Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat (CSAS)

Research Document 2022/060

Pacific Region

Abundance and distribution of Harbour Seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia; synthesis of the 2014 aerial survey and long-term trends

Sheena P. Majewski and Graeme M. Ellis

Pacific Biological Station
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9V 1T3

October 2022

Canada

Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Published by:

Fisheries and Oceans Canada
Canadian Science Advisory Secretariat
200 Kent Street
Ottawa ON K1A 0E6

http://www.dfo-mpo.gc.ca/csas-sccs/
csas-sccs@dfo-mpo.gc.ca

© His Majesty the King in Right of Canada,
as represented by the Minister of the Department of Fisheries and Oceans, 2022
ISSN 1919-5044
ISBN 978-0-660-45357-6 Cat No. Fs70-5/2022-060E-PDF

Correct citation for this publication:

Majewski, S. P. and Ellis, G.M. 2022. Abundance and distribution of Harbour Seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia; synthesis of the 2014 aerial survey and long-term trends. DFO Can. Sci. Advis. Sec. Res. Doc. 2022/060. iv + 59 p.

Aussi disponible en français :

*Majewski, S. P. et Ellis, G.M. 2022. Abondance et répartition du phoque commun (*Phoca vitulina*) dans le détroit de Georgie, en Colombie-Britannique; synthèse du relevé aérien de 2014 et tendances à long terme. Secr. can. des avis sci. du MPO. Doc. de rech. 2022/060. iv + 60 p.*

TABLE OF CONTENTS

ABSTRACT

The Strait of Georgia (SOG) supports the highest density of Harbour Seals (*Phoca vitulina*) on the British Columbia (BC) coast and has been the primary index site for population surveys since the protection of the species in 1973. There were an estimated ~39,000 Harbour Seals in the SOG as of 2008, representing 37% of the BC population. Harbour seals have been identified as the primary prey species of threatened Transient (aka Bigg's) killer whales along the coast of BC. It is suspected that the recovery of Harbour Seal populations has contributed to the increased observations of Transient Killer Whales in the SOG in recent years, with Harbour Seals having been found to account for more than half of their diet in this area. The Recovery Strategy for Transient Killer Whales identifies the need to determine the quantity, quality and distribution of Transient Killer Whale prey necessary to sustain or increase the current population level. In support of this recovery objective, an updated assessment of Harbour Seal abundance and distribution in the SOG is provided based on counts from aerial surveys conducted near the end of the pupping season in 2014. Based on survey logistics, the SOG was partitioned into 7 subareas and seals were counted from images of individual haulout sites. Counts were adjusted for haulout sites that were not surveyed and unborn pups, and subsequently corrected for animals that were in the water and therefore missed during surveys. Abundance estimates were generated by 1) summing corrected counts across all haulout sites, and 2) by fitting the corrected counts to a generalized logistic model of the time series (1973-2014). The calculated abundance estimate of 39,300 (95% Confidence Intervals (CI) 33,400-45,200, rounded to the nearest hundred) was similar to the modeled estimate of 39,000 (95% CI 35,000-42,100) for the SOG. These are not significantly different from the population size of 39,100 (95% CI 33,200 to 45,000) reported for 2008. However, there was evidence of continuing redistribution among subareas and individual haulout sites, with further increases in the proportion of animals in the southern Gulf subarea in 2014.

INTRODUCTION

The Pacific Harbour Seal *(Phoca vitulina richardsi)* is the most abundant pinniped species in the Northeast Pacific and is ubiquitous throughout coastal and estuarine waters of British Columbia (BC) (Olesiuk 2010). Coast wide, the Harbour Seal population was likely depleted to ~10,000 animals in large-scale predator control programs and harvests from the late 1800s to the mid-1900s. Harbour seal abundance increased dramatically following their protection in the early 1970s then slowed in the mid-1990s, with populations currently thought to be at carrying capacity along much of the west coast of North America (Brown *et al.* 2005). Standardized aerial censuses of Harbour Seal populations conducted by Fisheries and Oceans Canada in the Strait of Georgia (SOG; Figure 1), BC between 1973 and 2008 documented similar trends, although abundance appeared to stabilize in the mid-1990's. Based on historic reconstructions, it is estimated that a full recovery of populations has taken place across the entire BC coast (Olesiuk 2010).

Due to the high density of Harbour Seals in the SOG (an average of 13.1 seals per kilometre vs. 2.7 in other areas of the coast) and the importance of these waters for both marine mammal and fish species, the SOG continues to be used as a Harbour Seal index site for the BC coast and has the most extensive time-series of population estimates (Olesiuk 2010). The previous survey, flown in August 2008, provided an estimated abundance of Harbour Seals in the SOG of 39,100 (95% Confidence Interval (CI) 33,200 to 45,000), representing 37% of the estimated 105,000 (95% CI 90,900-118,900) Harbour Seals inhabiting BC coastal waters (Olesiuk 2010).

There is ongoing interest in the role of Harbour Seals in the SOG ecosystem both as key predators of fish including salmon, herring and hake (Olesiuk *et al.* 1990a, Cottrell 1995, Li *et al.* 2010, Priekshot *et al.* 2013), and as a prey species critical to the recovery of Transient Killer Whales (Ford *et al.* 2013). Harbour seals have been identified as the primary prey species for Transient Killer Whales in BC waters, representing 52% of observed predation events by Transient Killer Whales (Ford *et al.* 2013). The increase in occurrence of Transient Killer Whales in the SOG over the past four decades has been attributed, in part, to the return of Harbour Seal abundance to historic levels. The key habitat features identified as critical for the survival or recovery of the Transient Killer Whale are mostly linked to feeding and the adequate abundance and distribution of prey. Ongoing assessment of the abundance and distribution of key prey species has been identified as an important recovery objective for Transient Killer Whales (DFO 2007). Although Harbour Seals are predated upon in all regions of the coast, in all months of the year, observations suggest that the post-pupping season (which varies clinally along the coast) is likely a prime period for Transient Killer Whales foraging on Harbour Seals.

Systematic Harbour Seal surveys have been conducted along the Pacific coasts of Canada and the US using fixed-wing aircraft to count seals hauled out on land during peak diurnal haulout periods (typically low tide) either during the pupping season (BC, Washington, Oregon and California) or the annual moult (Southeast Alaska). Various studies have shown that animals generally exhibit a high degree of site fidelity; although individuals may undertake local movements of up to several hundreds of kilometres associated with feeding, breeding, and moulting, they are generally considered to be non-migratory (Bjørge *et al*. 1995; Suryan & Harvey 1998; Härkönen & Harding 2001; Cordes & Thompson 2015; Cunningham *et al*. 2009). Distribution and behaviour of Harbour Seals appears to be linked to prey availability (Harvey 1987, Thomas *et al.* 2011), predation pressures from killer whales and shore-based predators (Nordstrom 2002, London *et al.* 2012), as well as human disturbance (Jansen *et al.* 2015).

In BC, the first aerial Harbour Seal surveys were undertaken in the mid-1960s, and standardized aerial censuses were conducted periodically during the 1970s and regularly since

the early 1980s. Olesiuk *et al.* (1990b) analyzed survey data collected up to 1988, and concluded that Harbour Seal populations in BC had been increasing at a rate of about 12.5% per year. Using a crude correction factor based on the variability of replicated surveys, they speculated that the total abundance of Harbour Seals in BC had increased from about 9,000-10,500 when the species was protected in the early 1970s, to about 75,000-88,000 in 1988. Olesiuk *et al.* (1990b) suggested that this represented the recovery from predator control kills and commercial harvests conducted between the late 1800s and 1960s. Subsequent assessments (Olesiuk 1999; Olesiuk 2010) confirmed that Harbour Seal populations had increased dramatically during the 1970s and 1980s, and have been stable since mid-1990s. Similar trends were also observed in Harbour Seal populations in adjacent US waters (Jeffries *et al.* 2003).

Fisheries and Oceans Canada's (DFO) Species at Risk Program has requested science advice on the current population status of Harbour Seals to assist in further refining the features, functions and attributes of the habitat necessary for survival or recovery of the Transient Killer Whale. Based on surveys conducted since the last assessment in 2008, an updated abundance assessment for Harbour Seals in the SOG has been developed. This information will be used to meet objectives involving prey availability, as identified in the Recovery Strategy for Transient Killer Whales (DFO 2007).

In addition to supporting recovery of Transient Killer Whale populations, information on Harbour Seal abundance and distribution is routinely required for responding to management issues including environmental assessments, spill response, siting of aquaculture facilities, evaluating impacts of marine mammal populations on local fishery resources, evaluating potential impacts of changing ocean conditions, and supporting ecosystem-based management in the SOG.

The objective of this report is to update the state of knowledge regarding the population status and distribution of Harbour Seals in the SOG, BC. An updated assessment for areas outside of the SOG is forthcoming.

METHODS

STUDY AREA AND CENSUS TECHNIQUES

As per previous surveys, the SOG was defined as all Canadian waters from Race Rocks in Juan de Fuca Strait in the south to the north end of Quadra Island in the north (Figures 1 & 2). This is the most intensely surveyed region of the BC coast (123 flights between 1966 and 2008) and has been considered to be an index site. The region was partitioned into 7 subareas (*SGULF=Southern Gulf*, *BBAY=Boundary Bay, FRASERR=Fraser River*, *HOWESD=Howe Sound*, *GULFISL=Gulf Islands*, *NEGULF=Northeastern Gulf*, *NWGULF=Northwestern Gulf*) based on Pacific Fishery Management subarea boundaries originally delineated in the mid-1980s (Olesiuk *et al.* 1990b), to allow population trend analysis through time (Figure 2). It should be noted that the initial partitioning of the Strait into these subareas was based on survey logistics (i.e. what could be reasonably flown in a day). While practical, these partitions lack biological relevance and do not necessarily reflect or capture various habitat attributes or structure within the Strait. They have been retained here to facilitate comparison with results from previous surveys.

An aerial Harbour Seal census was conducted in the SOG between August 11-22, 2014 to coincide with low tide cycles during the peak pupping season, following standardized census methods described by Olesiuk (1999, 2010). These protocols coincide with conditions when the maximum numbers of seals are expected to be hauled out. Specifically, standardized censuses have been timed to coincide with low tides that occurred between approximately 08:30 and

11:30 PDT toward the end of the pupping season (03 August - 09 September). Censuses began about 2.0-2.5 hours prior to the lower daily low tide, which typically ranged from about 0 to 1.5 m above datum, and ended just before or within an hour after low tide. The precise point at which surveys were initiated and terminated was dictated by observations of seals made during the census flight (e.g. evidence of animals spooking easily or milling in water near the haulout). In contrast to previous surveys, in cases where our visual observations indicated that animals had not begun to terminate haulout bouts, we flew until up to 2 hours after low tide.

When possible, censuses in high traffic areas were conducted on weekdays so as to minimize disturbance by recreational boaters. Flights were canceled during inclement weather (i.e. rough seas, high winds or heavy precipitation) as seals appear to be less likely to haul out under such conditions and are difficult to count in the water.

The aerial censuses were conducted from a Cessna *180* flown at an altitude of 150-200m at an airspeed of 125 $km \cdot hr^{-1}$. Shorelines were followed and all islands circumnavigated at a height between 100-200 m. As in past surveys we conducted a detailed search of the entire survey area, checking all known haulout sites with 1-3 observers scanning (usually with the aid of 8X40 or 8x42 binoculars) for new haulout sites and swimming animals. During the 2014 survey there were 3 observers for all flights, including one observer who had participated in previous surveys to ensure consistency.

Flight tracklines were recorded at 1 sec intervals, as a precise record of survey coverage. Visual counts were made of swimming animals and small groups (<5) of hauled out animals. Larger groups were photographed with a hand-held 36.3 megapixel Nikon D810 camera equipped with an f2.8 70-200 mm lens. Most seals observed were photographed and counted from images, with the exception of small groups of swimmers (<5 animals) not associated with haulouts and scattered mom-pup pairs recorded in the survey notes. Digital images were shot in JPEG format, managed using *Adobe Bridge* or *Photo Mechanic* software and imported into *Adobe Photoshop* for analysis. Contrast and brightness levels were adjusted if necessary, counting areas delineated and seals tallied using the Count feature in Photoshop. Photos were geotagged to tracklines based on time to confirm haulout locations and compare survey tracks and haulout locations to previous surveys.

Large haulouts (>200 seals) were counted in duplicate; photos to be counted were chosen and counted independently. If there was more than 5% difference between counts the count was redone until the difference was <5% and the average of the two independent counts was used. This represents a change from previous survey analyses where one individual counted all photographs. Small haulouts (<200 seals) were counted by one individual.

As in the past, the survey protocol was modified from the above protocols for two categories of haulout sites: 1) smaller estuaries along the east side of Vancouver Island, and 2) sites in the northern SOG which were comprised of numerous inter-tidal boulders scattered along beaches. As both of these categories are difficult to photograph, visual counts of animals resting on the bottom underwater or hauled out on boulders were also made, circling repeatedly (ensuring that animals were not disturbed) until visual estimates had stabilized. Note that Olesiuk *et al.* (1990a) estimated that these small estuaries account for about 5% of the total SOG population during the census period.

COUNT ADJUSTMENTS

This study follows the methods described in Olesiuk (2010) to standardize counts for the geographic area covered and the survey timing within the pupping season according to observed pupping clines (Bigg 1969a). Raw survey counts were also adjusted to account for known haulout sites that were missed during the survey flight and differences in the seasonal

timing of surveys, prior to trend analysis as per Olesiuk (2010) (Appendix A). This adjustment was very minor because we only missed sites in highly disturbed areas where fewer than 5 seals had been observed in previous year.

The second adjustment accounted for differences in the dates of censuses, important when censuses were conducted at different stages of the pupping season (Olesiuk 2010) as life tables for Harbour Seals in the SOG indicated that pups comprised ~20% of the total post-pupping population (Bigg 1969b). Observations in the SOG by Bigg (1969a) indicated that pupping was normally distributed over time with a mean pupping date of July 27 and standard deviation of 16.1 days (see Figure 2, Olesiuk 2010). To reduce temporal bias created by counting haulout sites at different phases of the pupping season, all counts were adjusted to post-pupping levels, as described in Olesiuk 2010. Adjustments for all surveys (1973-2008) ranged from 1.25 for censuses conducted prior to any births to 1.00 for censuses conducted after pupping was completed. These adjustments are applied assuming no error in the adjustment factor.

ESTIMATES OF ABUNDANCE

Standardized counts underestimate actual abundance because some animals are not hauled out during the survey, and swimming animals are difficult to census.

To obtain the correction factor (CF) for SOG surveys, Olesiuk (1999b, 2010) estimated the proportion of seals hauled out during surveys based on haulout patterns indicated by time-depth recorders (TDRs) deployed at 10 haulout sites and recovered from 33 animals in the SOG from 1990-94. He found the most important factors dictating the proportion of animals hauled out were time-of-day, height of the low tide, and particularly the time relative to low tide. The TDR data revealed a consistent pattern (with the exception of estuaries) in which the proportion of seals hauled out increased during ebbing tides, peaked at low tide, and subsequently declined during flooding tides. Based on this consistent pattern he generated *haulout response curves* that varied in amplitude depending on the height and time of the low tide (see Figure 10 in Olesiuk 2010).

To estimate the proportion of animals hauled out during aerial surveys in the SOG, Olesiuk (2010) generated a haulout response curve that approximated the tidal conditions during each survey flight in order to determine the correction factor for that day. The haulout response curve was subsequently used to determine a CF (which will be referred to in this paper as variable CF) to adjust each count during the survey flight based on the time it had been made relative to low tide. Because haulout curves were not available to determine flight-specific CF for 2014 counts, the overall mean of the correction factors derived for the SOG (average CF) of 1.626 (Coefficient of Variation (CV)=0.042) was applied for this analysis (assuming that on average 62% of seals were hauled out during surveys). This correction factor was applied to counts of seals that were hauled out during surveys; swimmers were removed from the total count prior to applying the CF. This is comparable with the approach used by Olesiuk (2010) to estimate abundance of seals outside of the SOG, applying the average CF for the SOG based on the assumption that haulout behaviour appeared to be similar throughout the species range, and surveys were conducted under comparable conditions.

To check this approach, we contrasted abundance estimates derived using either the variable (values from Olesiuk 2010 are included in Appendix A) or the average CF applied to adjusted counts in the standardized time series 1973-2008. Corrected counts were subsequently fit with a theta-logistic model (see below, Equation 4) to generate abundance estimates and outputs were checked for overlap. Both subarea and total SOG abundance were derived for each survey in the time series.

Variance of the abundance estimates incorporate: 1) the inherent variability of survey counts; and 2) the uncertainty in survey correction factors based on variability in haulout patterns (Olesiuk 2010). The overall variance of the abundance estimate, Var(*N*), can be calculated by:

$$Var(N) = \frac{1}{p^2 Var(SC)} + SC^2 Var\left(\frac{1}{p}\right) - Var\left(\frac{1}{p}\right) Var(SC) \quad (1)$$

as per Goodman (1960) where *p* is the estimated proportion of animals hauled out during the survey and *SC* is the standardized count. Confidence intervals were subsequently calculated assuming a log-normal distribution as suggested in Buckland *et al.* (2001) and are thought to be conservative (i.e. wider than necessary) (Olesiuk 2010).

TREND ANALYSIS

To estimate population growth rates in each subarea using the estimated abundances from aerial surveys, we used a log-linear model:

$$ln(N_t) = ln(N_{init}) + b(t - t_{init}) + \varepsilon_t \quad (2)$$

$$\alpha = exp(b) - 1 \quad (3)$$

where N_t is the population size in year t, N_{init} is the population abundance in the year of the first survey t_{init}, b is the slope of the regression, and α (see Equation 3) is the mean annual growth rate (Olesiuk 2010). The residuals from the linear model were assumed to be normally distributed: $\varepsilon_t \sim N(0, \sigma^2)$.

To determine whether or not density-dependent effects were present within the population (i.e., decreasing growth rates), a second-order polynomial was also fit to abundance data and compared to Equation 2. The second-order polynomial was constructed by adding the term $c(t - t_{init})^2$ to Equation 2.

Akaike Information Criterion for small sample sizes (AIC_c) was used to assess goodness of fit for both models (Burnam and Anderson 2002). Akaike weights (w) were calculated to evaluate the weight of evidence in favour of the "best" model according to AIC_c. Where the regression analysis showed evidence of density dependence, historical, current, and future population trends for each subarea were assessed using the theta-logistic growth model:

$$N_{t+1} = N_t + rN_t\left(1 - \left(\frac{N_t}{K}\right)^{\theta}\right), \quad (4)$$

where N_t is the population size in year t, r is the population's intrinsic growth rate, K is the population carrying capacity, and θ is the parameter that adjusts the maximum net productivity level of the population (Brown *et al.* 2005). When $\theta = 1$, Equation 4 is the standard logistic growth model.

Because the standard parameterization of the theta-logistic model often results in strong correlations between r and K, we re-parameterized Equation 4 according to Monnahan *et al.* (2014):

$$N_{t+1} = N_t + rN_t\left(1 - \left(\frac{r\theta N_t}{MSY(\theta+1)^{\frac{1}{\theta}+1}}\right)^{\theta}\right), \quad (5)$$

which is possible because $MSY = rK\theta/(\theta+1)^{\frac{1}{\theta}+1}$; we then set $K = MSY(\theta+1)^{\frac{1}{\theta}+1}$.

We assumed that population abundance estimates are independent and log-normally distributed, and defined the likelihood function for fitting the model as

$$L = \prod_{t=1}^{n} \frac{1}{\sqrt{2\pi\sigma_t^2}} \frac{1}{N_t^{obs}} exp\left[-\frac{\left(ln\left(N_t^{obs}\right) - ln(N_t)\right)^2}{2\sigma_t^2}\right] \quad (6)$$

where $\sigma_t^2 = ln(CV_t^2 + 1)$, N_t^{obs} is the observed abundance in year t, N_t is the model predicted abundance in year t, and CV_t is the coefficient of variation of the observed abundances in year t. We assumed a *CV* (defined as the standard error of the mean expressed as a proportion of the mean) of 0.077 in all years for this analysis (see Olesiuk 2010 for detailed discussion of CV for BC Harbour Seal surveys).

A maximum likelihood approach was employed to fit models to data (Hilborn and Mangel 1997) in the R Programming Environment (R Core Team, 2014). Parametric model-conditioned bootstrapping (Efron and Tibshirani 1994) was used to estimate uncertainty around model parameters and quantities of interest (e.g., K, N_t). 1,000 bootstrap replicates (datasets) were generated by adding randomly sampled residuals (with replacement) to the predicted abundance estimates:

$$N_t^* = \widehat{N_t} exp(N\epsilon_t^*), \qquad N\epsilon_t^* \sim N(0, \sigma_t^2), \quad (7)$$

where N_t^* is the bootstrap generated abundance for year t, $\widehat{N_t}$ is the predicted abundance from the maximum likelihood estimation using the original dataset, $N\epsilon_t^*$ are the sampled residuals, and σ_t^2 is the observation error. The estimation model is re-fit to each of the bootstrap datasets, providing 1,000 estimates for each parameter and quantity of interest. 95% confidence intervals were calculated by ranking bootstrap generated estimates from lowest to highest and identifying the 2.5th and 97.5th percentiles as the upper and lower limits of the confidence interval, respectively.

The total corrected count (sum of all subareas) for each survey (see Appendix A) was fit with the theta-logistic model to generate a model abundance estimate for the SOG. A second model estimate (i.e. subarea model abundance) was generated by summing the separate modeled subarea abundance estimates (i.e. fit with subarea specific models). As described in Olesiuk (2010) the abundance for subareas not surveyed in a particular year in the time series data was estimated by interpolating between the preceding and proceeding censuses on a logarithmic scale, which assumes that rate of population change was constant between surveys.

Density was calculated in terms of number of seals per kilometre of shoreline, using shoreline lengths calculated by Olesiuk (2010).

RESULTS

The unadjusted counts for haulout sites, the adjustment factors used for missed sites and unborn pups with resulting adjusted counts, the correction factors for missed animals, corrected counts and the estimates of abundance for Strait of Georgia censuses conducted from 1973-2014 are summarized in Appendix A.

DISTRIBUTION OF SEALS ACROSS HAULOUT SITES

The observed distribution of seals across the haul-out sites surveyed in 2014 is shown in Figure 3. Although haulout sites are widely distributed throughout the SOG, counts of animals using any particular haulout varied from survey to survey and the importance of haulout sites varies widely, with sites used by a few to nearly 800 seals.

In 2014, seals were observed at a total of 408 haul-out sites in the survey area; this includes 17 locations not previously observed to be haulout sites (2 in FRASERR, 2 in HOWESD, 4 in GULFISL and 9 in NEGULF). Five additional sites were identified in a previously un-surveyed inlet – these sites are included in the NEGULF haulout summary, but the counts were not used in calculating estimated abundance, to ensure comparability with previous surveys. Refer to Appendix A for a summary of counts at each haulout by subarea and Appendix B for haulout site maps.

The largest haulout sites in descending order were Race Rocks (SGULF, Figure B2), Marina Reef (NEGULF, Figure B11), Chatham Islets (SGULF, Figure B2), Chain Islets (SGULF, Figure B2), Belle Chain Islets (GULFISL, Figure B3), Rebecca Rock (NEGULF, Figure B11), Mittlenatch (NEGULF, Figure B11), Norris Rocks (NWGULF, Figure B10), Vivian Island (NEGULF, Figure B11), S Qualicum Bay Reef (NWGULF, Figure B10) and Ada Islets (NWGULF, Figure B7). Three of these large sites (Race Rocks, Chatham and Chain Islets), located in SGULF, showed increases in numbers from previous surveys. Two of these haulout sites were boulders scattered over beaches in the NEGULF. At 23% of the haulout sites where seals were observed there were 10 seals or less, and most (64%) had fewer than 100 seals.

The density of seals was highly variable between subareas, ranging from 2.5 to 25.5 seals·km^{-1}, with an overall average density of 13.2 seals·km^{-1} for the SOG (Table 1).

VARIABLE AND AVERAGE CORRECTION FACTORS

Abundance estimates 1973-2008 and subsequent model fits derived using the average CF of 1.626 (range: 1.414-3.106) for the SOG were not significantly different from those obtained using the variable CF (Figure 4 and Appendix A).

ESTIMATES OF ABUNDANCE

In keeping with recent surveys (Olesiuk 2010), this survey was conducted toward the end of the pupping season so the adjustment for pups not yet born was minor, ranging from 1.004 to 1.061 (Appendix A).

In 2014 a total of 23,412 Harbour Seals were counted in the SOG, compared to 21,778 in 2008 and 23,819 in 2003. Assuming that ~62% of animals are hauled out during survey flights in the SOG (CF 1.626) the estimate of abundance based on adjusted counts in the SOG for 2014 is 39,287 (95% CI 33,397-45,179) as compared to 37,042 in 2008. The modelled abundance estimate for the overall SOG in 2014 is 38,986 (95% CI 35,043-42,079). This is similar to the estimate of 38,896 (95% CI 35,908-42,292) obtained by summing the subarea-specific model abundances (i.e. subarea model abundance) (Table 2; Figure 5).

The modelled estimate of abundance for the SOG for 1973-2014 falls within the ranges estimated by Olesiuk (2010) for 1973-2010 of 39,100 (95% CI of 33,200 to 45,000).

SUBAREA DISTRIBUTION

While overall abundance remains steady for the SOG there appears to be ongoing changes in distribution among subareas and amongst sites within subareas (Table 2; Figures 3, 5 and 6), with a continued increase in the relative importance of SGULF haulouts observed in 2014.

POPULATION GROWTH RATE

As reported in previous assessments, there was an exponential rate of population increase during the 1970s and into the late 1980s of about 13.0% per year, the maximum growth rate documented for this population. The growth rate subsequently began slowing around 1990 and the population appeared to have stabilized at an average level of about 39,000; this is consistent with the carrying capacity estimated by the generalized logistic model for the SOG K=38,986 (bootstrapped 95% confidence interval 37,900-42,000) (Table 2, Figure 4).

During 1973-2014 the SOG population grew at a mean rate of 6.8% per year, which was significantly lower (r^2=0.800; P<0.001) than the growth rate of 13.6% derived for the previous assessment period (1973-2008). Although there has been no significant change in overall abundance the growth rates have been variable between subareas. The mean annual finite rates of increase in subareas ranged from 0% to 8.4% per year (Table 3). The population trajectory for the entire SOG, and the subareas, was significantly improved by adding a second-order term (Table 4), indicating the growth rate had slowed overall, presumably as a result of density-dependent processes. The population trajectory was best described by a generalized logistic equation (see Equation 5), which allowed for a slowing of exponential growth with increasing population size.

DISCUSSION

The standardized counts are intended to represent counts made as if the geographic coverage and timing (relative to the pupping season) of surveys had been identical in all years since DFO began standardized Harbour Seal surveys in BC. Standardized aerial counts have been found to provide a reliable and reproducible index of Harbour Seal abundance in BC waters, and Olesiuk (1999, 2010) concluded that in light of the ongoing time-series of counts for the SOG and the population growth sustained over much of that period, the resulting population trend (a ten-fold increase in abundance) minimized the significance of any underlying variability due to slight differences in census conditions. That being said, the surveys still reflect all of the inherent inaccuracy of visual counts for animals whose haulout behaviour varies with tidal and environmental conditions, uncertainty in correction factors, and immigration and emigration from the census area (Olesiuk 2010). This survey also represents a break in continuity due to program staff turnover; below we discuss some key differences and exceptions to previous surveys.

This study reports that the abundance of Harbour Seals in the SOG continue to remain stable at levels observed for the past 20 years (~40,000). Olesiuk (2010) estimated that populations in the SOG were increasing at a rate of about 11.5% per year during 1970s and 80s, but that the growth rate subsequently slowed and stabilized in the early 1990s. These trends are supported by the strong fit of our generalized logistic model, assuming seal population growth exhibits density dependence, for the SOG from 1973-2014.

Data from the 2014 survey confirm observations from Olesiuk (2010) that 10% of the most significant haulout sites support almost 50% of the total SOG seal population, whereas 50% of the least significant sites supported about 10% of the total SOG seal population. As with the 2008 assessment, analysis of subareas within the SOG reveals geographic differences in population trajectories, reflected in subarea trends (Figure 5). Within each of the subareas there also appears to be a shuffling and concentration of animals among haulout sites and use of new haulout sites.

These patterns, as well as the resulting redistribution of animals observed during this study, suggest that seals moved from areas of higher density to areas of lower density, as opposed to experiencing a decline in overall productivity levels. Alternatively this could indicate reduced pupping or survival/mortality in some areas relative to others. Although overall numbers remain stable, there is continued evidence of changes in distribution among haulout sites within the SOG with a continued increase in the relative importance of southern Gulf haulout sites observed in 2014. While anecdotal at this point, this shift appears to be from haulout sites adjacent to deeper waters to those in shallow boulder beaches; these shifts are comparable to observations from Puget Sound (Steve Jeffries, Washington Department of Fish and Wildlife, Olympia, 2014 pers. comm) and may suggest predator avoidance. Other possible drivers behind shifts in distribution include resource availability and changes to patterns in human disturbance throughout the SOG.

Efforts have been made to coordinate surveys in the SOG with Washington state population censuses to look at overall trends and movements of Harbour Seals throughout the Salish Sea (extending from the north end of the SOG to the south end of Puget Sound). Regional analysis to examine how changes in the distribution and habitat use of Harbour Seals may be linked to changing predation pressure and prey availability over time is warranted. The large numbers of Harbour Seals observed in the southern end of the SOG (Race Rocks, Chatham and Chain Islets) could indicate an influx of animals from Washington potentially linked to ecosystem level changes in resource availability or differential changes in pupping or survival/mortality. Tagging studies in Washington have confirmed movement of seals between San Juan Islands and the SGULF subarea in the SOG (Steve Jeffries, Washington Department of Fish and Wildlife, Olympia, 2014 pers. comm.). While genetic studies of Pacific Harbour Seal suggest that there are a number of stocks (Burg *et al.* 1999, Huber *et al*. 2010) throughout the range, little is known about stock structure in BC, or the movement of animals between Puget Sound and the SOG. This can affect interpretation of abundance in BC relative to overall prey availability for Transient Killer Whales, depending on whether there is bidirectional movement vs an influx of animals from adjacent US waters.

As previously noted, the initial partitioning of the Strait into subareas was based on survey logistics (i.e. what could be reasonably flown in a day). These partitions were retained here to facilitate comparison with previous surveys, however, these partitions lack biological relevance and do not necessarily reflect or capture various habitat attributes or population structure within the Strait. A more thorough analysis of distribution in relation to habitat and population structure should be undertaken in the future.

While every effort was made to standardize the survey methods used for the current census, we shifted the previously prescribed census window of 2.5 hours before to 1 hour after low tide, to 2 hours before and 2 hours after low tide (Figure 7). This was based on observations of haulout behaviours during the survey.In contrast with observations reported from earlier surveys (Olesiuk *et al.* 1990b, Olesiuk 1999, 2010), we observed that animals were more easily spooked early in the survey window than late in the survey window, and in most cases seals remained hauled more than 2 hours after low tide. Careful observation was made each day to ensure animals were settled at the start of the survey and were not terminating haulout bouts before the

end of the survey window (i.e. animals were not easily spooked into the water and there were no animals seen milling around the haulout sites). We recommend comparison of estimates of abundance obtained from surveys flown an additional hour after low tide vs. those truncated at low tide, in conjunction with analysis of updated telemetry data, for future assessments.

This study used the average correction factor for the SOG used by Olesiuk (2010) for areas outside the SOG as opposed to daily haulout response curves. Comparison of trends and estimated abundance applying the average CF to the standardized time series (1973-2008) and those derived from the variable CF survey data were not significantly different. Likewise, 2014 abundance estimates (modelled and observed) derived using the average correction factor for the SOG were not significantly different from those obtained using the variable CF. This is not an unexpected result since the survey design already takes into account the largest source of variation in haulout behaviour (i.e. time of day of the low tide) with the surveys designed to observe the highest number of seals. Further, the survey window is compressed such that time of day is generally consistent across survey days (largest observed differences are between day and night) and tide-height has been observed to have little effect on the proportion of animals hauled out within a given low-tide window (Olesiuk 2010). The application of daily, variable CF (related to time relative to low tide) appears to be unnecessary at this time but it would be advisable to revisit once updated behavioural data (based on satellite telemetry) becomes available.

The present CFs were developed from tagging undertaken in the early 1990s. Much has changed in the SOG since that time, including changes in prey availability, predator and potential competitor abundance, and levels of potential human disturbance. For example, herring spawning biomass has been increasing in the SOG since 2010 (Chandler *et al*. 2015) as has the occurrence of humpback whales and Transient Killer Whales have increased to a historic high. How these factors might affect haulout behaviour (and CFs by extension) remain unclear. It should be noted that applicability of CFs developed from SOG deployments to outside areas is uncertain. Evidence in some areas of the BC Coast suggests that seals exhibit different haulout behavior to avoid predation by land-based predators (such as wolves and cougar) whereas in the SOG killer whale predation and human disturbance may be significant contributing factors to changing behavior and haulout use by Harbour Seals. We recommend an expanded time-depth recorder tagging program within and outside of the SOG to evaluate whether seal behaviour is consistent between areas of varying seal, prey and predator density.

There is uncertainty associated with the counts themselves, related to timing of surveys relative to the pupping season. It is possible that timing of peak pupping season has changed and the correction factor needs to be updated to reflect current conditions in the SOG.

Although abundance of Harbour Seals appear to be stable in the SOG, there is uncertainty as to whether availability of Harbour Seals to predation by Transient Killer Whales has changed with shifts in haulout use and haulout behaviour. Since the value of Harbour Seals to Transient Killer Whales is a function of both their abundance and their vulnerability to predation, this could affect the interpretation of the trends in abundance and distribution described in this study in relation to the assessment of prey availability and critical habitat for Transient Killer Whales. For example, seals often haul out on log booms in the SOG, which provide refuge from killer whale predation throughout the entire tide cycle. Thus, ongoing reductions in booming grounds is expected to increase the vulnerability of seals and make them more available to predation by killer whales. Further, although small estuary sites make up only ~5% of the total shoreline in the SOG (Olesiuk 2010), there is uncertainty associated with applying the CFs to sites where seals haul out on log booms located in these estuaries.

A better understanding of how haulout sites are used seasonally, through tide cycles and in relation to changes in predation and human disturbance as well as food availability would be valuable to better understand population dynamics and develop ecosystem models for the SOG. Exploring Harbour Seal distribution patterns relative to changes in the abundance and distribution of Transient Killer Whales, terrestrial predators and prey species as well as changes in patterns of human disturbance in the SOG might help to explain some of the changing patterns of behavior in haulout use.

As noted by Olesiuk (2010) understanding the tendency of Harbour Seals to abandon and colonize haulout sites at various spatial scales is essential to assess the utility of conducting index surveys designed to monitor a fixed set of haulout sites relative to this survey design whereby the entire survey area is covered and is not undermined by the changing distribution of seal haulout sites within the study area.

More information is also required to confirm whether patterns in Harbour Seal abundance and distribution SOG reflect other areas of coastal BC. While the SOG is a key index site with a reliable time series of standardized surveys, there have been relatively few surveys conducted in other areas of the BC coast. Development of correction factors for areas outside of the SOG, and updated standardized surveys are recommended to support updated estimated of overall abundance for the BC coast. This is important for understanding prey availability for Transient Killer Whales as they are highly mobile predators.

ACKNOWLEDGEMENTS

The survey techniques developed by the late Dr. Michael Bigg and further refined by Peter Olesiuk were the backbone of this study, as was the subsequent work done by Peter Olesiuk to continue the time series, expand survey coverage, develop correction factors and complete historic reconstructions of Harbour Seal populations in BC. Thanks to James Pilkington and Louis Rouleau for assisting with the aerial surveys, to Ben Nelson, Robin Abernethy and Chad Nordstrom for assisting with data analysis and mapping, and to Strahan Tucker for edits and advice on the final manuscript. Thanks to Dr. John Ford for support and feedback at all stages and to the National Marine Mammal Peer Review Committee for their review and ongoing advice. Funding for the 2014 survey in the SOG was provided by Fisheries and Oceans Canada's Species at Risk Program and Center of Expertise in Marine Mammalogy (CEMAM).

REFERENCES CITED

Bigg, M.A. 1969a. Clines in the pupping season of the Harbour Seal, *Phoca vitulina*. *Journal Fisheries Research Board Canada* 26:449-55.

Bigg, M.A. 1969b. The Harbour Seal in British Columbia. *Bulletin Fisheries Research Board Canada* No. 172. 33p.

Bjørge, A., Thompson, D., Hammond, P., Fedak, M., Bryant, E., Aarefjord, H., Roen, R. and M. Olsen, M. 1995. Habitat use and diving behaviour of Harbour Seals in a coastal archipelago in Norway. In *Developments in Marine Biology* 4:211-223. Elsevier Science.

Brown, R. F., B. E. Wright, S. D. Riemer, and J. Laake. 2005. Trends in abundance and current status of harbor seals in Oregon: 1997-2003. *Marine Mammal Science* 21:657-670.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L., and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, USA, Oxford.

Burg, T.M., A.W. Trites and M.J. Smith. 1999. Mitochondrial and microsatellite DNA analyses of Harbour Seal population structure in the northeast Pacific Ocean. *Canadian Journal of Zoology* 77(6):930-943.

Burnham, K. P. and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer Science and Business Media.

Chandler, P.C., King, S.A., and R.I. Perry (Eds.). 2015. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2014. *Canadian Technical Report of Fisheries and Aquatic Sciences* 3131:vi + 211 p.

Cordes, L. and P. Thompson. 2015. Mark-resight estimates of seasonal variation in harbor seal abundance and site fidelity. *Population Ecology* 57:467–472.

Cottrell, P. E. 1995. Diet, activity budgets, and movement patterns of Harbour Seals (*Phoca vitulina*) in Cowichan Bay and adjacent areas. *M.S. Thesis, University of Victoria, British Columbia. 118p. 1995.*

Cunningham, L., Baxter, J.M., Boyd, I.L., Duck, C.D., Lonergan, M., Moss, S.E. and B. McConnell. 2009. Harbour seal movements and haul-out patterns: implications for monitoring and management. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19(4):398-407.

DFO. 2007. Recovery Strategy for the Transient Killer Whale (*Orcinus orca)* in Canada, *Species at Risk Act Recovery Strategy Series*. Fisheries and Oceans Canada, Vancouver, vi + 46 pp.

Efron, B. and R.J. Tibshirani. 1994. An Introduction to the Bootstrap. CRC Press, UK. 456p.

Ford, J.K.B, E.H. Stredulinsky, J.R. Towers and G.M. Ellis. 2013. Information in Support of the Identification of Critical Habitat for Transient Killer Whales *(Orcinus orca)* off the West Coast of Canada. *DFO Canadian Science Advisory Secretariat Research Document* 2012/155. iv + 46 p.

Goodman, L.A. 1960. On the exact variance of products. *Journal of the American Statistical Association* 55:708-713.

Härkönen, T. and K.C. Harding. 2001. Spatial structure of Harbour Seal populations and the implications thereof. *Canadian Journal of Zoology* 79:2115–2127.

Harvey, J.T. 1987. Population dynamics, annual food consumption, movements and dive behaviors of harbor seals, *Phoca vitulina richardsi*, in Oregon. Unpubl. PhD. Thesis, Oregon State Univ. 177p.

Hilborn, R. and M. Mangel. 1997. The Ecological Detective: Confronting Models with Data. Princeton University Press. Princeton, N.J. 336p.

Huber, H.R., S. J. Jeffries, D. M. Lambourn and B. R. Dickerson. 2010. Population substructure of harbor seals *(Phoca vitulina richardsi)* in Washington State using mtDNA. *Canadian Journal of Zoology* 88(3):280-288.

Jansen, J. K., G. M. Brady, J. M. Ver Hoef and P. L. Boveng. 2015. Spatially estimating disturbance of harbor seals (*Phoca vitulina)*. PLoS ONE 10:e0129798. (Open Access).

Jeffries, S., H. Huber, J. Calambokidis and J. Laake. 2003. Trends and status of harbor seals in Washington State: 1978-1999. *Journal Wildlife Management* 67:208-219.

Li, L., C. Ainsworth and T. Pitcher. 2010. Presence of Harbour Seals *(Phoca vitulina)* may increase exploitable fish biomass in the Strait of Georgia. *Progress in Oceanography 87*(1-4):235–241.

London J.M., J.M. Ver Hoef, S.J. Jeffries, M.M. Lance and P.L., Boveng. 2012. Haul-Out behavior of harbor seals (*Phoca vitulina*) in Hood Canal, Washington. PLoS ONE 7(6): e38180. doi:10.1371/journal.pone.0038180.

Monnahan, C.C., T.A. Branch, A.E. Punt. 2014. Do ship strikes threaten the recovery of endangered eastern North Pacific blue whales? *Marine Mammal Science* 31:279-297.

Nordstrom, C.A. 2002. Haul-out selection by pacific harbor seals (*Phoca vitulina richardii*): isolation and perceived predation risk. *Marine Mammal Science* 18:194–205.

Olesiuk, P.F. 1999. An assessment of the status of Harbour Seals (*Phoca vitulina*) in British Columbia. DFO. *Canadian Science Advisory Secretariat Research Document* 1999/33. 71p.

Olesiuk, P.F. 2010. An assessment of population trends and abundance of Harbour Seals (*Phoca vitulina*) in British Columbia. DFO *Canadian Science Advisory Secretariat Research Document* 2009/105. vi + 157 p.

Olesiuk, P.F., M.A. Bigg, G.M. Ellis, S.J. Crockford and R.J. Wigen. 1990a. An assessment of the feeding habits of Harbour Seals (*Phoca vitulina*) in the Strait of Georgia, British Columbia, based on scat analysis. *Canadian Technical Report Fisheries and Aquatic Science* No. 1730: 135p.

Olesiuk, P.F., M.A. Bigg and G.M. Ellis. 1990b. Recent trends in the abundance of Harbour Seals, *Phoca vitulina*, in British Columbia. *Canadian Journal of Fisheries and Aquatic Science* 47: 992-1003.

Priekshot, D., R. Beamish and C.M. Neville. 2013. A dynamic model describing ecosystem-level change in the Strait of Georgia from 1960 to 2010. *Progress in Oceanography* 115:28-40.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Suryan, R.M. and J.T. Harvey. 1998. Tracking harbor seals *(Phoca vitulina richardsi)* to determine dive behavior, foraging activity, and haul-out site use. *Marine Mammal Science* 14:361– 372.

Thomas, A. C., M. M. Lance, S. J. Jeffries, B. G. Miner and A. Acevedo-Gutiérrez. 2011. Harbor seal foraging response to a seasonal resource pulse, spawning Pacific herring. *Marine Ecology Progress Series* 441:225–239.

TABLES

Table 1. Estimated density of seals (seals·km-1) in the Strait of Georgia (SOG) subareas for surveys conducted in 2014. Mean average densities from 1996-2008 (Olesiuk 2010) shown in parentheses for comparison. SGULF=Southern Gulf, BBAY=Boundary Bay, FRASERR=Fraser River, HOWESD=Howe Sound, GULFISL=Gulf Islands, NEGULF=Northeastern Gulf, NWGULF=Northwestern Gulf.

Subarea	Population size	Shoreline length (km)	Density of seals
SGULF	8,345	330	25.3 (19.0)
BBAY	710	60	11.8 (17.7)
FRASERR	1,613	277	5.8 (6.0)
HOWESD	657	247	2.7 (4.1)
GULFISL	9,645	699	13.8 (16.4)
NEGULF	13,296	1,099	12.1 (10.2)
NWGULF	5,021	254	19.8 (25.2)
Overall (Strait of Georgia)	**39,287**	**2,966**	**13.2 (13.1)**

Table 2. Abundance estimates (95% CI in parenthesis) based on Strait of Georgia (SOG) count data using the average SOG correction factor (CF) of 1.626 to adjust for the proportion of seals hauled out during surveys. Abundance calculated from the sum of corrected 2014 counts for each subarea (Appendix 1) is compared to estimates derived from a theta logistic model applied to the 1973-2014 time series. SOG model abundance is based on the sum of corrected counts for the entire SOG; subarea model abundance used the sum of the individual subarea models to get a total SOG estimate. See Table 1 caption for subarea abbreviations.

Subarea	Corrected Counts	SOG Model Abundance	Subarea Model Abundance
FRASERR	1,613 *(1,371-1,854)*	-	1,718 *(1,524-1,911)*
HOWESD	657 *(559-756)*	-	1,000 *(920-1,096)*
NEGULF	13,296 *(11,303-15,290)*	-	12,993 *(12,019-14,095)*
NWGULF	5,021 *(4,268-5,774)*	-	5,497 *(5,069-5,974)*
BBAY	710 *(603-816)*	-	1,350 *(1,272-1,434)*
SGULF	8,345 *(7,094-9,597)*	-	6,488 *(5,510-7,742)*
GULFISL	9,645 *(8,199-11,092)*	-	9,850 *(9,594-10,041)*
Total	**39,287** ***(33,397-45,179)***	**38,986** ***(35,043-42,079)***	**38,897** ***(35,907-42,293)***

Table 3. Mean finite population rate of increase and 95% confidence interval (CI) by subarea and the total Strait of Georgia calculated from log-linear regressions fitted to June-August abundance estimates for the period 1973-2014. The number of survey flights (n), the r^2 and significance level are provided for model fits. For comparison, the mean finite rates of increase for the period 1973-2008 (Olesiuk 2010) is shown in italics. See Table 1 caption for subarea abbreviations.

Subarea	n	r^2	Significance level	Finite rate of increase (%) 1973-2014	95% CI	Finite rate of increase (%) 1973-2008
BBAY	23	0.02	0.84	0	-2.0-1.6	0.3
FRASERR	23	0.47	<0.001	4	2.0-5.8	4.8
HOWESD	19	0.36	<0.001	4.4	1.3-7.3	6.2
SGULF	17	0.78	<0.001	5.2	3.6-6.6	5.9
GULFISL	15	0.72	<0.001	6.7	4.1-8.9	8.4
NWGULF	16	0.67	<0.001	8.4	4.7-11.5	10.6
NEGULF	14	0.72	<0.001	7.3	4.3-9.8	9.1
Total	**-**	**0.80**	**<0.001**	**6.8**	**4.9-8.3**	**8.3**

Table 4. Summary of log likelihood, Akaike Information Criterion for small sample sizes (AIC_c) and Akaike weight (w) values for model selection (first or second order polynomials) for each subarea and the entire Strait of Georgia (SOG). See Table 1 caption for subarea abbreviations.

Subarea	Polynomial Order	Log Likelihood	AIC_c	w
BBAY	First	-11.42	28.83	0.00
BBAY	Second	-1.89	11.79	1.00
FRASERR	First	-12.18	30.37	0.01
FRASERR	Second	-6.31	20.62	0.99
HOWESD	First	-15.60	37.20	0.00
HOWESD	Second	-1.61	11.22	1.00
SGULF	First	-3.85	13.70	0.00
SGULF	Second	4.10	-0.20	1.00
GULFISL	First	-9.15	24.30	0.00
GULFISL	Second	6.24	-4.47	1.00
NWGULF	First	-13.99	33.98	0.00
NWGULF	Second	2.51	2.99	1.00
NEGULF	First	-7.88	21.76	0.00
NEGULF	Second	8.06	-8.11	1.00
SOG	First	-7.62	21.24	0.00
SOG	Second	14.36	-20.71	1.00

FIGURES

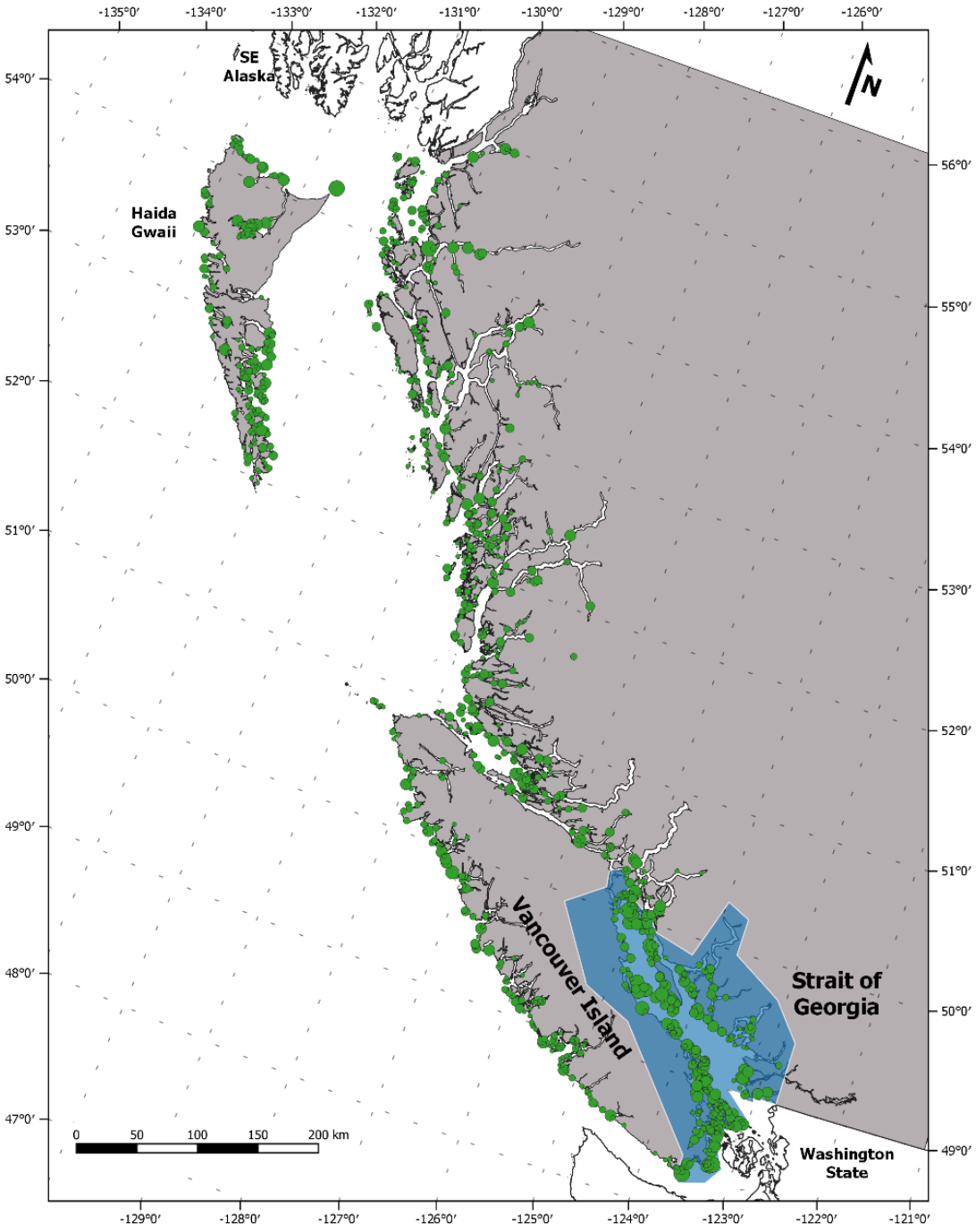

Figure 1. Harbour seal distribution at haulout sites throughout BC based on survey counts as of 2014. The Strait of Georgia (SOG) study area, indicated by the blue shading, supports the highest densities of Harbour Seals in BC, accounting for ~37% of estimated abundance (Olesiuk, 2010).

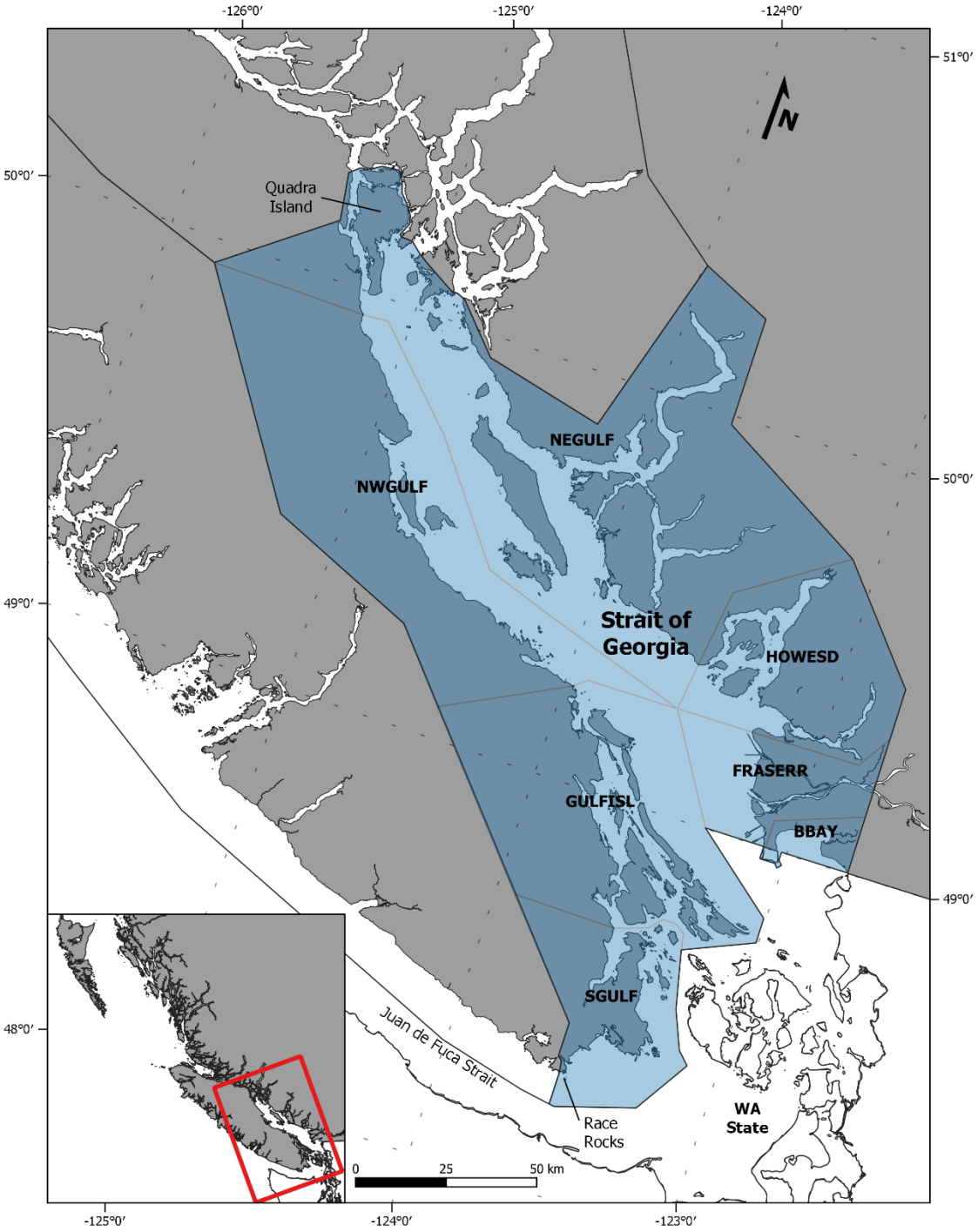

Figure 2. Strait of Georgia (SOG) study area indicating the subareas used for standardized aerial Harbour Seal surveys conducted 1973-2014 where SGULF=Southern Gulf, BBAY=Boundary Bay, FRASERR=Fraser River, HOWESD=Howe Sound, GULFISL=Gulf Islands, NEGULF=Northeastern Gulf, NWGULF=Northwestern Gulf.

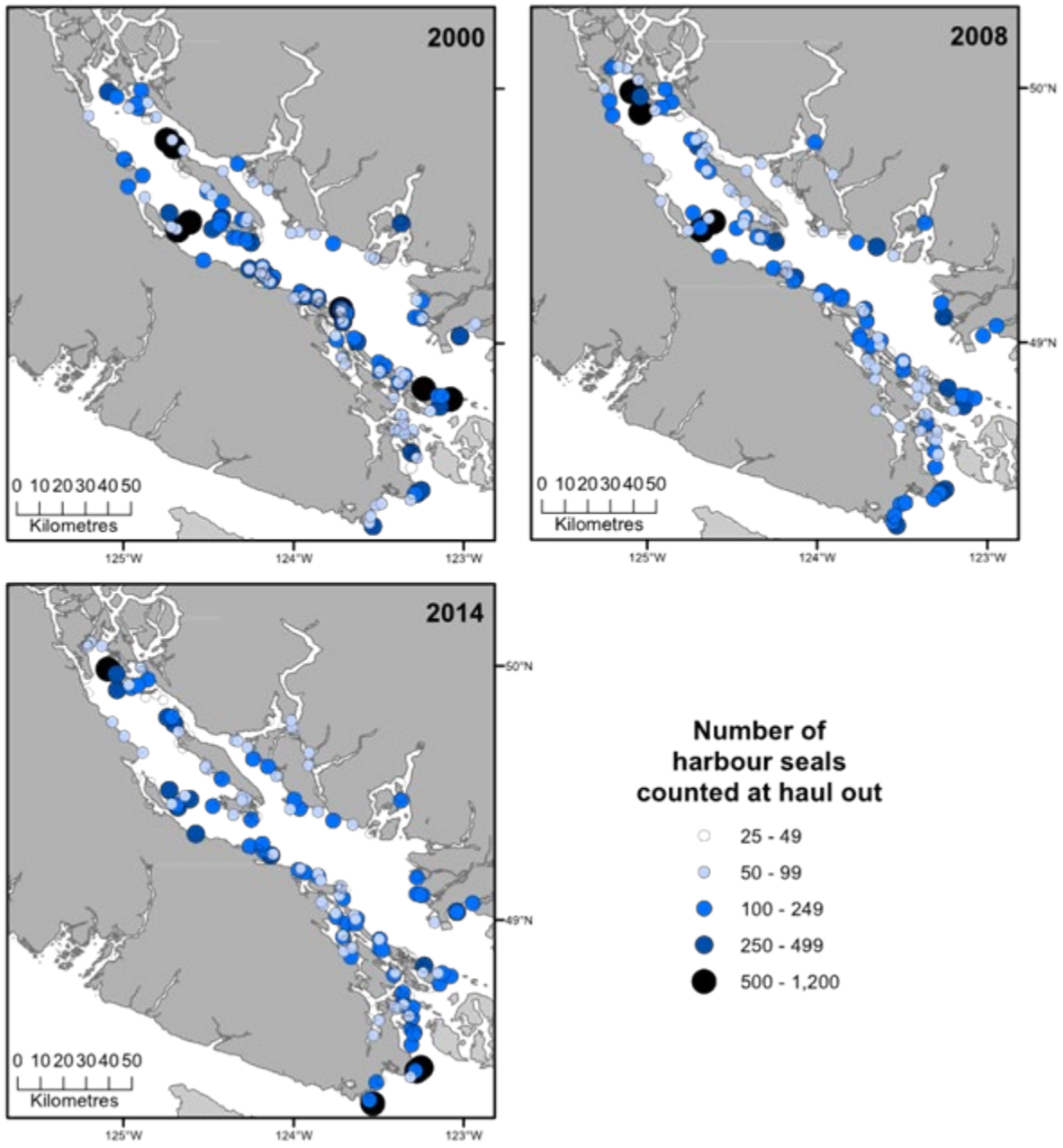

Figure 3. Harbour Seal distribution at haulout sites throughout the Strait of Georgia (SOG) from surveys flown in 2000, 2008 and 2014.

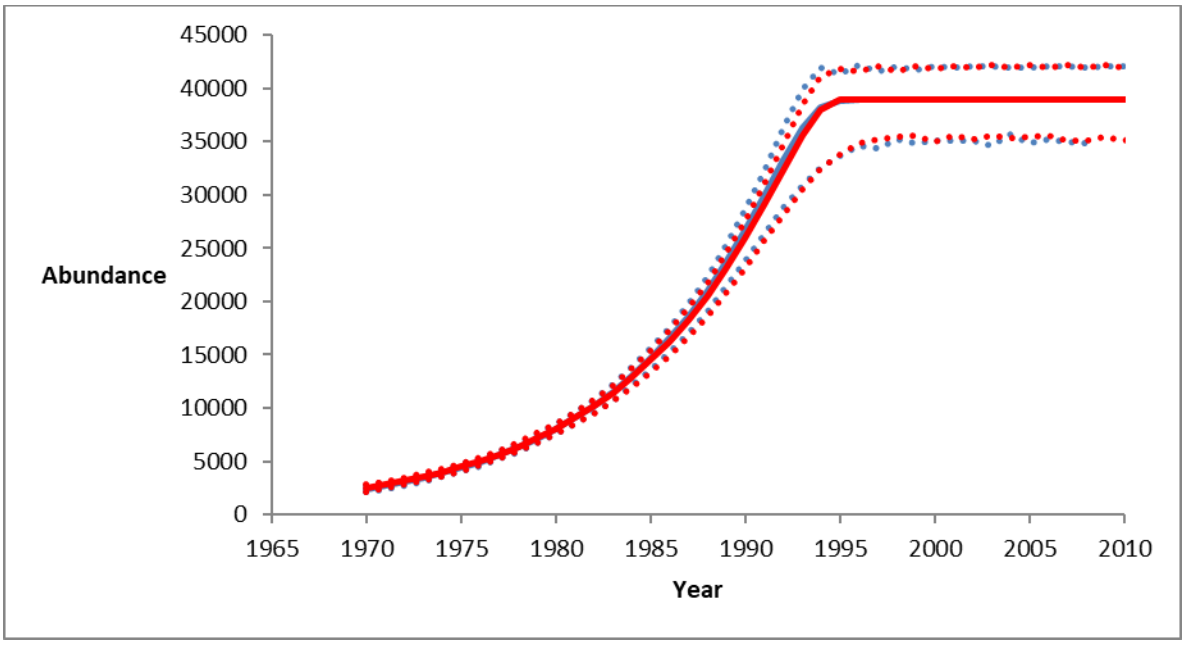

Figure 4. Comparison of population trends in the Strait of Georgia using a fixed, average correction factor (CF) of 1.626 (blue) and the variable CF used in Olesiuk 2010 (red). The solid lines show the generalized logistic model fitted by maximum likelihood to surveys 1973-2008 and the dotted lines show the 95% Confidence Intervals.

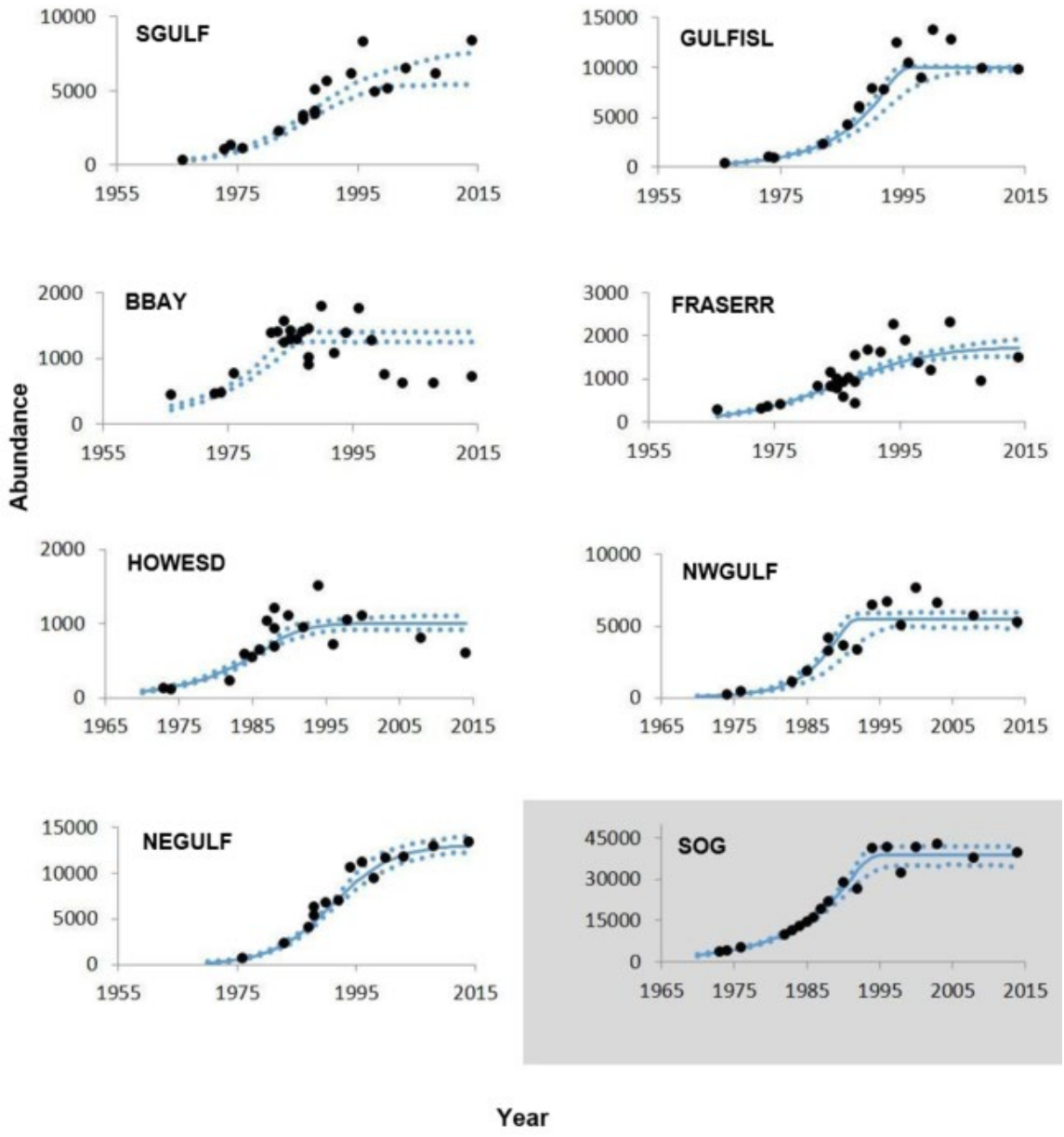

Figure 5. Population trends within each of the seven Strait of Georgia (SOG) subareas and the entire SOG for comparison (grey box). The solid lines show the generalized logistic model fitted by maximum likelihood, the dotted lines show the 95% Confidence Intervals, and the black dots show estimated abundance.

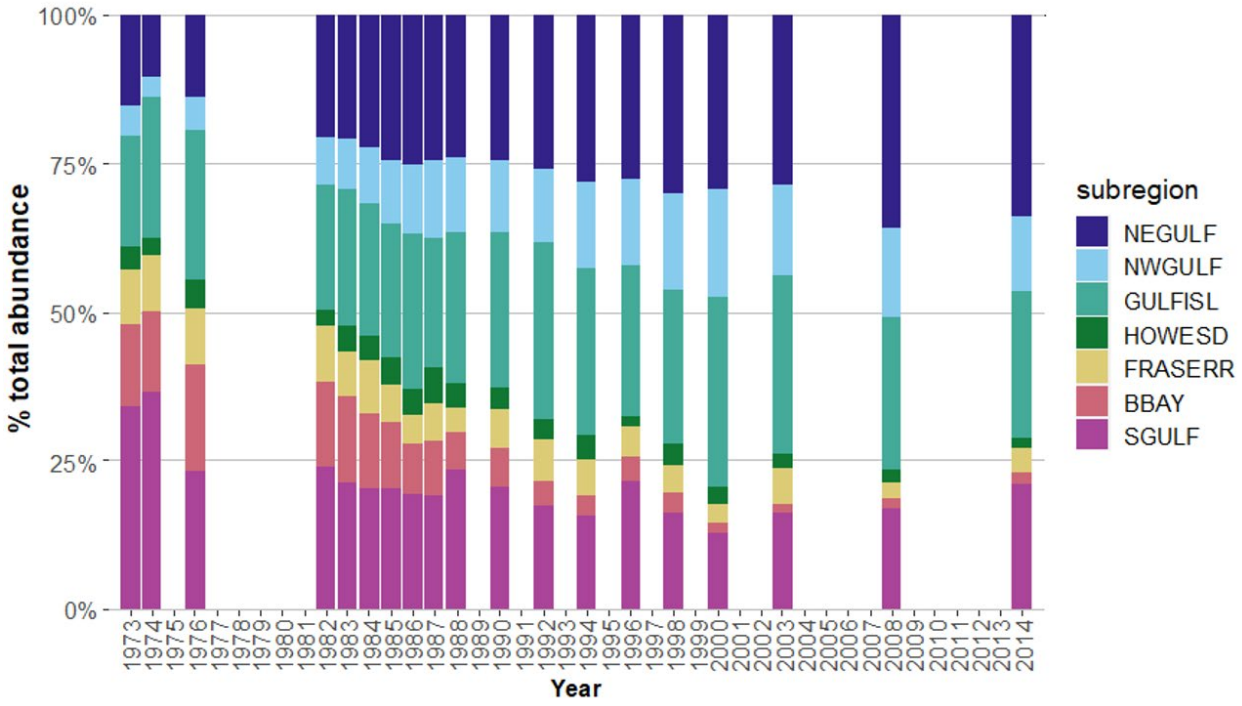

Figure 6. Relative abundance (% of total abundance) of Harbour Seals in the Strait of Georgia (SOG) subareas in each survey year 1973-2014.

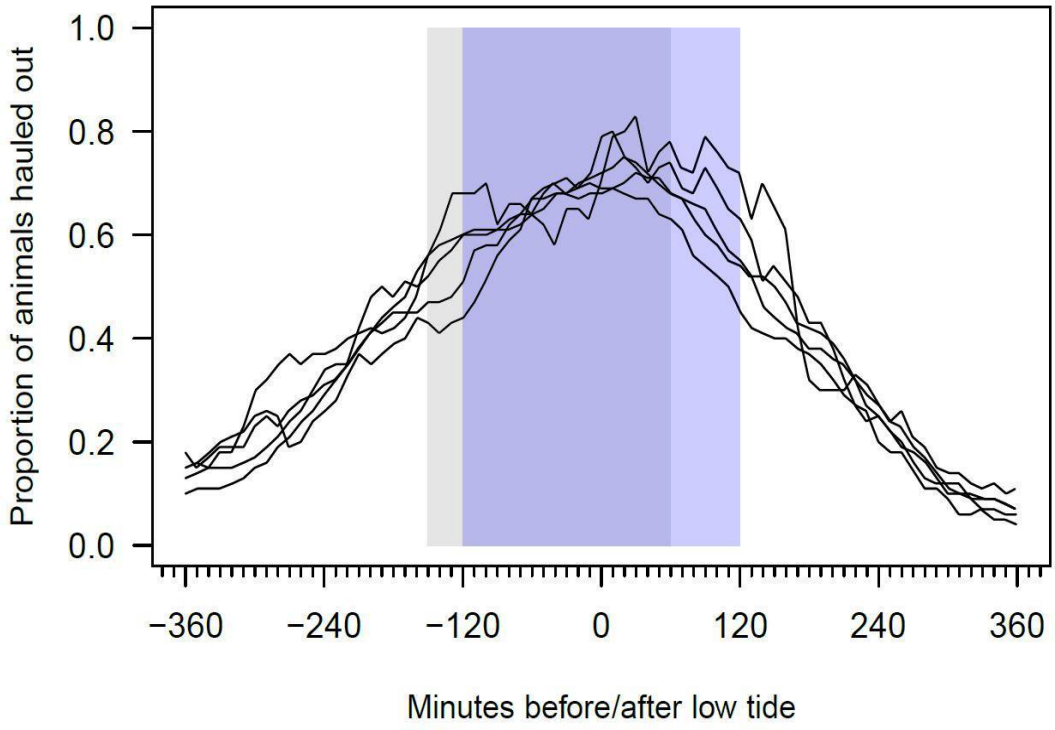

Figure 7. Proportion of animals hauled is shown in relation to time before and after low tide. The grey box shows the survey window of 2.5 hours before to 1 hour after low tide used in surveys prior to 2014. The purple box shows a survey window of two hours after low tide, which was used in 2014. The figure is adapted from haulout response curves adjusted for diel cycle and tidal range presented in Olesiuk (2010).

APPENDIX A

Summary of Harbour Seal survey counts and abundance estimates (corrected counts) for the Strait of Georgia (SOG) standardized breeding season surveys (1973-2014) partitioned into subarea Tables A1-A7. Count data and coordinates for haulout sites are available online.

Table A1. Survey counts by site (number and name) within the Southern Gulf (SGULF) subarea. Pre-2014 data and variable correction factors (CFs) are from Olesiuk (2010). Counts denoted by a '0' indicate the site was checked during the survey and no animals were present; counts denoted with a '-' indicate the area was surveyed but the site was not specifically checked; counts denoted with 'ns' indicate a known haulout site that was not surveyed. A summary for each survey is provided which includes the total number of seals counted summed across haulouts within the subarea, the proportion of the subarea surveyed, the different count adjustments (area surveyed, unborn pups) the correction for proportion of animals hauled out and estimated abundance using both the variable and fixed CF. Count data and estimated abundance derived from the average, fixed CF used in this assessment are bolded and highlighted in grey. Estimated abundance calculated from the variable CF used in Olesiuk (2010) is indicated in bold font.

Site Number	Site Name	13-15 June 1973	14-15 Aug 1974	12 Aug 1976	16 Aug 1982	16 Aug 1986	20 Aug 1986	31 May 1 June 1988	12-26 Aug 1988	24 Sept. 1988	6-7 Aug 1990	20-21 Aug 1994	30-31 July 1996	5-6 Sept. 1998	26-31 Aug 2000	25-29 Aug 2003	30-31 Aug 2008	12 Aug 2014
H0222	E CHADS ISL	-	-	ns	-	10	0	0	8	21	4	25	0	42	25	35	29	47
H0462	CANOE ROCK	-	-	ns	-	-	-	-	-	-	76	219	339	106	59	0	61	21
H0338	PARKIN PT	-	-	ns	-	-	-	3	0	0	4	0	0	0	4	0	0	2
H0180	REYNARD PT RF	1	13	ns	0	51	52		90	40	47	87	84	91	62	155	87	153
H0223	PELLOW ITS	-	-	ns	-	40	44	81	58	39	125	50	65	0	4	70	29	40
H0224	PELORUS PT	-	-	ns	-	24	42	0	26	38	0	19	0	0	0	1	0	36
H1454	SE MORESBY ISL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	0
H0226	S BRACKMAN ISL	-	-	ns	-	-	68	0	55	26	37	20	0	0	0	3	0	4
H0179	TORTOISE ITS	1	24	ns	0	13	13	0	0	1	1	0	0	0	0	0	3	15
H0365	ARBUTUS ISL	-	-	ns	-	-	-	-	2	12	1	4	0	30	36	30	6	10
H0463	W POINT FAIRFAX	-	-	ns	-	-	-	-	-	-	-	7	7	0	0	4	3	14
H0411	N KNAPP ISL	-	-	ns	-	-	-	-	-	14	0	0	0	0	0	0	0	0
H0221	CLIVE ISL	-	-	ns	-	22	36	52	47	1	22	50	45	28	45	60	25	40
H0366	PYM ISL	-	-	ns	-	-	-	-	2	10	0	0	0	0	0	0	0	0
H0378	POINT FAIRFAX	-	-	ns	-	-	-	-	5	37	0	3	0	14	2	75	43	4
H0161	IMRIE ISL	0	0	ns	0	54	20	0	15	1	0	87	64	80	84	80	132	221
H0360	HATCH PT	-	-	ns	-	-	-	-	16	ns	29	36	6	ns	ns	0	ns	0

Site Number	Site Name	13-15 June 1973	14-15 Aug 1974	12 Aug 1976	16 Aug 1982	16 Aug 1986	20 Aug 1986	31 May 1 June 1988	12-26 Aug 1988	24 Sept. 1988	6-7 Aug 1990	20-21 Aug 1994	30-31 July 1996	5-6 Sept. 1998	26-31 Aug 2000	25-29 Aug 2003	30-31 Aug 2008	12 Aug 2014
H0023	N GOUDGE ISL RF	1	0	ns	43	4	7	67	17	3	2	49	34	7	23	15	10	35
H0536	WAIN ROCK	-	-	ns	-	-	-	-	-	ns	-	46	33	ns	ns	40	68	1
H0841	ARACHNE REEF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	ns	2
H0554	SE SWARTZ HEAD RF	-	-	ns	-	-	-	-	-	-	-	-	22	20	19	7	18	38
H0018	REAY ISL	1	0	ns	28	3	1	0	6	3	3	1	12	0	1	0	8	55
H0025	E FERNIE ISL	-	-	ns	13	26	66	0	0	0	82	4	0	0	0	16	0	4
H0017	NW BRETHOUR ISL	-	9	ns	59	38	21		79	39	61	49	109	29	10	30	46	175
H0020	S COAL ISL RF	-	22	ns	41	21	7	11	82	67	31	6	0	0	0	40	7	1
H0019	GREIG ISL	14	9	ns	13	53	41	31	0	33	65	40	135	10	77	0	6	148
H0537	SW COAL ISLAND RF	-	-	ns	-	-	-	-	-	-	-	76	46	47	66	0	22	55
H0016	E BRETHOUR ISL RF	15	80	ns	91	61	66	96	136	75	129	92	217	42	3	25	22	10
H0022	TSEHUM HRBR RF	84	35	ns	16	17	32	26	15	0	0	24	23	0	28	20	15	0
H0844	NE LITTLE GRP RK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	2	36
H0323	DOCK ISL	-	-	ns	-	-	-	17	2	1	68	7	0	6	39	25	38	6
H0015	COOPER REEF	21	0	ns	72	100	45	86	223	102	198	162	0	159	77	45	38	101
H0363	W DOMVILLE ISL	-	-	ns	-	-	-	-	4	0	2	0	24	0	0	0	0	16
H0413	S COMET ISL	-	-	ns	-	-	-	-	-	13	0	9	7	5	0	0	3	16
H0021	S KER ISL RF	-	-	ns	38	10	7	0	52	30	56	58	49	116	67	73	92	62
H0158	N GOOCH ISL	0	0	ns	0	0	6	0	0	0	0	0	0	0	0	0	0	2
H0412	RUBLY ISL	-	-	ns	-	-	-	-	-	6	4	21	0	13	22	25	8	24
H0324	NE PATRICIA BAY	-	-	ns	-	-	-	40	15	0	1	0	3	ns	ns	3	4	42
H0219	TOM PT	-	-	ns	-	29	0	0	26	66	31	71	48	28	79	55	68	13
H0220	SE FORREST ISL RFS	-	-	ns	-	33	61	41	76	66	59	51	80	57	64	60	33	47
H0218	NORTH COD REEF	-	-	ns	-	9	7	17	39	0	55	17	49	0	5	55	22	36
H0024	MILL BAY	12	7	ns	0	ns	24	36	72	ns	17	11	5	ns	ns	18	ns	3
H0014	NW MANDARTE ISL RK	-	2	ns	6	6	9	1	20	6	12	32	44	57	50	41	73	60
H0225	S MANDARTE ISL RF	-	-	ns	-	-	5	4	7	7	36	23	117	33	38	87	70	139
H0552	TANNER ROCK	-	-	ns	-	-	-	-	-	ns	-	-	38	ns	ns	0	ns	36
H0367	DYER ROCKS	-	-	ns	-	-	-	-	22	ns	34	19	0	ns	ns	55	ns	71

Site Number	Site Name	13-15 June 1973	14-15 Aug 1974	12 Aug 1976	16 Aug 1982	16 Aug 1986	20 Aug 1986	31 May 1 June 1988	12-26 Aug 1988	24 Sept. 1988	6-7 Aug 1990	20-21 Aug 1994	30-31 July 1996	5-6 Sept. 1998	26-31 Aug 2000	25-29 Aug 2003	30-31 Aug 2008	12 Aug 2014
H0013	E SIDNEY ISL RF	30	35	ns	38	26	27	44	33	9	48	30	37	3	4	0	0	18
H0157	HALIBUT ISL	0	0	ns	0	18	31	20	31	28	13	34	14	39	47	33	22	45
H0461	TOZIER ROCK	-	-	ns	-	-	-	-	-	ns	10	10	2	ns	ns	21	ns	1
H0362	E JAMES ISL	-	-	ns	-	-	-	-	1	1	0	0	0	1	0	0	0	1
H0156	CORDOVA SPIT	0	0	ns	0	0	0	0	0	0	0	0	0	0	0	0	0	1
H0011	MUNROE ROCK	35	0	ns	33	34	40	1	35	39	5	21	12	46	48	30	19	34
H0318	N BAMBERTON	-	-	ns	-	-	-	48	64	ns	0	2	0	ns	ns	24	ns	0
H0010	S JAMES ISL RF	5	2	ns	7	1	0	0	2	0	0	0	10	0	0	0	0	0
H0009	SALLAS ROCKS	3	40	ns	124	152	107	126	223	148	274	265	289	149	259	115	157	196
H0008	NW LITTLE D'ARCY ISL RK	4	5	ns	46	13	5	17	22	38	17	50	64	0	29	25	68	187
H0012	COWICHAN HD	13	4	ns	10	12	25	49	30	24	0	2	15	0	14	0	0	0
H0319	SHEPPARD PT	-	-	ns	-	-	-	6	0	ns	39	3	9	ns	ns	2	ns	58
H0469	E D'ARCY ISL	-	-	ns	-	-	-	-	-	-	15	19	121	28	30	0	90	116
H0007	UNIT ROCKS	20	15	ns	58	65	46	19	20	69	31	100	21	91	75	60	7	29
H0006	S D'ARCY ISL RF	0	0	ns	5	6	0	0	55	0	49	0	95	56	0	15	17	3
H0842	KELP REEFS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	ns	3
H0361	ELBOW PT	-	-	ns	-	-	-	-	23	ns	44	19	0	ns	ns	28	ns	4
H0542	LITTLE ZERO ROCK	-	-	ns	-	-	-	-	-	-	-	4	10	0	7	6	18	17
H0005	ZERO ROCK	28	19	ns	18	55	65	0	71	52	83	109	155	111	47	125	141	157
H0538	CORDOVA BAY RF	-	-	ns	-	-	-	-	-	ns	-	42	8	36	0	35	33	23
H0843	E CHRISTMAS PT															2	ns	12
H0177	GORDON ROCK	-	5	ns	0	0	10	13	1	ns	8	0	0	0	0	0	0	0
H0320	GOLDSTREAM ESTUARY	-	-	ns	-	-	-	1	0	ns	ns	ns	ns	ns	ns	5	ns	0
H0594	S FINNERTY COVE REEF	-	-	ns	-	-	-	-	-	ns	-	-	-	8	3	0	17	17
H0539	CADBORO POINT	-	-	ns	-	-	-	-	-	ns	-	7	0	0	0	1	0	4
H0468	S FLOWER ISL RK	-	-	ns	-	-	-	-	-	ns	6	0	0	0	0	3	0	4
H0212	CHATHAM ISLS	-	2	ns	0	32	77	57	156	ns	134	237	236	232	273	413	363	529
H0321	BROTHERS ISLS	-	-	ns	-	-	-	33	47	ns	7	0	29	10	17	25	29	11
H0540	MAYOR CHANNEL RF	-	-	ns	-	-	-	-	-	ns	-	29	59	39	35	52	13	37

Site Number	Site Name	13-15 June 1973	14-15 Aug 1974	12 Aug 1976	16 Aug 1982	16 Aug 1986	20 Aug 1986	31 May 1 June 1988	12-26 Aug 1988	24 Sept. 1988	6-7 Aug 1990	20-21 Aug 1994	30-31 July 1996	5-6 Sept. 1998	26-31 Aug 2000	25-29 Aug 2003	30-31 Aug 2008	12 Aug 2014
H0004	CHAIN ITS	57	87	ns	180	216	231	240	309	ns	193	290	401	144	470	352	325	518
H0322	GREAT CHAIN ISL	-	-	ns	-	-	-	9	14	ns	23	47	103	185	109	100	211	128
H0840	GILLINGHAM ISL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	0	1
H1444	MCLOUGHLIN PT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	0
H0541	MOUAT REEF	-	-	ns	-	-	-	-	-	ns	-	3	0	0	2	24	4	13
H0171	GLIMPSE REEFS	6	5	ns	0	8	24	0	0	ns	2	0	0	3	0	1	0	0
H0178	TRIAL ISLS	-	29	ns	0	60	89	10	132	ns	79	100	119	105	51	95	152	70
H0217	ALBERT HD	-	-	-	-	5	17	0	41	ns	55	80	0	153	58	50	110	28
H0003	HAYSTOCK ITS	43	52	40	49	63	91	71	161	ns	182	179	193	129	71	120	205	130
H0467	PARKER BAY	-	-	-	-	-	-	-	-	ns	7	20	0	10	0	16	0	0
H0216	ANCHOR RK	-	-	-	-	26	26	1	44	ns	50	58	48	109	61	73	116	39
H1445	MANOR PT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	12
H0466	ROCKY PT	-	-	-	-	-	-	-	-	ns	14	8	0	37	0	50	43	47
H0001	W BENTINCK ISL RFS	1	13	35	54	94	ns	100	189	ns	174	76	412	173	90	380	145	183
H0002	RACE ROCKS	158	304	195	290	209	223	245	383	ns	617	485	858	359	387	570	306	595
Total number counted		**553**	**818**	**270**	**1,332**	**1,719**	**1,814**	**1,719**	**3,304**	**1,165**	**3,471**	**3,804**	**5,025**	**3,276**	**3,176**	**4,138**	**3,730**	**5,112**
Correction for unborn pups		1.2494	1.0362	1.0438	1.0293	1.0293	1.0187	1.2499	1.0414	1.0001	1.0617	1.0145	1.1067	1.0010	1.0037	1.0077	1.0041	1.0040
Proportion of area covered		1.0000	1.0000	0.4511	1.0000	0.9862	0.9507	1.0000	1.0000	0.4933	1.0000	1.0000	1.0000	0.9809	0.9809	1.0000	0.9579	1.0000
Adjusted count		690.9	847.6	624.8	1371.0	1794.1	1943.7	2148.6	3440.9	2361.9	3685.2	3859.0	5561.2	3343.1	3249.9	4169.9	3909.9	5132.5
Var Estimated proportion hauled out		0.648	0.653	0.577	0.611	0.582	0.579	0.634	0.680	0.648	0.651	0.625	0.668	0.678	0.633	0.643	0.638	n/a
Var Correction for missed animals		1.544	1.532	1.732	1.636	1.718	1.728	1.577	1.470	1.543	1.537	1.599	1.496	1.474	1.580	1.555	1.567	n/a
Estimated abundance - variable CF		**1,067**	**1,299**	**1,082**	**2,243**	**3,082**	**3,359**	**3,388**	**5,058**	**3,643**	**5,664**	**6,170**	**8,320**	**4,929**	**5,134**	**6,485**	**6,128**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**1,123**	**1,378**	**1,016**	**2,229**	**2,917**	**3,160**	**3,494**	**5,595**	**3,840**	**5,992**	**6,275**	**9,043**	**5,436**	**5,284**	**6,780**	**6,357**	**8,345**

Table A2. Survey counts by site (number and name) within the Boundary Bay (BBAY) subarea. See Table A1 caption for details.

Site Number	Site Name	27 July 1966	11 June 1973	16 Aug 1974	23 Aug 1976	17 Aug 1982	19 Aug 1983	9 Aug 1984	24 Aug 1984	12 Aug 1985	27 Aug 1985	18 Aug 1986	11 Aug 1987	31 May 1988	26 Aug 1988	24 Sept. 1988	5 Aug 1990	24 Aug 1992	5 Aug 1994	27 July 1996	5 Aug 1998	27 Aug 2000	24 Aug 2003	13 Aug 2008	7 Aug 2014
H0030	E BOUNDARY BAY SITE B	-	0	0	19	8	10	10	0	9	4	0	27	0	0	0	23	0	0	80	86	0	0	0	0
H0029	E BOUNDARY BAY SITE A	0	15	0	34	24	37	22	28	25	42	52	21	39	50	73	78	23	0	0	0	56	0	0	0
H0031	E BOUNDARY BAY SITE C	13	0	0	35	18	51	13	38	50	38	24	42	1	55	22	64	68	64	90	121	81	101	140	160
H0032	E BOUNDARY BAY SITE D	50	76	56	29	38	37	0	31	0	0	31	18	0	13	0	4	0	0	0	0	0	0	0	0
H0033	C BOUNDARY BAY SITE E	-	-	-	-	77	0	46	24	39	0	0	102	87	7	0	14	12	54	28	34	0	11	0	0
H0449	W BOUNDARY BAY SITE I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	9	33	0	16	0	0	0	251
H0034	W BOUNDARY BAY SITE F	118	116	247	304	593	740	827	677	746	755	610	643	303	694	525	714	594	604	631	284	305	250	212	0
H0155	C BOUNDARY BAY SITE H	-	-	-	-	-	44	67	0	22	31	44	0	0	0	10	77	5	12	48	118	0	0	0	0
H0035	W BOUNDARY BAY SITE G	40	0	0	41	38	20	59	21	4	0	24	52	0	57	0	27	3	0	0	0	0	8	0	0
H0172	KWOMAIS PT	-	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	ns	ns
H0170	SE POINT ROBERTS RFS	15	8	4	2	1	0	0	0	5	5	0	7	24	4	2	14	1	7	11	1	5	1	5	0
Total number counted		236	**223**	**307**	**464**	**797**	**939**	**1,044**	**819**	**900**	**875**	**785**	**912**	**454**	**880**	**632**	**1,043**	**715**	**774**	**889**	**661**	**447**	**371**	**357**	**411**
Correction for unborn pups		1.1320	1.2496	1.0293	1.0167	1.0264	1.0213	1.0149	1.0621	1.0438	1.0075	1.0238	1.0480	1.2500	1.0100	1.0000	1.0770	1.0110	1.0770	1.1310	1.0720	1.0068	1.0103	1.0364	1.0618
Proportion of area covered		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Adjusted count		267.2	278.7	316.0	471.7	818.0	959.0	1059.6	869.9	939.4	881.6	803.7	955.8	567.5	888.8	632.0	1123.3	722.9	833.6	1005.5	708.6	450.0	374.8	370.0	436.4
Var Estimated proportion hauled out		0.615	0.609	0.667	0.610	0.595	0.687	0.676	0.704	0.661	0.686	0.623	0.679	0.565	0.611	0.707	0.630	0.673	0.603	0.574	0.557	0.605	0.611	0.602	n/a
Var Correction for missed animals		1.626	1.641	1.499	1.640	1.681	1.456	1.480	1.420	1.513	1.458	1.605	1.472	1.769	1.637	1.415	1.587	1.485	1.658	1.743	1.796	1.653	1.637	1.661	n/a
Estimated abundance - variable CF		434	**457**	**474**	**774**	**1,375**	**1,396**	**1,568**	**1,235**	**1,421**	**1,285**	**1,290**	**1,407**	**1,004**	**1,455**	**894**	**1,783**	**1,073**	**1,382**	**1,753**	**1,273**	**744**	**613**	**615**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**434**	**453**	**514**	**767**	**1,330**	**1,559**	**1,723**	**1,414**	**1,528**	**1,433**	**1,307**	**1,554**	**923**	**1,445**	**1,028**	**1,827**	**1,175**	**1,355**	**1,635**	**1,152**	**732**	**609**	**602**	**710**

Table A3. Survey counts by site (number and name) within the Fraser River (FRASERR) subarea. See Table A1 caption for details.

Site Number	Site Name	14 June 1973	16 Aug 1974	22 Aug 1976	17 Aug 1982	8 Aug 1984	23 Aug 1984	12 Aug 1985	27 Aug 1985	17 Aug 1986	18 Aug 1986	11 Aug 1987	25 Aug 1988	4 Aug 1990	24 Aug 1992	4 Aug 1994	27 July 1996	5 Aug 1998	27 Aug 2000	24 Aug 2003	13 Aug 2008	7 Aug 2014
H0042	C STURGEON BANK SITE C	71	17	35	13	0	124	0	178	0	64	97	158	0	279	163	0	0	0	35	0	42
H0071	C STURGEON BANK SITE B	-	71	52	193	266	118	219	72	101	60	176	58	139	78		0	0	98	90	0	237
H0199	SWISHWASH ISL	0	0	0	0	0	0	0	12	0	0	0	6	0	0	51	6	190	195	215	0	0
H0573	STURGEON BANK - SITE G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	111	0	0	ns	ns
H0451	C STURGEON BANK SITE E	-	-	-	-	-	-	-	-	-	-	-	-	314	0	312	598	156	0	0	231	0
H0231	S STURGEON BANK SITE D	-	-	-	-	-	-	-	-	-	7	0	0	0	0	0	0	0	0	0	0	0
H0564	STURGEON BANK - SITE F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	71	0	0	0	0	0	0
H0070	S STURGEON BANK SITE A	0	53	3	20	33	11	0	3	8	8	29	10	36	4	4	0	0	0	0	0	6
H0481	GARRY PT	-	-	-	-	-	-	-	-	-	-	-	-	-	63	0	0	0	0	ns	0	0
H0206	N ROBERTS BANK SITE G	-	-	-	-	-	135	0	0	0	0	0	0	0	75	0	172	79	0	0	20	235
H0038	N ROBERTS BANK SITE C	1	0	30	47	0	47	20	17	0	7	0	0	106	0	239	0	0	126	90	0	0
H0565	ROBERTS BANK - SITE K	-	-	-	-	-	-	-	-	-	-	-	-	-	-	257	0	13	126	450	254	130
H0543	N ROBERTS BANK SITE J	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	103	0	143	140	47	0
H0041	N ROBERTS BANK SITE E	-	-	-	154	10	38	83	57	179	185	203	177	142	161	34	184	103	54	350	0	162
H0040	N ROBERTS BANK SITE F	0	41	125	69	193	252	193	354	0	189	123	194	217	418	122	81	69	29	0	29	0
H0039	N ROBERTS BANK SITE D		29	0	10	35	0	0	9	0	0	11	0	5	0	0	0	26	19	0	0	0
H0201	N ROBERTS BANK SITE H	74	0	0	0	0	0	0	0	-	14	0	0	73	23	63	0	0	0	55	0	18
H0408	S WESTHAM ISL	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0
H0036	C ROBERTS BANK SITE A	-	-	9	0	0	0	0	0	84	0	0		0	0	4	10	0	0	8	0	0
H0450	C ROBERTS BANK SITE I	-	-	-	-	-	-	-	-	-	-	-	-	24	0	0	0	110	0	0	0	0
H0037	C ROBERTS BANK SITE B	0	0	0	20	9	0	7	3	11	10	20	1	11	0	1	0	0	0	0	0	1
H0480	TSWASSEN BREAKWATER	-	-	-	-	-	-	-	-	-	-	-	-	-	10	2	20	18	17	95	23	66
H1502	TSWASSEN	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13
H1503	C ROBERTS BANK SITE L	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24
Total number counted		**146**	**211**	**254**	**526**	**546**	**725**	**522**	**705**	**383**	**544**	**659**	**604**	**1,067**	**1,111**	**1,323**	**1,174**	**875**	**807**	**1,528**	**604**	**934**
Correction for unborn pups		1.2492	1.0293	1.0167	1.0264	1.0621	1.0149	1.0438	1.0076	1.0264	1.0238	1.0480	1.0100	1.0770	1.0110	1.0770	1.1310	1.0777	1.0068	1.0103	1.0364	1.0618
Proportion of area covered		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
Adjusted count		182.4	217.2	258.2	539.9	579.9	735.8	544.9	710.3	393.1	556.9	690.6	610.0	1,149.2	1,123.2	1,424.9	1,327.8	943.0	812.5	1,543.7	626.0	991.7
Var Estimated proportion hauled out		0.615	0.616	0.649	0.664	0.696	0.649	0.704	0.707	0.682	0.598	0.674	0.667	0.690	0.692	0.632	0.700	0.691	0.674	0.671	0.666	n/a
Var Correction for missed animals		1.626	1.623	1.540	1.506	1.437	1.540	1.421	1.415	1.467	1.673	1.483	1.500	1.449	1.446	1.583	1.429	1.448	1.484	1.490	1.502	n/a
Estimated abundance - variable CF		**297**	**352**	**398**	**813**	**833**	**1,133**	**774**	**1,005**	**577**	**932**	**1,024**	**915**	**1,665**	**1,624**	**2,256**	**1,897**	**1,365**	**1,205**	**2,301**	**940**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**297**	**353**	**420**	**878**	**943**	**1,196**	**886**	**1,155**	**639**	**906**	**1,123**	**992**	**1,869**	**1,826**	**2,317**	**2,159**	**1,533**	**1,321**	**2,510**	**1,018**	**1,613**

Table A4. Survey counts by site (number and name) within the Howe Sound (HOWESD) subarea. See Table A1 caption for details.

Site Number	Site Name	11 June 1973	19 Aug 1974	17 Aug 1982	23 Aug 1984	27 Aug 1985	18 Aug 1986	11 Aug 1987	25 Aug 1988	3 Aug 1990	25 Aug 1992	4 Aug 1994	10 Aug 1996	5 Aug 1998	27 Aug 2000	13 Aug 2008	7 Aug 2014
H0317	SQUAMISH ESTUARY	-	-	-	-	-	-	-	-	ns	ns	ns	ns	ns	ns	ns	ns
H0316	N IRBY PT RKS	-	-	-	-	-	-	-	0	0	2	0	0	0	0	0	0
H0445	CHRISTIE IT	-	-	-	-	-	-	-	-	33		24	14	24	41	40	45
H0043	PAM ROCKS	37	38	65	195	180	126	251	219	204	180	288	187	214	323	224	128
H0410	PORT GRAVES	-	-	-	-	-	-	-	-	0	0	0	ns	ns	ns	0	0
H0446	N HALKETT PT	-	-	-	-	-	-	-	-	6	0	4	0	0	2	0	0
H0252	HALKETT PT	-	-	-	-	-	-	2	-	0	4	0	0	0	0	0	4
H0230	E BOWYER ISL	-	-	-	-	-	35	64	80	38	51	0	32	14	34	22	8
H0315	W HUTT ISL	-	-	-	-	-	-	-	0	1	4	1	0	0	7	0	6
H0372	NW BOWEN ISL	-	-	-	-	-	-	-	21	40	21	38	2	7	0	0	0
H0200	RAGGED ISL	-	-	-	-	10	8	12	18	26	0	0	9	0	8	1	0
H0253	N HERMIT ISL RK	-	-	-	-	-	-	2	7	1	14	1	16	0	16	4	26
H0484	MICKEY ISL	-	-	-	-	-	-	0	0	5	2	22	3	0	0	0	2
H0232	WHYTE IT	-	-	-	-	-	4	0	5	0	0	42	0	6	0	1	3
H0507	S HERMIT ISL REEF	-	-	-	-	-	-	-	-	-	-	22	11	0	0	8	0
H0044	N POPHAM ISL RFS	-	24	52	99	112	170	190	182	151	110	224	52	138	53	57	47
H0506	BOWEN BAY ROCK	-	-	-	-	-	-	-	-	-	-	20	0	0	0	0	0
H0229	S PASLEY ISL RK	-	-	-	-	-	0	0	0	36	42	11	28	67	46	0	0
H0482	EAGLE ISL	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0
H0574	N WORLCOMBE ISL RF	-	-	-	-	-	-	-	-	-	-	-	-	20	0	0	2
H0045	NW WORLCOMBE ISL RFS	27	1	31	34	68	77	73	77	84	122	244	63	187	81	10	1
H1455	NE ANVIL ISL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	26
H1456	WEST BAY LOGBOOMS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	6
H1457	SE TWIN CREEKS LOGBOOMS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	3
H1458	PRESTON ISL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17	18
H0483	GREBE ITS	-	-	-	-	-	-	-	-	-	21	20	10	2	46	41	21
H0409	E CAPE ROGER CURTIS	-	-	-	-	-	-	-	-	0	8	0	1	0	44	0	8

Site Number	Site Name	11 June 1973	19 Aug 1974	17 Aug 1982	23 Aug 1984	27 Aug 1985	18 Aug 1986	11 Aug 1987	25 Aug 1988	3 Aug 1990	25 Aug 1992	4 Aug 1994	10 Aug 1996	5 Aug 1998	27 Aug 2000	13 Aug 2008	7 Aug 2014
H1504	PASSAGE ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20
H1505	STRIP CREEK	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Total number counted		**64**	**63**	**148**	**328**	**370**	**420**	**594**	**609**	**625**	**581**	**961**	**428**	**679**	**701**	**478**	**379**
Correction for unborn pups		1.2496	1.0213	1.0264	1.0149	1.0075	1.0238	1.0480	1.0100	1.0820	1.0100	1.0770	1.0520	1.0777	1.0068	1.0364	1.0618
Proportion of area covered		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9905	1.0000	0.9953	0.9953	0.9953	0.9953	0.9953	0.9953	0.9953	0.9953
Adjusted count		80.0	64.3	151.9	332.9	372.8	430.0	628.5	615.1	679.4	589.6	1039.9	452.4	735.2	709.1	497.7	404.3
Var Estimated proportion hauled out		0.623	0.585	0.662	0.564	0.687	0.664	0.607	0.664	0.615	0.626	0.687	0.627	0.702	0.646	0.622	n/a
Var Correction for missed animals		1.605	1.709	1.511	1.773	1.456	1.506	1.647	1.506	1.627	1.598	1.455	1.596	1.424	1.548	1.608	n/a
Estimated abundance - variable CF		**128**	**110**	**230**	**590**	**543**	**648**	**1,035**	**926**	**1,105**	**942**	**1,513**	**722**	**1,047**	**1,098**	**800**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**130**	**105**	**247**	**541**	**606**	**699**	**1,022**	**1,000**	**1,105**	**959**	**1,691**	**736**	**1,195**	**1,153**	**809**	**657**

Table A5. Survey counts by site (number and name) within the Gulf Island (GULFISL) subarea. See Table A1 caption for details.

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H0589	HORSWELL BLUFF RF	-	-	-	-	-	-	-	-	-	13	34	20	8	16
H0370	NECK PT	-	-	-	-	8	0	0	2	0	0	0	0	0	4
H0053	FIVE FINGER ISL	-	-	1	4	12	2	30	15	45	44	113	90	119	82
H0335	HUDSON ROCKS	-	-	-	-	27	71	43	75	54	38	0	140	121	126
H0054	SNAKE ISL	6	15	61	139	156	149	216	236	407	187	275	140	249	176
H0233	NW ENTRANCE ISL RFS	-	-	-	38	34	37	99	162	130	123	211	150	138	65
H0052	INSKIP ROCK	-	-	-	24	1	34	43	42	39	56	71	57	54	47
H0055	SE ORLEBAR PT RK	7	0	5	7	12	29	45	131	55	117	189	110	133	103
H0056	NE GABRIOLA ISL RF A	-	6	10	27	85	74	69	27	20	33	37	35	43	60
H0057	NE GABRIOLA ISL RF B	-	9	8	15	9	32	5	0	50	0	0	0	0	2
H0527	S DESCANSO BAY PT	-	-	-	-	-	-	-	-	1	0	5	0	2	0
H0452	W PROTECTION ISL	-	-	-	-	-	2	0	0	0	2	0	0	0	4
H0058	NE GABRIOLA ISL RF C	6	10	22	51	36	67	11	8	20	0	28	30	16	2
H0061	NE GABRIOLA ISL RF D	-	-	6	17	7	15	14	53	2	0	9	5	14	8
H0523	CARLOS ISLAND	-	-	-	-	-	-	-	49	26	39	13	80	64	46
H0059	BRANT REEF	12	32	72	74	113	218	98	124	107	309	781	425	198	77
H0545	S ACORN ISLAND RF	-	-	-	-	-	-	-	-	37	0	167	0	13	15
H0060	SE ACORN ISL RF	0	0	44	69	124	17	225	182	0	232	415	225	113	100
H0051	NANAIMO RIVER FLATS	-	8	4	10	52	47	0	16	37	ns	ns	ns	46	0
H0544	SE TUGBOAT ISLAND RF	-	-	-	-	-	-	-	-	17	15	0	0	61	10
H0371	W BATH ISL	-	-	-	-	47	34	49	164	235	59	65	55	23	97
H0167	GABRIOLA REEFS	0	0	0	23	37	82	27	152	131	58	362	310	31	30
H0342	BREAKWATER ISL	-	-	-	-	30	51	1	0	21	0	2	2	0	2
H0526	DEGNEN BAY RF	-	-	-	-	-	-	-	7	0	ns	0	0	0	1
H0343	SE FALSE NARROWS	-	-	-	-	4	15	4	0	0	0	1	0	0	0
H0464	DIBUXANTE PT	-	-	-	-	-	21	0	0	0	0	10	12	0	2
H0524	N KENDRICK ISLAND RF	-	-	-	-	-	-	-	5	0	0	0	2	0	2
H0062	E KENDRICK ISL RK	9	0	6	10	18	64	19	0	46	18	34	13	9	88
H0050	NE LINK ISL RK	-	-	44	0	2	0	0	0	0	0	0	0	0	0

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H0373	S ROUND ISL RF	-	-	-	-	6	15	12	15	26	33	29	16	2	23
H0228	S DIBUXANTE PT	-	-	-	7	3	0	0	2	0	0	3	3	0	5
H0049	NE DE COURCY ISL RF	22	27	6	17	0	0	6	0	61	0	0	16	0	0
H0063	NE VALDES ISL RK	-	-	16	142	183	157	300	512	236	284	382	160	204	231
H0072	E DE COURCY ISL RF	-	-	3	0	4	0	0	11	25	0	13	0	19	0
H0344	NE REYNOLDS PT RF	-	-	-	-	77	92	40	48	63	31	33	40	1	57
H0234	SE FLEWETTE PT RF	-	-	-	55	0	3	12	38	43	31	50	65	10	90
H0227	N BLACKBERRY PT	-	-	-	4	28	58	3	10	4	0	0	3	0	5
H1464	ME VALDEZ ISL	-	-	-	-	-	-	-	-	-	-	-	-	4	14
H0028	DANGER REEFS	1	26	148	72	173	194	235	111	130	99	68	140	132	76
H0833	NW PYLADES ISL												12	0	12
H0591	NICHOLSON COVE REEF	-	-	-	-	-	-	-	-	-	4	0	0	2	0
H0064	E NOEL BAY RK	-	-	8	5	9	14	27	60	48	81	117	105	65	83
H0027	MIAMI IT	-	-	21	38	14	127	193	154	13	192	182	285	127	219
H0525	S SHINGLE POINT	-	-	-	-	-	-	-	2	2	0	0	0	0	0
H0243	CANOE IT	-	-	-	43	51	74	179	214	146	208	435	500	189	184
H0048	RAGGED ITS	1	13	2		1	0		13	29	0	0	0	0	2
H0590	S SHAH PT RF	-	-	-	-	-	-	-	-	-	14	0	70	0	61
H0174	CARDALE PT	3	1	0	0	0	12	9	0	0	2	2	0	0	1
H0047	ROSE ITS	0	17	45	41	63	75	78	104	121	64	46	130	148	107
H1460	BLACK RK	-	-	-	-	-	-	-	-	-	-	-	-	67	104
H1465	NE GALIANO ISL B	-	-	-	-	-	-	-	-	-	-	-	-	18	2
H0213	LADYSMITH HRBR	12	ns	0	0	15	0	0	0	0	0	0	0	0	0
H0453	NE GALIANO ISL A	-	-	-	-	-	19	0	51	16	0	16	1	2	1
H0346	S REID ISL RF	-	-	-	-	1	0	4	0	0	1	0	0	0	0
H0546	N HALL ISLAND	-	-	-	-	-	-	-	-	4	0	6	8	4	0
H0374	E HALL ISL	-	-	-	-	25	0	34	69	0	52	14	50	0	0
H1466	NE GALIANO ISL C	-	-	-	-	-	-	-	-	-	-	-	-	30	12
H0529	SW HALL ISLAND	-	-	-	-	-	-	-	10	0	3	12	15	0	15
H0181	S NORWAY ISL RF	-	23	0	9	16	19	26	23	63	42	33	32	22	36

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H0236	MOWGLI ISL	-	-	-	22	3	0	1	37	7	13	5	21	30	23
H0547	NE SECRETARY ISLANDS	-	-	-	-	-	-	-	-	9	0	0	0	0	0
H0182	HUDSON ISL	2	6	0	26	96	0	76	51	0	54	91	90	1	0
H0086	S MOWGLI ISL RK	1	2	16	14	28	25	4	2	16	2	6	30	0	21
H0528	E HUDSON ISLAND	-	-	-	-	-	-	-	22	0	22	30	20	27	74
H1467	NE GALIANO ISL D	-	-	-	-	-	-	-	-	-	-	-	-	6	6
H1462	ALARM RK	-	-	-	-	-	-	-	-	-	-	-	-	63	123
H0336	MW GALIANO ISL RF D	-	-	-	-	6	0	0	0	0	0	0	1	0	1
H0454	NME GALIANO ISL A	-	-	-	-	-	9	0	6	26	0	17	0	11	0
H0085	S SECRETARY ISLS RK	-	-	29	0	0	12	11	16	12	27	41	45	0	23
H0465	S CHIVERS PT RF	-	-	-	-	-	40	0	2	49	30	2	10	39	20
H0083	S JACKSCREW ISL RF	-	9	32	23	34	2	0	23	16	15	13	45	8	20
H0832	ME WALLACE ISL	-	-	-	-	-	-	-	-	-	-	-	4	5	3
H0084	MW WALLACE ISL	-	33	9	49	57	49	42	29	21	0	6	8	8	19
H0065	ME GALIANO ISL RF A	1	9	15	41	42	42	81	40	0	156	244	15	148	57
H1468	ME GALIANO ISL RF B	-	-	-	-	-	-	-	-	-	-	-	-	65	6
H1461	SW WALLACE RF	-	-	-	-	-	-	-	-	-	-	-	-	2	16
H0235	ESCAPE REEF	-	-	-	25	1	0	2	4	63	83	58	60	62	40
H0349	GRAPPLER ROCK	-	-	-	-	2	0	0	0	0	0	0	0	0	0
H0348	CONOVER COVE RFS	-	-	-	-	1	82	0	8	46	2	6	15	0	0
H0762	SE WALLACE ISL	-	-	-	-	-	-	-	-	-	-	13	0	25	16
H0082	MW GALIANO ISL RF C	2	0	3	15	3	0	0	2	0	11	12	0	0	1
H0347	PANTHER PT	-	-	-	-	47	25	20	31	19	44	0	30	0	0
H0530	NW COOK COVE	-	-	-	-	-	-	-	260	152	0	191	320	1	1
H0836	MW GALIANO ISL RF E	-	-	-	-	-	-	-	-	-	-	-	5	0	7
H0046	SANDSTONE ROCKS	-	-	2	60	0	0	13	12	0	0	0	0	52	39
H0066	S COOK COVE	-	6	11	46	55	0	0	0	0	0	47	0	1	9
H0081	MW GALIANO ISL RF B	8	7	13	30	8	0	5	0	0	1	1	0	0	0
H0501	IDOL ISL	-	-	-	-	-	-	10	0	0	0	0	0	0	0
H0345	NORTH REEF	-	-	-	-	45	46	38	60	0	59	46	10	86	62

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H0080	MW GALIANO ISL RF A	12	9	21	0	0	25	3	0	4	0	0	0	2	0
H0364	BALLINGALL ITS	-	-	-	-	8	15	14	85	0	99	111	200	162	111
H0169	WISE ISL	15	2	0	0	1	1	0	0	2	0	8	4	0	103
H0498	CHARLES ISL	-	-	-	-	-	3	4	0	0	1	ns	0	0	0
H0026	SHOAL ISLS FLATS	12	1	38	40	121	223	79	7	28	16	0	2	28	70
H0531	LION ISLETS	-	-	-	-	-	-	-	4	0	69	70	0	96	20
H0837	TWISS PT	-	-	-	-	-	-	-	-	-	-	-	15	0	0
H0350	YORK ROCKS	-	-	-	-	27	54	59	66	17	11	13	0	17	43
H0067	SE GOSSIP ISL RFS	-	-	9	31	15	25	75	192	104	59	129	83	40	49
H0548	NW RIP POINT	-	-	-	-	-	-	-	-	13	16	24	15	28	34
H0592	CROFTON REEF	-	-	-	-	-	-	-	-	-	80	0	2	56	166
H0168	ATKINS REEF	7	4	0	23	23	49	34	0	98	52	39	21	46	7
H0846	GEORGINA PT	-	-	-	-	-	-	-	-	-	-	-	4	36	45
H1459	PHILLIMORE PT	-	-	-	-	-	-	-	-	-	-	-		3	7
H0376	E DAVID COVE RF	-	-	-	-	15	0	32	29	23	28	32	35	43	33
H0497	W MARY ANNE PT	-	-	-	-	-	-	5	17	0	6	5	0	0	7
H0549	W GEORGESON BAY RF	-	-	-	-	-	-	-	-	43	27	125	0	75	27
H1469	HELEN PT	-	-	-	-	-	-	-	-	-	-	-	-	19	12
H0241	SE EDITH PT RFS	-	-	-	17	7	24	36	19	31	14	12	30	0	15
H0835	POWDER IT	-	-	-	-	-	-	-	-	-	-	-	12	0	2
H0375	NE NOSE PT	-	-	-	-	7	5	12	20	0	0	0	2	0	3
H0166	S PEILE PT	0	1	0	0	2	31	0	0	0	5	0	1	0	0
H0379	CHAIN ISLS	1	6	0	0	42	0	24	59	17	0	8	4	0	5
H1470	N GEORGESON PT	-	-	-	-	-	-	-	-	-	-	-	-	18	29
H0079	CHARLES ROCKS	33	14	63	20	81	3	15	23	123	14	21	15	53	49
H0502	HAWKINS ISL	-	-	-	-	-	-	53	21	0	0	0	1	0	29
H1463	SE THIRD SISTER ISL RF	-	-	-	-	-	-	-	-	-	-	-	-	6	3
H0457	DINNER PT	-	-	-	-	-	9	16	21	0	27	34	100	57	49
H0069	BELLE CHAIN ITS	14	106	140	471	753	573	800	0	755	458	608	1,175	438	486
H0068	E SAMUEL ISL RF	55	20	34	22	0	103	96	1,034	281	0	1	20	19	26

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H0503	E STANLEY PT	-	-	-	-	-	-	29	5	0	0	1	0	0	1
H0078	NE STANLEY PT	0	12	5	14	34	6	0	19	18	6	11	7	0	4
H0337	LIZARD ISL	-	-	-	-	0	0	0	0	2	0	1	1	0	1
H0550	E ELLEN BAY	-	-	-	-	-	-	-	-	18	0	2	0	0	2
H1451	SW ARBUTUS PT	-	-	-	-	-	-	-	-	-	-	-	-	39	0
H0173	NW ACLAND ISLS RFS	1	0	0	9	52	0	0	0	0	3	35	0	12	6
H0237	RED ITS	-	-	-	6	0	15	15	0	0	0	0	0	0	18
H0551	BOAT ISLET	-	-	-	-	-	-	-	-	8	2	6	5	22	11
H0460	SE ACLAND ISLS	-	-	-	-	-	7	0	0	4	0	0	0	0	65
H0240	KING ITS	-	-	-	52	41	65	66	6	105	26	25	30	42	62
H1452	BIRDS EYE COVE	-	-	-	-	-	-	-	-	-	-	-	-	11	0
H0238	FANE ISL	-	-	-	7	13	0	12	4	35	5	4	0	0	0
H0073	W TUMBO ISL RF	0	10	20	0	45	106	21	205	5	108	152	200	139	79
H0165	CHANNEL ISLS	27	0	0	68	51	114	63	135	169	66	82	45	70	125
H0074	PINE IT	10	6	26	103	107	157	247	355	236	185	132	175	144	135
H0242	TUMBO REEF	-	-	-	44	0	0	0	0	0	0	0	0	0	0
H1453	CHISHOLM ISL	-	-	-	-	-	-	-	-	-	-	-	-	11	0
H0532	TUMBO POINT	-	-	-	-	-	-	-	19	26	0	41	20	0	7
H0164	E NORTH PENDER ISL	2	4	0	24	26	13	48	17	11	5	12	4	0	0
H0505	S OTTER BAY RK	-	-	-	-	-	-	14	0	0	7	7	30	20	35
H0075	BOILING REEF	-	-	78	39	64	84	210	450	207	223	648	650	236	216
H0500	BOLD BLUFF PT	-	-	-	-	-	-	5	0	0	0	0	5	ns	14
H0845	PORT BROWNING RKS	-	-	-	-	-	-	-	-	-	-	-	5	8	0
H0455	NARVAEZ BAY RK	-	-	-	-	-	16	2	0	0	0	0	1	5	2
H0163	CROAKER PT	1	0	0	0	0	0	0	0	0	0	0	0	18	15
H0377	RAZOR PT	-	-	-	-	30	7	0	0	11	3	0	0	0	0
H0499	BURIAL IT	-	-	-	-	-	-	17	7	4	19	0	8	15	36
H0456	W MONARCH HD	-	-	-	-	-	17	0	0	0	0	0	0	0	0
H0077	BEDDIS ROCK	14	10	3	30	27	0	15	12	29	42	13	18	21	11
H0162	MURDER PT	2	4	0	10	23	30	11	3	0	12	5	2	0	1

Site Number	Site Name	14-15 June 1973	14-16 Aug 1974	16-18 Aug 1982	19-20 Aug 1986	12-26 Aug 1988	5-6 Aug 1990	28 Aug 9 Sept 1992	18-20 Aug 1994	28-30 July 1996	9 Aug 5 Sept 1998	28-30 Aug 2000	25-30 Aug 2003	28-30 Aug 2008	21-22 Aug 2014
H1471	S BOAT NOOK	-	-	-	-	-	-	-	-	-	-	-	-	16	2
H0076	JAVA ITS	1	42	64	112	67	223	316	109	224	294	340	225	259	218
H0458	N SOUTH PENDER ISL	-	-	-	-	-	9	6	4	0	0	1	2	0	0
H0593	N MUSGRAVE PT REEF	-	-	-	-	-	-	-	-	-	12	0	0	ns	5
H0535	ELEANOR POINT	-	-	-	-	-	-	-	11	0	0	0	6	0	3
H0459	S NORTH PENDER ISL	-	-	-	-	-	10	9	21	5	21	12	6	2	5
H0159	NE SOUTH PENDER ISL	0	0	0	0	0	0	0	0	0	0	0	0	0	0
H0175	COWICHAN BAY	4	1	ns	9	18	32	ns	40	38	ns	ns	82	95	17
H1450	OAKS BLUFF	-	-	-	-	-	-	-	-	-	-	-	-	14	3
H0239	BLUNDEN IT	-	-	-	37	30	31	96	73	112	74	63	30	66	35
H1473	HAY PT	-	-	-	-	-	-	-	-	-	-	-	-	6	0
H0534	SE HAY POINT	-	-	-	-	-	-	-	5	8	9	5	1	0	0
H0533	N GOWLLAND POINT RF	-	-	-	-	-	-	-	31	48	34	0	0	0	7
H0504	N WALLACE PT RK	-	-	-	-	-	-	15	25	33	48	19	25	ns	14
H1472	E TILLY PT ISL	-	-	-	-	-	-	-	-	-	-	-	-	16	6
H0553	PATEY ROCK	-	-	-	-	-	-	-	-	2	0	0	0	ns	34
H1522	ME GALIANO ISLAND REEF C	-	-	-	-	-	-	-	-	-	-	-	-	-	112
H1523	ANDAJE POINT	-	-	-	-	-	-	-	-	-	-	-	-	-	10
H1524	MAYNE ISL	-	-	-	-	-	-	-	-	-	-	-	-	-	10
Total number counted		**302**	**511**	**1,162**	**2,480**	**3,641**	**4,337**	**5,033**	**6,655**	**5,843**	**5,189**	**7,949**	**7,605**	**5,670**	**5,849**
Correction for unborn pups		1.2490	1.0329	1.0238	1.0213	1.0110	1.0696	1.0003	1.0190	1.1204	1.0040	1.0046	1.0053	1.0061	1.0142
Proportion of area covered		1.0000	0.9603	0.9963	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.9830	0.9830	0.9937	0.9661	1.0000
Adjusted count		377.2	549.6	1194.1	2532.8	3681.1	4638.9	5034.5	6781.4	6546.5	5299.8	8123.8	7694.0	5905.1	5931.9
Var Estimated proportion hauled out		0.374	0.600	0.528	0.592	0.615	0.587	0.652	0.543	0.627	0.592	0.589	0.601	0.593	n/a
Var Correction for missed animals		2.673	1.668	1.894	1.690	1.626	1.705	1.533	1.841	1.594	1.689	1.698	1.664	1.686	n/a
Estimated abundance - variable CF		**1,008**	**917**	**2,262**	**4,280**	**5,985**	**7,909**	**7,718**	**12,485**	**10,435**	**8,954**	**13,792**	**12,802**	**9,958**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**613**	**894**	**1,942**	**4,118**	**5,985**	**7,543**	**8,186**	**11,027**	**10,645**	**8,618**	**13,209**	**12,511**	**9,602**	**9,645**

Table A6. Survey counts by site (number and name) within the Northwestern Gulf (NWGULF) subarea. See Table A1 caption for details.

Site Number	Site Name	16-19 Aug 1974	10-11 Aug 1976	17-18 Aug 1983	14 Aug 1985	10-24 Aug 1988	17-18 Aug 1990	27-28 Aug 1992	7-17 Aug 1994	11-13 Aug 1996	8-9 Aug 1998	26-29 Aug 2000	10-28 Aug 2003	14-16 Aug 2008	11 Aug 2014
H0356	SHELTER PT RF	-	-	-	-	32	56	36	44	0	83	75	ns	144	41
H0588	OYSTER BAY RF	-	-	-	-	-	-	-	-	-	3	0	ns	0	3
H0329	S WILLIAMS BEACH	-	-	-	-	92	163	119	87	151	93	49	ns	25	61
H0330	N LITTLE RIVER RF	-	-	-	-	65	117	138	103	134	192	187	ns	100	86
H0522	LITTLE RIVER RF	-	-	-	-	-	-	-	-	18	11	40	ns	9	0
H0126	E CAPE LAZO RF	24	16	12	65	94	138	111	126	147	92	105	ns	27	67
H0104	COMOX HRBR	1	7	15	75	169	0	0	318	241	262	182	ns	17	1
H0102	E SEAL ITS RF	3	6	7	10	44	60	60	45	28	16	78	18	3	21
H1474	UNION PT	-	-	-	-	-	-	-	-	-	-	-	-	54	34
H0414	S UNION PT	-	-	-	-	-	19	26	2	0	0	ns	0	0	0
H1475	KOMAS BLUFF	-	-	-	-	-	-	-	-	-	-	-	-	6	28
H0204	S KOMAS BLUFF	-	-	-	5	12	51	46	15	19	15	0	44	6	14
H0103	COLLISHAW PT	16	14	32	65	165	126	226	220	262	144	434	300	163	279
H0357	TRALEE PT	-	-	-	-	12	0	0	30	0	0	0	ns	0	0
H0491	CAPE GURNEY	-	-	-	-	-	-	3	5	1	0	34	55	69	92
H0099	FLORA IT	-	-	65	106	186	219	251	505	559	356	847	575	777	258
H0332	NASH BANK RF	-	-	-	-	18	0	0	15	27	0	0	35	0	5
H0101	S FANNY BAY		3	32	10	14	37	2	11	43	17	6	ns	0	40
H0490	MAUDE REEF	-	-	-	-	-	-	-	28	18	21	66	45	46	75
H0203	E NORMAN PT	1	0	0	49	77	116	103	199	123	123	89	100	111	138
H0470	NORRIS ROCKS	-	-	-	-	-	60	136	229	266	350	571	450	519	366
H0202	E REPULSE PT	-	-	-	6	21	25	48	67	43	59	0	30	54	18
H0100	MUD BAY	2	28	25	67	81	98	50	51	81	15	3	ns	21	13
H0760	EAGLE RK	-	-	-	-	-	-	-	-	-	-	4	0	0	2
H0778	S REPULSE PT	-	-	-	-	-	-	-	-	-	-	-	15	0	2
H0358	N QUALICUM BAY RF A	-	-	-	-	5	28	2	2	2	0	0	0	0	3
H1476	N QUALICUM BAY RF B	-	-	-	-	-	-	-	-	-	-	-	-	3	0
H0331	S QUALICUM BAY RF	-	-	-	-	57	114	67	154	126	157	8	208	151	308
H0761	LITTLE QUALICUM RIVER	-	-	-	-	-	-	-	-	-	-	118	0	0	16

Site Number	Site Name	16-19 Aug 1974	10-11 Aug 1976	17-18 Aug 1983	14 Aug 1985	10-24 Aug 1988	17-18 Aug 1990	27-28 Aug 1992	7-17 Aug 1994	11-13 Aug 1996	8-9 Aug 1998	26-29 Aug 2000	10-28 Aug 2003	14-16 Aug 2008	11 Aug 2014
H0093	S BALLENAS ISLS RFS	3	1	10	17	77	88	65	111	132	107	156	199	100	116
H0094	NE MISTAKEN ISL RFS		12	85	94	85	28	173	275	245	221	282	326	221	169
H0359	COTTAM REEF	-	-	-	-	1	7	4	8	13	0	0	30	17	6
H0340	GERALD ISL	-	-	-	-	19	50	7	3	51	91	22	68	41	50
H0339	DOUGLAS ISL	-	-	-	-	34	25	35	13	0	12	70	100	48	24
H0092	YEO ISLS	-	-	59	65	53	73	71	321	187	187	267	155	99	134
H0368	AMELIA ISL	-	-	-	-	11	0	0	0	0	0	41	6	18	0
H0091	N SCHOONER REEF	-	-	5	0	18	25	12	38	21	18	103	20	44	25
H0369	WINCHELSEA ISLS	-	-	-	-	49	10	95	37	20	173	149	64	11	83
H0087	ADA ISLS	-	-	79	120	181	245	38	274	502	307	308	305	272	306
H0759	RUTH ISL	-	-	-	-	-	-	-	-	-	-	16	15	21	16
H0088	SOUTHEY ISL	24	50	78	67	73	76	70	41	72	24	132	50	113	9
H0496	N WALLIS PT RKS	-	-	-	-	-	-	12	20	8	0	3	2	0	49
H0089	E WALLIS PT RK	-	-	7	0	0	9	0	9	0	0	13	0	0	0
H0090	MAUDE ISL	-	3	35	36	24	18	30	43	30	2	34	17	27	0
H0341	NANOOSE BAY	-	-	-	-	1	0	0	0	0	0	ns	0	0	0
Total number counted		**74**	**140**	**546**	**857**	**1,770**	**2,081**	**2,036**	**3,449**	**3,570**	**3,151**	**4,492**	**3,232**	**3,337**	**2,958**
Correction for unborn pups		1.0293	1.0502	1.0264	1.0362	1.0337	1.0225	1.0067	1.0385	1.0399	1.0580	1.0063	1.0316	1.0268	1.0439
Proportion of area covered		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	0.8560	1.0000	1.0000
Adjusted count		76.2	147.0	560.4	888.0	1829.1	2127.9	2049.6	3581.6	3712.4	3333.8	4520.1	3895.3	3426.4	3088.0
Var Estimated proportion hauled out		0.450	0.322	0.509	0.483	0.560	0.585	0.617	0.553	0.558	0.660	0.589	0.587	0.604	n/a
Var Correction for missed animals		2.221	3.107	1.965	2.070	1.785	1.708	1.622	1.807	1.793	1.515	1.698	1.704	1.656	n/a
Estimated abundance - variable CF		**169**	**457**	**1,101**	**1,838**	**3,265**	**3,634**	**3,324**	**6,472**	**6,656**	**5,052**	**7,676**	**6,636**	**5,673**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**124**	**239**	**911**	**1,444**	**2,974**	**3,460**	**3,333**	**5,824**	**6,036**	**5,421**	**7,350**	**6,334**	**5,571**	**5,021**

Table A7. Survey counts by site (number and name) within the Northeastern Gulf (NEGULF) subarea. See Table A1 caption for details.

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0127	SE WAIATT BAY RF	-	24	ns	ns	ns	ns	ns	ns	ns	ns	0	0	0
H0797	CYRUS RKS	-	-	-	-	-	-	-	-	-	ns	12	7	18
H0128	M CHAINED ISLS	-	1	ns	ns	ns	ns	ns	ns	ns	ns	0	26	1
H0494	DUNSTERVILLE IT	-	-	-	-	-	31	26	ns	15	ns	75	18	74
H0822	READ PT	-	-	-	-	-	-	-	-	-	ns	32	0	21
H0493	NW VINER PT RK	-	-	-	-	-	6	7	ns	53	ns	0	53	0
H0821	VINER PT	-	-	-	-	-	-	-	-	-	ns	39	0	0
H0520	N BRETON ISLANDS IT	-	-	-	-	-	-	29	ns	5	ns	60	25	32
H0580	NE BRETON ISL	-	-	-		-	-	-	ns	136	ns	23	166	50
H1496	N SUBTLE ISLS	-	-	-	-	-	-	-	-	-	-	-	27	0
H0519	CENTRE ISLET	-	-	-	-	-	-	35	ns	30	ns	75	67	60
H0125	S BRETON ISLS	39	29	10	ns	ns	199	253	ns	57	ns	146	22	63
H0581	SW HYACINTHE PT RF	-	-	-	-	-	-	-	ns	20	ns	3	49	23
H0521	HYACINTHE BAY RF	-	-	-	-	-	-	7	ns	0	ns	0	0	0
H0579	SE SUBTLE ISLS	-	-	-	-	-	-	-	ns	5	ns	0	0	17
H0796	MAY ISL	-	-	-	-	-	-	-	-	-	ns	11	0	0
H0415	GOWLLAND HRBR	-	-	-	-	-	-	-	-	-	ns	125	19	16
H0334	NW MARINA ISL RF	-	-	-	1	52	12	18	ns	6	0	0	0	8
H1495	GUIDE ITS	-	-	-	-	-	-	-	-	-	-	-	91	30
H0839	S MANSON BAY	-	-	-	-	-	-	-	-	-	-	20	31	25
H0124	SW MARINA ISL RF	-	8	53	14	70	25	38	ns	57	0	1	0	0
H1493	S GROUSE ISL	-	-	-	-	-	-	-	-	-	-	-	57	9
H1492	W POWELL IT	-	-	-	-	-	-	-	-	-	-	-	19	41
H0120	POWELL ITS	11	123	190	177	288	226	164	191	112	147	ns	150	97
H0123	MARINA REEF	73	266	468	491	495	310	594	ns	517	346	102	507	554
H0794	N YACULTA RF	-	-	-	-	-	-	-	-	-	-	2	23	0
H0518	TOWNLEY ISLAND	-	-	-	-	-	-	23	22	2	3	ns	0	48
H0492	IRON PT	-	-	-	-	-	9	0	0	0	0	0	0	0
H1491	N COPELAND ISL	-	-	-	-	-	-	-	-	-	-	-	22	0

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0492	IRON PT	-	-	-	-	-	-	-	-	-	ns	7	0	0
H0578	S TWIN ISLS	-	-	-	-	-	-	-	-	8	7	7	0	3
H0122	SW SUTIL PT RF	11	89	149	161	141	50	204	244	20	163	20	305	255
H0758	FRANCISCO PT	-	-	-	-	-	-	-	-	-	18	0	0	7
H0495	CAPE MUDGE	-	-	-	-	-	11	24	ns	0	36	32	109	27
H0119	S COPELAND ISLS	-	48	1	1	0	0	0	6	0	0	ns	0	3
H0188	MAJOR IT	37	0	0	97	6	0	121	32	129	96	ns	124	191
H0117	ME HERNANDO ISL RK	-	19	18	0	31	28	28	0	0	104	ns	0	0
H0118	SW H0ERNANDO ISL	32	51	50	98	132	85	195	142	150	55	ns	29	64
H0116	KEEFER ROCK	-	22	36	85	68	190	37	50	136	163	0	107	105
H1494	ASHWORTH PT	-	-	-	-	-	-	-	-	-	-	-	89	199
H0489	INDIAN PT	-	-	-	-	-	22	0	0	0	8	0	0	9
H0121	MITLENATCH ISL	-	59	50	173	153	216	319	529	201	ns	ns	784	380
H0471	DINNER ROCK	-	-	-	-	2	0	0	2	0	13	ns	27	ns
H0115	SW SAVARY ISL	5	23	34	37	48	0	4	15	0	15	21	12	14
H0187	SE SAVARY ISL RFS	9	0	95	85	85	119	85	90	44	54	49	48	32
H0517	S BEACON POINT RF	-	-	-	-	-	-	52	56	32	28	8	1	3
H0114	STRADIOTTI REEF	-	25	3	60	50	61	28	13	27	0	53	0	26
H0113	MYSTERY REEF	2	10	90	85	105	95	98	240	141	19	160	ns	37
H0186	NW HARWOOD ISL	7	0	5	2	8	6	20	13	0	7	14	0	1
H0577	SE HARWOOD ISL	-	-	-	-	-	-	-	-	6	9	36	93	43
H0112	VIVIAN ISL	-	7	16	55	41	228	44	453	122	504	375	176	332
H0559	SW HARWOOD ISLAND	-	-	-	-	-	-	-	21	17	64	13	71	143
H1487	NE SYDNEY ISL RF	-	-	-	-	-	-	-	-	-	-	-	147	54
H0111	REBECCA ROCK	-	10	47	118	198	122	206	289	442	516	700	398	412
H0576	CYRIL RK	-	-	-	-	-	-	-	-	17	3	65	69	0
H0754	S GRILSE PT A	-	-	-	-	-	-	-	-		61	2	15	25
H0575	KIDDIE PT	-	-	-	-	-	-	-	-	4	0	0	0	0
H1479	S GRILSE PT B	-	-	-	-	-	-	-	-				27	9
H0354	MYRTLE ROCKS	-	-	-	26	0	0	67	34	8	0	1	0	18

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0132	MILLER IT	15	22	18	6	41	0	0	0	ns	ns	ns	34	92
H0110	N MARSHALL PT		2	7	15	10	2	29	22	14	0	22	53	94
H1480	HODGSON PT	-	-	-	-	-	-	-	-	-	-	-	16	41
H0327	ALBION PT	-	-	-	0	1	0	0	0	0	0	0	0	0
H0508	CRESCENT BAY IT	-	-	-	-	-	-	5	0	0	0	75	8	4
H1484	SUTTON ITS	-	-	-	-	-	-	-	-	-	-	-	21	44
H1481	E VANANDA	-	-	-	-	-	-	-	-	-	-	-	28	0
H0133	MCRAE IT	20	34	71	113	129	100	280	143	68	3	40	16	78
H0558	SW SCOTCH FIR PT IT	-	-	-	-	-	-	-	87	101	140	150	71	52
H0250	N FAVADA PT RK	-	-	12	26	0	13	10	14	20	25	27	150	41
H1490	DAVIS BAY	-	-	-	-	-	-	-	-	-	-	-	99	33
H0516	NOCTURNE ISLAND	-	-	-	-	-	-	12	12	0	0	15	0	14
H0185	NW KELLY ISL RK	24	7	11	35	30	21	82	17	0	45	37	0	51
H0184	NORTHEAST PT	5		13	42	51	85	50	60	58	76	111	74	3
H0563	SE DAVIS BAY IT	-	-	-	-	-	-	-	17	45	47	50	111	15
H0515	S KELLY ISLAND	-	-	-	-	-	-	7	0	0	0	5	15	11
H1489	SE WELCOME BAY	-	-	-	-	-	-	-	-	-	-	-	7	3
H0473	SW BILLINGS BAY	-	-	-	-	20	0	17	0	0	0	0	6	0
H0353	STRAWBERRY IT	-	-	-	14	1	16	50	42	32	31	60	4	23
H0326	NW HIGHLAND PT RF	-	-	-	125	117	0	0	0	ns	ns	ns	99	66
H0488	N GILES BAY	-	-	-	-	-	7	0	4	0	8	11	0	1
H1478	E COCKBURN BAY	-	-	-	-	-	-	-	-	-	-	-	9	9
H0134	E CAPE COCKBURN RK	-	-	8	4	21	1	0	35	19	95	56	51	138
H0135	W QUARRY BAY RF	-	1	2	0	0	0	42	0	0	0	0	0	0
H0205	MERMAID PT	-	-	7	1	0	0	15	0	0	0	2	0	0
H0249	S DICK ISL	-	-	48	39	31	49	68	69	78	68	65	11	73
H0472	NELSON ROCK	-	-	-	-	17	0	199	0	0	0	9	4	0
H1488	N MOUAT ISL	-	-	-	-	-	-	-	-	-	-	-	71	73
H0131	W HODGSON ISLS	20	79	151	87	100	86	11	159	95	59	99	37	140
H0109	MOUAT ISLS	2	53	114	132	146	159	267	265	165	237	205	90	87

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0557	NARES ROCK	-	-	-	-	-	-	-	18	18	0	0	11	0
H1486	E KUNECHIN PT	-	-	-	-	-	-	-	-	-	-	-	22	7
H0781	MARTIN ISLAND	-	-	-	-	-	-	-	-	-	-	4	0	24
H0248	MW TEXADA ISL	-	-	4	2	0	4	0	25	8	52	120	49	49
H1485	KUNECHIN ITS	-	-	-	-	-	-	-	-	-	-	-	48	50
H0784	DAVIE BAY IT	-	-	-	-	-	-	-	-	-	-	16	18	42
H0556	S EDGECOMBE ISLAND IT	-	-	-	-	-	-	-	20	0	0	7	0	27
H0448	N WHITESTONE ISLS	-	-	-	-	19	31	75	0	15	8	50	28	88
H0108	SE DAVIE BAY RFS	-	10	40	25	70	30	76	93	55	147	150	57	151
H0487	MSW TEXADA ISL	-	-	-	-	-	8	22	22	0	6	0	0	0
H0244	SE TEXADA ISL	-	-	9	9	72	40	32	45	10	24	86	47	1
H0783	W COOK BAY RKS	-	-	-	-	-	-	-	-	-	-	32	34	22
H0107	SW COOK BAY RK	-	9	0	24	10	0	24	11	0	0	0	23	2
H1483	N PARTINGTON PT	-	-	-	-	-	-	-	-	-	-	-	10	2
H0098	FEGAN ITS	38	104	155	257	276	129	310	327	291	321	150	155	330
H0477	SE BOAT COVE RK	-	-	-	-	35	0	48	0	18	26	10	0	1
H0474	PARTINGTON PT	-	-	-	-	40	26	9	0	0	58	0	15	2
H0475	NE LASQUETI ISL RK	-	-	-	-	7	ns	13	0	0	0	0	0	2
H0560	S FEGAN ITS	-	-	-	-	-	-	-	96	37	283	60	70	289
H0209	NW JERVIS ISL IT	-	-	-	-	-	-	194	155	352	184	150	84	72
H0245	NE JERVIS ISL	-	-	44	86	135	139	0	0	0	152	25	0	14
H0782	ANDERSON BAY IT	-	-	-	-	-	-	-	-	-	-	6	10	3
H0105	E JERVIS ISL RF	-	65	87	0	143	27	83	69	58	80	60	34	80
H0757	N JEDEDIAH ISL	-	-	-	-	-	-	-	-	-	4	0	22	0
H0176	N PAUL ISL RK	-	-	-	87	0	0	0	0	0	0	0	0	0
H0352	DERBY PT	-	-	-	11	0	31	3	0	0	0	0	1	22
H0756	TUCKER BAY RK	-	-	-	-	-	-	-	-	-	6	2	0	0
H0247	FINNERTY ISLS	-	-	23	15	16	21	93	94	70	172	60	55	36
H0562	E JEDEDIAH ISLAND	-	-	-	-	-	-	-	30	30	20	0	0	0
H0183	SE JEDDAH PT RKS	-	-	19	4	34	17	21	48	3	4	62	32	108

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0486	SW TEXADA ISL A	-	-	-	-	-	9	17	36	6	7	0	0	25
H0755	N UPWOOD PT	-	-	-	-	-	-	-	-	-	15	22	0	1
H0405	BOHO ISL	-	-	-	-	3	4	0	0	0	0	0	0	1
H0333	W JEDEDIAH ISL RF	-	-	-	11	2	0	0	0	0	0	ns	0	1
H0476	E JEDEDIAH ISL RK	-	-	-	-	14	45	41	0	0	0	0	0	0
H0561	S BOHO BAY IT	-	-	-	-	-	-	-	5	0	9	ns	13	16
H0512	S JEDEDIAH ISLAND	-	-	-	-	-	-	3	0	0	0	0	0	0
H1482	SW UPWOOD PT	-	-	-	-	-	-	-	-	-	-	-	8	1
H0251	SISTERS ITS	-	-	5	0	44	90	226	37	258	320	160	241	171
H0555	EGERTON ROCK	-	-	-	-	-	-	-	20	0	0	0	0	0
H0106	SHEER ISL	-	10	34	32	13	14	76	40	103	19	54	22	0
H0779	E THORMANBY ISL RK	-	-	-	-	-	-	-	-	-	0	10	12	0
H0130	MW SOUTH THORMANBY ISL	-	8	3	45	0	12	106	38	21	0	106	0	0
H0513	SE BULL ISLAND RF	-	-	-	-	-	-	22	0	0	0	60	27	14
H0511	S BULL ISLAND IT	-	-	-	-	-	-	3	0	0	0	0	4	0
H0510	S RABBIT ISLAND	-	-	-	-	-	-	5	23	0	0	20	0	0
H0355	HEATH IT	-	-	-	3	0	0	0	0	0	0	0	0	0
H0215	ME SOUTH THORMANBY ISL	-	-	0	20	26	0	21	4	19	4	35	0	16
H0479	SW LASQUETI ISL	-	-	-	-	2	6	0	0	0	27	16	3	9
H0129	SW SOUTH THORMANBY ISL	1	31	31	15	12	50	12	136	97	0	30	27	0
H0447	S SOUTH THORMANBY ISL RF	-	-	-	-	53	0	23	0	0	20	27	36	79
H0160	MERRY ISL	-	-	12	27	33	157	59	111	72	61	260	89	173
H0325	PIRATE ROCK	-	-	-	13	35	0	23	53	52	0	18	0	9
H0406	E LASQUETI RK	-	-	-	-	0	0	0	12	47	49	25	0	12
H0351	BERTHA ISL	-	-	-	4	28	22	5	57	0	53	85	5	19
H0096	BOAT COVE RFS	-	16	53	85	0	23	2	2	0	0	7	28	42
H0136	W TRAIL ISLS	3	1	105	27	93	126	14	174	126	81	115	17	24
H0154	M TRAIL ISLS	-	-	15	ns	18	43	32	1	24	2	20	28	90
H0514	E TRAIL ISLANDS	-	-	-	-	-	-	7	0	0	16	0	0	0
H0097	SEA EGG ROCKS	-	7	33	64	77	171	161	126	126	208	180	214	95

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
H0485	SE LASQUETI ISL	-	-	-	-	-	4	0	0	0	8	0	2	0
H0509	SW JENKINS ISLAND	-	-	-	-	-	-	8	5	28	10	70	91	0
H0478	E JENKINS ISL RK	-	-	-	-	15	14	72	38	46	160	80	115	4
H0246	E YOUNG PT RK	-	-	15	0	14	0	1	20	0	39	25	39	40
H0328	SEAL REEF	-	-	-	21	0	17	111	0	196	127	160	ns	26
H0095	SANGSTER ISL	-	37	54	61	86	240	299	288	191	333	180	277	172
H0153	WHITE ITS	-	-	16	0	7	102	49	67	119	208	101	102	207
H1477	NW CHASTER	-	-	-	-	-	-	-	-	-	-	-	290	75
H1506	WILLIAMS ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	7
H1507	PEARSON	-	-	-	-	-	-	-	-	-	-	-	-	15
H1508	OYSTER ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	9
H1509	EAGLE COVE	-	-	-	-	-	-	-	-	-	-	-	-	6
H1510	SW TEXADA ISL B	-	-	-	-	-	-	-	-	-	-	-	-	11
H1511	CIRCLE ISL	-	-	-	-	-	-	-	-	-	-	-	-	28
H1512	AVERY REEF	-	-	-	-	-	-	-	-	-	-	-	-	63
H1513	ANDERSON CREEK	-	-	-	-	-	-	-	-	-	-	-	-	79
H1514	SALMON INLET	-	-	-	-	-	-	-	-	-	-	-	-	27
H1515	CARLSON POINT	-	-	-	-	-	-	-	-	-	-	-	-	35
H1516	CARLSON REEF	-	-	-	-	-	-	-	-	-	-	-	-	15
H1517	SECHELT ISLETS	-	-	-	-	-	-	-	-	-	-	-	-	11
H1518	CAPTAIN ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	35
H1519	SYKES ISLAND	-	-	-	-	-	-	-	-	-	-	-	-	36
H1520	HEATHER ISLETS	-	-	-	-	-	-	-	-	-	-	-	-	8
H1521	DUNSTERVILLE ISLET	-	-	-	-	-	-	-	-	-	-	-	-	21
Total		**354**	**1,310**	**2,534**	**3,353**	**4,120**	**4,242**	**6,271**	**5,734**	**5,709**	**6,596**	**6,244**	**7,610**	**7,769**
Correction for unborn pups		1.0187	1.0238	1.0163	1.0539	1.0243	1.0086	1.0662	1.0461	1.0670	1.0086	1.0430	1.0307	1.0525
Proportion of area covered		0.9814	0.9861	0.9812	1.0151	0.9773	0.9773	0.9812	0.8406	0.9812	0.8915	0.8902	0.9544	1.0000
Adjusted count		367.4	1360.1	2624.8	3481.3	4318.0	4377.9	6814.3	7136.0	6208.3	7461.6	7316.0	8218.4	8177.2
Var Estimated proportion hauled out		0.573	0.606	0.653	0.646	0.644	0.629	0.644	0.637	0.656	0.643	0.624	0.635	n/a

Site Number	Site Name	11-24 Aug 1976	17-19 Aug 1983	21-22 Aug 1987	9-10 Aug 1988	3-20 Aug 1990	25-27 Aug 1992	5-7 Aug 1994	10-12 Aug 1996	6-8 Aug 1998	25-28 Aug 2000	10-11 & 30-31 Aug 2003	14-16 Aug 2008	08-10 Aug 2014
Var Correction for missed animals		1.746	1.650	1.531	1.547	1.554	1.591	1.552	1.569	1.524	1.555	1.603	1.575	n/a
Estimated abundance - variable CF		**642**	**2,244**	**4,019**	**5,386**	**6,710**	**6,965**	**10,576**	**11,196**	**9,463**	**11,604**	**11,724**	**12,942**	**n/a**
Av Estimated proportion hauled out		0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615	0.615
Av Correction for missed animals		1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626	1.626
Estimated abundance - fixed CF		**597**	**2,212**	**4,268**	**5,661**	**7,021**	**7,119**	**11,080**	**11,603**	**10,095**	**12,133**	**11,896**	**13,363**	**13,296**

APPENDIX B

Haulout Site Maps for the Strait of Georgia (SOG)

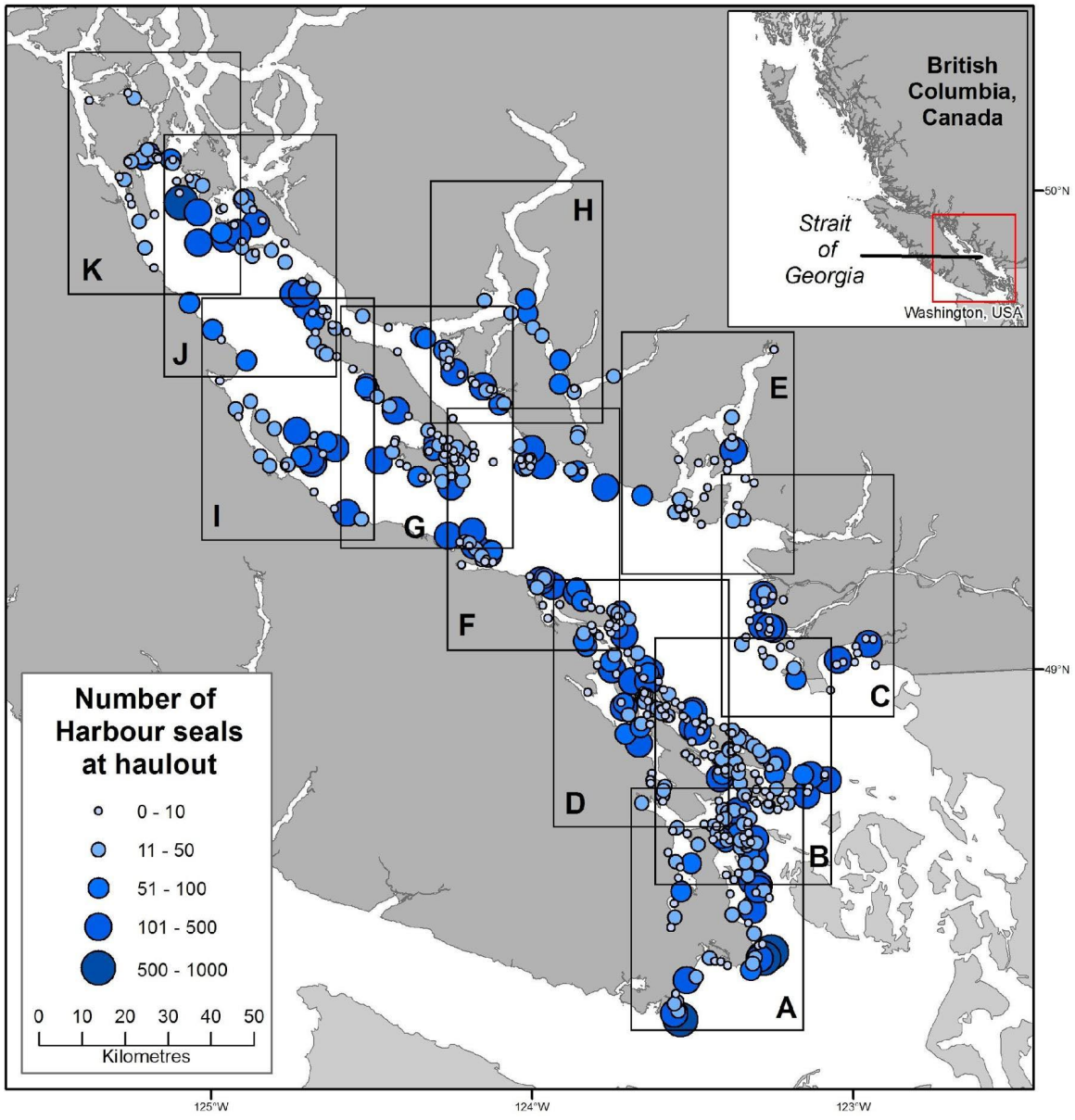

Figure B1. Overview map of the SOG showing the boundaries of the following 11 detailed maps (Figures B2-B12) and the location of haulout sites. Adjacent maps overlap by about 10-20%, so some haulout sites may appear on more than one map. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey.

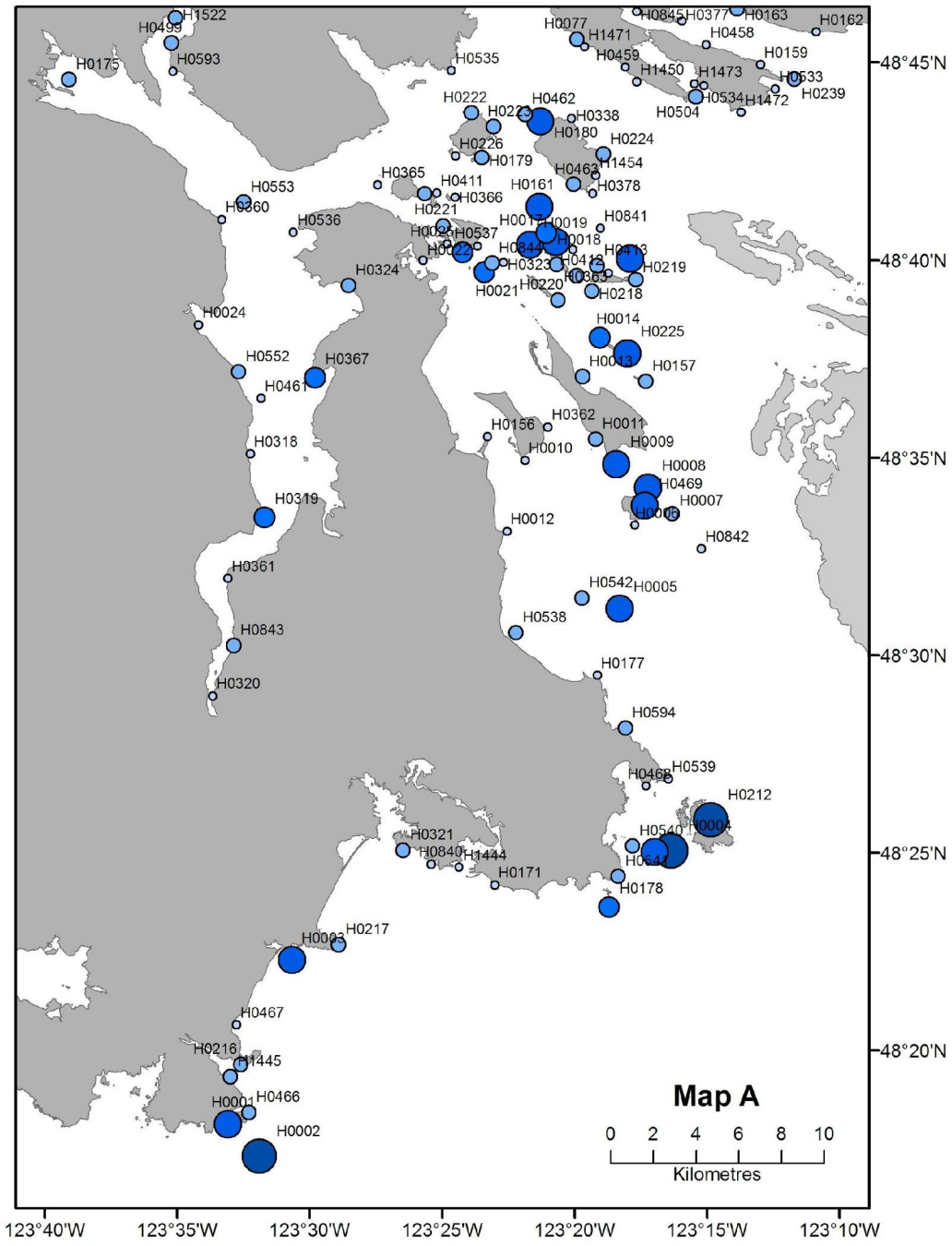

Figure B2. Map A – Southern Vancouver Island. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

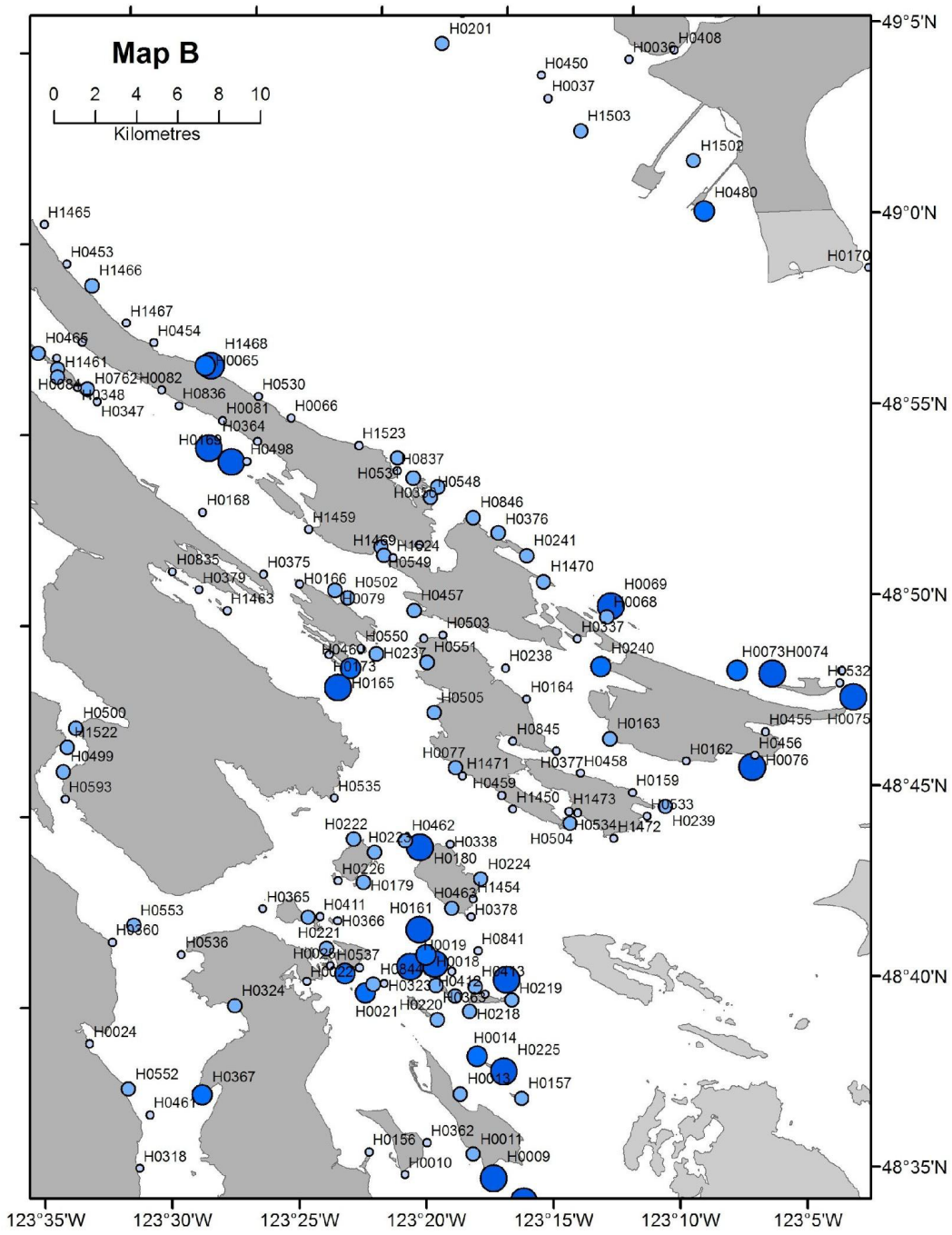

Figure B3. Map B – Southern Gulf Islands. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

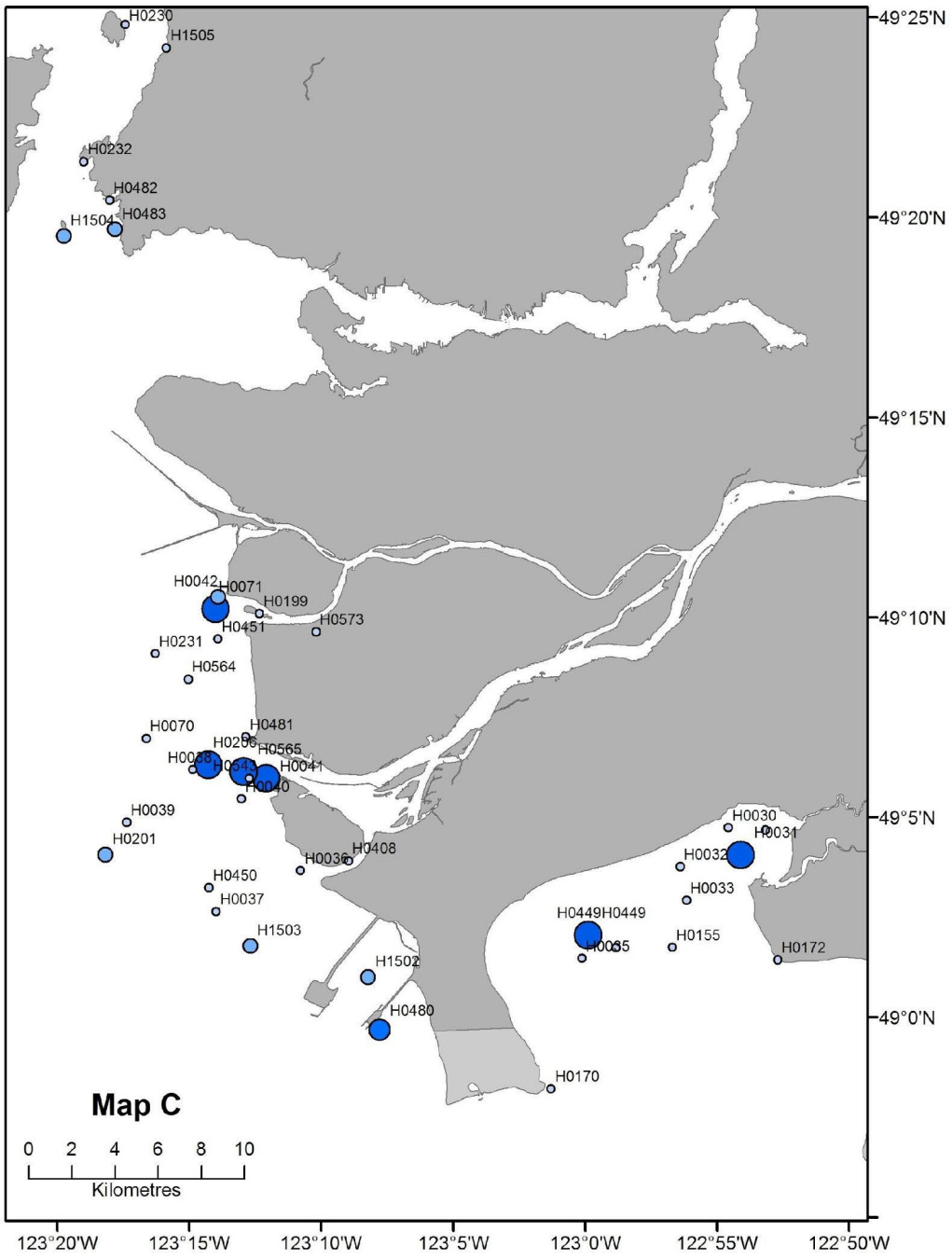

Figure B4. Map C – Fraser River Estuary-Boundary Bay. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

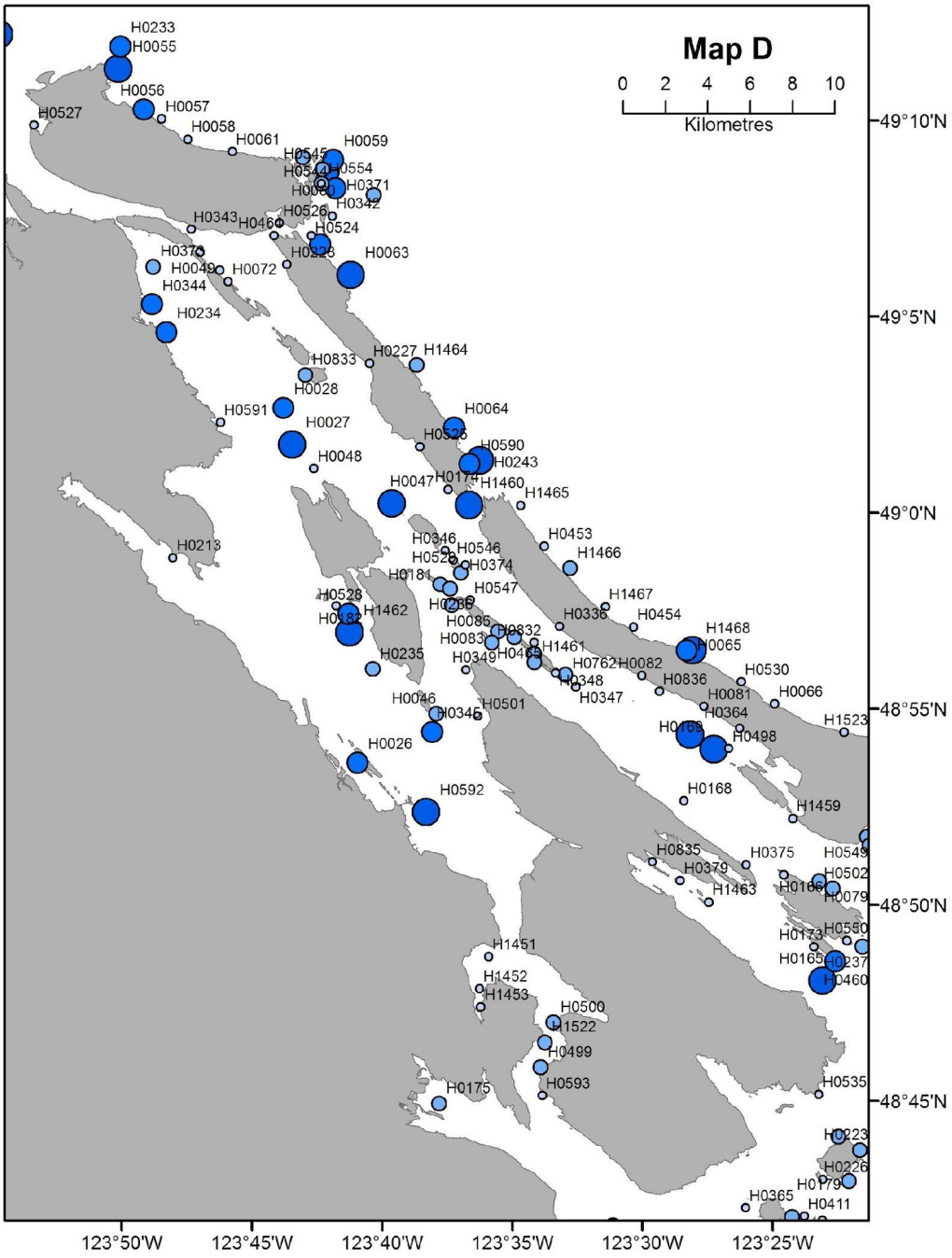

Figure B5. Map D – Central Gulf Islands. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

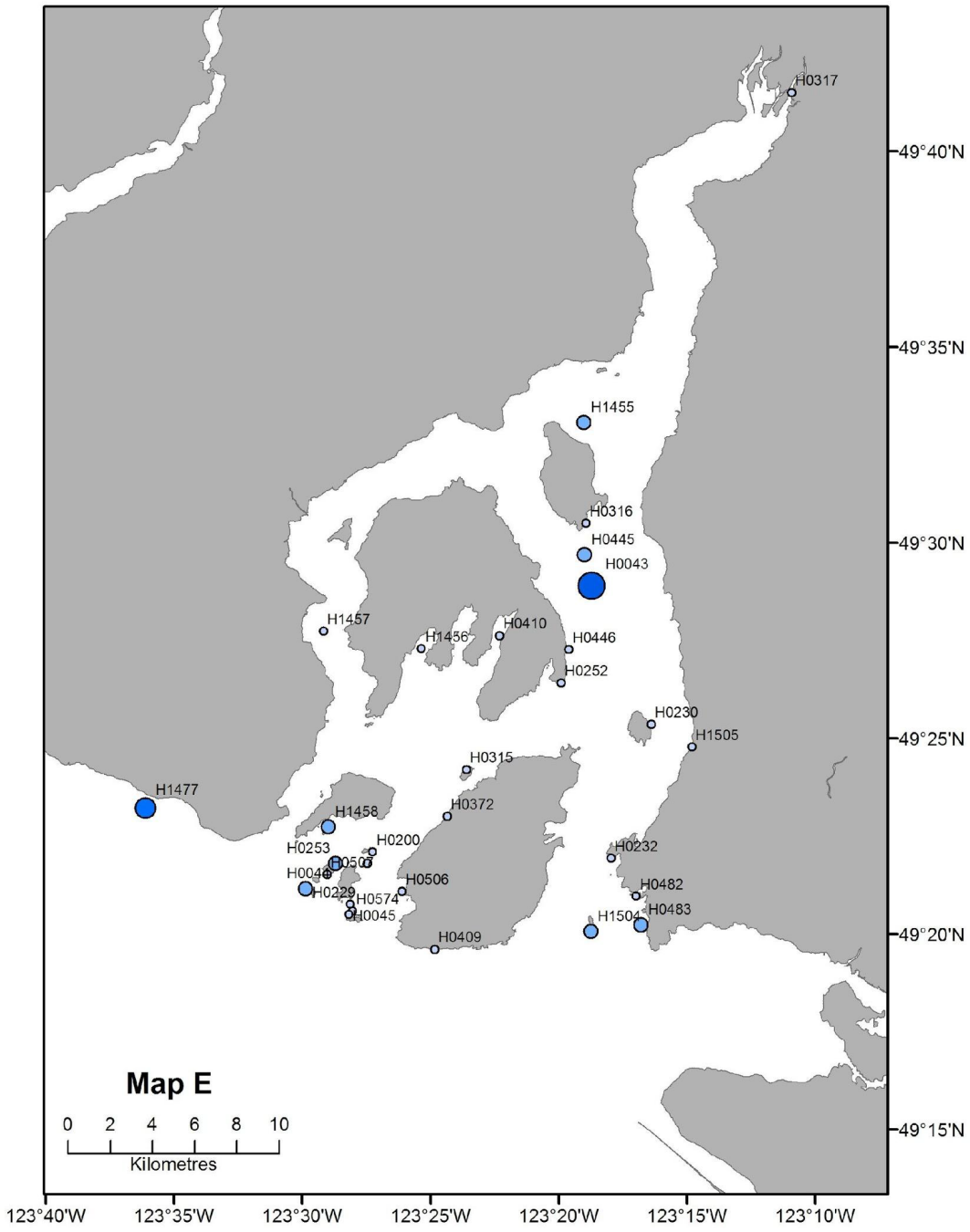

Figure B6. Map E – Howe Sound. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

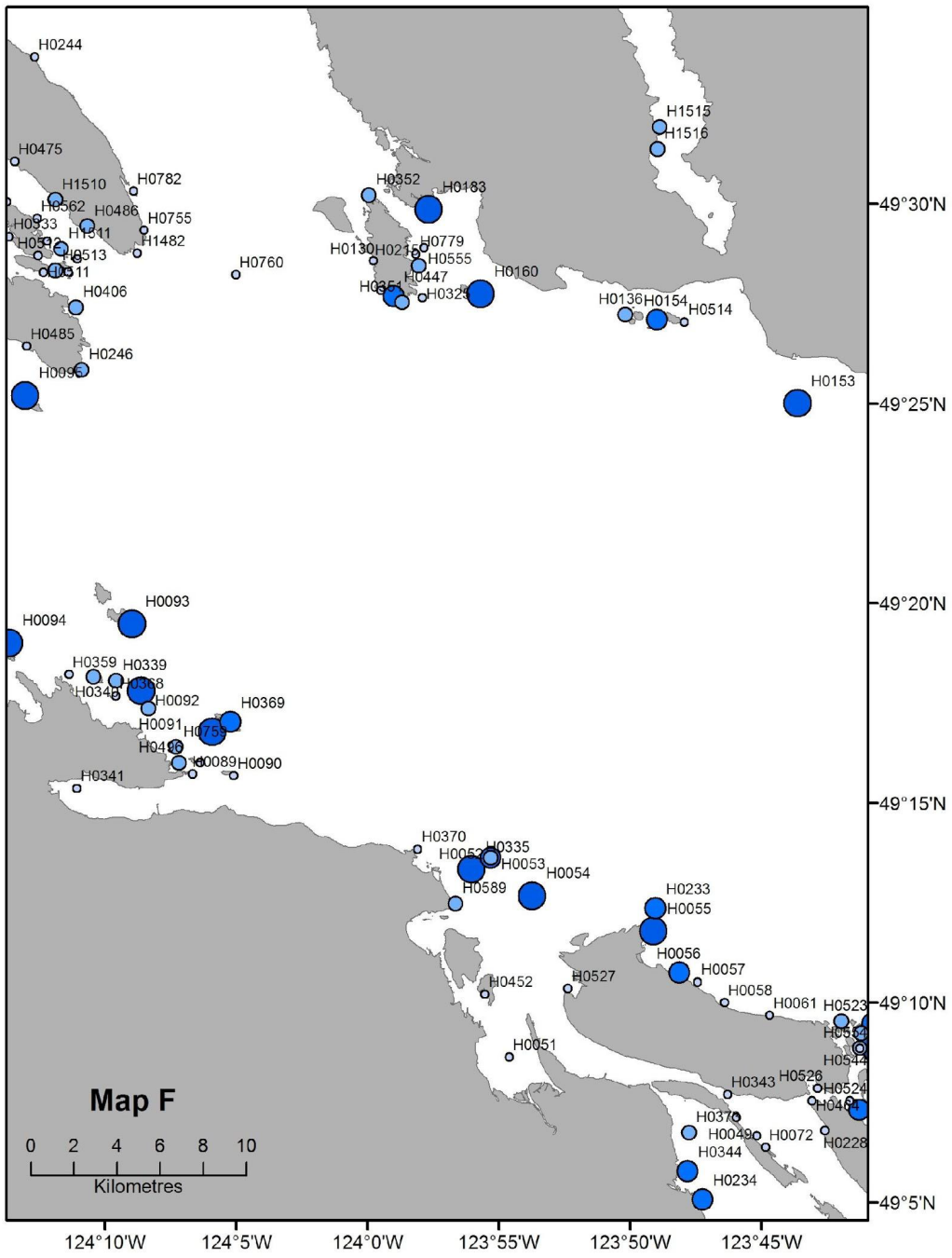

Figure B7. Map F – Northern Gulf Island-Nanaimo. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

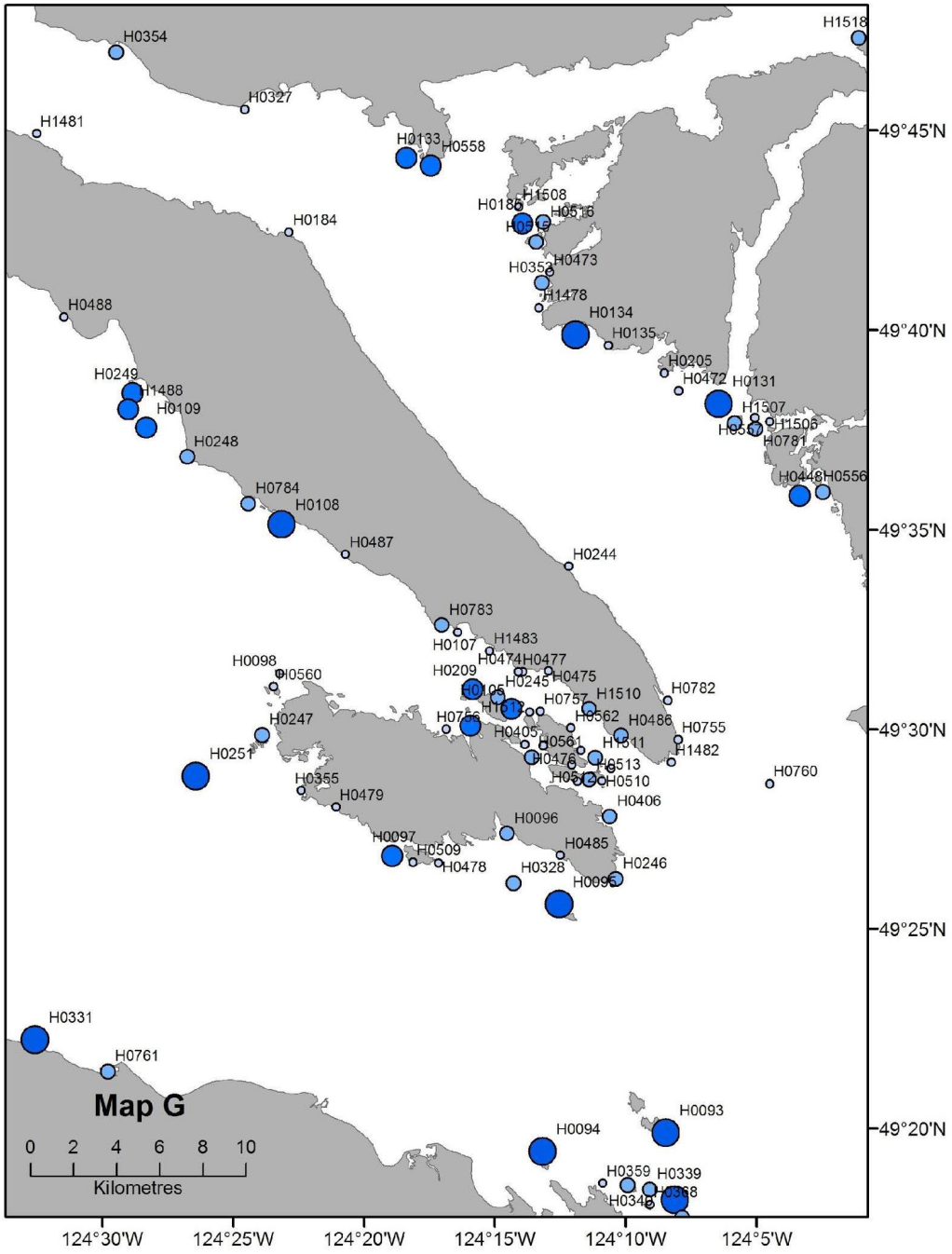

Figure B8. Map G – Central Strait of Georgia-Texada Island. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

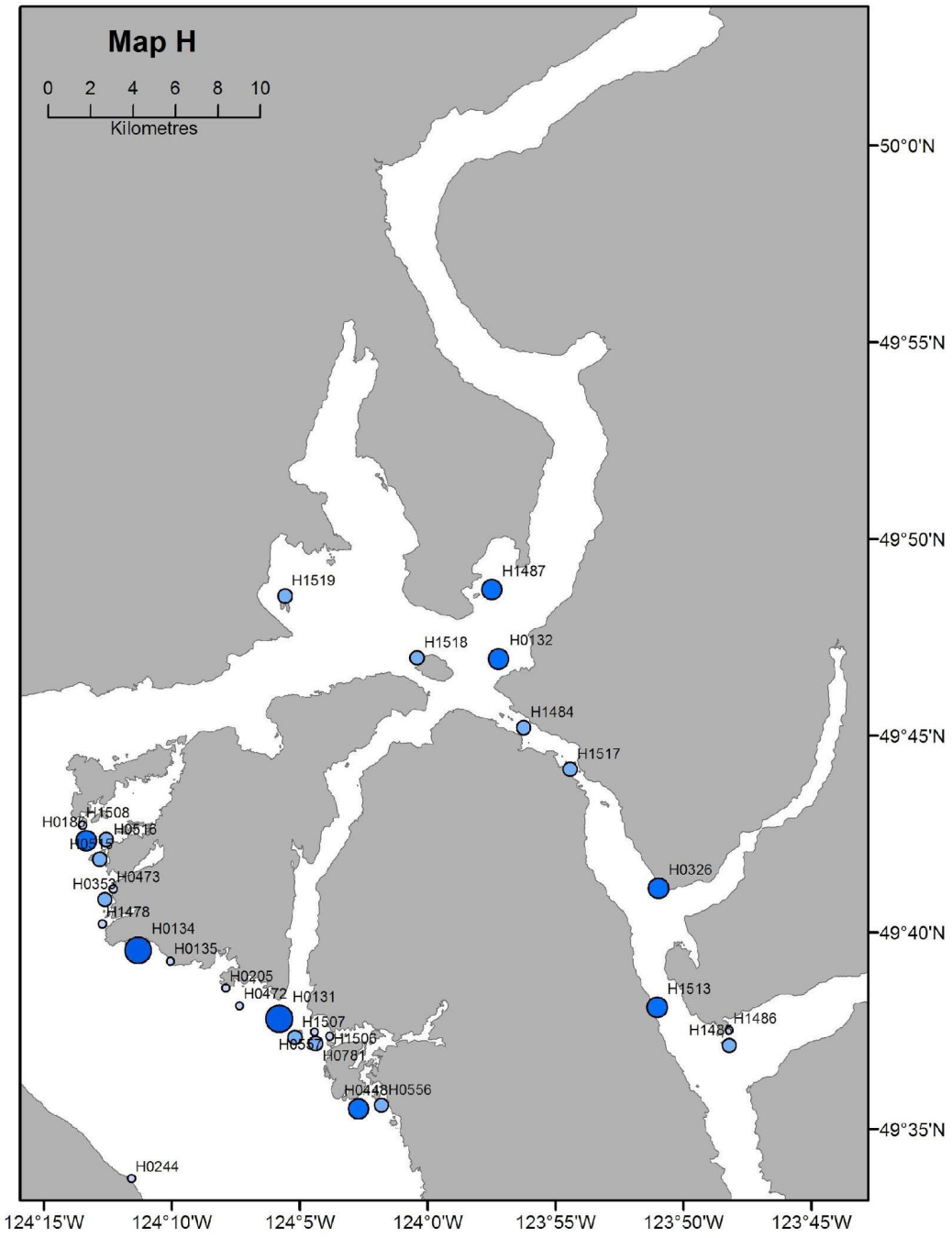

Figure B9. Map H – Malaspina Strait-Jervis Inlet. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

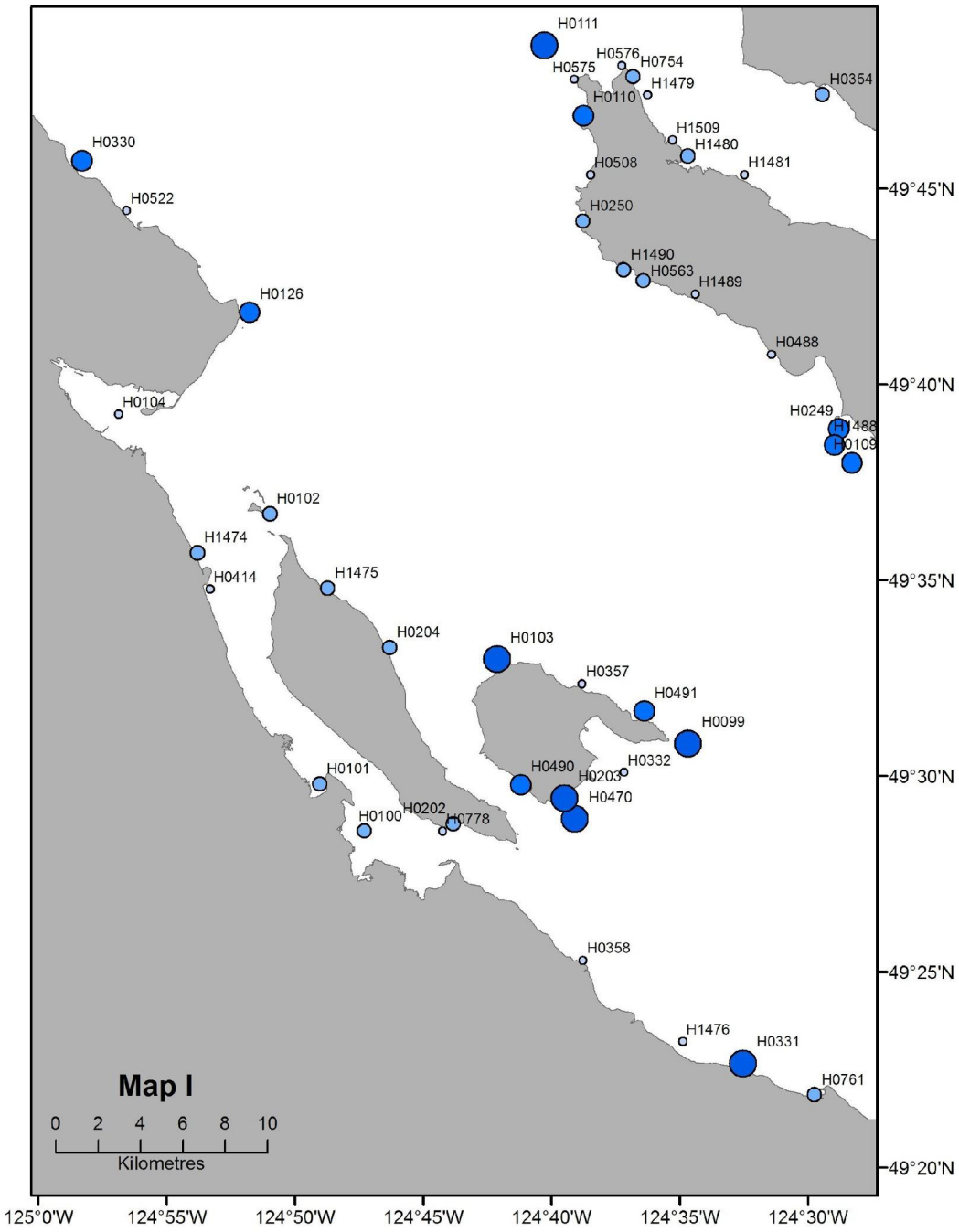

Figure B10. Map I – Denman, Hornby Northern Texada Islands. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

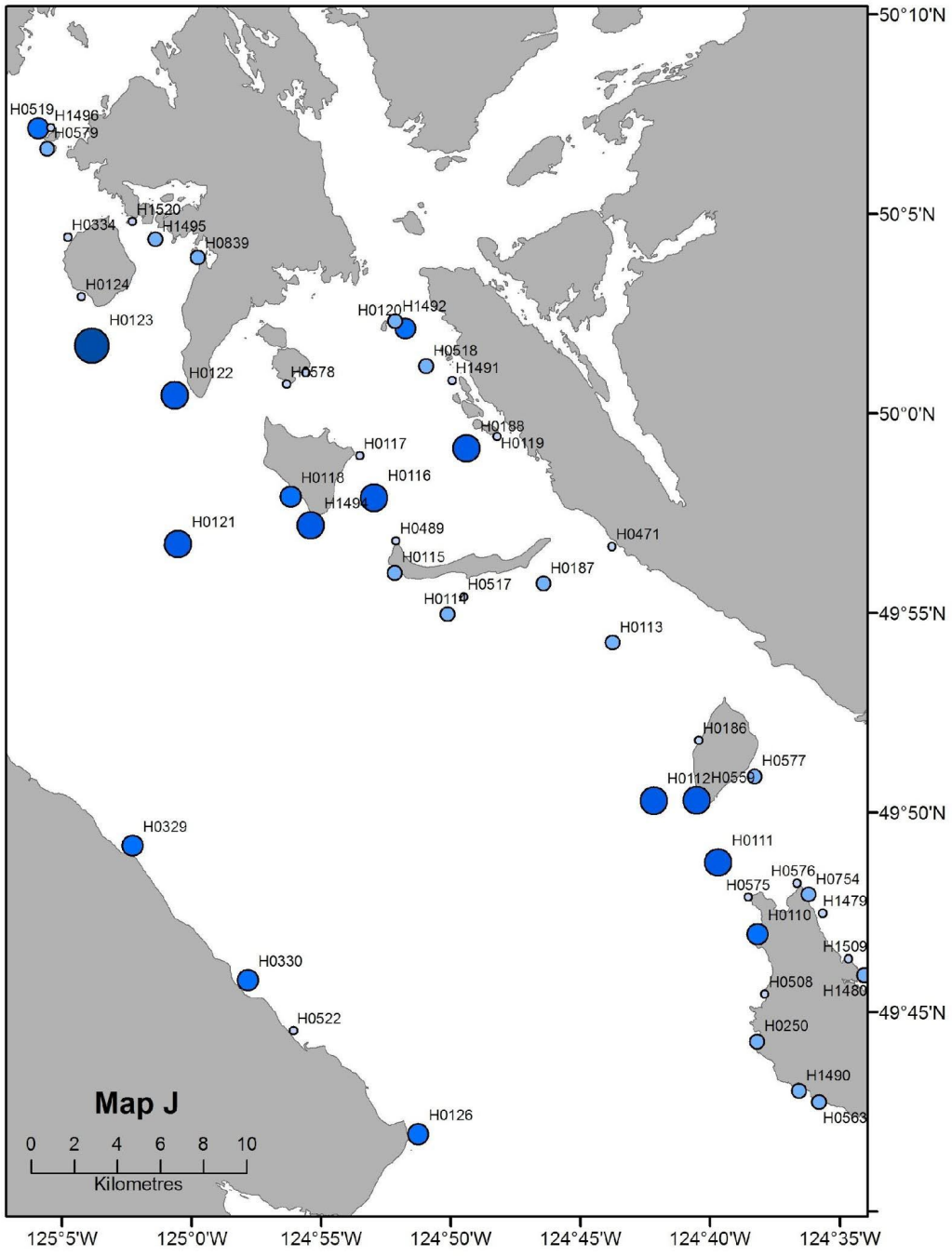

Figure B11. Map J – Northern Strait of Georgia. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).

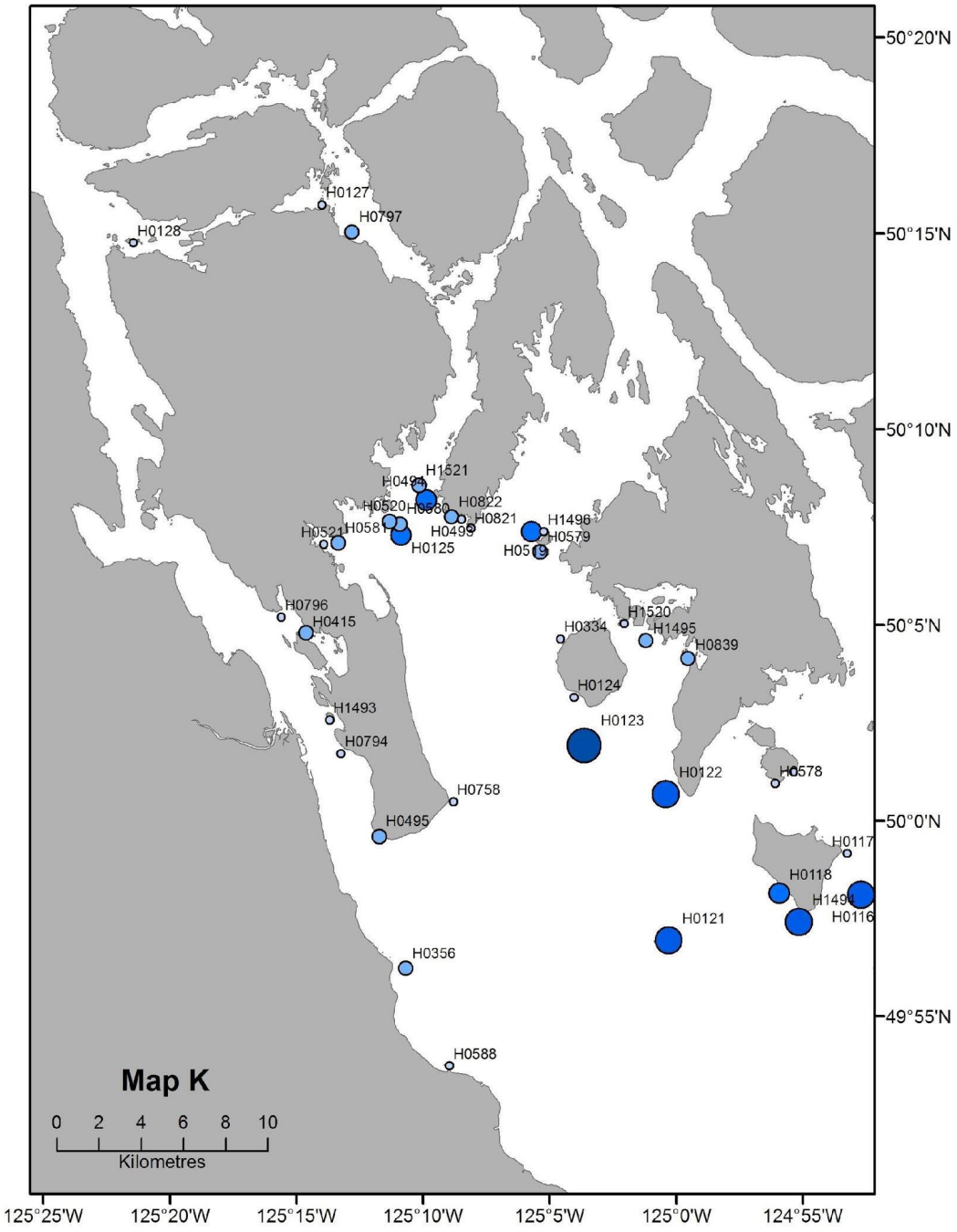

Figure B12. Map K – Quadra and Cortez Islands. Blue symbols are drawn proportional in size to the number of Harbour Seals counted at the site during the 2014 survey (see Legend in Figure B1).