a]							
Group/species	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Waterfowl								
Greater Scaup							x	x
Lesser Scaup				x	x	x		
Harlequin Duck				x	x	x		
Long-tailed Duck				x	x	x		
Surf Scoter				x	x	x		
Black Scoter				x	x	x		
White-winged Scoter				x	x	x		
Common Goldeneye				x	x	x		
Barrow's Goldeneye				x	x	x		
Bufflehead				x	x	x		
Hooded Merganser				x	x	x		
Common Merganser				x	x	x		
Red-breasted Merganser				x	x	x		
Raptors								
Bald Eagle		x	x	x				
Northern Harrier			x	x	x			
Red-tailed Hawk			x	x	x			
Peregrine Falcon			x	x	x			
Shorebirds								
Black-bellied Plover			x	x	x			
Killdeer			x	x	x			
Black Oystercatcher			x	x	x			
Greater Yellowlegs								x
Black Turnstone			x	x				
Surfbird			x	x	x			
Dunlin			x	x	x			
Sanderling			x	x	x			

Appendix 2 continued

Group/species	Survey months[a]							
	Sept	Oct	Nov	Dec	Jan	Feb	March	April
Gulls								
Bonaparte's Gull							x	x
Mew Gull		x	x	x	x			
Ring-billed Gull	x							
California Gull				x	x	x		
Herring Gull				x	x	x		
Thayer's Gull				x	x	x		
Glaucous-winged Gull				x	x	x		
Alcids								
Common Murre				x	x	x		
Marbled Murrelet				x	x			
Pigeon Guillemot				x	x	x		

[a]Months included in a species survey window are indicated by 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. Species' scientific names are given in Appendix 8.

Group/species	Site-pairs	Percent (%) annual change detectable using: Mean count	Max count	Difference (%) (Mean – Max)
Loons				
Red-throated Loon	107	6.0	6.2	-0.2
Pacific Loon	169	5.6	6.1	-0.4
Common Loon	236	2.4	2.8	-0.4
Grebes				
Red-necked Grebe	157	3.7	4.0	-0.3
Horned Grebe	226	2.8	3.2	-0.4
Western Grebe	137	6.3	6.6	-0.3
Cormorants				
Double-crested Cormorant	262	2.6	2.8	-0.2
Brandt's Cormorant	26	8.6	9.4	-0.9
Pelagic Cormorant	202	3.5	3.7	-0.3
Herons				
Great Blue Heron	250	2.9	3.2	-0.3
Waterfowl				
Trumpeter Swan	78	6.2	6.8	-0.6
Canada Goose	208	4.2	4.3	-0.1
Brant	57	9.3	9.7	-0.4
Mallard	279	2.3	2.6	-0.3
Gadwall	25	8.1	7.9	0.2
Northern Pintail	84	4.5	5.0	-0.5
American Wigeon	231	3.1	3.3	-0.2
Eurasian Wigeon	72	7.5	8.2	-0.6
Green-winged Teal	87	5.0	5.4	-0.5
Greater Scaup	99	8.0	8.1	-0.1
Lesser Scaup	59	7.3	8.0	-0.7
Harlequin Duck	183	2.4	2.8	-0.4
Long-tailed Duck	109	4.8	4.8	0.0

Appendix 3 continued

Group/species	Site-pairs	Percent (%) annual change detectable using: Mean count	Max count	Difference (%) (Mean – Max)
Waterfowl				
Surf Scoter	225	3.8	3.9	-0.1
Black Scoter	134	5.5	5.9	-0.4
White-winged Scoter	148	3.4	3.6	-0.2
Common Goldeneye	251	2.7	3.0	-0.4
Barrow's Goldeneye	178	3.5	4.3	-0.8
Bufflehead	308	1.9	2.1	-0.2
Hooded Merganser	155	3.9	4.1	-0.2
Common Merganser	239	3.2	3.6	-0.4
Red-breasted Merganser	226	3.3	3.7	-0.4
Raptors				
Bald Eagle	263	2.7	3.0	-0.3
Red-tailed Hawk	76	8.6	8.6	0.0
Shorebirds				
Black-bellied Plover	59	8.8	9.0	-0.2
Killdeer	85	7.9	8.0	-0.1
Black Oystercatcher	119	5.7	6.0	-0.3
Greater Yellowlegs	73	9.4	9.4	0.0
Black Turnstone	120	6.9	7.0	-0.1
Surfbird	37	13.0	12.8	0.1
Dunlin	84	6.8	7.5	-0.7
Sanderling	29	11.4	10.9	0.5

Appendix 3 continued

Group/species	Site-pairs	Percent (%) annual change detectable using: Mean count	Max count	Difference (%) (Mean – Max)
Gulls				
Bonaparte's Gull	86	11.4	11.5	-0.1
Mew Gull	173	3.3	3.7	-0.4
Ring-billed Gull	43	7.2	7.2	0.0
California Gull	58	10.8	11.9	-1.1
Herring Gull	81	9.1	8.5	0.6
Thayer's Gull	133	5.3	5.5	-0.2
Glaucous-winged Gull	309	3.4	3.6	-0.2
Alcids				
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

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. Species' scientific names are given in Appendix 8.

	Winter pairs				
Group/species	2000/01	2001/02	2002/03	2003/04	Total sites
Loons					
Red-throated Loon	25	27	31	24	107
Pacific Loon	40	51	44	34	169
Common Loon	62	68	61	45	236
Grebes					
Red-necked Grebe	49	41	40	27	157
Horned Grebe	63	66	55	42	226
Western Grebe	38	40	36	23	137
Cormorants					
Double-crested Cormorant	55	77	74	56	262
Brandt's Cormorant		10	7	9	26
Pelagic Cormorant	50	56	54	42	202
Herons					
Great Blue Heron	46	52	53	40	191
Waterfowl					
Mute Swan	3	3	4	4	14
Trumpeter Swan	20	24	19	15	78
Canada Goose	51	62	52	43	208
Brant	15	14	13	15	57
Snow Goose		6	5	4	15
Mallard	69	78	72	60	279
Gadwall	8	8	5	4	25
Northern Pintail	22	24	18	20	84
American Wigeon	45	50	50	41	186
Eurasian Wigeon	17	19	14	14	64
Green-winged Teal	24	20	22	21	87
Canvasback	4	5	5	2	16
Ring-necked Duck	3	2			5
Greater Scaup	27	22	21	29	99

Appendix 4 continued

Group/species	Winter pairs 2000/01	2001/02	2002/03	2003/04	Total sites
Waterfowl					
Lesser Scaup	11	15	17	16	59
Harlequin Duck	47	52	48	36	183
Long-tailed Duck	30	30	28	21	109
Surf Scoter	60	63	58	44	225
Black Scoter	36	38	37	23	134
White-winged Scoter	44	42	36	26	148
Barrow's Goldeneye	43	54	47	34	178
Bufflehead	75	86	83	64	308
Common Goldeneye	66	67	65	53	251
Common Merganser	58	71	60	50	239
Hooded Merganser	37	48	41	29	155
Red-breasted Merganser	58	64	59	45	226
Raptors					
Bald Eagle	44	85	69	65	263
Northern Harrier	7	7	6	6	26
Red-tailed Hawk	27	23	17	9	76
Peregrine Falcon	8	2	3	3	16
Shorebirds					
Black-bellied Plover	14	18	14	13	59
Killdeer	22	24	20	19	85
Black Oystercatcher	25	37	33	24	119
Greater Yellowlegs	20	19	16	18	73
Black Turnstone	33	34	29	24	120
Surfbird	9	14	7	7	37
Dunlin	27	21	20	16	84
Sanderling	9	10	5	3	27

Appendix 4 continued

Group/species	Winter pairs 2000/01	2001/02	2002/03	2003/04	Total sites
Gulls					
Bonaparte's Gull	24	23	19	20	86
Mew Gull	16	65	47	45	173
Ring-billed Gull	2	20	10	11	43
California Gull	15	17	15	11	58
Herring Gull	18	15	15	13	61
Thayer's Gull	39	34	32	28	133
Glaucous-winged Gull	53	62	63	50	228
Alcids					
Common Murre	20	17	12	13	62
Marbled Murrelet	13	16	12	7	48
Pigeon Guillemot	15	15	19	13	62

Appendix 5 Number of BCCWS sites included in trend analyses during each winter of the British Columbia Coastal Waterbird Survey. Species' scientific names are given in Appendix 8.

	Winter				
Group/species	1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Loons					
Red-throated Loon	47	48	54	41	41
Pacific Loon	65	76	81	55	59
Common Loon	82	93	98	70	75
Grebes					
Red-necked Grebe	66	72	77	55	60
Horned Grebe	89	96	108	72	80
Western Grebe	62	66	66	47	57
Cormorants					
Double-crested Cormorant	88	104	117	83	89
Brandt's Cormorant		19	16	14	17
Pelagic Cormorant	76	83	92	63	73
Herons					
Great Blue Heron	70	82	91	71	71
Waterfowl					
Mute Swan	8	6	10	7	4
Trumpeter Swan	31	34	37	27	27
Canada Goose	78	89	97	70	74
Brant	29	26	29	25	31
Snow Goose	2	12	10	9	9
Mallard	92	108	114	82	93
Gadwall	12	14	13	13	11
Northern Pintail	33	36	40	30	31
American Wigeon	63	75	83	63	65
Eurasian Wigeon	30	32	30	22	24
Green-winged Teal	35	39	44	33	39
Canvasback	10	10	10	8	7
Ring-necked Duck	13	11	13	11	6
Greater Scaup	51	50	46	40	49
Lesser Scaup	25	27	34	26	26

Appendix 5 continued

Group/species	Winter 1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Waterfowl					
Harlequin Duck	62	68	76	53	57
Long-tailed Duck	45	48	50	36	33
Surf Scoter	84	92	100	68	70
Black Scoter	53	56	59	43	43
White-winged Scoter	64	68	69	45	50
Common Goldeneye	95	104	114	80	87
Barrow's Goldeneye	73	81	92	61	64
Bufflehead	100	114	125	90	96
Hooded Merganser	60	74	81	56	58
Common Merganser	84	98	107	76	83
Red-breasted Merganser	76	91	94	70	77
Raptors					
Bald Eagle	56	114	115	86	102
Northern Harrier	15	13	16	13	12
Red-tailed Hawk	42	39	41	33	32
Peregrine Falcon	11	10	9	5	7
Shorebirds					
Black-bellied Plover	21	24	30	20	21
Killdeer	40	44	46	33	38
Black Oystercatcher	41	52	57	42	46
Greater Yellowlegs	36	34	31	30	32
Black Turnstone	47	53	58	41	51
Surfbird	18	19	24	16	19
Dunlin	38	39	40	30	32
Sanderling	15	16	16	9	11

Appendix 5 continued

Group/species	Winter 1999/2000	2000/2001	2001/2002	2002/2003	2003/2004
Gulls					
Bonaparte's Gull	37	35	38	31	38
Mew Gull	17	82	84	61	73
Ring-billed Gull	2	30	27	20	27
California Gull	33	31	41	28	28
Herring Gull	43	48	49	38	38
Thayer's Gull	63	63	71	51	51
Glaucous-winged Gull	76	86	101	74	75
Alcids					
Common Murre	31	34	37	24	25
Marbled Murrelet	18	26	24	16	18
Pigeon Guillemot	29	28	33	24	27

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. Species' scientific names are given in Appendix 8.

	Sites		Site-winters	
Group/species	Total	Species present	Total	Species present
Loons				
Red-throated Loon	166	67	553	231
Pacific Loon	166	101	553	336
Common Loon	166	128	553	418
Grebes				
Red-necked Grebe	166	100	553	330
Horned Grebe	166	132	553	445
Western Grebe	166	87	553	298
Cormorants				
Double-crested Cormorant	166	144	553	481
Brandt's Cormorant	125	22	383	66
Pelagic Cormorant	166	116	553	387
Herons				
Great Blue Heron	166	120	553	385
Waterfowl				
Mute Swan	166	13	553	35
Trumpeter Swan	166	45	553	156
Canada Goose	166	116	553	408
Brant	155	38	525	140
Snow Goose	150	14	481	42
Mallard	166	144	553	489
Gadwall	166	20	553	63
Northern Pintail	166	50	553	170
American Wigeon	166	110	553	349
Eurasian Wigeon	166	44	553	138
Green-winged Teal	166	57	553	190
Canvasback	166	15	533	45
Ring-necked Duck	166	16	553	54
Greater Scaup	170	64	584	236

Appendix 6 continued

Group/species	Sites		Site-winters	
	Total	Species present	Total	Species present
Waterfowl				
Lesser Scaup	166	39	553	138
Harlequin Duck	166	94	553	316
Long-tailed Duck	166	64	553	212
Surf Scoter	166	127	553	414
Black Scoter	166	74	553	254
White-winged Scoter	166	91	553	296
Common Goldeneye	166	146	553	480
Barrow's Goldeneye	166	113	553	371
Bufflehead	166	156	553	525
Hooded Merganser	166	99	553	329
Common Merganser	166	134	553	448
Red-breasted Merganser	166	121	553	408
Raptors				
Bald Eagle	156	146	498	473
Northern Harrier	166	16	553	56
Red-tailed Hawk	166	50	553	187
Peregrine Falcon	166	14	533	42
Shorebirds				
Black-bellied Plover	166	33	553	116
Killdeer	166	56	553	201
Black Oystercatcher	166	72	553	238
Greater Yellowlegs	184	40	667	163
Black Turnstone	181	71	620	250
Surfbird	166	27	553	96
Dunlin	166	53	553	179
Sanderling	166	21	553	67

Appendix 6 continued

	Sites		Site-winters	
Group/species	Total	Species present	Total	Species present
Gulls				
Bonaparte's Gull	170	49	584	179
Mew Gull	125	103	382	317
Ring-billed Gull	134	35	424	106
California Gull	166	48	553	161
Herring Gull	166	54	553	174
Thayer's Gull	166	86	553	299
Glaucous-winged Gull	166	130	553	412
Alcids				
Common Murre	166	47	553	151
Marbled Murrelet	181	32	620	102
Pigeon Guillemot	166	42	553	141

Appendix 7 Estimated linear rate of change (% / winter) in abundances of birds counted at BCCWS sites from winter 1999/2000 to 2003/2004. Species' scientific names are given in Appendix 8.

Group/species	Rate (% / winter)	Lower 95% CI	Upper 95% CI	p [a]
Loons				
Red-throated Loon	-4.4	-14.8	7.2	0.4335
Pacific Loon	22.3	9.3	37.0	0.0002
Common Loon	-0.1	-3.9	3.9	0.9632
Grebes				
Red-necked Grebe	-8.6	-14.0	-2.8	0.0038
Horned Grebe	-0.2	-5.2	5.1	0.9317
Western Grebe	12.7	2.1	24.5	0.0112
Cormorants				
Double-crested Cormorant	18.4	12.8	24.2	< 0.0001
Brandt's Cormorant	-12.5%	-31.1	12.9	0.2705
Pelagic Cormorant	12.0	5.3	19.1	0.0003
Herons				
Great Blue Heron	6.9	1.0	13.1	0.0216
Waterfowl				
Mute Swan	-9.3	-31.6	20.3	0.4949
Trumpeter Swan	-0.8	-12.9	12.9	0.8992
Canada Goose	3.1	-4.0	10.7	0.4025
Brant	-36.3	-46.1	-24.8	< 0.0001
Snow Goose	3.1	-15.4	25.6	0.7386
Mallard	3.2	-1.2	7.7	0.1410
Gadwall	47.3	13.5	91.3	0.0007
Northern Pintail	16.6	6.1	28.2	0.0007
American Wigeon	13.5	6.6	20.9	< 0.0001
Eurasian Wigeon	24.0	8.7	41.4	0.0010
Green-winged Teal	-8.1	-18.4	3.5	0.0845
Canvasback	-16.2	-28.5	-1.8	0.0166
Ring-necked Duck	-8.9	-26.0	12.1	0.3717
Greater Scaup	-18.3	-29.3	-5.7	0.0065
Lesser Scaup	5.4	-4.0	15.6	0.2249

Appendix 7 Continued

Group/species	Rate (% / winter)	Lower 95% CI	Upper 95% CI	p [a]
Waterfowl				
Harlequin Duck	-2.9	-6.8	1.3	0.1728
Long-tailed Duck	-19.4	-26.2	-12.0	< 0.0001
Surf Scoter	-3.4	-10.7	4.5	0.3714
Black Scoter	-8.2	-17.6	2.3	0.1038
White-winged Scoter	-0.3	-7.2	7.1	0.9284
Common Goldeneye	1.3	-3.2	6.0	0.5686
Barrow's Goldeneye	-6.9	-12.9	-0.5	0.0275
Bufflehead	5.5	2.1	9.1	0.0008
Hooded Merganser	-6.5	-13.3	0.9	0.0819
Common Merganser	-0.1	-5.4	5.6	0.9730
Red-breasted Merganser	4.3	-1.9	10.9	0.1678
Raptors				
Bald Eagle	-13.9	-18.3	-9.2	< 0.0001
Northern Harrier	1.3	-15.4	21.4	0.8903
Red-tailed Hawk	-23.4	-35.0	-9.8	0.0013
Peregrine Falcon	-2.0	-32.2	41.5	0.9162
Shorebirds				
Black-bellied Plover	-6.0	-17.1	6.5	0.3203
Killdeer	-16.7	-28.8	-2.5	0.0216
Black Oystercatcher	0.3	-8.4	9.8	0.9456
Greater Yellowlegs	23.5	7.2	42.3	0.0022
Black Turnstone	4.6	-5.6	15.8	0.3901
Surfbird	-3.2	-23.2	22.0	0.7532
Dunlin	10.8	-5.7	30.3	0.1372
Sanderling	-2.0	-22.3	23.7	0.8655

Appendix 7 Continued

Group/species	Rate (% / winter)	Lower 95% CI	Upper 95% CI	*p* [a]
Gulls				
Bonaparte's Gull	11.5	-8.6	36.1	0.2513
Mew Gull	10.8	3.6	18.6	0.0025
Ring-billed Gull	-15.6	-26.8	-2.7	0.0197
California Gull	34.6	8.6	66.9	0.0061
Herring Gull	-1.2	-16.8	17.3	0.8855
Thayer's Gull	-1.3	-11.3	9.9	0.8054
Glaucous-winged Gull	-1.6	-7.9	5.2	0.6316
Alcids				
Common Murre	-18.4	-29.6	-5.4	0.0025
Marbled Murrelet	14.1	-9.0	43.0	0.1894
Pigeon Guillemot	-10.5	-23.8	5.2	0.1704

[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 Species recorded on the BC Coastal Waterbird Survey between September 1999 and April 2004

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

Appendix 8 continued

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