Coastal waterbird population trends in the Strait of Georgia 1999–2011: Results from the first 12 years of the British Columbia Coastal Waterbird Survey

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Abstract: The British Columbia Coastal Waterbird Survey is a citizen science long-term monitoring program implemented by Bird Studies Canada to assess population trends and ecological needs of waterbirds using the province's coastal and inshore marine habitats. Standard monthly counts from more than 200 defined sites within the Strait of Georgia were analysed using route-regression techniques to estimate population indices and assess trends in 57 waterbird species over a 12-year period spanning the non-breeding periods from 1999–2000 to 2010–11. A power analysis was also conducted to validate the rigor of the survey design. Results indicate that the survey is detecting annual changes of 3% or less for populations of 29 waterbirds of a wide variety of guilds. Thirty-three species showed stable populations or no trend, 22 species showed significantly declining trends, and just three species showed significant increasing trends. We evaluate these results in the context of other long-term monitoring initiatives in the Salish Sea, highlighting specific birds to watch from a conservation perspective. Among those that showed a declining trend were a guild of piscivores, including Western and Horned Grebes, Common, Red-throated and Pacific Loons, and Rhinoceros Auklet; several sea ducks (Black and White-winged Scoters, Long-tailed Duck, Barrow's Goldeneye, Harlequin Duck); two shorebirds (Dunlin, Surfbird); and Great Blue Heron. In the stable/no trend group were 20 species for which the Salish Sea is of recognised global or continental conservation importance, including one grebe, two cormorants, eight waterfowl (including five diving ducks), three shorebirds and two gulls. Next steps in the application of the B.C. Coastal Waterbird Survey and related datasets to conservation and research management questions are discussed, underscoring the importance of continued monitoring using this cost-effective approach and expanding the use of these data to hypothesis-testing to investigate factors potentially driving population changes.

Keywords: British Columbia, Citizen Science, coastal, monitoring, overwintering, Pacific, population trends, waterbirds, waterfowl.

Introduction

Coastal and adjacent terrestrial habitats of the Salish Sea (comprising the Strait of Georgia, B.C. and adjacent Puget Sound, Wash.) support some of the largest concentrations of breeding, migratory and wintering waterbirds in North America (Butler and Campbell 1987, Butler and Cannings 1989, Butler and Vermeer 1994, Pacific Coast Joint Venture 2005, Butler 2009, Gaydos and Pearson 2011). There are more than 20 globally significant Important Bird Areas in the Salish Sea (Devenish *et al*. 2009), supporting more than 1% of the world population of at least 25 species at some point during each annual cycle. Seventy-two bird and 29 mammal species are highly dependent on the Salish Sea's intertidal and marine habitats, and further 100 bird and eight mammal species have varying degrees of dependence on the Salish Sea's marine and terrestrial ecosystems to meet significant life history needs (Gaydos and Pearson 2011).

The region is also one of North America's burgeoning important human places: the total number of people living within the Georgia Basin and adjacent Puget Sound, now exceeds seven million and continues to grow rapidly, placing unprecedented physical, chemical, and biological stresses on the Salish Sea ecosystem.

With these pressures in mind, and specifically in response to the paucity of information on waterbird populations in the region, especially trends and ecological linkages (Vermeer and Butler 1989), the British Columbia Coastal Waterbird Survey (BCCWS) was conceived by a group of scientists, local naturalists and conservation planners, and initiated in 1999 by Bird Studies Canada, with support from Environment Canada's Canadian Wildlife Service. The BCCWS is the only ongoing long-term monitoring program providing trend information on a broad suite of nonbreeding waterbird

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populations in the B.C. portion of the Salish Sea, and now represents the largest body of contemporary data on most non-breeding waterbirds in this region. Other long-term initiatives tracking trends in coastal waterbirds are occurring in the Puget Sound region of the Salish Sea (*e.g.* Bower 2009, Anderson *et al*. 2009, Gaydos and Pearson 2011).

This paper presents an analysis of population trends in 57 species of waterbird that regularly use coastal and marine habitats within the Strait of Georgia, from data collected by the BCCWS (1999–2011). This paper updates results from an earlier publication in this journal by Badzinski *et al*. (2008), which reported population trends from the first five years, 1999–2004. While the previous paper provided details regarding species distribution, this paper focuses primarily on new 12-year trend results from the Strait of Georgia, in the context of study results from other overlapping and adjacent regions of the Salish Sea, including Puget Sound (Bower 2009) and locally within Padilla Bay, Wash. (Anderson *et al.* 2009), and longer-term surveys within B.C. (*e.g.* Sauer *et al*. 1996, 2011). Where possible, trend information from other parts of each species' North American ranges is included.

Methods

Survey Design

Individual surveys were conducted from shore, by skilled volunteers familiar with most or all species of waterbird regularly occurring in B.C.; survey areas had spatially explicit, predefined boundaries. All waterbirds, raptors and corvids observed within survey boundaries were counted, except those that fly through without stopping that were clearly not using the area. Observations were separated into distance bands of 0–500m and 500m–*ca.*1km from the high tide mark. Distance was estimated visually by observers, based on guidance provided in the BCCWS (Survey) instructions. Information on site characteristics, including weather conditions, sea conditions, visibility and disturbance (human activities) were recorded at the time of the site visit. Counts were conducted on a monthly basis, on or around the second Sunday of each month, and within approximately two hours of the high tide. Surveys focused on the September–April period, continuing from May through August at some sites. Sites generally averaged 1–2 km in length, and covered a wide variety of habitats, including rocky shores, sandy beaches, saltmarshes, mudflats, fast-flowing channels, and other inshore waters. Sites were not randomly distributed because many areas of the coast were not accessible. Site locations and boundaries were digitized to the B.C. TRIM shoreline data layer.

Volunteers were required to use high quality optical equipment, binoculars as a minimum, and preferably a spotting scope as well. Surveyors were provided with a written protocol document which outlined the methods in detail. Volunteer support was provided by Bird Studies Canada to provide guidance to surveyors. Most data were entered by volunteers through a customized online data entry system available on Bird Studies Canada's website. A small number of volunteers submitted paper forms and these data were manually entered by Bird Studies Canada staff.

Analysis Metric

For each year, month and survey route, the total count for each species was the sum of counts across all distance bands. The basic statistical unit for all analyses was the mean total count of each species at a survey site across months within the speciesspecific survey window of each non-breeding season, *e.g.* December–February for most wintering birds. These annual means were used to determine initial variance estimates (for power analyses), annual abundance indices, and longterm trends for each species. Only sites within the Strait of Georgia and with 100% monthly coverage within the speciesspecific survey window were included in the analyses.

Power and Trend Analyses

In this paper, we present an update to the power and trend analyses that were conducted after the first five years of the program (Badzinski *et al*. 2006, 2008). For ease of comparison with the power analysis presented by Badzinski *et al*. (2006), we duplicated the power analysis exactly, using a quasi-Poisson distribution to generate parameter and variance estimates. RProject (R Development Core Team 2011) was used to perform all data manipulations, transformations, simulations, and statistical modeling of the Survey data.

The statistical analyses we used for power and trend analyses were generally modeled after the "routeregression" approach, 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 largescale population monitoring programs developed and/or administered by Bird Studies Canada (*e.g.* Weeber and Vallianatos 2000). This involved 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.

For the power analyses, we included count data (*i.e.* average number of birds counted across months within the speciesspecific survey window each year) for sites that were surveyed during at least two consecutive winters and where at least one individual of the species of interest was detected during one of those winters. For each species and site, the data from consecutive winters were grouped into winter-pairs. Quasi-Poisson regression models were used to generate species-specific variance estimates for each winter survey season (Y = Winter[class], BCCWS Site[class]).

Species-specific variance estimates were weighted by the total number of sites detecting each species during each of the survey periods. An average (weighted) variance for each species was used in all subsequent power calculations. Using Monte Carlo simulations and other analytical techniques, the percentage annual change in species abundance at different numbers of BCCWS sites (160, 200 and 240) surveyed after 10 and 20 winterintervals (11 and 21 survey seasons respectively) was estimated, assuming loglinear relationships and a uniform, consistent population change across all sites and winters. All power estimates were adjusted to account for the proportion (average over all ninewinter pairs) of sites that actually detected each species.

Trends in abundance for each species from 1999–2011 were assessed using similar statistical techniques to the power analyses to generate annual abundance indices. The number of sites included in the trend analyses of each species varied from year to year. For each species, three regression models were tested and compared using Likelihood ratio tests:

[1] Mean Count[Y] = BCCWS Site[class] + Winter[class]

[2] Mean Count[Y] = BCCWS Site[class] + Winter[continuous]

[3] Mean Count[Y] = BCCWS Site[class]

A Poisson distribution was used for those species that met its assumptions (without scaling for over-dispersion), and a negative binomial distribution was used for those species that did not meet the assumptions of the Poisson distribution. Negative binomial is better suited to data with many zero-observations, and models error distribution without having to correct for over-dispersion. Species-specific estimates of the rate of change in annual indices (% per year) were calculated by back-transforming the parameter estimate of the Winter coefficient from model [2] (trend = 100*(eâ -1), where e = base of natural logarithm, â is winter coefficient). Lower and upper 95% confidence intervals were calculated from standard errors associated with the "Winter" parameter.

Results

Power Analyses

Generally, the ability to detect an annual change in numbers of 3% or less is considered a sufficiently robust criterion for demonstrating a trend in a bird population (Weeber and Vallianatos 2000). Estimating power from 10 years of data and assuming 160 sites are surveyed annually, indicates that the BCCWS can detect annual changes of 3% or less within populations of 29 of 57 waterbird species (Tables 1, 2). The 29 species include two loons, two grebes, two cormorants, one heron, one goose, four dabbling ducks, 10 diving (including sea) ducks, one raptor, two shorebirds and three gulls.

The power of the BCCWS may be somewhat overestimated because the rate of bird population change may vary among sites. For example, if populations at some sites 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 uniformly by 5% per year (which is assumed in these analyses).

Species Population Trends

This section examines trend results, species by species, in the context of other trend information from the Salish Sea (*e.g.* Bower 2009, Anderson *et al*. 2009, Sauer *et al.* 1996, 2011) and relevant information from elsewhere within the species' North American range. Table 1 gives population trend indices, in terms of annual rates of change. Each individual species account presents a trend graph showing relative abundance indices (mean annual site-counts from within the Strait of Georgia) and their lower and upper 95% confidence intervals for species-specific survey windows in each winter period (Figs. 1–57). Results are reported as statistically significant when $p<0.05$. Each account begins with a statement describing the species' distribution in the Strait of Georgia, B.C. based on Survey results presented in Badzinski *et al.* (2006, 2008).

There may be slight differences in the graphs presented here compared to trend graphs from the first 5 years of the program as published in Badzinski *et al*. (2006, 2008). This may be because the current analytical technique used the first year as the reference year, as opposed to the last year which had been used previously. It's also possible that the current analysis includes additional Survey data from earlier years that had not been available for the previous analysis.

Geese and Swans

Brant (*Branta bernicla)*

Small numbers of Brant (of the Grey-bellied form) winter in the Fraser Delta, on Roberts Bank and in Boundary Bay, and a few are beginning to winter regularly in other parts of the Strait of Georgia (*e.g.* the Saratoga Beach–Oyster Bay area), but the species is most numerous during spring migration, when large concentrations (of both Grey-bellied and Dark-bellied forms) gather on eelgrass beds along the east coast of Vancouver

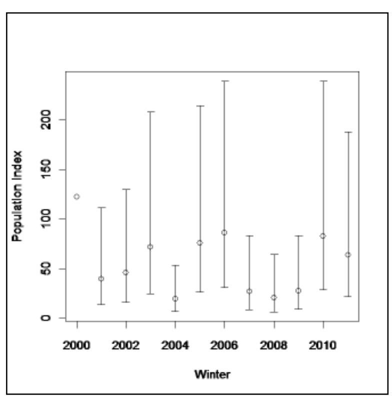

Fig. 2. Mean annual BCCWS site-counts (Feb–Apr) for Brant within the Strait of Georgia 1999–2011

Table 1. Annual population trends for 57 coastal waterbird species regularly using the Strait of Georgia, B. C., 1999-2011. An asterisk in the Species column indicates that the power analyses were able to detect a significant trend of 3% per year or less for that species based on 10 years of data at 160 sites. A statistically significant annual trend ($p < 0.05$) is denoted by "Declining" or "Increasing" in the Trend column, and "-" indicates that a statistically significant trend was not detected. Results for Snow Goose, Hooded Merganser and Herring Gull were not included due to data quality issues.

Species	Trend	Rate of change (% per year)
Brant	-	-4.7
Canada Goose*	Increasing	3.8
Mute Swan	-	1.2
Trumpeter Swan	-	-5.5
Gadwall	-	-7.3
Eurasian Wigeon	-	5.7
American Wigeon*	-	1.2
Mallard*	-	-1.1
Northern Shoveler	Increasing	19.7
Northern Pintail*	-	-2.6
Green-winged Teal*	Declining	-7.9
Canvasback	Declining	-22.9
Ring-necked Duck	-	4.7
Greater Scaup	Declining	-9.8
Lesser Scaup	Declining	-14.5
Harlequin Duck*	Declining	-2.6
Surf Scoter*	-	-0.7
White-winged Scoter*	Declining	-7.6
Black Scoter*	Declining	-19.2
Long-tailed Duck*	Declining	-7.0
Bufflehead*	-	-0.7
Common Goldeneye*	-	-0.2
Barrow's Goldeneye*	Declining	-4.3
Common Merganser*	-	1.7
Red-breasted Merganser*	-	-0.6
Red-throated Loon	Declining	-9.3
Pacific Loon*	Declining	-6.3
Common Loon*	Declining	-2.8
Horned Grebe*	Declining	-2.6
Red-necked Grebe*	-	-2.9
Western Grebe	Declining	-16.4
Brandt's Cormorant	-	-0.6
Double-crested Cormorant*	-	-0.4
Pelagic Cormorant*	-	1.8
Great Blue Heron*	Declining	-3.0
Bald Eagle*	Declining	-1.8
Northern Harrier	-	-4.3
Red-tailed Hawk	-	5.7
Peregrine Falcon	-	-7.5
Black-bellied Plover	-	-4.0
Killdeer	-	-2.6
Black Oystercatcher*	-	0.9
Greater Yellowlegs	Declining	-10.5
Black Turnstone*	-	0.4
Surfbird	Declining	-18.1
Sanderling	-	-7.7
Dunlin	Declining	-8.9
Bonaparte's Gull	Declining	-12.9
Mew Gull*	-	-2.5
Ring-billed Gull	-	-0.9
California Gull	-	-8.9
Thayer's Gull*	-	-4.1
Glaucous-winged Gull*	Declining	-4.3
Common Murre	-	3.8
Pigeon Guillemot	Increasing	21.7
Marbled Murrelet	-	-4.4
Rhinoceros Auklet	Declining	-17.6

Table 2. Species-specific survey power estimates (annual detectable trend) under various site-year scenarios (160.10 = 160 sites over 10 years; 240.20 = 240 sites over 20 years); annual survey site average is ~175. For those species with an asterisk, the survey is able to detect a significant trend of 3% per year or less based on 10 years of data at 160 sites.

Species	Sample Size	N	160.10	160.20	200.10	200.20	240.10	240.20
Brant	146	11	4.2	1.6	3.8	1.5	3.5	1.3
Canada Goose*	566	11	1.9	0.7	1.7	0.7	1.6	0.6
Mute Swan	33	9	6.7	2.7	6.1	2.4	5.6	2.2
Trumpeter Swan	155	11	6.3	2.5	5.8	2.3	5.3	2.1
Gadwall	49	11	5.5	2.2	5.0	1.9	4.6	1.8
Eurasian Wigeon	112	11	3.5	1.4	3.2	1.2	2.9	1.1
American Wigeon*	604	11	1.1	0.4	1.0	0.4	0.9	0.4
Mallard*	739	11	1.1	0.4	1.0	0.4	0.9	0.4
Northern Shoveler	35	10	18.9	7.8	17.6	7.3	16.6	6.8
Northern Pintail*	182	11	2.1	0.8	1.9	0.7	1.8	0.7
Green-winged Teal*	193	11	2.1	0.8	1.9	0.7	1.7	0.7
Canvasback	8	3	7.9	3.1	7.0	2.8	6.4	2.5
Ring-necked Duck	42	9	5.4	2.1	4.9	1.9	4.5	1.7
Greater Scaup	225	11	3.9	1.5	3.5	1.4	3.2	1.3
Lesser Scaup	106	11	4.3	1.7	3.9	1.5	3.6	1.4
Harlequin Duck*	440	11	1.3	0.5	1.1	0.4	1.0	0.4
Surf Scoter*	546	11	1.8	0.7	1.6	0.6	1.5	0.6
White-winged Scoter*	342	11	1.6	0.6	1.4	0.5	1.3	0.5
Black Scoter*	263	11	2.7	1.0	2.4	0.9	2.2	0.9
Long-tailed Duck*	230	11	2.5	1.0	2.3	0.9	2.1	0.8
Bufflehead*	810	11	0.8	0.3	0.7	0.3	0.7	0.3
Common Goldeneye*	628	11	1.2	0.5	1.1	0.4	1.0	0.4
Barrow's Goldeneye*	447	11	1.6	0.6	1.5	0.6	1.4	0.5
Common Merganser*	567	11	1.7	0.7	1.6	0.6	1.4	0.5
Red-breasted Merganser*	557	11	1.4	0.5	1.3	0.5	1.2	0.4
Red-throated Loon	152	11	3.8	1.5	3.4	1.3	3.1	1.2
Pacific Loon*	346	11	2.6	1.0	2.4	0.9	2.2	0.8
Common Loon*	516	11	1.2	0.5	1.1	0.4	1.0	0.4
Horned Grebe*	496	11	1.5	0.6	1.3	0.5	1.2	0.5
Red-necked Grebe*	263	11	2.3	0.9	2.1	0.8	1.9	0.7
Western Grebe	264	11	3.6	1.4	3.3	1.3	3.0	1.2
Brandt's Cormorant	89	10	4.8	1.9	4.4	1.7	4.0	1.6
Double-crested Cormorant*	639	11	1.3	0.5	1.2	0.5	1.1	0.4
Pelagic Cormorant*	485	11	1.6	0.6	1.5	0.6	1.3	0.5
Great Blue Heron*	437	11	1.8	0.7	1.6	0.6	1.5	0.6
Bald Eagle*	570	11	1.7	0.7	1.5	0.6	1.4	0.5
Northern Harrier	40	11	4.4	1.7	3.9	1.5	3.6	1.4
Red-tailed Hawk	51	10	6.9	2.7	6.3	2.5	5.8	2.3
Peregrine Falcon	16	8	8.6	3.4	7.6	3.0	6.9	2.7
Black-bellied Plover	123	11	4.4	1.7	4.0	1.6	3.7	1.4
Killdeer	171	11	4.1	1.6	3.7	1.4	3.4	1.3
Black Oystercatcher*	264	11	2.7	1.1	2.5	0.9	2.3	0.9
Greater Yellowlegs	170	11	3.8	1.5	3.5	1.3	3.2	1.2
Black Turnstone*	275	11	2.9	1.1	2.6	1.0	2.4	0.9
Surfbird	85	11	5.9	2.3	5.4	2.1	5.0	1.9
Sanderling	72	11	7	2.8	6.4	2.5	5.9	2.3
Dunlin	204	11	3.3	1.3	3.0	1.2	2.8	1.1
Bonaparte's Gull	169	11	5.7	2.2	5.2	2.0	4.8	1.9
Mew Gull*	485	11	1.7	0.7	1.5	0.6	1.4	0.5
Ring-billed Gull	207	11	3.4	1.3	3.0	1.2	2.8	1.1
California Gull	89	11	6.1	2.4	5.5	2.2	5.1	2.0
Thayer's Gull*	273	11	2.4	0.9	2.2	0.8	2.0	0.8
Glaucous-winged Gull*	831	11	1.4	0.5	1.3	0.5	1.1	0.4
Common Murre	114	11	6.2	2.4	5.6	2.2	5.2	2.0
Pigeon Guillemot	134	11	3.2	1.2	2.9	1.1	2.7	1.0
Marbled Murrelet	114	11	5.5	2.2	5.0	2.0	4.7	1.8
Rhinoceros Auklet	16	4	9	3.6	8.1	3.2	7.5	3.0

Island, particularly between Parksville and Qualicum Beach. The Survey did not detect a significant trend during the late winter-spring period from which data were analysed for this species. Numbers of Brant using the Parksville–Qualicum Beach area in spring appeared to be declining, but the Fraser Delta–Boundary Bay wintering population has been steadily increasing from being virtually absent in the mid-1980s (Pers. comm., A. Breault, Canadian Wildlife Service, 2010), a local trend that may be borne out by the BCCWS dataset if investigated at the sub-regional level. No significant change in Brant population numbers was detected between 1978–80 and 2003–06 in Puget Sound (Bower 2009), however a significant decline was detected for Brant in Padilla Bay over the same period (Anderson *et al*. 2009). The concurrent local decline in Padilla Bay and increase in the Fraser Delta–Boundary Bay suggests that a re-distribution may be occurring between the two areas.

Canada Goose (*Branta canadensis*)

Canada Goose populations found along the B.C. coast comprise a mix of native migratory populations and a resident multi-race population introduced to the Fraser River Delta and Vancouver Island in the early 1970s to improve hunting and public attention to wetlands (*e.g.* Dawe and Stewart 2010). It is now a common species year-round along much of B.C.'s coastline. The Survey detected a significant increasing trend of 3.8% per year over the past 12 years. The BCCWS may not be the best method to monitor this goose, which spends significant periods grazing inland, but can be considered a reliable indicator, in part because of the large dataset generated for the species (as indicated in the power analysis). Christmas Bird Count data from B.C. showed that wintering Canada Goose numbers increased dramatically (by 8.6% per year) over the period 1959–1988 (Sauer *et al.* 1996). Surveys from Puget Sound indicate a very large significant increasing trend in the overwintering Canada Goose population between 1978–80 and 2003–06 (Bower 2009). A significant increasing trend was also found in Padilla Bay over the same period (Anderson *et al*. 2009).

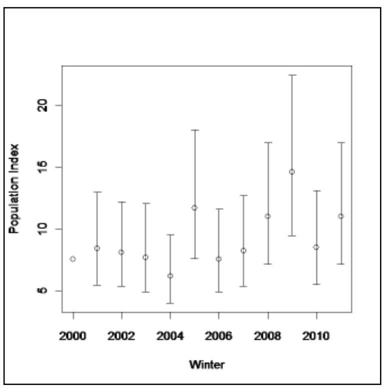

Fig. 2. Mean annual BCCWS site-counts (Dec–Feb) for Canada Goose within the Strait of Georgia 1999–2011

Mute Swan (*Cygnus olor*)

The Mute Swan is an introduced species from Europe that has established feral populations in several areas of coastal B.C. There have been concerns raised on the Atlantic Coast regarding this swan's threat to native vegetation from overgrazing (Allin and Husband 2003; Bailey *et al.* 2008). The BCCWS did not find a significant trend for Mute Swan.

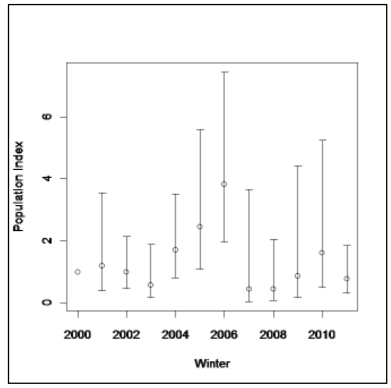

Fig. 3. Mean annual BCCWS site-counts (Dec–Feb) for Mute Swan within the Strait of Georgia 1999–2011

Trumpeter Swan (*Cygnus buccinator*)

There are two main concentrations of wintering Trumpeter Swan in coastal B.C., both occurring in estuaries adjacent to agricultural land: the Comox Valley and the Fraser Delta. A significant trend was not apparent from the BCCWS over the 1999–2011 period. The BCCWS may not be the best method to monitor this swan, which spends significant periods foraging on agricultural fields; the species' rather clustered distribution means that the estimated power of the Survey to detect annual changes of 3% after 10 years is poor. Prior to the Survey commencing, there had been a dramatic increase (>11% per year) reported on Christmas Bird Counts in B.C. from the period 1959–1988 (Sauer *et al.* 1996). Mid-winter aerial surveys in south coastal B.C. (Vancouver Island and Lower Fraser River Valley) by Environment Canada's Canadian Wildlife Service recorded a 615% total increase in Trumpeter Swan between 1970 and 2001, an average of >7% per year (Pers. comm., S. Boyd, Canadian Wildlife Service, 2010). Trumpeter Swan counts have been conducted in the Comox Valley for several decades. Winter numbers increased through the 1990's but have been relatively stable for the past 10 years at about 2000 individuals (1800–2500) (Pers. comm., A. Martell, Comox Valley Naturalists Society, 2012).

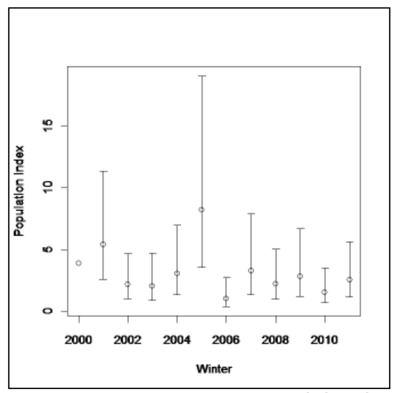

Fig. 4. Mean annual BCCWS site-counts (Dec–Feb) for Trumpeter Swan within the Strait of Georgia 1999–2011

Ducks

Gadwall (*Anas strepera*)

The Fraser River Delta supports the largest concentrations of this dabbling duck in coastal B.C. The highest counts are often tallied in fall (October–November), but do span the range of winter and spring months. No significant trend was apparent from the Survey over the 1999–2011 period. A significant increasing trend (5.8% per year) was shown by Christmas Bird Count data from B.C. from the period 1959–1988 (Sauer *et al.* 1996).

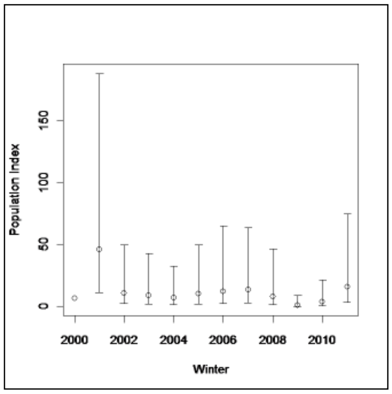

Fig. 5. Mean annual BCCWS site-counts (Dec–Feb) for Gadwall within the Strait of Georgia 1999–2011

Eurasian Wigeon (*Anas penelope*)

The Fraser Delta–Boundary Bay area supports the largest concentrations anywhere in B.C., and probably the Pacific Northwest, of this dabbling duck, which associates closely with its nearest congener, American Wigeon (*Anas americana*). No significant trend was apparent from the Survey over the 1999–2011 period. The long-term trend shown by Christmas Bird Count data from B.C. from the period 1959–1988 indicated a significant annual increase of 2.9% (Sauer *et al.* 1996).

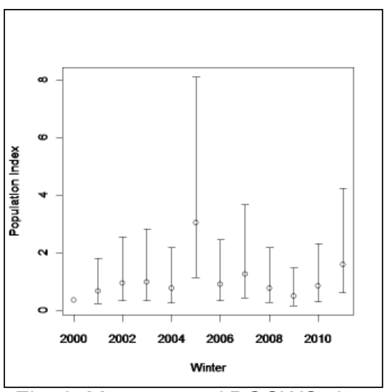

Fig. 6. Mean annual BCCWS site-counts (Dec–Feb) for Eurasian Wigeonwithin the Strait of Georgia 1999–2011

American Wigeon (*Anas americana*)

The Fraser Delta–Boundary Bay area supports the largest concentrations of this widespread dabbler; highest counts come from the western shores of Boundary Bay, where 10,000–43,000 are regularly recorded at Beach Grove between October and December. The Survey indicated no significant trend for American Wigeon between 1999 and 2011. No long-term trend was shown by B.C. Christmas Bird Count data from the period 1959–1988 (Sauer *et al.* 1996). No trend was detected for overwintering American Wigeon in Puget Sound between 1978–80 and 2003–06 (Bower 2009), whereas a significant increase was found in Padilla Bay for the same period (Anderson *et al.* 2009).

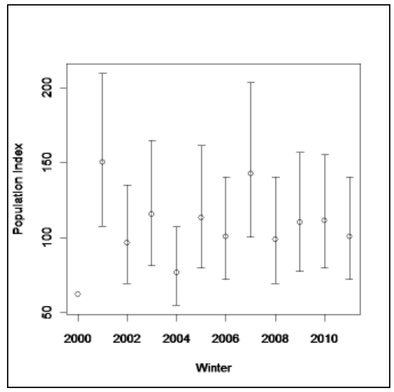

Fig. 7. Mean annual BCCWS site-counts (Dec–Feb) for American Wigeon within the Strait of Georgia 1999–2011

Mallard (*Anas platyrhynchos*)

This dabbling duck is common and widespread along the B.C. coast, with a clear centre of abundance in the Fraser Delta - Boundary Bay area. No significant trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. indicated no significant change in the wintering Mallard population from the period 1959–1988 (Sauer *et al.* 1996). A significant trend was not detected for overwintering Mallard in Puget Sound between 1978–80 and 2003–06 (Bower 2009) although a significant increase was detected in Padilla Bay for the same period (Anderson *et al.* 2009).

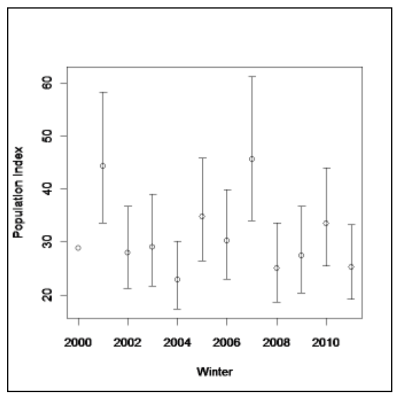

Fig. 8. Mean annual BCCWS site-counts (Dec–Feb) for Mallard within the Strait of Georgia 1999–2011

Northern Shoveler (*Anas clypeata*)

This species was not included in the previous analysis (Badzinski *et al.* 2006), but regularly occurs in small numbers and accordingly warrants attention here. The main centre of abundance is the Fraser Delta and Boundary Bay. Our trend analysis indi-

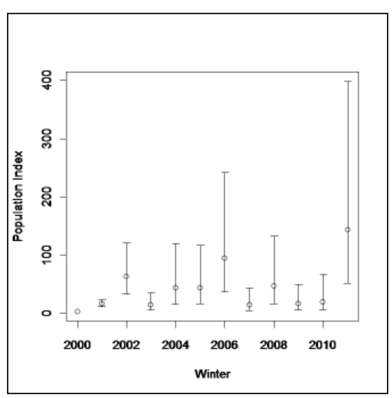

Fig. 9. Mean annual BCCWS site-counts (Dec–Feb) for Northern Shoveler within the Strait of Georgia 1999–2011

cated a significant increasing trend of 19.7% per year. The large variation in 2011 may be influencing the trend result since there does not appear to be an increase based on the graphical representation of the data (Fig. 9). Christmas Bird Count data from B.C. indicated no significant trend from the period 1959–1988 (Sauer *et al.* 1996).

Northern Pintail (*Anas acuta*)

The distribution of Northern Pintail broadly mirrors that of other dabbling ducks such as American Wigeon and Mallard, but if anything, shows an even greater concentration in the Fraser Delta–Boundary Bay area. No significant trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. indicated no significant trend from the period 1959–1988 (Sauer *et al.* 1996). Similarly, a trend was not apparent for overwintering Northern Pintail in Puget Sound, or more locally in Padilla Bay between 1978–80 to 2003–06 (Bower 2009; Anderson *et al*. 2009).

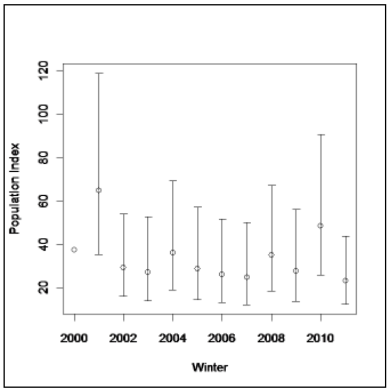

Fig. 10. Mean annual BCCWS site-counts (Dec–Feb) for Northern Pintail within the Strait of Georgia 1999–2011

Green-winged Teal (*Anas crecca*)

This species' distribution and abundance patterns broadly mirror those of other dabbling ducks, with a clear concentration in the Fraser Delta – Boundary Bay area. The Survey detected a significant declining trend (7.9% per year), despite large variance around annual means. Christmas Bird Count data from B.C. from the period 1959–1988 did not indicate a significant trend (Sauer *et al.* 1996). No significant trend was detected for overwintering Green-winged Teal in Puget Sound or more locally in Padilla Bay between 1978–80 and 2003–06 (Bower 2009; Anderson *et al.* 2009). The declining trend shown by BCCWS data is a flag for conservation managers to keep a close eye on this diminutive dabbling duck's numbers into the future; although waterbird populations can fluctuate widely under natural conditions (*e.g.* Wilkins and Otto 2003), the rate of trend (-7.9% per year) is steeper than might be expected naturally.

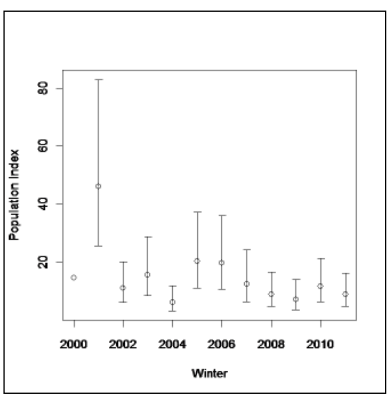

Fig. 11. Mean annual BCCWS site-counts (Dec–Feb) for Green-winged Teal within the Strait of Georgia 1999–2011

Canvasback (*Aythya valisineria*)

This diving duck is an uncommon but regular inhabitant of southern B.C. during winter, preferring freshwater bodies but also using coastal waters, especially with some freshwater input. The Survey detected a significant declining trend of approximately 22.9% per year over the 1999–2011 period. Christmas Bird Count data from B.C. from the period 1959–1988 did not detect a significant trend (Sauer *et al.* 1996). However, Breeding Bird Surveys of Canvasback in B.C. found a decline of 9.0% from 1966–2009, while a smaller decline of 1.6% was found across Canada for the same period. A significant decline of over 98% was found for Canvasback in Puget Sound between 1978–80 and 2003–06 (Bower 2009). Canvasback also underwent a significant decline in Padilla Bay during this same period (Anderson *et al.* 2009). The BCCWS is not the best method to monitor this species because of the bird's preference for freshwater habitats; the power analysis results (Table 2) showed the Survey's relatively poor ability in this regard.

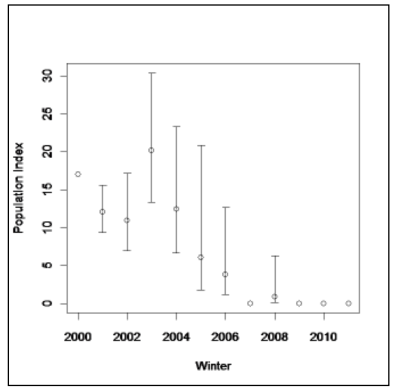

Fig. 12. Mean annual BCCWS site-counts (Dec–Feb) for Canvasback within the Strait of Georgia 1999–2011.

Ring-necked Duck (*Aythya collaris*)

Primarily a freshwater species, this diving duck occurs in small numbers along the B.C. coast in winter. No significant trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. from 1959–1988 showed no significant trend (Sauer *et al.* 1996). As noted under the Canvasback account, the BCCWS is not the best method to monitor

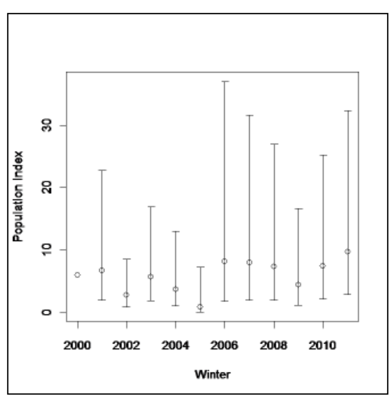

Fig. 13. Mean annual BCCWS site-counts (Dec–Feb) for Ring-necked Duck within the Strait of Georgia 1999–2011.

this species because of the bird's preference for freshwater habitats; the power analysis results (Table 2) showed the Survey's relatively poor ability in this regard.

Greater Scaup (*Aythya marila*)

Key areas highlighted by the Survey for this diving duck are the Fraser Delta - Boundary Bay, and several stretches on the east coast of Vancouver Island including Nanoose Bay, the Big Qualicum River Estuary, Craig Bay to Rathtrevor Beach Provincial Park, Deep Bay and Baynes Sound. The Survey showed a significant decline of 9.8% per year over the 1999–2011 period. Greater Scaup populations are a continental conservation concern, with declines documented throughout North America. Christmas Bird Count data from B.C. suggested a 4.4% annual decline from 1959–1988 (Sauer *et al.* 1996). That trend is mirrored by aerial survey data from southern Puget Sound, where a 72% decline was reported between 1978–79 and 1992–99 (Nyeswander *et al*. 2001). Significant declines occurred for both scaup species (combined Lesser [*A. affinis*] and Greater) in Padilla Bay between 1978–80 and 2003–06 (Anderson *et al*. 2009) and a significant decline of 64% was found for both scaup species combined in Puget Sound over the same period (Bower 2009). Long-term continental declines in combined scaup breeding populations are attributed to reduced recruitment, particularly in the Canadian western boreal forest (Afton and Anderson, 2001), perhaps as a result of climate change (Drever *et al.* 2009). The BCCWS indicates that the long-term decline is continuing; the steep rate of decline shown by the Survey is a red flag for conservation managers.

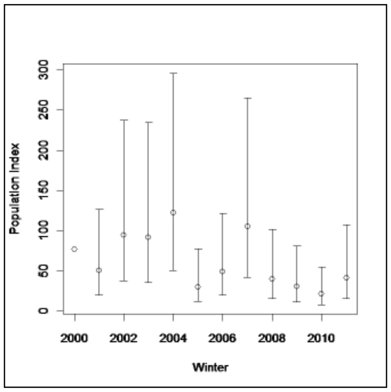

Fig.14. Mean annual BCCWS site-counts (Mar–Apr) for Greater Scaup within the Strait of Georgia 1999–2011.

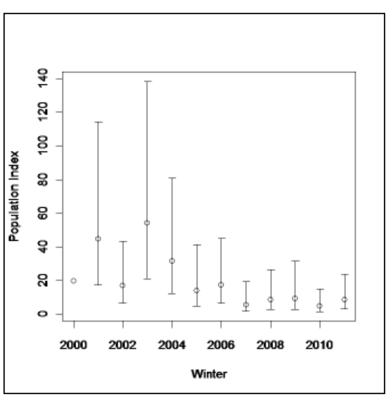

Fig. 15. Mean annual BCCWS site-counts (Dec–Feb) for Lesser Scaup within the Strait of Georgia 1999–2011.

Lesser Scaup (*Aythya affinis*)

This medium-sized diving duck uses salt water much less frequently than Greater Scaup; it tends to occur primarily along southern portions of the B.C. coast during winter, breeding in the interior. The Survey detected a significant declining trend for Lesser Scaup (14.5% annually). The Survey is not the best monitor of the species on account of the bird's preference for freshwater habitats. Declines have also been noted in breeding populations of Lesser Scaup, particularly those in the Canadian western boreal (Afton and Anderson, 2001), and populations of both scaup species combined in Puget Sound (see Greater Scaup account); across Canada, Breeding Bird Survey data indicate a decline of 3.0% from 1966–2009. However, Christmas Bird Counts from B.C. from 1959–1988 showed no significant trend (Sauer *et al.* 1996).

Harlequin Duck (*Histrionicus histrionicus*)

This omnivorous duck is a non-breeding visitor to the B.C. coast, favouring rocky shorelines and islets, with specific groups of individuals showing strong, very localised site-fidelity over long time periods (Pers. comm., S. Boyd, Canadian Wildlife Service, 2010). A distinct temporal pattern was borne out by BCCWS data; small wintering populations of 10–30 occurred in many areas, which later dispersed to the east coast of Vancouver Island in late winter/early spring and congregated in large numbers (highest individual site counts ranged from 500–1000) especially around Hornby and Denman Islands, Baynes Sound and the Courtenay-Comox area to feed on herring spawn in March. The population index from the BCCWS indicated a significant declining trend of 2.6% per year from 1999–2011. The long-term trend from Christmas Bird Count data in B.C. from 1959–1988 showed no significant trend (Sauer *et al.* 1996). Interestingly, aerial survey data from Puget Sound indicated a 186% increase between 1978–79 and 1992–99 (Nyeswander *et al*. 2001), and a 7% increase was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from the Salish Sea (Bower 2009). The apparent decline shown by BCCWS data over the past 12 years may be within the long-term natural variation of the population.

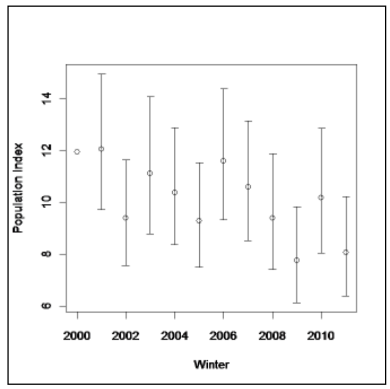

Fig. 16. Mean annual BCCWS site-counts (Dec–Feb) for Harlequin Duck within the Strait of Georgia 1999–2011.

Surf Scoter (*Melanitta perspicillata*)

Surf Scoter is widely distributed along the B.C. coast in shallower waters with rock and sediment substrates that support their preferred foods of mussels and clams. Important sites for the species include the Fraser River Delta and

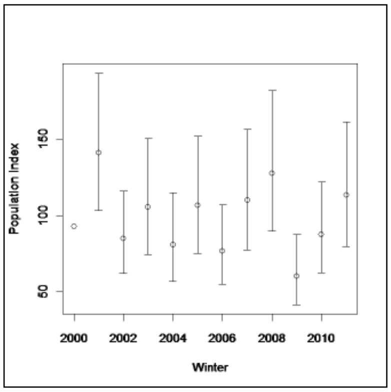

Fig. 17. Mean annual BCCWS site-counts (Dec–Feb) for Surf Scoter within the Strait of Georgia 1999–2011.

Boundary Bay , Vancouver Harbour, Howe Sound and stretches of the east coast of Vancouver, where large numbers redistribute to feed on herring spawn events in early spring (Lok *et al.* 2008). No trend was apparent from the Survey over the 1999–2011 period. This was encouraging; Christmas Bird Count data from B.C. from 1959–1988 showed a significant 2.5% annual decline (Sauer *et al.* 1996). Declines have occurred in the more developed areas of Puget Sound since the 1970s and across the Puget Sound region as a whole (Bower 2009), but increases are apparent locally, *e.g.* in Padilla Bay (Anderson *et al*. 2009). The pattern within the globally significant Salish Sea wintering population may be a complex one of local redistribution, with declines in some areas and increases in others, and warrants more detailed investigation.

White-winged Scoter (*Melanitta fusca*)

White-winged Scoter co-occurs with Surf Scoter, but is generally found in sand or gravel-bottomed bays, and rarely uses rocky shores. Important sites for the species included the Fraser River Delta, White Rock and the western shores of Boundary Bay (Centennial Beach), the north end of Denman Island, Chaster Beach on the Sunshine Coast and stretches of the east coast of Vancouver Island between Nanaimo and Comox, where large numbers redistribute to feed on herring spawn events in early spring (Lok *et al.* 2008). The Survey indicated a significant decline of 7.6% per year over the 1999–2011 period. Recent trend analyses of data from Puget Sound did not find a significant change for White-winged Scoter between 1978–80 and 2003–06 (Bower 2009), although a significant increase was found in Padilla Bay for all scoters during this period (Anderson *et al*. 2009).

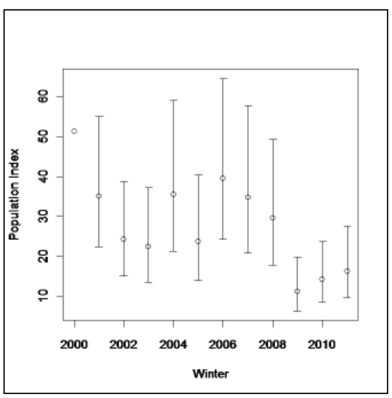

Fig. 18. Mean annual BCCWS site-counts (Dec–Feb) for White-winged Scoter within the Strait of Georgia 1999–2011.

Black Scoter (*Melanitta nigra*)

Black Scoter is less abundant than the other two scoter species along the B.C. coast, but is locally common where sand and gravel substrates support clams and other bivalves. Important wintering areas include Deep Bay, and the French Creek-Rathtrevor Beach Provincial Park area on the east coast of Vancouver Island, Roberts Creek on the Sunshine Coast and Sooke Basin (outside the Strait of Georgia) at the south end of Vancouver Island. The Survey showed a strong significant declining trend of approximately 19.2% per year in Black Scoter in the Strait of Georgia from 1999–2011. This rate of decrease is extremely high, and requires further investigation. Christmas Bird Count data from B.C. from the period 1959–1988 indicated a significant long-term decline of 3.1% annually (Sauer *et al.* 1996). An analysis of counts from Puget Sound conducted in 1978–80 and 2003–06 indicated that Black Scoter underwent a significant decline of ~65% (Bower 2009). Breeding surveys conducted in Alaska as part of the Waterfowl Breeding Pair and Habitat Survey indicated Black Scoter declined at a rate of 1.6% per year, or by almost 50% since the 1950's (Sea Duck Joint Venture 2003). Datasets from different parts of north-western North America consistently show quite strong declines for this species, raising a red flag for management agencies and highlighting the need for research to investigate potential causal factors.

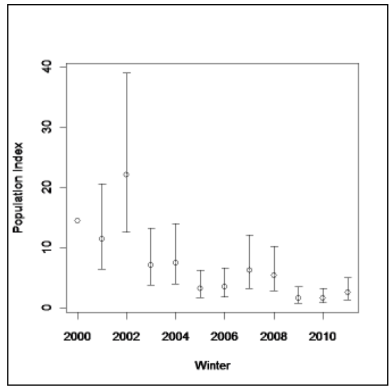

Fig. 19. Mean annual BCCWS site-counts (Dec–Feb) for Black Scoter within the Strait of Georgia 1999–2011.

Long-tailed Duck (*Clangula hyemalis*)

This sea duck spends much of its time in deeper water, often not visible from shorelines at sea level. Key wintering sites for the species include Cordova Bay and Bazan Bay to Roberts Point between Victoria and Saanich, White Rock and Iona Island on the Lower Mainland, and Hornby Island. High numbers are of-

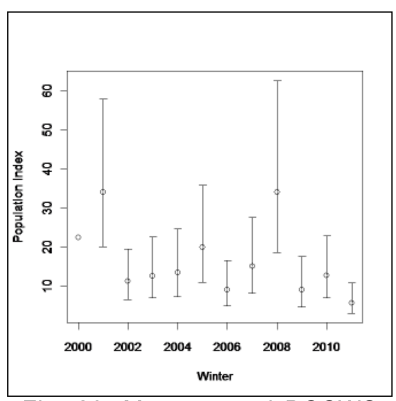

Fig. 20. Mean annual BCCWS site-counts (Dec–Feb) for Long-tailed Duck within the Strait of Georgia 1999–2011.

ten seen on the east coast of Vancouver Island during herring spawn events in spring. The Survey showed a significant declining trend in Long-tailed Duck (7% per year) for the period 1999–2011. Christmas Bird Count data from B.C. from the period 1959–1988 showed an annual decline of ~5% (Sauer *et al.* 1996). Large declines have been reported from aerial, shoreline and boat-based surveys in Puget Sound between the late 1970s and early 2000s (Nyeswander *et al*. 2001, Bower 2009), and long-term declining trends have been reported both continentally (Schamber *et al.* 2009) and globally (BirdLife International 2012a, b). The widespread, long-term decline indicated by numerous surveys is a major cause for concern. The species propensity to occupy offshore areas could potentially cloud interpretation of assessments of its population using shoreline-based surveys like the BCCWS.

Bufflehead (*Bucephala albeola*)

Bufflehead is a common, widespread and rather evenly distributed winter visitor to the B.C. coast. Like several other diving ducks, the largest concentrations regularly occur around Fillongley Provincial Park on Denman Island and Seal Bay, Comox, with occasional high counts along the Parksville–Qualicum Beach coastline of eastern Vancouver Island and also at the Squamish estuary. No trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count results suggested a stable wintering population in B.C. from 1959–1988 (Sauer *et al.* 1996). Trends from other regions of the Salish Sea show no consistent patterns, with local declines indicated in some parts of Puget Sound (Anderson *et al*. 2009), and increases in other parts of Puget Sound (Bower 2009).

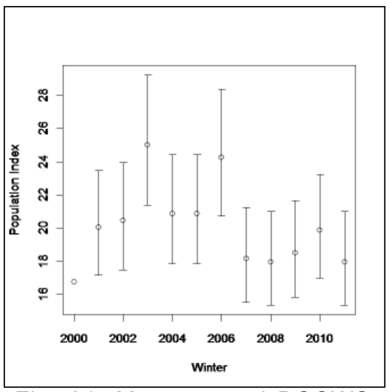

Fig. 21. Mean annual BCCWS site-counts (Dec–Feb) for Bufflehead within the Strait of Georgia 1999–2011.

Common Goldeneye (*Bucephala clangula*)

Common Goldeneye occurs all along the B.C. coast in winter, with regular concentrations at river estuaries such as the Big Qualicum, Nanoose, and Squamish. No significant trend was apparent from the BCCWS over the 1999–2011 period. Christmas Bird Count data from B.C. showed a significant decline of 2.4% per year during the period 1959–1988 (Sauer *et al.* 1996). Based on counts conducted in Puget Sound in 1978–80 and 2003–06, Common Goldeneye underwent a significant decline of ~48% (Bower 2009), and both goldeneyes combined underwent a significant decline in Padilla Bay over the same approximate period (Anderson *et al*. 2009).

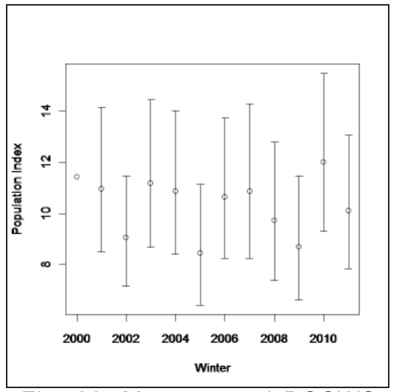

Fig. 22. Mean annual BCCWS site-counts (Dec–Feb) for Common Goldeneye within the Strait of Georgia 1999–2011.

Barrow's Goldeneye (*Bucephala islandica*)

Barrow's Goldeneye is chiefly distributed along rocky shores of the mainland coast, where it feeds on mussels and marine invertebrates. Key areas are the southern Sunshine Coast, the English Bay–Burrard Inlet area and Howe Sound. Vermeer (1982) and Savard (1989) showed that Barrow's Goldeneye is most numerous on the east shore of the Strait of Georgia, but why is not entirely clear. Ducks fitted with satellite transmitters on the B.C. south coast returned in subsequent years to the same stretch of coastline (Pers. comm., S. Boyd, Canadian Wildlife Service, 2009) but why apparently suitable areas are unoccupied is unknown. Individuals marked on the south coast nested in the B.C. Cariboo region near Riske Creek (Savard 1989). The population index from the BCCWS showed a significant decline over the period 1999–2011, at a rate of 4.3% per year. Site-counts at locations supporting very large numbers, such as Burrard Inlet, have dropped significantly over the past two decades (Pers. comm., E.M. Anderson, Simon Fraser University, 2011). A ~6% increase was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from across the Salish Sea (Bower 2009), but a 23% decline was reported between 1978–80 and 200305 in Puget Sound (Bower 2009). The BCCWS is a good barometer for this species, capturing sufficient data to detect relatively small annual changes in population, as indicated by the power analysis (Table 2). The declining trend indicated

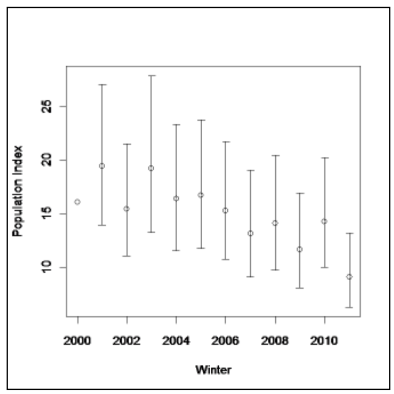

Fig. 23. Mean annual BCCWS site-counts (Dec–Feb) for Barrow's Goldeneye within the Strait of Georgia 1999–2011.

by this Survey and other surveys around the Salish Sea is a cause for potential management concern and warrants further investigation.

Common Merganser (*Mergus merganser*)

This fish-eating diving duck's breeding distribution is tied closely to large lakes and rivers in northern forested habitats, and in winter favours large lakes, rivers and reservoirs, and near shore habitats, occurring throughout coastal B.C. No trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. during the period from 1959–1988 found no significant trend (Sauer *et al.* 1996), and no significant trend was detected for either the Salish Sea or Puget Sound between the late 1970s and mid–2000s (Bower 2009). Common Merganser is sufficiently numerous at enough locations for the BCCWS to be a reliable indicator of its status in coastal habitats, as indicated by the power analysis (Table 2).

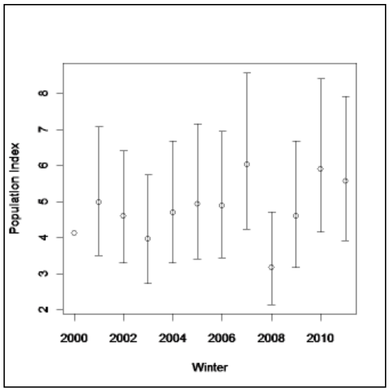

Fig. 24. Mean annual BCCWS site-counts (Dec–Feb) for Common Merganser within the Strait of Georgia 1999–2011.

Red Breasted Merganser (*Mergus serrator*)

This piscivorous 'sawbill' is a widespread nonbreeding visitor to the B.C. coast, breeding in the north on Haida Gwaii (Campbell *et al.* 1990). It has a similar ecology to the Common Merganser, but tends to occur more often in marine and estuarine environments in winter. It occurs all along the B.C. coast, especially in the south, and tends to concentrate off the Fraser Delta. No trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. from the period 1959–1988 did not detect a significant trend (Sauer *et al.* 1996). An ~18% decrease was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from the Salish Sea (Bower 2009), and a smaller decline (6%) was reported between 1978–80 and 2003–05 in Puget Sound (Bower 2009), but the local Padilla Bay trend was stable over the same approximate time period (Anderson *et al*. 2009).

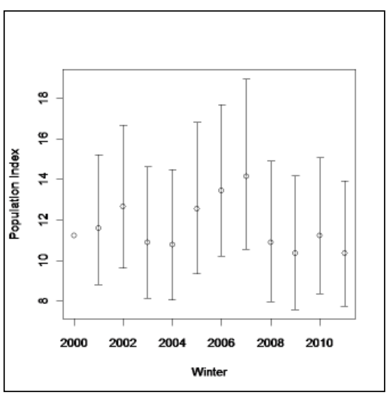

Fig. 25. Mean annual BCCWS site-counts (Dec–Feb) for Red-breaatsed Merganser within the Strait of Georgia 1999–2011.

Loons

Red-throated Loon (*Gavia stellata*)

Red-throated Loon winters all along the B.C. coast, with largest concentrations in areas of strong freshwater influence, including the Fraser Delta and Boundary Bay, and occasionally the Comox to Campbell River stretch of Vancouver Island's coast, and around Mayne Island. The Survey detected a significant declining trend (9.3% per year) from 1999–2011. This species has not been extensively studied in North America; however work from Alaska indicated that the species underwent a 53% decline on its breeding grounds from 1977–1993 (Groves *et al*. 1996). Recent analyses of several non-breeding survey datasets from Puget Sound also suggested a strong decline of 73.9% between 1978–80 and 2003–06 (Bower 2009), and a significant local decline over the same period in Padilla Bay (Anderson *et al*. 2009). The consistent reporting from western North America of significant declines over several decades is a red flag for this species, and requires further investigation.

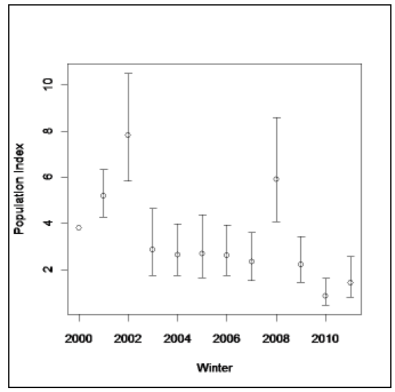

Fig. 26. Mean annual BCCWS site-counts (Dec–Feb) for Red-throated Loon within the Strait of Georgia 1999–2011.

Pacific Loon (*Gavia pacifica*)

This piscivore tends to flock where strong tidal currents concentrate high amounts of zooplankton and schooling fish. Peaks in abundance regionally occur in spring and fall, often associated with herring events on the east coast of Vancouver Island, and the Sunshine Coast. Historically,

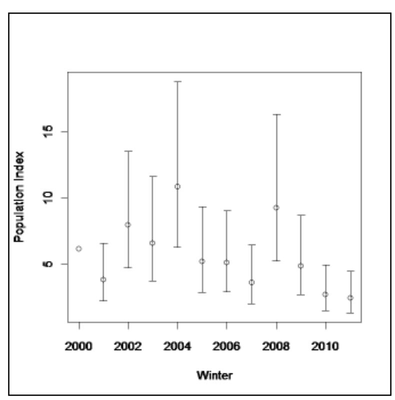

Fig. 27. Mean annual BCCWS site-counts (Dec–Feb) for Pacific Loon within the Strait of Georgia 1999–2011.

Active Pass was the single most important site for this species in the Strait of Georgia, with 2000 to 4000 birds regularly using the eastern entrance and Miner's Bay area in winter (Vermeer 1977, Campbell *et al*. 1990), but in recent years the highest count on the Survey totaled just 920 (March 2007). A significant declining trend (6.3% per year) was detected over the 1999–2011 period of the BCCWS. Christmas Bird Count data from B.C. from 1959–1988 indicated that the size of the wintering population increased by 5% (Sauer *et al.* 1996). However, a 50% decline was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from the entire Salish Sea (Bower 2009). An apparent increase in density was noted in Padilla Bay between 1978–79 and 2003–06 (Anderson *et al*. 2009). These different results suggest a complex pattern of temporal and spatial distribution and abundance in this region. Studies of breeding populations in Alaska did not find a significant population trend from 1977–1993 (Groves *et al*. 1996), with the exception of Prince William Sound where summering Pacific Loons declined by 94% from 1972 to 1989–1993 (Agler *et al.* 1999), probably related to the 1989 *Exxon Valdez* spill and a reduction in prey abundance resulting from a climatic regime (the Pacific Decadal Oscillation) shift in the North Pacific Ocean, during 1976–1977.

Common Loon (*Gavia immer*)

Common Loon is widely distributed along the Strait of Georgia coastline, particularly around the Fraser Delta and along the east coast of Vancouver Island. Largest concentrations on the Survey were recorded during fall and spring, at White Rock and in the Courtenay–Comox and Baynes Sound area of Vancouver Island. The Survey showed a significant declining trend (2.8% per year) from 1999–2011. Canada supports the majority of the continental population of Common Loon. Studies of breeding populations of Common Loon in Alaska did not find a significant population trend from 1977–1993 (Groves *et al*. 1996), but on the Cariboo, B.C., breeding grounds increases of 37% and 156% were reported between loon numbers in 1938 and 1958 compared with 2001 data (Dawe *et al.* 2003). Christmas Bird Count data from B.C. from 1959–1988 indicated no trend (Sauer *et al.* 1996), but across the wider Salish Sea, an apparent increase was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data (Bower 2009).

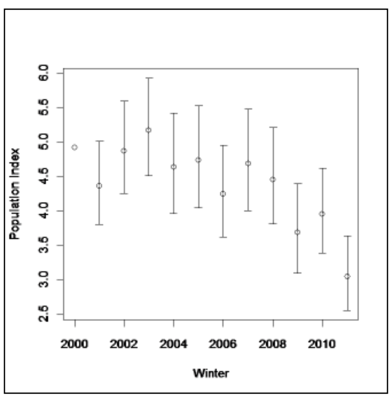

Fig. 28. Mean annual BCCWS site-counts (Dec–Feb) for Common Loon within the Strait of Georgia 1999–2011.

In Puget Sound, an apparent increase in density was noted in Padilla Bay between 1978–79 and 2003–06 (Anderson *et al*. 2009). These results suggest a complex pattern of distribution and abundance across the Salish Sea, with stable or increasing numbers in Washington, but possible cause for concern in B.C.

Grebes

Horned Grebe (*Podiceps auritus*)

This fish- and marine invertebrate-eating small grebe is a widespread and numerous non-breeding visitor (in all seasons, but chiefly in winter) to the Salish Sea, typically occurring in relatively small numbers at many locations, predominantly in coastal estuaries and bays. A significant decline (2.6% per year) was detected from Survey data from 1999–2011. Many Coastal Waterbird Surveyors around south-east Vancouver Island (Victoria, Saanich in particular) report substantial reductions in numbers in this region over a longer time period. The general longer-term picture in the Salish Sea is one of declines: Christmas Bird Count data from the Salish Sea indicated a 30% decline between the 1975–84 and 1998–2007 periods (Bower 2009), aerial surveys conducted in the Puget Sound reported an 82% decline between 1978–79 and 1992–99 (Nyeswander *et al*. 2001), and a ~60% decrease in density was noted in Padilla Bay between 1978–79 and 2003–06 (Anderson *et al*. 2009). The breeding range for this species has gradually contracted northwards over the last several decades, and, in April 2009, the western population of Horned Grebe was designated as a population of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2009).

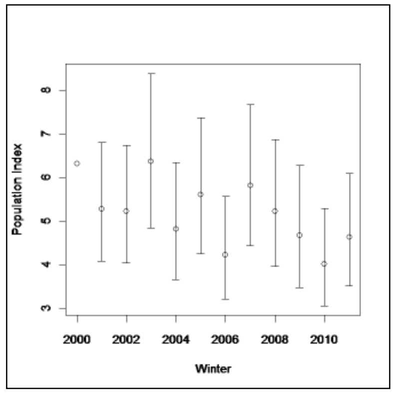

Fig. 29. Mean annual BCCWS site-counts (Dec–Feb) for Horned Grebe within the Strait of Georgia 1999–2011.

Red-necked Grebe (*Podiceps grisegena)*

Red-necked Grebe winters in marine waters along the entire length of the B.C. coast. Large concentrations regularly occur in the early- to mid-fall, and more sporadically at other times. Recent high abundances occurred at Deep Bay on the east coast of Vancouver Island and Powell River on the Sunshine Coast. No trend was apparent from the Survey over the 1999–2011 period. However, there is serious concern over the long-term health of the Salish Sea wintering population: Salish Sea Christmas Bird Counts indicated a

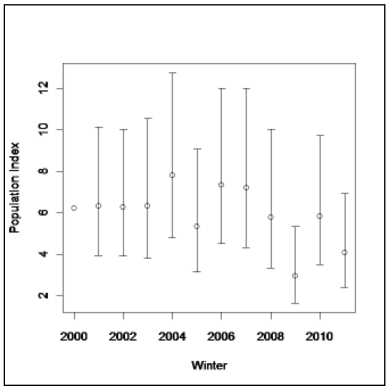

Fig. 30. Mean annual BCCWS site-counts (Dec–Feb) for Red-necked Grebe within the Strait of Georgia 1999–2011.

~35% decline between the 1975–1984 and 1998–2007 periods (Bower 2009), aerial survey data from southern Puget Sound reported an 89% decline in the two decades spanning 1978–79 to 1992–99 (Nyeswander *et al.* 2001), and local data from Padilla Bay in Washington indicated a 33% decline between 1978–79 and 2003–06 (Anderson *et al.* 2009). Christmas Bird Count data from B.C. indicated no trend from 1959–1988 (Sauer *et al.* 1996). Elsewhere, aerial survey data from Alaska suggested a 10% per year decline between 1988–1998 in the coastal zones of Yukon National Wildlife refuge (Alaska Department of Fish and Game 2006)), and declines have been observed at the southern limit of the Pacific wintering range between 1974 and 1993 (Pyle and De Sante 1994). The pattern of long-term decline in Washington versus apparent stability in B.C. warrants further investigation.

Western Grebe (*Aechmorphorus occidentalis)*

This specialist mid-water piscivore overwinters along southern portions of the B.C. coast, occurring in large flocks at some locations year after year, with largest numbers recorded at the Oyster River estuary and Fraser Estuary–Boundary Bay. Herring are an important food source for this species (Clowater 1998). Survey results showed a significant decreasing trend for Western Grebe over the past 12 years of 16.4% per year, indicating that the long-term decline of this species wintering in B.C. is continuing. A dramatic decline in Western Grebe has occurred across the northern part of its winter range over the past 40 years. An 85% decrease was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from the Salish Sea (Bower 2009); aerial survey data from southern Puget Sound reported a 95% decline between 1978–79 and 1992–99 (Nyeswander *et al*. 2001) and ongoing aerial surveys by the Washington Department of Fish and Wildlife throughout the inner marine waters of Washington also indicate that Western Grebe has declined between 1992 and 2010 (Anderson *et al.* 2011). Significant breeding colony declines and low reproductive success have been recorded in central, northeastern and northwestern Alberta (Alberta Sustainable Resource Development and Alberta Conservation Association 2006). This major conservation concern is receiving some attention, including the commissioning of a status assessment report by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2011) and collaboration between researchers working in the southern and northern portions of its breeding and winter ranges, including investigation of the hypothesis that wintering Western Grebe have shifted their centre of distribution southwards along the Pacific Coast (Anderson *et al.* 2011).

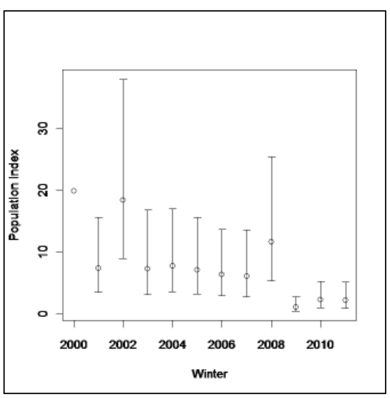

Fig. 31. Mean annual BCCWS site-counts (Dec–Feb) for Western Grebe within the Strait of Georgia 1999–2011.

Cormorants

Brandt's Cormorant (*Phalacrocorax penicillatus)*

This cormorant is endemic to western North America, occurring only in marine and outer estuarine habitats, and is more of a mid-water feeder and forage-fish specialist than the other cormorant species. It inhabits the southern coast of B.C. year round (breeding on the outer Pacific coast only), occurring along the central and north coast of the province in winter. Important wintering areas for Brandt's Cormorant in B.C. included Baynes Sound, the Sunshine coast, Victoria and the east coast of Vancouver Island. Active Pass formerly supported numbers in the thousands during the 1960s and 1970s, coinciding with Pacific Herring spawn (Edwards 1965, Vermeer 1977), but the species has seldom been recorded in three-figure numbers there over the past 12 years. No significant trend was apparent from the BCCWS over the 1999–2011 period. A 40% decline was reported between the 1975–84 and 1998–2007 periods, based on Christmas Bird Count data from the Salish Sea (Bower 2009), and several breeding colonies have disappeared in Washington (Ainley *et al.* 1994). The B.C. breeding population is small; it declined from 150 pairs in 1970 to 60 pairs in 1982 (Campbell *et al.* 1990), then rose again to 95 pairs in 1989 (Rodway 1991). In California, the population

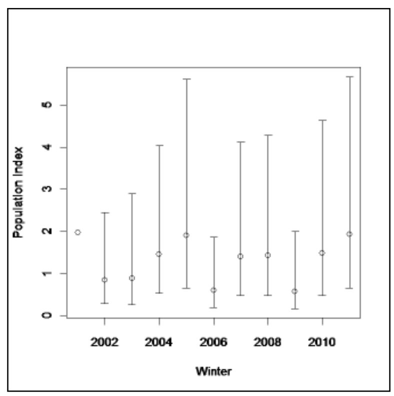

Fig. 32. Mean annual BCCWS site-counts (Sep–Oct) for Brandt's Cormorant within the Strait of Georgia 1999–2011.

has been increasing, after a sharp decline in 1982–83 due to shifts in the temperature regime of the Pacific Ocean (Carter *et al*. 1992) which led to reduced prey availability and a decline in breeding success. Declines are being reported from the Salish Sea for many piscivores (*e.g.* Bower 2009), including this species; re-distribution hypotheses need to be investigated as a possible alternative explanation.

Double-crested Cormorant (*Phalacrocorax auritus)*

This is the most generalist forager of the three cormorant species present in B.C., and the most widely distributed across North America. It is common in the Strait of Georgia, where it breeds on rocky islets and cliffs, but less common further north. No significant trend was found for the wintering population based on BCCWS data from 1999–2011. Surveys from Puget Sound indicated a significant increasing trend in overwintering Double-crested Cormorant (a near doubling of the population) between1978–80 and 2003–06 (Bower 2009), although more locally no trend was found in Padilla Bay for the same period (Anderson *et al*. 2009). However, since the 1980s (Vermeer *et al.* 1989), the breeding population in the Strait of Georgia plummeted by two thirds, perhaps due to eagle disturbance at colonies or food web changes (Chatwin *et al.* 2002). Continentally, Double-crested Cormorant has generally increased in population size since about 1975 in many areas of North America (Hatch 1995)); declining trends apparent in British Columbia, Washington, and Baja California are attributed to apparent movements of nesting birds during El Niño oceanographic conditions and habitat loss at interior colonies (Carter *et al.*, 1995). The pattern emerging seems to indicate declines or re-distribution of local breeding populations but stable or increasing wintering populations, possibly as a result of immigration from elsewhere.

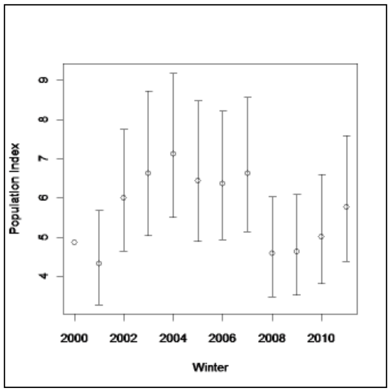

Fig. 33. Mean annual BCCWS site-counts (Dec–Feb) for Double-crested Cormorant within the Strait of Georgia 1999–2011.

Pelagic Cormorant (*Phalacrocorax pelagicus)*

Pelagic Cormorant prefers rockier shores and more saline waters than Double-crested Cormorant; they are benthic feeders, but also favour forage-fish species such as Pacific Sand Lance (*Ammodytes hexapterus*) . The Survey showed no significant trend for wintering Pelagic Cormorant in the Strait of Georgia from 1999–2011. Christmas Bird Count data from B.C. indicated no significant trend in B.C. from 1959–1988 (Sauer *et al.* 1996). Pelagic Cormorant in Puget Sound significantly increased (by over 87%) between 1978–80 and 2003–06 (Bower 2009). More locally, in Padilla Bay, no significant trend was found for Pelagic Cormorant over approximately the same time period (Anderson *et al*. 2009). However, studies of breeding colonies in the Strait of Georgia have found that numbers of nesting Pelagic Cormorant have declined by 50% since 1987 (Chatwin *et al*. 2002). The pattern of stable or increasing wintering populations contrasting with declining breeding populations indicates that the Salish Sea may be an increasingly important wintering area for this species. Research is needed to examine this.

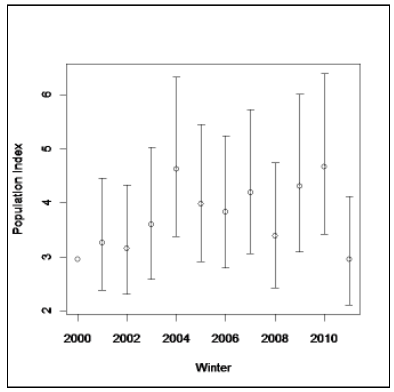

Fig. 34. Mean annual BCCWS site-counts (Dec–Feb) for Pelagic Cormorant within the Strait of Georgia 1999–2011.

Herons

Great Blue Heron (*Ardea herodias*)

This large wading bird is primarily a fish eater found along the shorelines of oceans, marshes, lakes and rivers, and it also uses agricultural fields where it preys on rodents, especially in winter. It is found throughout coastal B.C., with local concentrations around the Strait of Georgia (*e.g.* the Fraser Delta and Boundary Bay) and lower numbers spread more widely around the central and north coast (Butler 1997). The Survey indicated a significant declining trend (3% per year) over the 1999–2011 period. No significant trend was detected for Great Blue Heron in Puget Sound between 1978–80 and 2003–06 (Bower 2009). The coastal subspecies *A. h. fannini* is listed as Special Concern under the federal Species at Risk Act (Government of Canada 2012a); if taxonomic reviews currently underway split *A. h. fannini* into two subspecies, uplisting to Threatened may be recommended, based on a continuing decline (Pers. comm..

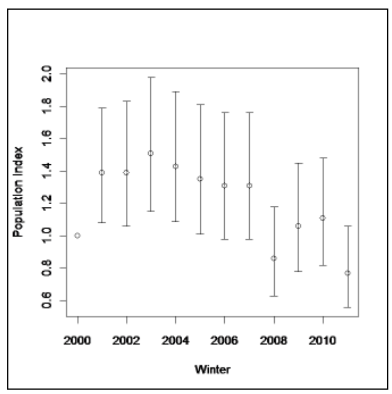

Fig. 35. Mean annual BCCWS site-counts (Dec–Feb) for Great Blue Heron within the Strait of Georgia 1999–2011.

R.W. Butler, Bird Studies Canada, 2010). The species is likely impacted by habitat loss, and nesting colonies are vulnerable to human disturbance and predation effects from Bald Eagle (Vennesland and Butler 2005).

Raptors

Bald Eagle (*Haliaeetus leucocephalus*)

The Bald Eagle is widely distributed along the B.C. coast, where the breeding population is augmented in fall and winter by birds from elsewhere. Highest numbers tend to occur in the late fall and early winter when birds gather to feed on salmon runs, then switch prey and feed more on waterfowl and other birds in the early winter, redistributing again to congregate at herring spawn sites in spring. The Bald Eagle plays a keystone ecological role along the B.C. coast as a top predator, depredating many coastal and marine bird species, including ducks, grebes, herons, cormorants, gulls and alcids, as well as scavenging fish, marine mammals and birds. The threat implied by the presence of eagles can affect the distribution of many bird species. A significant declining trend (1.8% per year) was apparent from the Survey over the 1999–2011 period. The Bald Eagle has undergone dramatic population fluctuations over the past two centuries, becoming rare in the mid- to late 1900s in the United States due first to human persecution and then impacts from pesticides (Elliot *et al*. 2011), but populations have since rebounded, with Christmas Bird Counts in B.C. from 1959–1988 showing significant increases of 4.5% per year (Sauer *et al.* 1996). In Puget Sound, Bald Eagle increased significantly by over 180% between 1978–80 and 2003–06 (Bower 2009). Data from raptor migration sites suggest the western North America population to have been stable over the past decade (Farmer *et al*. 2008, RPI Project 2011), but low sample sizes suggest winter surveys, like BCCWS, may provide better indicators (RPI Project 2011). The regional Strait of Georgia population may now have reached a plateau, and the slight decline indicated over the past decade by the Survey perhaps represents a correction from the population rebound, or may be driven by the high first winter value. The species' role as a top predator and disturbance agent means tracking its numbers will be important in interpreting data on other bird and fish abundance.

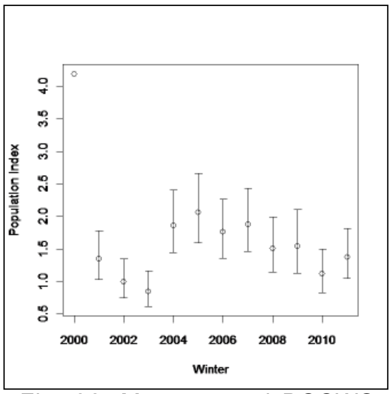

Fig. 36. Mean annual BCCWS site-counts (Oct–Dec) for Bald Eagle within the Strait of Georgia 1999–2011.

Northern Harrier (*Circus cyaneus*)

The Northern Harrier is found along much of the B.C. coast during winter, chiefly in areas with substantial fresh- and saltwater marshes, and agricultural fields (*e.g.* the Fraser Delta and stretches of the east coast of Vancouver Island). It is less common on the central and north coasts of B.C. No trend was apparent from the Survey over the 1999–2011 period. The Survey may not be ideal to assess trends in this raptor, which is more widely distributed on inland agricultural habitats. Canada-wide Breeding Bird Survey data from 1966 to 2009 show an annual decline in Northern Harrier of 1.9% (Sauer *et al.* 2011), while in B.C. no significant change was found for the same period. Christmas Bird Count data from B.C. from 1959–1988 did not find a significant trend (Sauer *et al.* 1996). Initial increases across the American West throughout the 1980s and 1990s gave way to marked decreases in the region since, possibly in connection with drought conditions (Farmer *et al*. 2008). Trends at migration sites in western North America over the past decade appear stable (RPI Project 2011).

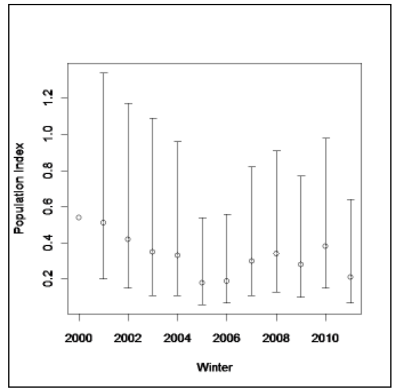

Fig. 37. Mean annual BCCWS site-counts (Nov–Jan) for Northern Harrier within the Strait of Georgia 1999–2011.

Red-tailed Hawk (*Buteo jamaicensis*)

The Red-tailed Hawk is common and widespread in B.C., occurring along the coast in areas with large stretches of open habitat such as agricultural fields, grassland and scrub. During the Survey, highest numbers were typically observed during the late winter and spring months. No trend was apparent from the Survey over the 1999–2011 period. Populations of Red-tailed Hawk appear secure across western North America (Farmer *et al.* 2008) although local declines at migration sites may have been observed locally over the past decade (RPI Project 2011). In addition to the removal of some key pollutants from the food

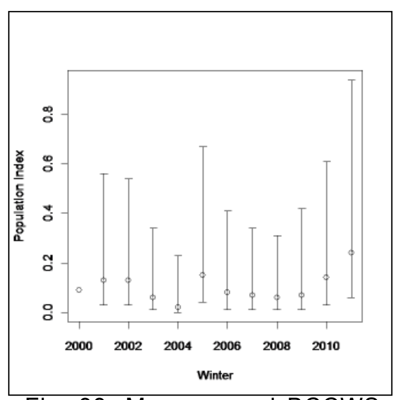

Fig. 38. Mean annual BCCWS site-counts (Nov–Jan) for Red-tailed Hawk within the Strait of Georgia 1999–2011.

chain, another factor which may be contributing to increased abundances of this raptor could be the widespread establishment of open, wooded parkland in place of grassland or dense forest. Christmas Bird Count data from B.C. from 1959–1988 showed a significant increasing trend of 4.1% per year (Sauer *et al*. 1996), and Breeding Bird Surveys in B.C. showed an increasing trend of 2.2% from 1966–2009 (Sauer *et al*. 2011). As for Northern Harrier, the BCCWS is not the best barometer for this species, but a useful indicator of its status in coastal habitats.

Peregrine Falcon (*Falco peregrinus*)

This widely distributed falcon is highly migratory and hunts smaller waterfowl and shorebirds as prey. In B.C., Peregrine Falcon winters in open coastal habitats with substantial populations of shorebirds and waterfowl, in particular in the Fraser Delta and Boundary Bay area. No trend was apparent from the Survey over the 1999–2011 period. Peregrine Falcon was severely affected by pesticides in the mid-twentieth century and experienced a serious population crash. It recovered well once the use of these chemicals ceased (Ydenberg *et al*. 2004). Christmas Bird Count data from B.C. showed no apparent trend from 1959–1988 (Sauer *et al*. 1996); population stability or increases were observed in trend analyses for the Peregrine Falcon in western North America over the past decade (Farmer *et al*. 2008, RPI Project 2011). As with Northern Harrier, the BCCWS is not the best barometer for this species, but a useful indicator of its status in coastal habitats.

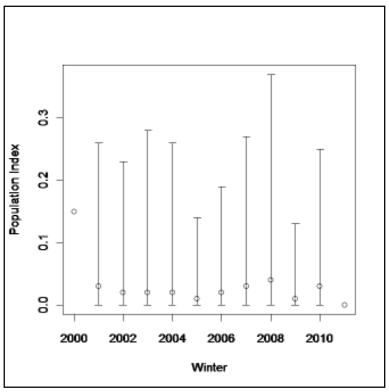

Fig. 39. Mean annual BCCWS site-counts (Nov–Jan) for Peregrine Falcon within the Strait of Georgia 1999–2011.

Shorebirds

Black-bellied Plover (*Pluvialis squatarola*)

This medium-sized shorebird winters locally along the southern B.C. coast, which is at the north end of its North American wintering range, and occurs more widely in larger numbers on passage in both spring and fall. During winter, Black-bellied Plover forages on sand and mudflat areas, and also uses agricultural fields to feed and roost. B.C.'s most important wintering sites are located around the Fraser River Delta, in particular Boundary Bay. No trend was apparent from the Survey over the 1999–2011 period. No trend was shown by Christmas Bird Count data from B.C. from 1959–1988 (Sauer *et al*. 1996). In a recent meta-analysis of North American shorebird population datasets, Andres (2009) noted that Black-bellied Plover showed declines on three of seven surveys that captured the species, all declines being shown in the eastern part of the continent.

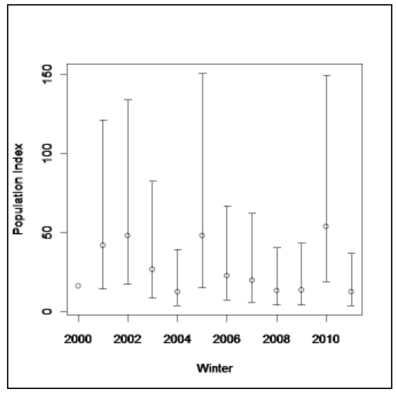

Fig. 40. Mean annual BCCWS site-counts (Nov–Jan) for Black-bellied Plover within the Strait of Georgia 1999–2011.

Killdeer (*Charadrius vociferus*)

This plover is widespread in low numbers all along the B.C. coast, frequenting mudflats, sand and gravel bars, a variety of short-sward habitats (natural and man-made) and agricultural fields. High counts of Killdeer were observed on the Survey at various locations on the coasts of the Lower Mainland and Vancouver Island. No significant trend was apparent from the Survey dataset from 1999–2011. A previous study suggested the population was stable in the Pacific Northwest (Morrison 1994). Within B.C, Breeding Bird Survey analyses (1966–2009) suggested a decline of 3% per year (Sauer *et al.* 2011), and Christmas Bird Count data from 1959–1988 also showed a significant decline, of 5.6% per year (Sauer *et al.* 1996). More widely, there is a consistent body of evidence pointing to a long-term decline in this shorebird's breeding population across much of the continent (Andres 2009), especially in Canada and western continental regions, although it appears to have increased in the Great Lakes area over the same period (Sanzenbacher and Haig 2001). In the context of widespread apparent declines, it will be important to maintain a close watch on the Survey's trend signal into the future.

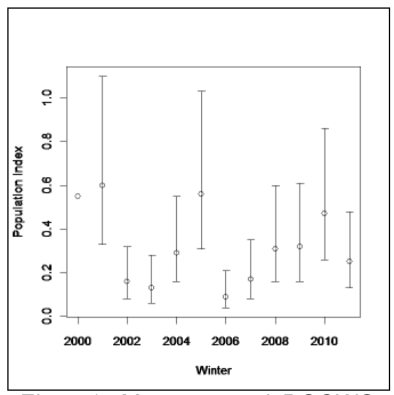

Fig. 41. Mean annual BCCWS site-counts (Nov–Jan) for Killdeer within the Strait of Georgia 1999–2011.

Black Oystercatcher (*Haematopus bachmani*)

The Black Oystercatcher is a monogamous, long-lived shorebird found only on rocky and stony shores along the

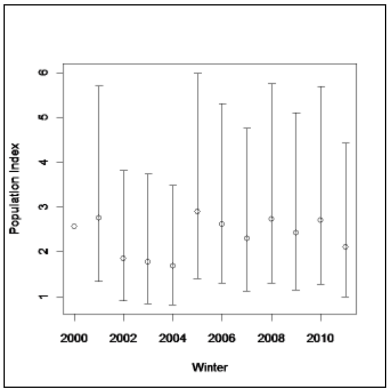

Fig. 42. Mean annual BCCWS site-counts (Nov–Jan) for Black Oystercatcher within the Strait of Georgia 1999–2011.

west coast of North America, where it forages for mussels and limpets. In B.C., Black Oystercatcher is found throughout the coast where it breeds and over-winters. The survey showed centres of winter abundance along the French Creek to Departure Bay stretch of Vancouver Island's east coast, on Hornby Island, in southern Victoria, West Vancouver, and at Sechelt on the Sunshine Coast. No trend in the winter population was apparent from the Survey over the 1999–2011 period. Butler and Golumbia (2008) concluded that the breeding population in the Strait of Georgia was either stable or slowly increasing. An estimated 210 pairs bred in the Salish Sea in 2005–06 (Golumbia *et al*. 2009). Christmas Bird Count data from B.C. from 1959–1988 suggested that Black Oystercatcher populations were stable (Sauer *et al.* 1996), but a more recent analysis of North American Christmas Bird Count data indicated an annual increase of 2.9% (Andres 2009). The relatively small breeding population in the Salish Sea is likely augmented in winter by immigrants from elsewhere.

Greater Yellowlegs (*Tringa melanoleuca*)

This large shorebird winters in small numbers around the southern coast of B.C., at the northern limit of its winter range, passing through in larger numbers in spring and fall. It prefers mudflats, where it forages for small fish and invertebrates, and on the Survey was found most commonly around Boundary Bay and the Fraser Delta during winter months. Insufficient data were available to analyse winter trends, so the trend was analysed for the March–April period when the largest dataset was available. A significant declining trend was apparent (10.5% per year) from BCCWS spring data over the 1999–2011 period. It is difficult to interpret this trend given potential biases from factors such as the Survey dates not consistently capturing annual variations in migration timing and the effects of predators (*e.g.* Peregrine Falcons) on shorebird distribution, abundance and behaviour (*e.g.* Pomeroy *et al.* 2008). Data from continental Christmas Bird Counts (1959–1988) indicated a significant increase at the northern limits of its winter range on both Atlantic (New Jersey, New York) and Pacific (California, Oregon and Washington) coasts, although this increase could be due to increased search effort (Sauer *et al*. 1996). In a recent meta-analysis of North American shorebird population datasets, Andres (2009) considers the North American population to be stable.

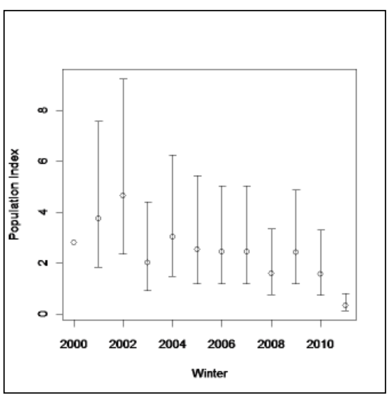

Fig. 43. Mean annual BCCWS site-counts (Apr) for Greater Yellowlegs within the Strait of Georgia 1999–2011.

Black Turnstone (*Arenaria melanocephala)*

The Black Turnstone is endemic to the Pacific coast of western North America. In B.C., it winters on rocky shorelines and around man-made structures (*e.g.* jetties) that support its favoured intertidal marine invertebrate prey. It is often found with another rocky shore specialist endemic to the north-east Pacific, the Surfbird (*Aphriza virgata*). No trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C., Washington and California (1959–1988) indicated that the wintering population is stable, but Christmas Bird Count data from the entire range indicated no trend (Andres 2009). Significant declines were recorded on Farallon Island, Calif., during the non-breeding season between 1974 and 1993 (Pyle and DeSante 1994). The BCCWS is a good barometer for this species, capturing sufficient data to detect relatively small annual changes in population, as indicated by the power analysis (Table 2).

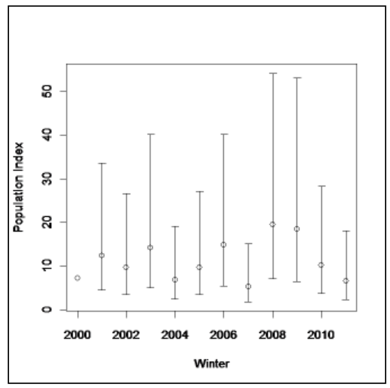

Fig. 44. Mean annual BCCWS site-counts (Nov–Jan) for Black Turnstone within the Strait of Georgia 1999–2011.

Surfbird (*Aphriza virgata*)

This rocky shore specialist occurs along the B.C. coast during the nonbreeding period, typically in flocks, and is very much tied to the narrow rocky intertidal zone where it forages on barnacles, amphipods and other intertidal invertebrates. Not much is known about its winter biology or breeding ecology, in part due to the remote location of its coastal wintering and mountain breeding grounds in Alaska and Yukon. A significant declining trend was found from BCCWS data for Surfbird (18.1% per year) over the 1999–2011 period. One issue relevant to interpreting this alarmingly high rate of apparent decline is that the species is rather local in its distribution and occurs on inaccessible offshore

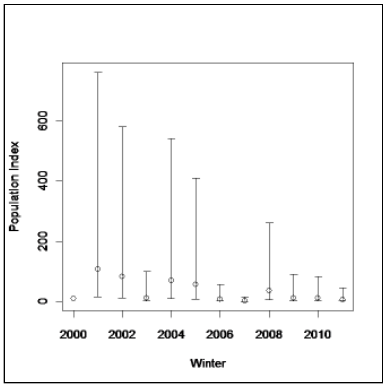

Fig. 45. Mean annual BCCWS site-counts (Nov–Jan) for Surfbird within the Strait of Georgia 1999–2011.

rocky islets; relatively few data for the species were collected by the Survey, so the power to detect trends is weak (Table 2). Nonetheless, it will be important to maintain a close watch on the trend signal from the Survey into the future, in part because there are little data from elsewhere to suggest how the species is faring (Andres 2009), although Morrison *et al*. (2006) indicated a declining trend.

Sanderling (*Calidris alba*)

The Sanderling is widespread along the North American west coast in winter and during migration, and in B.C. shows a patchy distribution, most commonly associated with sandy beaches and adjacent flats. No significant trend was apparent from BCCWS winter data for the 1999–2011 period. The Canadian population was apparently stable or decreasing, based on data that were not robust (Morrison 1994), but in a more recent meta-analysis of North American shorebird population datasets, Andres (2009) found that Sanderling showed declines on four of five surveys that captured the species, including the Christmas Bird Count. Christmas Bird Count data from B.C. from 1959–1988 showed no significant trend, while a significant decline of 3.7% per year was found in California for the same time period (Sauer *et al*. 1996).

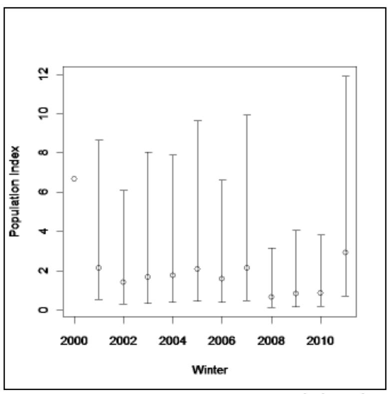

Fig. 46. Mean annual BCCWS site-counts (Nov–Jan) for Sanderling within the Strait of Georgia 1999–2011.

Dunlin (*Calidris alpina*)

This calidrid overwinters on large estuaries along the Pacific and Atlantic coasts, and like several other shorebirds reaches the northern limit of its winter range in southern B.C. It is strongly associated with coastal and intertidal areas and feeds on biofilm and marine invertebrates (Elner *et al*. 2005, Mathot *et al*. 2010). The Pacific Coast population (*C. a. pacifica*), is estimated at 500,000 birds, which is substantially larger than the other two populations in North America (Delaney and Scott 2006). In B.C., Dunlin occurs all along the coast in winter, but concentrates around the Fraser Delta–Boundary Bay area, with an estimated maximum on the Survey of 105,000 in November 2006. The Survey found a significant declining trend (8.9% per year) over the 1999–2011 period. A recent meta-analysis of North American shorebird population datasets (Andres 2009) revealed that Dunlin showed declines in six of eight surveys that captured the species, including the Christmas Bird Count. Mortality of Dunlin tends to be greatest during winter, likely due to avian predation from falcons (Ydenberg *et al*. 2004), and recent work indicates that predation risk during winter has contributed to a phenomenon known as over-ocean flocking (Ydenberg *et al*. 2010). Changes in behaviour driven by predation risk may have important implications for the interpretation of the Survey's trend estimates.

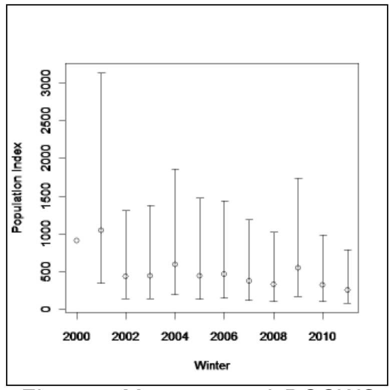

Fig. 47. Mean annual BCCWS site-counts (Nov–Jan) for Dunlin within the Strait of Georgia 1999–2011.

Gulls

Bonaparte's Gull (*Chroicocephalus philadelphia*)

This diminutive North American gull is chiefly a passage migrant along the B.C. coast, with a small number overwintering. Typically encountered on the Survey in (often large) flocks on migration in spring and fall, it concentrates around upwelling zones of tidal passages (*e.g.* Active Pass), where it feeds of plankton (Vermeer *et al*. 1987), and along specific stretches of the east Vancouver Island and Sunshine Coasts. The Survey showed a significant declining trend of 13% per year for the 1999–2011 period. Trends were assessed from data for the March–April spring migration period; the species propensity to pass through in large flocks during a rather narrow time window that does not consistently coin-

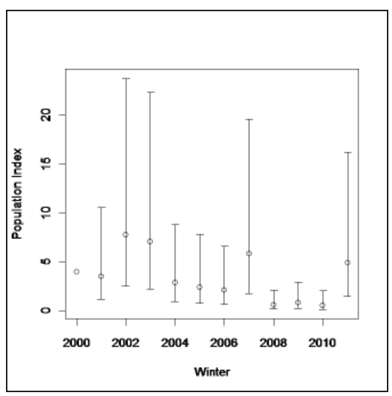

Fig. 48. Mean annual BCCWS site-counts (Mar–Apr) for Bonaparte's Gull within the Strait of Georgia 1999–2011.

cide with Survey dates make it rather difficult to interpret this trend. However, widespread and steep regional declines are reported by other sources for the winter period; Christmas Bird Count data from the Salish Sea for the 1975–84 and 19982007 periods and data from Puget Sound monitoring programs between 1978–80 and 2003–05 suggested declines of 72–89% (Bower 2009), and a significant decline in density was noted in Padilla Bay between 1978–79 and 2003–06 (Anderson *et al.* 2009). The reported declines from various sources are a cause for concern, although no current monitoring protocol in the Salish Sea is perfectly suited to this species, which is often sparsely distributed, and moves through the region in large numbers over a short time period, often offshore.

Mew Gull (*Larus canus*)

A very large nonbreeding population uses coastal and marine habitats throughout B.C. and freshwater-lake breeding colony populations commute to coastal habitats during the summer months. High counts for this gull consistently occurred during the month of March along the east coast of Vancouver Island, coinciding with herring spawn events. No trend was apparent from the Survey over the 1999–2011 period. Christmas Bird Count data from B.C. from 1959–1988 indicated a declining population trend in of 3.0 % per year (Sauer *et al.* 1996). Christmas Bird Count data from the Salish Sea for the 1975–84 and 1998–2007 periods suggested the population trend is stable (Bower 2009), but data from Puget Sound monitoring programs between 1978–80 and 2003–05 suggested a 25% decline (Bower 2009). The local trend in density in Padilla Bay between 1978–79 and 2003–06 was stable (Anderson *et al*. 2009). Previous studies indicated significant population growth from Gull Island, Alaska (Adamson 1988); however, the Exxon Valdez spill in Prince William Sound, Alaska, severely affected this species (Day *et al*. 1997).

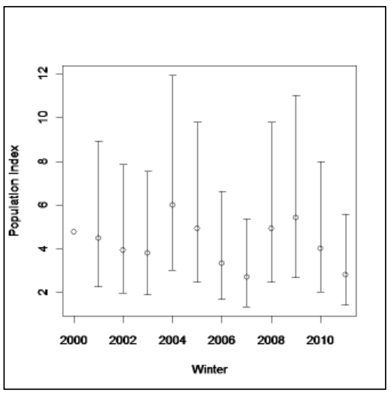

Fig. 49. Mean annual BCCWS site-counts (Oct–Jan) for Mew Gull within the Strait of Georgia 1999–2011.

Ring-billed Gull (*Larus delawarensis*)

This medium sized gull, which breeds on freshwater lakes across North America, disperses during late summer to winter to spend the non-breeding period especially in coastal habitats. On the Survey, the peak in abundance in B.C. occurred through the fall, with smaller numbers remaining through the winter along coastal beaches and adjacent agricultural and urban areas. It is most numerous around the southern coast, including Boundary Bay and the Comox Estuary. No trend was apparent from the Survey over the 1999–2011 period. The species' range continues to expand in the Northwest Territories and central and western B.C. Breeding Bird Survey data from 1966–2009 indicated numbers increased significantly in Canada and the U.S. at a rate of 3.3% per year (Sauer *et al.* 2011). Christmas Bird Count data from B.C. from 1959–1988 also suggested an increasing population trend at 2.7% per year (Sauer *et al.* 1996). No trend was detected for Ring-billed Gulls in Padilla Bay from 1978–80 to 2003–06 (Anderson *et al*. 2009).

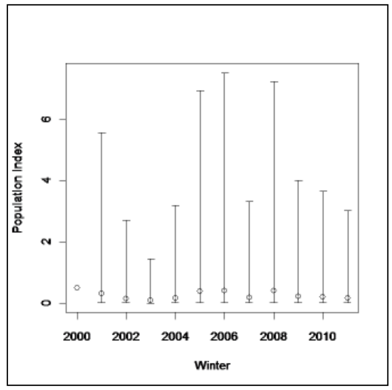

Fig. 50. Mean annual BCCWS site-counts (Sep) for Ring-billed Gull within the Strait of Georgia 1999–2011.

California Gull (*Larus californicus*)

California Gull breeds in the western interior of North American east to the Prairies, and spends the winter along the Pacific Coast. Large numbers migrate through southern coastal B.C. to their winter quarters in the United States and Mexico (Campbell *et al.* 1990). No significant trend was apparent from the Survey over the 1999–2011 period. Similarly, the long-term patterns from Christmas Bird Count data from B.C. from 1959–1988 (Sauer *et al.* 1996) and locally in Puget Sound (Anderson *et al.* 2009) were stable.

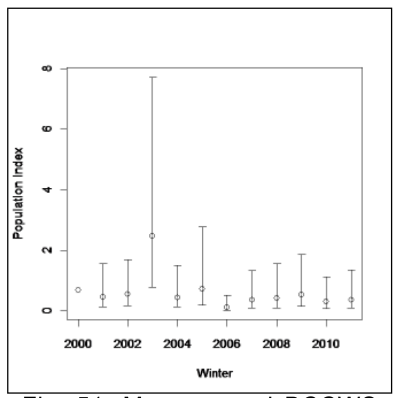

Fig. 51. Mean annual BCCWS site-counts (Dec–Feb) for California Gull within the Strait of Georgia 1999–2011.

Thayer's Gull (*Larus thayeri*)

A large proportion of the global population of Thayer's Gull, which breeds in the Canadian Arctic and Greenland, winters in B.C. along coastlines in the Strait of Georgia, and less commonly along the central–north coast. High numbers were consistently recorded on the Survey at the Oyster River estuary. No significant trend was apparent from the Survey

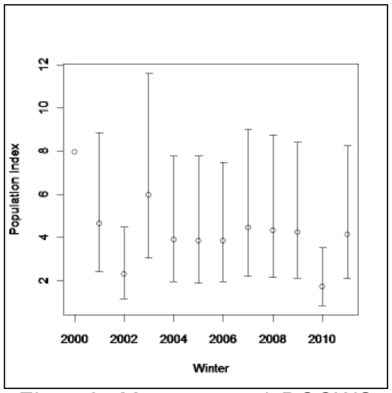

Fig. 52. Mean annual BCCWS site-counts (Dec–Feb) for Thayer's Gull within the Strait of Georgia 1999–2011.

over the 1999–2011 period. There is little information available from elsewhere from which to understand population trends in this species. The BCCWS may be one of the only monitoring programs regularly capturing population data on Thayer's Gull. Difficulties in separating Thayer's from some of the other large gulls mean that many gulls recorded on the Survey are assigned to the "unidentified gull" category, so a significant amount of potential data may have been lost.

Glaucous-winged Gull (*Larus glaucescens*)

The Glaucous-winged Gull is a widespread, common resident (subject to local movements) along the B.C. coast. It is a Pacific Coast endemic that forms part of a complex of similar species circling the northern hemisphere. Largest numbers of Glaucous-winged Gull were consistently recorded on the Survey on the east coast of Vancouver Island, near Nanaimo, Parksville, Big Qualicum River estuary, Baynes Sound and Campbell River, especially during March coincident with herring spawn events. A significant declining trend of 4.3% per year was found over the period 1999–2011. Christmas Bird Count data from the Salish Sea for the 1975–84 and 1998–2007 periods and data from Puget Sound monitoring programs between 1978–80 and 2003–05 suggested declines of 24–37% (Bower 2009), and a significant decline in density was noted in Padilla Bay between 1978–79 and 2003–06 (Anderson *et al*. 2009). In the Strait of Georgia, nesting pairs increased from 6,150 nesting pairs in 1959–1960, to 13,002 in 1986 (Vermeer and Devito 1989), but in 1997–1999, 14 islands in the Strait of Georgia contained only 3,506 nests compared to 5,116 nests in 1986, representing a 31% reduction, and many of the small islands that supported nesting gulls in the 1980s had been abandoned (Sullivan *et al*. 2002). These decreases may be due to increased disturbance levels and predation by Bald Eagle (Parrish *et al.* 2001, Sullivan *et al*. 2002). Research is showing that egg and clutch size reduction over the past 150 years, concurrent with an indication that Glaucous-winged Gull is now feeding at a lower trophic level, may be playing a role in observed declines (Blight and Arcese 2011). The consistent, continuing declining trend across several surveys is a major cause for concern, perhaps more so for this species whose range is confined to the Pacific Northwest than for some of the more widespread species.

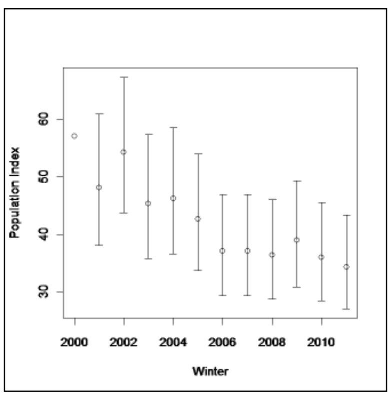

Fig. 53. Mean annual BCCWS site-counts (Dec–Feb) for Glaucous-winged Gull within the Strait of Georgia 1999–2011.

Alcids

Common Murre (*Uria aalge*)

In the Pacific, this large, fisheating alcid breeds in colonies on the outer coast from Alaska to Washington. The nearest breeding colonies to the Salish Sea are at the southern tip of Haida Gwaii, on Triangle Island off northern Vancouver Island and rocky islets off the Olympic Peninsula (*e.g.* Tatoosh Island). After breeding, it moves into the Strait of Georgia and other inner waters in late summer, where it undergoes a feather moult (Thomson *et al.* 1998), and then winters all along the coast, often in deeper water. In the Strait of Georgia, the Survey recorded largest concentrations off Mayne Island, the east coast of Vancouver Island and Victoria. No significant trend was apparent from the Survey over the 1999–2011 period, but the Survey may not adequately capture this alcid, which favours deeper water foraging areas often out of view of shorelines. A 27% decline was noted at the Triangle Island breeding colony between 1989 and 2003 (Hipfner 2005). Widespread, steep regional declines in nonbreeding populations were reported from Christmas Bird Count data from the Salish Sea between the 1975–84 and 1998–2007 periods and data from Puget Sound monitoring programs between 1978–80 and 2003–05, which suggested declines of 83–92% (Bower 2009). This is a trend shown by other mid-water forage fish feeders.

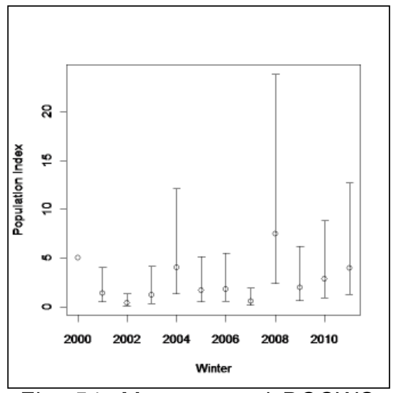

Fig. 54. Mean annual BCCWS site-counts (Dec–Feb) for Common Murre within the Strait of Georgia 1999–2011.

Pigeon Guillemot (*Cepphus columba*)

The Pigeon Guillemot is endemic to the North Pacific, found along rocky coastlines between Alaska and California. It is a widespread breeder along the B.C. coast, nesting in rock crevices, beneath logs and among pilings, and feed-

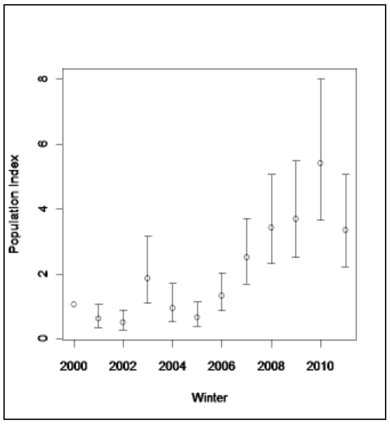

Fig. 55. Mean annual BCCWS site-counts (Dec–Feb) for Pigeon Guillemot within the Strait of Georgia 1999–2011.

ing in near shore areas on benthic fish and invertebrates. In the last five years, very high numbers of Pigeon Guillemot were observed on the Survey around the Victoria–Sidney area, especially during fall. The Survey showed a significant, strongly increasing trend of 21.7% per year over the 1999–2011 period. This rapid rate of increase may be over-inflated by the large numbers being recorded off the Victoria and Saanich Peninsula since 2005. Significant increasing nonbreeding population trends were apparent from Christmas Bird Count data from the Salish Sea between the 1975–84 and 1998–2007 periods, and data from Puget Sound monitoring programs between 1978–80 and 2003–05 found increases of 15–110% (Bower 2009). Only one survey (conducted from the air) contradicted these increasing trend signals, indicating a decline in Puget Sound (Nyeswander *et al.* 2001).

Marbled Murrelet (*Brachyramphus marmoratus*)

This North Pacific endemic is the only alcid to nest in trees in mature coastal forests throughout most of its range in North America and Asia. It occurs in inshore waters year-round along most of the B.C. coast. The Survey noted particular concentrations along the Sunshine Coast and in Johnstone Strait. No significant trend was apparent from the Survey over the 1999–2011 period, but this murrelet's diminutive size makes it difficult to see if far from shore; consequently it is not regularly recorded from many survey sites. It is listed as Threatened under the Species at Risk Act (Government of Canada 2012b) and globally as Endangered (IUCN 2011) based on rates of decline inferred from old growth forest loss. Major declines have been reported from the Salish Sea including Puget Sound, based on several different surveys (Bower 2009, Nyeswander 2001, Kelson *et al*. 1995). The BCCWS is not the best survey for assessing regional trends in this threatened alcid, but may provide some useful local insights to the wider picture of its status in coastal B.C.

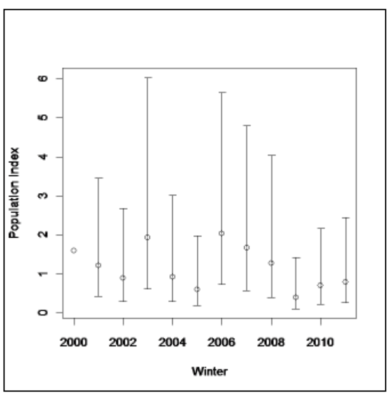

Fig. 56. Mean annual BCCWS site-counts (Dec–Feb) for Marbled Murrelet within the Strait of Georgia 1999–2011.

Rhinoceros Auklet (*Cerorhinca monocerata*)

This medium-sized alcid is found throughout temperate waters of the North Pacific. Most of the North American population breeds on a small number of islands on the coast of B.C. and adjacent parts of Washington and southeast Alaska. This auklet overwinters in the southern and central coasts of B.C. and further south along the Pacific coast. Large groups of Rhinoceros Auklet were observed on the Survey in the Johnstone Strait area and around Victoria. A significant declining trend was indicated by the Survey between 1999 and 2011 (17.7% per year), which may be driven by the high population index in the first year of the survey (Fig.57), and requires a more detailed examination of the data. Christmas Bird Count data from B.C. from 1959–1988 indicated a slight decline in Washington, but a substantial increasing trend in California (19% per year) (Sauer *et al.* 1996). At Cleland Island in B.C., the breeding population rose from a few in 1967 to 2,700 pairs in 1982 (Rodway 1991), and the area occupied by the main colony on Triangle Island expanded by 14% between 1984 and 1989 (Rodway *et al*. 1992). Numbers of Rhinoceros Auklet appear to have increased in Hecate Strait from 1984 to 1994, but predation by introduced raccoons may have impacted breeding colonies on some islands off Haida Gwaii (Gaston and Masselink 1997). Recent results from long-term breeding surveys on several colonies on the north and central coast of B.C. indicate that most Rhinoceros Auklet colonies are stable or increasing, except for the Pine Island colony (Rodway and Lemon 2011). Because Rhinoceros Auklet is an open marine water species, the shoreline-based BCCWS is not the best monitor for this alcid.

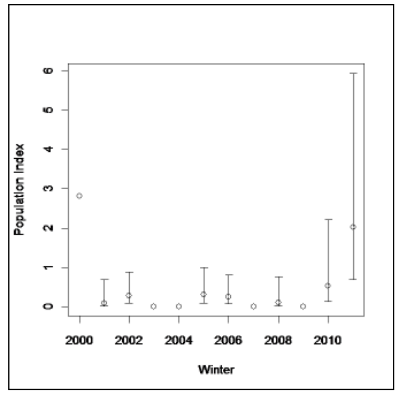

Fig. 57. Mean annual BCCWS site-counts (Dec–Feb) for Rhinoceros Auklet within the Strait of Georgia 1999–2011.

Discussion

The evolution and increasing value of the B.C. Coastal Waterbird Survey

Citizen science is increasingly being recognised by conservation biologists and management agencies as a key tenet for decision-making and research (*e.g.* Silvertown 2009, Dickinson *et al*. 2010). Several factors seem to be responsible for this, including the development of widely and easily available technical tools for data management and dissemination; the realisation among professional scientists that the public represent a highly cost-effective skill source (the field of ornithology in particular having a very large body of amateur experts); and research funders increasingly expect grantees to undertake project-related science outreach with the public. The B.C. Coastal Waterbird Survey exhibits elements of each of these. The trend analysis results are now posted annually online (Bird Studies Canada 2012). Many applied and basic ecological processes occur at geographic scales beyond the reach of ordinary research methods, and citizen science, which in particular enables large spatial coverage and long time series, has led to new, quantitative approaches to emerging questions about the distribution and abundance of organisms across space and time (Dickinson *et al*. 2010).

The BCCWS power analysis suggests that the Survey is performing well, now capable of detecting annual changes of 3% or less within populations of 29 species of 57 analysed (Tables 1, 2). This is an expected improvement from the estimates of survey power conducted using the first five years of data from the survey, which indicated that annual changes of 3% or less were detectable in 9 of 58 species analysed (Badzinski *et al*. 2006). This means that the survey is generating credible trend information for a wide range of species and guilds. It is consequently becoming a well respected trend information source by management agencies and research groups.

The estimated power of a survey depends on the adequacy of the survey design, volunteer adherence to survey protocols, inherent limitations within the data (Badzinski *et al.* 2006), and on the appropriateness of statistical methods used in analyses of data. It also must be remembered that power cannot be measured, it can only be estimated. Thus, if only a small sample (relatively few data from a small number of survey sites) 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. Although we duplicated the power analysis of Badzinski *et al.* (2006) here, other approaches, such as data simulations, to measure model fit are emerging as alternatives to traditional power analyses, and may be considered for future analyses.

Trends in specific species and guilds

Data from the last 12 years of the BCCWS indicated that the majority of species (33 of 57 species analysed) showed stable populations or no trend in the Strait of Georgia, almost 40% (22 species) showed significantly declining trends, and only three species showed significant increasing trends.

In the stable/no trend group are a group of 20 species for which the Strait of Georgia region is of global or continental conservation importance (Delaney and Scott 2006, Devenish *et al*. 2009, IBA Canada 2012). These include Red-necked Grebe, Brandt's Cormorant, Double-crested Cormorant, Pelagic Cormorant, American Wigeon, Mallard, Northern Pintail, Surf Scoter, Bufflehead, Common Goldeneye, Common Merganser, Red-breasted Merganser, Trumpeter Swan, Brant, Black Oystercatcher, Black Turnstone, Black-bellied Plover, Mew Gull and Thayer's Gull. This is encouraging news from both a management and restoration perspective (Butler 2009, Gaydos and Pearson 2011). Many of the Salish Sea ecosystem's key species appear to have a stable population base here.

Also of great interest to conservation managers and planners, for different reasons, are the species showing increasing population trends. Pigeon Guillemot shows one of the strongest statistically significant trends of any species recorded on the BCCWS over the past 12 years; its increase is mirrored over the longer-term in other parts of the Salish Sea (Bower 2009). It is a generalist feeder, with a preference for benthic fish and invertebrates, and peak abundance in B.C. has been noted in and around the Southern Gulf Islands (Davidson *et al.* 2010). One species showing an increasing trend that is prompting some concern is Canada Goose. Abundant Canada Geese can cause considerable damage by grazing and trampling, resulting in erosion of threatened plant communities, and facilitation of invasive grass colonization and domination of short plant communities through excessive nitrogenous nutrient input from faeces within the Southern Gulf Islands (Best and Arcese 2009, Dawe *et al.* 2011).

It is generally the declining trends that get the most attention. The BCCWS shows statistically significant declining trends for 22 species, including 12 for which the Survey generated very credible trend data after 12 years: Horned Grebe, Common Loon, Pacific Loon, Great Blue Heron, Green-winged Teal, Harlequin Duck, White-winged Scoter, Black Scoter, Long-tailed Duck, Barrow's Goldeneye, Bald Eagle and Glaucous-winged Gull. These species represent a broad spectrum of different guilds, and may be acting as sentinels for specific risk factors driving ecosystem-wide changes. The Strait of Georgia supports continentally or globally significant populations of several of these species. Some are already the focus of management and research attention (*e.g.* Great Blue Heron, Pers. comm., R.W. Butler, Bird Studies Canada, 2011; breeding Glaucous-winged Gulls, Pers. comm., L. K. Blight, University of British Columbia, 2011). For example, in April 2009 the western population of Horned Grebe was designated as a species of Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2009). But for other species such as Green-winged Teal, Black Scoter and Harlequin Duck, the BCCWS acts as an early warning or red flag that these species require a more specific focus from research groups and management agencies.

One guild – the forage fish feeders – has garnered special attention because of the steepness of decline shown by several members, especially in Puget Sound (Bower 2009, Anderson *et al*. 2009), but also in parts of the Strait of Georgia, including the Southern Gulf Islands (Davidson *et al*. 2010). The Western Grebe is the most prominent of these, and is now the subject of a status assessment by COSEWIC (COSEWIC 2011); others include Common Loon, Pacific Loon, Horned Grebe and Rhinoceros Auklet, all of which feed largely on small, mid-water schooling bait (or forage) fish when in the Salish Sea. Pacific Herring (*Clupea pallasii*) and Pacific Sand Lance are the two most important forage fish prey, particularly now that stocks of some species, such as Eulachon (*Thaleichthys pacificus*), have collapsed (Therriault *et al*. 2009). Significant changes have occurred in herring egg (spawn) and juvenile (less than one year old) life history stages, the two most important herring prey types for marine birds in the Salish Sea (Therriault *et al*. 2009).

There are numerous pressures on birds and their habitats within the Strait of Georgia and wider Salish Sea. Understanding which factors may be driving specific species or guild declines (or increases) is challenging, complicated by the possibility that some species showing apparent declines may in fact be re-distributing away from the areas being surveyed. Changes in behaviour (*e.g.* a change in propensity to aggregate offshore rather than nearshore) driven by predation risk by Bald Eagles may have important implications for the interpretation of trend data from surveys such as the BCCWS.

Next Steps for the B.C. Coastal Waterbird Survey

Whilst there is some congruence with monitoring program results from Puget Sound, the same stable picture is not apparent for all of these species, either locally, more widely in the southern Salish Sea south of the U.S.-Canada international border, or over the longer decadal timeframes over which trends are typically considered. It is important when interpreting the BCCWS 12-year dataset to look at longer time series data, including Christmas Bird Counts (with appropriate corrections for survey effort) and Washington Department of Fish and Wildlife surveys conducted during the mid-1970s and mid-2000s. Two efforts are now underway to consolidate datasets from different monitoring programs within standardized frameworks, one within the Salish Sea region, the other on a larger scale spanning the winter range of Dunlin and Western Sandpiper (*Calidris mauri*) from B.C. to South America. The BCCWS is a key element of both initiatives. The Salish Sea-wide approach is to bring different trend datasets within a standardized framework, in order to gain a better understanding of region-wide trends and the common risk factors that may be underlying population level changes. The shorebird project heeds the call of Dickinson *et al*. (2010) in taking an approach that will allow researchers to test hypotheses around several potential causes of population change, while at the same time assessing trends.

The BCCWS is now the largest contemporary monitoring database for a wide variety of coastal and marine bird species in B.C., for which all the data are accurately spatially geo-referenced. This offers the opportunity to align the seasonal survey count information with detailed habitat data available from the province (Shore-Zone, Howes *et al.* 1997), to identify specific habitats associated with the highest relative densities of different coastal waterbird species in specific seasons (*e.g.* moult periods, wintering grounds, and spring staging areas). Data-driven models of this type are required to help inform habitat management and securement through mechanisms such as the Pacific Coast and Sea Duck Joint Ventures, and predict species distributions in poorly known or unsurveyed areas of the B.C. coast to refine priorities for further work (*e.g.* for rocky shore specialists).

Acknowledgements

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