Status report for the acoustic and visual survey for cetaceans in Behm Canal and Southern Clarence Strait, Alaska

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Abstract

The Navy is interested in understanding marine mammal seasonal density and occurrence in and around a U.S. Navy Installation and Operation Area that is located within Behm Canal, in inland waters of Southeast Alaska. In this report, the results of a marine mammal vessel survey are described. This survey implemented visual line transect and passive acoustic methods to assess the presence and distribution and to estimate density and abundance of cetaceans in Behm Canal and central Clarence Strait. The study area was divided in two strata to optimize allocation of survey effort and to sample multiple habitats where species of interest, including harbor porpoise (*Phocoena phocoena*), are known or suspected to occur. Sonobuoys were used during the visual survey to augment visual observations with acoustic detections. A total of 320 nm (592.6 km) were successfully surveyed on proposed trackline and in transit between tracklines or from/to the harbor. A total of 75 sightings (162 individuals) of eight species were documented. The most frequently sighted species were Dall's porpoise (26 sightings of 81 individuals) and sea otters (26 sightings of 40 individuals), followed by harbor porpoise (9 sightings, 16 individuals), humpback whales (4 sightings, 5 individuals), killer whales (3 sightings, 12 individuals), fin whales (2 sightings, 2 individuals), Steller sea lion (1 sighting of 1 individual), and harbor seals (1 sighting of 1 individual). There were an additional three sightings, one of a single unidentified large whale and two sightings of three unidentified porpoises. A total of 18 sonobuoys were deployed, of which 15 successfully transmitted, for a success rate of 83.3%. The only species detected on sonobuoys were killer whales, detected on four buoys (26.7%). No sonobuoys were deployed for the first two days of the survey due to SEAFAC operations at the static site.

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14. ABSTRACT
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Background

Southeast Alaska Acoustic Measurement Facility (SEAFAC) is managed by Naval Base Kitsap and located at Back Island, in Behm Canal, Southeast Alaska. Multiple species listed under the Endangered Species Act (ESA) occur in this area, including humpback whales (*Megaptera novaeangliae*) (Mexico Distinct Population Segment [DPS]) and fin whales (*Balaenoptera physalus*), along with unlisted stocks of killer whales (*Orcinus orca*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), harbor porpoise (*Phocoena phocoena*), Dall's porpoise (*Phocoenoides dalli*), and Pacific white-sided dolphins (*Lagenorhynchus obliquidens*). The Navy maintains several in-water assets within Behm Canal. Maintenance of these assets require updated marine mammal mapping to provide temporal and spatial information on cetacean density to support the preparation of environmental planning documentation, including those needed for National Environmental Policy Act (NEPA), Marine Mammal Protection Act (MMPA), and Endangered Species Act (ESA) consultations.

The NMFS, 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 2023; 2) execute the survey using ship-based visual and limited passive acoustic methods; and 3) deliver a report on the survey design and results, including data for use in density modeling that will be undertaken by the Navy by January 2024.

Summary of tasks

The AFSC and CICOES developed and implemented a quantitative survey design for a ship-based visual and acoustic assessment of cetaceans in Behm Canal and Clarence Strait based on previous cetacean surveys in the study area. The survey was designed for maximum effectiveness and efficiency and included strata based on known distributions of key species and environmental features. Photographs of key species were collected when practicable for purposes of stock identification (humpback whales, killer whales) and abundance estimation. Incidental sighting data of pinnipeds and sea otters was also collected. The specific objectives were to:

1) Use visual and acoustic survey techniques to collect occurrence, distribution, and abundance data for cetaceans in Behm Canal and Clarence Strait (Fig. 1). Information on pinnipeds and sea otters will be collected opportunistically. Data collected will inform future density estimation efforts carried out by AFSC and the Navy.

2) Prepare a report on results from the survey conducted in spring 2023.

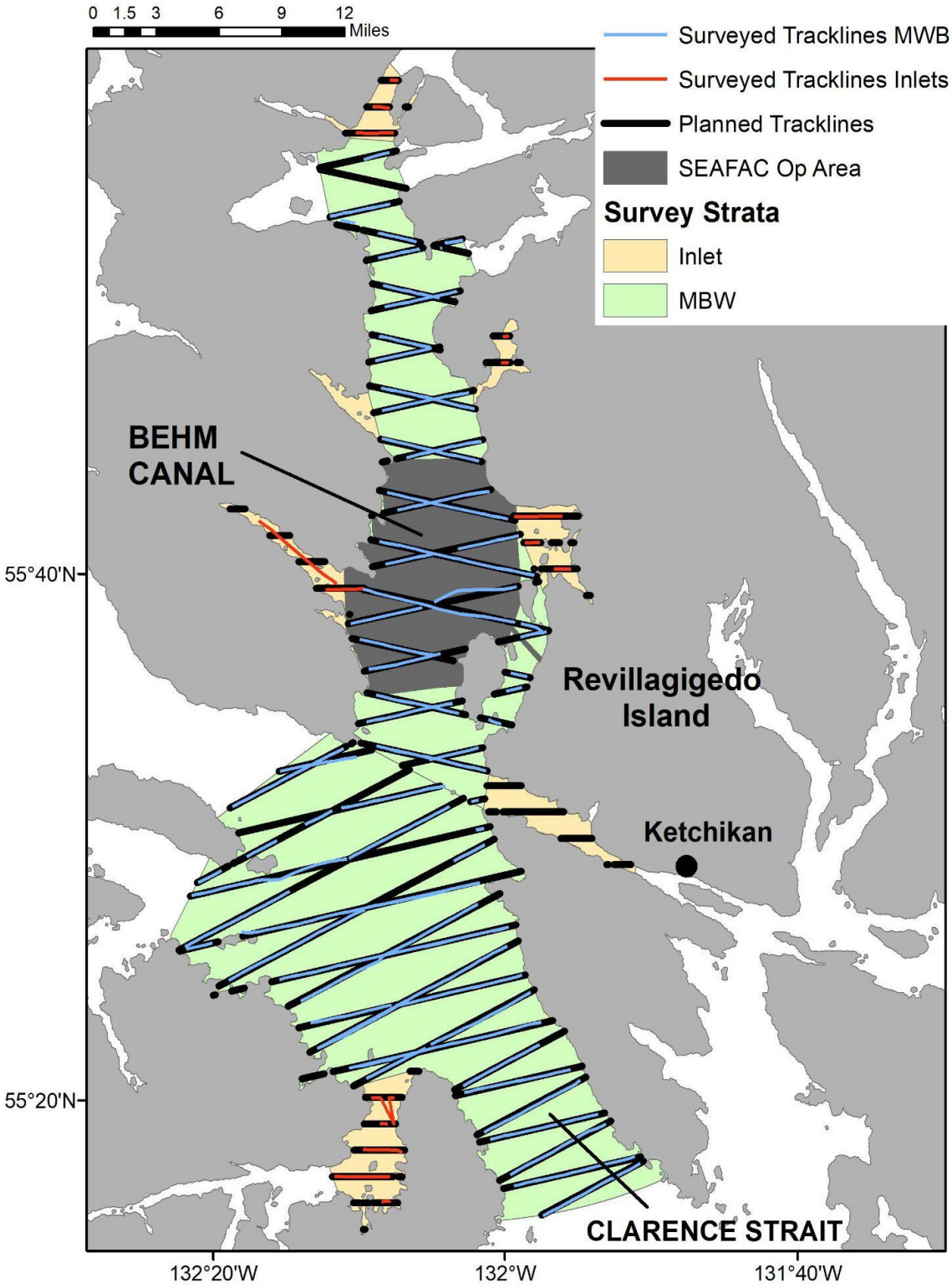

Figure 1. Study area, survey design and completed tracklines for the cetacean line transect vessel survey conducted in April 2023 in western Behm Canal and adjacent areas in inland waters of Southeast Alaska.

Survey results

Survey design

A vessel survey design was proposed for the Behm Canal survey consistent with the methods implemented in Zerbini et al. (2022) for a research cruise conducted in Southeast Alaska inland waters in 2019. We wanted to ensure the two surveys (2019 and 2023) were comparable if integration of data across the two studies is needed (e.g., to estimate the detection functions needed to compute density and abundance).

The survey area included Behm Canal (the area where the Navy SEAFAC area is located) west of Revillagigedo Island, central Clarence Strait, and adjacent fjords and inlets, a region of 1137 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 1014 km^2 (89% of the study area). The stratum labeled "Inlets" (I) 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.

Proposed effort (335 nm, 622 km) was calculated assuming it will be possible to cover the entire region 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 for satellite tag deployment or biopsy/environmental DNA (eDNA) sample collection from species of interest. Survey effort was allocated to each stratum proportional to their area (560 km for MBW and 60 km for I). Strata were divided into substrata (two for MBW and eight for I) to maximize efficiency in allocating survey tracklines (Fig. 1). Because of the relatively large number and relatively low survey effort (60 km) in stratum I, it is not practical to sample all eight substrata. Therefore, an algorithm was implemented to allocate effort in stratum I (Thomas et al. 2007; Zerbini et al. 2022) to ensure (1) the probability of selecting sub-strata was proportional to its area size (e.g., larger areas had greater probability of selection); (2) sampling would have a wide geographic spread; and (3) sub-strata 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).

Visual survey methods

The survey was carried out in passing mode (i.e., the ship did not divert from the trackline to close into detected cetacean groups; Hiby and Hammond 1989; Hammond et al. 2021) unless

the survey encountered a species of interest for biopsy sampling or satellite tagging (e.g., humpback whales, killer whales).

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 data recorder was not involved in active searching, but assisted observers with species identification and/or group size estimates when necessary.

Data were entered into a laptop computer connected to a portable GPS using a data logging software. 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 changed 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 also 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 only resumed when better conditions developed.

Acoustic methods

To acoustically monitor for marine mammals, sonobuoys were deployed consistently throughout the survey area to obtain an evenly-sampled cross-survey census of marine mammal vocalizations. Sonobuoys are free-floating (i.e., drift with the currents), expendable, short-term passive acoustic devices. They transmit audio signals to receivers on a vessel in real time using VHF radio waves; no data are stored on the sonobuoy itself. In addition, the sonobuoys are programmed to scuttle (i.e., a short is sent to a resistor in the float, which burns and deflates the float, sending the sonobuoy to the bottom). The scuttle time could be set anywhere from ½ hour to 8 hours.

For more details regarding sonobuoy data collection protocols and the complete system used, see Crance et al. (2017). In summary, a VHF marine antenna was installed on the aft rail of the flying bridge. A cable was run from the antenna down into the bridge to the monitoring station. Having the sonobuoy monitoring station in the bridge allowed the acoustic technician to interact with the captain and visual observation team and also to make simultaneous visual and acoustic observations (focal follows) where possible. Sonobuoys were deployed by hand over the rail of the vessel while underway. A custom MATLAB-based tracking and plotting program was used to plot the sonobuoy deployments and ship's position (updated every minute via

GPS). All audio data were recorded in ten-minute increments to an external hard drive using ISHMAEL software (Mellinger, 2001) and were analyzed *post hoc*.

Because of the in-water assets positioned in the SEAFAC Ops area, this whole area was considered a "no-go" zone for sonobuoy deployments (Fig. 1, gray area). No sonobuoys were deployed within this area. As an additional precaution and due to the narrow survey area, all sonobuoy deployments were programmed to scuttle after no more than 2 hours (often less). If a sonobuoy was deployed close to the Ops area, the acoustician communicated the deployment plans to SEAFAC personnel to ensure they approved of the plan and had personnel keeping an eye on the sonobuoy and the Ops area. In addition, daily communications took place with personnel at SEAFAC to discuss survey plans for the day and to ensure there was no interference with SEAFAC operations.

Results

Visual survey results

Effort

A total of 320 nm (592.6 km) were surveyed (Table 1, Fig. 1). Survey effort was divided into two modes: "transect" and "transit". Transect corresponded to survey effort completed while searching for marine mammals on actual survey tracklines, while transit corresponded to observation effort while transiting between the port or anchoring points to and from survey lines or between actual tracklines. Survey methods were kept consistent in transect and transit effort to maximize data collection. A total of 234.46 nm and 19.97 nm of transect effort were surveyed in the MBW and the I strata, respectively. This corresponds to 80% of the proposed (planned) trackline effort in the study area. Transit effort in the MWB and I strata corresponded to 50.77 and 13.89 nm. Survey effort by Beaufort Sea state is presented in Table 2. Almost all effort was conducted in a Beaufort 1-3, with fewer than 5 nm surveyed in either a Beaufort 0 or Beaufort 4. No surveys were conducted in sea conditions above Beaufort 4.

Table 1. Summary of effort by stratum and effort type during the 2023 spring Behm Canal survey.

Region Type	Effort Type	Effort (nm)
Inlet	Transect	19.97
Inlet	Transit	13.89
MBW	Transect	234.46
MBW	Transit	50.77
Total		**319.09**

Table 2. Summary of effort (nm) broken down by Beaufort Sea state during the 2023 spring Behm Canal survey.

Beaufort	Effort (nm)
0	4.7
1	92.2
2	126.5
3	92.5
4	4.1
> 4	0
Total	**320**

Distribution of sightings

A total of 75 sightings (162 individuals) of eight species were documented during the survey, 62 of which were sighted while on effort (Table 3, Fig. 2). A summary of species sighted per stratum is presented in Table 3 and the distribution of sightings is presented in Figure 2.

Table 3. Summary of all sightings during the 2023 spring Behm Canal survey. GS = Group size.

Species	On effort	Mean GS	Off effort	Mean GS	Total	Mean GS
Balaenoptera physalus	1	1	1	1	**2**	1
Megaptera novaeangliae	3	1.3	1	1	**4**	1.2
Orcinus orca	1	4	2	4	**3**	4
Phocoena phocoena	9	1.8	0	0	**9**	1.8
Phocoenoides dalli	19	3.4	7	2.4	**26**	3.1
unid. large whale	1	1	0	0	**1**	1
unid. porpoise	1	1	1	2	**2**	1.5
Enhydra lutris	25	1.6	1	1	**26**	1.5
Eumetopias jubatus	1	1	0	0	**1**	1
Phoca vitulina	1	1	0	0	**1**	1
Total	**62**		**13**		**75**	

The most frequently sighted species were Dall's porpoise (*Phocoenoides dalli*, 26 sightings of 81 individuals) and sea otters (*Enhydra lutris*, 26 sightings of 40 individuals), followed by harbor porpoise (*Phocoena phocoena*, 9 sightings, 16 individuals), humpback whales (*Megaptera novaeangliae*, 4 sightings, 5 individuals), killer whales (*Orcinus orca*, 3 sightings, 12 individuals), fin whales (*Balaenoptera physalus*, 2 sightings, 2 individuals), Steller sea lion (*Eumetopias jubatus*, 1 sighting of 1 individual), and harbor seals (*Phoca vitulina*, 1 sighting of 1 individual) (Fig. 2). There were an additional three sightings, one of a single unidentified large whale and two sightings of three unidentified porpoises. Because photos were only collected from the

second sighting, it is assumed, but not confirmed, that the second fin whale sighting was of the same individual.

Although distributed throughout the survey area, all but 3 of the 26 Dall's porpoise sightings were in the MBW stratum, and 12 were inside the SEAFAC Ops area. Harbor porpoise were primarily sighted in the northern half of the survey area, and all but two sightings were in the MBW stratum (Fig. 2). All killer whale sightings were in Clarence Strait (corresponds to acoustic detections). Both fin whale sightings were close together, and near the entrance to Tongass Narrows. Two of the three humpback sightings (totaling 3 individuals) and one unidentified large whale sighting were inside the SEAFAC Ops Area. A third humpback whale sighting was in northern Behm Canal, outside the entrance to Yes Bay, while the final humpback whale sighting was outside Tongass Passage. All sea otter sightings were in or near Clarence Strait; there were no sea otter sightings in the northern half of the study area. Both pinniped sightings were in Helm Bay.

Passive acoustic results

A total of 18 sonobuoys were deployed, of which 15 successfully transmitted, for a success rate of 83.3% and a total monitoring time of over 14 hours. The location of sonobuoy deployments and species detected are shown in Figure 2. The only species detected were killer whales, detected on four buoys (26.6%). All killer whale detections occurred in Clarence Strait in the same general area as, but slightly south of, the visual sightings (Fig. 2). No Dall's or harbor porpoises were detected, despite the numerous sightings. Interestingly, there were no fin or humpback whale detections, despite several sightings, or detections from the unidentified large whale. Additionally, there were no sea otter detections despite the numerous sightings, and no vocalizations were recorded from either pinniped species that was sighted. No sonobuoys were deployed during the first two days of the survey due to SEAFAC operations occurring at the static site, and no sonobuoys were deployed in or near any of the inlets due to their narrow, shallow nature. All sonobuoy deployment and detection info can be found in Appendix 1.

Discussion

Survey methods were appropriate for the survey area, and the vessel was well suited for the narrow inlets and tracklines. Survey conditions throughout the survey were generally good, with pockets of bad weather. We were able to complete 80% of planned tracklines, with 100% trackline completion within the SEAFAC Ops area (Fig. 1). As a result of poor weather and sea conditions, and because of few sightings of target species, the skiff was never launched, and there were no attempts to collect biopsy or eDNA samples. However, photo-ID photographs were collected for the three killer whale sightings, which were all identified as of the resident ecotype. Photos were taken of the fin whale sighting on 13 April 2023, but inclement weather conditions precluded photos being high enough quality to identify the individual.

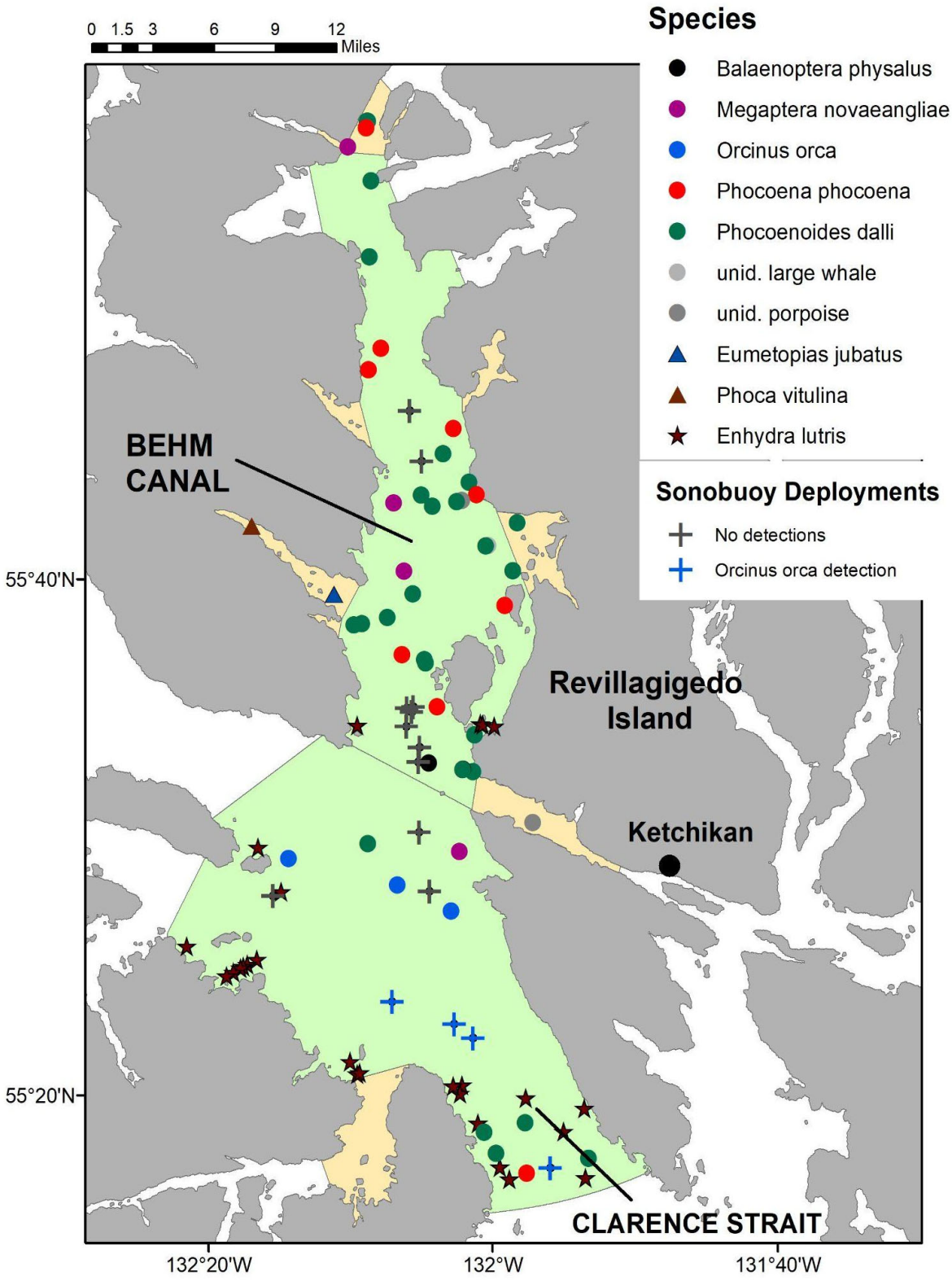

Figure 2. Distribution of marine mammal sightings, sonobuoy deployments and acoustic detections during the April 2023 ship survey in Behm Canal.

A total of 20 sightings of 48 individuals occurred within the SEAFAC Ops area, the majority of which were porpoises (Fig. 2). Three of the seven baleen whale sightings also occurred within the SEAFAC Ops area, with two more less than 4 nm south of the area. There were no pinnipeds or otters sighted within the SEAFAC Ops area, although one Steller sea lion was sighted in the inlet stratum immediately west of the area. Estimates of density are pending further analysis; however, due to the low numbers of sightings, we expect that density estimates will only be available for a few species and that the CVs for most density estimates will be >0.3.

The low number of acoustic detections, particularly of fin and humpback whales, was unexpected. Porpoise vocalizations are too high in frequency to be detected by sonobuoys. The low frequency vocalizations of fin whales can transmit over long distances, and humpback whales are highly vocal; therefore, it was expected that at least some calls would be detected. However, all sightings except one were of single individuals. Cetaceans tend to be less vocal when alone, or when feeding. This may account for the lack of vocalizations from these two species.

Killer whale detections aligned nicely with the sightings (Fig. 2). The acoustic detections occurred on 12 April and the morning of 13 April; the whales were then sighted in the afternoon on 13 April, approximately 10 nm north of the location of the acoustic detections. These results highlight the benefits of using sonobuoys, and how acoustic data nicely complements visual sighting data.

Although there were quite a few sea otter sightings, sea otters don't typically produce vocalizations underwater. Therefore, the lack of detections is not surprising. The only other species sighted were harbor seal and Steller sea lion. In both instances, the animals were sighted in an inlet, and we did not have a sonobuoy deployed, due to the narrow and shallow inlet and the risk of the sonobuoy drifting ashore.

Sonobuoy reception range (i.e., the distance over which we are able to receive a signal from the sonobuoy), was less than expected, and therefore resulted in shorter monitoring time. This may be due to two factors: the lower than usual antenna position, and the excessive VHF activity in the area. Our antennas are tuned to 168 MHz, and there was a large amount of radio traffic between 156 and 174 MHz. However, using lower frequencies to avoid the VHF interference also results in a shorter reception range, sometimes by half. For future surveys, we recommend either putting the antenna higher up on the vessel (if possible), or using both an omnidirectional and a yagi directional antenna, which greatly increases the signal strength and therefore the reception range. A switch can be installed at the monitoring station in the bridge to seamlessly switch from the omni antenna (required when the sonobuoy is not directly astern), and the yagi antenna (when the sonobuoy is directly behind the vessel).

A new survey is expected to take place in the fall of 2024. Data from this new cruise can be integrated with the one presented here to estimate season-specific density and abundance of marine mammals in the study area.

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APPENDIX 1. Complete list of all sonobuoy deployments and species detected during the 2023 Behm Canal survey. Success: 1 = successfully transmitted, 0 = did not successfully transmit. ADT = Alaska Daylight Time.

Station #	Success	Deploy Date	Deploy Time (ADT)	Latitude °N	Longitude °W	Water depth (m)	Species detected
1	1	4/10/23	7:08:06	55.50995	-131.89165	1000	0
2	1	4/10/23	8:23:44	55.66563	-131.77682	7000	0
3	0	4/10/23	12:45:07	55.83453	-131.75375	400	0
4	0	4/10/23	13:12:01	55.75908	-131.75108	660	0
5	1	4/10/23	13:51:25	55.7011	-131.7707	500	0
6	1	4/10/23	18:53:18	55.50922	-131.88353	440	0
7	1	4/11/23	7:19:21	55.50637	-131.8875	400	0
8	1	4/11/23	12:10:20	55.47262	-131.89908	320	0
9	1	4/11/23	14:59:52	55.41952	-132.12325	84	0
10	0	4/12/23	8:50:31	55.19532	-131.92635	400	0
11	1	4/12/23	9:16:01	55.17992	-131.90332	440	Orca
12	1	4/12/23	11:25:58	55.28158	-131.94295	380	Orca
13	1	4/12/23	15:13:49	55.32397	-132.02413	460	Orca
14	1	4/13/23	8:01:39	55.2951	-131.9594	366	Orca
15	1	4/13/23	11:44:58	55.38635	-131.93678	420	0
16	1	4/13/23	13:25:18	55.42712	-131.92578	200	0
17	1	4/13/23	19:32:43	55.48163	-131.8921	300	0
18	1	4/14/23	10:22:48	55.49813	-131.89922	360	0