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 2026/046

National Capital Region

Population Status Assessment and Potential Biological Removal (PBR) for the California Sea Lion (*Zalophus californianus*) in Canadian Pacific Waters, Based on 2020-2021 Winter Surveys

Sheena Majewski, Chad A. Nordstrom, Wendy Szaniszlo, Allison Bowker, M. Kurt Trzcinski and Strahan Tucker

Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC V9V 1T3

June 2026

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/
DFO.CSAS-SCAS.MPO@dfo-mpo.gc.ca

ISSN 1919-5044
ISBN 978-0-662-03997-6 Cat. No. Fs70-5/2026-046E-PDF

Correct citation for this publication:

Majewski, S., Nordstrom, C.A., Szaniszlo, W., Bowker, A., Trzcinski, M.K., and Tucker, S. 2026. Population Status Assessment and Potential Biological Removal (PBR) for the California Sea Lion (*Zalophus californianus*) in Canadian Pacific Waters, Based on 2020-2021 Winter Surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2026/046. iv + 33 p.

Aussi disponible en français :

*Majewski, S., Nordstrom, C.A., Szaniszlo, W., Bowker, A., Trzcinski, M. K., et Tucker, S. 2026. Évaluation de l'état de la population et prélèvement biologique potentiel (PBP) pour l'otarie de Californie (*Zalophus californianus*) dans les eaux canadiennes du Pacifique, d'après les relevés de l'hiver 2020-2021. Secr. can. des avis sci. du MPO. Doc. de rech. 2025/046. iv + 35 p.*

TABLE OF CONTENTS

ABSTRACT

Monthly aerial surveys were conducted during the winter of 2020 – 21 to assess abundance and distribution of California Sea Lions *(Zalophus californianus)* overwintering in British Columbia (BC). Between 5,387 and 6,158 California Sea Lions were counted during five winter surveys conducted from November to March 2020 – 21. The total population size overwintering in BC waters was estimated by applying monthly species-specific correction factors to counts of animals hauled out on land to account for animals that were at sea and missed during surveys. Monthly abundance estimates ranged from 12,839 – 14,559 and the mean total abundance estimate for California Sea Lions overwintering in Canadian Pacific waters in 2020 – 21 was 13,575 (95% Confidence Interval (CI): 11,284 – 16,331). This represents a three-fold increase in abundance estimated from surveys flown in winter 2009 – 10 and an approximately 13% increase since 2017. The Potential Biological Removal for California Sea Lions overwintering in Canadian Pacific waters, based on the average estimated abundance in winter 2020 – 21 and adjusted for the proportion of time spent in BC, was 433 individuals.

INTRODUCTION

Since recovery from commercial harvest and predator control measures, following protections implemented under the Marine Mammal Protection Act (MMPA) in 1975, the US population of California Sea Lions (*Zalophus californianus*) has stabilized around carrying capacity in recent years and was last estimated to be 257,606 in 2014 (Laake et al 2018, Lowry et al 2017, Caretta et al 2021). The annual Potential Biological Removal (PBR) for the population was estimated to be 14,011 sea lions per year.

The genetically distinct US/Pacific temperate population of California Sea Lions (CSL) breeds at rookery sites in southern California and the Coronados Islands (Mexico) during May-June, after which subadult and adult males typically migrate northward to Oregon, Washington, and British Columbia (BC) with some sightings in southern Alaska over the fall and winter (Schramm et al 2009, Wright et al 2010; Maniscalco et al, 2004; Melin et al 2000).

Animals typically start arriving in BC waters in August and leave in May (Gearin et al 2017; Edgell and Demarchi 2012), with large numbers observed by October (Figure 1). However, it remains unclear if the bulk of animals arrive all at once or in waves and whether the total abundance varies over the winter period. A small number of California Sea Lion males (n = 1 – 10) have been documented during summer sea lion surveys (at Race Rocks, Perez Rocks and most recently Seabird Rocks). Previous surveys throughout the range have shown considerable variability in their abundance and distribution throughout the fall and winter, likely linked to changes in prey availability over time and space (Bigg 1985; Melin et al 2012; Kuhn and Costa 2014). There is evidence that the proportion of the total population overwintering in BC has increased in recent years and that the range of overwintering haul-outs has expanded (Figure 1). These increases in abundance and range have raised questions over the past decade about potential impacts on local ecosystems, including competition for prey resources, and impacts on local fisheries (Costa et al 2007).

Observations from recent (2009 – 2017) coastwide fall and winter sea lion aerial surveys in BC (conducted at all known Steller Sea Lion *(Eumetopias jubatus)* and California Sea Lion haul-out sites as the species frequently co–occur) confirm that more California Sea Lions are migrating to northern Vancouver Island (including the Scott Islands off the NW tip of Vancouver Island) during the fall and winter (Figure 1). The proportion of California Sea Lions occupying sites north of Vancouver Island ranged from 0 to 7% in fall and winter 2009 – 2017, representing only 1.4% of the total in the most recent BC coastwide survey in winter of 2017 (Figure 1). The surveys support satellite tagging data indicating that few California Sea Lions migrate north of the Scott islands, and fewer still make it as far north as southern Alaska (Gearin et al 2017). Maniscalco et al (2004) reported a total of 52 California Sea Lions in Alaska over a 30-year period, suggesting that for all practical purposes, California Sea Lions remain a species of the California current ecosystem (CCE) confined mostly to waters below northern Vancouver Island. In fact, California Sea Lions are considered an indicator species for the CCE, as various life-history parameters (reproductive success, pup growth, and pup mortality) are linked to both large and small-scale changes in ocean conditions within the ecosystem (Melin et al 2012).

There are distinctive oceanographic regions in the north Pacific with diverse physical and chemical oceanographic attributes, as well as different biological communities (Batten et al 2006; Batten and Freeland 2007; Hickey and Banas 2008). The eastward flowing Sub-Arctic Current bifurcates as it approaches the North American coast into the equator-ward flowing California Current System (CCS) and the pole-ward flowing Alaskan Coastal Current (ACC: Wells et al 2008). The North American Pacific coast can consequently be divided into three general oceanographic regions; an upwelling zone south of northern Vancouver Island within the CCS, a downwelling zone north of Vancouver Island within the ACC, and a transition zone between the two (Wells et al 2008). Oceanographic differences, as well as differences in phytoplankton and zooplankton communities (Mackas et al 2004) are paralleled by general differences in fish community composition and abundances (Orsi et al 2007). In terms of proportions of total catch, the CCS is dominated by clupeids such as Pacific sardines *(Sardinops sagax)*, northern anchovies *(Engraulis mordax),* and Pacific herring *(Clupea pallasi)*, while the ACC is dominated by juvenile salmonids with a distinct breakpoint in species assemblages off Vancouver Island (Orsi et al 2007). These broader oceanographic regions can provide a useful framework for interpreting general patterns in abundance and distribution for a species such as California Sea Lions, whose movements are strongly influenced by prey availability (Robinson et al 2018, Brown et al 2020).

While correction factors (CFs) to account for swimming animals not counted during standardized aerial surveys have been developed for Steller Sea Lions tagged in Canada (Olesiuk 2018), CFs for periods outside of the breeding season were developed for California Sea Lions tagged in Washington State (DeLong et al 2017a). As sea lions in Pacific waters undergo moulting from August through November (Daniel 2003), it has not been possible to derive survey CFs for this time period using biologging instruments that are typically attached to the animal's pelage. Satellite tags successfully deployed on animals post-moult in nearby Puget Sound, WA provided detailed wet-dry data from which monthly survey CFs were derived for December through March (DeLong et al 2017a). All tagged animals were male CSL that had migrated from, and subsequently returned to, breeding colonies in the south. Puget Sound forms the most southerly part of the Salish Sea and is contiguous with southern survey areas in BC.

The objective of this study is to provide updated information on the abundance and distribution of California Sea Lions overwintering in Canadian Pacific waters and to estimate Potential Biological Removal (PBR), as required under the US Marine Mammal Protection Act (MMPA) bycatch provisions. We report on results of a series of five monthly California Sea Lion surveys of southern BC conducted from November through March 2020 – 21. The surveys are restricted to the winter period for which survey correction factors were available (DeLong et al 2017a) and to the haul-out sites south of northern Vancouver Island where previous survey data suggested that most (≥ 93%) animals overwinter (Figure 1). The surveys are flown in series to estimate monthly variability in count numbers and to track shifts in distribution of California Sea Lions through the winter. Total winter abundance for the population is estimated by applying the available correction factors derived from satellite telemetry data to account for animals that are at sea and missed during surveys. PBR is calculated for the portion of the population present in Canadian Pacific waters outside of the breeding season.

METHODS

SURVEY DESIGN

A series of five standardized aerial surveys of southern British Columbia (BC) sea lion haul-outs were conducted every month from November through March 2020 – 21. The southern BC/Vancouver Island survey area was divided into three regions to coincide with major oceanographic divisions: Pacific (PAC) includes haul-outs along the West Coast of Vancouver Island north of Port Renfrew to the Scott Islands, Salish Sea (SS) includes haul-outs throughout the Strait of Georgia and Juan de Fuca Strait; and Queen Charlotte Strait (QCS) includes haul-outs in Queen Charlotte and Johnstone Straits (Figure 2). The purpose of this division was to facilitate a broad overview of the distribution of animals in BC waters over the winter. These regions are also unique oceanographic regions supporting distinct biological communities and facilitate an understanding of ecosystem-level processes (Rubidge et al 2016).

A core list of survey locations was generated to include all sites where sea lions (both California and Steller Sea Lions) had been observed to haul out on land during DFO Steller Sea Lion surveys of southern BC since 2009 (Figure 1). Emerging winter haul-outs observed by local experts were also added to the core list, as were haul-outs observed during Pacific Harbour Seal surveys of the entire BC coast flown between 2015-19. Data from these surveys produced a total of 77 sea lion haul-out sites (16 in Queen Charlotte Strait, 30 in Salish Sea and 31 in Pacific region).

Survey methods remained consistent with those described in previous reports (Olesiuk 2018, Majewski et al 2024) to facilitate comparison with previous sea lion surveys. Surveys were conducted under standardized conditions between 10:00 and 18:00 local time when peak numbers were expected to be hauled out (Olesiuk 2018). While surveys were flown without consideration of tide height, temperature, or wind direction, they were not flown when there were high winds (> 25 kts) or heavy precipitation as these conditions have been shown to affect haul-out behaviour (Olesiuk 2018).

The comprehensive list of survey locations/haul-outs were uploaded to a GPS-enabled iPad tablet configured with marine chart software (Garmin and iNavX) where cumulative track lines and any new haulout observations were recorded. Detailed track lines (1s interval) were also recorded using a standalone BadElf GPS. All known/pre-identified haul-out sites were surveyed during the monthly winter 2020 – 21 surveys, as permitted by logistical constraints and weather conditions. Additionally, the shoreline was scanned opportunistically between sites, and potential haul-out areas (including sites where swimming animals had been previously documented) were examined for additional haul-outs whenever possible.

The 2020 – 21 aerial surveys were conducted by 1 – 2 observers from a *Cessna* 180 floatplane flown at an altitude of ~180-250 meters and airspeed of ~150 $km \cdot hr^{-1}$. Sites were circled and sea lions photographed from directly overhead (vertically) through an open window with a handheld 21 Megapixel Nikon D6 digital SLR camera equipped with a 70 – 200 mm (VRII f2.8) lens. Overviews of sites were taken with a second handheld digital SLR camera equipped with a wide angle 12 – 24 mm (VRII f2.8) lens to aid in reconstruction of complex sites where required.

COUNTS AND ERROR ESTIMATION

Photographs were sorted/geotagged to survey tracklines then counted on 5K monitors in Adobe Photoshop using the built in Count tool, with custom scripts to count and tally animals. California Sea Lions were differentiated from Steller Sea Lions and elephant seals by the image readers. The brush tool in Photoshop was used to mark areas of overlap between photos (using individual animals and physical landmarks to delineate boundaries). Overview photos were used where possible to piece together the sites, ensuring that all groups were counted without duplication, and individual animals were not missed. Counts were done by two readers, including the reader who did the fall and winter 2016 – 17 counts. Variability associated with the counts themselves (including total numbers of sea lions counted and differences in species identification at mixed haul-outs of Steller and California Sea Lions) was assessed by comparing independent counts of 104 (out of a total of 566) images representing a variety of haul-out types, photo qualities and sea lion densities.

All pre-identified survey sites were covered during 2020 – 21 surveys. However, a few sites were missed in a given month; these were typically sites where few animals had been recorded in the past (an observation which persisted during this study). We imputed the number of animals at these sites (a total of 8 occurrences) by calculating the average count at the same location from the other months, which resulted in the addition of 7.74 animals.

ABUNDANCE ESTIMATION

The raw counts from the aerial surveys cannot be used to represent a total population abundance estimate as they do not account for animals at sea during surveys (and therefore not available to be counted). An estimate of abundance was therefore calculated by applying survey correction factors (CFs) to counts of animals hauled out on land. Monthly survey correction factors used for this study were based on winter haul-out patterns derived from satellite tagged animals in the Puget Sound, WA from December through March (see DeLong et al 2017a for detailed description of correction factors and associated CV).

In summary, haul-out patterns were determined from satellite tags deployed on 26 adult male California Sea Lions in 2014 – 16 (Table 1; DeLong et al 2017a). Animals in the study area at that time were still moulting in November (a noted anomaly) therefore first deployments were delayed until December. Subsequently, the December correction factor was applied to the November counts for this study as haul-out behaviour was expected to be similar for both months.

Monthly specific CFs were applied to winter 2020 – 2021 survey counts of California Sea Lions hauled out on land (Table 1). While the CFs are generally consistent across months (range 2.08 – 2.70, average 2.33), we opted to apply monthly-specific values as they may reflect predictable variation in behavior coupled to changes in resource exploitation over the winter months. For example, California Sea Lions consistently shift from a diet dominated by chum salmon in late fall to a predominantly herring diet during late winter/early spring (DFO unpublished).

Monthly estimates of abundance (N) are estimated through adjustments for missed animals:

$$(1)\ \mathrm{N} = \mathrm{C} * \mathrm{cf}$$

where C = count adjusted for any missed sites (as above), cf = haul-out correction factor = 1/proportion of time animals are hauled out (P).

The uncertainty in the estimate of abundance (N) is composed of three parts: the variance due to counting error, the binomial variance from P, and the uncertainty around the mean value of P. First, we assume a normally distributed error $\varepsilon \sim N(\mu = 0, {\sigma_r}^2)$ is added to the log of each count. Therefore, the counts are adjusted by a log-normally distributed multiplicative error (allowing for the error to become larger with larger numbers of sea lions to count):

$$(2)\ \hat{N} = \frac{C}{P} \times \varepsilon \text{ with } \varepsilon \sim logN(\mu = 0, {\sigma_r}^2)$$

With mean $M = e^{\mu + {\sigma_r}^2/2}$ and variance $V = (e^{{\sigma_r}^2} - 1)e^{2\mu + {\sigma_r}^2}$

To estimate ${\sigma_r}^2$, we used the difference between the counts made by the two readers, which itself can be assumed to follow a normal distribution with ${SD_{diff}}^2 = 2{\sigma_r}^2$. Therefore, we estimate ${\sigma_r}^2 = {SD_{diff}}^2/2$ from the observed residuals between the dual counts and a 1:1 line.

Second, we assume the number of individuals available to be counted at any given time follows a binomial distribution, which has mean NP and variance NP(1-P). Third, as there is uncertainty around the value of the haul-out proportion, P becomes a random variable with a normally distributed error (SD_P) around its point estimate $\hat{P}$. $\hat{P}$ and $var(\hat{P}) = {SD_P}^2$ were estimated from an independent telemetry study (DeLong et al 2017a; Table 1). Here, SD_P is the standard deviation of the estimator (i.e., the standard error of the mean), which accounts for the number of individual animals tagged in each month and reflects that certainty around the mean proportion increases as the sample size increases.

With uncertainty around P, the estimator of abundance becomes $\widehat{N} = C/\hat{P}$, which does not change its point estimate. To calculate the total variance, we follow Thompson and Seber (1994) and use the delta-method approximation. The full variance becomes:

$$(3)\ var(\widehat{N}) \cong \widehat{N}^2 \frac{V}{M^2} + \widehat{N}\frac{1-\hat{P}}{\hat{P}} + \frac{\widehat{N}^2}{\hat{P}^2} var(\hat{P})$$

$\widehat{N}$, $var(\hat{P})$ and $var(\widehat{N})$ were calculated for each of the monthly surveys, which accounts for the variation in P among months. Confidence Intervals (CIs) were calculated from the CV assuming a lognormal distribution for $\widehat{N}$.

To provide a single estimate of abundance for the 2020 – 21 survey, the monthly abundance estimates were averaged; an overall mean estimate of abundance and associated variance are reported.

Since nearly all sites covered in winter in 2020 – 21 were flown in winters 2009 – 10 (Dec/Jan) and 2017 (Jan/Feb), we considered the recent surveys to be comparable. We estimated abundance for these years as above. However, since the 2009 – 10 survey was completed by flying different areas in December and January (with some overlap), counts from the 2009 – 10 surveys were averaged if the same site was surveyed more than once, and then all areas were compiled to calculate the BC coastwide 2009 – 10 count and abundance estimate. The 2020 – 21 average value was used to compare with 2017 and 2009 – 10.

POTENTIAL BIOLOGICAL REMOVAL (PBR)

Guidelines have been developed to evaluate whether a stock lends itself to a Data Rich or a Data Poor framework within the context of applying the Precautionary Approach (DFO 2018). For the purpose of this study the population was considered to be data poor given the limited recent survey data for California Sea Lions overwintering in BC waters and a PBR approach was selected (DFO 2018). The Potential Biological Removal (PBR), was therefore calculated as:

$$(1)\ PBR = 0.5 \cdot R_{max} \cdot f \cdot N_{min}$$

where R_{max} is the maximum rate of population increase and was set to the default of 12% for pinnipeds (Wade and Angliss 1997, NMFS 2016), *f* is a recovery factor and was set to 1 (DFO 2018) and N_{min} is the estimated population size using the $20^{\text{-percentile}}$ of the log-normal distribution of the most recent population estimate (Wade 1998).

Since California Sea Lions are a transboundary population, the total annual PBR for the proportion of the population overwintering in BC was adjusted for the estimated proportion of the year spent in Canadian Pacific waters (Wade and Angliss 1997; Gavrilchuk and Doniol-Valcroze 2021). While California Sea Lions start to arrive in August and leave by May, an average residency of 7 months (from October to the end of April) was used to represent the period during which the majority of the animals remain in BC (Gearin et al 2017). In the absence of explicit current data regarding residency time for California Sea Lions in BC, we considered this a precautionary and conservative estimate of residency. The proportion of the year used was therefore 57.55% (or 210 out of 365 days).

For comparison, a second estimate of PBR was calculated by adjusting the published annual PBR of 14,011 for the US breeding season population as assessed in the US (Caretta et al 2021) and the proportion of the population overwintering in BC (i.e., mean N as estimated here divided by US stock total of 257,606) and time spent in Canadian Pacific waters (7 months).

RESULTS

SURVEY COVERAGE AND DISTRIBUTION

Surveys were completed in three days, with the exception of February which was flown over four days. All previously documented sea lion haul-outs were surveyed in 2020 – 2021 (Figure 3). A total of two new sites were added where animals were found hauled out where previously only swimmers were documented. No other additional sites were discovered.

While on average 51% of animals were found in the Salish sea region, 48.6% in the Pacific region and 0.4% in the Queen Charlotte Strait region, there was redistribution of animals among sites and regions throughout the winter months (Figure 4). Animals appear to have concentrated over the winter with large aggregations at Perez Rocks on the west coast of Vancouver Island and log boom sites in the Strait of Georgia in March. For example, the overall proportion of sea lions using the top five populated sites increased progressively from 62% in November (3,735 of 6,034), to 74% in January (4,006 of 5,387), and to 83% in March (5,114 of 6,158).

COUNTS AND ESTIMATED ABUNDANCE

Between 5,387 and 6,158 California Sea Lions were counted each month during the winter surveys from November to March (Table 2). There was some variation in counts from month to month, particularly between the Pacific and Salish Sea sub-regions, but the total counts were quite stable with a maximum of 12.5% difference between months.

Log-transformed counts of California Sea Lions between readers were found to be highly correlated, with an R^2 of 0.997 (Figure 5). The largest discrepancies between counts resulted from differences in species identification and ability to distinguish between individuals in large concentrated aggregations at one particular site. The CV for the counting error was 0.16, the CV for the binomial distribution for each month ranged from 0.0091 – 0.011, and the CV for the uncertainty around the mean proportion hauled out for each month ranged from 0.073 – 0.110.

The range of adjusted monthly 2020-21 winter population estimates was 12,829 – 14,559 and the average total abundance of California Sea Lions estimated to be overwintering in BC in 2020 – 21 was 13,575 (95% CI 11,284 – 16,874) (Table 3, Figure 6). The CV of abundance for each survey month during 2020-21 ranged from 0.175 – 0.194.

From a previously completed survey in late January-early February 2017, 4,701 California Sea Lions were counted on land for an estimated abundance of 11,783 (95% CI 9,897 – 14,029). In a compilation of partial winter surveys conducted from January 2009 through January 2010, a total of 1,685 California Sea Lions were counted on land for an estimated abundance of 4,179 (95% CI 3,567 – 4,896) (Figure 7).

POTENTIAL BIOLOGICAL REMOVAL (PBR)

N_{MIN} was calculated from the average estimated abundance in BC waters and its associated average variance and was found to be 12,539. Using a recovery factor of 1.0 and the default R_{MAX} of 12%, the annual PBR for the population of California Sea Lions overwintering in BC is estimated as 752. Adjusting this annual number for the proportion of the year spent in BC (estimated average residency time of 210 days), PBR for California Sea Lions in Canadian Pacific waters is 433 individuals.

The second estimate of PBR, calculated by adjusting the published annual PBR of 14,011 for the US breeding season population (Caretta et al 2021) for time spent in Canadian Pacific waters and the proportion of the population overwintering in BC is 425 individuals.

DISCUSSION

SURVEY COVERAGE AND DISTRIBUTION

Previous winter surveys in BC and US waters suggested that high variability in local distribution and abundance over the winter months could be a significant consideration in determining total abundance for the overwintering population (Figure 1, DeLong et al 2017a; Lowry et al 2017). A series of monthly winter surveys were therefore flown to support abundance estimates and capture the potential flux of animals both in and out of BC waters. Telemetry derived survey correction factors were not available for the fall period due to the moulting period thereby limiting the value of fall surveys for population estimation. Consequently, we did not initiate a survey during the fall of 2020. The geographic scope of the survey was restricted to southern BC based on weight of evidence from previous sea lion surveys in BC and published reports in Alaska; few animals (0 to 7% in previous surveys) in BC have been observed north of Vancouver Island.

Although shoreline coverage was incomplete during sea lion surveys in 2009 – 2017, the entire shoreline and all possible haul-out locations were searched during Pacific Harbour Seal surveys, which cover ~90% of the coastline (Majewski and Ellis 2022, DFO 2022, Tucker et al In press). New observed sea lion haul-out sites are noted and checked on subsequent sea lion surveys and local experts (including observers during aerial herring spawning and creel surveys) are consulted prior to (and during) surveys to include emerging or transient haul-outs. Previous survey data and movement studies suggest that haul-out behaviour appears to be largely habitual with animals using the same sites over time, often in association with more frequently surveyed Steller Sea Lions (Gearin et al 2017).

California Sea Lions overwintering in BC are roughly divided between Pacific and Salish Sea Regions, with some redistribution between regions occurring throughout the winter months, and with a small number observed in Queen Charlotte Strait in recent years (Figures 6 and 7). In both of the main regions, animals appear to have become more aggregated at fewer sites over the winter period (Figure 4); this behavior appears to align with the main herring spawn locations in the Strait of Georgia and the west coast of Vancouver Island in late winter (DFO 2021). The appearance of animals in Queen Charlotte Strait region in December – February likely coincided with Chum salmon runs in the area.

California Sea Lions are more often associated with infrastructure such as docks, log booms, and shellfish aquaculture pens than Steller Sea Lions. Some of the changes in specific site-use over time in our study area appear to be related to changes in location/availability of infrastructure (e.g., Fanny Bay structure has been removed, location and size of log booms have changed at several sites).

ESTIMATED ABUNDANCE

There was little variation in monthly total abundance of California Sea Lions over the 2020 – 21 survey period, with the maximum abundance estimate occurring in January (14,559) and with other months within 4 – 12% of that total (Table 3, Figure 6). The relatively stable numbers across surveyed months suggests that most animals had arrived in Canadian Pacific waters by November and stayed through at least March. Based on the satellite tagging in neighboring Washington State, more than half the males instrumented in December initiated movements out of the US inland waters in January. They transited south to Oregon or north to BC (27% of animals), or spent periods of time offshore, suggesting that mid-winter shifts across federal and state boundaries still occur on a small scale but that such minor influxes appear to stabilize by the end of January (DeLong et al 2017a). The US tagging data therefore represents a range of foraging behaviors across relevant habitat types encountered within our study area (i.e., inland Salish Sea, exposed north Pacific), and consequently, we consider their use directly applicable to our study.

Monthly correction factor values used for this study ranged from 2.08 – 2.70 with an average of 2.3 (Table 1 from Delong et al 2017a). It is notable that the highest CF of 2.70 (January) was associated with the lowest monthly count and when tagging data suggests more animals may be transiting longer distances between haul-outs, indicating the elevated CF may be correctly accounting for a short-term change in winter behaviour when fewer animals are ashore to be surveyed. It is also interesting that the average monthly CF (2.30) used for this study was similar to the CF of 2.43 developed for Steller Sea Lions by Olesiuk (2018) based on the estimated proportion of Steller Sea Lions hauled out between 10:00 – 18:00 during winter surveys. This suggests that winter haul-out behavior may be similar for the two species and that the standardized winter Steller Sea Lion surveys could also support estimates of California Sea Lions in Canadian Pacific waters, as all known sea lion haul-outs were surveyed.

Inter-counter error was found to be low, i.e., error associated with the counts themselves related to differences in total number of sea lions counted or potential error in distinguishing species at mixed haul-outs of Steller and California Sea Lions during winter surveys (Figure 5). The largest contributor to the inter-counter error was species identification in photos with low densities of sea lions. There is also uncertainty in exactly how inter-counter error should be estimated, whether at the scale of a photo (as done in this report), or at a slightly larger scale of a haulout site, which may require multiple photos for complete coverage.

It is possible that animals were missed during surveys as sea lions are highly mobile, and distribution is strongly linked to availability of key prey species (including herring, salmon, and eulachon), in turn driven by climate and ocean conditions and very dynamic through time and space (Robinson et al 2018, Weise and Harvey 2008, Lowry et al 2017). Further deployments of satellite tags to track movements of animals could reveal important wintering areas that are not currently being surveyed. Ongoing consultation with local observers throughout the coast is also recommended.

RECENT TRENDS

California Sea Lions (primarily subadult and adult males) began to appear regularly off southern Vancouver Island in the 1960's and were counted during standardized DFO aerial sea lion surveys starting in the early 1970's. Counts from these surveys increased from less than 500 animals in the early 1970's to over 4,500 in the mid-1980's (Bigg 1985). While the species continued to expand its range northward, counts of California Sea Lions declined from an average of ~2,600 animals in the 1980s to ~1,600 in the 2000s, with most of the declines occurring along the southwest coast of Vancouver Island (Olesiuk In prep)[1]. Counts remained low until unusually large numbers of California Sea Lions were observed during fall sea lion surveys along the southwest coast of Vancouver Island in 2008 (~ 3000 animals) and 2012 (nearly 10, 000 animals) (Figure 1; Olesiuk In prep)[2]. The reasons for this sudden increase remain unclear but could be due to possible shifts in food availability due to changes in oceanographic processes (warming sea surface temperatures and corresponding decreases in

---

[1] Olesiuk, P.F. In prep. Status of sea lions *(Eumetopias jubatus* and *Zalophus californianus)* wintering off southern Vancouver Island. Unpublished NMMPRC Working Paper.

[2] Olesiuk, P.F. In prep. Status of sea lions *(Eumetopias jubatus* and *Zalophus californianus)* wintering in British Columbia. Unpublished NMMPRC Working Paper.

availability of key prey species in the southern part of their range). For example, Northern anchovy and Pacific sardines declined substantially in CCS waters in 2008 – 2009 and remained low until recently (California Current IEA Indicators | Integrated Ecosystem Assessment (noaa.gov). In addition, there may have been confounding density dependent processes in US waters associated with the breeding population reaching carrying capacity in 2008 (Laake et al 2018), driving more males to seek foraging opportunities to the north.

The results of this study confirm that both abundance and distribution of California Sea Lions in Canadian Pacific waters have increased significantly since 2009 – 10. The average estimated abundance of 13,575 from the 2020 – 21 winter surveys represents a three-fold increase compared to winter 2009 – 10. We recognize that the 2009 – 10 survey may not be entirely comparable to subsequent surveys given it is a compilation of partial surveys conducted over two winters, but we remain confident in the approximate magnitude of increase observed between 2009 and 2020 – 21. Assuming that the US California Sea Lion population has remained stable since 2009 (Laake et al 2018), over 5.3% of the total population overwintered in Canadian waters in 2020 – 21 as compared to 4.6% in 2017 and 1.5% in 2009 – 10.

Total population size appears to have stabilized in recent years, but declines may be expected for the US stock due to decreased survival caused by impacts of changes in sea surface temperature on prey availability (DeLong et al 2017b). Unfortunately, the stock has not been assessed since 2014, but the increased proportion of males overwintering in Canadian Pacific waters could be related to changes in prey availability elsewhere in the range (Lowry et al 2022).

California Sea Lions are highly mobile, and animals range widely during the non-breeding season with distribution highly influenced by prey availability. They are a well-known generalist predator and have demonstrated a feeding plasticity over short (seasonal) and long (decadal) time spans in response to shifts in primary or preferred prey (Lowry et al 2022). The increasing numbers found in the Salish Sea during winter 2017 and 2021 relative to 2009 – 10 could therefore be driven by the increase in spawning biomass of the Strait of Georgia herring stock culminating in historic highs in recent years (Boldt et al 2022).

It should be noted that there is greater uncertainty in sea lion abundance estimates for winter (vs summer breeding season) because animals are more mobile, widely dispersed across sites, and larger correction factors are required to adjust for animals at sea and missed during surveys. There is uncertainty associated with applying the correction factors for animals captured in Washington in 2014 –16 to animals overwintering in BC in from 2009 – 2021 as behavior could be different between animals foraging in different locations and in different years.

California Sea Lions co-occur with Steller Sea Lions (whose Eastern population breeds at a wider range of rookery sites from California to Alaska) in BC waters. Significant dietary niche overlap has been documented between the two species in nearby Washington State (Scordino et al 2022; Trzcinski et al unpublished). Since California Sea Lions share many haul-out sites with Steller Sea Lions in southern BC and appear to have a similar winter diet consisting largely of herring and salmon (DFO unpublished), they represent a potentially significant interspecific competitor for space and prey resources, This study supports evidence of continued change in the winter distribution of California Sea Lions in Canadian Pacific waters, as well as a large increase in the numbers of males overwintering in the Salish Sea and Pacific regions.

The overall stability of counts and estimated abundance from November-March suggests that going forward, monthly surveys through the winter are not required. Going forward, a winter survey of the entire BC coast (ideally coupled with studies of California Sea Lion movement) is recommended to estimate overwintering abundance of California Sea Lions while capturing ongoing changes in distribution.

OVERWINTERING POPULATION PBR

Based on abundance estimates from winter 2020 – 21 surveys, adjusted for the proportion of time spent in BC, PBR for the portion of the California Sea Lions overwintering in Canadian Pacific waters in 2020 – 21 is 433 individuals. A recovery factor of 1.0 was determined to be most appropriate for this population due to its overall abundance, stability and the available time series and demographic data for the US population (DFO 2018; Laake et al 2018, Lowry et al 2017, Caretta et al 2022).

There is uncertainty regarding the current status and trends in the overall population, as the most recent breeding season assessment is based on data from 1975 – 2014. Some proportion of the US stock of California Sea Lions, specifically males, enter Canadian waters for a substantial portion of the year. PBR is intended to take into account all removals (e.g. aquaculture sites, bycatch, harvest etc.). An ideal approach for PBR in cases of transboundary populations would therefore be to have one total PBR and ensure the sum of removals across countries do not exceed that number. That is, the removals would be apportioned and not the PBR. However, we are not aware of any initiatives to consider and manage stocks of sea lions (both Steller and California) in a transboundary manner. Here we have essentially presented both: a BC PBR value based on the abundance of animals overwintering in Canada, and a 'unified' PBR where the NOAA PBR is apportioned based on the proportion of the total population found in Canada over the year. In this case, the two approaches to calculate PBR converged on similar values. However, since the PBR values presented here for Canadian waters refer to males only this represents a more conservative estimate of PBR.

There is also considerable uncertainty in the amount of time animals, specifically males, spend in Canadian waters. The residency time has a direct effect on the PBR estimate. There is a need to better document the arrival and departure of California Sea Lions to better parameterize the number of days the segment of the transboundary population spends in British Columbia, perhaps through expanded brand resighting or general haul-out monitoring and new satellite tagging studies.

It should be noted that the specific value for the unified PBR option, despite being calculated from a potentially more integrated and accountable approach, is severely disadvantaged at the present time given the stock has not been assessed since 2014. The value for PBR will change with updates to the stock status and current trend for the US population.

ACKNOWLEDGEMENTS

We are grateful to Dr. Michael Bigg and Peter Olesiuk for establishing the standardized sea lion surveys used for this assessment and to Steve Jeffries and Scott Pearson from WDFW for advice regarding survey design and correction factors. Thanks to Brian Gisborne, Brian Congdon, Jackie Hildering, Graeme Ellis and John Ford for reporting their invaluable sightings. Thanks to CEMAM and DFO Species at Risk Program, for providing funds to conduct surveys and subsequent analysis. And finally, these surveys wouldn't be the same without the dedication and knowledge of Louis Rouleau who keeps us safe flying in ever challenging conditions.

REFERENCES CITED

Batten, S. D., and Freeland, H. J. 2007. Plankton populations at the bifurcation of the North Pacific Current. Fish. Oceanogr. 16(6): 536–546.

Batten, S. D., David Hyrenbach, K., Sydeman, W. J., Morgan, K. H., Henry, M. F., Yen, P. P. Y., and Welch, D. W. 2006. Characterising meso-marine ecosystems of the North Pacific. Deep-Sea Research Part II: Topical Studies in Oceanography 53(3–4): 270–290.

Bigg, M.A. 1985. Status of the Steller Sea Lion (*Eumetopias jubatus*) and California Sea Lion (*Zalophus californianus*) in British Columbia. Can. Spec. Publ. Fish. Aquat. Sci. 77: 20 p.

Boldt, J.L., Joyce, E., Tucker, S., and Gauthier, S. (Eds.). 2022. State of the physical, biological and selected fishery resources of Pacific Canadian marine ecosystems in 2021. Can. Tech. Rep. Fish. Aquat. Sci. 3482: vii + 242 p.

Brown, R.F., Wright, B.E., Tennis, M.J., and Jeffries, S. 2020. California sea lion *(Zalophus californianus)* monitoring in the Lower Columbia River, 1997–2018. Northwest Nat. 101:92–103.

Carretta, J. V., Oleson, E. M., Forney, K. A., Muto, M. M., Weller, D. W., Lang, A. R., Baker, J., Hanson, B., Orr, A. J., Barlow, J., Moore, J. E. and Brownell Jr., R.L. 2022. US Pacific marine mammal stock assessments: 2021. US Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-663.

Costa, D. P., Kuhn, C., and Weise, M. 2007. Foraging Ecology of the California Sea Lion: Diet, Diving Behavior, Foraging Locations, and Predation Impacts on Fisheries Resources. CA Sea Grant Final Report.

Daniel, R.G. 2003. The timing of moulting in wild and captive Steller Sea Lions (*Eumetopias jubatus*). MSc. Thesis University of British Columbia.

Delong, R. L., Melin, S. R., Harris, J. D., Gearin, P., Orr, A. J., Laake, J. L., Jeffries, S., Lambourn, D., and Oliver, J. 2017a. Satellite Tag Tracking and Behavioral Monitoring of Male California Sea Lions in the Pacific Northwest to Assess Haul-out Behavior on Puget Sound Navy Facilities and Foraging Behavior in Marine Navy Testing and Training Areas. Final Report submitted to US Navy in support of 2017 Annual Pacific Marine Species Monitoring Report.

Delong R., Melin S., Laake J., Morris P., Orr A., and Harris, J. 2017b. Age and sex-specific survival of California Sea Lions (*Zalophus californianus*) at San Miguel Island, California. Mar. Mamm. Sci. 33:1097–1125.

DFO. 2018. Harvest advice for eastern and western Hudson Bay Beluga (*Delphinapterus leucas*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2018/008.

DFO. 2021. Stock status update with application of management procedures for Pacific Herring (*Clupea pallasii*) in British Columbia: Status in 2021 and forecast for 2022. DFO Can. Sci. Advis. Sec. Sci. Resp. 2021/039.

DFO. 2022. Stock Assessment of Pacific Pacific Harbour Seals (*Phoca vitulina richardsi*) in Canada in 2019. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2022/034.

Edgell, T. C., and Demarchi, M. W. 2012. California and Steller Sea Lion use of a major winter haulout in the Salish Sea over 45 years. Mar. Ecol. Prog. Ser. 467: 253–262.

Gavrilchuk, K. and Doniol-Valcroze, T. 2021. Recovery Potential Assessment for the Grey Whale (*Eschrichtius robustus*): Pacific Coast Feeding Group and Western Pacific Population in Canadian Waters. DFO Can. Sci. Advis. Sec. Res. Doc. 2021/020. iv+52 p.

Gearin, P. J., Melin, S. R., Delong, R. L., Gosho, M. E., and Jeffries, S. J. 2017. Migration patterns of adult male California Sea Lions (*Zalophus californianus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-346, 29 p.

Hickey, B. M., and Banas, N. S. 2008. Why is the northern end of the California Current System so productive? Oceanogr. 21(4): 90–107.

Kuhn, C.E. and Costa, D.P. 2014. Interannual variation in the at sea behavior of California Sea Lions (*Zalophus californianus*). Mar. Mamm. Sci. 30:1297−1319.

Laake, J.L., Lowry, M.S., Delong, R.L., Melin, S.R., and Carretta, J.V. 2018. Population growth and status of California Sea Lions. J. Wildl. Manage. 82:583–595.

Lowry, M.S., Melin, S.R., and Laake, J.L. 2017. Breeding season distribution and population growth of California Sea Lions, *Zalophus californianus*, in the United States during 1964−2014. NOAA Tech Mem NOAA-TM-NMFS-SWFSC-574.

Lowry, M.S., Nehasil, S.E., and Moore, J.E. 2022. Spatio-temporal diet variability of the California Sea Lion *Zalophus californianus* in the southern California Current Ecosystem. Mar. Ecol. Prog. Ser. 692:1-21.

MacKas, D. L., Peterson, W. T., and Zamon, J. E. 2004. Comparisons of interannual biomass anomalies of zooplankton communities along the continental margins of British Columbia and Oregon. Deep-Sea Research Part II: Topical Studies in Oceanography 51(6–9): 875–896.

Majewski, S. P. and Ellis, G.M. 2022. Abundance and distribution of Pacific 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.

Majewski, S., Szaniszlo, W., Nordstrom, C.A., Abernethy, R. M. and Tucker, S. 2024. Trends in Abundance of Steller Sea Lions (*Eumetopias jubatus*) in British Columbia: updates from 2016-17 Aerial Surveys. DFO Can. Sci. Advis. Sec. Res. Doc. 2024/047. v + 29 p.

Maniscalco, J.M., Wynne, K., Pitcher, K.W., Hanson, M.B., Melin, S.R., and Atkinson, S. 2004. The occurrence of California Sea Lions (*Zalophus californianus*) in Alaska. Aqu. Mamm. 30:427–433.

Melin, S. R., DeLong, R.L., Thomason, J.R. and VanBlaricom, G. R. 2000. Attendance patterns of California Sea Lion (*Zalophus californianus*) females and pups during the nonbreeding season at San Miguel Island. Mar. Mamm. Sci. 16:169–185.

Melin S.R., Orr A.J., Harris J.D., Laake J.L., and DeLong, R.L. 2012. California Sea Lions: an indicator for integrated ecosystem assessment of the California Current System. CCOFI Rep 53:140−152.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the *Marine Mammal Protection Act*. 23 p.

Olesiuk, P.F. 2018. Recent trends in Abundance of Steller Sea Lions (*Eumetopias jubatus*) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2018/006. v + 67 p.

Orsi, J. A., Harding, J. A., Pool, S. S., Brodeur, R. D., Haldorson, L. J., Murphy, J., Moss, J., Farley, E. Jr., Sweeting, R., Morris, J., Trudel, M., Beamish, R., Emmett, R., and Fergusson, E. 2007. Epipelagic Fish Assemblages Associated with Juvenile Pacific Salmon in Neritic Waters of the California Current and the Alaska Current. Am. Fish. Soc. Sym. 57:105–155.

Robinson, H., Thayer, J., Sydeman, W. J., and Weise, M. 2018. Changes in California Sea Lion diet during a period of substantial climate variability. Mar. Biol. 165(10):169.

Rubidge, E., Gale, K.S.P., Curtis, J.M.R., McClelland, E., Feyrer, L., Bodtker, K., and Robb, C. 2016. Methodology of the Pacific Marine Ecological Classification System and its Application to the Northern and Southern Shelf Bioregions. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/035. xi + 124 p.

Schramm, Y., Mesnick, S.L., de la Rosa, J., Palacios, D.M., Lowry, M.S. Aurioles-Gamboa, D.Snell, H.M., and Escorza-Treviño, S. 2009. Phylogeography of California and Galapagos sea lions and population structure within the California Sea Lion. Mar. Biol. 156:1375-1387.

Scordino, J. J., Akmajian, A. M. and Edmondson, S. L. 2022. Dietary niche overlap and prey consumption for the Steller sea lion *(Eumetopias jubatus)* and California sea lion *(Zalophus californianus)* in northwest Washington during 2010–2013. Fish. Bull. 120:39–54.

Thompson S.K, Seber G.A. 1994. Detectability in conventional and adaptive sampling. Biometrics. 1:712-24.

Tucker, S., Majewski, S., Nordstrom, C., Trzcinski, M.K. and Doniol-Valcroze, T. In press. Population Status Assessment and Potential Biological Removal (PBR) for the Pacific Harbour Seal (*Phoca vitulina richardsi*) in Canadian Pacific Waters. DFO Can. Sci. Advis. Sec. Res. Doc.

Wade, P. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mamm. Sci. 14:1-37.

Wade, P.R. and Angliss, R.P. 1997. Guidelines for assessing marine mammal stocks: Report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. NOAA Technical Memorandum NMFS-OPR-12. Available from Office of Protected Resources, MFS, Silver Spring, MD. 93 p.

Weise, M. J., and Harvey, J. T. 2008. Temporal variability in ocean climate and California Sea Lion diet and biomass consumption: Implications for fisheries management. Mar. Ecol. Prog. Ser. 373:157–172.

Wells, B. K., Grimes, C. B., Sneva, J. G., McPherson, S., and Waldvogel, J. B. 2008. Relationships between oceanic conditions and growth of Chinook salmon (*Oncorhynchus tshawytscha*) from California, Washington, and Alaska, USA. Fish. Oceanogr. 17(2):101–125.

Wright, B.E., Tennis, M.J., and Brown, R.F. 2010. Movements of male California Sea Lions captured in the Columbia River. Northwest Sci. 84:60–72.

TABLES

Table 1. Summary of animals tagged by Washington Department of Fish and Wildlife showing the proportion of time hauled out (adapted from DeLong et al *2017a, Table 2). Note: programming error resulted in a drop in tag numbers in March.*

Animal ID	**Dec** n=15	**Jan** n=18	**Feb** n=24	**Mar** n=5
ZC2014PSM1	0.40	0.19	0.30	0.40
ZC2014PSM10	-	0.40	0.26	-
ZC2014PSM11	-	0.70	0.69	-
ZC2014PSM16	-	0.50	0.51	0.59
ZC2014PSM2	0.46	0.53	0.39	0.54
ZC2014PSM3	0.46	0.36	0.52	-
ZC2014PSM4	0.45	0.52	-	-
ZC2014PSM5	0.57	0.41	0.37	0.41
ZC2014PSM6	0.25	0.44	0.44	0.46
ZC2014PSM7	0.60	0.41	0.40	-
ZC2014PSM8	0.44	0.53	0.32	-
ZC2014PSM9	0.41	0.17	-	-
ZC2015PSM17	0.09	0.29	0.28	-
ZC2015PSM18	0.74	0.18	0.33	-
ZC2015PSM19	0.86	0.27	0.29	-
ZC2015PSM20	0.18	0.19	0.51	-
ZC2015PSM21	0.53	0.35	0.41	-
ZC2015PSM22	0.53	0.16	0.36	-
ZC2015PSM23	-	-	0.52	-
ZC2015PSM24	-	-	0.43	-
ZC2015PSM25	-	-	0.20	-
ZC2015PSM26	-	-	0.50	-
ZC2015PSM27	-	-	0.33	-
ZC2015PSM28	-	-	0.33	-
ZC2015PSM29	-	-	0.89	-
ZC2015PSM30	-	-	0.52	-
Average	**0.46**	**0.37**	**0.42**	**0.48**

Table 2. California sea lion counts on land by region for winter 2020-21 surveys.

Region	NOV	DEC	JAN	FEB	MAR
Queen Charlotte Strait	0	40	24	43	0
Salish Sea	2,837	4,357	3,498	2,782	3,464
Pacific	3,192	1,759	1,865	3,054	2,694
Total	**6,029**	**6,156**	**5,387**	**5,879**	**6,158**

Table 3. Abundance of California Sea Lions estimated by region and for BC overall based on aerial surveys conducted November-March 2020 – 21. 95% Confidence Intervals (CI) are shown in brackets.

Region	NOV	DEC	JAN	FEB	MAR
Queen Charlotte Strait	0	87 (67-112)	65 (51-82)	102 (86-121)	0
Salish Sea	6,167 (4821-7890)	9,472 (7405-12,116)	9453 (7586-11,780)	6,624 (5635-7787)	7,217 (6076-8571)
Pacific	6,939 (5425-8877)	3,824 (2989-4892)	5,041 (4045-6282)	7,271 (6186-8548)	5,613 (4725-6667)
BC	**13,107** (8541-20,112)	**13,383** (8721-20,535)	**14,559** (9621-22,030)	**13,998** (9506-20,612)	**12,829** (8677-18,969)

FIGURES

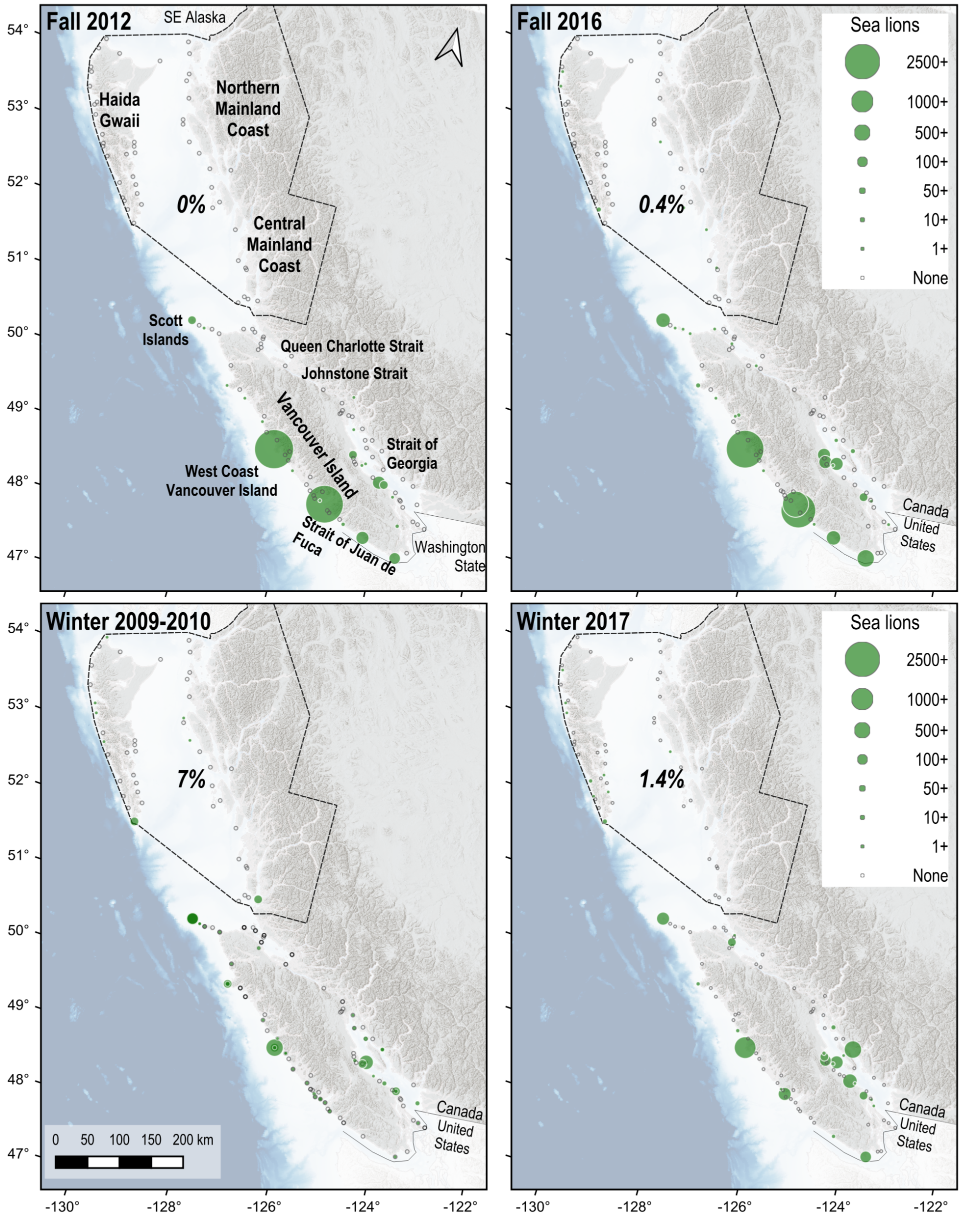

Figure 1. Distribution of California Sea Lions during BC coastwide non-breeding season Steller Sea Lion surveys conducted between 2009 – 2017: a) fall 2012; b) fall 2016; c) winter 2009 – 2010; and d) winter 2017. Green circles are proportional to the total number of animals counted on land at each site. Open black circles indicate sites surveyed without California Sea Lions present. Percent values indicate the proportion of animals found in northern BC. The vast majority of animals occurred at haul-outs around Vancouver Island with 1.4% of counted animals north of Vancouver Island in winter 2017.

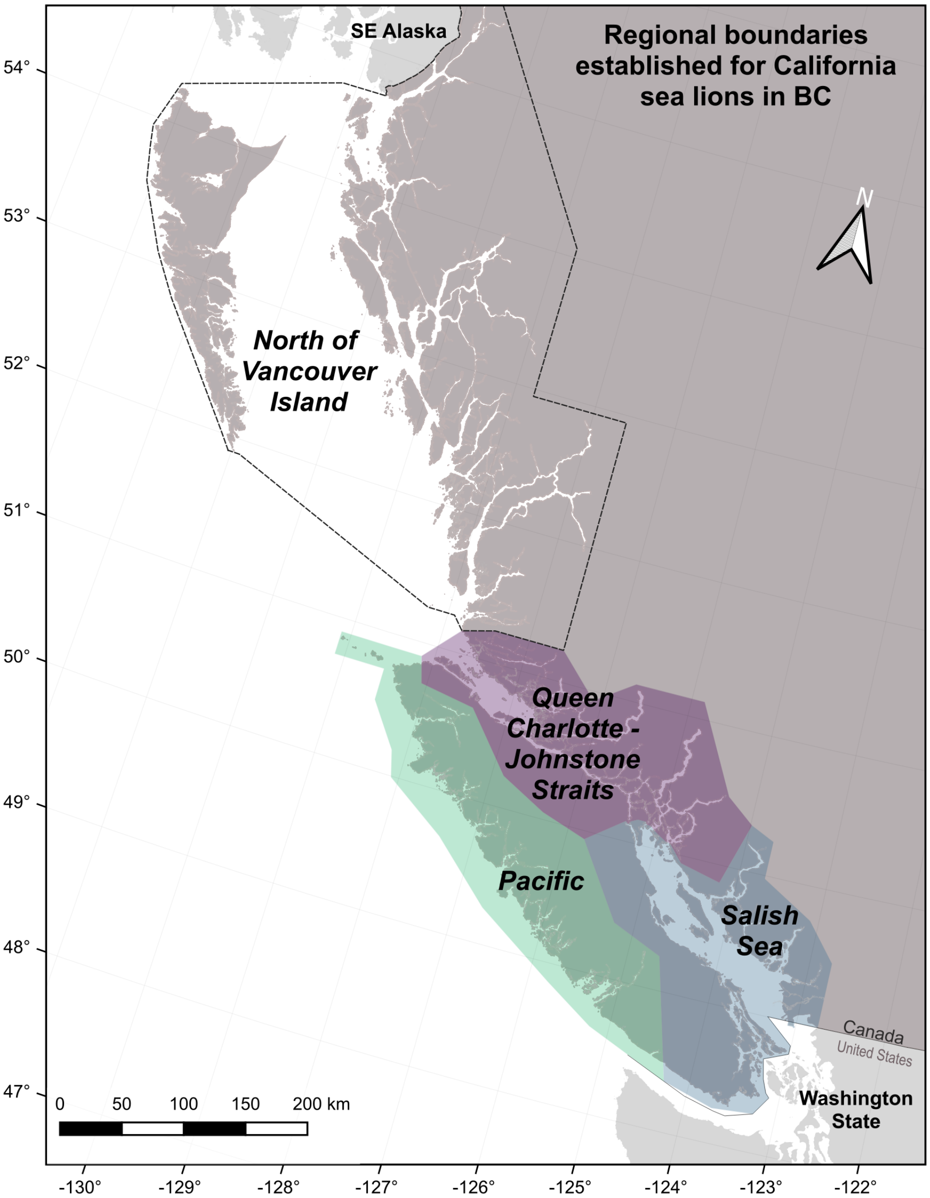

Figure 2. Overview of survey design showing survey regions for winter 2020 – 21 California Sea Lion surveys. North of Vancouver Island was not surveyed for this assessment.

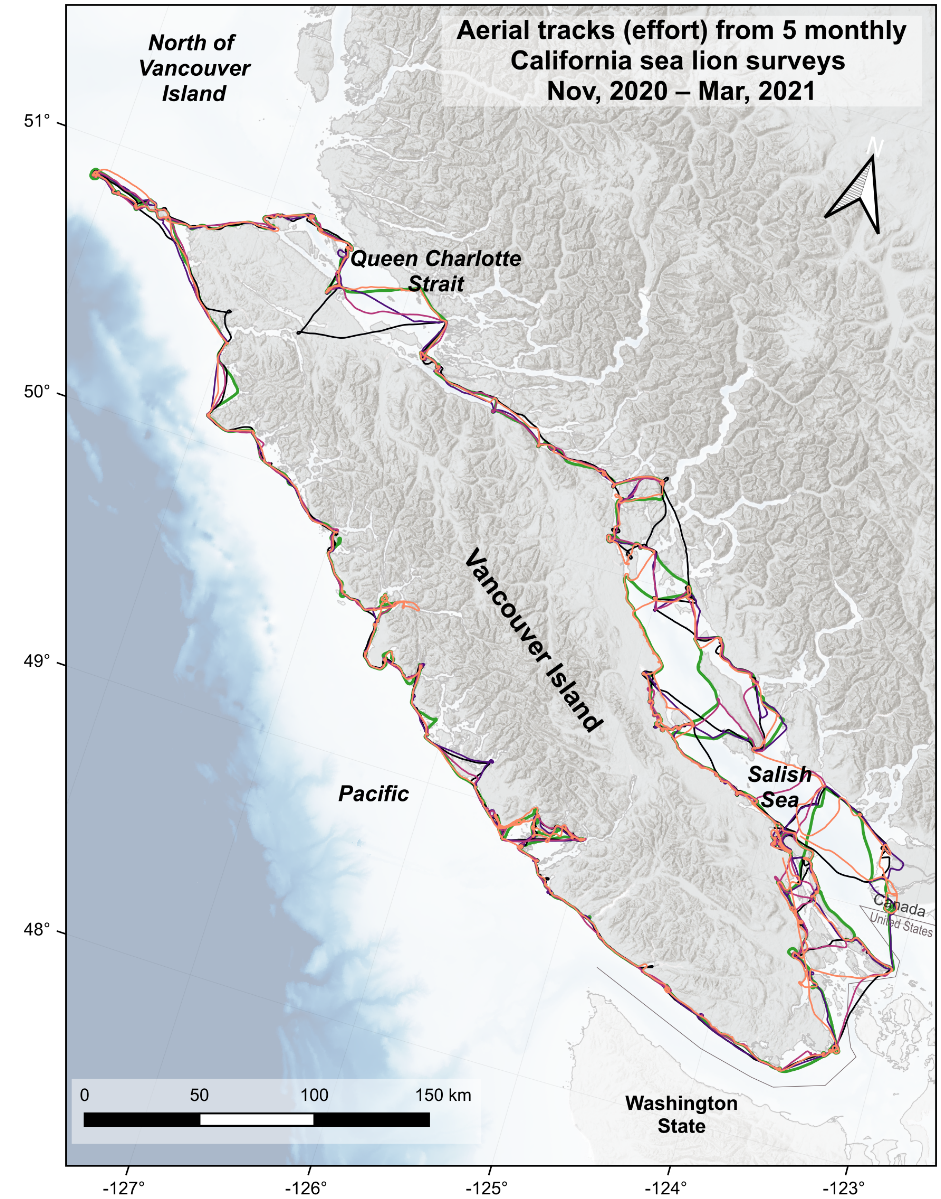

Figure 3. Summary of survey effort/coverage for winter 2020 – 21 California Sea Lion surveys. Monthly survey tracks are depicted by different colored lines.

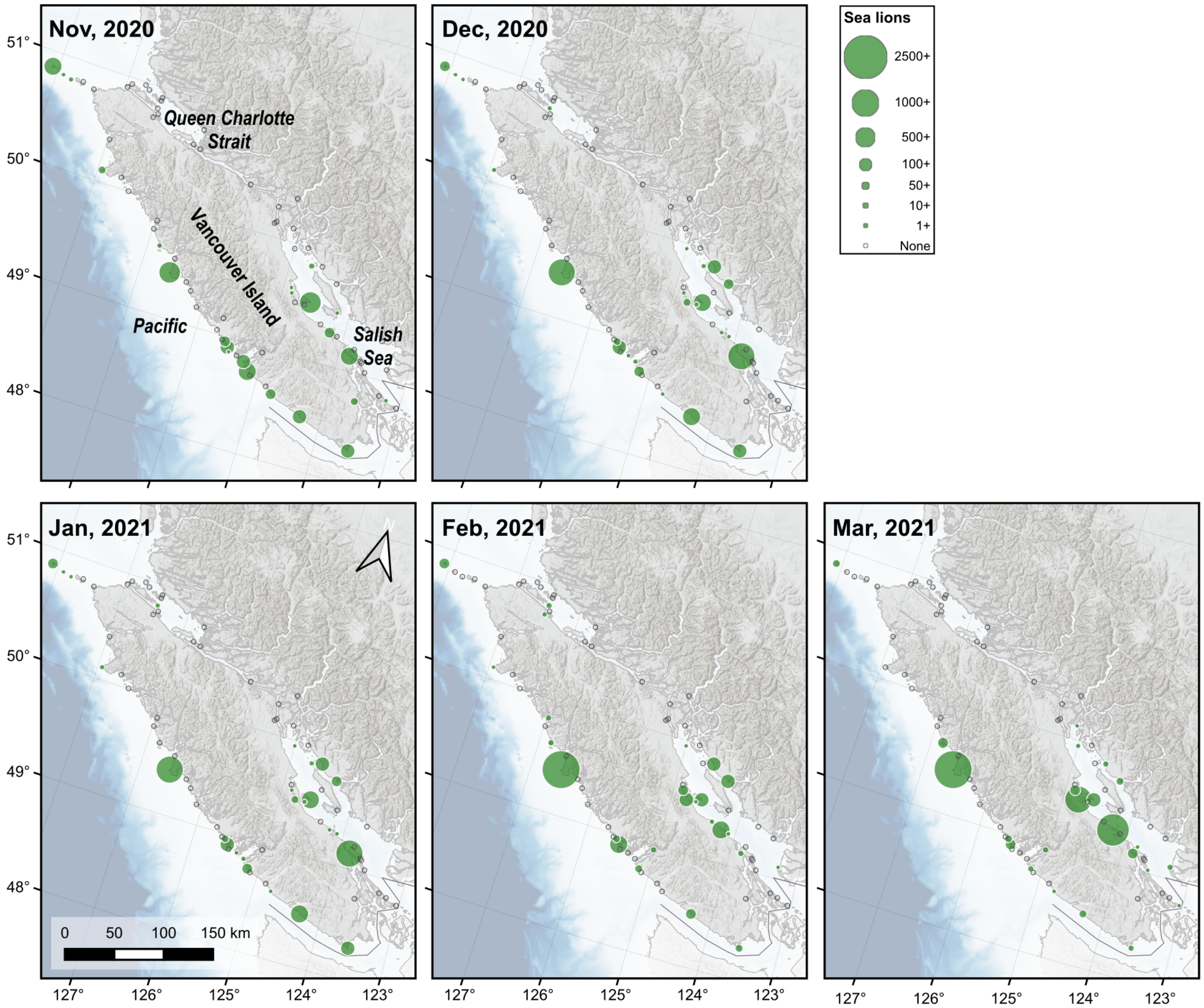

Figure 4. Counts of animals at individual haul-out sites November to March, 2020 — 21. Green circles are proportional to the total number of animals counted on land at each site. Open black circles indicate sites surveyed without California Sea Lions present.

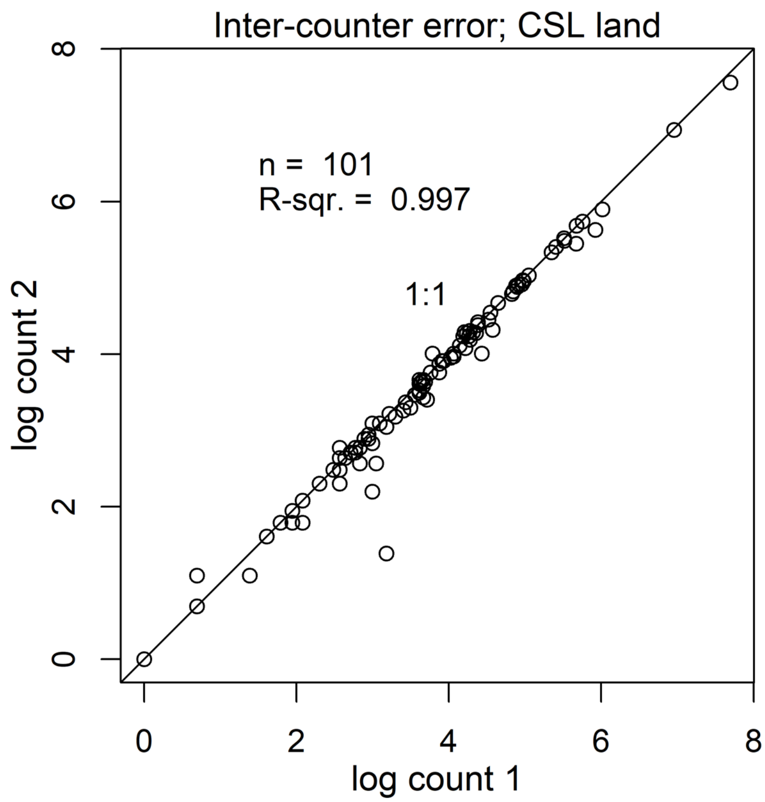

Figure 5. Estimation of inter-counter error for log-transformed California Sea Lion counts on land for 101 photographs.

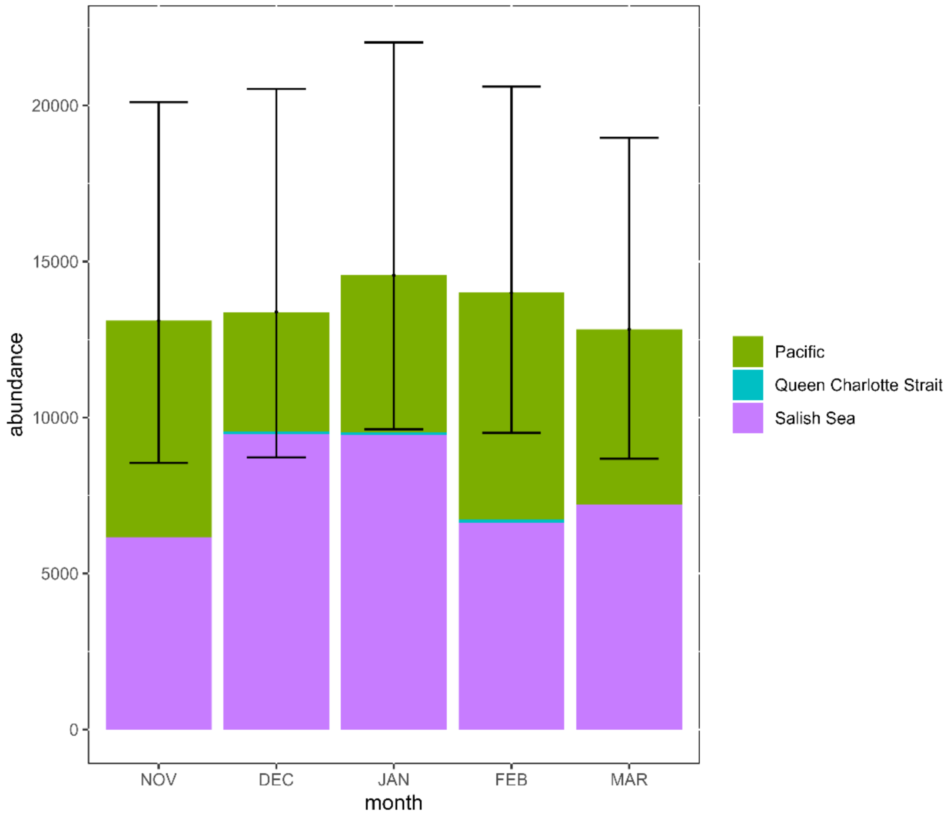

Figure 6. Abundance estimates and 95% CI of California Sea Lions hauled out during monthly 2020 – 2021 winter sea lion surveys of Vancouver Island, BC (November to March).

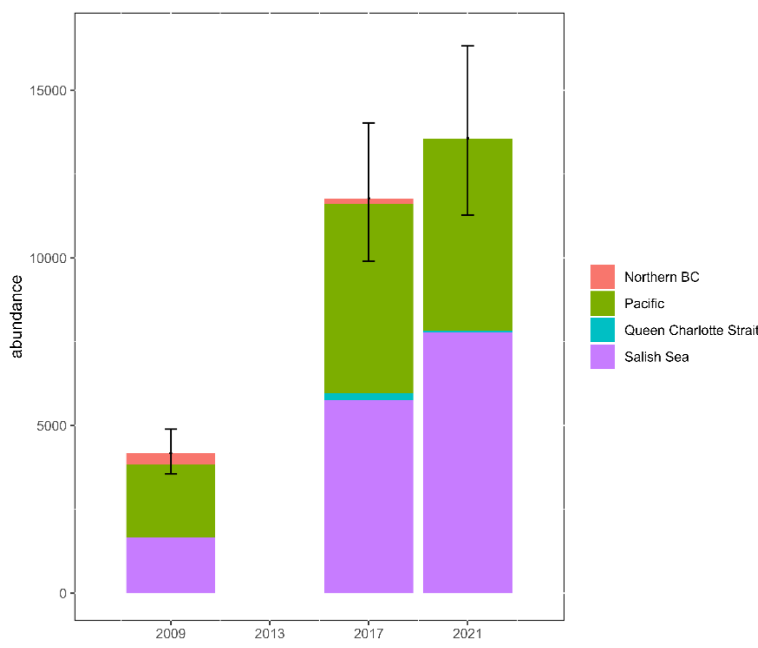

Figure 7. Abundance estimates and 95% CI of California Sea Lions hauled out during 2009 – 2021 winter sea lion surveys.

APPENDIX

Table A.1. California Sea Lions counts in three regions based on aerial surveys conducted November to March 2020 – 21. (QCS = Queen Charlotte Strait) n = 77 sites.

Region	SiteID	Complex	NOV 2020	DEC 2020	JAN 2021	FEB 2021	MAR 2021
Pacific	SL001	Ucluelet Harbour	167	31	74	85	60
Pacific	SL002	George Fraser Islands	322	132	294	623	210
Pacific	SL003	Florencia - Wya	0	0	0	0	0
Pacific	SL005	Long Beach Rocks	0	0	0	0	0
Pacific	SL006	Berryman Point	0	0	ns	ns	ns
Pacific	SL007	Plover-Cleland	0	0	0	0	0
Pacific	SL008	Raphael Point	0	0	0	0	0
Pacific	SL009	W Hot Springs Cove	0	0	0	0	0
Pacific	SL013	Perez - Estevan	920	1155	1123	2049	2056
Pacific	SL015	Escalante Point	0	0	0	0	0
Pacific	SL018	Bajo-SW Nootka	18	0	0	41	226
Pacific	SL019	Ferrer Point	0	0	0	0	0
Pacific	SL020	Rosa Island	0	0	0	25	0
Pacific	SL022	Barrier Islands	0	0	0	0	0
Pacific	SL025	O'Leary Islets	0	0	0	0	0
Pacific	SL026	Solander Island	87	36	18	5	0
Pacific	SL027	Rowley Reefs	0	10	0	0	0
Pacific	SL028	Nawhitti Point	0	0	0	0	0
Pacific	SL030	Cape Scott	0	0	0	0	0
Pacific	SL032	Maggot-Beresford	13	0	1	0	0
Pacific	SL033	Sartine Island	2	0	2	0	0
Pacific	SL034	Triangle Island	562	241	179	145	68
Pacific	SL174	Carmanah Point	140	0	7	0	1
Pacific	SL175	Pachena Point	0	0	0	0	0

Region	SiteID	Complex	NOV 2020	DEC 2020	JAN 2021	FEB 2021	MAR 2021
Pacific	SL176	Folger-Leach	269	41	15	0	0
Pacific	SL177	Wouwer-Batley	0	0	1	0	0
Pacific	SL178	Mara-Starlight	1	0	0	0	0
Pacific	SL185	Chup Point	0	0	0	28	37
Pacific	SL200	Seabird Rocks	691	113	151	53	36
Pacific	SL203	Nitinat Narrows	0	0	0	0	0
Pacific	SL204	N Cox Island	0	0	0	0	0
QCS	SL093	Ashby Point	0	0	0	0	0
QCS	SL094	Pine-Tree	0	0	0	0	0
QCS	SL095	Bright Island	0	0	0	0	0
QCS	SL096	Millar Group	0	0	0	0	0
QCS	SL097	Echo Islands	0	0	0	0	0
QCS	SL098	SE Gordon Islands	0	40	24	32	0
QCS	SL099	Masterman Islands	0	0	0	0	0
QCS	SL100	Port Hardy	0	0	0	11	0
QCS	SL101	W Eden-Screen Islands	0	0	0	0	0
QCS	SL103	Plumper-Stubbs Islands	0	0	0	0	0
QCS	SL106	Helmcken Island	0	0	0	0	0
QCS	SL109	Jimmy Judd-Stuart Islands	0	0	0	0	0
QCS	SL111	Granite Point	0	0	0	0	0
QCS	SL114	Seymour Narrows East	0	0	0	0	0
QCS	SL205	Hansen Island	0	0	0	0	0
QCS	X145	Menzies Bay logbooms	0	0	0	0	0
Salish Sea	SL118	Centre Islet	0	0	0	0	9
Salish Sea	SL120	Major Islet	0	0	0	0	0

Region	SiteID	Complex	NOV 2020	DEC 2020	JAN 2021	FEB 2021	MAR 2021
Salish Sea	SL121	Mittlenatch Island	0	0	3	3	13
Salish Sea	SL123	Vivian Island	29	8	16	0	0
Salish Sea	SL124	Powell River	0	1115	372	311	43
Salish Sea	SL127	Scotch Fir-McRae	0	73	235	336	90
Salish Sea	SL128	Mud Bay	0	149	53	416	1017
Salish Sea	SL129	Mouat Island	ns	ns	0	ns	0
Salish Sea	SL130	North Union Point logbooms	4	0	0	0	0
Salish Sea	SL134	Norris-Heron Rocks	0	0	15	1	0
Salish Sea	SL135	N Buckley Bay Oyster Farms	4	17	6	247	156
Salish Sea	SL136	Flora Islet	976	786	677	454	311
Salish Sea	SL139	Northwest Bay	243	199	7	738	1504
Salish Sea	SL140	Ada-Winchelsea Islands	0	0	8	6	0
Salish Sea	SL142	SE Jedediah Island	3	0	0	0	0
Salish Sea	SL145	White Islets	0	0	0	0	0
Salish Sea	SL147	Worlcombe Island	0	0	ns	0	0
Salish Sea	SL149	Entrance Island	0	0	0	0	7
Salish Sea	SL150	Harmac logbooms	586	852	1255	33	181
Salish Sea	SL153	SE Kendrick Island	0	10	0	0	0
Salish Sea	SL154	Sand Heads	0	0	ns	1	30
Salish Sea	SL155	Canoe Islet	0	44	0	0	1
Salish Sea	SL162	Cowichan Bay	94	0	0	0	0
Salish Sea	SL164	Active Pass-Helen Point	0	0	0	0	0
Salish Sea	SL165	Belle Chain	2	0	0	0	0
Salish Sea	SL167	Tumbo-East Point	0	0	0	0	1
Salish Sea	SL172	Race Rocks	424	379	265	98	34
Salish Sea	SL173	Sombrio Point	472	700	578	123	67

Region	SiteID	Complex	NOV 2020	DEC 2020	JAN 2021	FEB 2021	MAR 2021
Salish Sea	SL197	French Creek	0	25	0	15	0
Salish Sea	SL199	NE Valdes Island	0	0	0	0	0

Table A.2. Abundance of California Sea Lions estimated by region based on aerial surveys conducted Jan/Feb 2017. (QCS - Queen Charlotte Strait) n = 135 sites.

Region	SiteID	Complex	JAN 2017	FEB 2017
Northern BC	SL035	Virgin Rocks	NA	0
Northern BC	SL036	Watch Rock	NA	0
Northern BC	SL037	Pearl Rocks	NA	0
Northern BC	SL038	Dugout Rocks	NA	0
Northern BC	SL039	Airacobra Rock	NA	0
Northern BC	SL040	Blenheim Island	NA	0
Northern BC	SL041	Gosling Rocks	NA	0
Northern BC	SL043	McInnes Island	NA	0
Northern BC	SL063	Cape St James	NA	34
Northern BC	SL064	Anthony Island	NA	0
Northern BC	SL066	McLean Fraser Point	NA	4
Northern BC	SL067	Gowgaia	NA	12
Northern BC	SL068	S Tasu Head	NA	0
Northern BC	SL069	Kootenay Inlet	NA	0
Northern BC	SL070	Moresby Islets	NA	0
Northern BC	SL071	Marble Island	NA	5
Northern BC	SL072	Kindakun	NA	1
Northern BC	SL073	Cone Head	NA	0
Northern BC	SL074	Hippa Island	NA	0
Northern BC	SL075	Joseph Rocks	NA	0
Northern BC	SL076	Sadler Point	NA	0
Northern BC	SL077	Langara Island	NA	0
Northern BC	SL079	Cape Naden	NA	0
Northern BC	SL081	Rose Spit	NA	0
Northern BC	SL086	Skedans Island	NA	0
Northern BC	SL087	Reef Island	NA	0
Northern BC	SL088	Helmet Island	NA	0
Northern BC	SL089	Tatsung Rock	NA	5
Northern BC	SL090	Scudder Point	NA	0
Northern BC	SL091	Joyce Rocks	NA	5
Northern BC	SL092	Garcin Rocks	NA	0
Northern BC	SL196	N Chads Point	NA	0
Northern BC	SL206	Tian Islets	NA	1
Northern BC	SL207	Tuft-Tar	NA	0
Northern BC	SL208	Juan Perez	NA	0
Northern BC	X282	Nagas Point	NA	0
QCS	SL028	Nawhitti Point	NA	ns
QCS	SL093	Ashby Point	0	NA

Region	SiteID	Complex	JAN 2017	FEB 2017
QCS	SL094	Pine-Tree	0	NA
QCS	SL095	Bright Island	0	NA
QCS	SL096	Millar Group	2	NA
QCS	SL097	Echo Islands	0	NA
QCS	SL098	SE Gordon Islands	70	NA
QCS	SL099	Masterman Islands	NA	0
QCS	SL100	Port Hardy	NA	0
QCS	SL101	W Eden-Screen Islands	NA	0
QCS	SL103	Plumper-Stubbs Islands	NA	0
QCS	SL106	Helmcken Island	NA	0
QCS	SL109	Jimmy Judd-Stuart Islands	NA	0
QCS	SL111	Granite Point	NA	0
QCS	SL112	Deepwater Bay	NA	0
QCS	SL114	Seymour Narrows East	NA	0
QCS	SL205	Hansen Island	NA	0
QCS	X145	Menzies Bay logbooms	NA	0
Northern BC	SL045	Lindsay Rocks	NA	0
Northern BC	SL046	Steele Rock	NA	0
Northern BC	SL047	Isnor-McKenney	NA	0
Northern BC	SL049	Ashdown Island	NA	0
Northern BC	SL050	McDonald Island	NA	0
Northern BC	SL051	Joseph Island	NA	1
Northern BC	SL052	North Danger Rocks	NA	0
Northern BC	SL054	Bonilla-Northwest Rocks	NA	0
Northern BC	SL055	Bonilla-Northwest Rocks	NA	0
Northern BC	SL056	Cape George Rocks	NA	0
Northern BC	SL057	Warrior Rocks	NA	0
Northern BC	SL058	Roland Rocks	NA	0
Northern BC	SL060	Chearnley-Connel	NA	0
Northern BC	SL061	Zayas Island	NA	0
Salish Sea	SL118	Centre Islet	NA	0
Salish Sea	SL120	Major Islet	NA	38
Salish Sea	SL121	Mittlenatch Island	NA	0
Salish Sea	SL123	Vivian Island	NA	0
Salish Sea	SL124	Powell River	NA	0

Region	SiteID	Complex	JAN 2017	FEB 2017
Salish Sea	SL127	Scotch Fir-McRae	NA	987
Salish Sea	SL128	Mud Bay	NA	0
Salish Sea	SL129	Mouat Island	NA	1
Salish Sea	SL130	North Union Point logbooms	NA	10
Salish Sea	SL131	Fanny Bay-Baynes Sound	NA	114
Salish Sea	SL134	Norris-Heron Rocks	NA	10
Salish Sea	SL135	N Buckley Bay Oyster Farms	NA	97
Salish Sea	SL136	Flora Islet	NA	305
Salish Sea	SL137	N Qualicum	NA	0
Salish Sea	SL138	Qualicum Beach	NA	0
Salish Sea	SL139	Northwest Bay	NA	639
Salish Sea	SL140	Ada-Winchelsea Islands	NA	1
Salish Sea	SL142	SE Jedediah Island	NA	0
Salish Sea	SL145	White Islets	NA	0
Salish Sea	SL147	Worlcombe Island	NA	0
Salish Sea	SL149	Entrance Island	NA	0
Salish Sea	SL150	Harmac logbooms	NA	69
Salish Sea	SL153	SE Kendrick Island	NA	0
Salish Sea	SL154	Sand Heads	NA	0
Salish Sea	SL155	Canoe Islet	NA	6
Salish Sea	SL162	Cowichan Bay	NA	0
Salish Sea	SL164	Active Pass-Helen Point	NA	0
Salish Sea	SL165	Belle Chain	NA	0
Salish Sea	SL167	Tumbo-East Point	NA	0
Salish Sea	SL169	Discovery Island	NA	0
Salish Sea	SL170	Trial Islands	NA	0
Salish Sea	SL172	Race Rocks	NA	117
Salish Sea	SL197	French Creek	NA	0
Salish Sea	SL199	NE Valdes Island	NA	2
Salish Sea	SL173	Sombrio Point	NA	25
Pacific	SL001	Ucluelet Harbour	NA	0
Pacific	SL002	George Fraser Islands	NA	376
Pacific	SL003	Florencia - Wya	NA	1
Pacific	SL005	Long Beach Rocks	NA	0
Pacific	SL006	Berryman Point	0	NA
Pacific	SL007	Plover-Cleland	0	NA

Region	SiteID	Complex	JAN 2017	FEB 2017
Pacific	SL008	Raphael Point	NA	0
Pacific	SL009	W Hot Springs Cove	0	NA
Pacific	SL013	Perez - Estevan	1,432	NA
Pacific	SL015	Escalante Point	0	NA
Pacific	SL018	Bajo-SW Nootka	15	NA
Pacific	SL019	Ferrer Point	0	NA
Pacific	SL020	Rosa Island	0	NA
Pacific	SL021	Esperanza Inlet	0	NA
Pacific	SL022	Barrier Islands	0	NA
Pacific	SL025	O'Leary Islets	0	NA
Pacific	SL026	Solander Island	22	NA
Pacific	SL027	Rowley Reefs	0	NA
Pacific	SL030	Cape Scott	0	NA
Pacific	SL032	Maggot-Beresford	0	NA
Pacific	SL033	Sartine Island	0	NA
Pacific	SL034	Triangle Island	294	NA
Pacific	SL174	Carmanah Point	NA	0
Pacific	SL175	Pachena Point	NA	0
Pacific	SL176	Folger-Leach	NA	0
Pacific	SL177	Wouwer-Batley	NA	0
Pacific	SL178	Mara-Starlight	NA	0
Pacific	SL185	Chup Point	NA	ns
Pacific	SL200	Seabird Rocks	NA	0
Pacific	SL203	Nitinat Narrows	NA	0
Pacific	SL204	N Cox Island	NA	0
Pacific	X204	Stopper Islands	NA	0

Table A.3. Abundance of California Sea Lions estimated by region based on aerial surveys conducted winter 2009 – 2010. (QCS - Queen Charlotte Strait) n = 127 sites.

Region	SiteID	Complex	JAN 2009	FEB 2009	DEC 2009	JAN 2010
Northern BC	SL035	Virgin Rocks	NA	NA	NA	0
Northern BC	SL036	Watch Rock	NA	NA	NA	0
Northern BC	SL037	Pearl Rocks	NA	NA	NA	0
Northern BC	SL038	Dugout Rocks	NA	NA	NA	62
Northern BC	SL039	Airacobra Rock	NA	NA	NA	0
Northern BC	SL040	Blenheim Island	NA	NA	NA	0
Northern BC	SL041	Gosling Rocks	NA	NA	NA	0
Northern BC	SL043	McInnes Island	NA	NA	NA	0
Northern BC	SL063	Cape St James	54	NA	NA	NA
Northern BC	SL064	Anthony Island	0	NA	NA	NA
Northern BC	SL066	McLean Fraser Point	0	NA	NA	NA
Northern BC	SL067	Gowgaia	0	NA	NA	NA
Northern BC	SL068	S Tasu Head	0	NA	NA	NA
Northern BC	SL069	Kootenay Inlet	1	NA	NA	NA
Northern BC	SL070	Moresby Islets	0	NA	NA	NA
Northern BC	SL071	Marble Island	1	NA	NA	NA
Northern BC	SL072	Kindakun	1	NA	NA	NA
Northern BC	SL074	Hippa Island	0	NA	NA	NA
Northern BC	SL075	Joseph Rocks	0	NA	NA	NA
Northern BC	SL076	Sadler Point	0	NA	NA	NA
Northern BC	SL077	Langara Island	4	NA	NA	NA
Northern BC	SL079	Cape Naden	0	NA	NA	NA
Northern BC	SL081	Rose Spit	0	NA	NA	NA
Northern BC	SL085	Cumshewa	0	NA	NA	NA
Northern BC	SL086	Skedans Island	0	NA	NA	NA
Northern BC	SL087	Reef Island	0	NA	NA	NA
Northern BC	SL088	Helmet Island	0	NA	NA	NA
Northern BC	SL089	Tatsung Rock	0	NA	NA	NA
Northern BC	SL090	Scudder Point	0	NA	NA	NA
Northern BC	SL091	Joyce Rocks	0	NA	NA	NA
Northern BC	SL092	Garcin Rocks	0	NA	NA	NA
QCS	SL028	Nawhitti Point	NA	NA	NA	ns
QCS	SL093	Ashby Point	NA	0	0	0
QCS	SL094	Pine-Tree	NA	NA	0	NA
QCS	SL095	Bright Island	NA	0	0	NA
QCS	SL096	Millar Group	NA	0	0	NA
QCS	SL097	Echo Islands	NA	NA	0	NA

Region	SiteID	Complex	JAN 2009	FEB 2009	DEC 2009	JAN 2010
QCS	SL098	SE Gordon Islands	NA	0	0	NA
QCS	SL099	Masterman Islands	ns	NA	NA	NA
QCS	SL100	Port Hardy	NA	NA	0	NA
QCS	SL101	W Eden-Screen Islands	NA	0	0	NA
QCS	SL103	Plumper-Stubbs Islands	NA	NA	0	NA
QCS	SL106	Helmcken Island	NA	NA	NA	0
QCS	SL109	Jimmy Judd-Stuart Islands	NA	NA	NA	ns
QCS	SL111	Granite Point	NA	0	NA	NA
QCS	SL112	Deepwater Bay	NA	0	NA	NA
QCS	SL114	Seymour Narrows East	NA	NA	NA	0
QCS	X145	Menzies Bay logbooms	NA	0	NA	NA
Northern BC	SL045	Lindsay Rocks	NA	NA	NA	0
Northern BC	SL046	Steele Rock	NA	NA	NA	0
Northern BC	SL047	Isnor-McKenney	NA	NA	NA	0
Northern BC	SL049	Ashdown Island	NA	NA	NA	0
Northern BC	SL050	McDonald Island	NA	NA	NA	0
Northern BC	SL051	Joseph Island	NA	NA	NA	NA
Northern BC	SL052	North Danger Rocks	NA	NA	NA	1
Northern BC	SL054	Bonilla-Northwest Rocks	NA	NA	NA	0
Northern BC	SL055	Bonilla-Northwest Rocks	NA	NA	NA	1
Northern BC	SL056	Cape George Rocks	NA	NA	NA	0
Northern BC	SL057	Warrior Rocks	NA	NA	NA	0
Northern BC	SL058	Roland Rocks	NA	NA	NA	0
Northern BC	SL060	Chearnley-Connel	NA	NA	NA	0
Northern BC	SL061	Zayas Island	NA	NA	NA	0
Salish Sea	SL118	Centre Islet	NA	0	NA	NA
Salish Sea	SL120	Major Islet	NA	0	NA	NA
Salish Sea	SL121	Mittlenatch Island	NA	0	NA	NA
Salish Sea	SL123	Vivian Island	NA	47	NA	NA
Salish Sea	SL124	Powell River	NA	0	NA	NA

Region	SiteID	Complex	JAN 2009	FEB 2009	DEC 2009	JAN 2010
Salish Sea	SL126	Favada Point	NA	ns	NA	NA
Salish Sea	SL127	Scotch Fir-McRae	NA	23	NA	NA
Salish Sea	SL128	Mud Bay	NA	0	NA	NA
Salish Sea	SL129	Mouat Island	NA	ns	NA	NA
Salish Sea	SL130	North Union Point logbooms	NA	0	NA	NA
Salish Sea	SL134	Norris-Heron Rocks	NA	55	NA	NA
Salish Sea	SL135	N Buckley Bay Oyster Farms	NA	0	NA	NA
Salish Sea	SL136	Flora Islet	NA	523	NA	NA
Salish Sea	SL139	Northwest Bay	NA	0	NA	NA
Salish Sea	SL140	Ada-Winchelsea Islands	NA	33	NA	NA
Salish Sea	SL142	SE Jedediah Island	NA	NA	NA	NA
Salish Sea	SL145	White Islets	NA	NA	NA	NA
Salish Sea	SL147	Worlcombe Island	NA	NA	NA	0
Salish Sea	SL148	Snake - Hudson	NA	0	NA	NA
Salish Sea	SL149	Entrance Island	NA	12	NA	NA
Salish Sea	SL150	Harmac logbooms	NA	NA	NA	ns
Salish Sea	SL153	SE Kendrick Island	NA	0	NA	NA
Salish Sea	SL154	Sand Heads	NA	NA	NA	NA
Salish Sea	SL155	Canoe Islet	NA	0	NA	NA
Salish Sea	SL162	Cowichan Bay	NA	NA	NA	ns
Salish Sea	SL164	Active Pass-Helen Point	NA	0	NA	NA
Salish Sea	SL165	Belle Chain	NA	0	NA	NA
Salish Sea	SL167	Tumbo-East Point	NA	0	NA	NA
Salish Sea	SL170	Trial Islands	NA	0	NA	NA
Salish Sea	SL172	Race Rocks	NA	0	NA	NA
Salish Sea	SL197	French Creek	NA	3	NA	NA
Salish Sea	SL199	NE Valdes Island	NA	0	NA	NA
Salish Sea	SL173	Sombrio Point	NA	0	NA	NA
Pacific	SL001	Ucluelet Harbour	NA	NA	NA	0
Pacific	SL002	George Fraser Islands	NA	NA	NA	13

Region	SiteID	Complex	JAN 2009	FEB 2009	DEC 2009	JAN 2010
Pacific	SL003	Florencia - Wya	NA	0	NA	0
Pacific	SL005	Long Beach Rocks	NA	0	NA	0
Pacific	SL006	Berryman Point	NA	NA	NA	0
Pacific	SL007	Plover-Cleland	NA	0	NA	0
Pacific	SL008	Raphael Point	NA	NA	NA	0
Pacific	SL009	W Hot Springs Cove	NA	1	NA	3
Pacific	SL013	Perez - Estevan	NA	11	NA	66
Pacific	SL015	Escalante Point	NA	2	NA	0
Pacific	SL018	Bajo-SW Nootka	NA	NA	NA	0
Pacific	SL019	Ferrer Point	NA	NA	NA	1
Pacific	SL020	Rosa Island	NA	NA	NA	0
Pacific	SL021	Esperanza Inlet	NA	NA	NA	ns
Pacific	SL022	Barrier Islands	NA	0	NA	0
Pacific	SL025	O’Leary Islets	NA	0	NA	0
Pacific	SL026	Solander Island	NA	28	NA	10
Pacific	SL027	Rowley Reefs	NA	0	1	0
Pacific	SL030	Cape Scott	NA	0	0	0
Pacific	SL032	Maggot-Beresford	NA	NA	0	4
Pacific	SL033	Sartine Island	NA	1	NA	NA
Pacific	SL034	Triangle Island	NA	131	179	268
Pacific	SL174	Carmanah Point	NA	0	NA	NA
Pacific	SL175	Pachena Point	NA	0	NA	NA
Pacific	SL176	Folger-Leach	NA	0	NA	0
Pacific	SL177	Wouwer-Batley	NA	0	NA	35
Pacific	SL178	Mara-Starlight	NA	0	NA	0
Pacific	SL183	W Forbes Island Islet	NA	NA	NA	0
Pacific	SL185	Chup Point	NA	NA	NA	ns
Pacific	SL200	Seabird Rocks	NA	0	NA	NA
Pacific	SL203	Nitinat Narrows	NA	0	NA	NA
Pacific	SL204	N Cox Island	NA	0	NA	NA