Submitted in Support of the U.S. Navy's 2024 Annual Marine Species Monitoring Report for the Pacific

Report on Seasonal Estimates of Density and Abundance of Cetaceans in Behm Canal, Southeast Alaska

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Executive Summary

The Alaska Fisheries Science Center (AFSC), NOAA Fisheries, with support from the U.S. Navy, conducted line transect surveys in Behm Canal and adjacent areas in the spring of 2023 and fall of 2024 to obtain estimates of density and abundance of cetaceans and information on marine mammal distribution and occurrence. Estimates for the summer were also computed from a survey carried out by AFSC in 2019. In this report, group size, density and abundance of five cetacean species (Harbor porpoise, Dall's porpoise, killer whales, humpback whales and fin whales) were computed using line transect methods. Detection probability on the trackline (g[0]) was assumed to be one for all species but harbor porpoise, which was estimated using a correction factor for g(0) calculated from previous surveys. Estimates of absolute abundance suggest that a fraction of the known cetacean stocks occur in Behm Canal and lower Clarence Strait Seasonal abundance of Dall's porpoise in Behm Canal and Clarence Strait ranged between 61 (CV = 0.35) to 99 (CV=0.30) individuals and are not statistically different across seasons. The summer estimate of 83 (CV = 0.32) porpoise in the study area in 2019, represents only 4% of the most recent estimate for the whole of SEAK in 2012. Abundance of harbor porpoise in Behm Canal and lower Clarence Strait was also consistent across seasons, with nearly 25 individuals estimated to occur in the area. Abundance of fin, humpback and killer whales were relatively low, with maximum estimates of 1 fin whale (CV=1.1) and 18 humpback whales (CV=0.25) and in the fall and 9 killer whales (CV = 0.6) in the Spring.

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14. ABSTRACT
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Background

The Southeast Alaska Acoustic Measurement Facility (SEAFAC) is a field activity of Naval Sea Systems Command (NAVSEA) operated by Naval Surface Warfare Center Carderock Division (NSWCCD). SEAFAC has a shore complex on Back Island, adjacent to in-water testing infrastructure in Western Behm Canal, Southeast Alaska. NSWCCD conducts acoustic testing within Western Behm Canal that requires environmental planning. Updated marine mammal mapping provides temporal and spatial information on cetacean density that supports the preparation of required environmental planning documentation, including those needed for National Environmental Policy Act (NEPA), Marine Mammal Protection Act (MMPA), and Endangered Species Act (ESA) consultations.

Multiple species listed under the ESA occur in this area, including humpback whales (Mexico Distinct Population Segment [DPS]) and fin whales, along with unlisted stocks of killer whales, minke whales, humpback whales, harbor porpoise, Dall's porpoise, and Pacific white-sided dolphins. The National Marine Fisheries Service, Alaska Fisheries Science Center (AFSC), and University of Washington Cooperative Institute for Climate, Ocean and Ecosystem Studies (CICOES) have partnered to design and implement field assessments for marine mammals in Behm Canal and Clarence Strait. Although this project was designed to collect information on cetaceans, opportunistic sightings of other marine mammals, such as pinnipeds and sea otters (*Enhydra lutris*), were also recorded.

Under this agreement, the AFSC and CICOES agreed to: 1) develop an appropriate survey design for maximal effect in the spring of 2023 and the fall of 2024; 2) execute the survey using vessel-based visual and limited passive acoustic methods; and 3) deliver a report on the survey design and results of the 2023 and 2024 surveys, as well as estimates of density and abundance for comparable areas from a vessel survey conducted by AFSC in the summer of 2019 (Zerbini et al., 2022). Estimates of density and other relevant quantities will be used in density modeling that will be undertaken by the Navy in the future.

In this report, we present final estimates of group size, density and abundance of five species of cetaceans in Behm Canal and adjacent areas for three seasons (summer of 2019, spring of 2023 and fall of 2024). We also provide information on [Catherine/Jess to add acoustics]

This report includes information on the distribution of marine mammals and estimates of density and abundance of five cetacean species in Behm Canal and adjacent areas during Summer of 2019, Spring of 2023 and Fall of 2024.

Methods

Data from three surveys were used to compute estimates of density and abundance for three seasons (summer, fall and spring) in this study. The summer survey was conducted between 19 July and 13 August 2019 and covered the whole of the Southeast Alaska inside waters (Zerbini et al., 2022). The spring and fall surveys took place in Behm Canal and a portion of Clarence Strait (Fig. 1) on 8-14 April 2023 and 24-29 September 2024, respectively.

Survey Design

The design of the summer 2019 research cruise was described in detail in Zerbini et al. (2022) and survey effort (time spent searching along a survey line) and trackline data from this study were re-analyzed here to compute estimates of density/abundance for areas comparable to those established as the study area in the 2023 and 2024 surveys (Fig 1). The survey area included Behm Canal (the area where the Navy SEAFAC Operational Area is located) west of Revillagigedo Island, central Clarence Strait, and adjacent fjords and inlets, a region of 1,137 km^2 (Fig. 1). For greater efficiency in the allocation of survey effort, the study area was divided into two main strata of varying geometry (Fig. 1). The stratum labeled "Main

Bodies of Water" (MBW) encompassed the main waterways within Behm Canal and Clarence Strait and spanned an area of 1,014 km^2 (89% of the study area). Within the MBW region, two substrata were proposed, the MBW 1 corresponded to the southern portion of the study area in Clarence Strait while the sub-stratum MBW 2 corresponded to Behm Canal, including the SEAFAC operation area. The stratum labeled "Inlet" (INL) included eight small inlets adjacent to the MBWs (Fig. 1) whose area, together, represented the remaining 11% (123 km^2) of the total study region. The trackline designs for the spring 2023 and the fall 2024 surveys are illustrated in Fig. 1.

Proposed effort was calculated assuming the entire region could be surveyed in seven days for a total of eight hours a day at a survey speed of 10 kts. Effort allowed for transit time between survey tracklines, for time lost due to poor weather conditions (as much as 40% of the survey period), and for the time needed to launch a small skiff, if feasible, for biopsy/environmental DNA (eDNA) sample collection from species of interest. Survey effort was allocated to each stratum proportional to their area. Strata were divided into substrata (two for MBW and eight for INL) to maximize efficiency in allocating survey tracklines (Fig. 1). Because of the relatively large number of substrata and relatively low survey effort in stratum INL, it was not always practical to sample all eight substrata. Therefore, an algorithm was implemented to allocate effort in stratum INL (Thomas et al. 2007; Zerbini et al. 2022) to ensure (1) the probability of selecting substrata was proportional to the size of its area (e.g., larger areas had greater probability of selection); (2) sampling would have a wide geographic spread; and (3) substrata would be sampled without replacement.

Survey tracklines were allocated proportional to the substratum area using the design tool in software *Distance* (version 7.2, Thomas et al. 2010). An equal spacing zig-zag design (Strindberg and Buckland 2004) was adopted for the MBW whereas a parallel transect design was chosen for the Inlets given the narrowness of most areas within the latter (Strindberg and Buckland 2004; Thomas et al. 2007). The trackline design resulted in equal sampling probability within each stratum.

<u>Visual Survey Methods</u>

The 2023 and 2024 surveys were carried out on board the R/V Alaskan Song using passing mode (i.e., the vessel did not divert from the trackline to approach detected cetacean groups; Hiby and Hammond 1989; Hammond et al. 2021) unless the survey encountered a species of interest for biopsy sampling and photo-identification (e.g., killer whales, humpback whales and fin whales). The Alaskan Song was a vessel with dimensions, especially the height of the observation platform, similar to the vessel used during the summer 2019 survey in Southeast Alaska inside waters (the R/V Zephyr). The use of boats with similar dimensions in 2019 and 2023/24 was needed to ensure data were comparable for integration of data across years (e.g., combine datasets to estimate the detection functions needed to compute density and abundance) if needed.

Four observers rotated through two observation platforms (port and starboard) located 5.1 meters above the waterline every 40 minutes (each observer alternating between 80 minutes on-effort and 80 minutes resting). Observations started approximately 30 minutes after sunrise, ended 30 minutes before sunset, and only occurred in appropriate visibility conditions (i.e., 2 km or greater) and/or sea state below 4 on the Beaufort scale. Port and starboard observers searched from the beam (90°) of their respective side to approximately 10° on the opposite side of the survey line using Fujinon 7x50 reticle binoculars (~80% of the time) or naked eye (~20% of the time). A dedicated data recorder was not involved in active searching, but assisted observers with species identification and/or group size estimates when necessary.

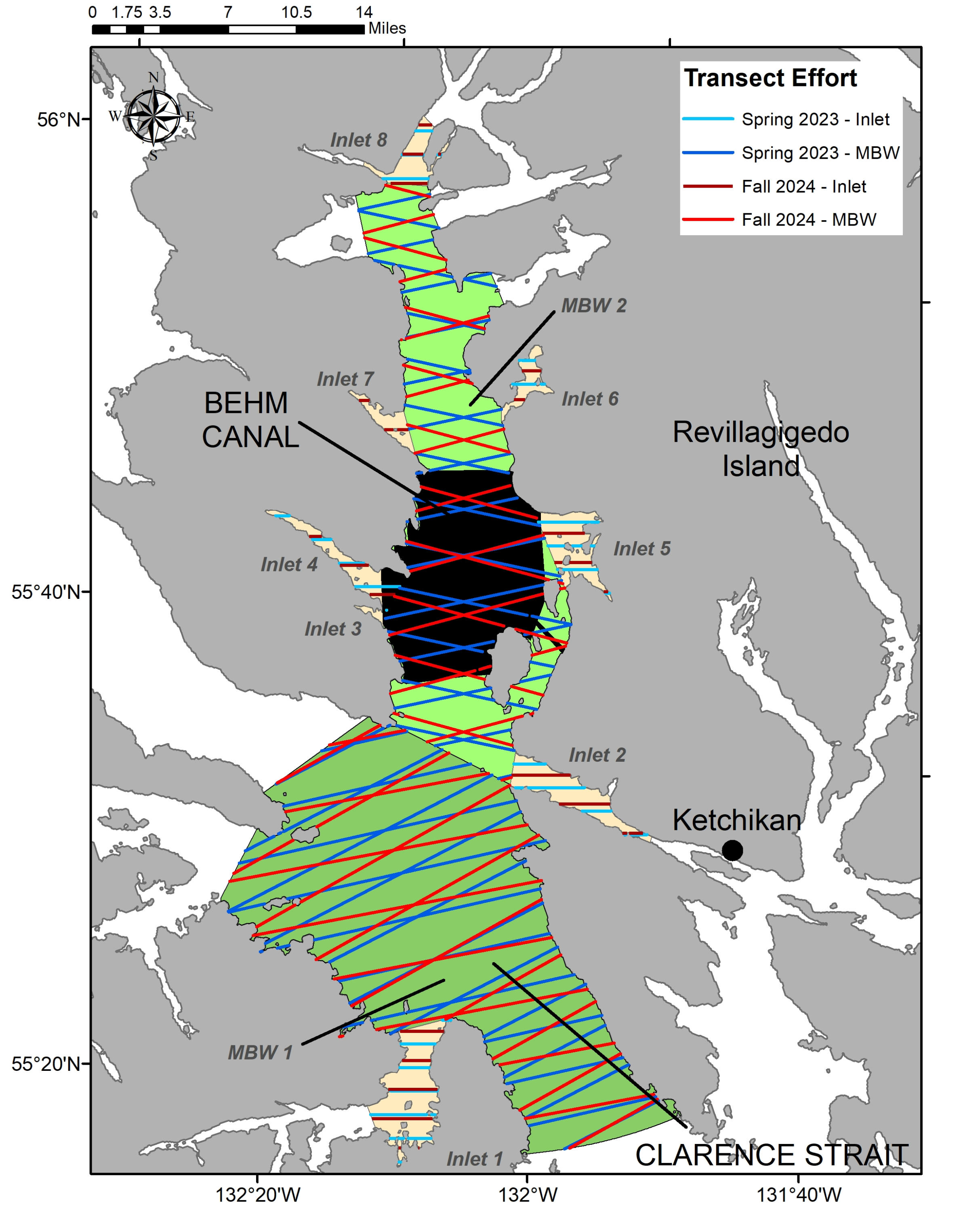


Fig. 1 – Trackline design (proposed effort) for the spring 2023 (blue lines) and fall 2024 (red lines) vessel surveys in Behm Canal and adjacent areas (MBW 1 [Behm Canal] = light green area, SEAFAC Operational Area = dark grey area, MBW 2 [Clarence Strait] = dark green area, Inlets = light orange areas).

In addition to collecting sighting data on the sampling transect, observers remained "on-effort" while the vessel was transiting between transects or from the port/anchoring sites to the survey transects. Sighting data collected in these transit lines was useful to augment what was obtained in the transect lines and improve estimation of detection probability (but these data are not used in the estimation of density/abundance). All other opportunistic sightings when observers were not actively searching on-effort were considered "off-effort" (e.g., sighted by the crew inside the wheelhouse or after the end of the survey day), and were not used in the estimation of density/abundance.

Data were entered into a laptop computer connected to a portable GPS unit using data logging software (WinCruz, Southwest Fisheries Science Center, NOAA). Position information was automatically logged every two minutes; navigational and environmental information were entered at the start of the day, at every observer rotation, and when conditions changed; and sighting information was recorded whenever marine mammals were detected. Weather and visibility conditions change frequently in Southeast Alaska, with the potential to influence the observer search pattern. To maximize data collection, observers maintained search effort with slight changes in survey protocol under light rain and under foggy conditions when the visibility was greater than ~2 km as described in Zerbini et al. (2022). Search effort ceased in moderate to severe rain or if visibility in foggy conditions was less than 2 km, and resumed when better conditions developed.

Analytical Methods

Estimates of density and abundance were computed for each MWB substrata and for all INL substrata combined for species with a reasonable sample size (n ~ 20 or more sightings) across the three surveys. This resulted in estimates for humpback whale (*Megaptera novaeangliae*), killer whale (*Orcinus orca*), harbor porpoise (*Phocoena phocoena*) and Dall's porpoise (*Phocoenoides dalli*). In addition, estimates of abundance for fin whales (*Balaenoptera physalus*) was computed by pooling sightings across all large whale species (humpback, fin and unidentified large whales) given they may have similar detection characteristics (e.g., Barlow 2001).

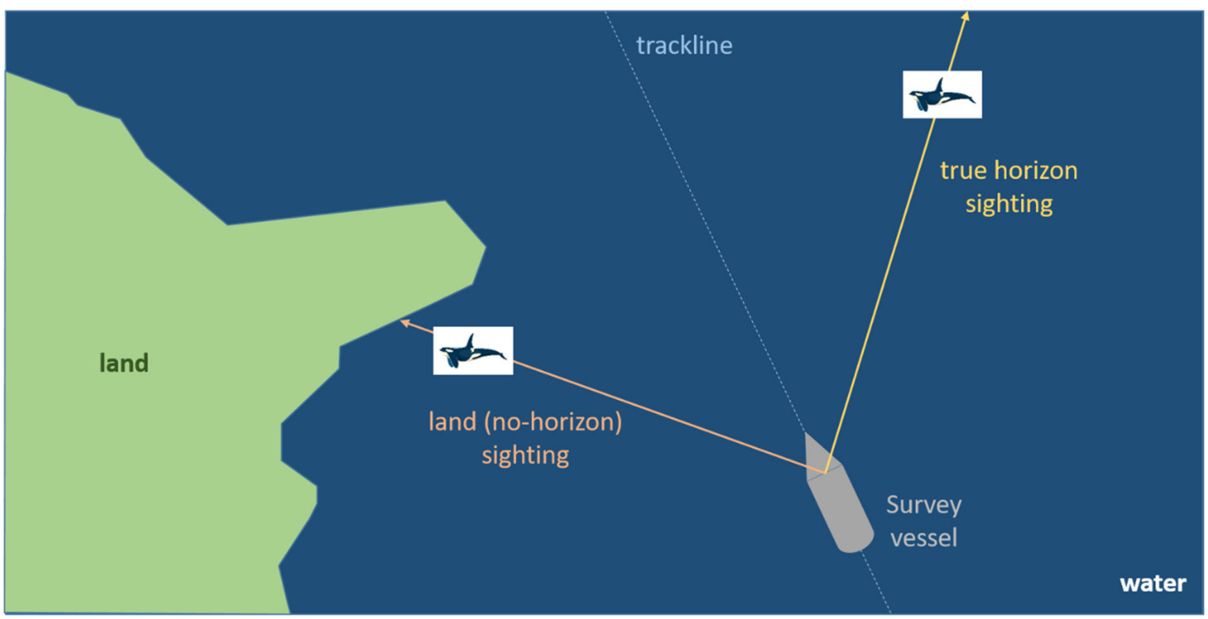


Fig. 2 – Schematics showing the difference between a land (no-horizon, when reticles were taken from the shore because land obstructed the view of the horizon) and a true horizon sighting (when reticles were taken from the actual, unobstructed, horizon).

Calculation of Radial and Perpendicular Distance

Radial distances to each sighted animal or group of animals were computed as described in Dahlheim et al. (2015), by using binocular reticle readings from the horizon or from land when the true horizon was obstructed by land (Fig. 2). All sightings and lines representing the distance to the real horizon, at the correct radial angle, were plotted in ArcGIS Pro. In cases where sightings were seen against land (as opposed to the "true horizon" of water to the furthest extent of sight), the horizon line was truncated wherever it crossed land (Fig. 2). The length of this new line, representing the distance from the observer to the shore at the angle of the sighting, was then converted to "reticles to land" using the formulas described in Lerczak and Hobbs (1998), to account for the corresponding observer height and radians per reticle for 7 x 50 binoculars. Final distance from the observer to the animal was calculated from this new reticle value. Perpendicular distances were computed by multiplying the radial distance by the sine of the radial angle.

Estimation of the Effective Strip Width (ESW) and Detection Probability on the Trackline

Both Conventional (CDS) and Multiple Covariate (MCDS) Distance Sampling methods (Buckland et al. 2001; 2004; Marques and Buckland 2004) were used to estimate detection probability (*P*) by modeling perpendicular distance data truncated at 1.5 km for harbor and Dall's porpoise, 3 km for killer whales, and 3.5 km for fin and humpback whales using sightings detected on transects and on transit lines. These include a large number of sightings seen during the 2019 survey outside of the area of interest in this study (Behm Canal and Clarence Strait). Species-specific sighting data were used to estimate detection probability, except for fin whales. Because of the relatively small number of sightings of this ESA-listed species, perpendicular distance data from fin whales, humpback whales and unidentified large baleen whales (hereafter referred to "large whales") were pooled for the estimation of detection probability.

CDS models assume that environmental covariates do not affect detection probability whereas in MCDS models such covariates (e.g., group size, sea state) are modelled to estimate *P.* Two types of models traditionally used to compute detection probability (Buckland et al. 2001), half normal or hazard rate, were fit to perpendicular distance data. Covariates used to model *P* are summarized in Table 1. Covariate models that did not conform to the detection probability hypothesis being tested were excluded from the analysis. One example of a situation where models are inconsistent with the hypothesis being tested is when detection probability increases as sea state increases (e.g., Zerbini et al. 2006). Because greater sea state reduces detection distances by the observer, detection probability should also decrease. Model selection was conducted following the Akaike Information Criterion (AIC) (Akaike 1973). The average effective strip half width (ESW) was computed by multiplying *P* by the truncation distance.

Table 1. Covariates for detection probability models (with abbreviations used in the model descriptions).

Covariate name	Model abbreviations	Covariate type
Cue	Cue	Categorical (levels: Blow, animal body, splash, and presence of birds)
Distance (km)	Dist	Numerical variable
Group size	Size	Numerical variable
Sea state category (Beaufort)	BeaufCat	Categorical: Low (Beaufort state 0-2) and High (Beaufort state above 3)
Species or species category*	Species	Categorical (species name or category)
Vessel	Vessel	Categorical (R/V Zephyr [2019] and R/V Alaskan Song, [2023 and 2024]).

*The species covariate was only included in the detection probability models used in the estimation of fin whale abundance because data were pooled across large baleen whale species.

One of the main assumptions of distance sampling methods is that animals on the survey line (i.e., when perpendicular distance = 0) are detected with certainty (which is also known as the *g(0)*=1 assumption, Laake and Borchers 2004). This assumption is rarely met in marine mammal surveys, because cetaceans are often submerged and not available for detection as the survey vessel travels along the transect lines. Estimation of the proportion of animals missed (*g[0]*) requires the use of independent survey teams, which implementation was not feasible during this study. Therefore, estimates of *g(0)* were not computed for any species, except harbor porpoise for which an estimate of *g(0)* for inland waters of Southeast Alaska using observation platforms of similar height to the ones employed in this surveys was computed (*g[0]* = 0.53, CV = 0.11; Zerbini et al. 2022). Therefore, estimates of density and abundance of harbor porpoise are corrected for groups missed on the survey line in the present report.

Group Size Estimation

Group size has the potential to influence estimates of detection probability. For example, if larger groups are easier to detect farther away from the trackline than smaller groups, then using average group sizes can bias estimates of density and abundance (Buckland et al. 2001). Exploratory analysis of sighting data (regression of group size versus detection probability) indicated that detections were independent of group size across all years. Therefore, mean group size was used in estimating distance and abundance for Conventional Distance Sampling (CDS) models. For Multiple Covariate Distance Sampling (MCDS) models (see below), estimates of expected group size were obtained by dividing the estimated density of individuals by the estimated density of groups (Marques and Buckland 2004).

Density and Abundance

Estimates of abundance were computed using CDS or MCDS methods (Buckland et al., 2004) for three different regions within the study area: MBW 1 and MBW 2 substrata and the INL stratum using the most supported detection probability model based on the model's AIC score. Statistical analyses were performed using the packages *distance* version 1.0.9 (Miller et al. 2019) and *mrds* version 2.3.0 (Laake et al. 2023) for R statistical software version 4.3.3 (R Development Core Team 2024). Analytical variance of parameters of interest were computed as described in the R packages. Variance of estimates of density and abundance were computed using the method proposed by Fewster et al. (2009) as implemented in the *mrds* package.

Results

Effort

A total of 1400.82 km was surveyed during the three years (Table 2); with 78% (1088.22 km) of the survey effort comprising effort on transect lines (Figure 3) and 22% (312.66 km) on transit lines. The weather conditions limited observation effort to a relatively large extent in the Spring of 2023 and Fall of 2024. Therefore, and because completing transects for density/abundance estimation was the primary goal of the surveys, no deployments of a small boat occurred to collect biopsy samples or deploy satellite tags.

Sightings

A total of 1345 sightings of marine mammals were detected in transit and transect lines during the three surveys (Table 3). These include 958 cetacean sightings, 225 pinniped sightings and 162 sea otter sightings. The majority of these data were observed during the summer 2019 AFSC abundance cruise outside of Behm Canal and lower Clarence Strait (but within inside waters of Southeast Alaska). Perpendicular distance data from on-effort sightings from the summer 2019 survey were used to increase sample size for estimation of detection probability for all species for which density estimates were computed in this report. The overall average group size, CVs, minimum and maximum number of individuals seen for each species is illustrated in Table 3.

Table 2. Effort (km) surveyed on transect and transit in each of the three regions of interest during the Behm Canal surveys.

Year (Season)	Effort type	MBW 1	MBW 2	Inlet	Total
Region area (km^2)		606.9	407.5	122.2	1136.6
2019 (summer)	Transect	70.84	53.70	36.49	161.03
	Transit	44.65	78.00	-	122.65
2023 (spring)	Transect	256.17	178.04	36.99	471.2
	Transit	12.68	81.33	-	94.01
2024 (fall)	Transect	245.32	156.62	54.05	455.99
	Transit	63.02	32.92	-	95.94
All years	Transect	572.33	388.36	127.53	1088.22
	Transit	120.35	192.25	-	312.66
TOTAL Effort		692.68	580.61	127.53	1400.82

Cetacean sightings in the survey area of interest in this study (Behm Canal and lower Clarence Strait) are summarized in Table 4. A total of 140 sightings (125 on-effort and 15 off-effort) of seven species or group of species was documented. On-effort sightings were used to compute region-specific estimates of abundance for Dall's and harbor porpoise, for fin and humpback whales and for killer whales. The distribution of sightings in the summer 2019, spring 2023 and fall 2024 surveys are illustrated in Figs 4-6.

Table 3 – Number of marine mammal sightings and overall group sizes (mean, CV, minimum and maximum) observed in Southeast Alaska during the 2019, 2023 and 2024 surveys (note that no CVs are available for species with single sightings and CV = 0 for species with invariable group sizes).

Species	On-effort	Off-effort	Total	Mean size	CV	Min size	Max size
Dall's porpoise	240	7	247	2.94	0.11	1	10
Fin whale	3	1	4	1.25	0.29	1	2
Harbor porpoise	205	1	206	1.60	0.06	1	5
Humpback whale	406	5	411	1.95	0.09	1	20
Minke whale	2		2	1.00	0.00	1	1
Killer whale	17	2	19	4.74	0.59	2	12
Unidentified cetacean	1		1	1.00	-	1	1
Unidentified large whale	21		21	1.24	0.12	1	3
Unidentified porpoise	46		46	1.74	0.16	1	7
California sea lion		1	1	1.00	0.00	1	1
Harbor seal	181	1	182	1.38	0.15	1	25
Northern elephant seal	2		2	1.00	0.00	1	1
Northern fur seal	1		1	1.00	-	1	1
Steller sea lion	37		37	11.30	8.29	1	300*
Unidentified seal	1		1	1.00	-	1	1
Sea otter	162	1	163	2.87	0.47	1	50

*Sighting of a large group of animals on shore

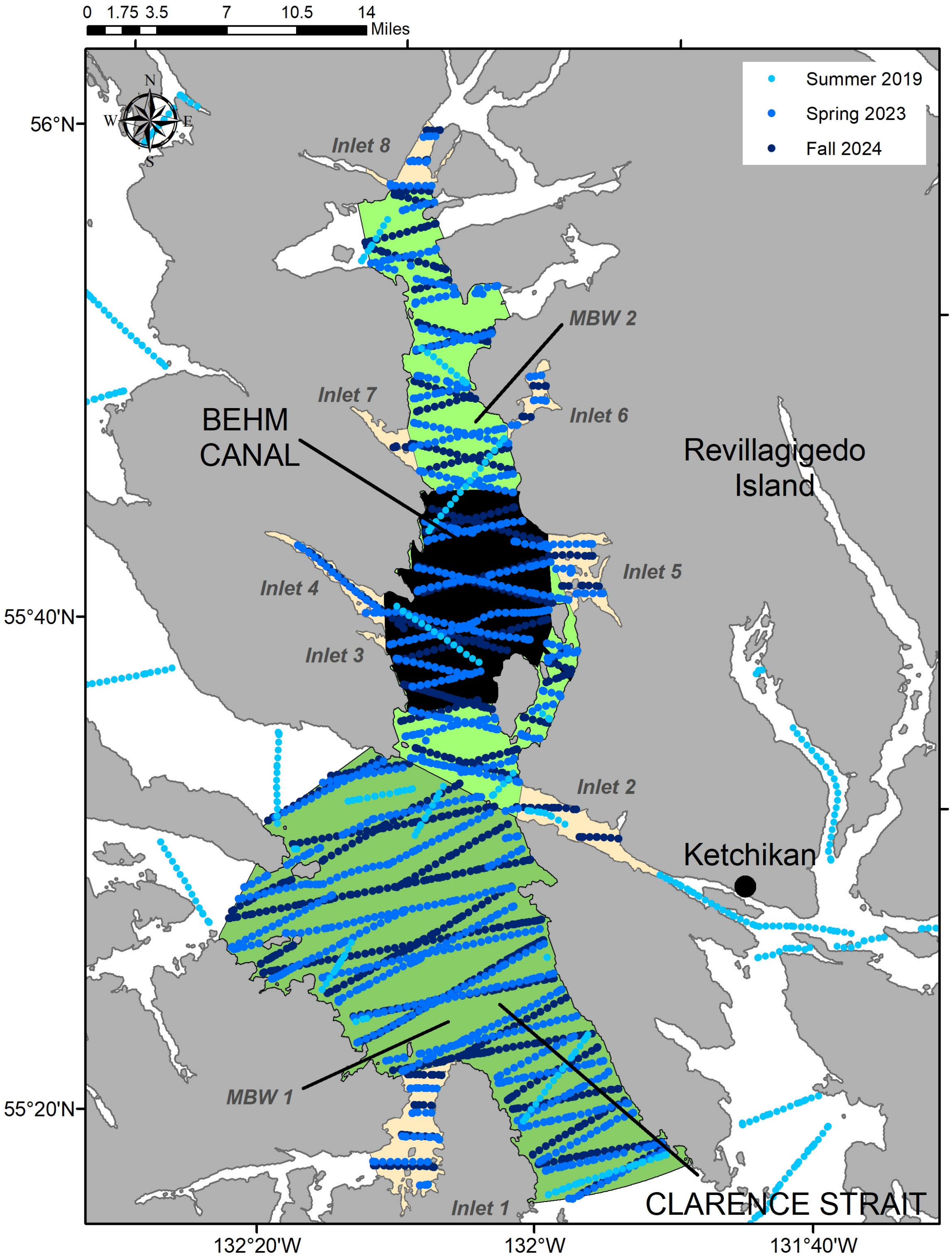


Fig. 3 – Distribution of transect effort for the 2019, 2023 and 2024 surveys in Behm Canal and adjacent areas (MBW 1 [Behm Canal] = light green area, SEAFAC Operational Area = dark grey area, MBW 2 [Clarence Strait] = dark green area, Inlets = light orange areas).

Table 4 – Number of cetacean sightings in Behm Canal and lower Clarence Strait per year and survey region

		2019		2023		2024	
Species	Region	On-effort	Off-effort	On-effort	Off-effort	On-effort	Off-effort
Dall's porpoise	MBW 1	12	-	4	1	11	-
	MBW 2	-	-	12	4	1	-
	Inlet	1	-	2	1	3	-
Fin whale	MBW 1	-	-	-	-	2	-
	MBW 2	-	-	1	1	-	-
	Inlet	-	-	-	-	-	-
Harbor porpoise	MBW 1	2	-	1	-	-	-
	MBW 2	-	-	6	-	2	1
	Inlet	-	-	-	-	-	-
Humpback whale	MBW 1	3	-	1	-	20	2
	MBW 2	2	-	1	1	1	1
	Inlet	-	-	1	-	5	1
Killer whale	MBW 1	-	-	1	2	3	-
	MBW 2	1	-	-	-	-	-
	Inlet	-	-	-	-	-	-
Unidentified large whale	MBW 1	-	-	-	-	18	-
	MBW 2	-	-	1	-	-	-
	Inlet	-	-	-	-	-	-
Unidentified porpoise	MBW 1	3	-	-	-	-	-
	MBW 2	-	-	1	-	1	-
	Inlet	-	-	-	-	-	-

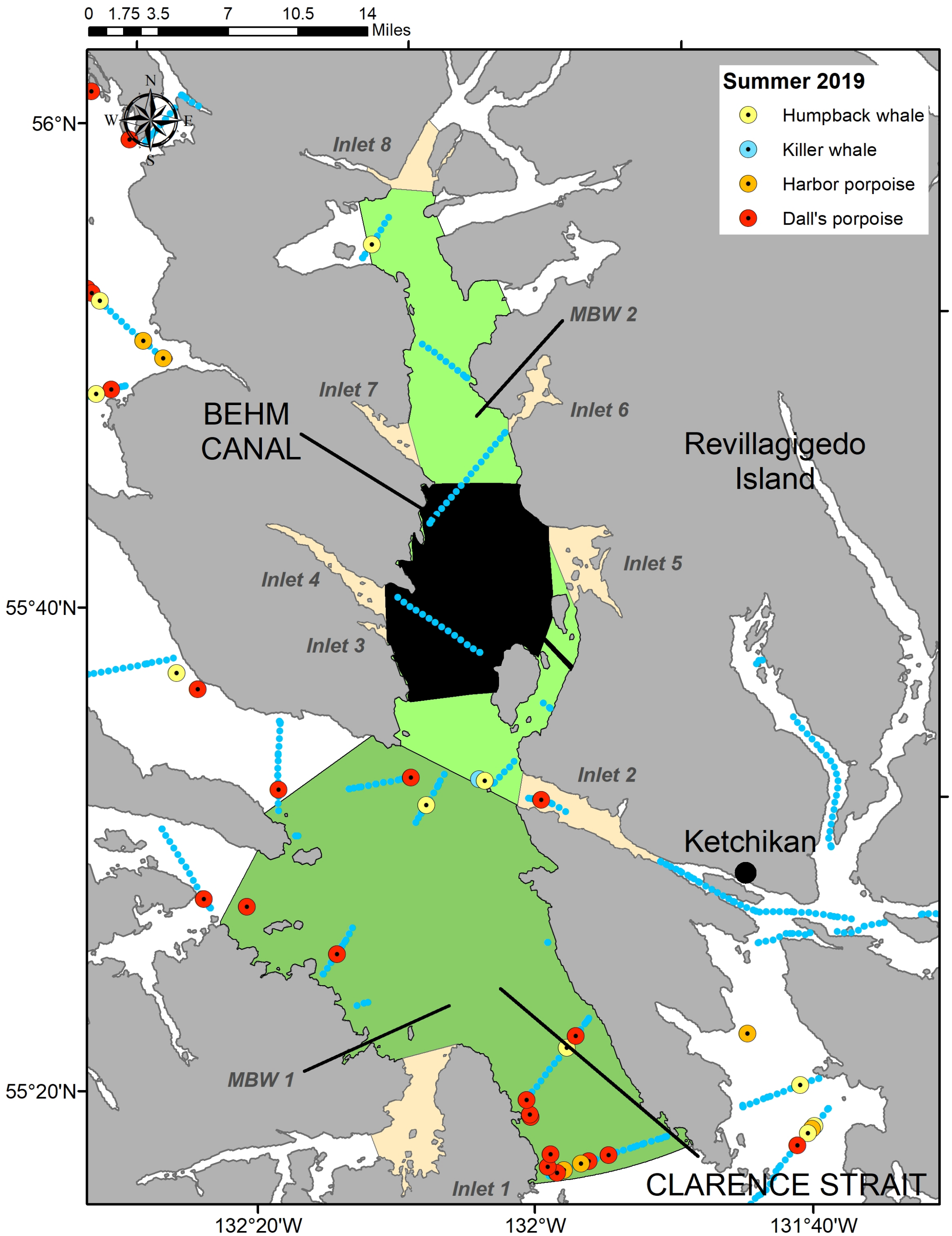


Fig. 4 – Distribution of transect survey effort (blue dots) and cetacean sightings during the 2019 summer survey in Behm Canal and adjacent waters (MBW 1 [Behm Canal] = light green area, SEAFAC Operational Area = dark grey area, MBW 2 [Clarence Strait] = dark green area, Inlets = light orange areas).

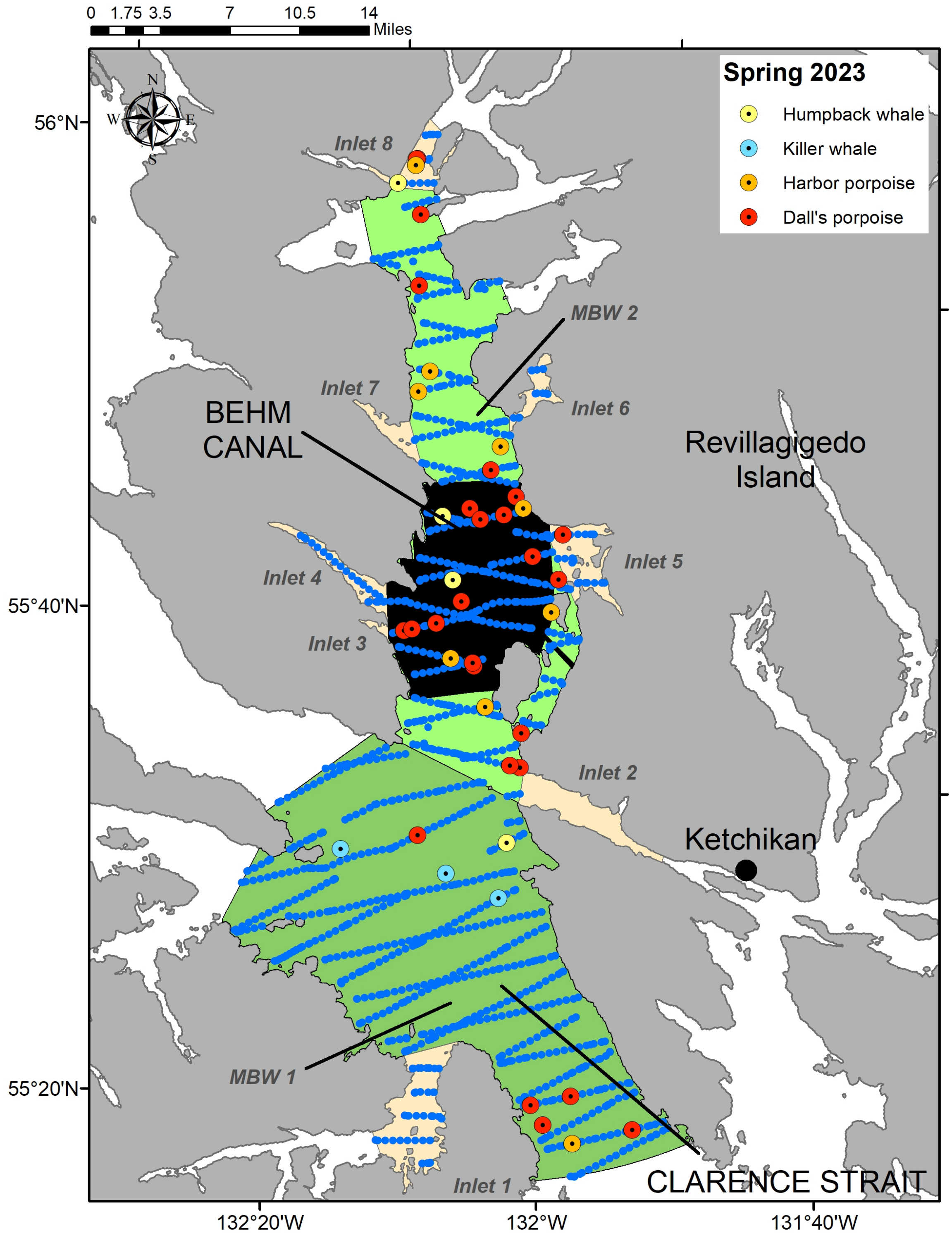


Fig. 5 – Distribution of transect survey effort (blue dots) and cetacean sightings during the 2023 spring survey in Behm Canal and adjacent waters (MBW 1 [Behm Canal] = light green area, SEAFAC Operational Area = dark grey area, MBW 2 [Clarence Strait] = dark green area, Inlets = light orange areas).

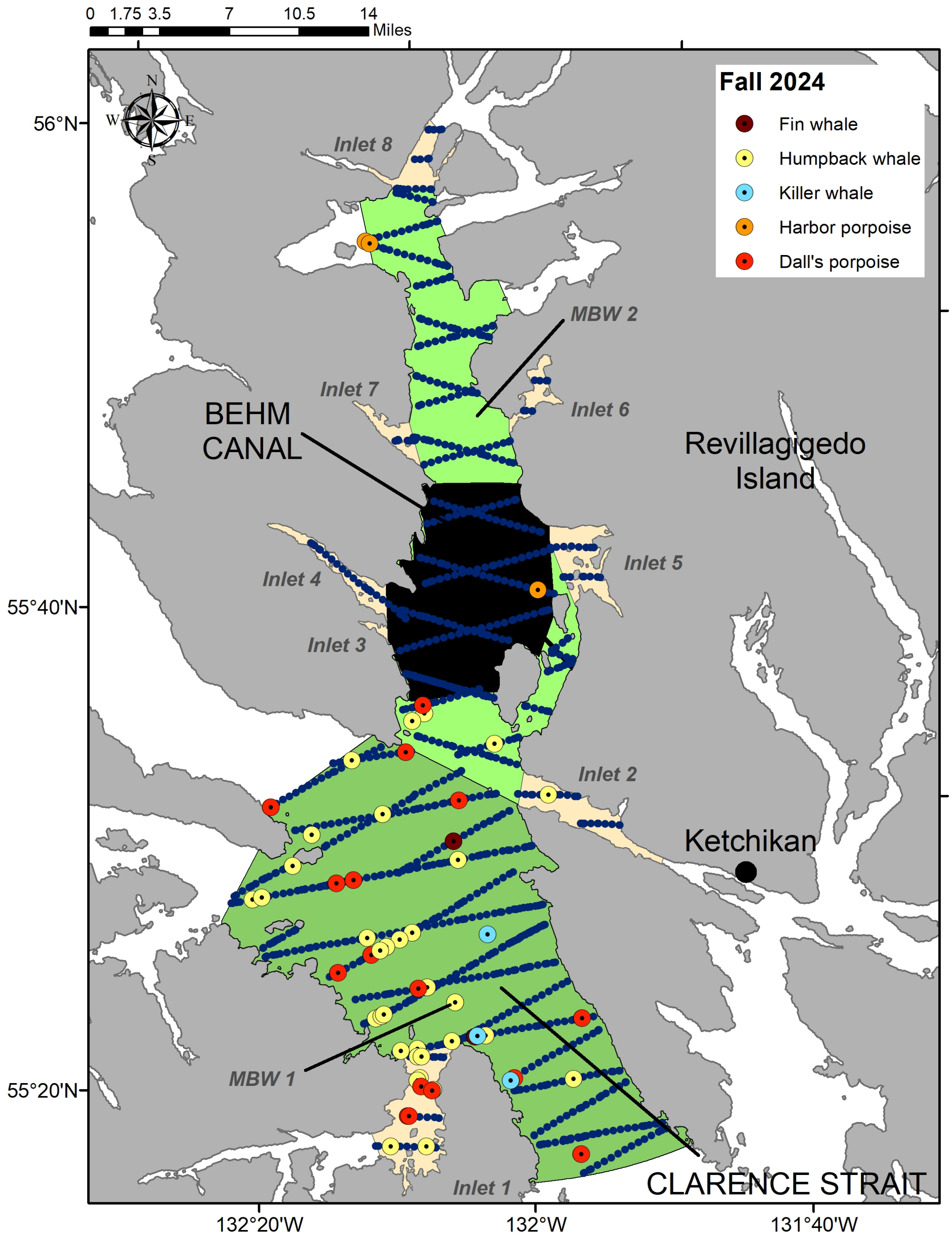


Fig. 6 – Distribution of transect survey effort (blue dots) and cetacean sightings during the 2024 fall survey in Behm Canal and adjacent waters (MBW 1 [Behm Canal] = light green area, SEAFAC Operational Area = dark grey area, MBW 2 [Clarence Strait] = dark green area, Inlets = light orange areas).

Estimates of Density and Abundance

Detection Probability

The set of candidate detection probability models for each species or species group and their associated AIC and Delta AIC values are presented in Appendix 1. The most supported models based on AIC and their respective parameter estimates are provided in Table 5 and model fit of each of these models is illustrated in Appendix 2.

Table 5 – Estimates of detection probability (*P*) and associated uncertainty (standard errors, SE) for the most supported detection probability models (DS = distance sampling, n = number of sightings using to fit the detection function, hn = half normal and hr = hazard rate, size = group size).

	Dall's Porpoise		Harbor Porpoise		Humpback		Large whales		Killer whale	
DS model	~hn + Beaufort Category + Size + Vessel		~hn + Beaufort Category		~hr + Size		~hr + Size + Species		~hn	
n	215		201		383		395		18	
Coefficient/ Parameter	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*	*Estimate*	*SE*
Intercept	-1.15	0.30	-0.74	0.24	-0.035	0.25	-0.38	1.18	0.22	0.21
Beaufort Category (Low)	0.36	0.16	0.32	0.25						
size	0.09	0.05			0.17	0.10	0.15	0.09		
Vessel (Zephyr)	0.32	0.18								
Species[1] (humpback)	N/A		N/A				0.38	1.17	N/A	
Species[1] (unid. large whale)	N/A		N/A				3.02	1.15	N/A	
hr shape parameter	N/A		N/A		0.38	0.18	0.40	0.18	N/A	
Average *P*	0.56	0.03	0.52	0.03	0.56	0.04	0.56	0.04	0.51	0.09

For Dall's porpoise and harbor porpoise, the half normal model function was preferred over the hazard rate and the most supported detection probability model included Beaufort category, group size and vessel as covariates for Dall's and Beaufort category for harbor porpoise. For humpback and for large whales (the model used to estimate fin whale abundance), the hazard

[1] The intercept for covariate species corresponds to "fin whale".

rate function was preferred over the half normal. Group size was present in the most supported detection probability model for both humpback and large whales, but species was also an important covariate for the latter. Finally, for killer whales, the most supported detection probability model was the half normal function without covariate. The choice of a simpler model is probably (at least partially) explained by the small sample size for this species.

Density and abundance

Estimates of density and abundance in the three regions of interest for five cetacean species are provided in Tables 6-10. Seasonal estimates of density and confidence intervals for these species in the two MBW substrata and in the INL strata as a whole are illustrated in Figure 7. Overall seasonal abundance for each species in the survey area is depicted in Fig. 8.

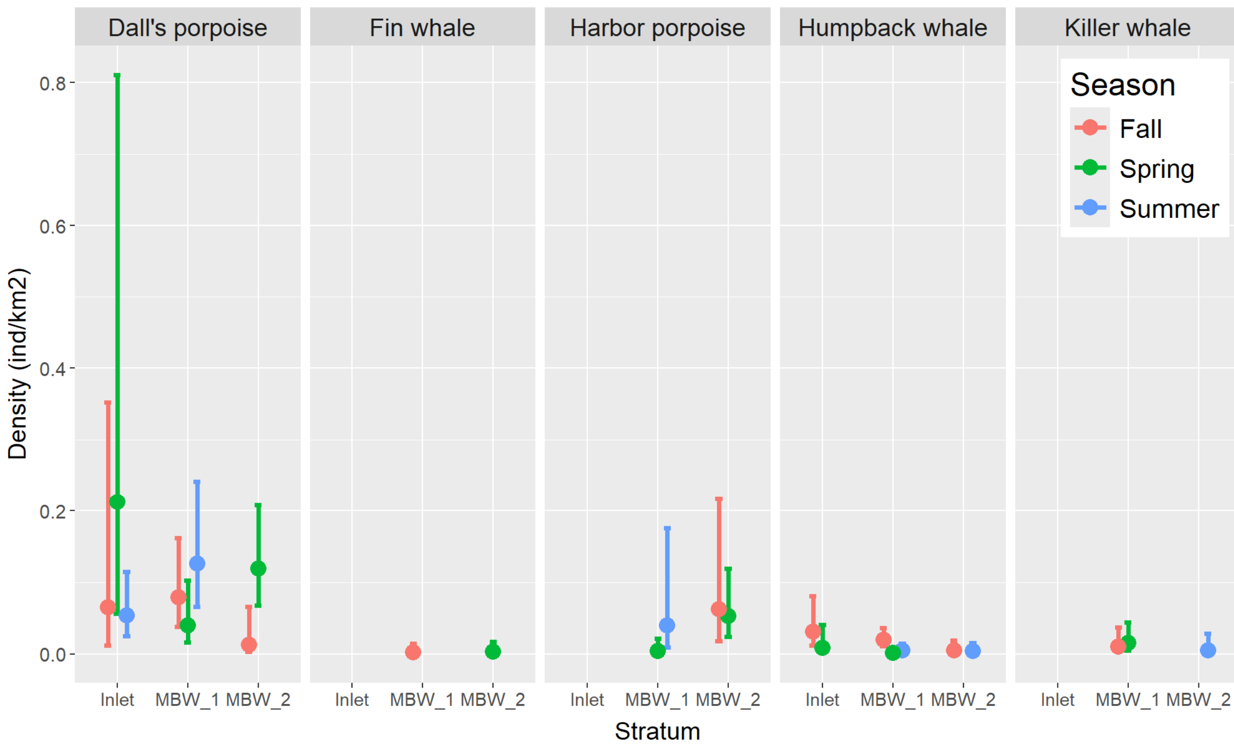


Fig. 7 – Stratum specific seasonal density estimates of five cetacean species in Behm Canal and adjacent areas (point estimates are indicated by a circle and the 95% confidence intervals by the error bars, see also Tables 6-10).

With few exceptions (e.g., Dall's porpoise and humpback whales), these estimates are based on small samples within the survey region either because of limited survey effort (e.g., in 2019) and because of the relatively low density of cetaceans within the area. Consequently, many of the density and abundance estimates are of relatively poor precision (e.g., CVs are greater than 0.5, sometimes exceeding 1.0) and those should be considered with care.

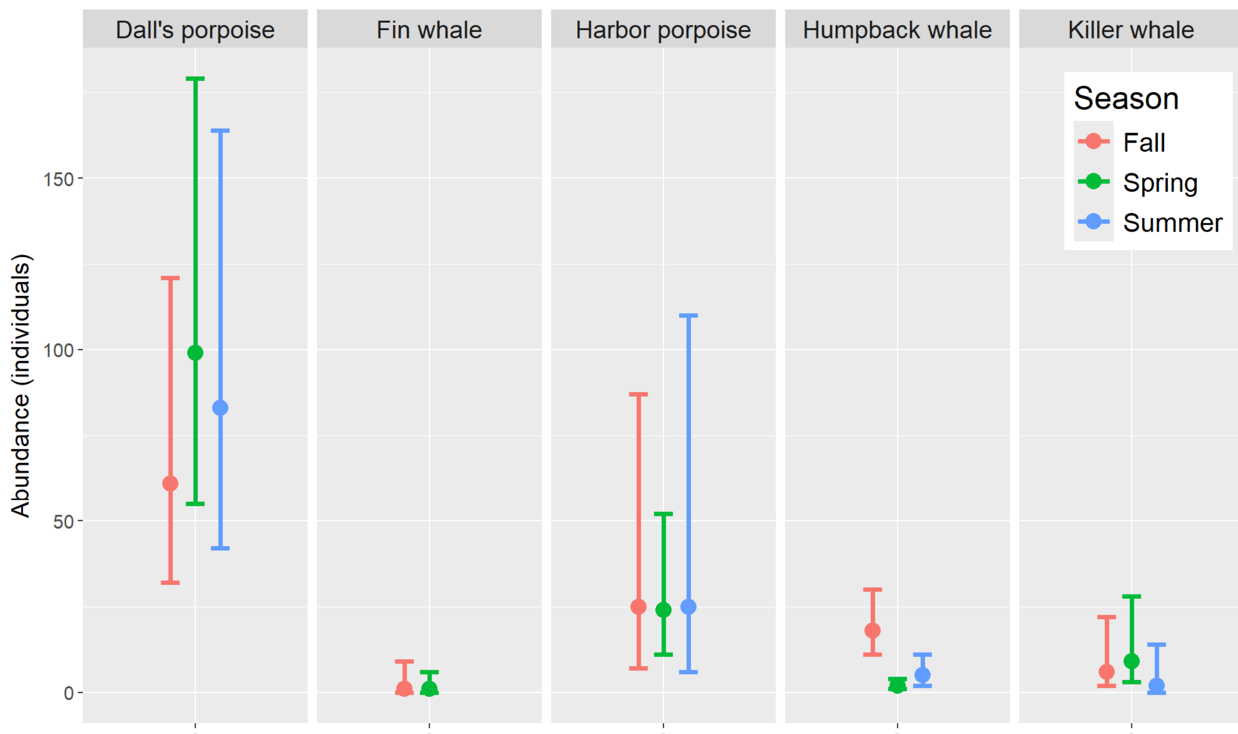


Fig. 8 – Seasonal estimates of abundance for five cetacean species in Behm Canal and adjacent areas (point estimates are indicated by a circle and the 95% confidence intervals by the error bars, see also Tables 6-10).

Discussion

The occurrence of marine mammals documented during the surveys in Behm Canal and adjacent areas is largely consistent with historical distribution of cetaceans in this region (e.g., Dahlheim et al., 2009). The most comprehensive dataset on seasonal presence of these species in southeast Alaska (SEAK) comes from surveys conducted by MML/AFSC/NOAA in inland waters (including Clarence Strait and Behm Canal) between the early 1990s and the mid 2010s (Dahlheim et al., 2009; 2015, Jefferson et al., 2019). During these surveys, all the five species of cetaceans for which abundance estimates were produced here were previously documented in Clarence Strait. All species but fin whales were commonly seen in the spring, summer and fall surveys in this region (Dahlheim et al., 2009). Fin whales were only documented on an occasional basis in the summer, and this study shows that this species also occurs in the region in the spring and the fall.

Historical information on the distribution of cetaceans in Behm Canal were limited because of the relatively low observation effort (Dahlheim et al., 2009). For example, from 1991 to 2007, a total of 38 research cruises were conducted in inlands waters of SEAK in all three seasons. Behm Canal was only briefly sampled in ten of these surveys. One advantage of the present study was that the relatively regional focus of the 2023 and 2024 vessel surveys provided an opportunity to develop a fine scale sampling design for Behm Canal, which demonstrated that harbor porpoise, Dall's porpoise and humpback whales were regularly found within the Canal (and within the SEAFAC Operational Area), as illustrated in Figs 4-6.

Cetaceans were more prevalent in the more open areas (MBW stratum) in the surveyed areas within Behm Canal and Clarence Strait. One two species were documented in the INL stratum, Dall's porpoise and humpback whales, but in a much lower proportion than in the other stratum. This is consistent with findings from previous studies where inlets in SEAK were sampled (Dahlheim et al., 2015; Zerbini et al., 2022).

Density and abundance estimates were computed for the two MBW substrata separately and for all of the INL substrata combined, largely because there were sufficient sample sizes for most species within MBW, but not for individual inlets. Estimates of density varied seasonally for most species (Fig. 7), but it is not possible to identify whether true densities were different across the strata because of the relatively wide and overlapping confidence intervals. Yet, these density estimates provide information necessary to the Navy to fulfill regulatory needs in SEAK. Except for harbor porpoise, density estimates are likely biased low because they are not corrected for cetacean groups missed on the trackline (g[0] was assumed to be 1)

Estimates of absolute abundance suggest that a fraction of the known cetacean stocks occur within the study area. The seasonal abundance of Dall's porpoise in Behm Canal and Clarence Strait ranged between 61 (CV = 0.35) to 99 (CV=0.30) individuals and are not statistically different across seasons. The summer estimate of 83 (CV = 0.32) porpoise in the study area in 2019, represents only 4% of the most recent estimate for the whole of SEAK in 2012 (N = 1991, CV = 0.19, Jefferson et al., 2019), which constitutes part of the Dall's porpoise Alaska Stock (Young et al., 2024; Parsons et al., 2025). Abundance of harbor porpoise in Behm Canal and lower Clarence Strait was also consistent across seasons, with nearly 25 individuals estimated to occur in the area (Table 7, Fig. 8). Harbor porpoise in this region is part of the Southern SEAK Inland Waters stock (Young et al., 2024), which is considered a strategic stock because current levels of Potential Biological Removal (PBR), estimated at 6.1 porpoise, are already exceeded by bycatch estimates (Zerbini et al., 2022). Any additional human-induced mortality to porpoise in the survey region is likely going to negatively affect this stock.

Abundance of both humpback and killer whales were relatively low (maximum estimates were 18 humpback whales [CV=0.25] and in the fall and 9 killer whales [CV = 0.6] in the Spring). The National Marine Fisheries Service (NMFS) recognizes three humpback whale Distinct Population Segments (DPS) in the North Pacific: Central America (listed as Endangered under the ESA), Mexico (listed as Threatened under the ESA) and Hawaii (not listed). In addition, NMFS recognizes that three killer whale ecotypes inhabit the North Pacific: offshore, resident and transient killer whales. The waters of SEAK are visited by two humpback whale DPSs and all three of the killer whale ecotypes. It is unclear whether the whales observed in this study correspond to one or two of these DPS and it was not possible to assign killer whale sightings to ecotype during the surveys conducted during this study. Further information (e.g., biopsy samples, photo-identification data) are required to assigns humpback and killer whales to their respective DPS and ecotypes.

Table 6 – Seasonal estimates of encounter rate (ER, groups/km), expected group size (E[S], individuals/group), density of groups (D[g], groups/km^2), density of individuals (D[i] ind/km^2) abundance (N, individuals) and their respective coefficients of variation (CV) and 95% lower (LCL) and upper (UCL) confidence intervals for Dall's porpoise.

Region	ER	CV(ER)	E(S)	CV(E[S])	D(g)	CV(D[g])	D (i)	CV(D[i])	N	CV(N)	95% LCL	95% UCL
Inlet (Summer)	0.027	0	4	3.49	0.013	0.78	0.054	0.4	7	0.4	0	324
MBW_1 (Summer)	0.095	0.33	2.25	0.27	0.056	0.33	0.126	0.34	76	0.34	37	159
MBW_2 (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Summer)			*2.33*	*0.29*	*0.010*	*0.31*	*0.024*	*0.32*	*83*	*0.32*	*42*	*164*
Inlet (Spring)	0.081	0.77	3.04	0.65	0.07	0.86	0.213	0.77	26	0.77	6	110
MBW_1 (Spring)	0.019	0.5	2.91	0.63	0.014	0.53	0.04	0.51	24	0.51	9	65
MBW_2 (Spring)	0.054	0.24	3.01	0.41	0.04	0.29	0.119	0.29	49	0.29	28	86
TOTAL (Spring)			*2.99*	*0.31*	*0.010*	*0.32*	*0.029*	*0.30*	*99*	*0.30*	*55*	*179*
Inlet (Fall)	0.037	1.04	2.48	0.01	0.026	1.05	0.065	1.05	8	1.05	1	50
MBW_1 (Fall)	0.032	0.28	3.42	1.09	0.023	0.31	0.079	0.38	48	0.38	23	102
MBW_2 (Fall)	0.005	0.98	4	0	0.003	0.99	0.013	0.99	5	0.99	1	29
TOTAL (Fall)			*3.3*	*0.84*	*0.005*	*0.32*	*0.018*	*0.35*	*61*	*0.35*	*32*	*121*

Table 7 – Seasonal estimates of encounter rate (ER, groups/km), expected group size (E[S], individuals/group), density of groups (D[g], groups/km^2), density of individuals (D[i] ind/km^2) abundance (N, individuals) and their respective coefficients of variation (CV) and 95% lower (LCL) and upper (UCL) confidence intervals for harbor porpoise (note that densities and abundance are corrected for g[0], where g[0] = 0.53 and CV(g[0]) = 0.11).

Region	ER	CV(ER)	E(S)	CV(E[S])	D(g)	CV(D[g])	D (i)	CV(D[i])	N	CV(N)	95% LCL	95% UCL
Inlet (Summer)	-	-	-	-	0.000		0.000	-	0	-	-	-
MBW_1 (Summer)	0.017	0.86	2	0	0.021	0.88	0.040	0.88	25	0.88	6	110
MBW_2 (Summer)	-	-	-	-	0.000		0.000		0		-	-
TOTAL (Summer)					*0.004*	*0.88*	*0.008*	*0.88*	*25*	*0.88*	*6*	*110*
Inlet (Spring)	-	-	-	-	0.000		0.000		0		-	-
MBW_1 (Spring)	0.004	1.01	1	0	0.004	1.03	0.004	1.03	2	1.03	1	11
MBW_2 (Spring)	0.023	0.4	1.75	0.3	0.030	0.43	0.053	0.43	21	0.43	9	47
TOTAL (Spring)					*0.008*	*0.41*	*0.008*	*0.41*	*24*	*0.41*	*11*	*52*
Inlet (Fall)	-	-	-	-	0.000		0.000		0		-	-
MBW_1 (Fall)	-	-	-	-	0.000		0.000		0		-	-
MBW_2 (Fall)	0.011	0.7	5	0	0.013	0.71	0.062	0.71	25	0.71	7	87
TOTAL (Fall)					0.002	*0.71*	*0.008*	*0.71*	*25*	*0.71*	*7*	*87*

Table 8 - Seasonal estimates of encounter rate (ER, groups/km), expected group size (E[S], individuals/group), density of groups (D[g], groups/km^2), density of individuals (D[i] ind/km^2) abundance (N, individuals) and their respective coefficients of variation (CV) and 95% lower (LCL) and upper (UCL) confidence intervals for humpback whales.

Region	ER	CV(ER)	E(S)	CV(E[S])	D(g)	CV(D[g])	D (i)	CV(D[i])	N	CV(N)	95% LCL	95% UCL
Inlet (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Summer)	0.017	0.54	1	0	0.005	0.55	0.005	0.55	3	0.55	1	9
MBW_2 (Summer)	0.015	0.75	1	0	0.004	0.75	0.004	0.75	2	0.75	0	8
TOTAL (Summer)			*1*	*0*	*0.001*	*0.45*	*0.001*	*0.45*	*5*	*0.45*	*2*	*11*
Inlet (Spring)	0.027	0.99	1	0	0.008	1.00	0.008	1.00	1	1	0	5
MBW_1 (Spring)	0.004	0.99	1	0	0.001	1.00	0.001	1.00	1	1	0	4
MBW_2 (Spring)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Spring)			*1*	*0*	*0.002*	*0.72*	*0.002*	*0.72*	*2*	*0.72*	*1*	*4*
Inlet (Fall)	0.111	0.51	1	0	0.031	0.52	0.031	0.52	4	0.52	1	11
MBW_1 (Fall)	0.052	0.27	1.45	0.16	0.014	0.28	0.02	0.3	12	0.3	7	22
MBW_2 (Fall)	0.011	0.69	1.9	0.71	0.003	0.7	0.005	0.75	2	0.75	1	8
TOTAL (Fall)			*1.36*	*0.13*	*0.004*	*0.24*	*0.005*	*0.25*	*18*	*0.25*	*11*	*30*

Table 9 - Seasonal estimates of encounter rate (ER, groups/km), expected group size (E[S], individuals/group), density of groups (D[g], groups/km^2), density of individuals (D[i] ind/km^2) abundance (N, individuals) and their respective coefficients of variation (CV) and 95% lower (LCL) and upper (UCL) confidence intervals for fin whales.

Region	ER	CV(ER)	E(S)	CV(E[S])	D(g)	CV(D[g])	D (i)	CV(D[i])	N	CV(N)	95% LCL	95% UCL
Inlet (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_2 (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
Inlet (Spring)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Spring)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_2 (Spring)	0.008	0.68	1	0	0.003	1.1	0.003	1.1	1	1.1	0	6
TOTAL (Spring)			*1*	*0*	*0.003*	*1.1*	*0.003*	*1.1*	*1*	*1.1*	*0*	*6*
Inlet (Fall)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Fall)	0.003	0.99	2	0	0.001	1.29	0.002	1.29	1	1.29	0	9
MBW_2 (Fall)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Fall)			*2*	*0*	*0.001*	*1.29*	*0.002*	*1.29*	*1*	*1.29*	*0*	*9*

Table 10 - Seasonal estimates of encounter rate (ER, groups/km), expected group size (E[S], individuals/group), density of groups (D[g], groups/km^2), density of individuals (D[i] ind/km^2) abundance (N, individuals) and their respective coefficients of variation (CV) and 95% lower (LCL) and upper (UCL) confidence intervals for killer whales.

Region	ER	CV(ER)	E(S)	CV(E[S])	D(g)	CV(D[g])	D (i)	CV(D[i])	N	CV(N)	95% LCL	95% UCL
Inlet (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Summer)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_2 (Summer)	0.008	1.06	2	0	0.002	1.07	0.005	1.07	2	1.07	0	14
TOTAL (Summer)			*2*	*0*	*0.002*	*1.07*	*0.005*	*1.07*	*2*	*1.07*	*0*	*14*
Inlet (Spring)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Spring)	0.011	0.53	4	0.96	0.004	0.57	0.015	0.6	9	0.6	3	28
MBW_2 (Spring)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Spring)			*4*	*0.96*	*0.004*	*0.57*	*0.015*	*0.6*	*9*	*0.6*	*3*	*28*
Inlet (Fall)	-	-	-	-	-	-	-	-	-	-	-	-
MBW_1 (Fall)	0.006	0.7	4.5	0.36	0.002	0.73	0.010	0.74	6	0.74	2	22
MBW_2 (Fall)	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (Fall)			*4.5*	*0.36*	*0.002*	*0.73*	*0.010*	*0.74*	*6*	*0.74*	*2*	*22*

References

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. pp.267-81. In: Petran, B.N. and Csaáki, F. (eds). International Symposium on Information Theory. Akademia Kiado, Budapest, Hungary. 451pp.

Barlow, J., Gerrodette, T. and Forcada, J. 2001. Factors affecting perpendicular sighting distances on shipboard line-transect surveys for cetaceans. *Journal of Cetacean Research Management* 3(2): 201-212.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. 2001. Introduction to Distance Sampling: Estimating Abundance of Biological Populations. Oxford University Press, New York, USA. vi+xv+432pp.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L. 2004. Advanced Distance Sampling. Oxford University Press, New York, USA. 416pp.

Dahlheim, M. E., P. A. White, and J. M. Waite. 2009. Cetaceans of southeast Alaska: Distribution and seasonal occurrence. *Journal of Biogeography* 36: 410-426.

Dahlheim, M.E., Zerbini, A.N., Waite, J.M. and Kennedy, A.S. 2015. Temporal changes in abundance of harbor porpoise (*Phocoena phocoena*) inhabiting the inland waters of Southeast Alaska. *Fishery Bulletin* 113(3): 242-55.

Fewster, R.M., Buckland, S.T., Burnham, K.P., Borchers, D., Jupp, P.E., Laake, J. and Thomas, L. 2009. Estimating the encounter rate variance in distance sampling. *Biometrics* 65(1): 225-36.

Hammond, P.S., Francis, T.B., Heinemann, D., Long, K.J., Moore, J.E., Punt, A.E., Reeves, R.R., Sepúlveda, M., Sigurðsson, G.M., Siple, M.C., Víkingsson, G., Wade, P.R., Williams, R. and Zerbini, A.N. 2021. Estimating the abundance of marine mammal populations. *Frontiers in Marine Science* 8: 735770.

Hiby, A.R. and Hammond, P.S. 1989. Survey techniques for estimating abundance of cetaceans. *Report of the International Whaling Commission* (special issue) 11: 47-80.

Jefferson, T.A., Dahlheim, M.E., Zerbini, A.N., Waite, J.M. and Kennedy, A.S. 2019. Abundance and Seasonality of Dall's Porpoise (*Phocoenoides dalli*) in Southeast Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-385, 45 p.

Laake, J. and Borchers, D. 2004. Methods for incomplete detection at distance zero. pp.108-89. In: Buckland, S.T., Anderson, K.P., Burnham, K.P., Laake, J., Borchers, D. and Thomas, L. (eds). Advanced Distance Sampling. Oxford University Press, Oxford. 595pp.

Laake, J., Borchers, D., Thomas, L., Miller, D., Bishop, J. and McArthur, J. 2023. Mrds: Mark-Recapture Distance Sampling. R package version 2.2.9 <https://CRAN.R-project.org/package=mrds>.

Lerczak, J.A. and Hobbs, R.C. 1998. Calculating sighting distances from angular readings during shipboard, aerial, and shore-based marine mammal surveys. *Marine Mammal Science* 14(3): 590-99. [See Errata. 1998. Mar. Mammal Sci. 14(4):903].

Marques, F.F.C. and Buckland, S.T. 2004. Covariate models for the detection function. pp.31-47. In: Buckland, S.T., Anderson, K.P., Burnham, K.P., Laake, J., Borchers, D. and Thomas, L. (eds). Advanced Distance Sampling. Oxford University Press, Oxford. 595pp.

Miller D.L., Rexstad, E., Thomas, L., Marshall, L. and Laake, J.L. 2019. Distance Sampling in R. *Journal of Statistical Software* 89(1): 1-28. https://doi.org/10.18637/jss.v089.i01

Parsons, Kim M., May, Samuel A., Gold, Z., Dahlheim, M., Gabriele, C., Straley, Janice M., Moran, John R., Goetz, K., Zerbini, Alexandre N., Park, L. and Morin, Phillip A. 2025. Using eDNA to Supplement Population Genetic Analyses for Cryptic Marine Species: Identifying Population Boundaries for Alaska Harbour Porpoises. *Molecular Ecology* 34(5): e17563.

R Core Team 2024. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

Strindberg, S., & Buckland, S. T. 2004. Zigzag survey designs in line transect sampling. *Journal of Agricultural, Biological, and Environmental Statistics* 9(4): 443.

Thomas, L., Buckland, S.T., Rexstad, E.A., Laake, J.L., Strindberg, S., Hedley, S.L., Bishop, J.R., Marques, T.A. and Burnham, K.P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology* 47(1): 5-14.

Thomas, L., Williams, R. and Sandilands, D. 2007. Designing line transect surveys for complex survey regions. *Journal of Cetacean Research and Management* 9: 1–13.

Young, N. C., Brower, A. A., Muto, M. M., Freed, J. C., Angliss, R. P., Friday, N. A., Birkemeier, B. D., Boveng, P. L., Brost, B. M., Cameron, M. F., Crance, J. L., Dahle, S. P., Fadely, B. S., Ferguson, M. C., Goetz, K. T., London, J. M., Oleson, E. M., Ream, R. R., Richmond, E. L., Shelden, K. E. W., Sweeney, K. L., Towell, R. G., Wade, P. R., Waite, J. M., and Zerbini, A. N. 2024. Alaska marine mammal stock assessments, 2023. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-493, 327 p.

Zerbini, A.N., Waite, J.M., Laake, J.L. and Wade, P.R. 2006. Abundance, trends and distribution of baleen whales off Western Alaska and the central Aleutian Islands. *Deep Sea Research Part I: Oceanographic Research Papers* 53(11): 1772-90.

Zerbini, A.N., Goetz, K.T., Forney, K.A. and Boyd, C. 2022. Estimating abundance of an elusive cetacean in a complex environment: Harbor porpoises (*Phocoena phocoena*) in inland waters of Southeast Alaska. Frontiers in Marine Science 9:966489. https://doi.org/10.3389/fmars.2022

Appendix 1 – Model selection tables for distance sampling models proposed in this study.

Dall's porpoise

Key function	Model	AIC	Delta AIC
hn	~size+as.factor(BeaufCat)+Vessel	107.602	0.000
hn	~as.factor(BeaufCat)	108.492	0.890
hn	~size+as.factor(BeaufCat)	108.575	0.973
hn	~1	109.136	1.534
hn	~as.factor(BeaufCat)+Vessel	109.620	2.018
hn	~size+Vessel	109.834	2.232
hn	~size	110.052	2.450
hn	~Vessel	110.480	2.878
hr	~1	113.401	5.799
hr	~as.factor(BeaufCat)	113.483	5.880
hr	~size+as.factor(BeaufCat)	114.046	6.444
hr	~size	114.726	7.124
hr	~size+as.factor(BeaufCat)+Vessel	115.142	7.540
hr	~Vessel	115.391	7.789
hr	~as.factor(BeaufCat)+Vessel	115.416	7.813
hr	~size+Vessel	116.695	9.093

Harbor porpoise

Key function	Model	AIC	Delta AIC
hn	~as.factor(BeaufCat)	82.770	0.000
hn	~1	82.780	0.010
hr	~Vessel	82.968	0.198
hn	~as.factor(BeaufCat)+Vessel	83.293	0.523
hn	~Vessel	83.474	0.704
hr	~1	84.439	1.670
hn	~size+as.factor(BeaufCat)	84.768	1.998
hn	~size	84.775	2.005
hr	~as.factor(BeaufCat)+Vessel	84.846	2.076
hr	~size+Vessel	84.952	2.182
hn	~size+as.factor(BeaufCat)+Vessel	85.281	2.511
hn	~size+Vessel	85.448	2.678
hr	~size	86.165	3.395
hr	~as.factor(BeaufCat)	86.430	3.660

hr	~size+as.factor(BeaufCat)+Vessel	86.814	4.044
hr	~size+as.factor(BeaufCat)	88.165	5.395

Humpback whales

Key function	Model	AIC	Delta AIC
hr	~size	868.525	0.000
hr	~size+as.factor(BeaufCat)	869.222	0.697
hr	~size+Vessel	870.483	1.958
hr	~1	871.114	2.589
hr	~size+as.factor(BeaufCat)+Vessel	871.207	2.683
hn	~size	872.069	3.545
hr	~as.factor(BeaufCat)	872.746	4.221
hr	~Vessel	873.070	4.545
hn	~1	873.539	5.014
hn	~size+as.factor(BeaufCat)	873.990	5.465
hn	~size+Vessel	874.053	5.528
hr	~as.factor(BeaufCat)+Vessel	874.659	6.134
hn	~Vessel	875.394	6.869
hn	~as.factor(BeaufCat)	875.538	7.014
hn	~size+as.factor(BeaufCat)+Vessel	875.957	7.432
hn	~as.factor(BeaufCat)+Vessel	877.382	8.857

Large whales

Key function	Model	AIC	Delta AIC
hr	~size+as.factor(Species_Name)	900.5479	0.0000
hr	~size+as.factor(BeaufCat)+as.factor(Species_Name)	901.3242	0.7764
hr	~as.factor(Species_Name)	902.8489	2.3011
hn	~size+as.factor(Species_Name)	902.9659	2.4180
hr	~size+as.factor(BeaufCat)	903.4488	2.9009
hr	~size	903.8374	3.2895
hn	~as.factor(Species_Name)	904.2866	3.7388
hr	~as.factor(BeaufCat)+as.factor(Species_Name)	904.5054	3.9575

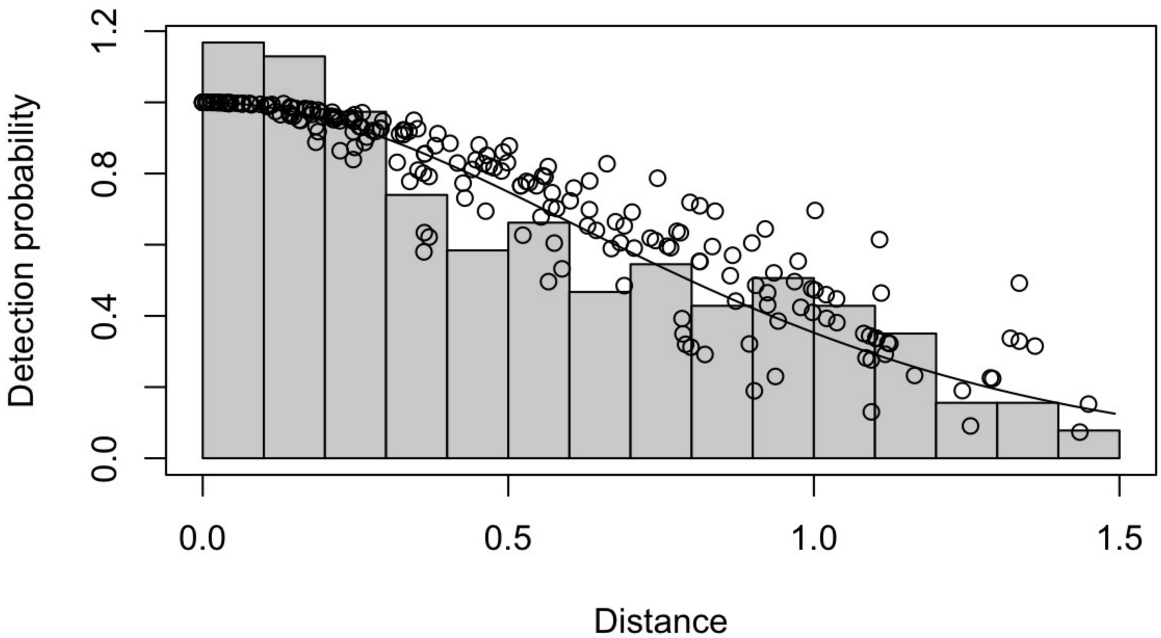
hn	~size+as.factor(BeaufCat)+as.factor(Species_Name)	904.8893	4.3414
hr	~1	905.5807	5.0329
hn	~as.factor(BeaufCat)+as.factor(Species_Name)	906.2858	5.7379
hr	~as.factor(BeaufCat)	906.4894	5.9416
hn	~size	908.5598	8.0119
hn	~1	908.9184	8.3706
hn	~size+as.factor(BeaufCat)	910.0680	9.5201
hn	~as.factor(BeaufCat)	910.7105	10.1627

Orcas

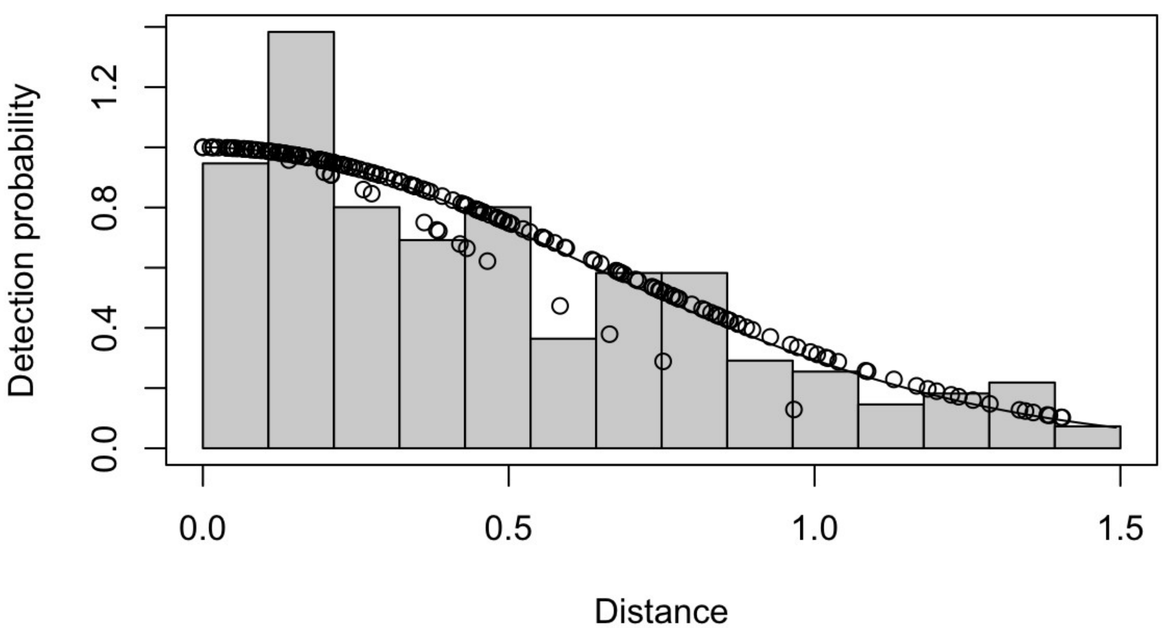
Key function	Model	AIC	Delta AIC
hn	~1	33.508	0.000
hn	~as.factor(BeaufCat)	34.605	1.097
hn	~size	34.963	1.455
hr	~1	35.793	2.285
hr	~size	35.971	2.463
hr	~as.factor(BeaufCat)	37.310	3.801

Appendix 2 – Most supported detection probability models as described in Table 5 (distance in km)

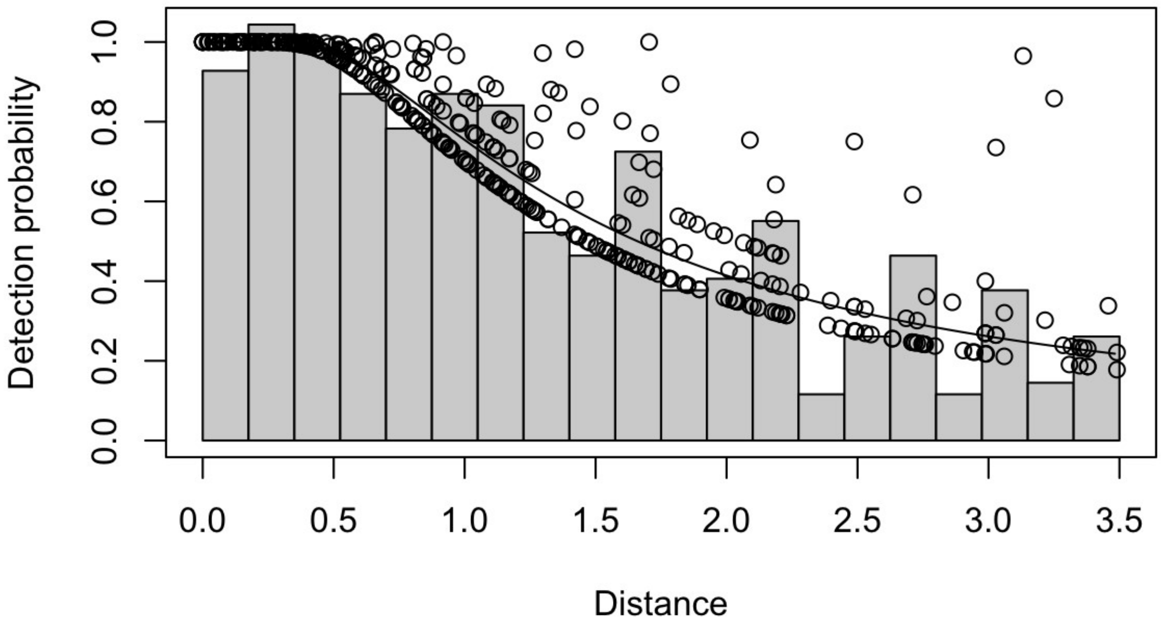
Dall's porpoise (model: ~hn + BeaufCat + Size + Vessel)



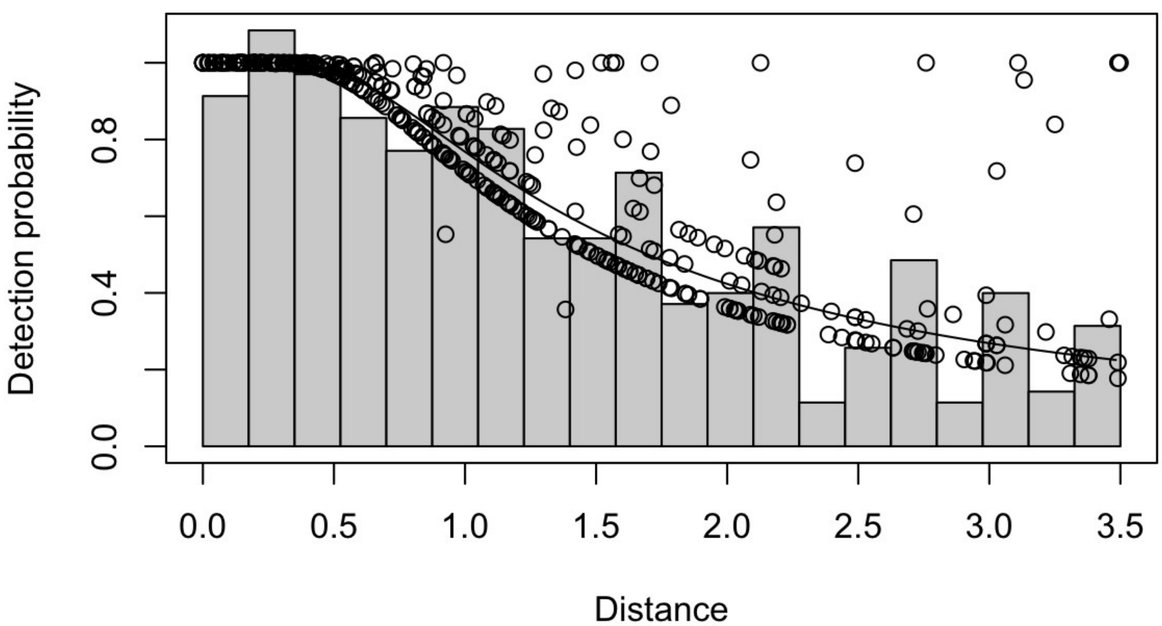
Harbor porpoise (model: ~hn + BeaufCat)



Humpback whale (model: ~hr + Size)



Large whales (model: ~hr + Size + Species)



Orca (model: ~hn)