Summary report: 2022 Swiftsure Bank voluntary ship slowdown trial

ECHO Program

Vancouver Fraser Port Authority

June 2023

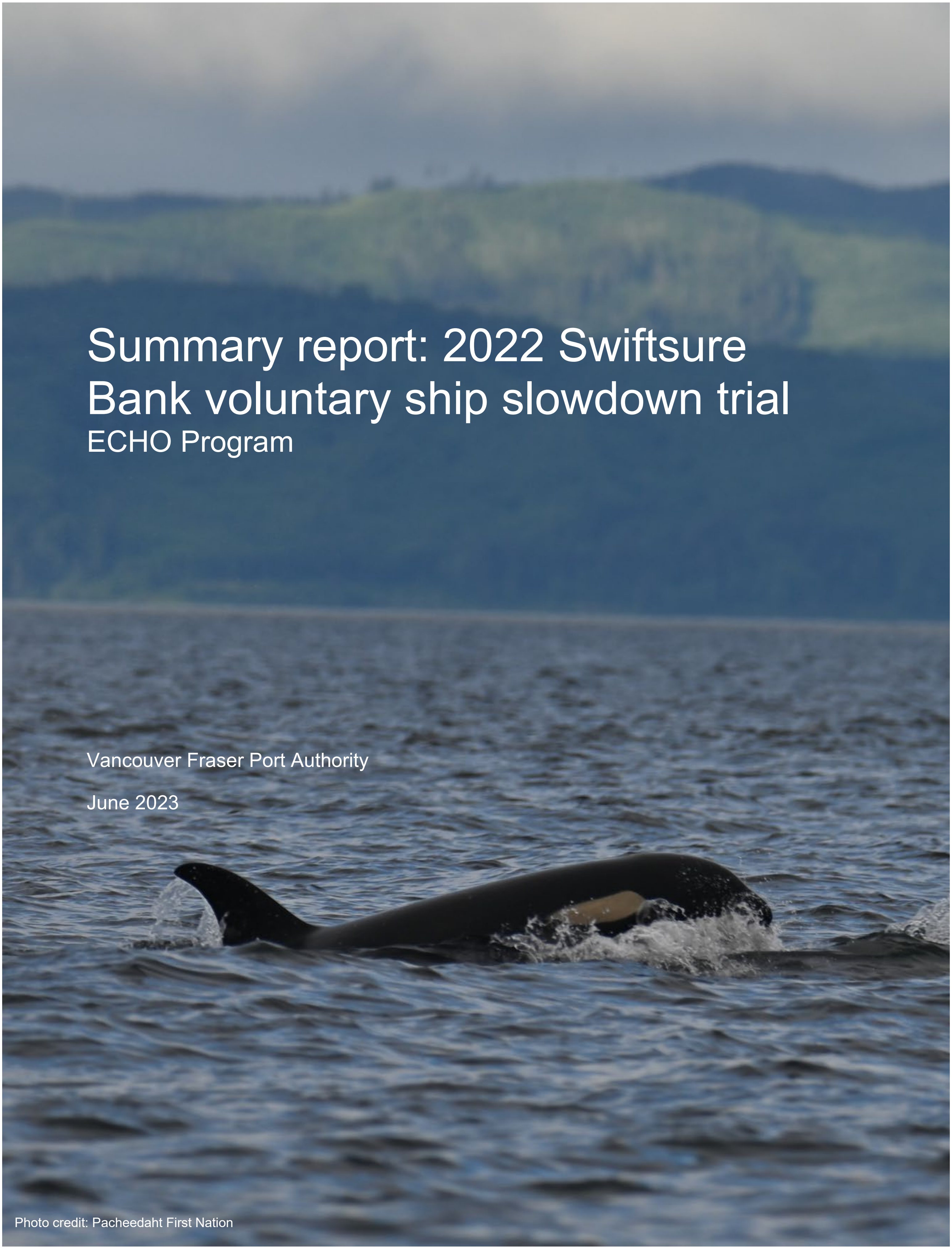

Photo credit: Pacheedaht First Nation

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Acknowledgements

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Executive summary

This report summarizes the results of the 2022 Swiftsure Bank voluntary ship slowdown trial. The slowdown was coordinated by the Vancouver Fraser Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program, with input and advice from the ECHO Program's vessel operators committee and advisory working group members.

Swiftsure Bank is a known foraging area within the critical habitat of endangered southern resident killer whales (SRKW) that overlaps with commercial shipping lanes in both Canadian and U.S. waters, as well as the treaty-protected Usual and Accustomed Fishing Area of the Makah Tribe and the maritime territory of the Pacheedaht First Nation.

The Swiftsure Bank slowdown trial ran from June 1 to October 31, 2022. The purpose of the slowdown was to reduce acoustic disturbance, or underwater noise, from ships, as underwater noise is one of the key threats to endangered SRKW identified by both the Canadian and U.S. governments.

Overview

Slowdown period

June 1 to October 31, 2022

Participation

82% of vessel transits

Impact

40 - 51% reduction in underwater noise intensity

During the slowdown, inbound and outbound vessels were encouraged to slow down while traveling between the U.S./Canada Coast Guard 124-40 line and the end of the traffic separation scheme, when safe and operationally feasible to do so. Car carriers, passenger vessels and container ships were encouraged to travel at 14.5 knots or less speed through water, while bulk cargo vessels, tankers and government vessel operators were asked to travel at 11 knots or less speed through water.

In collaboration with the Makah Tribe and the Canadian and U.S. Coast Guards, the inbound shipping lane at Swiftsure Bank was included in the 2022 slowdown on a trial basis, whereas previous years of Swiftsure slowdowns included only the outbound shipping lane. The slowdown speed targets by vessel type and the duration of the slowdown were unchanged from 2021.

Despite the increased geographical scope of the slowdown, marine transportation organizations voluntarily participated at a strong cumulative participation rate of 82% — with 81% of outbound ship transits and 83% of inbound ship transits participating.

Ambient noise levels in the Swiftsure Bank area were estimated using a model that simulated the 2022 slowdown traffic measures against July 2019 (pre-slowdown) baseline traffic conditions. This model assessed the mean monthly changes in underwater noise levels associated with the slowdown to be a 3.1dB (51%) reduction in broadband sound intensity in the outbound lane, and a 2.2dB (40%) reduction in broadband sound intensity in the inbound lane as a result of the slowdown.

Pacheedaht First Nation monitored and recorded whale presence at Swiftsure Bank through boat surveys within their territorial waters. Between June and October, the Pacheedaht First Nation's boat crew undertook 71 marine mammal observation surveys and recorded a total of 766 cetacean sightings, including 24 sightings of killer whales during the slowdown period. In addition, the B.C. Cetacean Sightings Network received five reports of humpback whale and killer whale sightings in the Swiftsure Bank area during the slowdown period.

1. Background

1.1. The ECHO Program

The ECHO Program is a regional collaborative initiative led by the Vancouver Fraser Port Authority to better understand and reduce the cumulative effects of commercial shipping on at-risk whales off the coasts of British Columbia and Washington State. Since 2014, the ECHO Program has brought together Canadian and U.S. advisors and partners from across government, the marine transportation industry, Indigenous communities, and environmental groups to develop and implement underwater noise reduction initiatives for at-risk whales.

To date, these initiatives have encouraged thousands of ship operators to slow down or stay distanced while traveling within key areas of SRKW critical habitat — helping to measurably reduce underwater noise, one of the key threats to SRKW identified by Canadian and United States governments.

In May 2019, the Government of Canada entered into a first-of-its-kind *Species at Risk Act*, Section 11 conservation agreement with the Vancouver Fraser Port Authority, Pacific Pilotage Authority and five marine transportation industry partners to support the recovery of SRKW. The agreement formalizes the role of the ECHO Program and other conservation agreement signatories to continue working collaboratively over a five-year term to reduce acoustic and physical disturbance from large commercial vessels on SRKW.

In addition to its underwater noise reduction measures, the ECHO Program spearheads world-leading research efforts to broaden understanding of ship-generated underwater noise and inform potential solutions. The ECHO Program has been invited to present its findings to international forums including the International Maritime Organization (IMO) and is recognized as one of the world's most well-known and broadly spanning programs to address underwater noise from ships.

1.2. Context for the voluntary ship slowdown

Several at-risk species of cetaceans (whales, dolphins and porpoises) inhabit the Pacific waters of southern B.C. and northern Washington State. Key among these species is the endangered SRKW with a population of 73 individuals as of July 1, 2022 (Center for Whale Research, 2023). The key threats to SRKW and other at-risk whales in this region include acoustic disturbance (underwater noise), physical disturbance (presence and proximity of vessels), environmental contaminants and availability of prey. Acoustic disturbance related to commercial shipping traffic is a priority focus area for the ECHO Program.

Fisheries and Oceans Canada's recovery strategy (Fisheries and Oceans Canada 2017; 2018; 2022) designates much of the southern B.C. coastal waters as SRKW critical habitat— which is defined as the habitat necessary for the survival or recovery of the species. Under the U.S. *Endangered Species Act*, critical habitat has also been designated in much of the coastal waters of northern Washington state. Killer whales use sound to navigate, communicate and locate prey via echolocation, and underwater noise generated by vessels can impede these functions.

Since 2018, scientists from Fisheries and Oceans Canada have conducted extensive studies on SRKW habitat use and behavior throughout their critical habitat, including at Swiftsure Bank. In late 2019, Fisheries and Oceans Canada presented study results to the ECHO Program's advisory working group that highlighted Swiftsure Bank as an important foraging area for SRKW, prompting the decision to coordinate a slowdown in the area in 2020. In early 2021, Fisheries and Oceans Canada published a Science Advisory Report on areas for mitigation of vessel-related threats to survival and recovery for SRKW, confirming that Swiftsure Bank is an important foraging area (Fisheries and Oceans Canada, 2021).

Results from previous ECHO-led voluntary vessel slowdowns in Haro Strait, Boundary Pass and Swiftsure Bank demonstrated that slowing down is an effective way of reducing both the underwater noise generated at the ship source (MacGillivray et al., 2018a, 2018b, 2019; JASCO and SMRU, 2020, 2021; Grooms et al., 2022) and total underwater noise in nearby habitats, which is in turn predicted to benefit the behaviour and feeding success of SRKW (SMRU, 2018b, 2019a, 2019b).

1.3. Development of the slowdown parameters

In 2022, several parameters of the Swiftsure Bank voluntary slowdown changed including the addition of a trial slowdown in the inbound lane at Swiftsure Bank. This slowdown was set up as a one-year trial, following discussions and confirmation from the Makah Tribal Council. Ensuring the inbound trial would not pose any safety concerns, preparing an emergency stop mechanism, and regularly sharing information were important topics agreed upon for the trial.

1.3.1. Slowdown area

Fisheries and Oceans Canada has identified the bathymetric feature of Swiftsure Bank as important foraging habitat for SRKW (Fisheries and Oceans Canada, 2021). International shipping lanes for vessels entering and exiting the coastal waters from ports in British Columbia and Washington State directly overlap with this area. The outbound shipping lane is in Canadian waters, whereas the inbound shipping lane is in U.S. waters. Pilotage is mandatory for international vessels of a certain size in the interior coastal waters, however, in the Strait of Juan de Fuca and the Swiftsure Bank area, pilotage is not required.

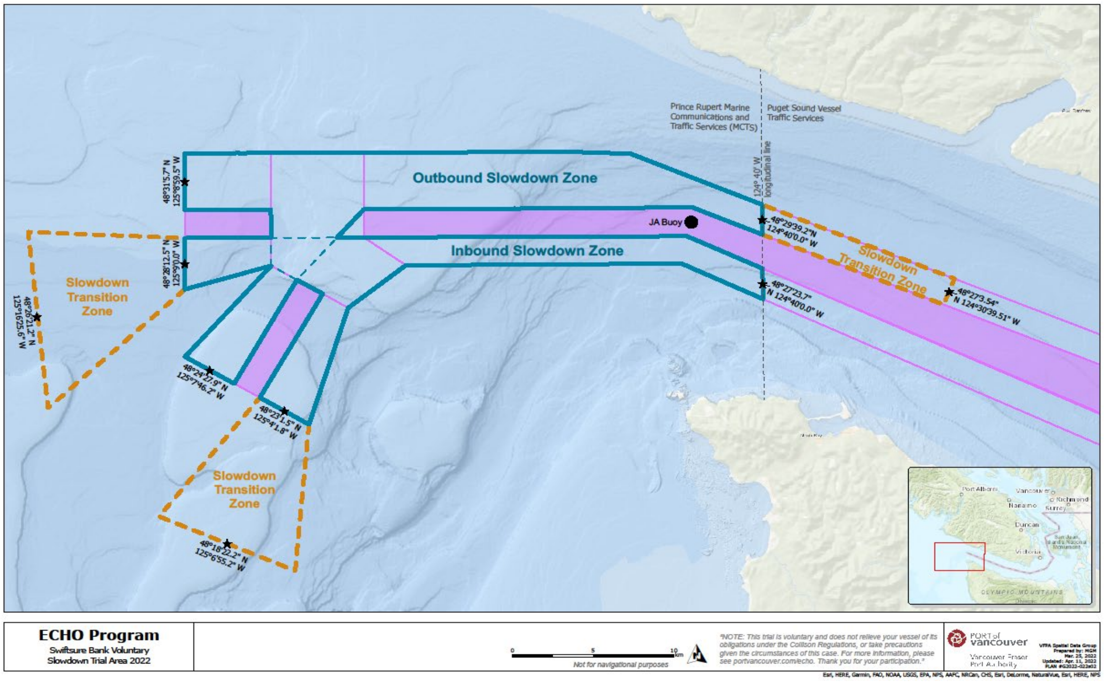
In light of Fisheries and Oceans Canada research indicating the importance of Swiftsure Bank as a key SRKW foraging habitat (Fisheries and Oceans Canada, 2021), the ECHO Program coordinated voluntary slowdowns for outbound ships at Swiftsure Bank in 2020 and 2021. These trial slowdowns aimed to evaluate the level of voluntary transboundary participation that could be achieved in these un-piloted waters, and the associated reduction in underwater noise.

Previous, outbound-only slowdowns at Swiftsure Bank were in effect from the start of the outbound shipping lane to the JA buoy. In 2022, the slowdown was extended east to include both the outbound and inbound shipping lanes from the 124-40 line (defining the deep-sea vessel traffic lanes) as shown in Figure 1. This extension of the slowdown's geographic scope was made to overlap with the SRKW frequency hotspot identified by Fisheries and Oceans Canada in its Science Advisory Report (Fisheries and Oceans Canada, 2021). In 2022, this amendment and addition of the inbound lane creates a slowdown distance of 23 nautical miles. A transition zone was defined on either side of the slowdown area to encourage vessel operators to slow to the target speed prior to entering the designated area.

Vessels in both the inbound (U.S.) and outbound (Canadian) international shipping lanes at Swiftsure Bank are managed by the Canadian Coast Guard. There are west and south entrances for inbound vessels and exits for outbound vessels.

The Swiftsure Bank slowdown took place within the traditional marine territory of the Pacheedaht First Nation, and within the treaty-protected Usual and Accustomed Fishing Area of the Makah Tribe, an area of significant cultural and spiritual value and where harvested resources of Indigenous nations are located. Pacheedaht First Nation and the Makah Tribal Council are key advisors to the ECHO Program in the development and implementation of safe vessel slowdown practices in this important area.

Figure 1: 2022 Swiftsure Bank voluntary ship slowdown area



Source: Vancouver Fraser Port Authority

1.3.2. Slowdown speeds

Throughout this report, vessel types are grouped together based on business sector, cargo type and vessel size and shape. Bulk carrier refers to cargo vessels carrying bulk, breakbulk and project cargo. Tanker refers to tanker vessels carrying liquid bulk cargo. Passenger refers to cruise ships and large piloted passenger vessels. The ‘other’ category includes yachts, tugs, government vessels and heavy lift vessels.

As in prior years, the 2022 Swiftsure Bank slowdown target speeds were set to be consistent with the Haro Strait and Boundary Pass slowdown target speeds. When it was safe and operationally feasible to do so, car carriers, passenger vessels and container vessel operators were encouraged to transit the slowdown area at 14.5 knots or less speed through water. Bulk carriers, tankers and government vessel operators were asked to transit at 11 knots or less speed through water. There was no change in speed targets from 2021.

Table 1 shows the average predicted increase in transit time for vessels transiting the slowdown area, relative to typical vessel speeds in this area. Transiting the slowdown area at the target speed was estimated to add between 11 and 32 minutes to the total transit time, depending on the vessel type. These calculations are based on vessels using the longest route (23 nautical miles) and represent worst case delays.

Table 1: Predicted average increases in transit time due to 2022 slowdown participation

Vessel type	Slowdown target speed through water (knots)	Average speed through water – normal conditions (knots)	Average increase in transit time due to slowdown (minutes)	
			Outbound	Inbound trial
Bulk carrier	11	12.0	13	12
Car carrier	14.5	16.7	16	14
Container	14.5	16.6	13	11
Passenger	14.5	20.3	32	29
Tanker	11	13.5	22	19

1.3.3. Start and end dates

The Swiftsure Bank slowdown began on June 1 and ended on October 31, 2022 – the same duration as in 2021. The slowdown's start and end dates were determined based on historical data on the presence of SRKW in the area, which is typically highest between June and September, while also considering weather and navigational safety.

The start and end of the slowdown was communicated to mariners through a Navigational Warning (NAVWARN) from Canadian Coast Guard, DFO Marine Mammal Desk, and a Marine Safety Information Bulletin and Notice to Mariners from the U.S. Coast Guard. Key partners, including Canadian and U.S. shipping associations, agents, and pilots were informed of the slowdown's launch through direct communication from the ECHO Program via email, as well as on social media, the port authority's website, and a news release.

2. Implementation

Implementation of the ship slowdown requires robust coordination and engagement with stakeholders from across Canada and the U.S. The following section provides further details on the methods used to coordinate the slowdown's launch and monitor voluntary participation throughout the slowdown.

2.1. Engagement and communications

The ECHO Program advisory working group convened seven times in 2022 to share input and advice during the development, implementation, and evaluation phases of the slowdown. The ECHO Program vessel operators committee convened six times throughout the year to assist in the development of parameters for the 2022 slowdown and support monitoring of participation. The Fraser Basin Council provided independent facilitation services for all ECHO Program advisor meetings. A list of the advisory working group and vessel operators committee members can be found here.

Several communication tools were developed and made publicly available to raise awareness of the slowdown, including fact sheets, maps, presentations, webpages, and an infographic. An instructional handout was also prepared and distributed to ship crews in nine languages. Email newsletters from the ECHO Program were sent every two weeks throughout the slowdown to provide updates on participation rates and whale presence.

At the end of the slowdown, certificates of appreciation, social media graphics and letters of thanks were provided to each organization that supported or directly participated in the ECHO Program voluntary initiatives.

2.2. Intent to participate by company

Prior to the slowdown period, the ECHO Program solicited information about marine transportation organizations' intention to participate through an online survey, which was sent to the mailing lists of all major shipping associations that are part of the ECHO Program advisory working group. More than 100 marine transportation organizations indicated their intention to participate in the Swiftsure Bank slowdown. In addition, shipping associations and shipping agents shared key communication materials (ex. fact sheets, web pages, and infographics) developed by the ECHO Program with their members to encourage participation.

During the slowdown, the BC Coast Pilots, Puget Sound Pilots, the DFO Marine Mammal Desk, Prince Rupert Marine Communications and Traffic Services (MCTS) and U.S. Coast Guard were instrumental in encouraging participation and capturing participation data from Canadian and U.S. ship owners and operators.

2.3. Intent to participate by transit

2.3.1. Outbound vessels

For outbound transits, pilots disembark the vessel near the eastern end of the Strait of Juan de Fuca, well before entering the Swiftsure Bank area. The Haro Strait and Boundary Pass ship slowdowns conducted since 2017 proved that communications by pilots with international masters and crew about the slowdowns is extremely valuable. As such, BC Coast Pilots and Puget Sound Pilots were asked to communicate the outbound Swiftsure Bank slowdown prior to disembarking, including distributing the translated instructional handout and requesting the vessel master's intent to participate.

Once discussed with the vessel master, BC Coast Pilots and Puget Sound Pilots indicated the vessel's intent to participate (yes or no) with their respective Coast Guards, as Canadian and U.S. Coast Guard share information about vessel traffic in the Strait of Juan de Fuca and Swiftsure Bank area. As each vessel departed the slowdown area, Prince Rupert Marine Communications and Traffic Services (MCTS) collated and relayed the information to the ECHO Program via an online data collection tool, including vessel ID, time of transit and intent to participate in the slowdown.

2.3.2. Inbound vessel trial

As the Swiftsure Bank area is in non-piloted waters, the Canadian Coast Guard Marine Mammal Desk and Prince Rupert MCTS were instrumental in communicating the slowdown and gathering the vessel master's intent to participate as part of their standard 96-hour arrival communications.

Each weekday, arrival data exported from Transport Canada's 96-hour arrival report was provided to the Canadian Coast Guard Marine Mammal Desk for direct outreach via email to incoming vessels, sharing information on the voluntary slowdown, and requesting their intention to participate. This information was then shared with Prince Rupert MCTS who collated and relayed the information via an online data collection tool to the ECHO Program, reflecting the same process for outbound vessels.

Future slowdown years will focus on the potential for further outreach and information capture for U.S.-bound vessels through the Swiftsure Bank area.

2.4. Monitoring

Participation rates of outbound and inbound transits were monitored and assessed using data from the automated information system (AIS) provided by Canadian Coast Guard. These data include vessel type, name, speed-over-ground and draught for each AIS-enabled vessel transiting the slowdown area. Speed-over-ground was corrected to speed through water using the Bedford Institute of Oceanography's WebTide tidal current model. These speed through water values were then used to evaluate participation, which is described further in Section 3.

To better understand the presence and behaviour of whales at both Swiftsure Bank and in the Strait of Juan de Fuca, the ECHO Program supported Pacheedaht First Nation to undertake marine mammal monitoring between June and October 2022. The results of these monitoring activities are described in Section 6, and the complete technical report is included as Appendix C.

A co-benefit analysis was conducted in relation to the 2022 slowdown to quantify the benefits of the slowdown in relation to air emissions and whale strike risk. Further details and results are described in Section 5.

3. Evaluation and results: industry participation

Participation rates by vessel class in the 2022 slowdown are outlined in this section.

3.1. Overall intent to participate

Prince Rupert MCTS recorded a vessel's intention to participate for 2,598 of the total 4,331 vessel transits (60%). Of these 2,598 transits, 2,359 vessel masters (91%) expressed their intent to participate in the slowdown trial and 9% expressed they did not intend to participate. A further 770 of the 4,331 vessels were contacted but were uncertain about their participation.

An overview of participation rates by vessel type is included in Table 2. The overall figures from 2021 are also included for reference and in 2022 there was an improvement in the intent to participate from 89% to 92%.

Table 2: Intent to participate responses by vessel type and direction

Vessel Type	Inbound trial		Outbound	
Bulk carrier	91%	380 of 416	94%	434 of 461
Car carrier	93%	100 of 108	90%	93 of 103
Container	86%	278 of 325	90%	315 of 351
Tanker	87%	177 of 203	92%	168 of 182
Passenger	97%	146 of 151	94%	149 of 159
Other	85%	46 of 54	86%	73 of 85
All Vessels 2022	**90%**	**1,127 of 1,257**	**92%**	**1,232 of 1,341**
All Vessels 2021	*Outbound only*		89%	1,344 of 1,512

3.2. Participation rates

Participation was evaluated through AIS data and the WebTide model to determine speed through water. AIS data was collected by the Canadian Coast Guard, which includes vessel position and speed-over-ground for each AIS-enabled vessel transiting the slowdown area. Using several locations from the WebTide current/tidal prediction model over the slowdown area, AIS speed-over-ground data points were corrected for current speed and direction to calculate a speed through water value. The mean speed through water was then calculated on a per-transit basis over the entire slowdown area.

Due to the momentum of the vessel combined with tidal currents and wind, the speed through water can vary throughout the slowdown zone while the vessel engine speed may be constant. As such, participation is calculated based on a vessel transiting the slowdown area within 1 knot of the target speed averaged over the length of the transit.

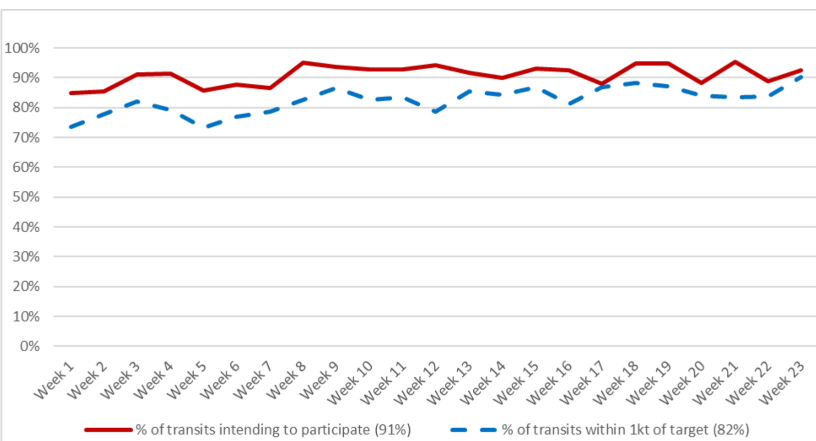
Based on the mean speed through water values, 82% (3,565 of 4,331) of all vessels were able to transit within 1 knot of their respective target speeds (Table 3). Inbound vessels typically had a slightly higher participation rate than outbound vessels, however this varied considerably between vessel type. These variations are discussed further in section 3.5.

Table 3: Calculated speed through water participation within 1 knot, by vessel type

Vessel type	Inbound trial	Outbound	Combined
Bulk carrier	554 of 691 (80%)	593 of 686 (86%)	1,147 of 1,377 (83%)
Car carrier	132 of 157 (84%)	110 of 156 (71%)	242 of 313 (77%)
Container	451 of 520 (87%)	433 of 514 (84%)	884 of 1,034 (85%)
Passenger	240 of 281 (85%)	220 of 284 (77%)	460 of 565 (81%)
Tanker	217 of 251 (86%)	200 of 251 (80%)	417 of 502 (83%)
Other	217 of 276 (79%)	198 of 264 (75%)	415 of 540 (77%)
All Vessels (2022)	**1,811 of 2,176 (83%)**	**1,754 of 2,155 (81%)**	**3,565 of 4,331 (82%)**
All Vessels (2021)	*Outbound only*	1,589 of 1,973 (81%)	*Outbound only*

Figure 2 shows the trend of calculated speed through water participation compared to the intent to participate 'yes' responses by week. The intent to participate and actual participation values are closely matched.

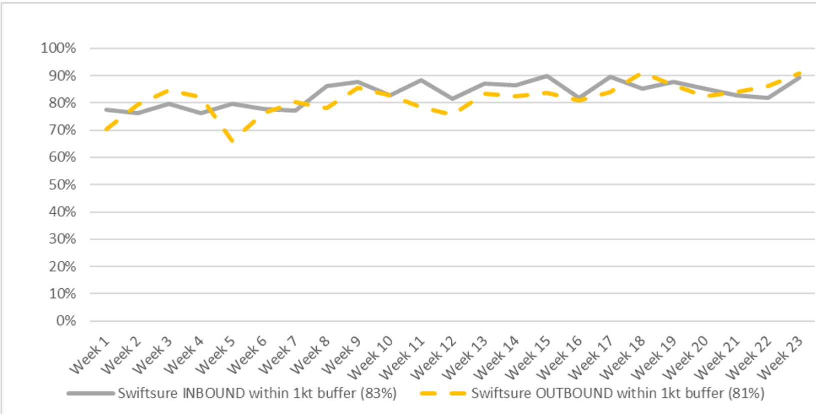
Figure 2: Calculated speed participation rates versus intent to participate by week



Data source: Canadian Coast Guard, JASCO Applied Sciences Ltd.

Figure 3 shows the variation in participation rates for inbound and outbound vessels by week. Overall, inbound vessels had a higher participation rate compared to outbound vessels.

Figure 3: Inbound trial vs. outbound participation rates



Data source: Canadian Coast Guard, JASCO Applied Sciences Ltd.

In addition to the request for vessels to slow down to 11 or 14.5 knots where safe and feasible, a research project was conducted to indicate the possibility for container ships to transit Swiftsure Bank at a slower speed of 11 knots, when safe and feasible to do so. The project was discussed during advisory working group meetings with member associations resulting in two container ship companies anonymously volunteering to participate in the research project.

As a result of this project, Company A was able to achieve a speed within 1 knot of the 11 knot target in 83% (10 of 12) of inbound and 67% (10 of 15) of outbound transits, with an overall participation of 74%. Company B was able to achieve a speed within 1 knot of the 11 knot target in 88% (14 of 16) of inbound and 46% (5 of 11) of outbound transits, with an overall trial participation of 70%. Both companies had 100% participation rates to within 1 knot of the usual container ship 14.5 knot speed target.

3.3. Speed reductions relative to the Strait of Juan de Fuca

In order to better understand the vessel's change in behaviour during the voluntary slowdown, the mean speed through water over a 10 nautical mile control area on the east side of the slowdown area (called the Strait of Juan de Fuca [SJDF] control area) was compared to the mean speed through water within the slowdown area. This analysis was undertaken for all 2,176 inbound and 2,155 outbound vessels with valid AIS vessel tracks, regardless of whether the vessel expressed their intent to participate in the slowdown.

As a result of this analysis, all vessel types showed a reduction in mean speed through water within the Swiftsure slowdown area compared to the control area. While outbound vessels showed a greater speed through water reduction (weighted mean of 1.7 knots) compared to inbound vessels (weighted mean of 0.7 knots), the actual weighted mean speed through water for outbound vessels was around 0.6 knots faster.

As shown in Table 4, passenger vessels achieved the greatest speed through water reductions, however the outbound speed in the control area was significantly higher than other vessels.

2022 was the first year of an inbound trial, therefore we cannot compare year over year for inbound. When comparing outbound vessels in 2022 with 2021, while the weighted mean speed through water reduction was the same as 2021, the weighted mean speed through water (STW) was 0.4 knots higher for outbound vessels both in the SJDF control area and Swiftsure. This overall increase in speed through water is reflected in the number of vessels that met the speed through water targets. Feedback from associations indicated that increased wait times at port may have led to increased urgency for outbound vessels to reach the next destination. Table 4 provides an overview of the speed through water reductions in relation to direction of transit and vessel type.

Table 4: Change in mean speed through water (STW) by vessel type during the slowdown period

Vessel type	Transits	Mean STW (knots)		Speed reduction (knots)	Transits	Mean STW (knots)		Speed reduction (knots)
		SJDF control area	Slowdown area			SJDF control area	Slowdown area	
	Inbound trial				Outbound			
Bulk carrier	691	10.9	**10.7**	0.1	686	11.6	**10.9**	0.7
Car carrier	157	14.5	**13.2**	1.3	156	17.1	**15.0**	2.1
Container	520	12.8	**12.6**	0.2	514	14.9	**13.8**	1.1
Passenger	281	17.9	**14.9**	3.0	284	20.0	**15.0**	5.0
Tanker	251	11.3	**10.4**	0.8	251	13.0	**11.1**	1.9
Other	276	11.1	**10.9**	0.1	264	12.3	**11.5**	0.8
All vessels 2022	**2,176**	**12.8**	**11.9**	**0.7**	**2,155**	**14.2**	**12.5**	**1.7**
All vessels 2021	*No inbound trial*				1,973	13.8	12.1	1.7
All vessels 2020					1,044	13.7	12.3	1.4

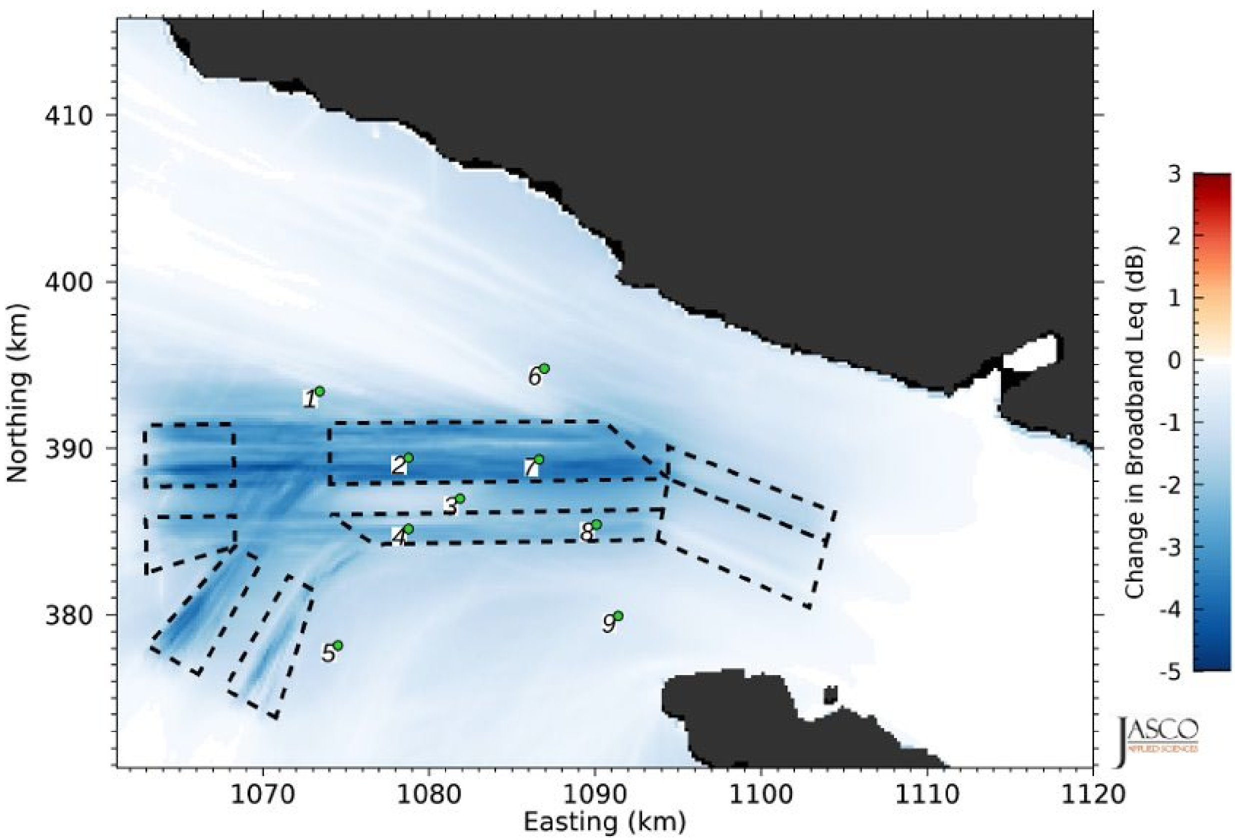
4. Evaluation and results: acoustics

Efforts to determine the potential acoustic benefits of a ship slowdown in the Swiftsure Bank area have been adapted from year to year. For 2022, the potential acoustic benefit of the slowdown was modelled relative to a marine traffic baseline using AIS data from July 2019. July 2022 traffic was simulated to reflect actual vessel participation and speed during the slowdown. The frequency bands modelled in the study included those identified by an expert technical working group convened by the Coastal Ocean Research Institute (Heise et al., 2017) to be of importance to SRKW. The frequency bands analyzed included: broadband (10 Hz to 63 kHz), SRKW communication band (500 Hz to 16 kHz) and SRKW echolocation band (16 kHz to 63 kHz). For all vessel categories that participated in the slowdown, the model showed significant reductions in underwater radiated noise compared to the baseline. Further details are discussed in this section, and the full report can be found in Appendix B.

The model simulated vessel tracks representative of the 2022 slowdown speeds and participation rates, compared against a July 2019 baseline of vessel speeds (before there were any inbound or outbound slowdowns at Swiftsure Bank). Within the model, any AIS-enabled fishing, recreational, tug and 'other' vessels not subject to the ECHO voluntary slowdown request were kept constant between baseline and slowdown simulations to allow for evaluation of the slowdown benefit. The model only slowed commercial vessel types including bulkers, tankers, passenger vessels, container ships, car carriers and government vessels, as these are within the scope of the slowdown. There was similar density of traffic for both inbound and outbound transits.

Monthly mean underwater sound levels (L_{eq}) for the baseline and slowdown model simulations were compared to evaluate predicted noise reduction. Figure 4 shows the receivers locations set in the model. Locations 2 and 7 represent the outbound shipping lane, which showed a 3.1 dB (51%) reduction in broadband sound intensity in the outbound lane, and a 2.2 dB (40%) reduction in broadband sound intensity in the inbound lane. Mean sound levels were reduced in all frequency bands modelled, with the greatest reductions seen in the SRKW echolocation band for receiver locations proximate to the shipping lanes.

Figure 4: Difference in modelled broadband (10 Hz to 63 kHz) monthly average sound levels for the slowdown in July 2022 compared to a July 2019 baseline period



Source: JASCO Applied Sciences

5. Co-benefit analysis

A co-benefit analysis was conducted to estimate the benefits of the slowdown on greenhouse gas emissions and whale strike risk, compared to a baseline period between March and May 2022.

5.1. Air emission co-benefits

The voluntary slowdown at Swiftsure Bank was presumed to provide a co-benefit of reduced air emissions in the slowdown region when compared to normal, non-slowdown, traffic speeds. The ECHO Program commissioned Starcrest Consulting to evaluate the emissions associated with vessel traffic at Swiftsure.

Emissions were calculated on a transit-by-transit basis using Starcrest Consulting's catalogue of recorded air emissions based on vessel particulars such as engine type, fuel type, and operational variables.

To evaluate the air emission benefits of the slowdown, the emissions were calculated for commercial traffic on a transit-by-transit basis during the slowdown and then summed. The emissions were then recalculated for each transit of the slowdown using speed data taken from vessel traffic analyzed during a baseline period prior to the voluntary slowdown (March to May of 2022). The difference between these two scenarios represents the air emissions benefit attributed to the Swiftsure Bank slowdown.

Emissions were calculated for particulate matter, diesel particulate matter, nitric oxide and nitrogen dioxide, sulfur oxides and carbon dioxides. The slowdown efforts at Swiftsure Bank showed a localized decrease in these emission levels of between 11% and 13%, changes directly attributable to the changes in vessel speed.

Detailed results can be found in the slowdown co-benefits study summary available on the ECHO Program webpage.

5.2. Whale strike risk co-benefits

The voluntary slowdown at Swiftsure Bank was presumed to provide a co-benefit of decreased whale strike risk in the slowdown region when compared to normal, non-slowdown, traffic speeds. This evaluation was undertaken by Point Blue Conservation Science on behalf of the ECHO Program.

Whale strike risk was modelled for both fin and humpback whales, and considers the vessel speed, draft and breadth as well as the avoidance patterns of the whales. Due to limitations in knowledge on avoidance behaviour of killer whales, this analysis was not conducted for any of the killer whale eco-types common to Swiftsure Bank. Similarly, a lack of information on whale density at Swiftsure Bank for either fin or humpback whales limited the analysis to a relative percent benefit.

As the relationship between risk of whale strike and vessel speed is non-linear, the evaluation of the potential benefits of slower speeds was undertaken for each AIS data point of each vessel transit. The strike risk was calculated for each transit and summed for all transits over the entirety of the slowdown period. The strike risk was then recalculated for each transit of the slowdown using speed data taken from vessel traffic analysed during a baseline period prior to the voluntary slowdown (March to May of 2022). The ratio of these calculations provided a relative reduction in strike risk associated with vessel speed changes. This strike risk reduction was calculated to be slightly more than 27% for both fin whales and humpback whales at Swiftsure Bank in 2022.

Detailed results can be found in the slowdown co-benefits study summary available on the ECHO Program webpage.

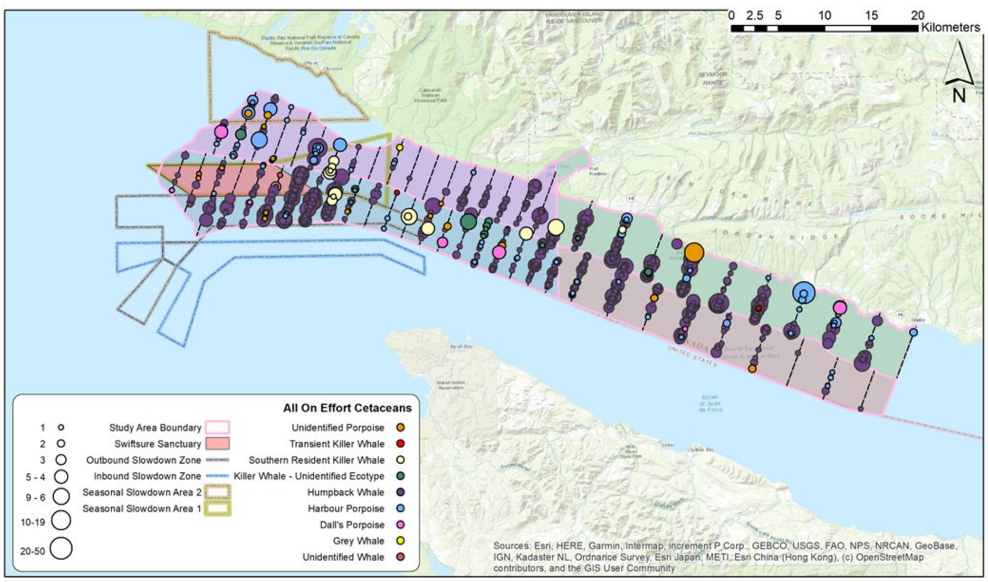
6. Evaluation and results: marine mammal presence

Since 2020, Pacheedaht First Nation, in collaboration with the ECHO Program and consultants Seaview Marine Sciences and SMRU Consulting, have conducted marine mammal observation surveys in the Strait of Juan de Fuca and Swiftsure Bank during the slowdown period. Consultants provided in-person marine mammal observer training to the Pacheedaht First Nation crew and updated the design of the marine mammal survey to be conducted aboard *Seafoam Spirit*, the Pacheedaht First Nation vessel. The marine mammal survey area was divided into four strata for sampling purposes (Figure 4) and included a total of 59 line transects for the 2022 season.

Over 71 survey days, between June and October 2022, the *Seafoam Spirit* crew recorded 766 cetacean sightings of an estimated 1,563 animals. Killer whales were observed on a total of 24 separate days of systematic effort, of which SRKW were sighted on seven days, transient killer whales on two days, and 15 additional days where killer whales were sighted but the ecotype could not be determined. Humpback whales remain the primary species present across all three survey years.

Figure 5 shows all cetacean sightings recorded during line transect surveys undertaken by the Pacheedaht First Nation crew between June and October 2022. The different sizes and colours of circles shown on Figure 5 represent the number of sightings recorded by species. The complete report on marine mammal surveys and observations (Hall et al., 2023) can be found in Appendix B.

Figure 5: Cetacean sightings by Pacheedaht First Nation crew from June to October 2022



Source: Seaview Marine Services / SMRU Consulting

In 2022, there was a significant increase in survey days, line transects completed, and killer whale sightings. It should be noted that sightings are not corrected for observer effort. The full report in Appendix B includes recommendations for further improvement, to be considered for future years.

In addition to the surveys completed by Pacheedaht First Nation, the B.C. Cetacean Sightings Network (BCCSN) collects citizen scientist reports of opportunistic whale sightings. In the Swiftsure Bank area between June 1 and October 31, 2022, the BCCSN received four reports of humpback whales in August, September and October, and one report of SRKW in August. No information on the number of animals was included in these reports. Data obtained from the B.C. Cetacean Sightings Network were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sightings at any location does not demonstrate absence of cetaceans.

7. Key findings and conclusions

Thanks to the contributions of the ECHO Program's many partners and advisors in both Canada and the U.S., the 2022 Swiftsure Bank ship slowdown trial successfully reduced vessel speeds and underwater noise within a key foraging area for endangered SRKW. Key findings and conclusions of the 2022 slowdown are summarized below:

The key findings of the 2022 voluntary ship slowdown are:

- 81% of all outbound transits participated by slowing down to within one knot of the speed through water targets.
- 83% of all inbound transits participated by slowing down to within one knot of the speed through water targets, as part of an inbound trial for 2022.
- Due to the complexities of this area and seasonal fluctuations in sound levels, underwater noise was modelled for the slowdown compared to a 2019 traffic baseline, resulting in an estimated mean monthly reduction in broadband noise of 3.1 dB (51%) in the outbound lane, and 2.2 dB (40%) in the inbound lane.
- Between June and October 2022, a total of 71 marine mammal observation survey days were undertaken by Pacheedaht First Nation. The crew recorded 766 cetacean sightings, 27 of which were killer whales, with SRKW confirmed on at least seven separate days and killer whales of unknown ecotype seen on 15 additional days.

The following conclusions are drawn from the 2022 slowdown:

- High transboundary voluntary participation rates were achieved, despite the area being in non-piloted waters, and extending the initiative to the inbound lane. The communications support from the Canadian and U.S. Coast Guards, BC Coast Pilots, Puget Sound Pilots, industry associations and others were instrumental in achieving this high level of participation.
- Slower vessel speeds were modelled were found to provide quieter conditions in key SRKW foraging habitat during the slowdown, when compared to baseline traffic conditions.
- Additional investigation is recommended to further understand natural seasonal fluctuations in sound levels in order to achieve further accuracy in quantifying the potential benefit of the slowdown to underwater noise.

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Appendix A

List of organizations that participated in the ECHO Program 2022 slowdown initiatives

AAL Shipping
ACGI Shipping Inc.
Alaska Tanker Company, LLC
Amix Group
Armateurs du Saint-Laurent
Blue Water Shipping
Canpotex Shipping Services Ltd.
Carnival Cruise Line
Celebrity Cruises
Champion Tankers AS
CMA CGM Canada Inc.
Coast Island Marine
Colley West Shipping Ltd.
Compagnie du Ponant (Ponant)
ConocoPhillips Company / Polar Tankers, Inc.
COSCO Shipping Lines (Canada) Inc.
Crowley Marine Services Inc.
CSL Americas
Cunard Line
Disney Cruise Line
Evergreen Shipping Agency (America) Corp.
Fairmont Shipping (Canada) Ltd.
Fednav
FK Warren Limited / Mclean Kennedy Inc
Fleet Seaspan Ship Management Ltd.
G2 Ocean AS
General Steamship Corp., Ltd.
GFY Marine Group Inc.
Hamburg Süd
Hapag-Lloyd
HMM
Holland America Line
Hudson Shipping Lines, Inc.
Hurtigruten
Hyundai America Shipping Agency, Inc. (PNW Region)
Inchcape Shipping Services
Intercruises Shoreside & Port Services
Island Tug and Barge Ltd
"K" Line America Inc.
Kirby Corporation
Kirby Offshore Marine, LLC
LBH Shipping Canada Inc.
Ledcor Resources & Transportation
Maersk Line
Mason Agency Ltd.
Matson, Inc.
Mediterranean Shipping Company
MOL (Americas) LLC
MOL Chemical Tankers America Inc.
Montship Inc.
MV Seabourn Sojourn
Navitrans Shipping Agencies West Inc.
Neptune Bulk Terminals
Norton Lilly International Inc.
Norwegian Cruise Line
NYK Group Americas Inc.
Oak Maritime (Canada) Inc.
Ocean BC Towing Inc
Ocean Network Express (Canada) Inc.
Oceania Cruises
Oldendorff Carriers
OOCL (CANADA) INC
Pacific Basin Shipping Limited
Pacific Industrial & Marine Ltd.
Pacific Northwest Ship & Cargo Services Inc
Pinnacle Renewable Energy
Ponant Yacht Cruises & Expeditions
Princess Cruises
Regent Seven Seas Cruises
Robert Reford Shipping Agency
Royal Caribbean International
SAAM Towage
Saga Welco AS. Inc.
Scenic Luxury Cruises & Tours
Seabourn Cruise Line
Seaspan ULC
Seaward Engineering and Research Ltd.
Silversea Cruises
Sino Star Management Ltd.
SM Line Corp
SMS International Shore Operations US Inc
Southport Agencies Inc.
Sultran Limited
Swire Bulk
Swire Shipping Pte. Ltd.
Talon Marine Services
Teekay Shipping
Tormar Inc.
TOTE Maritime
Trans Mountain
Transmarine Navigation Corp
Trans-Oceanic Shipping
Valles Steamship Company, Limited
Vancouver Island Agencies (VI Marine)
Varamar
Waterfront Shipping Ltd.
Western Towboat Co.
Westward Shipping Ltd.
Westwood Shipping Lines
Wheelhouse Shipping Agency Ltd.
Wilhelmsen Ships Service
Windstar Cruises
World Logistics Service (U.S.A.) Inc.
Yang Ming Marine Transport Corp
Zim Integrated Shipping Services Ltd.

Appendix B

2022 voluntary ship slowdown acoustic study

Assessment of Changes in Vessel Noise during the 2022 Slowdown at Swiftsure Bank

JASCO Applied Sciences (Canada) Ltd

10 March 2023

Submitted to:

Krista Trounce

Vancouver Fraser Port Authority

Contract No. 22-0164

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Contents

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Executive Summary

In 2022, the Vancouver Fraser Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program coordinated a voluntary vessel slowdown at Swiftsure Bank. From 1 Jun to 31 Oct 2022, vessels were encouraged to slow down over a 23 nautical mile distance in the outbound and inbound shipping lanes. Vehicle carriers, cruise ships, and container vessels were asked to slow down to speeds through water of 14.5 kn or less; bulkers, tankers, and government vessels were asked to slow down to 11 kn or less.

JASCO Applied Sciences (Canada) Ltd performed a modelling study to assess the changes in underwater noise levels associated with this slowdown at Swiftsure Bank. This study accounts for the actual vessel speed distributions measured using Automatic Identification System (AIS) data collected during the 2022 trial. Underwater noise maps, representing baseline and slowdown traffic conditions, were compared to produce maps of changes in monthly average underwater sound levels (L_{eq}) in three frequency bands: broadband (10 Hz to 63 kHz), Southern Resident killer whale (SRKW) communication band (500 Hz to 15 kHz), and SRKW echolocation band (above 15 to 63 kHz).

Time-averaged noise maps were calculated using JASCO's Acoustic Real-time Exposure Model Incorporating Ambient (ARTEMIA), a cumulative noise model. Baseline noise maps were calculated from historical shipping traffic density and speed, based on July 2019 AIS data, the last year of vessel traffic in the region without a seasonal slowdown. To assess the reduction in noise levels due to the participation in the 2022 slowdown, the speeds of vessels in the 2019 data set were modified according to the speed distributions measured in 2022. The vessel noise emissions data used in the model were based on a large database of monopole source level (MSL) measurements from the ECHO program.

This study shows that the 2022 vessel slowdowns resulted in a reduction of mean underwater sound levels throughout the Swiftsure Bank region, from the coast of Vancouver Island to Cape Flattery, USA. The areas with the largest sound level reductions were within the slowdown zone, with a broadband change in L_{eq} of -3.1 dB in the outbound lane and -2.2 dB in the inbound lane. Mean sound levels were reduced in all frequency bands, with the greatest reductions in the SRKW echolocation band.

1. Introduction

In 2022, the Vancouver Fraser Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program coordinated a voluntary vessel slowdown at Swiftsure Bank. From 1 Jun to 31 Oct 2022, vessels were encouraged to slow down over a 23 nautical mile distance in the outbound and inbound shipping lanes. Vehicle carriers, cruise ships, and container vessels were asked to slow down to speeds through water of 14.5 kn or less; bulkers, tankers, and government vessels were asked to slow down to 11 kn or less.

JASCO Applied Sciences (Canada) Ltd performed a modelling study to assess the changes in underwater noise levels associated with this slowdown at Swiftsure Bank (see Figure 1). Reducing sound pressure levels (SPLs) in areas of importance to Southern Resident killer whales (SRKW) is expected to increase acoustic space available for communication and/or echolocation, depending on the frequencies of the noise reduction (Wladichuk 2021). Lower noise levels may also reduce stress levels (Holt et al. 2009, Rolland et al. 2012) and increase foraging efficiency (Holt et al. 2021a, Holt et al. 2021b). Unlike previous studies that predicted the effect of slowdown zones prior to their implementation, this study accounts for the vessel speed distributions recorded during the slowdown. Underwater noise maps representing baseline and slowdown traffic conditions were compared to produce maps of changes in monthly average underwater SPL (L_{eq}) in three frequency bands: broadband (10 Hz to 63 kHz), SRKW communication band (500 Hz to 15 kHz), and SRKW echolocation band (15 to 63 kHz; limited by the modelled frequency range). The model area and slowdown zone are shown in Figure 1; SPLs were sampled from sound maps (numbered in Figure 1) at the locations listed in Table 1.

Section 2 of this report summarises the methods used to assess changes in sound levels achieved during the trial and the project-specific parameters. More details on the terminology, parameters and methodology are provided in Appendices A to D. Section 3 presents the results, and Section 4 includes a discussion of the study findings.

Table 1. List of SPL sampling locations.

Sample location		Latitude	Longitude	Easting (m) [1]	Northing (m) [1]
1	Centre of Swiftsure Bank, north of the traffic lanes	48°33'7.188" N	125°0'27.015" W	1073411	393408
2	In the outbound lane, at Swiftsure Bank	48°30'55.319" N	124°56'9.435" W	1078764	389420
3	Between the lanes, on the eastern slope	48°29'34.309" N	124°53'40.264" W	1081870	386970
4	In the inbound lane, at Swiftsure Bank	48°28'36.847" N	124°56'12.212" W	1078771	385151
5	South of the lanes, south of Swiftsure Bank	48°24'51.921" N	124°59'43.629" W	1074519	378155
6	North of the lanes, north of the eastern slope	48°33'44.835" N	124°49'27.552" W	1086940	394776
7	In the outbound lane, on the eastern slope	48°30'48.013" N	124°49'46.691" W	1086637	389319
8	In the inbound lane, in deep water	48°28'39.436" N	124°47'2.205" W	1090087	385413
9	South of the lanes, in deep water	48°25'40.726" N	124°46'3.685" W	1091387	379926

[1] Projection NAD83/BC Albers (EPSG:3005)

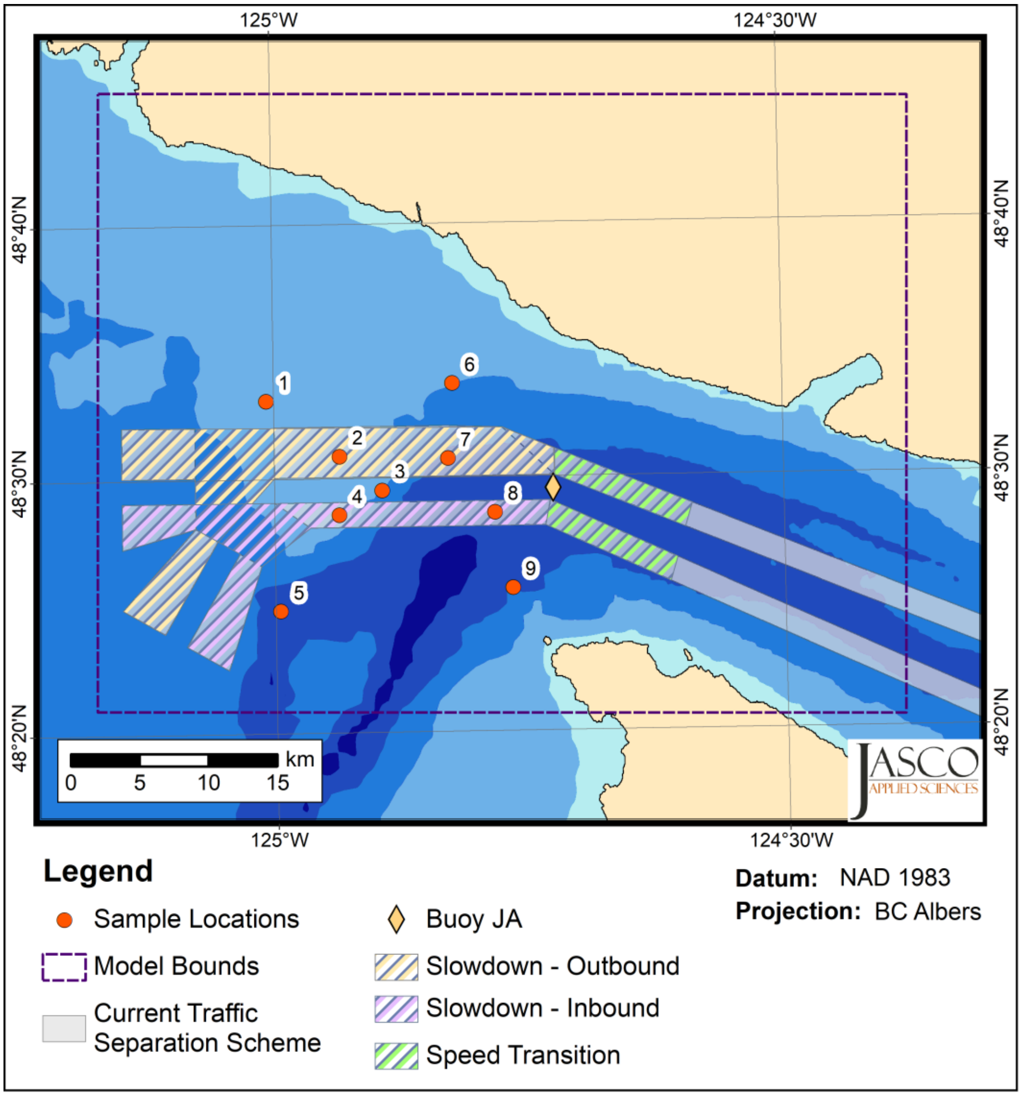

Figure 1. Map of the modelled area showing the slowdown zones, speed transition zones, and SPL sampling locations listed in Table 1.

2. Methods

Time-averaged noise maps present large-scale cumulative sound fields that account for multiple moving sound sources. The metric used to represent this long-term time-averaged noise is the equivalent continuous monthly average underwater SPL (L_{eq}; refer to Appendix A for more details). The L_{eq} is calculated by dividing the cumulative sound exposure level (SEL; see Appendix A.1) by the averaging period, in seconds. This metric is useful for presenting geographic distributions of mean noise levels. Here, L_{eq} was calculated using JASCO's ARTEMIA model (presented in Appendix C.2) over a one-month period (July). Section 2.1 describes some of the model input parameters specific to this study.

Sound propagation through the ocean depends on the environmental parameters of a region, including ocean temperature and salinity profiles, water depth, and geoacoustic properties of the seabed such as sediment types (e.g., sand, silt, and bedrock) and the corresponding thickness of each sediment layer. Five environmental zones have been defined in prior similar studies, based on Swiftsure Bank's unique seabed geoacoustics and five water depth ranges (see Appendix B). Salish Sea water temperature and salinity data for July were used to define monthly average underwater sound speed profiles (also see Appendix B).

The vessel traffic data were based on July 2019 Automatic Identification System (AIS) data obtained from MarineTraffic (www.marinetraffic.com) for the region. This relatively recent data set is expected to be representative of the traffic density in summer of 2022 because it provides AIS data from the year before the 2020 COVID-19 pandemic. It is also prior to the implementation of any ECHO program-led slowdown efforts at Swiftsure Bank, which began only in the outbound lane in 2020. Section 2.2 describes the process used to simulate baseline and slowdown traffic conditions.

2.1. Model Parameters

The model grid (purple dashed line in Figure 1), with a cell resolution of 200 × 200 m, is large enough (59 km × 45 km) to ensure all important noise contributors (i.e., including vessels outside of the slowdown areas) are included in the noise maps.

Six source depths, from 1 to 6 m, were used to represent the monopole source position for each vessel category. The depth at which the sound levels were computed (i.e., the depth of the receiver) was set to 10 m. This receiver depth was deep enough to not underestimate received noise levels due to various propagation effects but shallow enough to represent a depth at which SRKW spend a significant portion of their time (Tennessen et al. 2019).

Acoustic propagation loss quantifies the decrease in sound intensity with increasing distance from each ship. The sound propagation model ORCA (see Appendix C.1) was used to calculate propagation loss in each environmental zone for the six source depths for the month (July). The resulting set of sound propagation curves was used by the ARTEMIA model to calculate sound levels over the region. More details are provided in Appendix C.1.

2.1.1. Frequency Bands

The results were calculated in decidecade frequency bands with centre frequencies from 10 Hz to 63 kHz. Decidecade frequency bands represent narrow frequency ranges that are relevant for mammalian hearing; these frequency bands are often used to approximate hearing critical bands, within which biologically important sounds can be masked in the presence of noise (Richardson et al. 1995). Sound levels were also calculated by summing decidecade bands over three wider frequency ranges: broadband (from 10 Hz to 63 kHz), killer whale communication band (from 500 Hz to 16[1] kHz), and killer whale echolocation band (from 16[1] kHz to 63 kHz). The latter two bands are based on the frequency ranges proposed by the Coastal Ocean Research Institute (CORI) expert panel for assessing noise effects on killer whales (Heise et al. 2017). Note that the CORI killer whale echolocation band is from 15 to 100 kHz, so it extends beyond the maximum modelled frequency of 63 kHz. Including bands above 63 kHz would have a negligible influence on the results of this study, because vessels source levels are much lower at these frequencies and seawater absorption strongly limits high-frequency sound propagation.

2.2. Vessel Traffic

To assess the effect of the 2022 slowdown on underwater noise levels, monthly average L_{eq} were calculated for historical shipping traffic density and speed. These baseline results are based on a month of pre-pandemic AIS data for July 2019, before any slowdown was implemented at Swiftsure Bank. To assess the effect of the 2022 slowdown on noise levels, the speed of vessels in the 2019 data set was modified according to the speed distributions of vessel traffic measured from June through October 2022, the duration of the 2022 slowdown. Modifying the 2019 baseline data ensures that modelled differences in L_{eq} are not due to year-over-year differences in vessel traffic, but only caused by speed reductions associated with the 2022 slowdown. The vessel noise emissions were based on a large database of monopole source level (MSL) measurements from the ECHO program.

The speeds through water of the six participating vessel categories in 2022 were analysed using AIS data (provided by the Canadian Coast Guard and analyzed by JASCO) collected for the duration of the slowdown. Since there are differences between statistical distributions of vessel speeds in the inbound and outbound lanes, the two lanes were considered as two separate slowdown zones in the model, with distinct speed distributions for each vessel category. These speed distributions were applied to the 2019 vessel tracks. Table 2 lists the number of transits in the inbound and outbound traffic lanes for each participating vessel category; the historical values (July 2019) are compared to those measured during the slowdown (1 Jun to 31 Oct 2022). Figure 2 compares the historical baseline (July 2019) and slowdown (Jun–Oct 2022) vessel speed distributions for the same vessel categories, in both the inbound and outbound traffic lanes. The shaded area represents the speeds at or below the encouraged speed targets.

Table 2. Number of transits (tracks) for each participating vessel category in each slowdown zone. Appendix D lists the AIS vessel types that were grouped together to form each vessel category.

Vessel category	Historical Baseline (Jul 2019)		Slowdown (Jun-Oct 2022)	
	Inbound	Outbound	Inbound	Outbound
Bulker	168	152	691	686
Container	118	102	520	514
Cruise ship	55	52	157	156
Government	143	116	72	84
Tanker	65	44	251	251
Vehicle carrier	60	39	281	284

[1] The recommended frequency limit at which the killer whale communication band ends and the echolocation band begins is 15 kHz. The decidecade band that includes this frequency (band 32 centred on 16 kHz) was included in both the communication band and the echolocation band.

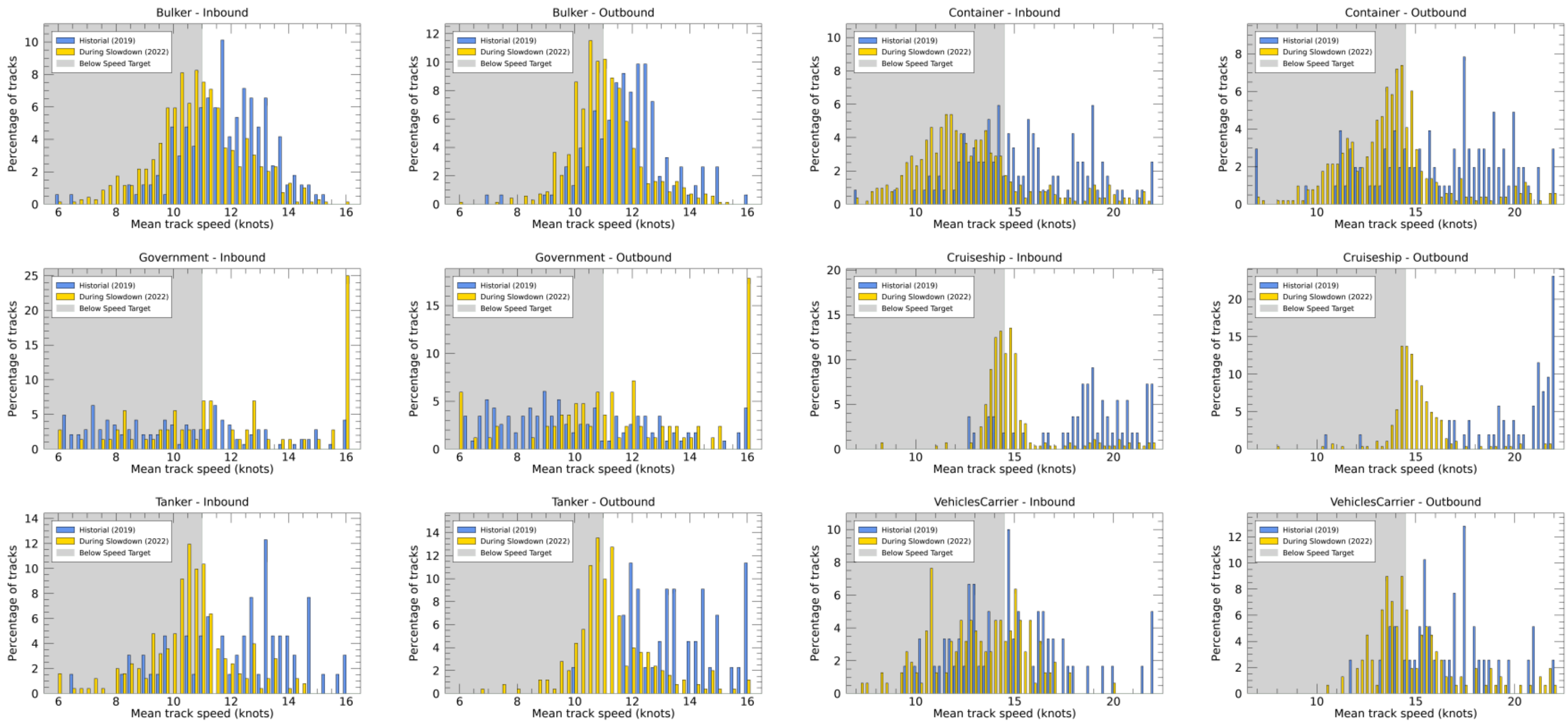

Figure 2. Historical baseline (blue) and 2022 slowdown (yellow) vessel speed distributions for the six participating vessel categories.

3. Results

Model results are presented as maps of differences in L_{eq} (i.e., ΔL_{eq}) between the slowdown and the baseline scenarios (Figures 3 to 5). They represent the expected change in mean noise level over the 2022 slowdown; a negative ΔL_{eq} represents a reduction of sound levels. The results are also sampled at the nine locations within key SRKW habitat listed in Table 1. Table 3 presents the sampled baseline L_{eq}, scenarios L_{eq} and ΔL_{eq} in three frequency bands: broadband (10 Hz to 63 kHz), SRKW communication band (500 Hz to 15 kHz) and SRKW Echolocation band (15 to 63 kHz).

Table 3. In each frequency band, the baseline equivalent continuous noise level (L_{eq}; dB re 1 µPa) is compared to that of the slowdown scenario and the change in equivalent continuous noise levels (ΔL_{eq}; dB) at each key sample location in the Southern Resident killer whale (SRKW) critical habitat.

Sample location	Broadband (dB)			Communication band (dB)			Echolocation band (dB)		
	Baseline	Slowdown	Difference	Baseline	Slowdown	Difference	Baseline	Slowdown	Difference
1	109.8	108.3	-1.5	106.5	105.1	-1.4	79.7	78.8	-0.9
2	123.8	120.7	-3.1	115.3	113.1	-2.2	95.2	91.6	-3.6
3	117.3	115.8	-1.5	113.4	112.6	-0.8	84.4	81.5	-2.9
4	124.5	122.3	-2.2	116.0	114.5	-1.5	94.4	91.7	-2.7
5	110.4	109.4	-1.0	106.4	105.7	-0.7	76.1	75.7	-0.4
6	110.8	109.6	-1.2	107.1	106.1	-1.0	80.2	80.0	-0.2
7	123.4	120.3	-3.1	113.0	111.2	-1.8	92.4	88.9	-3.5
8	123.6	121.4	-2.2	113.3	111.8	-1.5	91.8	88.5	-3.3
9	113.3	112.6	-0.7	108.8	108.2	-0.6	85.7	85.7	0

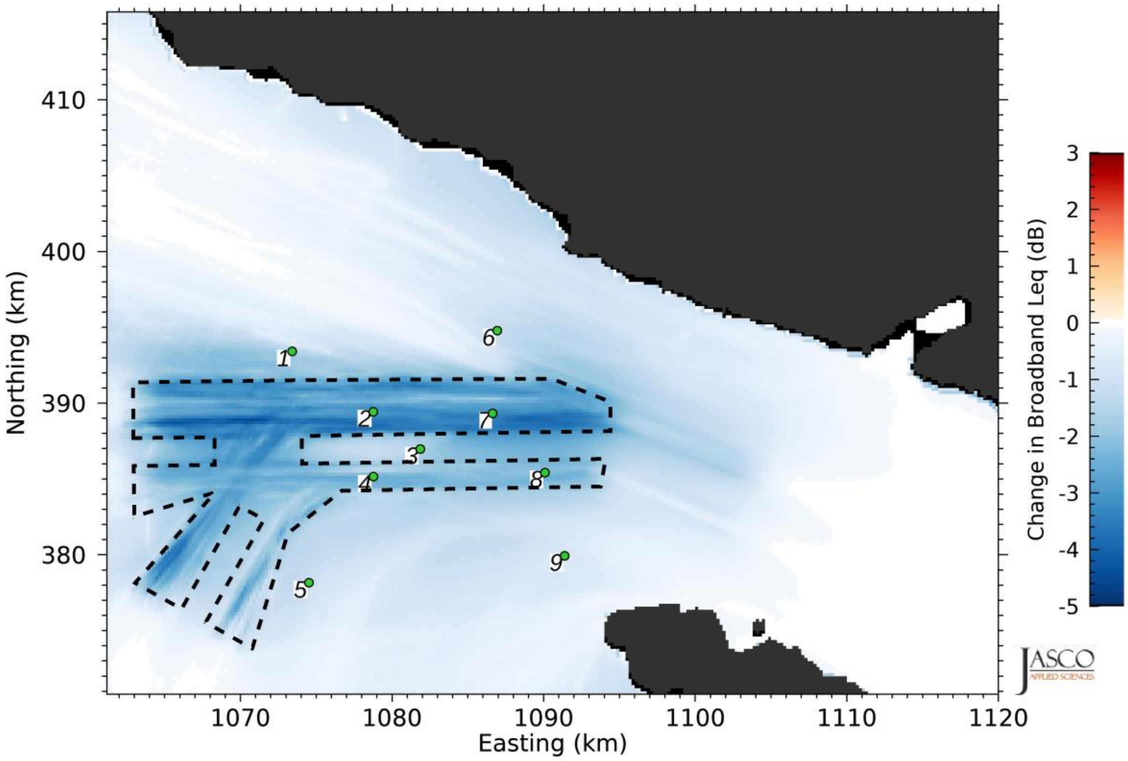

Figure 3. Broadband: Changes in equivalent continuous sound levels (ΔL_{eq}) during the 2022 slowdown. The grid resolution is 200 × 200 m.

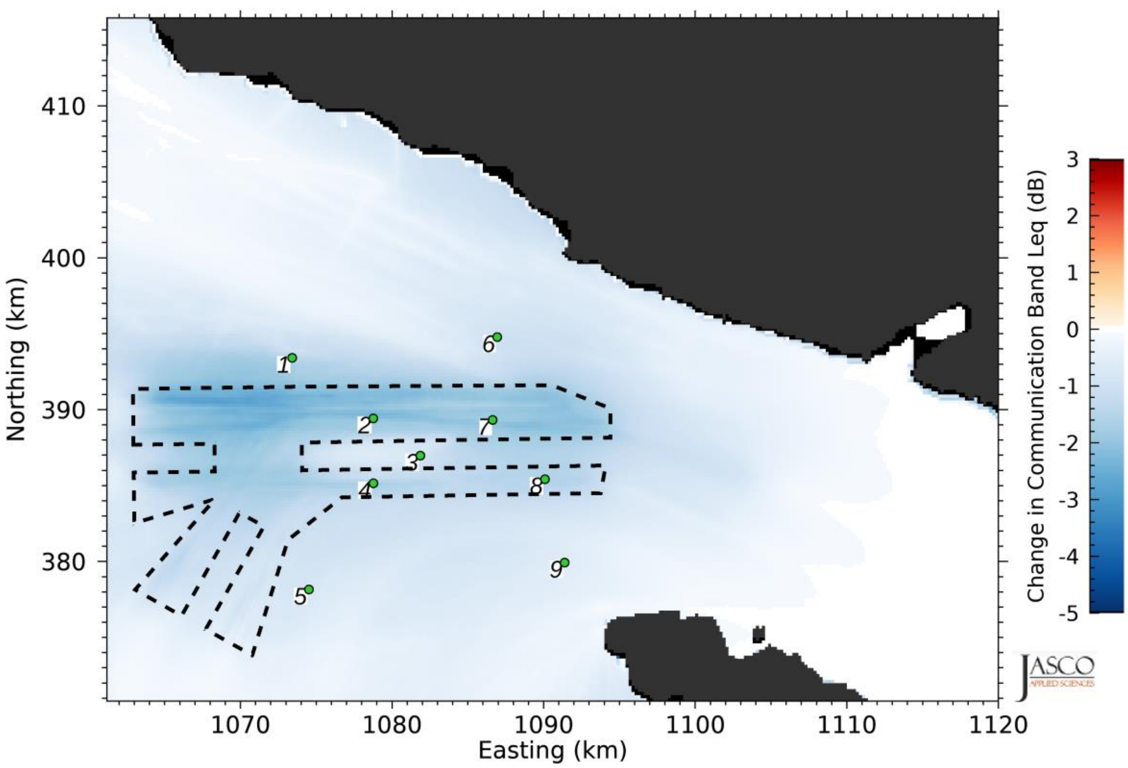

Figure 4. SRKW Communication band: Changes in equivalent continuous sound levels (ΔL_{eq}) during the 2022 slowdown. The grid resolution is 200 × 200 m.

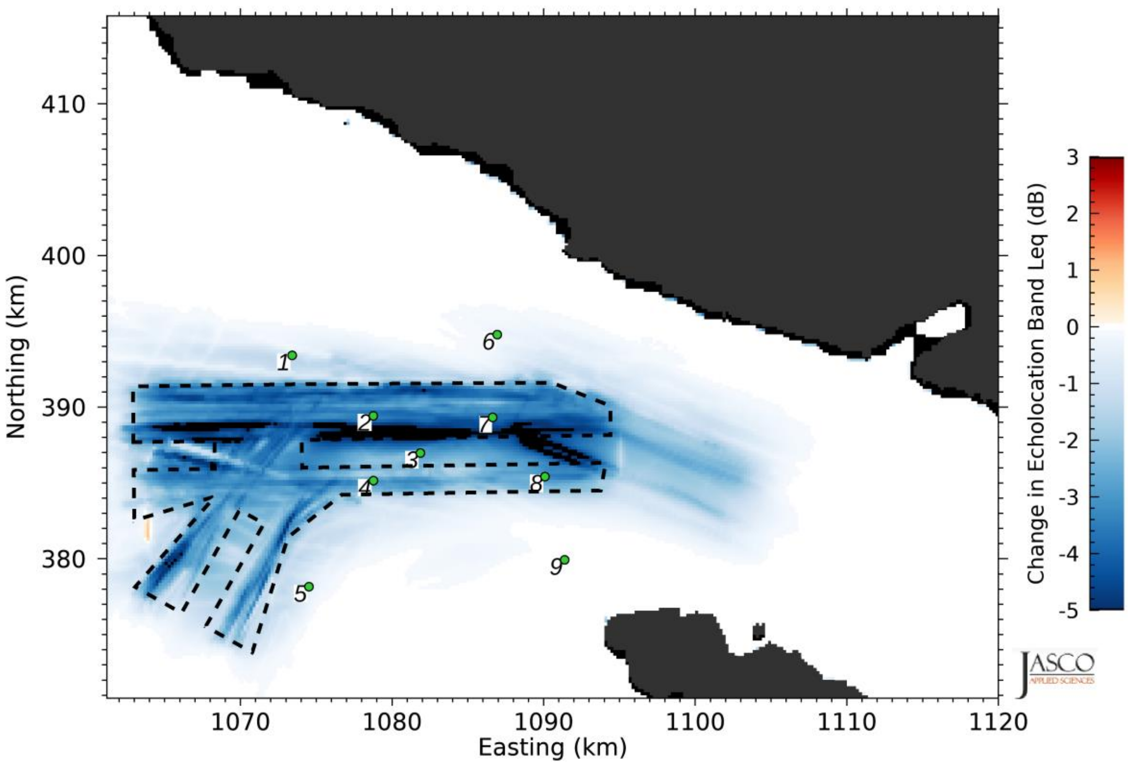

Figure 5. SRKW Echolocation band: Changes in equivalent continuous sound levels (ΔL_{eq}) during the 2022 slowdown. The grid resolution is 200 × 200 m.

4. Discussion and Conclusion

The changes in underwater noise at Swiftsure Bank during the 2022 slowdown were estimated by comparing modelled noise levels based on historical baseline speed distributions versus measured speed distributions during the slowdown. Of the six vessel categories that were encouraged to slow down, only the government vessels did not show a reduction in speed in comparison with historical (July 2019) values, but a higher number of vessels (mainly Coast Guard search and rescue (SAR) and military vessels) were measured at high speed (i.e., above 16 kn, see Figure 2). Cruise ships showed the largest decrease in mean speed, followed by containers and vehicle carriers. While the speed distributions are different between inbound and outbound traffic, the same per-category trend is seen in both directions. The changes in speed distributions resulted in a reduction of mean underwater sound levels throughout the Swiftsure Bank region, from the coast of Vancouver Island to Cape Flattery, USA.

The modelled baseline sound levels were based on vessel speed over ground, from AIS, rather than speed through water (i.e., as affected by ocean currents, which are predominantly tidally-driven at Swiftsure Bank). While vessel noise emissions primarily relate to speed through water (MacGillivray et al. 2019), this quantity is not available in AIS records. Nonetheless, the use of speed over ground in this study should not affect the model predictions, since mean speed over ground will be equal to mean speed through water when averaged over several tide cycles. Thus, it is reasonable to expect that statistics of speed over ground and speed through water would be equivalent on the study time scale of 1 month.

As expected, the areas with the largest changes are within the slowdown zone, with a sampled broadband ΔL_{eq} of -3.1 dB in the outbound lane and -2.2 dB in the inbound lane. Reductions were smaller outside the slowdown areas, particularly at locations where traffic was dominated by fishing vessels and tugs (e.g., between the traffic lanes and north and south of the lanes, respectively).

The 2022 voluntary slowdown at Swiftsure Bank reduced mean sound levels in all frequency bands. While reductions were greatest in the SRKW echolocation band ($\Delta L_{eq} \geq -6.3$ dB), they were also more localized than in the communication band ($\Delta L_{eq} \geq -2.8$ dB). This is because sounds at SRKW echolocation frequencies generally propagate to shorter range than sounds at SRKW communication frequencies.

Note that in 2022, vessels were asked not to exit the outbound lane at Buoy JA (at the turn, from the Strait of Juan de Fuca to Swiftsure Bank, shown on Figure 1). Therefore, some cruise ships that were historically navigating northwesterly, exiting the shipping lanes and navigating near sample location 6 in Figure 1 (approximately five transits in the July 2019 data), did travel through the slowdown zone in 2022. Since these vessels recorded the highest decrease in mean speed, and baseline tracks were not re-routed in the model, we expect that the effect would have been a slightly larger noise reduction north of the lanes than presented in the current results.

The proportion of vessel traffic in July 2019 (Table 2) is representative of the traffic during the 2022 slowdown, with the exception of government vessels which were more numerous in 2019. Combined with the fact that a portion of those vessels increased speed in 2022 compared to the historical speeds, we expect that a better representation in traffic density for this vessel category would increase the noise reduction compared to that modelled here.

Glossary of Acoustics Terms

Unless otherwise stated in an entry, these definitions are consistent with ISO 18405 (2017).

1/3-octave

One third of an octave. *Note*: A 1/3-octave is approximately equal to one decidecade (1/3 oct ≈ 1.003 ddec).

1/3-octave-band

Frequency band whose bandwidth is one 1/3-octave. *Note*: The bandwidth of a 1/3-octave-band increases with increasing centre frequency.

absorption

The conversion of sound energy to heat energy. Specifically, the reduction of sound pressure amplitude due to particle motion energy converting to heat in the propagation medium.

acoustic noise

Sound that interferes with an acoustic process.

acoustic self-noise

Sound at a receiver caused by the deployment, operation, or recovery of a specified receiver, and its associated platform (ISO 18405:2017).

ambient sound

Sound that would be present in the absence of a specified activity (ISO 18405:2017). It is usually a composite of so

und from many sources near and far, e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation

The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium. Attenuation depends on frequency—higher frequency sounds are attenuated faster than lower frequency sounds.

azimuth

A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also known as bearing.

background noise

Combination of ambient sound, acoustic self-noise, and, where applicable, sonar reverberation (ISO 18405:2017) that is detected, measured, or recorded with a signal.

bandwidth

A range within a continuous band of frequencies. Unit: hertz (Hz).

broadband level

The total level measured over a specified frequency range. If the frequency range is unspecified, the term refers to the entire measured frequency range.

cetacean

Member of the order Cetacea. Cetaceans are aquatic mammals and include whales, dolphins, and porpoises.

compressional wave

A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called a longitudinal wave. In seismology/geophysics, it's called a primary wave or P-wave. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

continuous sound

A sound whose sound pressure level remains above the **background noise** during the observation period and may gradually vary in intensity with time, e.g., sound from a marine vessel.

decade

Logarithmic frequency interval whose upper bound is ten times larger than its lower bound (ISO 80000-3:2006). For example, one decade up from 1000 Hz is 10,000 Hz, and one decade down is 100 Hz.

decibel (dB)

Unit of level used to express the ratio of one value of a power quantity to another on a logarithmic scale. Especially suited to quantify variables with a large dynamic range.

decidecade

One tenth of a decade. Approximately equal to one third of an octave (1 ddec ≈ 0.3322 oct), and for this reason sometimes referred to as a 1/3-octave.

decidecade band

Frequency band whose bandwidth is one decidecade. *Note*: The bandwidth of a decidecade band increases with increasing centre frequency.

energy spectral density

Ratio of energy (time-integrated square of a specified field variable) to bandwidth in a specified frequency band from f_1 to f_2. In equation form, the energy spectral density E_f is given by:

$E_f = 2\int_{f_1}^{f_2}|X(f)|^2\,\mathrm{d}f/(f_2 - f_1)$ where $X(f)$ is the **Fourier transform** of the field variable $x(t)$:
$X(f) = \int_{-\infty}^{+\infty} x(t)\exp(-2\pi i f t)\,\mathrm{d}t$

The field variable $x(t)$ is a scalar quantity, such as sound pressure. It can also be the magnitude or a specified component of a vector quantity such as sound particle displacement, velocity, or acceleration. The unit of energy spectral density depends on the nature of x, as follows:

If x = sound pressure: Pa^2 s/Hz
If x = sound particle displacement: m^2 s/Hz
If x = sound particle velocity: $(m/s)^2$ s/Hz
If x = sound particle acceleration: $(m/s^2)^2$ s/Hz

Note: The factor of two on the right side of the equation for E_f is needed to express a spectrum that is symmetric about f = 0, in terms of positive frequencies only. See entry 3.1.3.9 of ISO 18405 (2017).

far field

The zone where, to an observer, sound originating from an array of sources (or a spatially distributed source) appears to radiate from a single point.

Fourier transform, Fourier synthesis

A mathematical technique which, although it has varied applications, is referenced in a physical data acquisition context as a method used in the process of deriving a spectrum estimate from time-series data (or the reverse process, termed the inverse Fourier transform). A computationally efficient numerical algorithm for computing the Fourier transform is known as the fast Fourier transform (FFT).

frequency

The rate of oscillation of a periodic function measured in cycles per unit time. The reciprocal of the period. Unit: hertz (Hz). Symbol: f. 1 Hz is equal to 1 cycle per second.

frequency weighting

The process of applying a frequency-weighting function.

frequency-weighting function

The squared magnitude of the sound pressure transfer function (ISO 18405:2017). For sound of a given frequency, the frequency-weighting function is the ratio of output power to input power of a specified filter, sometimes expressed in decibels.

geoacoustic

Relating to the acoustic properties of the seabed.

hertz (Hz)

Unit of frequency defined as one cycle per second. Often expressed in multiples such as kilohertz (1 kHz = 1000 Hz).

hydrostatic pressure

The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

knot (kn)

Unit of vessel speed equal to 1 nautical mile per hour.

level

A measure of a quantity expressed as the logarithm of the ratio of the quantity to a specified reference value of that quantity. For example, a value of sound pressure level with reference to 1 μPa^2 can be written in the form *x* dB re 1 μPa^2.

monopole source level (MSL)

A source level that has been calculated using an acoustic model that accounts for the effect of the sea-surface and seabed on sound propagation, assuming a point source (monopole). Often used to quantify source levels of vessels or industrial operations from measurements. See also **radiated noise level**.

octave

The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

point source

A source that radiates sound as if from a single point.

power spectral density

Generic term, formally defined as power in a unit frequency band. Unit: watt per hertz (W/Hz). The term is sometimes loosely used to refer to the spectral density of other parameters such as squared sound pressure. Ratio of **energy spectral density**, E_f, to time duration, Δt, in a specified temporal observation window. In equation form, the power spectral density P_f is given by $P_f = E_f/\Delta t$. Power spectral density can be expressed in terms of various field variables (e.g., sound pressure, **sound particle displacement**).

power spectral density level

The level ($L_{P,f}$) of the power spectral density (P_f) in a stated frequency band and time window. Defined as: $L_{P,f} = 10\log_{10}(P_f/P_{f,0})$. Unit: decibel (dB).

As with power spectral density, power spectral density level can be expressed in terms of various field variables (e.g., sound pressure, sound particle displacement). The reference value ($P_{f,0}$) for power spectral density level depends on the nature of the field variable.

propagation loss (PL)

Difference between a source level (SL) and the level at a specified location, $\mathrm{PL}(x) = \mathrm{SL} - L(x)$.
Unit: decibel (dB). See also transmission loss.

radiated noise level (RNL)

A source level that has been calculated assuming sound pressure decays geometrically with distance from the source, with no influence of the sea-surface or seabed. Often used to quantify source levels of vessels or industrial operations from measurements. See also monopole source level.

received level

The level of a given field variable measured (or that would be measured) at a given location.

reference value

Standard value of a quantity used for calculating underwater sound level. The reference value depends on the quantity for which the level is being calculated:

Quantity	Reference value
Sound pressure	p_0^2 = 1 μPa^2 or p_0 = 1 μPa
Sound exposure	E_0 = 1 μPa^2 s
Sound particle displacement	δ_0^2 = 1 pm^2
Sound particle velocity	u_0^2 = 1 nm^2/s^2
Sound particle acceleration	a_0^2 = 1 μm^2/s^4

shear wave

A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called a secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

sound

A time-varying disturbance in the pressure, stress, or material displacement of a medium propagated by local compression and expansion of the medium. In common meaning, a form of energy that propagates through media (e.g., water, air, ground) as pressure waves.

sound exposure

Time integral of squared sound pressure over a stated time interval in a stated frequency band. The time interval can be a specified time duration (e.g., 24 h) or from start to end of a specified event (e.g., a pile strike, an airgun pulse, a construction operation). Unit: pascal squared second (Pa^2 s). Symbol: E.

sound exposure level (SEL)

The level (L_E) of the sound exposure (E) in a stated frequency band and time window: $L_E = 10\log_{10}(E/E_0)$ (ISO 18405:2017). Unit: decibel (dB). Reference value (E_0) for sound in water: 1 μPa^2 s.

sound field

Region containing sound waves.

sound intensity

Product of the sound pressure and the **sound particle velocity** (ISO 18405:2017). The magnitude of the sound intensity is the sound energy flowing through a unit area perpendicular to the direction of propagation per unit time. Unit: watt per metre squared (W/m^2). Symbol: I.

sound particle displacement

Displacement of a material element caused by the action of sound, where a material element is the smallest element of the medium that represents the medium’s mean density (ISO 18405:2017). Unit: metre (m). Symbol: δ.

sound particle velocity

The velocity of a particle in a material moving back and forth in the direction of the pressure wave. Unit: metre per second (m/s). Symbol: u.

sound pressure

The contribution to total pressure caused by the action of sound (ISO 18405:2017). Unit: pascal (Pa). Symbol: p.

sound pressure level (SPL), rms sound pressure level

The level (L_p) of the time-mean-square sound pressure (p_{rms}^2) in a stated frequency band and time window: $L_p = 10\log_{10}(p_{\mathrm{rms}}^2/p_0^2) = 20\log_{10}(p_{rms}/p_0)$, where rms is the abbreviation for root-mean-square. Unit: decibel (dB). Reference value (p_0^2) for sound in water: 1 µPa^2. SPL can also be expressed in terms of the root-mean-square (rms) with a reference value of p_0 = 1 µPa. The two definitions are equivalent.

sound speed profile

The speed of sound in the water column as a function of depth below the water surface.

soundscape

The characterization of the ambient sound in terms of its spatial, temporal, and frequency attributes, and the types of sources contributing to the sound field (ISO 18405:2017).

source level (SL)

A property of a sound source equal to the sound pressure level measured in the far field plus the propagation loss from the acoustic centre of the source to the receiver position. Unit: decibel (dB). Reference value: 1 µPa^2 m^2.

spectrum

Distribution of acoustic signal content over frequency, where the signal's content is represented by its power, energy, mean-square sound pressure, or sound exposure.

transmission loss (TL)

The difference between a specified level at one location and that at a different location: $\mathrm{TL}(x_1,x_2) = L(x_1) - L(x_2)$ (ISO 18405:2017). Unit: decibel (dB). See also propagation loss.

wavelength

Distance over which a wave completes one cycle of oscillation. Unit: metre (m). Symbol: λ.

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Appendix A. Underwater Acoustic Metrics

A.1. Sound Pressure Level (SPL), Sound Exposure Level (SEL), and Energy Equivalent Sound Pressure Level (L_{eq})

Underwater sound pressure amplitude is measured in decibels (dB) relative to a fixed reference pressure of p_0 = 1 µPa. Because the perceived loudness of sound, especially pulsed sound such as from seismic airguns, pile driving, and sonar, is not generally proportional to the instantaneous acoustic pressure, several sound level metrics are commonly used to evaluate sound and its effects on marine life. Here we provide specific definitions of relevant metrics used in the accompanying report. Where possible, we follow International Organization for Standardization definitions and symbols for sound metrics (e.g., ISO 2017, ANSI S1.1-2013).

The sound pressure level (SPL or L_p; dB re 1 µPa) is the root-mean-square (rms) pressure level in a stated frequency band over a specified time window (T; s). It is important to note that SPL always refers to a rms pressure level and therefore not instantaneous pressure:

$$L_p = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right)\ \text{dB} \qquad \text{(A-1)}$$

The sound exposure level (SEL or L_E; dB re 1 µPa^2 s) is the time-integral of the squared acoustic pressure over a duration (T):

$$L_E = 10\log_{10}\left(\int_T p^2(t)\,dt \Big/ T_0 p_0^2\right)\ \text{dB} \qquad \text{(A-2)}$$

where T_0 is a reference time interval of 1 s. SEL continues to increase with time when non-zero pressure signals are present. It is a dose-type measurement, so the integration time applied must be carefully considered for its relevance to impact to the exposed recipients. SEL can be calculated over a fixed duration, such as the time of a single event or a period with multiple acoustic events.

Energy equivalent SPL (L_{eq}; dB re 1 µPa) denotes the SPL of a stationary (constant amplitude) sound that generates the same SEL as the signal being examined, $p(t)$, over the same time period, T:

$$L_{\text{eq}} = 10\log_{10}\left(\frac{1}{T}\int_T p^2(t)\,dt \Big/ p_0^2\right) \qquad \text{(A-3)}$$

The equations for SPL and the energy-equivalent SPL are numerically identical. Conceptually, the difference between the two metrics is that the SPL is typically computed over short periods (typically of 1 s or less) and tracks the fluctuations of a non-steady acoustic signal, whereas the L_{eq} reflects the average SPL of an acoustic signal over time periods of, for example, 1 min, several hours, or an entire month.

The change in energy equivalent SPL (ΔL_{eq}; dB) denotes the difference between two L_{eq} values, in dB:

$$\text{D}L_{\text{eq}} = L_{\text{eq},1} - L_{\text{eq},2} \qquad \text{(A-4)}$$

A.2. Decidecade Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. However, this splitting of the spectrum into passbands of a constant width of 1 Hz does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analyzing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into decidecade bands, which are one tenth of a decade wide. A decidecade is sometimes referred to as a "1/3 octave" because one tenth of a decade is approximately equal to one third of an octave. Each decade represents a factor 10 in sound frequency. Each octave represents a factor 2 in sound frequency. The centre frequency of the ith band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{\frac{i}{10}}\ \mathrm{kHz} \tag{A-5}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith decade band are defined as:

$$f_{lo,i} = 10^{\frac{-1}{20}} f_c(i) \quad \text{and} \quad f_{hi,i} = 10^{\frac{1}{20}} f_c(i) \tag{A-6}$$

The decidecade bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1).

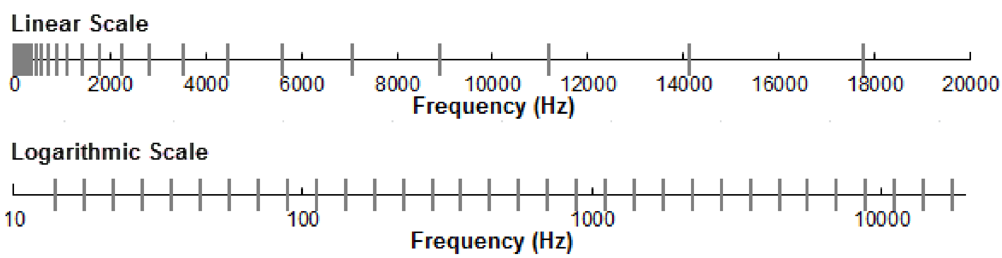

Figure A-1. Decidecade frequency bands (vertical lines) shown on a linear frequency scale and a logarithmic scale.

The sound pressure level in the ith band ($L_{p,i}$) is computed from the spectrum $S(f)$ between $f_{lo,i}$ and $f_{hi,i}$:

$$L_{p,i} = 10 \log_{10} \int_{f_{lo,i}}^{f_{hi,i}} S(f)\, \mathrm{d}f \ \ \mathrm{dB} \tag{A-7}$$

Summing the sound pressure level of all the bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{\frac{L_{p,i}}{10}} \ \mathrm{dB} \tag{A-8}$$

Figure A-2 shows an example of how the decidecade band sound pressure levels compare to the sound pressure spectral density levels of an ambient sound signal. Because the decidecade bands are wider than 1 Hz, the decidecade band SPL is higher than the spectral levels at higher frequencies. Acoustic modelling of decidecade bands requires less computation time than 1 Hz bands and still resolves the frequency-dependence of the sound source and the propagation environment.

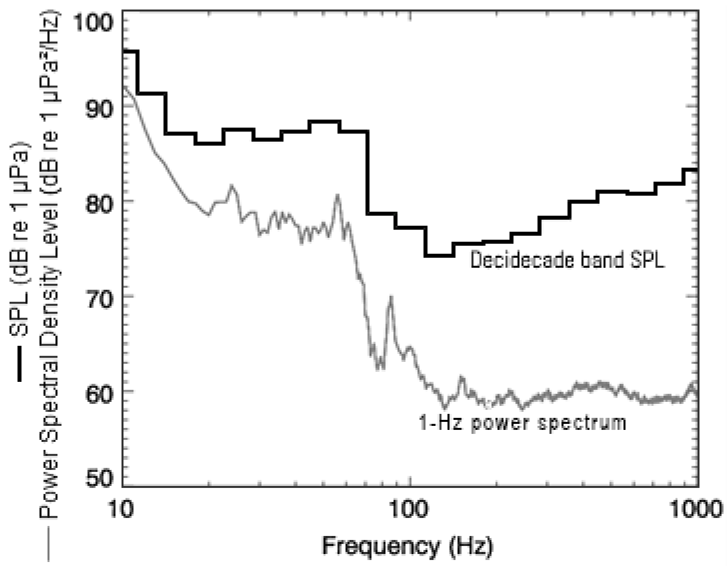

Figure A-2. Sound pressure spectral density levels and the corresponding decidecade band sound pressure levels of example ambient sound shown on a logarithmic frequency scale. Because the decidecade bands are wider with increasing frequency, the decidecade-band SPL is higher than the power spectrum.

Appendix B. Environmental Parameters

B.1. Sound Speed Profiles

In temperate zones, the temperature and salinity profile of oceans greatly change over the seasons. These changes affect the speed that sound travels through the water. Water column sound speed profiles for January and July were computed from historical temperature and salinity data in the southern region of the Salish Sea (ONC and U Vic 2017). These monthly averaged sound speed profiles are most variable in the upper 80 m of the water column, as seen in Figure B-1. Solar heating in summer increases the surface water temperature, which increases the sound speed at the top of the water column and, therefore, redirects sound toward the seafloor. Wind-driven mixing in winter combined with atmospheric cooling results in lower surface water temperatures, which decrease the sound speed at the top of the water column and redirect sounds toward the surface. The mean sound speed profile for July was used to represent the acoustic properties of the water column in the model. Analysis of the sound speed profiles showed no strong geographical variations in the data; therefore, a single sound speed profile was assumed for all study areas.

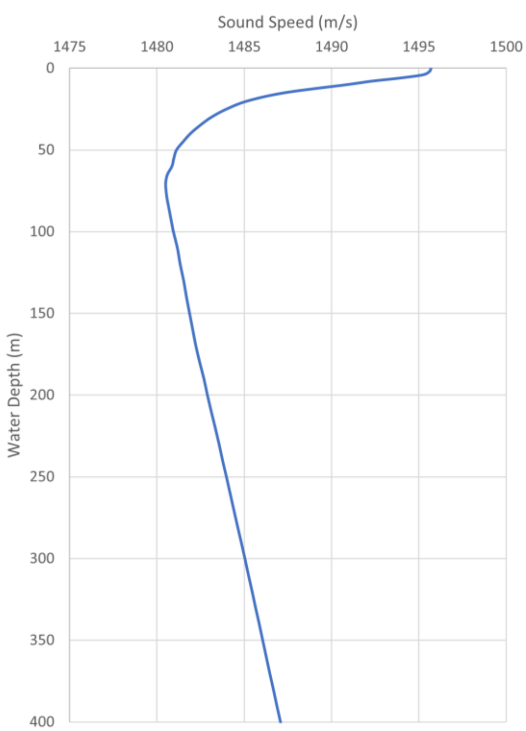

Figure B-1. Mean sound speed profile for the study area, based on historical ocean temperature and salinity profiles for July.

B.2. Bathymetry

The bathymetry (depth contours) inside the study area was modelled on a 20 m resolution BC Albers grid. It was compiled from the following sources:

1. NOAA digital elevation model (NGDC 2013) for data south of latitude 49°N.
2. Canadian Hydrographic Service digital elevation map from Nautical Data International Inc. for data north of latitude 49°N.

The water depths in the region range from 0 to 870 m.

B.3. Geoacoustic Properties

The geoacoustic properties of the seabed strongly influence how sound travels through the water. Reflection and absorption of sound energy at the seabed is the dominant mechanism by which sound is attenuated in shallow (less than ~200 m) water (Urick 1983). The seabed geoacoustic properties for studied area were obtained by combining geoacoustic inversion results from acoustic measurements (JASCO 2015) and reviewing scientific literature (Hamilton 1980, Erbe et al. 2012). The geoacoustic properties for the Swiftsure Bank region are listed in Table D-1.

Table B-1. Seabed profiles for the Swiftsure Bank geoacoustic regions.

<table>
<tr><th>Depth below the seafloor (m)</th><th>Sediment type</th><th>Compressional speed (m/s)</th><th>Density (g/cm^3)</th><th>Compressional attenuation (dB per λ)</th><th>Shear speed (m/s)</th><th>Shear attenuation (dB per λ)</th></tr>
<tr><td>0–50</td><td>Sand</td><td>1713–1763</td><td>1.94</td><td>0.90</td><td rowspan="2">500</td><td rowspan="2">3.4</td></tr>
<tr><td>>50</td><td>Bedrock</td><td>2275</td><td>2.20</td><td>0.10</td></tr>
</table>

Appendix C. Sound Propagation Models

C.1. Propagation Loss Model—ORCA

The ARTEMIA model takes as input a database of precomputed propagation loss curves at any given vessel location in the study area. These curves were calculated using the ORCA propagation loss model, which is described here.

The propagation of sound through the environment was modelled by predicting the acoustic propagation loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which propagation loss occurs. It also happens when the sound is absorbed and scattered by the seawater, and when absorbed, scattered, and reflected at the water surface and within the seabed. Therefore, propagation loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic source level (SL), expressed in dB re 1 µPa²m²s, and propagation loss (PL), in units of dB, at a given frequency are known, then the received level (RL) at a receiver location can be calculated in dB re 1 µPa²s by:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{PL} \tag{C-1}$$

The normal mode code ORCA model (Westwood et al. 1996) was used to calculate frequency-dependent sound propagation loss curves for different environments within the study area. ORCA accounts for environmental factors that influence underwater sound propagation, including the water depth, sound speed profile of the water, and the seabed sediment layering. These parameters were used to calculate a set of frequency- and range-dependent propagation loss curves, which represent sound propagation in different parts of the modelled area in the summer. In prior studies by JASCO (MacGillivray et al. 2018, Matthews et al. 2018), the southern Salish Sea was divided into 20 zones, shown in Figure C-1, based on the four unique geoacoustic regions and the five water depth ranges, listed in Table C-1. Zones 4, 8, 12, 16, and 20 were used to describe the environment in the Swiftsure Bank study area. Propagation loss was computed using an incoherent mode sum in decidecade bands with centre frequencies between 10 Hz and 63 kHz, out to a maximum distance of 75 km from the source to represent frequency-averaged propagation loss in shallow water where modes interact substantially with the seabed (Jensen et al. 1994). Six modelled source depths, from 1 to 6 m in 1 m increments, were used to represent the nominal acoustic emission centres of small and large draft vessels. The receiver depth was chosen to be 10 m, near the sea surface (where marine mammals spend a relatively large amount of their time), but not too close to the surface where surface reflections cancel a lot of low-frequency sound energy and not too deep to avoid quiet “shadow” zones created by upward refracting sound speed profiles (e.g., in winter). The propagation loss curves were used as input to the ARTEMIA model. Figure C-2 presents plots that help visualize how the modelled propagation loss varies with distance from the source and frequency, as well as with zones and seasons.

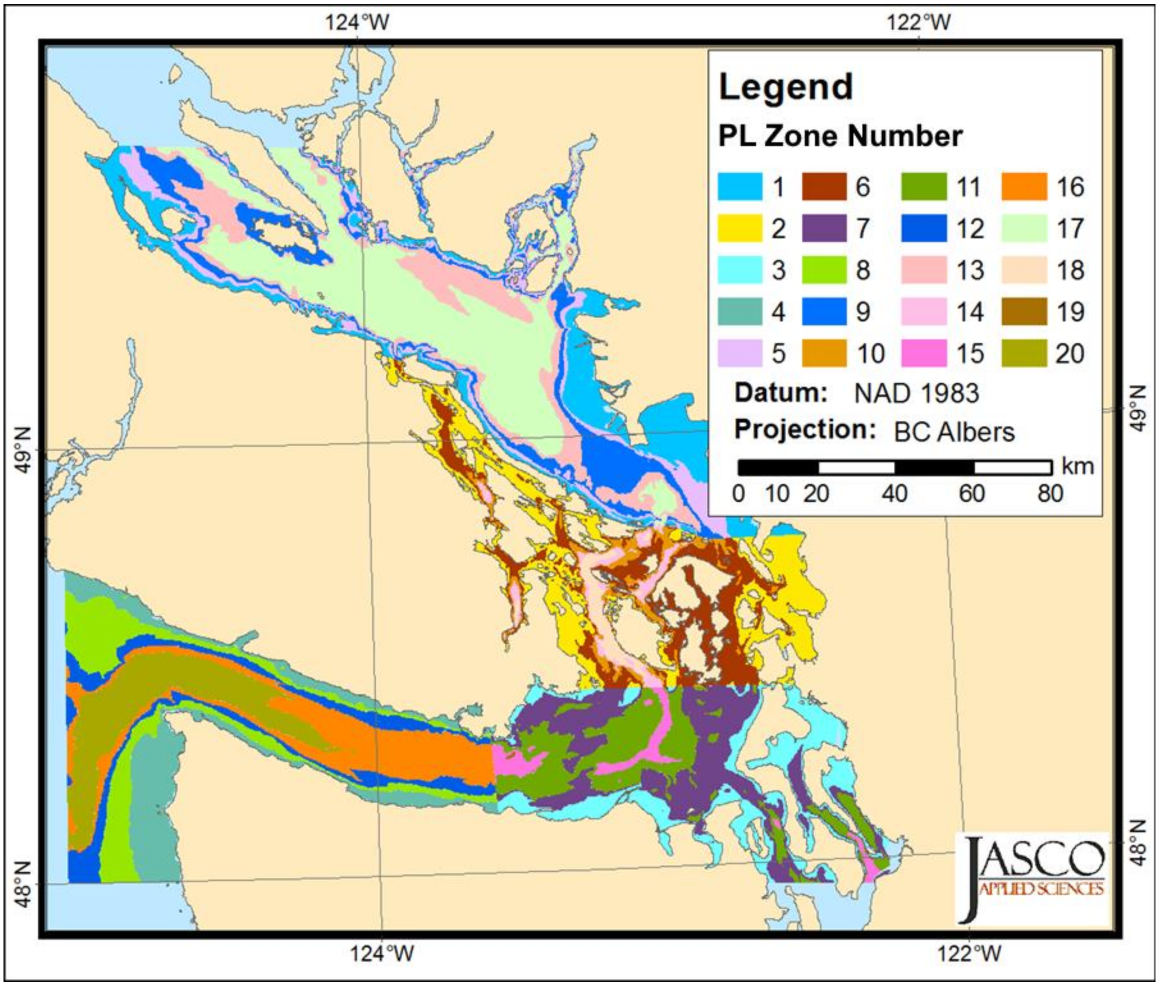

Figure C-1. Map of propagation loss (PL) zones 1–20, some of which were used for modelling sound propagation in the study areas (MacGillivray et al. 2018).

Table C-1. Zone numbers, corresponding geoacoustics, and water depths (MacGillivray et al. 2018). Geoacoustic properties of each region are listed in Table B-1.

Zone	Water depth range (m)	Modelled water depth (m)	Geoacoustic region
1	0–50	25	Strait of Georgia
2			Haro Strait and Rosario Strait
3			East Juan de Fuca Strait
4			West Juan de Fuca Strait
5	50–100	75	Strait of Georgia
6			Haro Strait and Rosario Strait
7			East Juan de Fuca Strait
8			West Juan de Fuca Strait
9	100–150	125	Strait of Georgia
10			Haro Strait and Rosario Strait
11			East Juan de Fuca Strait
12			West Juan de Fuca Strait
13	150–200	175	Strait of Georgia
14			Haro Strait and Rosario Strait
15			East Juan de Fuca Strait
16			West Juan de Fuca Strait
17	>200	225	Strait of Georgia
18			Haro Strait and Rosario Strait
19			East Juan de Fuca Strait
20			West Juan de Fuca Strait

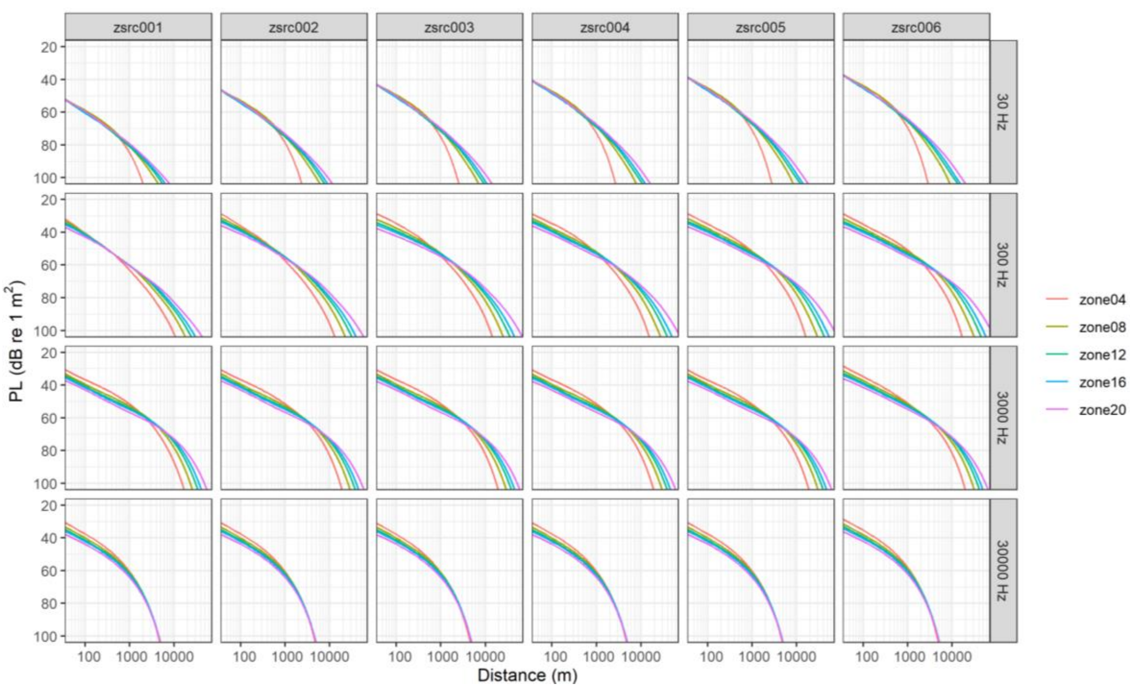

Figure C-2. Example plots of modelled propagation loss at 30, 300, 3000, and 30 000 Hz, as a function of distance from the source. This example represents the propagation loss for July in zones found in Swiftsure Bank, seen in Figure C-1. The source depths (srcz, top row) were 1 to 6 m, and the receiver depth was 10 m.

C.2. Cumulative Noise Model—ARTEMIA

JASCO's Acoustic Real-Time Exposure Model Incorporating Ambient (ARTEMIA) is a cumulative noise exposure model that simulates underwater sound levels generated by large ensembles of marine sound sources on a regional scale. ARTEMIA uses information from several different data sources to predict underwater sound levels in the marine environment (Figure C-3):

Vessel traffic data: Information about the vessel traffic throughout the study area, including vessel types/categories, vessel densities or positions versus time, and speeds.

Sound propagation curves: Database of precomputed propagation loss curves at any given vessel location in the study area (these curves are based on site- and time-specific environmental parameters) or predefined environmental zones for the use of the integrated CRAM model.

Vessel source levels: The level of noise emitted by each vessel category; these levels are frequency- and speed-dependent.

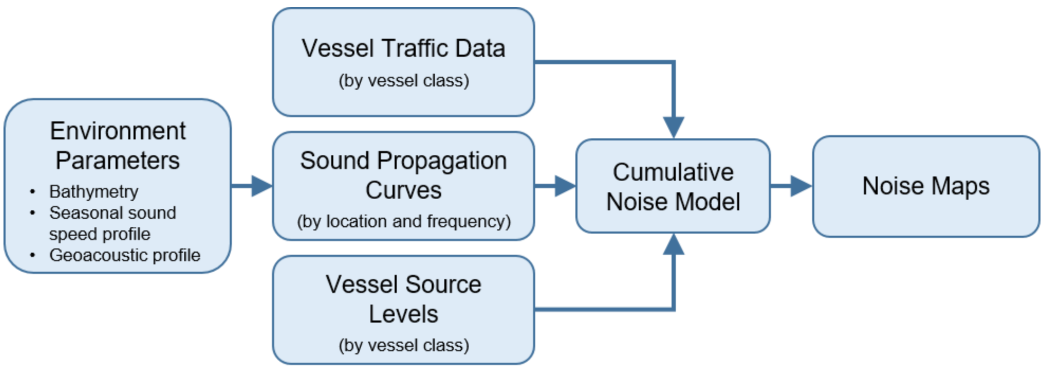

Figure C-3. High-level flowchart of cumulative noise model inputs and outputs.

Vessel noise emissions are determined by referencing a database of source levels (according to vessel type/category and speed). The propagation of sound from each source is determined according to a database of pre-computed propagation loss curves for the study area (see Appendix C.1). When run in time-independent (i.e., spatial, as in the current study) mode, ARTEMIA generates 2-dimensional (2-D) maps of equivalent sound pressure levels (L_{eq}) as a function of easting and northing for the studied frequency bands, area, and period.

ARTEMIA uses a grid representation of a region (Figure C-4), where the area is divided into equally sized square cells. Each source is assumed to be a point at the centre of its respective grid cell, with the sound propagating outwards from that cell into neighbouring cells. A radial sound field is produced from each source, with the sound in each grid cell being added to create the overall regional sound field.

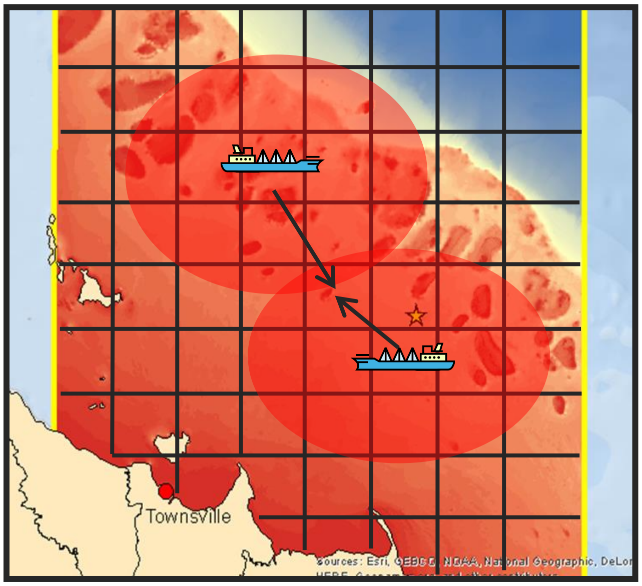

Figure C-4. Representation of model gridding and calculation overview used by ARTEMIA.

The main calculations in the ARTEMIA model involve determining the sound levels produced by different sources and summing them up to produce an overall map of the underwater soundscape. This is done by individually propagating the sound from a source (one or multiple vessels) along a 360° fan of rays (Figure C-5) according to the source levels, the source's speed, and the propagation loss. Sound rays are blocked by coastline features and very shallow water depths (<0.5 m).

Spatial variations in propagation loss conditions throughout the region are represented by numbered zones, where each zone corresponds to a unique range of water depth, sound speed profile, and geoacoustic properties (see Appendix C.1). Range-dependence is treated by calculating propagation loss at each receiver point according to a weighted average of the propagation loss curves from all zones encountered along a ray.

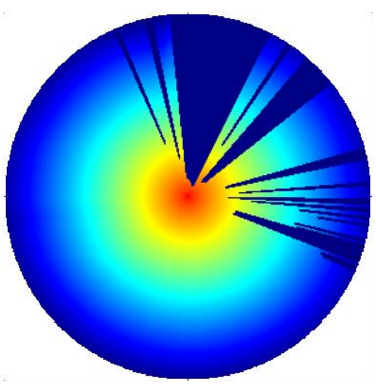

Figure C-5. Example of a range- and azimuth-dependent sound field computed by ARTEMIA for an individual source at a specific location. Red represents the highest sound levels; the sound levels decrease away from the central source . Zones of dark blue result from areas of shallow bathymetry or islands that prevent sound from propagating along those azimuths.

Appendix D. AIS Vessel Category Assignments

Table D-1. The AIS type codes assigned to each vessel category.

Vessel category	AIS vessel type*
Bulker	Bulk Carrier, Cargo, Heavy Load Carrier, General Cargo, LPG Tanker, Reefer, Self Discharging Bulk Carrier, Timber Carrier
Container	Cargo/container ship, Container ship, Ro-Ro/Container Carrier
Cruise ship	Passenger, Passenger ship (greater than 100 m in length)
Fishing	Factory trawler, Fish factory, Fishing, Fishing vessel, Trawler
Government	Buoy-Laying Vessel Law Enforce, Logistics Naval Vessel, Military Ops, Replenishment Vessel, Research/Survey Vessel, SAR
Recreational	Pleasure craft, Yacht, Passenger (less than 100 m in length), Passenger ship (less than 100 m in length)
Tanker	Crude oil tanker, Oil product tanker, Oil/Chemical tanker, Tanker
Tug	Offshore Supply Ship, Pusher Tug, Towing Vessel, Tug, Pollution Control Vessel, Tug/Supply Vessel
Vehicle carrier	Vehicle carrier
Other/miscellaneous	Anti-Pollution, Cable Layer, Dive Vessel, Local Vessel, Other, Pilot Vessel, Port Tender, Tender, Unspecified, Icebreaker, Special Craft, Special Vessel

* Automatic Identification System (AIS) vessel type from MarineTraffic.com.

Appendix C
Marine Mammal Survey 2022 - Pacheedaht First Nation and ECHO Program

SEA VIEW MARINE SCIENCES

Marine Mammal Survey 2022
Pacheedaht First Nation and ECHO Program

Prepared for the ECHO Program

[February 2023]

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Acknowledgements

The 2022 marine mammal survey would not have been possible without the dedication and hard work of the *Seafoam Spirit* captains and crew. Gratitude is extended to Guy Louie, Kevin McKenna, Brett Smith, Connie Robinson-Charlie, Andrea Jones, Shelton Redcalfe, Desmond Jack, Pam Jones, Molly Underwood, Sophie Adams, Trystan Dunn-Jones, and Carl Carlson Sr. for their dedication and commitment to the 2022 field season. Thanks are also extended to Kristine Gatzke for coordinating the 2022 season, and the ECHO Program for providing the funding that facilitated this important project. Lastly, continued gratitude is extended to the late Ken Balcomb and his team at the Center for Whale Research for their more than four decades of commitment to the study, conservation, and protection of southern resident killer whales, and without whose efforts the ability to identify individual whales and their families would not be possible.

1 Introduction

Northeast Pacific southern resident killer whales (*Orcinus orca*) are one of four distinct populations of killer whales that inhabit the Pacific waters of British Columbia (BC). Throughout the year, southern resident killer whales range from California to Alaska, spending much of their time in the inland waters of BC and Washington State—a transboundary region known as the Salish Sea. Much of the Salish Sea has been designated as critical habitat in both Canada and the United States (US) (DFO 2017a, EPA 2021). The US Center for Whale Research has studied this population of whales for the past 47 years. As of 1 July 2022, the southern resident killer whale community was composed of a total of 73 individuals from three pods known as J (N=25), K (N=16), and L pods (N=32) (CWR 2022). They were listed as *Endangered* under the Species at Risk Act in 2003 in Canada (GoC 2022) and the Endangered Species Act in the USA in 2005 (NOAA 2022).

The international focus on this endangered population has resulted in a suite of conservation actions in both Canada and the US. These actions have focused on addressing known threats including (in no particular order): environmental contamination, underwater anthropogenic noise, physical disturbance from vessels, and reduced availability or quality of prey, with emphasis on their preferred prey, chinook salmon (*Oncorhynchus tshawytscha*) (DFO 2017b). Management measures implemented in Canadian waters of the Salish Sea included fishery closures, Interim Sanctuary Zones (ISZ), Seasonal Slowdown Areas, and changes to mandatory vessel approach distances (DFO 2020, 2021, 2022). In addition to these Government of Canada actions, additional conservation efforts were taken by other stakeholders including the Enhancing Cetacean Habitat and Observation (ECHO) Program of the Vancouver Fraser Port Authority (see Section 1.1). Conservation measures have also been enacted in the US, including implementation of Recovery Plan actions (NOAA 2021), development of the National Oceanic and Atmospheric Administration (NOAA) Fisheries - Species in the Spotlight 5-Year Priority Action Plan (NOAA 2021), and a Washington State Governor's Task Force directed to identify immediate and long-term actions to benefit southern resident killer whales. Actions taken in Washington State also led to new laws protecting southern resident killer whales in 2019. Such laws address disturbance, shipping safety, ecosystem recovery, contamination, and boater education (NOAA 2021).

In 2022, Canadian southern resident killer whale management measures were adapted and updated from previous years. These include area-based fishing closures at Swiftsure Bank, in the Juan de Fuca Strait (SJF) and the Gulf Islands, and at the mouth of the Fraser River, designed to increase prey availability and reduce potential disturbance by vessel traffic (DFO 2022). These seasonal closures are triggered by the presence of southern resident killer whales (DFO 2022). Voluntary measures are also in place asking fishers to stop fishing within 1000 metres (m) of killer whales (DFO 2022). The ISZs in the Gulf Islands (off North Pender and Saturna Islands) have been renewed, while the Swiftsure Bank ISZ was replaced with two Seasonal Slowdown Areas limiting vessel speeds to 10 knots (kn) (DFO 2022). An Interim Order was executed under the *Canada Shipping Act* which restricts vessels to a 400 m minimum approach distance near killer whales in southern BC coastal waters (DFO 2022) until May 2023, an increase from the *Marine Mammal Regulations* of 200 m. The ECHO Program voluntary large commercial vessel measures in 2022 included an extension of the seasonal slowdown area at Swiftsure Bank to both the inbound (trial for 2022) and outbound shipping lanes, seasonal slowdown in Haro Strait and Boundary Pass, as well as the inshore lateral displacement zone in the SJF for tugboat operators (ECHO 2022a, 2022b, 2022c). These three measures were first implemented in 2020, 2017, and 2018, respectively, and have been shown to be effective measures in reducing potential acoustic disturbance to southern resident killer whales (ECHO 2022a, 2022b, 2022c).

While conservation actions were implemented with the goal of reducing some of the known threats to individual whales, and subsequently population survival, it was also recognised that spatial and temporal gaps in scientific understanding remained. These gaps are most prevalent along the western Pacific coasts of California, Oregon, Washington, and British Columbia and in the westernmost regions of the Salish Sea.

The western and outermost area of the Salish Sea lies within the SJF, which connects the inland waters of Washington and British Columbia to the open Pacific Ocean. At approximately 156 kilometers (km) in length (Thomson 1981), the strait provides increasingly sheltered passage from the vastness of the Pacific Ocean to coastal regions for whales and ships alike. The western extent is a remote expansive channel with increasing depths and is intersected by the ecological richness of Swiftsure Bank. The area is characterised by a west coast wildness that affords logistical challenges to scientific research, but that directly contributes to the diversity of marine life that is supported by the deep, cold, up-welled waters of the western Salish Sea (Thomson 1981). This region is also characterised by a lower human population and few sheltered marinas. These combined attributes result in an observational data gap for southern resident killer whales, as well as the diversity of other marine mammal species that occupy these waters.

The western waters of SJF and Swiftsure Bank provide habitats for a variety of marine mammal species from the ubiquitous harbour seals (*Phoca vitulina*) to the strikingly fast Dall's porpoise (*Phocoenoides dalli*). The species-specific habitat needs in this area are not well understood, but likely include foraging, mating, parturition, socializing and traveling. There may be other important uses of this region by marine mammals that have not yet been scientifically defined. Despite the emergent state of species-specific scientific knowledge for this region, the biological diversity and importance of the area for west coast ecosystem integrity is well known.

Transient (also known as Bigg's) killer whales can be found in the area throughout the year, and occasional sightings of offshore killer whales also occur. Northern resident killer whales have also been detected using the area around Swiftsure Bank (DFO 2017a). An area off the southwest coast of Vancouver Island, near the study area, has previously been identified as critical habitat for humpback whales (*Megaptera novaeangliae*) (DFO, 2013). Additional species of marine mammals that may be encountered in western SJF and at Swiftsure Bank include minke whales (*Balaenoptera acutorostrata*), grey whales (*Eschrichtius robustus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), harbour porpoise (*Phocoena phocoena*), Dall's porpoise, harbour seals, Steller sea lions (*Eumetopias jubatus*), California sea lions (*Zalophus californianus*) (Ford, 2014), elephant seals (*Mirounga angustirostris*), and the occasional sea otter (*Enhydra lutris*). This report focuses on the cetaceans observed during the 2022 field season.

Background

In 2020, the ECHO Program, led by the Vancouver Fraser Port Authority, coordinated the first voluntary slowdown trial at Swiftsure Bank — a known foraging area for southern resident killer whales near the entrance to SJF. This slowdown was conducted in an attempt to reduce acoustic disturbance from large commercial vessels in key southern resident killer whale feeding areas. This action was based on the research trial led by the ECHO Program in 2017 (MacGillivray et al. 2019) to evaluate whether slowing vessels would decrease underwater noise and how this could potentially affect the behaviour and foraging success of southern resident killer whales in Haro Strait (in the central Salish Sea).

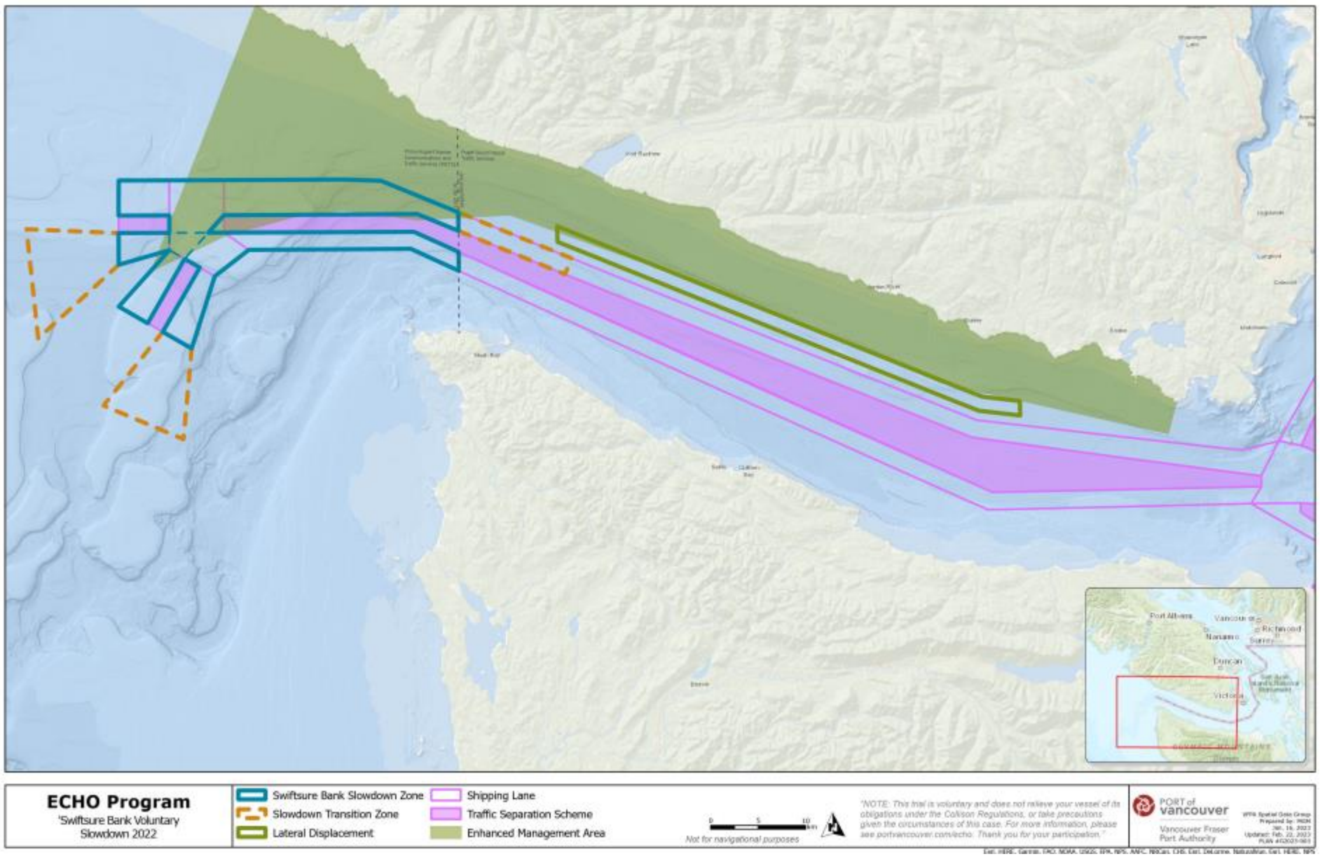
The voluntary large commercial slowdown in Haro Strait in 2017 determined that reducing vessel speed was an effective way of decreasing the underwater sound produced by individual vessels (Joy et al. 2019; MacGillivray et al. 2019). This contributed to reducing the anthropogenic contribution to overall soundscape in nearby habitats, which may ultimately positively affect the foraging success of southern resident killer whales (ECHO 2018), as well as other marine mammal species. Since the initial research trial in Haro Strait, the on-water measures have expanded to include a voluntary seasonal slowdown in Haro Strait, Boundary Pass, and the Swiftsure Bank area, as well as a lateral displacement for tugs in SJF. The on-water initiatives are a continuation of the ECHO Program's efforts which began in 2014, when the ECHO Program advisory working group helped identify underwater noise related to marine traffic as a priority focus area for the program (ECHO 2022a). The ECHO Program also supports other threat-reduction projects for whales in BC related to reducing physical disturbance and environmental contaminants (ECHO 2022a).

The ECHO Program's voluntary on-water initiatives continued in 2022 (Figure 1). The voluntary Swiftsure Bank slowdown and the SJF voluntary inshore lateral displacement were in effect from 1 June 2022 through to 31 October 2022 (ECHO 2022b). The Swiftsure Bank Slowdown requested that large commercial ships transiting both outbound and inbound (trial for 2022) from SJF voluntarily reduce the vessel's speed during the transit from the JA Buoy to the end of the traffic separation scheme (Figure 1)—a distance that ranged from 17–23 nautical miles (nm) (32–43 km) (ECHO 2022b). The recommended vessel speed targets were:

- 14.5 kn or less through the water for vehicle carriers, passenger and container vessels
- 11 kn or less through the water for bulkers, tankers, and government vessels (ECHO 2022c).

In addition to the Swiftsure Bank voluntary slowdown, the voluntary SJF lateral tug displacement initiative has been in place since 2018 as an effort to further reduce underwater noise by asking tugboats to laterally displace away from important killer whale foraging areas. Tugboats transiting in the Canadian inshore area of SJF were asked to move south of the known southern resident killer whale feeding area and navigate through the inshore lateral displacement zone or the outbound shipping lane (Figure 1) (ECHO 2022b). Tugboats were encouraged to participate regardless of whether they were engaged in towing a barge (ECHO 2022b).

Figure 1. Juan de Fuca Strait and Swiftsure Bank region with Traffic Separation Scheme, boundaries of the 2022 ECHO Program noise reduction measures, including the voluntary slowdown zone in the outbound and inbound traffic lanes that cross onto Swiftsure Bank and the inshore tug lateral displacement zone.



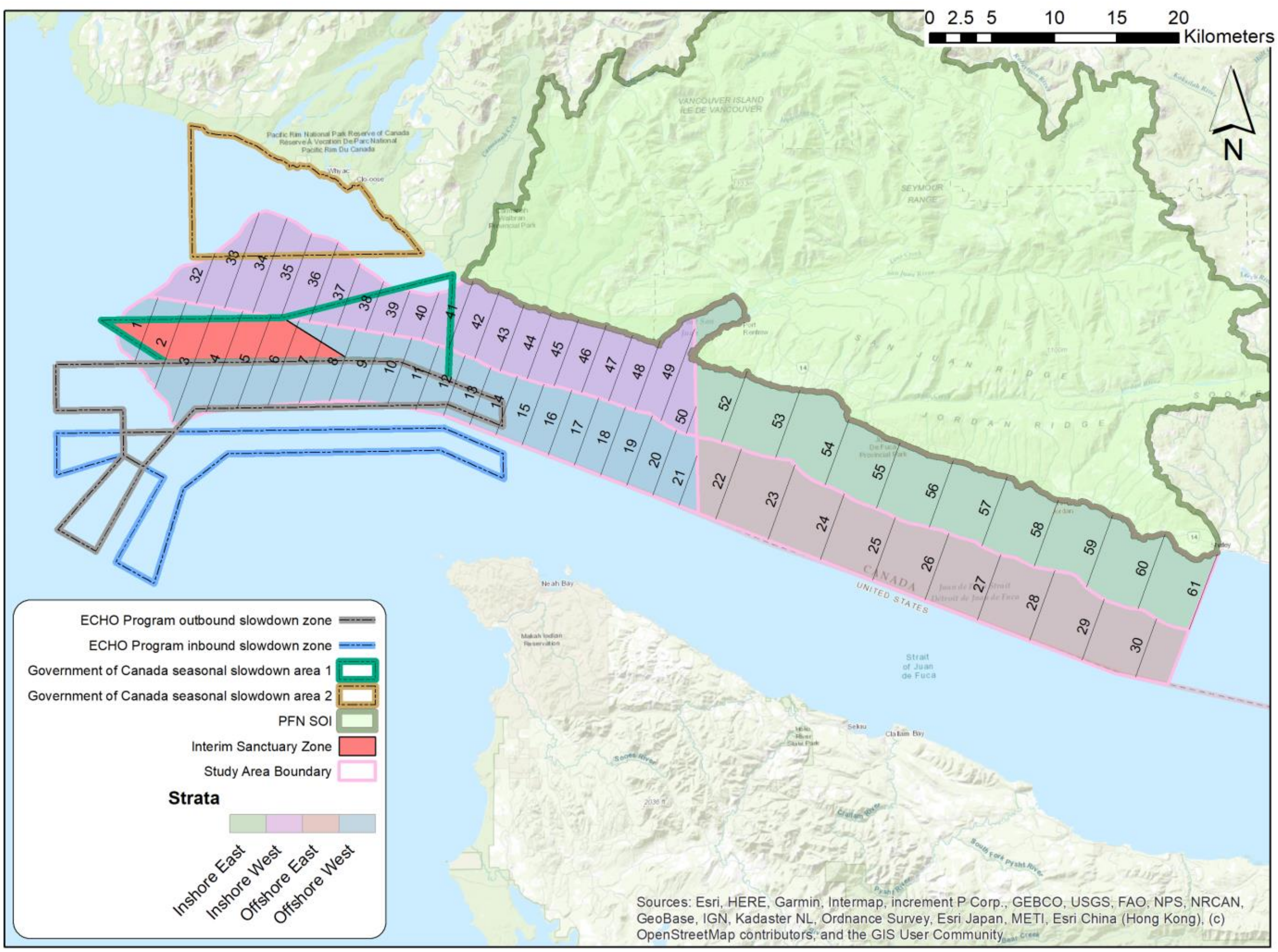
ECHO conservation initiatives within the study area have seen increasing success and participation over time. In 2021, 81% of vessels transiting outbound through Swiftsure Bank participated in the slowdown within about 1 kn of the target speed. The SJF voluntary inshore lateral displacement achieved 88% of tug transits spending greater than half of their transit in the inshore lateral displacement zone or the outbound shipping lane in 2021. The Haro Strait and Boundary Pass voluntary vessel slowdown also achieved 90% participation (ECHO 2022d).

As part of the voluntary initiatives, the ECHO Program was also seeking to better understand the presence and behaviour of southern resident killer whales and other whale species at both Swiftsure Bank and in western SJF. In 2020, the ECHO Program partnered with Pacheedaht First Nation, near Port Renfrew, to help achieve this goal. The focus of this effort was on the presence of southern resident killer whales, and to gain insight into the potential for positive effects of the slowdown and lateral displacement initiatives. This report encompasses the third year of marine mammal surveys and combines systematic survey data collected during the first and second year of this partnership (see Hall et al. 2021, 2022).

Objectives

The objective of the 2022 effort was to build upon the initial marine mammal distribution study conducted in 2020 and 2021 (Hall et al. 2021, 2022), and to better understand cetacean presence and habitat use, with a focus on southern resident killer whales in the western SJF and at Swiftsure Bank through partnership with Pacheedaht First Nation. This objective was aimed at reducing the spatial and temporal knowledge gaps on southern resident killer whale habitat use known to exist in the western regions of the whales' critical habitat. The study area remained unchanged from previous years and intersected some of the federal conservation management efforts from 2022 and previous years (Figures 1 and 2).

Figure 2. 2022 Marine mammal survey design for the Pacheedaht marine territory in the Statement of Interest and other key management features. Note that the Interim Sanctuary Zone was not continued in 2022.



1.1 Project Description

The project was divided into four main tasks that were described as follows:

Task 1 – Provide marine mammal observer training to Pacheedaht First Nation boat crew

Task 1 involved the delivery of an in-person Marine Mammal Observer Training (MMOT) program originally developed by Sea View Marine Sciences for Indigenous nations skills and capacity building in 2016. This respectful training program was tailored for the marine mammal species expected to be encountered in SJF and Swiftsure Bank with emphasis on Species at Risk, particularly southern resident killer whales and humpback whales. This training was offered as a refresher course for those Pacheedaht crew who participated in 2021, and as a new course for new participants in 2022. Training also included appropriate vessel etiquette in the presence of other marine mammal researchers that may be in the study area.

Task 2 – Marine mammal survey

Task 2 involved updating the design of the 2021 marine mammal survey for the Pacheedaht First Nation to be conducted aboard the *Seafoam Spirit* with the Pacheedaht crew. The design was for two days of "on effort" survey per week and included potential safety aspects that should be considered around the commercial shipping lanes, two Seasonal Slowdown Areas, and whale "hot spots".

The marine mammal survey was based on the Distance-based stratified survey design of 2020 and 2021 that provided wide-scale coverage, was built on current best practice in survey design for geographically complex areas (Thomas et al. 2010) and covered the PFN Statement of Interest (SOI). As with the 2020 and 2021 studies, the survey area was divided into four strata (see Figure 2).

Task 3 – Provide support to Pacheedaht First Nation during the survey season

Task 3 included providing ongoing support to the Pacheedaht First Nation crew via email, phone, text messaging, and in person (following COVID-19 Public Health Orders and guidance) throughout 2022, from the completion of the MMOT to the completion of the marine mammal surveys. This support ensured crew confidence and capacity, and data quality assurance and quality control. A file sharing platform was again implemented to facilitate transfer of data files, photographs, or field assistance documents.

Task 4 - Data analysis and reporting

Task 4 included review of the data collected by the *Seafoam Spirit* crew on a regular basis, synthesis of the visual data, photograph organization, marine mammal species identification, and provision of a final report (i.e., this document) jointly authored by Sea View Marine Sciences, SMRU Consulting, and noting field support by the Pacheedaht First Nation for submission to the ECHO Program.

2 Methods

2.1 Task Descriptions

The methods undertaken for the 2022 season are described for each of the four project main tasks outlined in Section 1.2.

Task 1 – Provide marine mammal observer training to Pacheedaht First Nation boat crew
Marine mammal observer (MMO) training was provided by Sea View Marine Sciences to 13 members and representatives of the Pacheedaht First Nation on 24–25 May 2022 and 17 June 2022. The training was based on the MMOT program previously developed by Sea View Marine Sciences (see Section 1.3) and was delivered by Dr. A. Hall and Ms. C. Carrières.

The MMOT included classroom, coastal, and at-sea components. All participants were provided with the field guide Marine Mammals of the Pacific Northwest: including Oregon, Washington, British Columbia, and Southern Alaska (Folkens 2001). The classroom component was held at the Pacheedaht Band Office in Port Renfrew, British Columbia on 24–25 May 2022. The at-sea components were held on 25 May and 17 June 2022 aboard the Pacheedaht First Nation's vessel the *Seafoam Spirit* in the study area (Figure 2).

The MMOT program consisted of a series of training modules that included:

- Marine Mammal Observer Roles and Responsibilities
- Marine Mammal Species and Natural History Overviews
- Killer Whale Ecotypes and Behaviours
- Marine Mammal Behaviours
- Photo-ID (with emphasis on killer whales)
- Effects of Underwater Noise on Marine Mammals
- Threats to Marine Mammals including Oil Spills
- Federal Regulations and Recent Changes to Vessel Proximity to Killer Whales
- Be Whale Wise
- Human-Whale History in British Columbia
- Scientific Data Recording
- Field Protocols including Distance Estimation
- Line Transect Background
- Line Transect Data Collection, Analysis, Results and Applicability
- Environmental Conditions and Limitations
- Personal Protective Equipment (PPE)
- Personal Safe Working Practices
- Vessel Safety in and Near Shipping Lanes and High-Density Aggregations
- Vessel Etiquette
- Communications

- Additional Resources (including other reporting platforms such as the Porpoise Conservation Society (PCS) and the British Columbia Cetacean Sightings Network (BCCSN)).
- Respect and Care of the Marine Environment
- Digital Data Collection using Transect Pro Software
- Written Data Collection
- File Transfer
- Marine Mammal Observer Applications

The at-sea component provided an opportunity to implement the training module information into practice during marine mammal sightings, data collection, reporting, and field practices. The at-sea component included theoretical and practical components of scientific data collection and built upon the classroom training. The Certification through the MMOT required successful completion of the classroom, coastal, and at-sea components. Nine participants received a *Certificate of Completion of the Introductory Level Course in At-Sea Observation and Data Recording* for successful completion of the MMOT in 2022.

Task 2 – Marine mammal survey

The marine mammal survey of 2022 used the same Distance-based stratified survey design as in 2020 and 2021 (Hall et al. 2021, 2022) that was built on current best practice in survey design for geographically complex areas (Thomas et al. 2010) and completed using the Survey Design Engine in Distance 7.3 software (Thomas et al. 2010). The marine mammal survey covered the PFN SOI in four strata (Figure 2) and considered potential safety aspects regarding survey designs that include commercial shipping lanes, the Seasonal Slowdown Areas, potential whale "hot spots" and vessel etiquette for other researchers that may be operating in the same region. Throughout the 2022 survey season, Sea View provided in-person field support for land and sea operations in all weeks (1–5 days), with the exception of two weeks (21–27 August and 23–29 October), as well as remote operational support for the full extent of the field season.

As in 2020 and 2021, following stakeholder input, the goal was to achieve a 2:1 sampling ratio with emphasis on the western strata over the eastern strata (Figure 2). The marine mammal survey design and 2022 goals and objectives were reviewed with the Pacheedaht field team prior to the commencement of surveys. The line placement and operational procedures were also reviewed with the Pacheedaht field team including cross-referencing with Canadian Hydrographic Chart L/C 3606 for navigable waters to ensure field safety.

As previously described for the 2020 and 2021 marine mammal survey (Hall et al. 2021, 2022), the 2022 marine mammal survey was a Distance-based systematic line transect survey with transects placed in a parallel configuration with 4.5 km spacing in the two eastern strata and 2.25 km spacing in the two western strata (Figure 2). The transect lines were angled perpendicular to the depth gradient and offset from True North by 68°. The Pacheedaht First Nation provided the geographical area of interest which was defined as their SOI (Figure 2). The SOI defined the eastward and westward study area extents, while land/navigable waters defined the northern extent, and the US/Canadian border defined the southern extent (Figure 2).

The study area was divided into four strata for sampling purposes and were labelled according to general direction and proximity to shore. The strata were designated as Inshore east (Inshore east stratum in SJF), Offshore east (Offshore east stratum in SJF), Inshore west (Inshore west stratum in SJF and the northern waters of Swiftsure Bank area) and Offshore west (Offshore west stratum in SJF and the southern waters of Swiftsure Bank area) (Figure 2). The transect lines were placed entirely within the confines of the survey area (i.e., minus sampling) (Figure 2) but the observers were able to see beyond the study area limits. A total of 61 line transects were modelled, with 59 transect lines in the final field design as line numbers 31 and 51 were removed due to the short length of line 31 and the intermittently navigable waters at line 51. These transects were divided between four strata (Inshore east, Offshore east, Inshore west, and Offshore west) (Figure 2).

The study area intersected with the regions demarcated for the ECHO Program voluntary inshore lateral displacement area and Swiftsure Bank large vessel voluntary outbound slowdown area, the two Seasonal Slowdown Areas and the traffic separation scheme for outbound deep-sea traffic (Figures 1 and 2).

The study area encompassed 1038.6 square kilometers (km^2) of western SJF and the exposed Pacific waters of Swiftsure Bank spanning from the shore to the US/Canadian border (Figure 2). Marine mammal observational data were collected during the line transects both using dedicated survey software (i.e., full on-effort dataset and meta-data available), but also during periods considered more opportunistic, where only summary information was provided in a field notebook.

Task 3 – Provide support to Pacheedaht First Nation during the survey season

Support was provided by Sea View Marine Sciences to the Pacheedaht First Nation marine mammal administration and survey crew throughout the field season from June to October 2022, inclusive. This included regular communications with survey crew and supervisory staff on a daily to weekly basis, provision of a file-sharing platform to facilitate data (both visual and photographic) transfer, in-person meetings to support accurate data collection, species, pod or individual whale identification, and photograph review to confirm (where possible) species or killer whale ecotypes.

A survey protocol was developed and provided to the field team to help with daily operations (Appendix A). The protocol was updated throughout the 2022 field season based on feedback from the Pacheedaht field team as communicated during in-person meetings. Communication was maintained via email, phone, text, and in-person visits in Port Renfrew, BC throughout the field season. Weekly communications included: weather forecasts, tentative survey schedules, survey sightings, field equipment, and data recording.

Task 4 - Data analysis and reporting

Transect data, recorded in Transect Pro software (Wernicke and Hall 2015) provided by the Porpoise Conservation Society, were uploaded to the shared OneDrive. Daily database files were downloaded and exported to MS Excel for review and analysis. Marine mammal location data were visualised in ArcMap 10.8.2. These data were compiled and summarised for reporting (see Section 3).

In 2022, the field team completed 846 line transects between June and October. Data were reviewed prior to analysis resulting in 80 line transects lines being removed for data quality reasons. This resulted in an analytical data set for the 2022 field season of 766 line transects. To maximise the killer whale data set, the killer whale sightings collected on-effort that had been removed from the analytical data set were compiled, reviewed, and added to the opportunistic data set. These data are presented as a part of the opportunistic data in Appendix C. Weather associated with opportunistic sightings were extrapolated from the daily description of conditions logged by the field crew on each day.

Photographic data were uploaded to the shared OneDrive by the Pacheedaht or Sea View field team members and submitted to Sea View Marine Sciences for analysis. These data were processed with the line transect and field notebook data and sorted by species. Killer whale photographs were reviewed using photo-identification to identify ecotypes and individuals when possible. Any potential southern resident killer whales were compared to the Centre for Whale Research Orca Survey Guide (e.g., CWR 2022), and previous Sea View Marine Sciences photographs for individual whale identification.

3 Results

3.1 Field Effort

During the 2022 field season, marine mammal effort was conducted with line transect surveys from 23 June–29 October 2022, during which time a total of 766 line transects were completed (Tables 1 and 2). The line transect survey effort consisted of systematic marine mammal visual data collected over a transect distance of 4103.9 km, for a minimum on-effort time duration of 211.5 hours (h) across the whole field season.

A third (32.25%, n=247) of the transects were undertaken in the Offshore west stratum (i.e., Swiftsure Bank), 33.55% (n=257) in the Inshore west (i.e., western end of SJF study area), while 15.67% (n=120) and 18.54% (n=142) of transects were completed through Offshore east and Inshore east strata (i.e., eastern SJF strata of study area), respectively. This apportioning of survey effort aimed to better balance the Inshore west strata under-sampled in 2020 and 2021 (see Hall et al. 2021, 2022). The overall ratio of transect number effort comparing western strata with eastern strata was 1.92:1 in 2022.

When 2022 transect effort was partitioned by stratum, the Offshore west stratum had the highest amount of completed survey transect lines (1408 km, 34.3%), followed by Inshore west (1340 km, 32.7%), Inshore east (733 km, 17.9%), and Offshore east (623 km, 15.2%). The overall ratio of transect effort comparing western strata with eastern strata was 2.03:1, as planned in 2020 project scoping.

The 2022 field effort consisted of 71 field excursions. Several field excursions were terminated early or cancelled entirely due to illness, statutory holidays, weather changes, deteriorating sea conditions, and National Indigenous Peoples Day. Occasionally data were compromised by technical issues related to the Global Positioning System (GPS) unit, incomplete data collection for a sighting or transect line, or diversion from the field protocol. In most cases, these issues were resolved in the field on the same day. In total, 71 line transect survey days resulted in systematic (i.e., on-effort) marine mammal data (Table 2). Opportunistic data were also collected on 68 of the field days (i.e., only three survey days with no opportunistic sightings) while transiting to and from the transect line locations.

Systematic data were collected using the dedicated Transect Pro survey software (Wernicke and Hall 2015, with confirmed vessel location, activity, and effort information available. Opportunistic data collection included locations and information for survey times when dedicated survey software was not used, when transiting to and from line transect survey lines and the port. The source of the opportunistic data was the handwritten notes in the dedicated marine mammal survey field notebook provided. All cetacean sightings without valid latitude-longitude locations were removed from the analytical data set.

During the 2022 field season, each line transect was completed at least eight times (Table 1). This resulted in a completion rate of 100%, with Transects 1–30, 32–50, and 52–61 having between eight and 19 replicates throughout the 2022 season (Table 1). Transect lines 32–37 (north of Swiftsure Bank) were not conducted during the 2020 field season (see Hall et al. 2021) but were all completed during the 2021 and 2022 field seasons. The line transect effort in 2022 (n=766) was nearly triple that from 2021 (n=280) and six times the effort the first year of the study in 2020 (n=152).

Table 1. Line transects completed during the 2022 field season with total number of replicates. Transect numbers by strata are Offshore west (1–21), Inshore west (32–50), Offshore east (22–30) and Inshore east (52–61).

Transect Line Number	Number of Replicates	Transect Line Number	Number of Replicates	Transect Line Number	Number of Replicates
1	9	21	18	42	13
2	11	22	17	43	13
3	10	23	16	44	13
4	9	24	16	45	16
5	10	25	16	46	16
6	11	26	14	47	18
7	10	27	11	48	14
8	8	28	8	49	19
9	11	29	11	50	18
10	10	30	11	52	18
11	11	32	12	53	17
12	12	33	12	54	16
13	11	34	10	55	15
14	12	35	9	56	15
15	11	36	8	57	13
16	12	37	10	58	12
17	15	38	12	59	13
18	16	39	15	60	12
19	14	40	15	61	11
20	16	41	14		

In some cases, surveys were constrained by crew obligations and weather changes. Thus, the effort per field day ranged from a low of one transect line on 15 October 2022, when the field work was interrupted due to deteriorating sea conditions, to a high of 18 transect lines in multiple strata being completed in a single field day on 11 July 2022 (Table 2). Table 2 presents the transect lines used for analysis with both the eastern and western strata sampled throughout the June–October field season (Tables 1 and 2).

Table 2. 2022 Field excursion and line transect completion summary.

Excursion Number	Date	Stratum	Transect Lines
1	23-Jun-22	Inshore West, Inshore East	50, 52–54
2	24-Jun-22	Offshore West	2, 3, 8–12
3	25-Jun-22	Inshore West	32–41
4	26-Jun-22	Offshore West, Inshore West	13–18, 42–49
5	29-Jun-22	Offshore West, Offshore East	17–30
6	7-Jul-22	Offshore West	2–10
7	8-Jul-22	Offshore West, Offshore East, Inshore West, Inshore East	11–23, 49, 50, 52, 53
8	9-Jul-22	Offshore East, Inshore East	23–25, 29, 30, 54–61
9	11-Jul-22	Inshore West	32–48, 50
10	16-Jul-22	Offshore West	2–6
11	17-Jul-22	Offshore West, Offshore East	7–22
12	20-Jul-22	Inshore West, Inshore East	43–50, 52–57
13	21-Jul-22	Offshore West, Offshore East, Inshore East	19, 20, 22–30, 59, 60
14	22-Jul-22	Offshore West, Inshore West	1, 32–42
15	23-Jul-22	Offshore West, Inshore West, Inshore East	12, 49, 50, 52–61
16	27-Jul-22	Offshore West, Inshore East	21, 22, 53–55
17	4-Aug-22	Inshore West, Inshore East	47–49, 52–59, 61
18	5-Aug-22	Offshore West, Inshore West	17–30
19	7-Aug-22	Offshore West	1–12
20	11-Aug-22	Inshore West	32–42, 45, 46
21	13-Aug-22	Offshore West, Inshore West	1–7, 32–35
22	14-Aug-22	Offshore West, Inshore West	13–15, 19–21, 45
23	15-Aug-22	Offshore East, Inshore West, Inshore East	25–27, 49, 50, 53, 59, 60, 61
24	16-Aug-22	Inshore East	53, 54
25	17-Aug-22	Offshore West, Inshore West	9–13, 15, 16, 18, 39, 40, 46
26	18-Aug-22	Offshore West, Offshore East, Inshore West, Inshore East	21–26, 47, 52–58
27	19-Aug-22	Inshore West	42–50
28	20-Aug-22	Offshore West, Offshore East, Inshore East	19–30, 59–61
29	21-Aug-22	Offshore West	1–10
30	22-Aug-22	Offshore West, Inshore West	11, 12, 32–35, 37–41
31	31-Aug-22	Offshore East, Inshore West, Inshore East	21–24, 55–57
32	1-Sep-22	Offshore West	6–18
33	2-Sep-22	Inshore West	32, 33, 37–42
34	3-Sep-22	Offshore East, Inshore East	25–30, 58–61
35	4-Sep-22	Offshore West, Inshore West, Inshore East	17–22, 43–50, 52, 53
36	5-Sep-22	Offshore West, Inshore West	1, 2, 5, 6, 32–36
37	6-Sep-22	Offshore West, Inshore West, Inshore East	16–22, 50, 55–61
38	7-Sep-22	Inshore West, Inshore East	45–50, 52–54

Excursion Number	Date	Stratum	Transect Lines
39	9-Sep-22	Offshore West, Inshore West	18, 19, 37–47
40	10-Sep-22	Offshore East, Inshore West, Inshore East	23–26, 50, 52, 54–57
41	11-Sep-22	Inshore West	32, 38–47
42	12-Sep-22	Offshore West, Inshore West	1–7, 32, 33
43	15-Sep-22	Offshore West, Inshore West	8–12, 33–36
44	16-Sep-22	Offshore West, Inshore West	14–17, 36–42, 44–47
45	17-Sep-22	Offshore West, Offshore East, Inshore West, Inshore East	17–26, 50, 52–56
46	18-Sep-22	Offshore East, Inshore West, Inshore East	27–30, 48, 49, 57–61
47	19-Sep-22	Offshore West, Offshore East, Inshore West, Inshore East	20, 23–26, 46–49, 52, 57
48	20-Sep-22	Offshore West, Inshore West	1–5, 32–38
49	21-Sep-22	Offshore West, Inshore West	6–18, 49
50	22-Sep-22	Inshore West, Inshore East	50, 52–56
51	23-Sep-22	Offshore West, Offshore East, Inshore East	21–30, 57–61
52	26-Sep-22	Inshore West	39, 49
53	29-Sep-22	Inshore West	39–48
54	30-Sep-22	Offshore West, Inshore West	11–14, 43–45
55	1-Oct-22	Offshore West, Offshore East, Inshore West, Inshore East	21, 22, 24–30, 49, 50, 54–56
56	2-Oct-22	Offshore West, Offshore East, Inshore West, Inshore East	17–20, 23, 24, 47–49, 56–61
57	4-Oct-22	Offshore West	6, 7, 9, 13–17
58	5-Oct-22	Offshore West, Inshore West	1–5, 40, 41
59	6-Oct-22	Inshore East	52, 53, 56–58, 60
60	7-Oct-22	Offshore West, Offshore East, Inshore East	21–27, 29, 30, 58–61
61	8-Oct-22	Offshore West, Inshore West, Inshore East	14–20, 44–50, 52
62	9-Oct-22	Inshore West, Inshore East	39–43, 49, 52–56
63	10-Oct-22	Inshore West	46, 47, 50
64	11-Oct-22	Offshore West, Offshore East, Inshore West	18–27, 29, 30, 49
65	12-Oct-22	Inshore West, Inshore East	47, 48, 50, 52–56, 58, 59
66	13-Oct-22	Offshore West	1–7, 9–12
67	14-Oct-22	Offshore West, Inshore West	13–18, 38–45
68	15-Oct-22	Inshore East	52
69	16-Oct-22	Offshore West, Offshore East, Inshore West, Inshore East	20–25, 43–48, 55
70	17-Oct-22	Offshore West, Inshore West	13, 14, 32–34, 37–43
71	29-Oct-22	Offshore West, Inshore West, Inshore East	20, 21, 49, 50, 52–54

3.2 Systematic Line Transect Data

A minimum of five cetacean species were observed during the systematic data collection in 2022 (Table 3, Appendix B). Two populations of killer whale were confirmed (southern resident and transient) through field observations and photo-ID. There were also large numbers of killer whale sightings that could not be identified to ecotype/population (Table 3), in part due to the crew maintaining federal distance regulations of 400 m. Pinnipeds and mustelids were also observed including Steller sea lions, California sea lions and sea otters, but are not presented in this report.

A list of cetacean species sighted per week is summarized in Table 3, with one week (Oct 22–28) of no effort during the 2022 field season, and therefore no sightings. To note, a single sighting can encompass one to any number of individuals (i.e., a sighting denotes a marine mammal detection, regardless of the group size). In some cases, individual animals were detected more than once during a monitoring period. These data were not corrected for re-sights of individual animals as emphasis was on monitoring rather than individual identification. As such these data cannot be used to infer estimates of species density or relative species abundance but are rather an indication of marine mammal presence within the study area. Killer whales were most often observed in the late summer to fall months (weeks 13–18 of the field study; Table 3). Over two-thirds of the killer whale sightings were identified to ecotype (Table 3).

Table 3. Total number of cetacean sightings summarized by week during line transect surveys June–October 2022 with total number of animals presented in brackets for each week.

Week Number	2022 Survey Dates	Number of Transects	DP	HP	UP	GW	HB	KW	UW	Total Number Species
1	Jun 18–24	11	1 (1)	1 (1)	1 (1)	0	13 (19)	1 (1)	0	5
2	Jun 25–Jul 1	38	1 (5)	9 (10)	3 (5)	0	4 (4)	1 (4)	0	5
3	Jul 2–8	26	1 (3)	0	3 (5)	0	26 (52)	0	0	3
4	Jul 9–15	31	1 (4)	17 (29)	0	0	5 (10)	0	0	3
5	Jul 16–22	60	1 (1)	0	0	0	23 (36)	1 (3)	2 (2)	4
6	Jul 23–29	18	0	1 (1)	0	0	2 (2)	0	0	2
7	Jul 30–Aug 5	26	0	8 (10)	0	0	34 (49)	0	0	2
8	Aug 6–12	25	0	4 (4)	0	0	14 (26)	1 (1)	0	3
9	Aug 13–19	64	0	4 (6)	0	0	62 (110)	0	0	2
10	Aug 20–26	36	1 (1)	16 (36)	6 (8)	0	22 (59)	0	2 (2)	5

Week Number	2022 Survey Dates	Number of Transects	DP	HP	UP	GW	HB	KW	UW	Total Number Species
11	Aug 27–Sep 2	28	0	1 (1)	0	0	22 (56)	0	0	2
12	Sep 3–9	72	0	4 (5)	1 (1)	0	64 (105)	0	0	3
13	Sep 10–16	54	0	2 (2)	1 (1)	1 (1)	27 (50)	5 (8)	4 (6)	6
14	Sep 17–23	85	1 (4)	1 (50)	1 (16)	0	152 (381)	8 (25)	1 (1)	7
15	Sep 24–30	19	0	0	0	0	2 (2)	0	0	1
16	Oct 1–7	63	0	0	1 (1)	0	98 (189)	2 (6)	0	3
17	Oct 8–14	77	0	4 (6)	0	0	58 (99)	7 (17)	0	4
18	Oct 15–21	26	0	0	0	0	0	3 (15)	0	2
19	Oct 22–28	0	0	0	0	0	0	0	0	0
20	Oct 29–31	7	0	0	0	0	3 (4)	0	0	1
Total	Jun 18–Oct 31	766	7 (19)	72 (161)	17 (38)	1 (1)	631 (1253)	29 (80)	9 (11)	

All transect data included.
DP – Dall's porpoise
HP – Harbour porpoise
UP – Unknown porpoise
GW – Grey whale
HB – Humpback whale
SRKW – Southern resident killer whale
TKW – Transient killer whale
UKW – Unknown killer whale
UW – Unknown whale

During the 2022 line transect surveys, there was a total of 766 transects completed with 766 sightings of an estimated 1563 animals (Tables 3 and 4). Of this total, humpback whales were the most numerically abundant and most often encountered species in terms of the total estimated number of animals (n=1253) and the number of sightings (n=631) (Tables 3 and 4). This species was observed throughout the 2022 field season; however, sightings were more numerous, with increased estimated numbers of animals, mid-August through mid-October (Table 3), noting the number of surveys in this period also was relatively high. Harbour porpoise and killer whales were the next most frequently observed cetaceans in terms of the number of sightings and estimated number of animals (Table 4). Grey whales were the least frequently observed cetacean during the line transect surveys, with only one encounter of a single animal observed on 16 September 2022 (Tables 3 and 4). It is important to note, that the total number of animals likely includes re-sights of individual animals across transects and days and therefore does not provide an index of overall abundance.

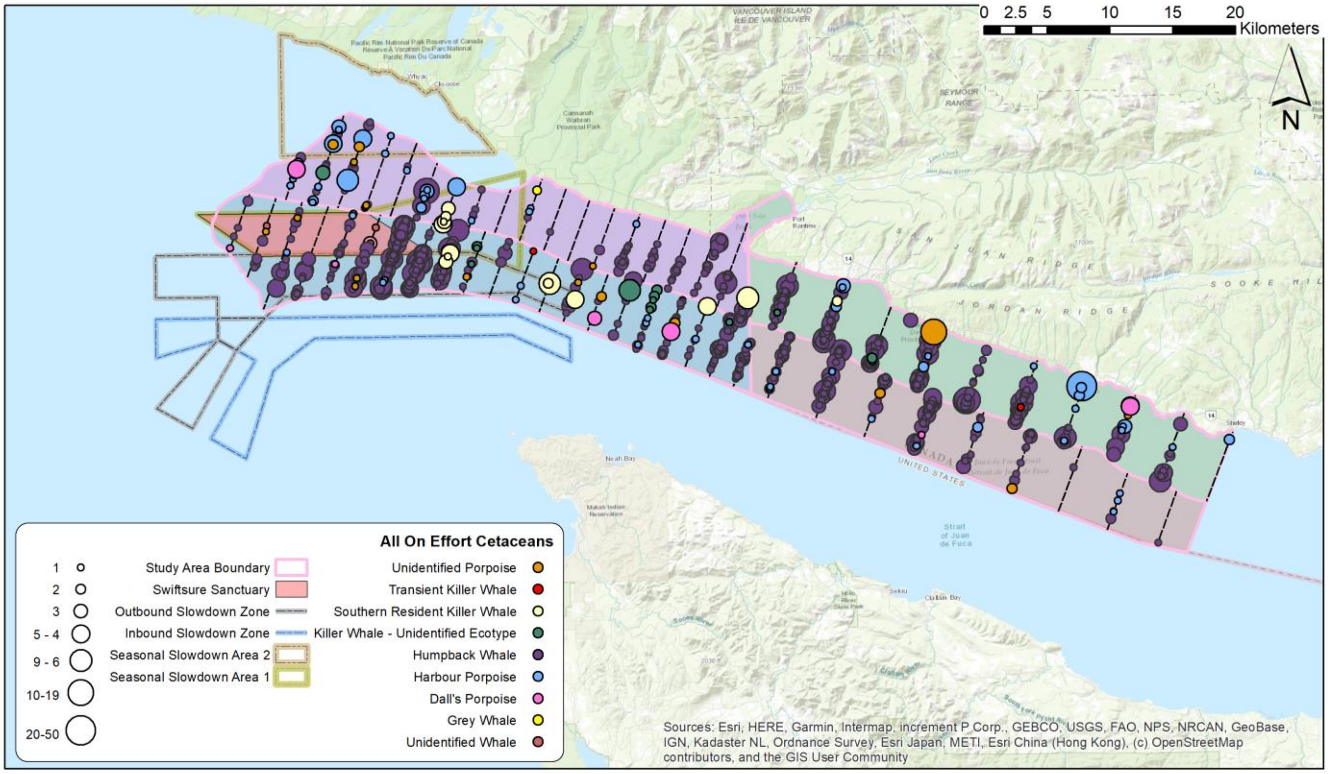
Table 4. Line transect data summary of cetacean species with estimated total number of animals observed and total number of sightings per species, 23 June–29 October 2022.

Species	Estimated Total Number Animals	Total Number of Sightings
Dall's Porpoise	19	7
Grey Whale	1	1
Harbour Porpoise	161	72
Humpback Whale	1253	631
Killer Whale (Ecotype Unknown)	27	13
Southern Resident Killer Whale	51	14
Transient Killer Whale	2	2
Unidentified Porpoise	38	17
Unidentified Whale	11	9
Total	1563	766

A variety of different species and behaviours were observed during each day of the systematic on-effort survey in 2022, with daily species encounters presented in Appendix B. For each observation, in addition to the species and behaviour, descriptive data were recorded including the latitude and longitude of the vessel at the time of sighting, the estimated group size, the weather and a description of the sea state using the Beaufort Scale (Thomson 1981). The duration of encounters was not recorded during the line transect surveys as the survey was conducted in passing mode (i.e., the vessel proceeded along the survey line and did not deviate from the course for an observation). Similarly, a summary of vessels during each encounter was not recorded as the field team's focus was on marine mammal data collection.

Locations of systematic cetacean line transect sightings data are presented in Figure 3. Humpback whales, harbour porpoise and Dall's porpoise were observed in all four strata, while grey whales were only observed on-effort in the inshore western stratum on line 41 (Figure 3). Southern resident killer whales were confirmed in both western strata and the inshore east stratum (Figure 3). Transient killer whales were confirmed only in the offshore western stratum, and unconfirmed ecotype killer whales were sighted in both western strata and inshore east stratum (Figure 3).

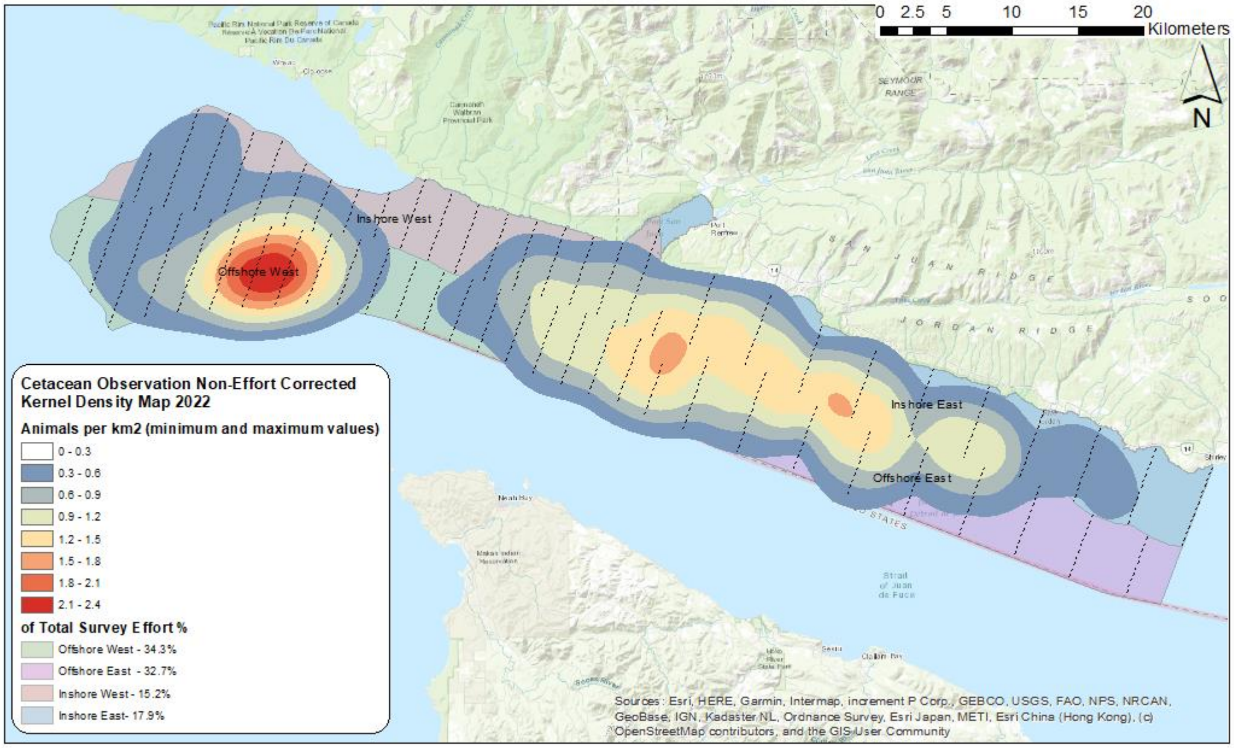
Figure 3. 2022 Marine Mammal Survey — all systematic line transect cetacean sightings.



A simple kernel heat map of cetacean sightings is provided in Figure 4, highlighting the numerical non-effort corrected "hot spots" of sightings for all cetaceans in the Offshore west (Swiftsure Bank) stratum, central study area, and Inshore east stratum. Peak values exceed 2 animals per km^2. These overlap with the ECHO Program's Swiftsure Bank voluntary outbound ship slowdown area, and to a lesser extent, the more southerly Seasonal Slowdown Area, and are dominated by humpback whale sightings (Figure 3). However, as previously documented, it should be noted that these heat maps have not been corrected for effort, and that survey effort was unequal amongst strata (i.e., a deliberate 2:1 focus on western strata).

To provide an estimate of relative importance across the four strata, combined systematic survey data for 2020, 2021, and 2022 were used to provide numbers of each cetacean species per 100 km of strata surveyed (see Section 3.5).

Figure 4. 2022 Marine Mammal Survey — Kernel heat map of all line transect cetacean sightings (not effort corrected).



3.3 2022 Opportunistic Observational Data — Only Cetaceans

In addition to the systematic line transect survey data, opportunistic (off-effort) data were collected during the 2022 field season (Appendix C). Between 24 June and 11 October 2022, there were an additional 394 opportunistic sightings of at least four cetacean species (n=1421 individuals) (Table 5 and Appendix C). The complete list of all cetacean opportunistic sightings is presented in Appendix C, including humpback whales, grey whales, killer whales, and harbour porpoise (Table 5).

Table 5 Opportunistic cetacean species observations with the estimated total number of animals and total number of sightings during the 2022 field season (species absolute or relative abundance not noted).

Species	Estimated Number of Animals	Number of Sightings
Dall's Porpoise	0	0
Grey Whale	10	8
Harbour Porpoise	175	65
Humpback Whale	973	261
Killer Whale (Ecotype Unknown)	17	4
Southern Resident Killer Whale	198	35
Transient Killer Whale	37	14

Unidentified Porpoise	7	3
Unidentified Whale	4	4
Total	1421	394

Consistent with the systematic data, humpback whales, killer whales and harbour porpoise were again the most frequent opportunistically sighted cetaceans (Table 5). The high number of individual southern resident killer whales reported (Table 5) indicates that resights of individuals occurred on multiple occasions as the total number reported is greater than the known population (CWR 2022). There were also several days when multiple sightings of small groups of animals occurred, particularly in September and October 2022.

The opportunistic cetacean data were distributed in each stratum, with many observations located along the margins of the strata and several sightings well beyond the study area boundary (Figures 5 and 6). It is likely that this reflects the continuation of observational effort upon completion of transect lines and while transiting to and from transect line locations or while on other excursions. Southern resident killer whales were opportunistically detected in the two western strata of the study area and the inshore east strata (Figure 5). Transient killer whales were opportunistically sighted in inshore strata (Figure 5). Killer whales of unknown ecotypes were observed in every stratum (Figure 5). It was not always possible to identify individual animals and still ensure that 400 m approach distance regulations were adhered to. Humpback whales were also detected in every stratum (Figure 6). Grey whales were only observed in the inshore western stratum (Figure 6).

Due to the large volume of opportunistic data collected during the 2022 field season, the dataset was split into the categories of odontocetes and mysticetes (sub orders of Cetacea), so as to represent these data (Figure 5 and Figure 6) more clearly. Toothed whales (odontocetes—killer whales and porpoise) and baleen whales (mysticetes—humpback, grey and minke whales) make differential use of various habitats or areas based on reproductive strategies and prey species, with some following phenological migratory paths and are found in the Salish Sea only seasonally. The cetacean sightings are taxonomically grouped into separate figures illustrating odontocete and mysticetes habitat use and distribution, based on opportunistic sightings, within the study area (Figures 5 and 6).

Figure 5. Opportunistic odontocete sighting locations during the 2022 marine mammal survey.

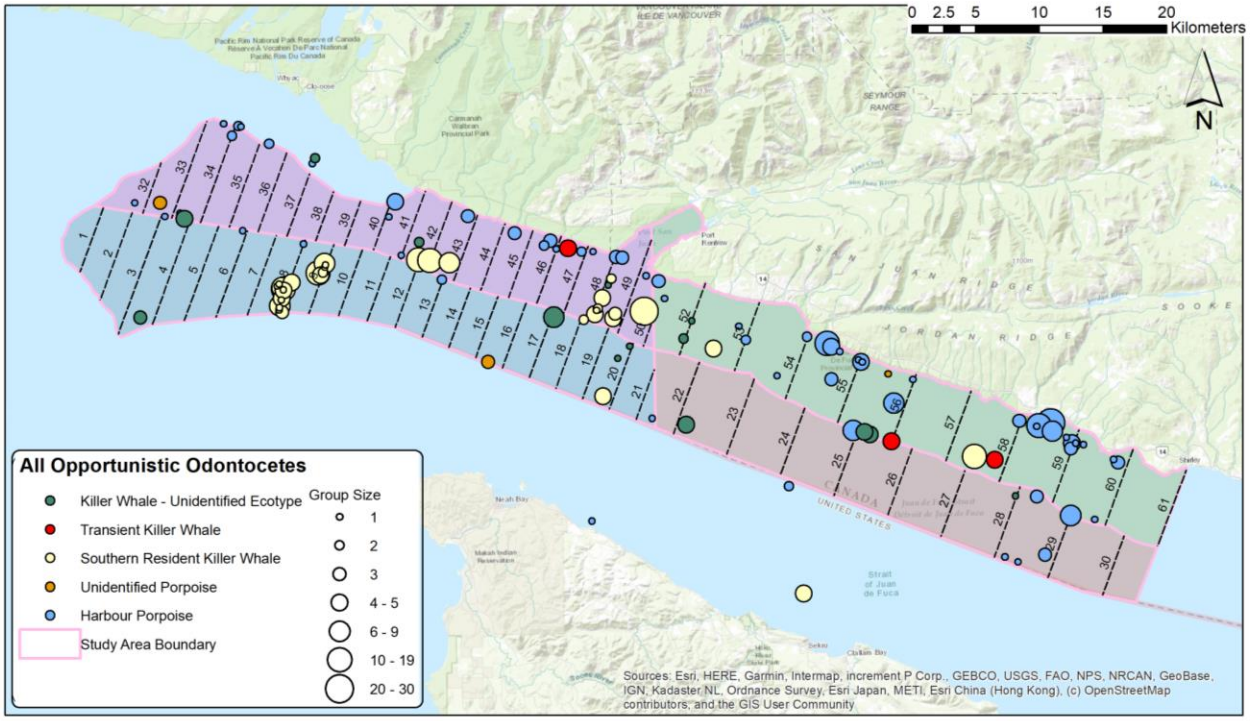
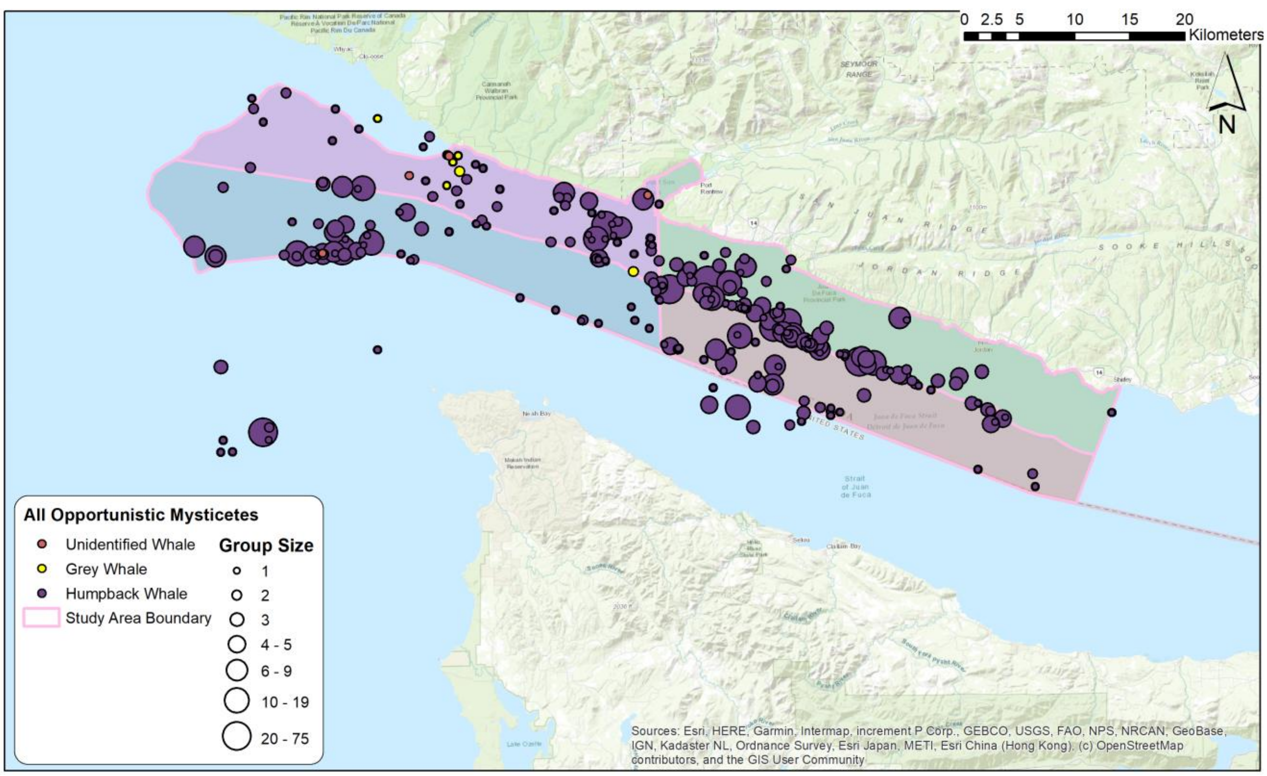


Figure 6. Opportunistic mysticete sighting locations during the 2022 marine mammal survey.



3.4 2022 Systematic and Opportunistic Data

During the 2022 field season, 10 of the 71 days resulted in neither killer whales nor humpback whales being sighted during systematic on-effort line transects or opportunistically (Table 6). There were 16 survey days with neither killer whales nor humpback whales observed while on effort (i.e., no systematic sightings) (Table 6). Humpback whales were sighted on 60 days (84.5%), while killer whales were sighted on 29 days (40.8%) (Table 6). Southern resident killer whales were sighted on 11 survey days in 2022 with both systematic and opportunistic observations. Transient killer whales were sighted on two survey days while on effort and were sighted opportunistically on three additional days. There were other sightings of, killer whales but the ecotype could not be determined. Both killer whales and humpback whales were observed during each month of the field work (Table 6). On 28 of the 71 survey days (39.4%), both species were positively identified on the same day (Table 6). On 4 October 2022, southern resident killer whales and humpback whales were observed in close proximity and in relatively large groups near Swiftsure Bank. The humpback whales were audible from the surface and were tail slapping and breaching when the killer whales were close by. The killer whales were exhibiting repeated foraging/feeding behaviours during the observation period. Killer whales, including southern residents, were observed actively foraging when observed in August, September, and early October 2022 (Appendices B and C, Table 7).

Table 6. Summary of humpback and killer whale sighting days during the 2022 field season. Numbers represent the number of sightings during both line transect and opportunistic data collection.

Excursion Number	Date	Humpback Whales	Killer Whales	Data Type
1	23-Jun-22	0 / 0	1 / 0	Systematic / Opportunistic
2	24-Jun-22	13 / 3	0 / 1	Systematic / Opportunistic
3	25-Jun-22	0 / 1	0 / 1	Systematic / Opportunistic
4	26-Jun-22	1 / 0	0 / 0	Systematic / Opportunistic
5	29-Jun-22	3 / 1	1 / 1	Systematic / Opportunistic
6	7-Jul-22	26 / 7	0 / 0	Systematic / Opportunistic
7	8-Jul-22	0	0	No Sightings
8	9-Jul-22	0	0	No Sightings
9	11-Jul-22	5 / 3	0 / 0	Systematic / Opportunistic
10	16-Jul-22	0	0	No Sightings
11	17-Jul-22	10 / 3	0 / 0	Systematic / Opportunistic
12	20-Jul-22	0	0	No Sightings
13	21-Jul-22	10 / 3	0 / 0	Systematic / Opportunistic
14	22-Jul-22	3 / 0	1 / 0	Systematic / Opportunistic
15	23-Jul-22	2 / 1	0 / 0	Systematic / Opportunistic
16	27-Jul-22	0	0	No Sightings
17	4-Aug-22	22 / 8	0 / 0	Systematic / Opportunistic
18	5-Aug-22	12 / 7	0 / 0	Systematic / Opportunistic
19	7-Aug-22	14 / 9	1 / 0	Systematic / Opportunistic
20	11-Aug-22	0	0	No Sightings
21	13-Aug-22	11 / 2	0 / 0	Systematic / Opportunistic

Excursion Number	Date	Humpback Whales	Killer Whales	Data Type
22	14-Aug-22	17 / 4	0 / 0	Systematic / Opportunistic
23	15-Aug-22	1 / 4	0 / 0	Systematic / Opportunistic
24	16-Aug-22	0 / 3	0 / 0	Systematic / Opportunistic
25	17-Aug-22	1 / 0	0 / 0	Systematic / Opportunistic
26	18-Aug-22	30 / 17	0 / 2	Systematic / Opportunistic
27	19-Aug-22	2 / 2	0 / 0	Systematic / Opportunistic
28	20-Aug-22	10 / 9	0 / 0	Systematic / Opportunistic
29	21-Aug-22	9 / 2	0 / 0	Systematic / Opportunistic
30	22-Aug-22	3 / 3	0 / 3	Systematic / Opportunistic
31	31-Aug-22	0 / 3	0 / 0	Systematic / Opportunistic
32	1-Sep-22	22 / 0	0 / 0	Systematic / Opportunistic
33	2-Sep-22	0	0	No Sightings
34	3-Sep-22	1 / 7	0 / 0	Systematic / Opportunistic
35	4-Sep-22	17 / 4	0 / 0	Systematic / Opportunistic
36	5-Sep-22	0	0	No Sightings
37	6-Sep-22	29 / 5	0 / 1	Systematic / Opportunistic
38	7-Sep-22	3 / 5	0 / 1	Systematic / Opportunistic
39	9-Sep-22	14 / 4	0 / 9	Systematic / Opportunistic
40	10-Sep-22	5 / 3	0 / 0	Systematic / Opportunistic
41	11-Sep-22	0 / 5	0 / 0	Systematic / Opportunistic
42	12-Sep-22	6 / 1	0 / 1	Systematic / Opportunistic
43	15-Sep-22	15 / 4	5 / 6	Systematic / Opportunistic
44	16-Sep-22	1 / 1	0 / 0	Systematic / Opportunistic
45	17-Sep-22	16 / 4	1 / 3	Systematic / Opportunistic
46	18-Sep-22	24 / 13	0 / 0	Systematic / Opportunistic
47	19-Sep-22	22 / 2	1 / 1	Systematic / Opportunistic
48	20-Sep-22	5 / 2	0 / 1	Systematic / Opportunistic
49	21-Sep-22	15 / 5	6 / 0	Systematic / Opportunistic
50	22-Sep-22	38 / 2	0 / 1	Systematic / Opportunistic
51	23-Sep-22	32 / 23	0 / 0	Systematic / Opportunistic
52	26-Sep-22	1 / 5	0 / 0	Systematic / Opportunistic
53	29-Sep-22	1 / 0	0 / 0	Systematic / Opportunistic
54	30-Sep-22	0	0	No Sightings
55	1-Oct-22	24 / 9	0 / 2	Systematic / Opportunistic
56	2-Oct-22	18 / 8	0 / 0	Systematic / Opportunistic
57	4-Oct-22	22 / 12	1 / 12	Systematic / Opportunistic
58	5-Oct-22	8 / 4	0 / 1	Systematic / Opportunistic
59	6-Oct-22	20 / 6	1 / 0	Systematic / Opportunistic
60	7-Oct-22	6 / 9	0 / 0	Systematic / Opportunistic
61	8-Oct-22	20 / 1	0 / 1	Systematic / Opportunistic
62	9-Oct-22	6 / 3	1 / 0	Systematic / Opportunistic
63	10-Oct-22	0	0	No Sightings

Excursion Number	Date	Humpback Whales	Killer Whales	Data Type
64	11-Oct-22	8 / 6	0 / 4	Systematic / Opportunistic
65	12-Oct-22	7 / 2	1 / 0	Systematic / Opportunistic
66	13-Oct-22	15 / 4	0 / 1	Systematic / Opportunistic
67	14-Oct-22	2 / 3	5 / 0	Systematic / Opportunistic
68	15-Oct-22	0 / 1	0 / 0	Systematic / Opportunistic
69	16-Oct-22	0 / 1	0 / 0	Systematic / Opportunistic
70	17-Oct-22	0 / 1	3 / 0	Systematic / Opportunistic
71	29-Oct-22	3 / 1	0 / 0	Systematic / Opportunistic
Total		631 / 261	29 / 53	Systematic / Opportunistic

Table 7. Summary of line transect and opportunistic killer whale sightings in 2022.

Date	Survey Type or Transect Number	Species	Behaviour	Group Size
23-Jun-22	52	Killer Whale (Ecotype Unknown)	Surfacing	1
24-Jun-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing and Blowing	3
25-Jun-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	2
29-Jun-22	Opportunistic	Southern Resident Killer Whale	Surfacing and Blowing	16
29-Jun-22	19	Southern Resident Killer Whale	Swimming and Travelling	4
22-Jul-22	33	Killer Whale (Ecotype Unknown)	Fast-Surfacing	3
7-Aug-22	12	Transient Killer Whale	Fluking and Blowing	1
18-Aug-22	Opportunistic	Transient Killer Whale	Fast-Surfacing and Spy Hopping	4
18-Aug-22	Opportunistic	Transient Killer Whale	Tail Lobbing	4
22-Aug-22	Opportunistic	Southern Resident Killer Whale	Feeding and Swimming	6
22-Aug-22	Opportunistic	Southern Resident Killer Whale	Fluking, Breaching and Blowing	10
22-Aug-22	Opportunistic	Southern Resident Killer Whale	Breaching, Feeding, Fluking and Reproduction	19
6-Sep-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing and Blowing	6
7-Sep-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	1
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing and Breaching	4
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Spy Hopping and Fluking	3

Date	Survey Type or Transect Number	Species	Behaviour	Group Size
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Surfacing and Blowing	2
9-Sep-22	Opportunistic	Southern Resident Killer Whale Putative	Blowing	1
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing	4
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing	2
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Breaching	1
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing	4
9-Sep-22	Opportunistic	Southern Resident Killer Whale	Surfacing	4
12-Sep-22	Opportunistic	Transient Killer Whale	Fast-Surfacing	5
15-Sep-22	9	Southern Resident Killer Whale	Surfacing and Fluking	3
15-Sep-22	9	Southern Resident Killer Whale	Blowing and Surfacing	1
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Fast-Surfacing	5
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing, Fast-Surfacing, Breaching and Spy Hopping	14
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Slow Rolling	2
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Breaching and Slow Rolling	1
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Blowing and Fast-Surfacing	1
15-Sep-22	Opportunistic	Southern Resident Killer Whale	Swimming, Fluking and Blowing	9
15-Sep-22	10	Killer Whale (Ecotype Unknown)	Surfacing	2
15-Sep-22	10	Killer Whale (Ecotype Unknown)	Blowing and Surfacing	1
15-Sep-22	10	Killer Whale (Ecotype Unknown)	Surfacing	1
17-Sep-22	Opportunistic	Southern Resident Killer Whale	Feeding, Slow Rolling, Breaching, Surfacing and Blowing	30
17-Sep-22	50	Southern Resident Killer Whale	Blowing and Surfacing	8
17-Sep-22	Opportunistic	Southern Resident Killer Whale	Surfacing	1
17-Sep-22	Opportunistic	Southern Resident Killer Whale	Surfacing	5
19-Sep-22	20	Killer Whale (Ecotype Unknown)	Surfacing	1
19-Sep-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	1

Date	Survey Type or Transect Number	Species	Behaviour	Group Size
20-Sep-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	5
21-Sep-22	16	Killer Whale (Ecotype Unknown)	Blowing and Surfacing	8
21-Sep-22	17	Killer Whale (Ecotype Unknown)	Feeding and Slow Rolling	2
21-Sep-22	17	Killer Whale (Ecotype Unknown)	Blowing and Milling	2
21-Sep-22	17	Killer Whale (Ecotype Unknown)	Surfacing	1
21-Sep-22	17	Killer Whale (Ecotype Unknown)	Surfacing	2
21-Sep-22	17	Killer Whale (Ecotype Unknown)	Surfacing	1
22-Sep-22	Opportunistic	Killer Whale (Ecotype Unknown)	Blowing and Surfacing	1
1-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	2
1-Oct-22	Opportunistic	Transient Killer Whale	Blowing and Surfacing	4
4-Oct-22	9	Southern Resident Killer Whale	Travelling and Surfacing	5
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Breaching, Feeding, Fluking and Surfacing	3
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing	1
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing	1
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Blowing and Surfacing	8
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Fluking	1
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Breaching and Blowing	5
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing and Blowing	4
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Fluking and Blowing	1
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Breaching and Fluking	15
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Fluking and Blowing	8
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Blowing and Surfacing	1
4-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing	1
5-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Fluking	2
6-Oct-22	57	Transient Killer Whale	Not Reported	1
8-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing	2

Date	Survey Type or Transect Number	Species	Behaviour	Group Size
9-Oct-22	53	Southern Resident Killer Whale	Blowing and Breaching	2
11-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	1
11-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing	4
11-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Surfacing, Breaching and Feeding	4
11-Oct-22	Opportunistic	Killer Whale (Ecotype Unknown)	Tail Slapping, Fluking, Breaching	4
12-Oct-22	54	Killer Whale (Ecotype Unknown)	Surfacing	2
13-Oct-22	Opportunistic	Southern Resident Killer Whale	Surfacing	4
14-Oct-22	38	Southern Resident Killer Whale	Blowing and Surfacing	3
14-Oct-22	38	Southern Resident Killer Whale	Blowing	2
14-Oct-22	38	Southern Resident Killer Whale	Blowing and Surfacing	3
14-Oct-22	38	Southern Resident Killer Whale	Blowing	1
14-Oct-22	38	Southern Resident Killer Whale	Blowing and Surfacing	4
17-Oct-22	13	Southern Resident Killer Whale	Surfacing	8
17-Oct-22	13	Southern Resident Killer Whale	Swimming	2
17-Oct-22	14	Southern Resident Killer Whale	Travelling	5

3.4.1 Killer Whale Ecotype Identification

Photographs of killer whales were taken on 15 days from June to October 2022 (Table 8). Ecotype determination presented in Tables 7 and 8 results from field identifications by the Pacheedaht crew and post-field work photo-identification.

Table 8. Killer whale sightings and photographic analysis for ecotype.

Date	Data Type	Photo Taken	Ecotype	Stratum
23-Jun-22	Systematic	No	Unknown	Inshore East
24-Jun-22	Opportunistic	No	Unknown	NA
25-Jun-22	Opportunistic	No	Unknown	NA
29-Jun-22	Systematic /Opportunistic	No/Yes	Unknown/Southern Resident Killer Whale	Offshore West/ NA
22-Jul-22	Systematic	No	Unknown	Inshore West
07-Aug-22	Systematic	Yes	Transient Killer Whale	Offshore West

Date	Data Type	Photo Taken	Ecotype	Stratum
18-Aug-22	Opportunistic	Yes	Transient Killer Whale	NA
22-Aug-22	Opportunistic	Yes	Southern Resident Killer Whale	NA
06-Sep-22	Opportunistic	No	Unknown	NA
07-Sep-22	Opportunistic	No	Unknown	NA
09-Sep-22	Opportunistic	No	Southern Resident Killer Whale	NA
12-Sep-22	Opportunistic	Yes	Transient Killer Whale – suspected T109Bs	NA
15-Sep-22	Systematic / Opportunistic	Yes/Yes	Southern Resident Killer Whale and Unknown	Offshore West/ NA
17-Sep-22	Systematic / Opportunistic	Yes/Yes	Southern Resident Killer Whale/Southern Resident Killer Whale	Inshore West/ NA
19-Sep-22	Systematic / Opportunistic	No/No	Unknown/Unknown	Offshore West/ NA
20-Sep-22	Opportunistic	No	Unknown	NA
21-Sep-22	Systematic / Opportunistic	No/No	Unknown/Unknown	Offshore West / NA
22-Sep-22	Opportunistic	No	Unknown	NA
01-Oct-22	Opportunistic	No/Yes	Unknown/Transient Killer Whale – T123A	NA
04-Oct-22	Systematic / Opportunistic	Yes	Southern Resident Killer Whale	Offshore West/ NA
05-Oct-22	Opportunistic	No	Unknown	NA
06-Oct-22	Systematic	Yes	Transient Killer Whale	Inshore East
08-Oct-22	Opportunistic	Yes	Southern Resident Killer Whale	NA
09-Oct-22	Systematic	No	Southern Resident Killer Whale	Inshore East
11-Oct-22	Opportunistic	Yes	Unknown	NA
12-Oct-22	Systematic	No	Unknown	Inshore East
13-Oct-22	Opportunistic	Yes	Southern Resident Killer Whale – including K26 and K36	NA
14-Oct-22	Systematic	Yes	Southern Resident Killer Whale	Inshore West
17-Oct-22	Systematic	Yes	Southern Resident Killer Whale	Offshore West

3.4.2 Killer Whale and Humpback Whale Spatial Distribution

Several sightings of humpback whales, one southern resident killer whale sighting, one unknown killer whale sighting and several sightings of harbour porpoise were beyond the study area boundary (Figures 5, 6, 7 and 8). Killer whales were more often observed in the western strata with the fewest sightings in the eastern strata (Figure 7). Humpback whales were observed in all four strata, with clusters in the southern regions of the offshore west stratum and the central regions of the eastern study area (Figures 3, 6 and 8). The inclusion of opportunistic data means that these clusters in part reflect locations of the boat crew while between on-effort periods and therefore at the end of a transect line or transiting to and from port.

Figure 7. 2022 Marine Mammal Survey - line transect and opportunistic data killer whale sightings (southern resident, transient and unknown ecotype).

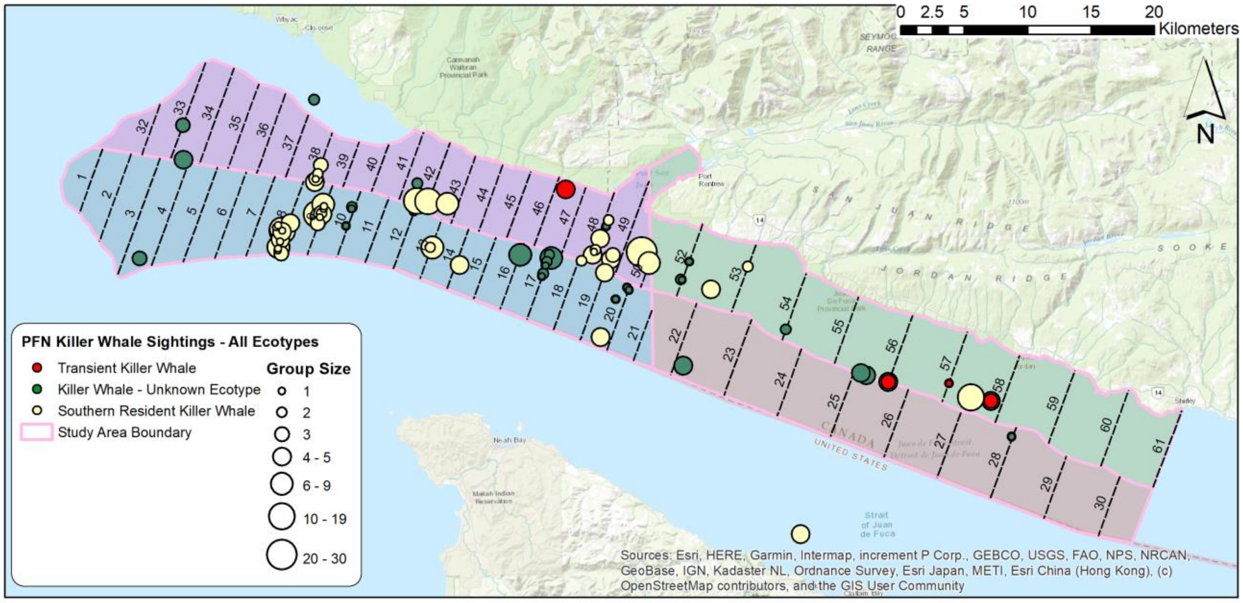
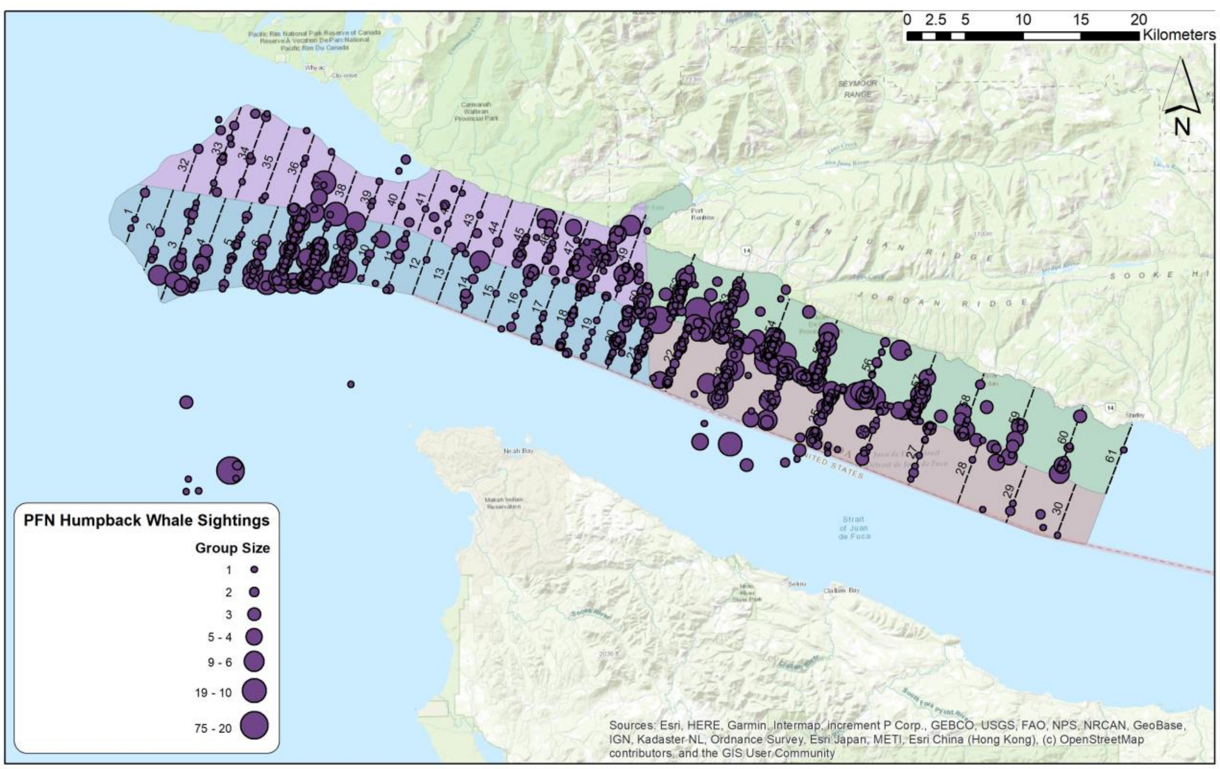


Figure 8. 2022 Marine Mammal Survey - line transect and opportunistic data humpback whale sightings.



3.5 Combined 2020, 2021 and 2022 Cetacean Data Summary

3.5.1 Combined Cetacean Sightings Distribution Data - Survey Effort 2020, 2021 and 2022

Combined sightings data for 2020, 2021 and 2022 for systematic and opportunistic sightings of humpback whales and killer whales (all ecotypes) are provided in Figures 9 and 10. These sightings data are dominated by observations made in 2022, noting one encounter had a sighting of an estimated group of fifty humpback whales. Group size information has not been plotted to provide greater clarity on each sighting location. Notably, the central region cluster of humpback whales within the eastern study area coincides with a notable shelf break that runs parallel to the shore at this location, while the cluster of humpback whales in the west stratum are mainly located in deeper water just off Swiftsure Bank. Killer whale sightings are lowest in the eastern offshore strata, with southern resident killer whales observed mainly in the western strata. Transient killer whales were observed in all strata.

Figure 9. Combined humpback whale line transect and opportunistic sightings data for 2020–2022 across study area.

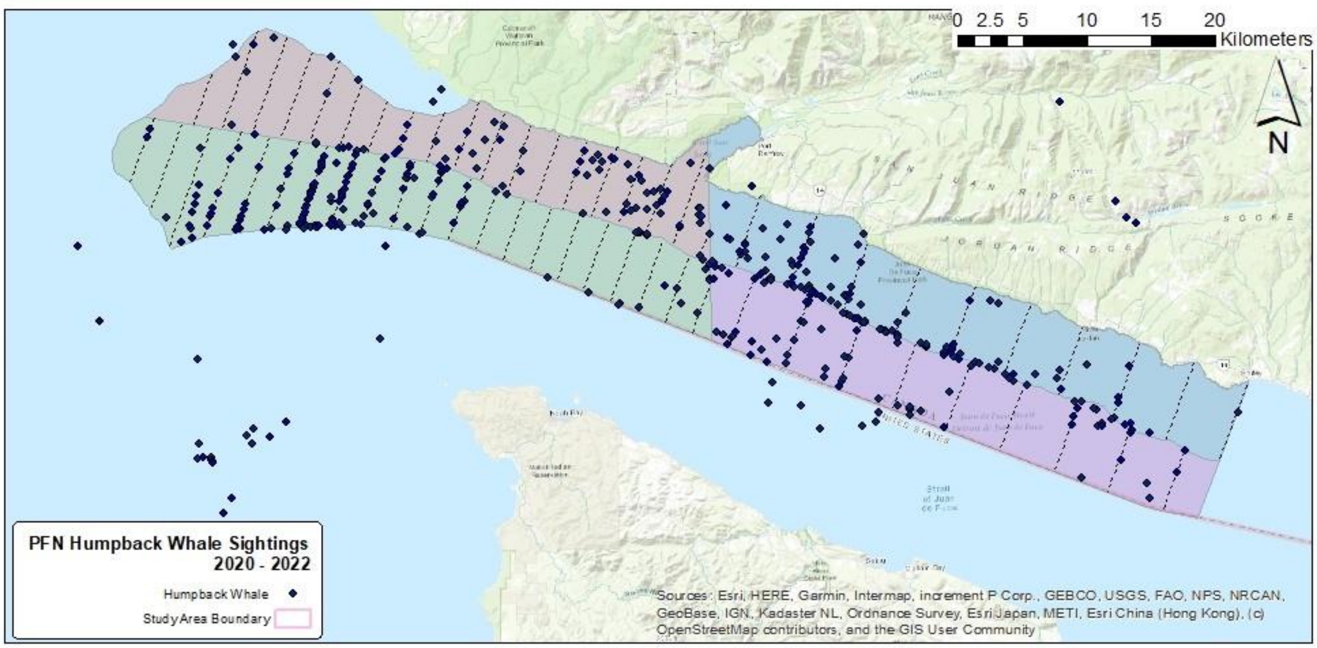
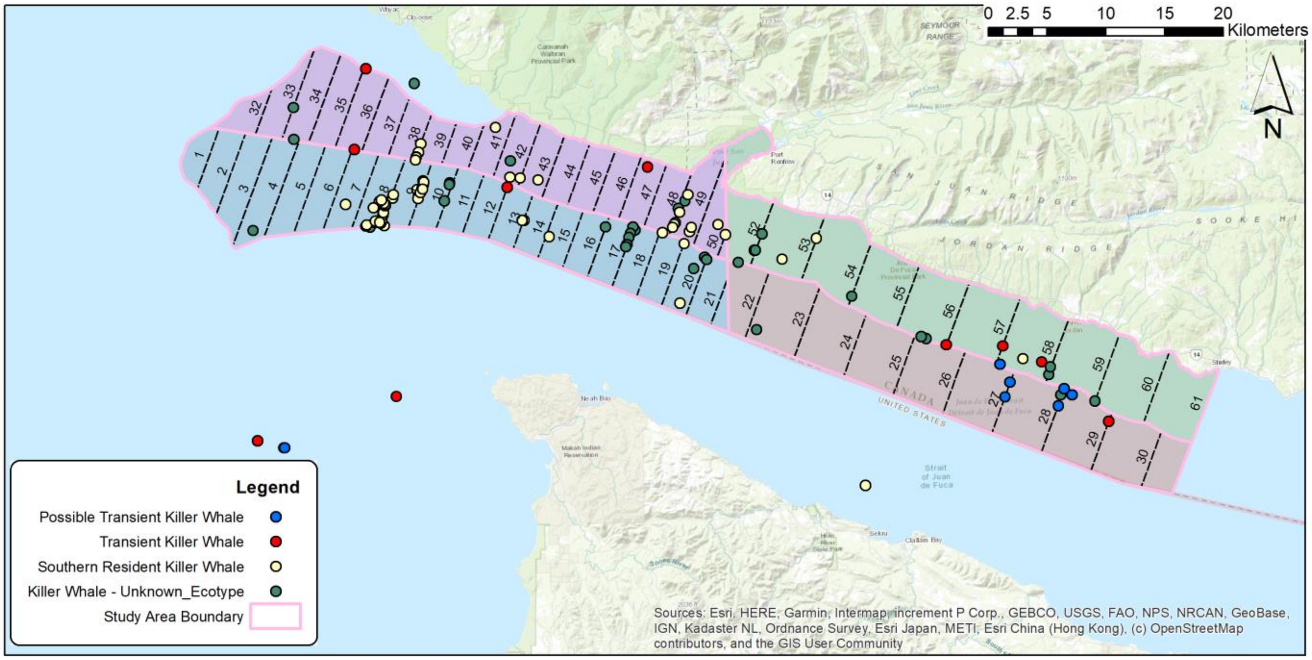


Figure 10. Combined killer whale (all ecotypes) line transect and opportunistic sightings data for 2020-2022 across study area. The sightings listed as possible transient killer whale were sighted in 2020.



3.5.2 Effort-Corrected Line Transect Cetacean Sightings Data - Survey Effort 2020, 2021 and 2022

Focusing only on combined systematic transect line sightings for 2020, 2021 and 2022 allows an analysis that takes into account effort (kms of line transects surveyed) across years and across strata, noting total effort in terms of distance surveyed for 2022 was six-fold that of 2020 and more than two and half times that of 2021 (Table 9).

The number of animals observed per hundred kilometers of survey was calculated based on the systematic line transect cetacean sightings for 2020, 2021 and 2022 separately and all three years combined (Table 9). When correcting for effort, there were greater numbers of animals observed per unit effort in 2022 than 2020 and 2021 for all species of cetacean, with the exception of Dall's porpoise (seen in greater numbers per unit effort in 2021) and killer whales (seen in greater numbers per unit effort in 2020) (Table 9, Figure 11). Humpback whales were observed in significantly greater numbers across all years than any other species per unit of effort (Table 9), but 2021 was clearly the lowest year for humpback whale sightings per unit effort compared to 2020 and 2022, with sightings in 2021 less than a quarter and less than a sixth, respectively.

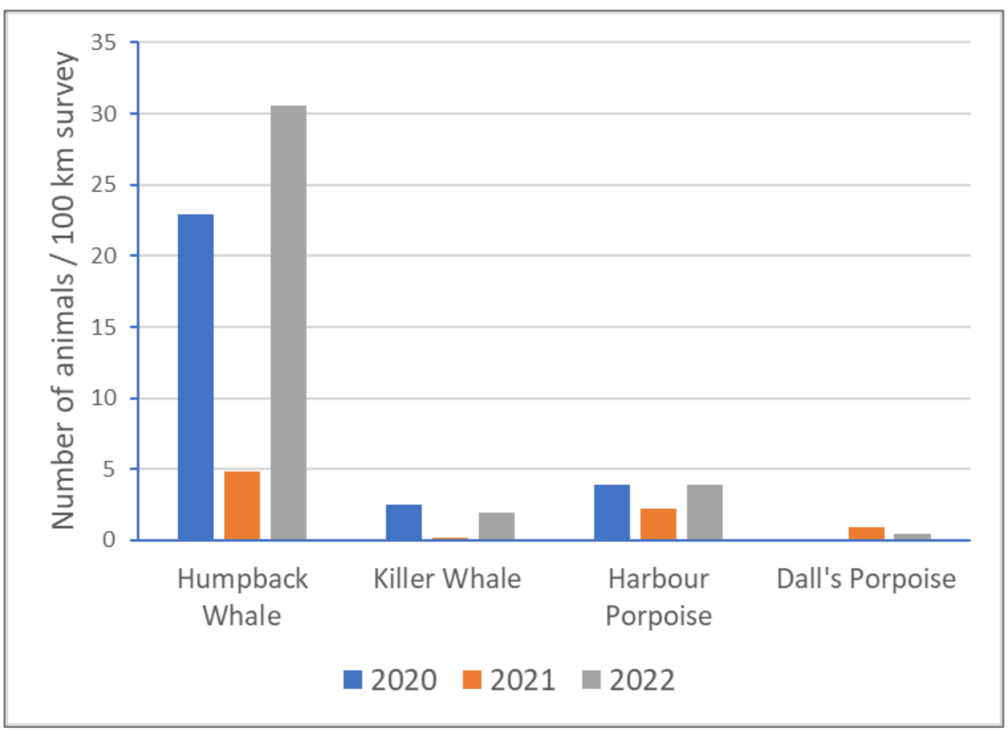
Across the three years (2020–2022), humpback whales were sighted most often at a rate of 23.31 animals per 100 km effort, followed by harbour porpoise at 3.49 animals per 100 km effort (Table 9). Grey whales had the lowest encounter rate of cetacean species per 100 km effort at 0.02, followed by Dall's porpoise with 0.53 (Table 9). Killer whales had a higher encounter rate (1.56 animals per 100 km effort) than Dall's porpoise, taking into account combined sightings of all ecotypes including southern resident, transient, and unknown killer whale ecotypes (Table 9).

Table 9 . Effort-corrected cetacean species sightings of number of animals (#) per hundred kilometers for the 2020, 2021 and 2022 line transect surveys, as well as combined across all years.

	2020			2021			2022			2020-2022 Combined		
Species Name	#	On effort survey km	# / per 100 km	#	On effort survey km	# / per 100 km	#	On effort survey km	# / per 100 km	#	On effort survey km	# / per 100 km
Humpback Whale	154	673	22.88	76	1584.3	4.80	1253	4103.9	30.53	1483	6361.2	23.31
Grey Whale	0	673	0.00	0	1584.3	0.00	1	4103.9	0.02	1	6361.2	0.02
Killer Whale	17	673	2.53	2	1584.3	0.13	80	4103.9	1.94	99	6361.2	1.56
Harbour Porpoise	26	673	3.86	35	1584.3	2.21	161	4103.9	3.92	222	6361.2	3.49
Dall's Porpoise	0	673	0.00	15	1584.3	0.95	19	4103.9	0.46	34	6361.2	0.53
Unidentified Porpoise	0	673	0.00	0	1584.3	0.00	38	4103.9	0.93	38	6361.2	0.60
Unidentified Whale	7	673	1.04	0	1584.3	0.00	11	4103.9	0.27	18	6361.2	0.28

Note: killer whale numbers include all ecotypes

Figure 11. Effort-corrected cetacean species sightings of number of animals (#) per hundred kilometers for the 2020, 2021 and 2022 line transect surveys.



Note: killer whale numbers include all ecotypes

When 2020, 2021 and 2022 data were partitioned by stratum, the Offshore west stratum had the highest amount of completed survey transect lines (2179 km, 34.5%), followed by Inshore west (2056 km, 32.5%), Inshore east (1138 km, 18.0%), and Offshore east (951 km, 15.0%). The overall 2020–2022 ratio of transect distance effort comparing western strata with eastern strata was also 2.03:1, as planned in scoping the overall project goals.

Taking effort per stratum into account, the three highest species sightings rates were humpback whales in the eastern Inshore stratum (36.9 per 100 km), as well as the western Offshore stratum (26.8 per 100 km) and eastern Offshore stratum (26.2 per 100 km) (Table 10) with similar rates. The next highest sighting rate was harbour porpoise with 7.2 animals seen per 100 km in the eastern Inshore stratum (Table 10). Harbour porpoise sighting rates were ~63% lower in the western Inshore strata and ~94% lower in both the Offshore strata (Table 10). Killer whale sightings rates (with all ecotypes combined) were highest in the western Inshore stratum followed by the western Offshore stratum but were observed in all four strata (Table 10). Dall's porpoise sightings were similar across strata, with the exception of lower sightings rates in the eastern offshore stratum (Table 10).

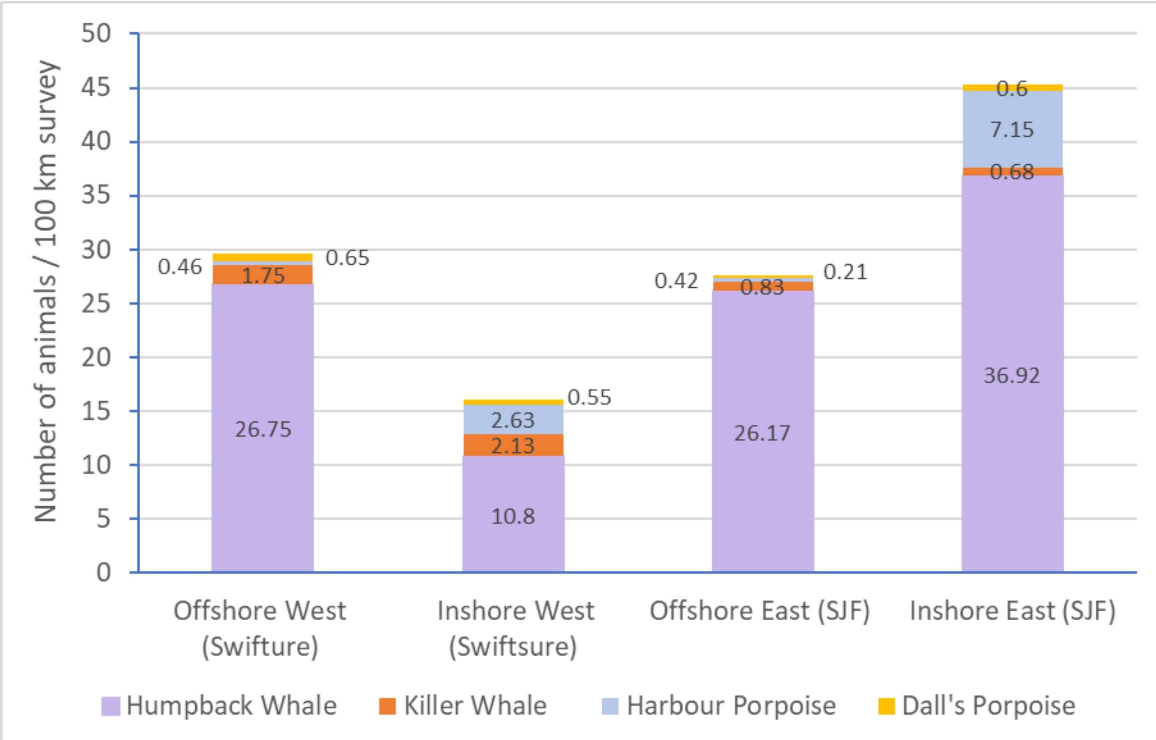
Table 10. Effort corrected cetacean species sightings of number of animals per hundred kilometers for each stratum for 2020, 2021 and 2022 combined line transect surveys.

Species	Number / 100 km – Offshore West (Swiftsure) Stratum	Number / 100 km – Inshore West (Swiftsure) Stratum	Number / 100 km – Offshore East (SJF) Stratum	Number / 100 km – Inshore East (SJF) Stratum
Humpback Whale	26.75	10.80	26.17	36.92
Grey Whale	0.00	0.05	0.00	0.00
Killer Whale	1.75	2.13	0.83	0.68
Harbour Porpoise	0.46	2.63	0.42	7.15
Dall's Porpoise	0.65	0.55	0.21	0.60
Unidentified Porpoise	0.46	0.35	0.42	1.45
Unidentified Whale	0.65	0.10	0.00	0.00

Note: killer whale numbers include all ecotypes

When effort corrected sighting rates were accumulated across these five cetacean species, the eastern Inshore stratum of the SJF had the highest overall sightings rates, followed by the western Offshore stratum that encompasses the ECHO vessel slowdown zone (Figure 12). The western Inshore stratum clearly had the lowest overall sightings rates, approximately three times lower than observed for the eastern Inshore stratum (Figure 12).

Figure 12 Effort corrected cetacean species sightings of number of animals (#) per hundred kilometers for each stratum for 2020, 2021 and 2022 combined line transect surveys.



Note: killer whale numbers include all ecotypes

4 Summary and Discussion

This report details a collaborative study to better understand marine mammal presence and habitat use, with a focus on southern resident killer whales, in SJF and at Swiftsure Bank through partnership with Pacheedaht First Nation during the summer and autumn months in 2022. Scientific survey design, training, and support was provided by SMRU Consulting and Sea View Marine Sciences.

The study area included the Canadian marine waters of the Pacheedaht First Nation SOI in SJF extending along the west coast of Vancouver Island to the Swiftsure Bank area. The study area was divided into four strata for sampling purposes (Inshore east, Offshore east, Inshore west, and Offshore west) (Figure 2) and to reflect known survey, weather, and swell constraints. The study area intersected with the regions demarcated for the ECHO Program Lateral Displacement and Swiftsure Bank Slowdown, and the Government of Canada Swiftsure Bank Seasonal Slowdown Areas (Figures 1 and 2). Stakeholders agreed a stronger survey effort (2:1) should be continued in the Swiftsure Bank (western strata) area.

MMO training was provided by Sea View Marine Sciences to 13 representatives of the Pacheedaht First Nation on 24-25 May 2022 and 17 June 2022. In total, nine participants received a *Certificate of Completion of the Introductory Level Course in At-Sea Observation and Data Recording* for successful completion of the MMO training in 2022. Seven observers were new, and all were non-scientists, so support and training were extended throughout the summer to assist the ongoing development and implementation of the procedures. The 2022 season has seen more than a 2.5-fold increase in survey distance effort from 2021 and over a six-fold increase from 2020 (Hall et al. 2021, 2022) and an improvement in the quality of data collected. It has been a successful third season and it is expected that this program will keep improving over time. This year, the field effort was weighted toward the summer and early fall months, late June through September and October.

Of the accumulated 1046 transects undertaken over the three years of the project, 63% were those west of Port Renfrew towards the Swiftsure Bank area (30% offshore strata, 33% inshore strata). As planned, fewer transects were conducted across the Offshore east (16%) and Inshore east (21%) strata, the survey region east of Port Renfrew. Systematic survey effort in 2022 focused on Inshore west due to under sampling of this stratum in 2020. The overall ratio of transect number effort comparing western strata with eastern strata in 2022 was 1.92:1. When 2022 transect distance data were partitioned by stratum, the Offshore west stratum had the highest amount of completed survey transect lines (1408 km, 34.3%), followed by Inshore west (1340 km, 32.7%), then Inshore east (733 km, 17.9%), and finally Offshore east (623 km, 15.2%). The overall ratio of transect distance effort comparing western strata with eastern strata was 2.03:1, as planned in 2020 project scoping.

During the 2022 on-effort line transect surveys, there were 766 cetacean sightings of an estimated 1563 animals (Table 4). Of the 766 cetacean sightings, humpback whales were the most numerically abundant and most often encountered species (85% of days, most notably between mid-August and mid-October; Table 3) in terms of the total estimated number of animals (n=1253) and the number of sightings (n=631) (Table 4). Harbour porpoise and killer whales were the next most frequently observed cetaceans in terms of the estimated total numbers of animals and the number of sightings during the 2022 field season (Table

4). Killer whales were most often observed in the late summer to fall months (weeks 13–18 of the field study; Table 3). Grey whales were the least frequently observed cetacean in 2022 with only one encounter during the line transect surveys. Southern resident killer whales were confirmed in the study area and it is of interest to note that there were a number of sightings of smaller groups, rather than fewer sightings of larger pod-sized groups, with most sightings in September and October 2022. Overall, southern resident killer whales were sighted on seven days during systematic line transects surveys in 2022 and opportunistic southern resident killer whale sightings on another four days. Transient killer whales were sighted on two transect survey days and on three other days opportunistically. On an additional 15 days, killer whales were sighted but ecotype was not determined.

Locations of line transect cetacean sightings for 2022 presented in Figures 3 and 4 highlight the numerical (non-effort corrected) hotspot for cetaceans (>2 animals per square km), predominantly in the Offshore west (Swiftsure Bank) stratum, and clearly overlap with the ECHO Program Swiftsure slowdown area for commercial shipping, and to a lesser extent the more southerly Seasonal Slowdown Area. Secondary "hot spots" were located in the eastern strata. However, as documented earlier, it should be noted that 2022 survey effort (transect distance) for Offshore west was similar to both eastern strata combined.

To take into account differences in survey effort by year and across different strata, the number of animals observed per hundred kilometers was calculated based on all systematic effort for 2020, 2021 and 2022 (Tables 9 and 10). When effort corrected sighting rates were accumulated across cetacean species (2020-2022), the eastern Inshore stratum of the SJF had the highest overall sightings rates, followed by the western Offshore stratum that encompasses the ECHO vessel slowdown zone (Figure 12). The western Inshore stratum clearly had the lowest overall sightings rates, approximately three times lower than observed for the eastern inshore stratum (Figure 12).

These data also highlight inter-annual differences and spatial distribution differences across multiple cetacean species. When correcting for effort, there were greater numbers of animals observed per unit effort in 2022 than 2020 and 2021 for all species of cetacean with the exception of Dall's porpoise (seen in greater numbers in 2021) and killer whales (seen in greater numbers in 2020) (Table 9). Humpback whales were observed in significantly greater numbers across all years (annual mean=23.3 animals per 100 km effort) than any other species per unit of effort (Table 9), but 2021 was clearly the lowest year for humpback whale sightings per unit effort. Harbour porpoise had an annual mean encounter rate of 3.5 animals per 100 km effort (Table 9), followed by killer whales (1.6 animals per 100 km effort) when taking into account combined sightings of all ecotypes including southern resident, transient, and unknown killer whale ecotypes and then Dall's porpoise (0.5 animals per 100 km effort, Table 9). No other cetaceans were identified, noting that Pacific grey whale migrations typically do not occur during the summer and fall survey period.

5 Recommendations

Review of the 2022 field effort and data provides an opportunity to make suggestions to further improve the data quality and facilitate a continued marine mammal observation program. These include:

- Increasing the number of Pacheedaht crew trained for marine mammal data collection and/or larger team to accommodate for crew absences.
- Designating a member of the Pacheedaht field crew as a Team Lead(s) position that carries specific roles and responsibilities that has a liaison responsibility with the Sea View Marine Sciences point of contact.
- Continue assigning a Sea View Marine Science liaison to be present on the survey vessel on a regular basis as needed.
- Articulating survey captain experience including prior demonstratable experience with operating vessels during scientific data collection and operation around marine mammals in accordance with federal regulations.
- Demonstratable certification to operate vessels with a scientific survey team.
- Evaluate industry standards for marine crew certifications and provide training as appropriate, including marine safety.
- Consistency in data collection across all field team members including marine mammal behavioural states.
- Improve the communication and check-in with the marine mammal team lead before departure and upon return from the field effort for each survey day.
- Weekly check-in meetings with marine mammal team lead.
- Weekly to bi-weekly data review and follow-up with field crew.
- Conduct a pre-survey protocol review meeting, with monthly follow-up discussions on progress and potential issues.
- Conduct a pre-survey kick-off meeting with participation by all field crew and support team members.
- Strict adherence to data collection protocols and conventions.
- Implement a formal distance calibration into the field protocol.
- Include a final exam in the MMOT with a minimum passing grade predetermined.
- Revisions to field plans to offset data deficiencies or gaps that resulted from the 2020-2022 seasons.
- Ensure quality photographs are taken for as many killer whale encounters as possible.
- Provide an update to the field protocol which outlines procedures for photographic data collection.
- Storage and processing of only clear photos of marine mammals on a consistent basis and creation of an in-field cataloguing protocol for easier processing.
- Continuing to provide table headings in the field notebook for opportunistic data collection to ensure consistency and accuracy.
- Continue building the field team cohesion from year to year for data quality control.
- Apply for a DFO SARA permit to approach killer whales closer than 400 m to increase chance of ecotype identification.
- Consider an additional analysis of whale sightings with respect to water depth and fine-scale seasonality of observation taking into account weekly effort.
- Consider an underwater acoustics (whale detection and ambient noise focus) component to provide greater temporal coverage and/or conduct surveys at other times of year to further reduce temporal data gaps.

Modifying some of the 2022 season's practices and improving communication with Pacheedaht field crew is expected to further increase the quality of data collection which will allow for a better appreciation of marine mammal presence in the area and the continued contribution to filling spatial and temporal data gaps.

In order to increase focus on detecting killer whales in relevant zones of interest, such as the ECHO Program's voluntary initiative areas and current and proposed federal conservation management actions, continued survey effort should be considered in 2023 and 2024 maintaining the 2:1 survey goal. This should ideally be cross-referenced with other Pacheedaht areas of marine mammal interest within the SOI. Lastly, recognition of the success of the 2022 field team, it is suggested that as much as possible, continuity should be maintained with interested members of the field team into the 2023 and 2024 seasons as these results speak to the importance of inter-annually coordinated marine studies.

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Appendix A: Field Protocol Steps

Pacheedaht First Nations Killer Whale Study Reporting
Field Protocol Steps

Websites for other sightings reporting platforms

https://porpoise.org/get-involved/report/
https://wildwhales.org/sightings/

Tablet login information: Removed for Privacy.

Field Protocol Steps

1. Charge tablets over night before trips.
2. Post in the messenger group who will be on the field team for the survey and note the estimated time of departure.
3. Decide the transect route with the captain.
4. Record data in the Yellow Book (date, crew, sea state, weather, survey goal for the day).
5. Calibrate distance estimations and zero protractors before starting line transects to help get everyone adjusted.
6. Turn on the tablet, plug in GPS, and open the Transect Pro X program.
7. If the GPS becomes unplugged, you must press disconnect on the tablet in Transect Pro X, then plug the GPS back in, and press reconnect on the software.
8. Bring backup data sheets & yellow book (for opportunistic sightings and notes).
9. Launch the software a few minutes before beginning the survey
10. Assign roles for the members of the field team (decide who will be observer/data collector, etc.). The observer and data collector should rotate positions each line.
11. If the previous day's transect data are visible, you need to reset the database.
12. Confirm the start of the transect line with the captain.
13. Begin on-effort until the captain ends the line.
14. Boats and other vessels will be noted in the "Notes" section, but animals take priority over boats for data entry.
15. End the transect.
16. Repeat for the duration of the day.
17. When you are finished your last line of the day, create a backup file of the days data.
18. At the end of the day, review data in Transect Pro and Yellow book. Make sure all entries are correct and complete.
19. Bring the tablets back somewhere with WIFI. Transfer the data and scan of the yellow book onto OneDrive – Ensure there are folders for each.
20. Review photographs, delete unnecessary ones, and load Photo-ID photographs into the folder as well - include notes with them from which trip/where they were taken.
21. Send a quick update to the messenger group on the trip including who was there, how many lines were completed, which lines were done, and the plan for the next survey day.

22. If you need to email the data file to info@seaviewmarinesciences.com the same day. Go to backups, Local Disc C, TSPX (transect pro x) – it contains all backup files.
23. Copy & paste the data file from the "Backup" file to the "Transfer Files here" folder so that SVMS can then find the data.

Appendix B: Daily cetacean species sighting locations, times, estimated group sizes, behaviours, and weather and sea state during line transect surveys in 2022.

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-06-23 8:49	48.482	-124.424	KW	1	SURFACE	No Data	No Data
2022-06-24 9:21	48.568	-124.981	HB	1	BLOW	Sunny	1
2022-06-24 9:22	48.563	-124.983	UP	1	FAST-SURFACE	Sunny	1
2022-06-24 9:23	48.559	-124.985	HB	2	BLOW	Sunny	1
2022-06-24 9:25	48.554	-124.988	HB	1	SURFACE	Sunny	1
2022-06-24 9:27	48.547	-124.991	HB	1	FLUKE	Sunny	1
2022-06-24 9:30	48.536	-124.996	HP	1	FAST-SURFACE	Sunny	1
2022-06-24 9:35	48.521	-125.004	HB	4	BLOW FLUKE	Sunny	1
2022-06-24 10:30	48.558	-124.922	HB	2	FLUKE BLOW	No Data	No Data
2022-06-24 10:31	48.554	-124.924	HB	1	BLOW	No Data	No Data
2022-06-24 10:36	48.540	-124.932	HB	1	BLOW	No Data	No Data
2022-06-24 10:37	48.537	-124.933	HB	1	BLOW	No Data	No Data
2022-06-24 10:37	48.535	-124.935	HB	1	SWIM	No Data	No Data
2022-06-24 10:40	48.526	-124.940	DP	1	FAST-SURFACE	No Data	No Data
2022-06-24 12:26	48.532	-124.806	HB	2	FLUKE BREACH	Sunny	1
2022-06-24 12:31	48.515	-124.816	HB	1	BLOW	No Data	No Data
2022-06-24 13:04	48.542	-124.736	HB	1	BLOW	PCPS	1
2022-06-25 8:57	48.620	-124.940	UP	2	FAST-SURFACE	Sunny	2
2022-06-26 9:13	48.520	-124.505	HB	1	No Data	No Data	No Data
2022-06-26 10:36	48.521	-124.638	UP	1	FAST-SURFACE	Sunny	2
2022-06-29 9:29	48.335	-124.030	HP	1	BLOW	Overcast	2
2022-06-29 9:31	48.329	-124.033	HP	1	FAST-SURFACE	Overcast	2
2022-06-29 9:34	48.320	-124.038	HP	1	FAST-SURFACE	Overcast	2
2022-06-29 10:13	48.389	-124.193	HP	2	FAST-SURFACE	No Data	No Data
2022-06-29 10:53	48.417	-124.307	UP	2	FAST-SURFACE	Overcast	0
2022-06-29 11:12	48.413	-124.375	HB	1	BLOW SURFACE	Overcast	0
2022-06-29 11:20	48.436	-124.361	HP	1	FAST-SURFACE	Overcast	0
2022-06-29 11:22	48.442	-124.357	HB	1	FLUKE	Overcast	0
2022-06-29 11:25	48.451	-124.352	HB	1	BLOW	Overcast	0
2022-06-29 12:44	48.488	-124.506	SRKW	4	SWIM TRAVEL	PCPS	0
2022-06-29 12:59	48.469	-124.549	DP	5	FAST-SURFACE	Overcast	0
2022-06-29 13:01	48.466	-124.551	HP	1	FAST-SURFACE	Overcast	0
2022-06-29 13:12	48.459	-124.588	HP	1	FAST-SURFACE	Overcast	1
2022-06-29 13:18	48.477	-124.578	HP	1	FAST-SURFACE	Overcast	1
2022-06-29 13:19	48.480	-124.576	HP	1	FAST-SURFACE	Overcast	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-07-07 11:18	48.546	-125.024	HB	2	BLOW	Overcast	0
2022-07-07 11:35	48.508	-125.009	HB	5	BREACH BLOW	Overcast	0
2022-07-07 11:39	48.520	-125.003	HB	2	BLOW BREACH	Overcast	0
2022-07-07 11:42	48.526	-124.999	HB	2	BREACH	Overcast	0
2022-07-07 11:43	48.531	-124.997	HB	1	BLOW BREACH	Overcast	0
2022-07-07 12:17	48.531	-124.970	HB	3	BLOW FAST-SURFACE	Overcast	1
2022-07-07 12:20	48.522	-124.975	HB	4	BLOW	No Data	No Data
2022-07-07 12:21	48.520	-124.977	HB	4	No Data	Overcast	0
2022-07-07 12:22	48.517	-124.978	HB	1	FAST-SURFACE	Overcast	0
2022-07-07 12:22	48.515	-124.979	HB	1	FAST-SURFACE	Overcast	0
2022-07-07 12:26	48.507	-124.984	HB	2	FAST-SURFACE BLOW	Overcast	0
2022-07-07 12:28	48.504	-124.985	HB	2	FAST-SURFACE BLOW	Overcast	1
2022-07-07 12:29	48.501	-124.987	HB	1	SLOW-ROLLING	Overcast	0
2022-07-07 12:38	48.501	-124.952	HB	1	FLUKE BLOW	PCPS	0
2022-07-07 12:40	48.505	-124.950	HB	2	SLOW-ROLLING	PCPS	0
2022-07-07 12:46	48.524	-124.940	HB	1	FAST-SURFACE	PCPS	0
2022-07-07 12:53	48.543	-124.929	HB	1	FLUKE FAST-SURFACE	PCPS	0
2022-07-07 13:17	48.530	-124.905	HB	1	BLOW	PCPS	0
2022-07-07 13:20	48.521	-124.911	HB	1	BLOW	PCPS	0
2022-07-07 13:22	48.517	-124.914	HB	5	BLOW FAST-SURFACE	PCPS	1
2022-07-07 13:24	48.511	-124.917	HB	1	FLUKE	PCPS	1
2022-07-07 13:27	48.507	-124.919	HB	4	BLOW	PCPS	1
2022-07-07 14:04	48.514	-124.882	HB	1	SURFACE	Overcast	0
2022-07-07 14:09	48.530	-124.873	HB	2	BLOW	Sunny	0
2022-07-07 14:10	48.534	-124.870	HB	1	BLOW SURFACE	Sunny	0
2022-07-07 14:40	48.513	-124.850	HB	1	BLOW	Sunny	1
2022-07-08 10:32	48.509	-124.656	UP	1	FAST-SURFACE	PCPS	0
2022-07-08 10:51	48.481	-124.638	DP	3	FAST-SURFACE	PCPS	1
2022-07-08 10:57	48.498	-124.629	UP	2	FAST-SURFACE	PCPS	1
2022-07-08 12:03	48.476	-124.544	UP	2	FAST-SURFACE	PCPS	1
2022-07-09 9:39	48.442	-124.315	HP	1	FAST-SURFACE	PCPS	0
2022-07-09 10:04	48.463	-124.241	HP	1	FAST-SURFACE	PCPS	0
2022-07-09 10:10	48.446	-124.249	HP	1	FAST-SURFACE	PCPS	0
2022-07-09 11:21	48.402	-124.079	HP	1	FAST-SURFACE	PCPS	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-07-09 11:42	48.386	-124.022	HP	3	FAST-SURFACE	PCPS	1
2022-07-11 10:30	48.610	-124.978	HB	2	FAST-SURFACE	Sunny	2
2022-07-11 10:33	48.601	-124.983	DP	4	FAST-SURFACE	Sunny	2
2022-07-11 10:43	48.575	-124.965	HP	1	FAST-SURFACE	No Data	No Data
2022-07-11 10:44	48.576	-124.964	HP	2	FAST-SURFACE	Sunny	No Data
2022-07-11 10:47	48.587	-124.958	HP	1	FAST-SURFACE	Sunny	1
2022-07-11 11:00	48.631	-124.933	HP	1	FAST-SURFACE	Sunny	2
2022-07-11 11:11	48.624	-124.905	HP	5	FAST-SURFACE	Sunny	1
2022-07-11 11:21	48.592	-124.923	HP	6	BOW FAST-SURFACE	Sunny	1
2022-07-11 11:32	48.571	-124.903	HP	1	FAST-SURFACE	Sunny	2
2022-07-11 12:03	48.599	-124.854	HP	1	FAST-SURFACE	Sunny	2
2022-07-11 12:36	48.577	-124.834	HP	1	FAST-SURFACE	Sunny	1
2022-07-11 12:37	48.581	-124.832	HB	1	RESTING	Sunny	1
2022-07-11 12:38	48.583	-124.830	HP	1	FAST-SURFACE	Sunny	1
2022-07-11 13:38	48.567	-124.710	HP	1	FAST-SURFACE	Sunny	2
2022-07-11 14:51	48.554	-124.587	HP	1	FAST-SURFACE	Sunny	2
2022-07-11 15:07	48.538	-124.563	HB	1	BLOW	Sunny	1
2022-07-11 15:26	48.519	-124.540	HB	1	FLUKE	Sunny	2
2022-07-11 15:42	48.537	-124.490	HB	5	SWIM	Sunny	2
2022-07-16 15:06	48.534	-124.904	UW	1	BLOW	Overcast	1
2022-07-17 9:10	48.552	-124.860	UW	1	BLOW	Overcast	2
2022-07-17 9:22	48.513	-124.882	HB	1	BLOW FAST-SURFACE	PCPS	1
2022-07-17 9:34	48.520	-124.845	HB	2	FAST-SURFACE	Overcast	1
2022-07-17 9:35	48.525	-124.842	HB	3	BLOW FAST-SURFACE	Overcast	1
2022-07-17 9:42	48.547	-124.830	HB	1	FAST-SURFACE	Overcast	1
2022-07-17 9:55	48.543	-124.801	HB	2	BLOW FAST-SURFACE	Overcast	1
2022-07-17 9:58	48.536	-124.805	HB	1	BLOW	Overcast	1
2022-07-17 10:18	48.522	-124.782	HB	1	BLOW	Overcast	2
2022-07-17 10:20	48.526	-124.780	HB	2	BLOW	Overcast	2
2022-07-17 10:45	48.526	-124.746	HB	2	BLOW FAST-SURFACE	Overcast	1
2022-07-17 13:34	48.471	-124.517	HB	1	BREACH	PCPS	2
2022-07-21 10:37	48.365	-124.208	HB	2	BLOW SURFACE	No Data	No Data
2022-07-21 10:37	48.363	-124.209	HB	1	FLUKE	No Data	No Data
2022-07-21 10:39	48.359	-124.211	HB	3	BLOW	No Data	No Data
2022-07-21 11:19	48.374	-124.267	HB	1	BLOW	PCPS	2
2022-07-21 11:21	48.379	-124.264	HB	1	BLOW	Rain	2

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-07-21 12:12	48.415	-124.373	HB	3	BLOW	PCPS	2
2022-07-21 12:14	48.419	-124.371	HB	2	BLOW	PCPS	2
2022-07-21 12:17	48.427	-124.367	HB	2	BLOW	PCPS	2
2022-07-21 12:17	48.429	-124.365	HB	1	BLOW	PCPS	2
2022-07-21 12:20	48.436	-124.361	HB	1	FLUKE	PCPS	2
2022-07-22 8:04	48.560	-124.714	HB	1	BLOW	Fog	1
2022-07-22 10:00	48.570	-124.904	HB	1	FAST-SURFACE BLOW	Fog	2
2022-07-22 11:02	48.598	-124.952	KW	3	FAST-SURFACE	PCPS	2
2022-07-22 12:32	48.556	-125.053	HB	1	BLOW FAST-SURFACE	Overcast	3
2022-07-22 12:39	48.540	-125.062	DP	1	WAKE	Overcast	3
2022-07-23 10:13	48.474	-124.362	HB	1	FAST-SURFACE BLOW	Overcast	1
2022-07-23 10:56	48.429	-124.260	HB	1	FAST-SURFACE BLOW	Overcast	1
2022-07-23 11:09	48.463	-124.242	HP	1	FAST-SURFACE	Overcast	1
2022-08-04 9:06	48.374	-123.901	HP	2	FAST-SURFACE	Overcast	1
2022-08-04 9:52	48.386	-124.024	HP	1	FAST-SURFACE	No Data	No Data
2022-08-04 9:53	48.384	-124.025	HP	1	FAST-SURFACE	No Data	No Data
2022-08-04 10:08	48.377	-124.094	HP	1	FAST-SURFACE	Overcast	1
2022-08-04 10:32	48.425	-124.131	HB	1	FLUKE	No Data	No Data
2022-08-04 10:34	48.421	-124.133	HB	4	BLOW FLUKE	Overcast	1
2022-08-04 10:35	48.417	-124.135	HB	1	BLOW	Overcast	No Data
2022-08-04 10:35	48.415	-124.137	HB	2	BLOW	Overcast	1
2022-08-04 10:36	48.412	-124.138	HB	1	FAST-SURFACE	No Data	No Data
2022-08-04 10:37	48.410	-124.140	HB	1	BLOW FAST-SURFACE	Overcast	1
2022-08-04 10:38	48.408	-124.141	HB	2	FLUKE BLOW	Overcast	1
2022-08-04 10:40	48.401	-124.145	HB	1	FLUKE	Overcast	1
2022-08-04 10:54	48.409	-124.206	HB	2	BLOW FAST-SURFACE	Overcast	1
2022-08-04 11:29	48.445	-124.251	HB	1	BLOW	Overcast	1
2022-08-04 11:31	48.439	-124.254	HB	2	BLOW FAST-SURFACE	Overcast	1
2022-08-04 11:32	48.435	-124.256	HB	1	FLUKE	Overcast	1
2022-08-04 11:35	48.426	-124.261	HB	1	SURFACE	Overcast	1
2022-08-04 11:36	48.424	-124.262	HB	1	BLOW	Overcast	1
2022-08-04 11:37	48.421	-124.263	HB	1	BLOW	PCPS	1
2022-08-04 11:51	48.439	-124.318	HB	1	BLOW	PCPS	1
2022-08-04 11:52	48.440	-124.317	HB	1	FAST-SURFACE	PCPS	1
2022-08-04 11:52	48.441	-124.316	HB	1	SURFACE	PCPS	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-08-04 11:53	48.443	-124.315	HB	2	BLOW FAST-SURFACE	PCPS	1
2022-08-04 12:19	48.491	-124.352	HB	1	SURFACE	No Data	No Data
2022-08-04 12:21	48.486	-124.355	HP	2	FAST-SURFACE	No Data	No Data
2022-08-04 12:29	48.459	-124.371	HB	1	BLOW	No Data	No Data
2022-08-04 14:22	48.513	-124.480	HB	1	SWIM SURFACE	Sunny	2
2022-08-05 10:52	48.347	-124.152	HB	2	FAST-SURFACE	Sunny	0
2022-08-05 12:02	48.429	-124.300	HB	1	FLUKE	No Data	No Data
2022-08-05 12:03	48.427	-124.301	HB	3	FLUKE	Sunny	0
2022-08-05 12:05	48.422	-124.304	HB	1	SURFACE FLUKE	Sunny	No Data
2022-08-05 12:05	48.420	-124.305	HB	1	FLUKE	Sunny	0
2022-08-05 12:06	48.416	-124.307	HB	1	FAST-SURFACE BLOW	Sunny	0
2022-08-05 12:12	48.400	-124.316	HB	1	SURFACE	Sunny	0
2022-08-05 12:13	48.398	-124.317	HP	1	FAST-SURFACE	Sunny	0
2022-08-05 12:39	48.448	-124.354	HB	1	FLUKE	Sunny	1
2022-08-05 13:06	48.423	-124.435	HP	1	FAST-SURFACE	Sunny	2
2022-08-05 13:15	48.439	-124.471	HB	1	BLOW	Sunny	1
2022-08-05 13:16	48.440	-124.470	HB	1	SURFACE	Sunny	1
2022-08-05 13:18	48.447	-124.466	HB	3	BREACH BLOW	Sunny	1
2022-08-05 13:22	48.458	-124.459	HP	1	FAST-SURFACE	Sunny	2
2022-08-05 13:29	48.478	-124.480	HB	3	BREACH BLOW	Sunny	2
2022-08-07 13:08	48.507	-124.920	HB	1	BLOW	Sunny	2
2022-08-07 13:11	48.511	-124.917	HB	1	BLOW	Sunny	2
2022-08-07 13:12	48.514	-124.915	HB	1	BLOW	Sunny	2
2022-08-07 13:39	48.540	-124.867	HB	2	BLOW	Sunny	2
2022-08-07 13:40	48.537	-124.869	HB	1	BLOW	Sunny	2
2022-08-07 13:43	48.530	-124.873	HB	6	BLOW FAST-SURFACE	Sunny	2
2022-08-07 13:44	48.527	-124.874	HB	2	BLOW	Sunny	2
2022-08-07 13:44	48.525	-124.875	HB	1	BLOW	Sunny	2
2022-08-07 13:46	48.520	-124.879	HB	1	BLOW	Sunny	2
2022-08-07 13:47	48.518	-124.880	HB	2	BLOW	Sunny	2
2022-08-07 13:48	48.516	-124.881	HB	1	BLOW	No Data	No Data
2022-08-07 13:48	48.515	-124.882	HB	1	BLOW	Sunny	2
2022-08-07 14:05	48.528	-124.841	HB	1	FAST-SURFACE	Sunny	1
2022-08-07 14:31	48.518	-124.815	HB	5	BLOW	Sunny	2
2022-08-07 15:36	48.534	-124.708	TKW	1	FLUKE BLOW	No Data	No Data
2022-08-11 11:20	48.594	-124.988	HP	1	FAST-SURFACE	Sunny	0
2022-08-11 11:21	48.597	-124.986	HP	1	FAST-SURFACE	Sunny	0

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-08-11 12:32	48.626	-124.872	HP	1	FAST-SURFACE	Sunny	0
2022-08-11 12:36	48.612	-124.879	HP	1	FAST-SURFACE	Sunny	0
2022-08-13 10:28	48.522	-124.881	HB	1	FAST-SURFACE	Rain	3
2022-08-13 12:46	48.525	-125.034	HB	1	SURFACE	Overcast	1
2022-08-13 12:47	48.527	-125.033	HB	2	SURFACE FLUKE	Overcast	1
2022-08-13 12:48	48.532	-125.031	HB	2	FLUKE	Overcast	1
2022-08-13 13:18	48.549	-125.057	HB	1	BLOW SURFACE	Overcast	2
2022-08-13 14:12	48.618	-124.940	HB	1	BLOW	Overcast	1
2022-08-13 14:36	48.584	-124.927	HB	1	BLOW	Overcast	2
2022-08-13 14:41	48.601	-124.917	HB	2	SWIM FAST-SURFACE	Overcast	2
2022-08-13 14:51	48.634	-124.898	HB	2	BLOW	Overcast	2
2022-08-13 14:52	48.637	-124.896	HB	1	BLOW	Overcast	2
2022-08-13 15:15	48.573	-124.901	HB	1	FLUKE	Overcast	1
2022-08-14 9:31	48.530	-124.602	HB	1	BLOW	Sunny	1
2022-08-14 10:09	48.494	-124.669	HB	2	BLOW FLUKE	No Data	No Data
2022-08-14 12:31	48.441	-124.502	HB	1	FLUKE	Sunny	2
2022-08-14 12:32	48.443	-124.501	HB	1	SURFACE	Sunny	2
2022-08-14 12:33	48.446	-124.499	HB	1	BREACH	Sunny	2
2022-08-14 12:36	48.453	-124.495	HB	1	No Data	No Data	No Data
2022-08-14 12:36	48.454	-124.494	HB	1	BLOW FLUKE	No Data	No Data
2022-08-14 12:37	48.455	-124.493	HB	5	FLUKE SURFACE	Sunny	2
2022-08-14 12:38	48.456	-124.492	HB	1	SURFACE BLOW	No Data	No Data
2022-08-14 12:39	48.457	-124.491	HB	3	BLOW SURFACE	Sunny	2
2022-08-14 12:40	48.459	-124.489	HB	2	BREACH BLOW	Sunny	2
2022-08-14 12:42	48.466	-124.484	HB	3	SURFACE BLOW	Sunny	2
2022-08-14 12:43	48.469	-124.482	HB	1	FLUKE	Sunny	No Data
2022-08-14 12:44	48.470	-124.481	HB	2	BLOW FLUKE	No Data	No Data
2022-08-14 12:46	48.472	-124.479	HB	3	BLOW SURFACE	Sunny	2
2022-08-14 12:55	48.460	-124.455	HB	1	SURFACE	Sunny	2
2022-08-14 12:55	48.459	-124.456	HB	2	BLOW FLUKE	Sunny	2
2022-08-15 10:50	48.502	-124.347	HP	3	FAST-SURFACE	Fog	3
2022-08-15 11:49	48.381	-124.198	HB	1	BLOW	Sunny	3
2022-08-15 13:04	48.369	-123.967	HP	1	FAST-SURFACE	Sunny	2
2022-08-17 10:39	48.494	-124.601	HB	1	BLOW	Sunny	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-08-18 9:23	48.497	-124.414	HB	1	SURFACE BLOW	Sunny	1
2022-08-18 9:25	48.492	-124.416	HB	2	FLUKE BLOW	Sunny	1
2022-08-18 9:26	48.487	-124.420	HB	2	BLOW FLUKE	Sunny	1
2022-08-18 9:40	48.460	-124.370	HB	1	BLOW	Sunny	1
2022-08-18 9:42	48.463	-124.368	HB	3	BLOW SURFACE	Sunny	1
2022-08-18 10:10	48.460	-124.306	HB	1	BLOW	Sunny	1
2022-08-18 10:10	48.458	-124.306	HB	1	BLOW	No Data	No Data
2022-08-18 10:10	48.457	-124.307	HB	1	BLOW	Sunny	1
2022-08-18 10:11	48.455	-124.309	HB	7	BLOW	Sunny	1
2022-08-18 10:12	48.451	-124.311	HB	5	BLOW SWIM	Sunny	1
2022-08-18 10:16	48.442	-124.317	HB	2	BLOW SWIM	Sunny	1
2022-08-18 10:35	48.423	-124.262	HB	1	SURFACE FEEDING	PCPS	1
2022-08-18 10:36	48.426	-124.259	HB	1	BLOW FAST-SURFACE	PCPS	1
2022-08-18 11:00	48.449	-124.181	HB	2	SURFACE SLOW-ROLLING	Sunny	0
2022-08-18 11:04	48.442	-124.185	HB	1	FAST-SURFACE	Sunny	1
2022-08-18 11:07	48.433	-124.191	HB	2	BLOW	Sunny	1
2022-08-18 11:09	48.425	-124.197	HB	1	BLOW	Sunny	1
2022-08-18 11:57	48.384	-124.090	HB	1	FAST-SURFACE	Sunny	1
2022-08-18 11:58	48.386	-124.088	HB	1	FLUKE	Sunny	0
2022-08-18 12:16	48.436	-124.126	HP	1	FAST-SURFACE	Sunny	0
2022-08-18 12:40	48.397	-124.190	HB	1	BLOW	Sunny	1
2022-08-18 13:04	48.374	-124.268	HB	1	FAST-SURFACE	Sunny	0
2022-08-18 13:16	48.409	-124.246	HB	2	SURFACE BLOW	Sunny	0
2022-08-18 13:24	48.430	-124.299	HB	1	RESTING	Sunny	1
2022-08-18 13:52	48.429	-124.365	HB	1	FLUKE	Sunny	0
2022-08-18 13:56	48.442	-124.357	HB	5	BLOW FAST-SURFACE	Sunny	1
2022-08-18 13:59	48.452	-124.351	HB	6	BLOW FAST-SURFACE	Sunny	1
2022-08-18 14:11	48.454	-124.417	HB	2	SURFACE	Sunny	1
2022-08-18 14:18	48.437	-124.428	HP	1	FAST-SURFACE	Sunny	1
2022-08-18 14:20	48.430	-124.432	HB	2	SURFACE BLOW	Sunny	1
2022-08-18 15:02	48.509	-124.547	HB	1	BREACH	Sunny	2
2022-08-18 15:04	48.517	-124.542	HB	2	BLOW	Sunny	2

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-08-19 15:19	48.516	-124.505	HB	1	BLOW SURFACE	Sunny	3
2022-08-19 16:02	48.496	-124.491	HB	1	BLOW BREACH	PCPS	2
2022-08-20 8:09	48.403	-124.015	HP	4	FAST-SURFACE	Overcast	2
2022-08-20 8:10	48.400	-124.016	HP	2	FAST-SURFACE	PCPS	2
2022-08-20 8:19	48.381	-124.026	HB	1	BLOW	PCPS	2
2022-08-20 8:20	48.380	-124.027	HB	1	BLOW	PCPS	2
2022-08-20 10:50	48.341	-124.156	UP	2	FAST-SURFACE	Overcast	2
2022-08-20 11:54	48.376	-124.266	HP	1	FAST-SURFACE	PCPS	1
2022-08-20 11:58	48.384	-124.259	DP	1	FAST-SURFACE	PCPS	2
2022-08-20 13:29	48.461	-124.412	HB	1	FLUKE RESTING	Sunny	1
2022-08-20 13:33	48.453	-124.417	HB	1	BLOW	Sunny	1
2022-08-20 13:37	48.445	-124.421	HB	1	BLOW	Sunny	1
2022-08-20 13:44	48.431	-124.430	HB	1	BLOW	No Data	No Data
2022-08-20 13:44	48.431	-124.431	HB	2	BLOW	Sunny	1
2022-08-20 13:45	48.430	-124.431	HB	2	BLOW	Sunny	1
2022-08-20 14:01	48.445	-124.466	HB	1	BLOW	Sunny	1
2022-08-20 14:04	48.451	-124.462	HB	1	FLUKE	Sunny	1
2022-08-20 14:47	48.463	-124.520	HP	1	FAST-SURFACE	Sunny	2
2022-08-21 9:34	48.552	-125.020	UP	1	FAST-SURFACE	Overcast	1
2022-08-21 9:36	48.557	-125.019	UW	1	BREACH	Overcast	1
2022-08-21 11:55	48.509	-124.916	UP	1	FAST-SURFACE	PCPS	1
2022-08-21 12:29	48.555	-124.859	HB	9	BLOW	Sunny	0
2022-08-21 12:32	48.549	-124.862	HB	3	BLOW	Sunny	0
2022-08-21 13:04	48.513	-124.850	HB	2	BLOW SURFACE	PCPS	0
2022-08-21 13:07	48.520	-124.845	HB	1	BLOW	PCPS	0
2022-08-21 13:10	48.526	-124.842	HB	6	BLOW FAST-SURFACE	PCPS	0
2022-08-21 13:14	48.535	-124.838	HB	3	BLOW FLUKE	PCPS	0
2022-08-21 13:30	48.551	-124.796	HB	8	BLOW FLUKE	PCPS	0
2022-08-21 13:35	48.541	-124.803	HB	2	BLOW FLUKE	PCPS	0
2022-08-21 13:36	48.537	-124.806	HB	9	SWIM BLOW	PCPS	0
2022-08-21 13:39	48.535	-124.808	HP	3	FAST-SURFACE	PCPS	0
2022-08-21 14:04	48.515	-124.786	UP	1	FAST-SURFACE	PCPS	0
2022-08-22 9:22	48.606	-124.981	HP	2	FAST-SURFACE	Overcast	0
2022-08-22 9:30	48.588	-124.991	HP	1	FAST-SURFACE	Overcast	0
2022-08-22 10:03	48.620	-124.940	HP	4	SWIM FAST-SURFACE	Overcast	0
2022-08-22 10:09	48.634	-124.933	HP	3	FAST-SURFACE	Sunny	0
2022-08-22 10:28	48.618	-124.910	UP	2	FAST-SURFACE	Overcast	0

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-08-22 10:33	48.606	-124.916	UP	1	FAST-SURFACE	Overcast	0
2022-08-22 10:34	48.604	-124.917	HB	1	SURFACE BLOW	Overcast	0
2022-08-22 11:43	48.583	-124.831	HP	3	FAST-SURFACE	Overcast	0
2022-08-22 11:45	48.579	-124.834	HP	2	FAST-SURFACE	Overcast	0
2022-08-22 11:49	48.570	-124.838	HP	2	FAST-SURFACE	Overcast	0
2022-08-22 12:15	48.585	-124.796	HP	5	FAST-SURFACE	Overcast	0
2022-08-22 12:30	48.563	-124.777	UW	1	BLOW	Overcast	0
2022-08-22 12:32	48.559	-124.779	HP	1	FAST-SURFACE	Overcast	1
2022-08-22 13:18	48.538	-124.739	HB	1	FLUKE	Overcast	0
2022-08-22 13:20	48.533	-124.741	HB	3	BREACH FLUKE	Overcast	1
2022-08-22 13:39	48.496	-124.729	HP	1	FAST-SURFACE SWIM	Overcast	1
2022-08-22 13:45	48.507	-124.723	HP	1	FAST-SURFACE	No Data	No Data
2022-08-31 9:47	48.425	-124.434	HP	1	BLOW	Sunny	2
2022-09-01 9:26	48.479	-124.543	HB	1	BREACH	Overcast	1
2022-09-01 9:27	48.476	-124.545	HB	1	BLOW	Overcast	1
2022-09-01 9:28	48.474	-124.546	HB	1	BLOW	Overcast	1
2022-09-01 9:28	48.473	-124.547	HB	1	BLOW	Overcast	1
2022-09-01 9:36	48.452	-124.559	HB	1	BLOW	Overcast	1
2022-09-01 9:45	48.466	-124.584	HB	1	BLOW	Overcast	0
2022-09-01 10:51	48.485	-124.670	HB	1	FLUKE SURFACE	Overcast	1
2022-09-01 12:07	48.520	-124.785	HB	1	FLUKE	Sunny	1
2022-09-01 12:11	48.507	-124.791	HB	1	SURFACE FLUKE	Sunny	1
2022-09-01 12:21	48.514	-124.817	HB	5	SURFACE	Overcast	1
2022-09-01 12:40	48.550	-124.828	HB	1	SURFACE	Sunny	No Data
2022-09-01 12:45	48.537	-124.835	HB	1	BLOW	Sunny	1
2022-09-01 12:47	48.531	-124.839	HB	3	BLOW FLUKE	Overcast	1
2022-09-01 12:49	48.527	-124.841	HB	12	SURFACE BLOW	Overcast	1
2022-09-01 12:51	48.522	-124.844	HB	2	BLOW SURFACE	Overcast	1
2022-09-01 12:52	48.518	-124.846	HB	1	FLUKE SURFACE	Overcast	1
2022-09-01 12:57	48.506	-124.853	HB	4	SURFACE	Overcast	1
2022-09-01 13:04	48.507	-124.887	HB	7	BLOW SURFACE	Overcast	1
2022-09-01 13:04	48.509	-124.885	HB	4	BLOW SURFACE	No Data	No Data
2022-09-01 13:07	48.517	-124.881	HB	3	BLOW SURFACE	PCPS	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-01 13:09	48.520	-124.880	HB	2	SURFACE BLOW	PCPS	1
2022-09-01 13:10	48.523	-124.878	HB	2	BLOW	No Data	No Data
2022-09-03 8:39	48.368	-124.202	HB	1	SURFACE FLUKE	Overcast	1
2022-09-03 12:24	48.405	-124.014	HP	1	FAST-SURFACE	Sunny	2
2022-09-04 9:42	48.519	-124.575	HB	1	BLOW	Rain	2
2022-09-04 9:45	48.526	-124.570	HB	1	FLUKE RESTING	Rain	2
2022-09-04 10:08	48.533	-124.600	HB	1	SURFACE	No Data	No Data
2022-09-04 10:10	48.524	-124.605	HB	3	BLOW FLUKE	Rain	2
2022-09-04 10:22	48.534	-124.630	HB	2	RESTING FLUKE	Fog	2
2022-09-04 11:14	48.504	-124.516	HB	1	SURFACE	Rain	2
2022-09-04 11:36	48.498	-124.457	HB	1	SURFACE	Rain	2
2022-09-04 11:37	48.497	-124.456	HB	1	BLOW SURFACE	Rain	2
2022-09-04 11:38	48.494	-124.457	HB	2	FLUKE SURFACE	Rain	2
2022-09-04 11:42	48.483	-124.465	HB	1	BLOW SURFACE	Rain	2
2022-09-04 12:40	48.461	-124.412	HB	1	BLOW	Rain	1
2022-09-04 12:41	48.458	-124.414	HB	1	FLUKE	Rain	1
2022-09-04 12:44	48.450	-124.418	HB	2	FLUKE	Rain	2
2022-09-04 13:35	48.450	-124.529	HB	1	BLOW SURFACE	Fog	2
2022-09-04 14:46	48.503	-124.485	HB	1	BLOW	PCPS	2
2022-09-04 14:47	48.506	-124.483	HB	6	BLOW SURFACE	PCPS	2
2022-09-04 14:48	48.510	-124.481	HB	1	BLOW	PCPS	2
2022-09-05 8:46	48.572	-124.902	UP	1	FAST-SURFACE	Fog	0
2022-09-05 13:07	48.566	-124.917	HP	1	FAST-SURFACE	Fog	1
2022-09-05 13:08	48.564	-124.919	HP	1	FAST-SURFACE	Fog	1
2022-09-06 9:26	48.412	-124.074	HP	2	FAST-SURFACE	Sunny	0
2022-09-06 11:29	48.492	-124.460	HB	4	BLOW	Sunny	2
2022-09-06 11:31	48.485	-124.464	HB	4	BLOW FLUKE	Sunny	2
2022-09-06 11:32	48.479	-124.467	HB	3	BLOW FAST-SURFACE	No Data	No Data
2022-09-06 11:33	48.477	-124.468	HB	3	BLOW SURFACE	No Data	No Data
2022-09-06 11:50	48.454	-124.416	HB	2	BLOW	No Data	No Data
2022-09-06 11:51	48.451	-124.417	HB	1	BLOW	No Data	No Data
2022-09-06 11:52	48.449	-124.419	HB	2	BLOW SURFACE	No Data	No Data
2022-09-06 11:54	48.442	-124.423	HB	1	SURFACE	No Data	No Data

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-06 11:55	48.436	-124.427	HB	2	SURFACE	No Data	No Data
2022-09-06 11:59	48.423	-124.435	HB	2	SURFACE	No Data	No Data
2022-09-06 12:08	48.431	-124.474	HB	1	RESTING	No Data	No Data
2022-09-06 12:09	48.433	-124.473	HB	1	SURFACE	No Data	No Data
2022-09-06 12:09	48.433	-124.473	HB	1	SURFACE	No Data	No Data
2022-09-06 12:10	48.435	-124.472	HB	2	SURFACE BLOW	No Data	No Data
2022-09-06 12:11	48.440	-124.469	HB	1	SURFACE BLOW	No Data	No Data
2022-09-06 12:13	48.444	-124.467	HB	1	SURFACE	Sunny	0
2022-09-06 12:14	48.447	-124.465	HB	2	SURFACE BLOW	No Data	No Data
2022-09-06 12:15	48.450	-124.463	HB	2	SURFACE BLOW	No Data	No Data
2022-09-06 12:17	48.457	-124.459	HB	2	BLOW SURFACE	No Data	No Data
2022-09-06 12:32	48.475	-124.481	HB	2	FLUKE BLOW	Sunny	1
2022-09-06 12:39	48.455	-124.494	HB	2	BLOW FLUKE	Sunny	1
2022-09-06 12:40	48.452	-124.496	HB	2	BLOW FLUKE	Sunny	1
2022-09-06 12:43	48.444	-124.500	HB	1	BLOW SURFACE	Sunny	1
2022-09-06 12:44	48.439	-124.504	HB	1	BLOW	Sunny	1
2022-09-06 12:56	48.462	-124.522	HB	1	BLOW	Sunny	1
2022-09-06 13:12	48.489	-124.537	HB	1	BLOW FLUKE	Sunny	1
2022-09-06 13:16	48.475	-124.544	HB	1	BLOW SURFACE	Sunny	1
2022-09-06 13:37	48.465	-124.584	HB	1	FLUKE	Sunny	1
2022-09-06 14:08	48.468	-124.616	HB	2	BLOW	Sunny	1
2022-09-07 8:29	48.509	-124.407	HB	2	BLOW FAST-SURFACE	Fog	1
2022-09-07 8:32	48.502	-124.411	HB	3	BLOW FAST-SURFACE	Fog	1
2022-09-07 10:12	48.520	-124.573	HB	2	FAST-SURFACE	Fog	2
2022-09-09 9:01	48.568	-124.775	HB	1	BLOW	Sunny	2
2022-09-09 9:03	48.563	-124.777	HB	1	BLOW	Sunny	2
2022-09-09 10:09	48.549	-124.687	HB	1	BLOW	Sunny	2
2022-09-09 11:36	48.524	-124.604	HB	1	BLOW FLUKE	Sunny	3
2022-09-09 11:39	48.517	-124.608	HB	2	BLOW	Sunny	3
2022-09-09 12:40	48.492	-124.534	HB	1	BLOW	Sunny	2
2022-09-09 12:45	48.480	-124.542	HB	1	BLOW	Sunny	2
2022-09-09 12:46	48.476	-124.544	HB	2	BLOW	Sunny	2
2022-09-09 12:49	48.471	-124.548	HB	2	BLOW	Sunny	2

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-09 12:53	48.460	-124.554	HB	1	BREACH	Sunny	2
2022-09-09 12:55	48.454	-124.558	HB	2	BLOW FLUKE	Sunny	2
2022-09-09 12:56	48.452	-124.560	HB	2	BLOW	Sunny	2
2022-09-09 13:07	48.455	-124.527	HB	1	BLOW	Sunny	2
2022-09-09 13:22	48.489	-124.506	HB	1	BLOW SURFACE	No Data	No Data
2022-09-10 8:37	48.423	-124.370	HB	1	BLOW	Sunny	3
2022-09-10 8:43	48.409	-124.378	HB	1	SURFACE BLOW	Sunny	3
2022-09-10 9:54	48.380	-124.265	HB	1	BREACH	No Data	No Data
2022-09-10 9:55	48.378	-124.266	HB	5	BLOW BREACH	Sunny	5
2022-09-10 9:57	48.374	-124.269	HB	1	BLOW	No Data	No Data
2022-09-12 8:31	48.547	-124.863	UW	1	BLOW	Sunny	1
2022-09-12 8:34	48.541	-124.867	HB	4	BLOW SURFACE	Sunny	1
2022-09-12 8:36	48.537	-124.869	HB	1	BREACH	Sunny	0
2022-09-12 8:37	48.534	-124.871	HB	1	BLOW	Sunny	1
2022-09-12 8:38	48.532	-124.872	HB	2	BLOW SURFACE	Sunny	1
2022-09-12 8:39	48.528	-124.874	HB	1	BREACH	Sunny	1
2022-09-12 8:41	48.525	-124.876	HB	1	BLOW	Sunny	1
2022-09-12 8:45	48.513	-124.882	HP	1	FAST-SURFACE	Sunny	1
2022-09-12 8:46	48.511	-124.884	HP	1	FAST-SURFACE	Sunny	1
2022-09-12 8:58	48.515	-124.914	UP	1	FAST-SURFACE	No Data	No Data
2022-09-12 9:08	48.542	-124.898	UW	3	BLOW	No Data	No Data
2022-09-12 9:12	48.555	-124.891	UW	1	FAST-SURFACE	PCPS	0
2022-09-15 7:58	48.628	-124.935	HB	2	SURFACE	PCPS	0
2022-09-15 8:02	48.618	-124.941	HB	1	SURFACE	PCPS	0
2022-09-15 8:08	48.605	-124.948	HB	1	BLOW	PCPS	0
2022-09-15 8:09	48.604	-124.949	HB	1	BLOW	PCPS	0
2022-09-15 8:10	48.601	-124.951	HB	2	SURFACE	PCPS	0
2022-09-15 10:48	48.534	-124.837	HB	4	No Data	No Data	No Data
2022-09-15 10:49	48.533	-124.839	HB	2	SURFACE	No Data	No Data
2022-09-15 10:49	48.532	-124.839	HB	2	FLUKE SURFACE	No Data	No Data
2022-09-15 10:53	48.527	-124.841	HB	2	BLOW SURFACE	Sunny	0
2022-09-15 10:54	48.525	-124.843	HB	2	BLOW SURFACE	No Data	No Data
2022-09-15 10:57	48.521	-124.845	HB	1	BLOW SURFACE	No Data	No Data

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-15 11:28	48.510	-124.821	HB	1	BLOW SURFACE	Sunny	1
2022-09-15 11:30	48.514	-124.818	HB	2	BLOW SURFACE	Sunny	1
2022-09-15 11:31	48.518	-124.816	HB	2	FLUKE BLOW	Sunny	1
2022-09-15 11:33	48.520	-124.814	HB	4	BLOW FLUKE	Sunny	1
2022-09-15 11:35	48.527	-124.810	SRKW	3	BLOW FLUKE	Sunny	1
2022-09-15 11:38	48.531	-124.808	SRKW	1	BLOW SURFACE	Sunny	1
2022-09-15 12:41	48.538	-124.773	KW	2	SURFACE	Sunny	1
2022-09-15 12:42	48.537	-124.774	KW	1	BLOW SURFACE	Sunny	1
2022-09-15 12:52	48.525	-124.780	KW	1	SURFACE	Sunny	1
2022-09-15 12:57	48.515	-124.785	UW	1	BLOW	Sunny	1
2022-09-16 11:52	48.582	-124.702	GW	1	BLOW	Sunny	2
2022-09-16 14:51	48.528	-124.568	HB	2	BLOW	Sunny	2
2022-09-17 8:17	48.494	-124.458	SRKW	8	BLOW SURFACE	No Data	2
2022-09-17 8:50	48.503	-124.563	HB	1	BLOW	Sunny	2
2022-09-17 9:24	48.493	-124.534	UW	1	BLOW	Sunny	2
2022-09-17 10:16	48.479	-124.479	HB	1	BLOW SURFACE	Sunny	2
2022-09-17 11:38	48.430	-124.299	HB	1	BLOW FLUKE	Sunny	0
2022-09-17 12:25	48.410	-124.206	HB	10	BLOW FLUKE	Sunny	1
2022-09-17 12:28	48.416	-124.202	HB	2	BLOW	Sunny	1
2022-09-17 12:45	48.464	-124.242	UP	16	FAST-SURFACE	Sunny	1
2022-09-17 12:47	48.457	-124.246	HB	7	BLOW	Sunny	0
2022-09-17 12:47	48.454	-124.247	HB	2	BLOW	Sunny	1
2022-09-17 12:48	48.452	-124.248	HB	5	BREACH BLOW	Sunny	1
2022-09-17 12:50	48.448	-124.250	HB	2	BLOW SURFACE	Sunny	1
2022-09-17 12:50	48.445	-124.251	HB	2	BLOW	Sunny	1
2022-09-17 12:54	48.434	-124.256	HB	2	BLOW SURFACE	Sunny	1
2022-09-17 13:05	48.441	-124.317	HB	1	BLOW	PCPS	2
2022-09-17 13:28	48.500	-124.349	HB	1	BLOW SURFACE	Sunny	0
2022-09-17 13:31	48.492	-124.353	HB	1	BLOW	Sunny	1
2022-09-17 13:33	48.487	-124.356	HB	2	SURFACE BLOW	Sunny	1
2022-09-17 13:35	48.482	-124.359	HB	1	BLOW	Sunny	1
2022-09-18 8:17	48.412	-124.138	HB	5	BLOW SURFACE	Sunny	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-18 8:19	48.407	-124.141	HB	8	BLOW SURFACE	Sunny	1
2022-09-18 8:21	48.402	-124.144	HB	1	BLOW SURFACE	Sunny	1
2022-09-18 8:21	48.401	-124.146	HB	3	BLOW SURFACE	Sunny	1
2022-09-18 8:22	48.398	-124.147	HB	1	BLOW	Sunny	1
2022-09-18 8:23	48.396	-124.148	HB	2	BOW SURFACE	Sunny	1
2022-09-18 8:34	48.375	-124.094	HB	1	BLOW	Sunny	0
2022-09-18 8:35	48.376	-124.094	HB	3	SURFACE	Sunny	1
2022-09-18 8:35	48.377	-124.093	HB	2	BLOW	Sunny	1
2022-09-18 8:35	48.378	-124.092	HB	2	FLUKE	Sunny	0
2022-09-18 8:36	48.379	-124.092	HB	6	BLOW	Sunny	1
2022-09-18 8:38	48.387	-124.087	HB	1	BLOW	Sunny	1
2022-09-18 9:03	48.402	-124.015	DP	4	FAST-SURFACE	No Data	No Data
2022-09-18 9:09	48.384	-124.025	HB	1	No Data	No Data	No Data
2022-09-18 9:10	48.381	-124.027	HB	4	No Data	No Data	No Data
2022-09-18 9:13	48.371	-124.033	HB	4	BLOW	Sunny	1
2022-09-18 9:15	48.365	-124.036	HB	3	BLOW	No Data	No Data
2022-09-18 9:25	48.343	-123.983	HB	6	BLOW	Sunny	1
2022-09-18 9:27	48.348	-123.980	HB	2	BLOW	No Data	No Data
2022-09-18 9:27	48.350	-123.979	HB	4	BLOW	Sunny	1
2022-09-18 9:28	48.354	-123.976	HB	1	BLOW	Sunny	1
2022-09-18 9:31	48.363	-123.971	HB	2	SURFACE	Sunny	1
2022-09-18 9:32	48.365	-123.970	HB	1	SURFACE	Sunny	1
2022-09-18 11:48	48.381	-124.133	HB	1	BLOW	Sunny	1
2022-09-18 11:49	48.383	-124.132	HB	2	BLOW	Sunny	1
2022-09-19 7:51	48.522	-124.571	HB	2	BLOW	Sunny	3
2022-09-19 8:20	48.521	-124.537	HB	1	BREACH BLOW	Sunny	2
2022-09-19 10:33	48.407	-124.312	HB	3	BLOW	Sunny	0
2022-09-19 10:48	48.412	-124.245	HB	4	BLOW	Sunny	1
2022-09-19 10:50	48.406	-124.249	HB	2	BLOW	Sunny	1
2022-09-19 10:52	48.402	-124.251	HB	2	BLOW	Sunny	1
2022-09-19 10:53	48.398	-124.254	HB	1	BLOW	Sunny	1
2022-09-19 10:55	48.394	-124.256	HB	2	BLOW	Sunny	1
2022-09-19 11:01	48.379	-124.265	HB	3	BLOW	Rain	0
2022-09-19 11:03	48.374	-124.268	HB	3	BLOW	Sunny	0
2022-09-19 11:21	48.385	-124.196	HB	2	BLOW	Sunny	1
2022-09-19 11:32	48.392	-124.150	HB	3	BLOW	Sunny	1
2022-09-19 11:33	48.393	-124.149	HB	2	BLOW	Sunny	1
2022-09-19 11:34	48.397	-124.147	HB	1	BLOW	Sunny	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-19 11:34	48.398	-124.147	HB	2	BLOW SURFACE	Sunny	1
2022-09-19 11:35	48.400	-124.145	HB	1	FLUKE	No Data	No Data
2022-09-19 11:35	48.401	-124.144	HB	5	BLOW	No Data	No Data
2022-09-19 11:36	48.403	-124.144	HB	1	FLUKE BLOW	Sunny	1
2022-09-19 11:44	48.405	-124.142	HB	3	BLOW	Sunny	1
2022-09-19 11:47	48.413	-124.138	HB	2	BREACH SURFACE	Sunny	1
2022-09-19 12:40	48.498	-124.414	HB	1	BLOW SURFACE	Sunny	2
2022-09-19 13:15	48.476	-124.480	KW	1	SURFACE	Sunny	2
2022-09-19 13:36	48.510	-124.482	HB	1	BLOW	Sunny	3
2022-09-20 11:38	48.583	-124.960	HB	1	BLOW	Sunny	2
2022-09-20 13:07	48.602	-124.853	HB	1	BLOW	Sunny	2
2022-09-20 13:27	48.582	-124.831	HB	15	BLOW	Sunny	2
2022-09-20 13:31	48.571	-124.838	HB	4	BLOW	Sunny	2
2022-09-20 13:35	48.562	-124.843	HB	1	BLOW	No Data	2
2022-09-21 8:28	48.513	-124.916	HB	6	BLOW	Sunny	2
2022-09-21 8:29	48.516	-124.914	HB	2	BLOW	Sunny	2
2022-09-21 8:31	48.520	-124.912	HB	2	BLOW	Sunny	2
2022-09-21 8:34	48.528	-124.908	HB	3	BLOW	Sunny	2
2022-09-21 8:38	48.538	-124.902	HB	3	BLOW	Sunny	2
2022-09-21 9:01	48.542	-124.866	HB	1	BLOW	Sunny	2
2022-09-21 9:05	48.533	-124.871	HB	1	BLOW SURFACE	Sunny	2
2022-09-21 9:06	48.531	-124.872	HB	3	BLOW	Sunny	2
2022-09-21 9:11	48.518	-124.879	HB	1	BLOW	Sunny	2
2022-09-21 9:15	48.509	-124.886	HB	7	BLOW	Sunny	2
2022-09-21 9:16	48.507	-124.888	HB	2	BLOW	Sunny	2
2022-09-21 9:31	48.505	-124.854	HB	2	FLUKE BLOW	No Data	No Data
2022-09-21 9:32	48.507	-124.854	HB	2	FLUKE BLOW	No Data	2
2022-09-21 9:51	48.550	-124.828	HB	1	BLOW	Sunny	1
2022-09-21 10:19	48.522	-124.812	HB	3	BLOW	Sunny	3
2022-09-21 13:10	48.502	-124.596	KW	8	BLOW SURFACE	Sunny	2
2022-09-21 13:21	48.502	-124.564	KW	2	FEEDING SLOW-ROLLING	Sunny	1
2022-09-21 13:23	48.497	-124.567	KW	2	BLOW MILLING	No Data	No Data
2022-09-21 13:25	48.494	-124.569	KW	1	SURFACE	Sunny	1
2022-09-21 13:28	48.489	-124.572	KW	2	SURFACE	Sunny	1
2022-09-21 13:36	48.487	-124.573	KW	1	SURFACE	Sunny	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-22 7:35	48.476	-124.427	HB	1	BLOW	Overcast	1
2022-09-22 7:38	48.484	-124.422	HB	3	BLOW FLUKE	Overcast	1
2022-09-22 7:40	48.488	-124.420	HB	1	BLOW SURFACE	Overcast	0
2022-09-22 7:41	48.490	-124.419	HB	1	BLOW SURFACE	Overcast	0
2022-09-22 7:42	48.491	-124.418	HB	3	BLOW SURFACE	Overcast	0
2022-09-22 8:09	48.488	-124.355	HB	2	BLOW SWIM	Overcast	1
2022-09-22 8:10	48.485	-124.357	HB	2	BLOW SWIM	No Data	No Data
2022-09-22 8:11	48.483	-124.358	HB	1	SWIM BLOW	Overcast	1
2022-09-22 8:13	48.478	-124.360	HB	3	SURFACE FLUKE	Overcast	1
2022-09-22 8:15	48.471	-124.364	HB	3	BLOW FLUKE	Overcast	1
2022-09-22 8:29	48.439	-124.318	HB	3	BLOW SURFACE	Overcast	2
2022-09-22 8:30	48.441	-124.317	HB	4	BLOW SWIM	Overcast	2
2022-09-22 8:31	48.441	-124.317	HB	2	BLOW SWIM	Overcast	2
2022-09-22 8:32	48.442	-124.316	HB	3	BLOW	Overcast	2
2022-09-22 8:33	48.443	-124.316	HB	2	BLOW	Overcast	2
2022-09-22 8:33	48.445	-124.315	HB	2	BLOW	Overcast	2
2022-09-22 8:34	48.446	-124.314	HB	1	BLOW SURFACE	Overcast	2
2022-09-22 8:35	48.448	-124.313	HB	2	BLOW FLUKE	Overcast	2
2022-09-22 8:36	48.449	-124.313	HB	2	BLOW FLUKE	Overcast	2
2022-09-22 8:36	48.450	-124.312	HB	1	BLOW	PCPS	2
2022-09-22 9:10	48.474	-124.269	HB	3	BLOW	PCPS	2
2022-09-22 9:14	48.449	-124.249	HB	1	BLOW	PCPS	2
2022-09-22 9:14	48.447	-124.250	HB	9	BLOW SURFACE	PCPS	3
2022-09-22 9:16	48.442	-124.253	HB	1	BLOW	PCPS	3
2022-09-22 9:19	48.436	-124.256	HB	1	BLOW FLUKE	PCPS	2
2022-09-22 9:21	48.431	-124.258	HB	1	FLUKE	No Data	No Data
2022-09-22 9:21	48.430	-124.259	HB	2	BLOW SURFACE	PCPS	2
2022-09-22 9:22	48.429	-124.260	HB	5	BLOW FLUKE	PCPS	2
2022-09-22 9:22	48.427	-124.261	HB	5	BLOW SURFACE	PCPS	2
2022-09-22 9:24	48.423	-124.263	HB	3	BLOW FLUKE	PCPS	3
2022-09-22 9:35	48.407	-124.207	HB	2	BLOW FLUKE	PCPS	No Data
2022-09-22 9:35	48.408	-124.207	HB	4	BLOW	No Data	No Data
2022-09-22 9:35	48.408	-124.207	HB	4	BLOW FLUKE	PCPS	No Data

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-22 9:36	48.410	-124.206	HB	2	BLOW FLUKE	No Data	No Data
2022-09-22 9:37	48.411	-124.205	HB	10	BLOW FLUKE	PCPS	No Data
2022-09-22 9:37	48.411	-124.204	HB	1	BLOW FLUKE	PCPS	No Data
2022-09-22 9:38	48.413	-124.204	HB	1	FLUKE	No Data	No Data
2022-09-22 9:43	48.424	-124.198	HB	1	BLOW SWIM	PCPS	3
2022-09-23 7:50	48.392	-124.150	HB	3	BLOW FLUKE	Overcast	1
2022-09-23 7:51	48.394	-124.149	HB	2	BLOW	Overcast	1
2022-09-23 7:52	48.396	-124.147	HB	3	BLOW	Overcast	1
2022-09-23 7:53	48.399	-124.146	HB	3	SURFACE BLOW SURFACE	Overcast	1
2022-09-23 7:56	48.410	-124.140	HB	1	FLUKE	Overcast	1
2022-09-23 8:14	48.419	-124.071	HP	50	FAST-SURFACE	Overcast	0
2022-09-23 10:31	48.356	-124.083	HB	1	BLOW	PCPS	1
2022-09-23 10:51	48.352	-124.150	HB	1	BLOW	Overcast	1
2022-09-23 10:57	48.372	-124.138	HB	1	BREACH BLOW	Overcast	1
2022-09-23 10:59	48.378	-124.135	HB	1	BLOW	Overcast	1
2022-09-23 11:00	48.383	-124.131	HB	1	BLOW	Overcast	1
2022-09-23 11:00	48.384	-124.131	HB	1	BLOW	Overcast	1
2022-09-23 11:10	48.396	-124.190	HB	1	BLOW FLUKE	Fog	1
2022-09-23 11:38	48.399	-124.251	HB	1	SURFACE	Fog	0
2022-09-23 11:40	48.401	-124.250	HB	2	FLUKE	Fog	1
2022-09-23 11:41	48.403	-124.249	HB	2	SURFACE BLOW SURFACE	Fog	0
2022-09-23 11:42	48.404	-124.248	HB	1	BLOW	Fog	0
2022-09-23 11:43	48.405	-124.248	HB	1	BLOW	Fog	0
2022-09-23 11:43	48.406	-124.247	HB	3	SURFACE FLUKE SURFACE	Fog	0
2022-09-23 11:45	48.408	-124.246	HB	1	SURFACE	Fog	0
2022-09-23 11:46	48.410	-124.245	HB	5	BLOW	No Data	No Data
2022-09-23 11:29	48.413	-124.245	HB	4	SURFACE BLOW SURFACE	Overcast	0
2022-09-23 12:23	48.408	-124.378	HB	3	BLOW	Fog	2
2022-09-23 12:26	48.417	-124.373	HB	2	BLOW	Fog	2
2022-09-23 12:27	48.418	-124.372	HB	1	BREACH	Fog	2
2022-09-23 12:28	48.420	-124.371	HB	6	BLOW	Fog	2
2022-09-23 12:29	48.424	-124.368	HB	2	BLOW MILLING	Fog	2
2022-09-23 12:31	48.429	-124.365	HB	3	BLOW	Fog	2
2022-09-23 12:32	48.432	-124.364	HB	4	BLOW BREACH	Overcast	2

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-09-23 12:40	48.452	-124.351	HB	2	BREACH FLUKE	Overcast	2
2022-09-23 12:57	48.464	-124.410	HB	1	BLOW	Fog	1
2022-09-23 12:57	48.463	-124.411	HB	2	BLOW	Fog	1
2022-09-23 13:02	48.449	-124.420	HB	3	SURFACE BLOW SURFACE	Fog	1
2022-09-26 8:01	48.583	-124.767	HB	1	BREACH	PCPS	2
2022-09-29 12:46	48.534	-124.598	HB	1	FLUKE	Fog	2
2022-10-01 9:24	48.321	-124.038	HB	1	BLOW	Sunny	2
2022-10-01 9:26	48.315	-124.041	HB	2	SURFACE BLOW	Sunny	2
2022-10-01 10:03	48.360	-124.145	HB	1	BLOW	Sunny	2
2022-10-01 10:09	48.342	-124.155	HB	1	BLOW	Sunny	2
2022-10-01 10:25	48.388	-124.193	HB	1	SURFACE	Sunny	2
2022-10-01 10:27	48.395	-124.189	HB	1	BLOW RESTING	Sunny	2
2022-10-01 10:54	48.434	-124.191	HB	2	BLOW	Sunny	2
2022-10-01 11:14	48.441	-124.253	HB	1	BLOW	Sunny	2
2022-10-01 11:26	48.411	-124.246	HB	1	BLOW	Sunny	2
2022-10-01 11:27	48.408	-124.248	HB	1	SURFACE BLOW SURFACE	Sunny	2
2022-10-01 11:27	48.406	-124.249	HB	1	BLOW	Sunny	2
2022-10-01 11:29	48.400	-124.253	HB	5	BLOW	Sunny	2
2022-10-01 11:31	48.394	-124.257	HB	1	BLOW	Sunny	2
2022-10-01 11:32	48.390	-124.259	HB	3	BLOW FLUKE	Sunny	2
2022-10-01 11:36	48.381	-124.265	HB	1	BLOW	Sunny	2
2022-10-01 11:54	48.411	-124.310	HB	1	SURFACE BLOW FLUKE	Sunny	1
2022-10-01 12:43	48.497	-124.350	HB	3	BLOW	Sunny	2
2022-10-01 12:44	48.492	-124.352	HB	1	BLOW	Sunny	2
2022-10-01 12:45	48.490	-124.353	HB	1	BLOW FLUKE	Sunny	2
2022-10-01 12:48	48.481	-124.359	HB	1	BLOW	Sunny	2
2022-10-01 12:51	48.473	-124.364	HB	3	BLOW	Sunny	2
2022-10-01 12:53	48.468	-124.367	HB	1	BLOW	Sunny	2
2022-10-01 12:54	48.464	-124.370	HB	2	BLOW	Sunny	2
2022-10-01 12:56	48.459	-124.372	HB	3	BLOW	Sunny	2
2022-10-02 11:05	48.429	-124.300	HB	2	SURFACE BLOW	No Data	No Data
2022-10-02 11:07	48.424	-124.303	HB	2	BLOW	Sunny	1
2022-10-02 12:16	48.477	-124.480	HB	2	BLOW	Sunny	2
2022-10-02 12:25	48.456	-124.492	HB	3	BLOW FLUKE	Sunny	2
2022-10-02 12:57	48.490	-124.505	HB	2	BLOW	Sunny	2

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-10-02 13:05	48.492	-124.537	HB	1	BLOW	No Data	No Data
2022-10-02 13:53	48.510	-124.546	HB	1	BLOW	Sunny	2
2022-10-02 13:55	48.517	-124.541	HB	1	BLOW	Sunny	2
2022-10-02 13:58	48.524	-124.536	HB	2	BLOW SURFACE	Sunny	2
2022-10-02 14:13	48.540	-124.488	HB	2	BLOW	No Data	No Data
2022-10-02 14:14	48.538	-124.490	HB	4	BLOW	Sunny	2
2022-10-02 14:16	48.535	-124.492	HB	3	BLOW SURFACE	No Data	No Data
2022-10-02 14:19	48.528	-124.497	HB	2	BLOW	No Data	No Data
2022-10-02 14:22	48.520	-124.504	HB	2	BLOW	Sunny	2
2022-10-02 14:31	48.499	-124.521	HB	1	BLOW	No Data	No Data
2022-10-02 14:48	48.501	-124.487	HB	1	BLOW	Sunny	2
2022-10-02 14:51	48.511	-124.482	HB	1	FLUKE	Sunny	2
2022-10-02 14:51	48.512	-124.481	HB	2	BOW	Sunny	2
2022-10-04 7:34	48.502	-124.564	HB	1	FLUKE	Overcast	2
2022-10-04 7:46	48.477	-124.578	HB	1	FLUKE SURFACE	Overcast	2
2022-10-04 7:48	48.474	-124.580	HB	1	SURFACE BLOW	Overcast	2
2022-10-04 8:17	48.502	-124.596	HB	2	FLUKE BLOW	Overcast	2
2022-10-04 8:19	48.507	-124.593	HB	1	FLUKE	Overcast	2
2022-10-04 8:20	48.510	-124.592	HB	4	BLOW	Overcast	2
2022-10-04 9:01	48.513	-124.655	HB	1	BLOW SURFACE	Overcast	2
2022-10-04 9:03	48.519	-124.651	HB	6	BLOW SURFACE	Overcast	2
2022-10-04 10:43	48.538	-124.802	HB	2	BREACH BLOW	Overcast	0
2022-10-04 10:45	48.534	-124.805	SRKW	5	TRAVEL SURFACE	Overcast	0
2022-10-04 10:47	48.529	-124.807	HB	1	BREACH BLOW	Overcast	0
2022-10-04 10:50	48.522	-124.811	HB	1	FLUKE	Overcast	0
2022-10-04 10:51	48.520	-124.813	HB	1	BREACH BLOW	Overcast	0
2022-10-04 10:52	48.516	-124.815	HB	4	BREACH FLUKE	Overcast	0
2022-10-04 10:54	48.512	-124.818	HB	5	BLOW SURFACE	Overcast	0
2022-10-04 13:14	48.556	-124.858	HB	2	BLOW FLUKE	Overcast	0
2022-10-04 13:14	48.554	-124.859	HB	4	BLOW	Overcast	0
2022-10-04 13:18	48.547	-124.863	HB	2	BREACH	Overcast	0
2022-10-04 13:24	48.533	-124.872	HB	1	BLOW SURFACE	Overcast	0
2022-10-04 13:28	48.523	-124.877	HB	1	BLOW	Overcast	0

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-10-04 13:29	48.522	-124.877	HB	1	BLOW FLUKE	Overcast	0
2022-10-04 13:30	48.520	-124.878	HB	3	BREACH	Overcast	0
2022-10-04 13:56	48.533	-124.905	HB	2	BLOW FLUKE	Overcast	0
2022-10-05 8:22	48.535	-124.935	HB	2	BLOW	PCPS	0
2022-10-05 8:25	48.525	-124.941	HB	2	SWIM BLOW	PCPS	0
2022-10-05 8:26	48.523	-124.942	HB	1	BLOW FLUKE	PCPS	1
2022-10-05 8:28	48.518	-124.945	HB	1	BLOW SWIM	PCPS	0
2022-10-05 8:29	48.515	-124.946	HB	1	BREACH	PCPS	0
2022-10-05 8:41	48.504	-124.985	HB	1	BREACH	PCPS	1
2022-10-05 9:15	48.564	-124.982	HB	1	BLOW SWIM	Sunny	1
2022-10-05 10:13	48.577	-125.041	HB	2	BLOW SURFACE	PCPS	1
2022-10-06 7:55	48.503	-124.412	HB	6	BLOW SWIM	Sunny	0
2022-10-06 7:56	48.499	-124.415	HB	1	BLOW SWIM	No Data	No Data
2022-10-06 7:57	48.497	-124.416	HB	3	BLOW	Sunny	0
2022-10-06 7:58	48.494	-124.417	HB	1	FLUKE	No Data	No Data
2022-10-06 7:58	48.493	-124.418	HB	3	BREACH BLOW	Sunny	0
2022-10-06 8:00	48.492	-124.419	HB	3	BLOW FLUKE	No Data	No Data
2022-10-06 8:00	48.492	-124.420	HB	2	BLOW	No Data	No Data
2022-10-06 8:00	48.492	-124.420	HB	1	BLOW	Sunny	0
2022-10-06 8:01	48.492	-124.420	HB	3	BLOW	Sunny	0
2022-10-06 8:05	48.488	-124.422	HB	2	BLOW RESTING	Sunny	No Data
2022-10-06 8:05	48.486	-124.423	HB	1	BREACH	No Data	No Data
2022-10-06 8:06	48.485	-124.424	HB	3	BLOW	Sunny	0
2022-10-06 8:07	48.482	-124.425	HB	1	BREACH	Sunny	0
2022-10-06 8:08	48.479	-124.425	HB	3	FLUKE BLOW	Sunny	0
2022-10-06 8:10	48.472	-124.429	HB	1	BLOW FLUKE	Sunny	0
2022-10-06 8:19	48.459	-124.371	HB	6	BLOW	Sunny	0
2022-10-06 8:20	48.461	-124.370	HB	6	BLOW	Sunny	0
2022-10-06 8:22	48.466	-124.367	HB	1	BLOW SURFACE	Sunny	0
2022-10-06 8:23	48.469	-124.365	HB	1	BLOW SURFACE	Sunny	0
2022-10-06 8:57	48.454	-124.310	HB	2	BLOW SWIM	No Data	No Data
2022-10-06 10:05	48.404	-124.143	TKW	1	No Data	No Data	No Data
2022-10-06 10:45	48.395	-124.018	UP	1	SURFACE	Sunny	0
2022-10-07 7:48	48.444	-124.422	HB	1	SURFACE	Sunny	2
2022-10-07 7:55	48.463	-124.410	HB	1	BLOW	Sunny	0
2022-10-07 8:03	48.452	-124.351	HB	1	SURFACE	No Data	No Data
2022-10-07 8:03	48.451	-124.353	HB	1	BLOW SURFACE	No Data	No Data

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-10-07 8:04	48.450	-124.354	HB	2	SURFACE BLOW	PCPS	No Data
2022-10-07 8:44	48.427	-124.301	HB	2	BLOW SWIM	PCPS	2
2022-10-08 8:06	48.522	-124.604	HB	2	BLOW FLUKE	Fog	1
2022-10-08 8:11	48.537	-124.596	HB	1	BLOW	Sunny	0
2022-10-08 8:32	48.532	-124.566	HB	1	BREACH FLUKE	Sunny	0
2022-10-08 8:45	48.503	-124.552	HB	1	RESTING FLUKE	Sunny	1
2022-10-08 8:49	48.509	-124.547	HB	1	BLOW	No Data	0
2022-10-08 9:12	48.530	-124.496	HB	1	BREACH BLOW	Sunny	1
2022-10-08 9:18	48.514	-124.508	HB	1	BREACH	Sunny	1
2022-10-08 10:25	48.505	-124.659	HB	2	BLOW FLUKE	No Data	0
2022-10-08 10:30	48.491	-124.667	HB	3	BLOW	Sunny	1
2022-10-08 10:49	48.494	-124.633	HB	1	BREACH	Sunny	1
2022-10-08 11:02	48.508	-124.593	HB	1	BLOW SWIM	Sunny	0
2022-10-08 11:07	48.493	-124.601	HB	1	BLOW SWIM	Sunny	1
2022-10-08 11:14	48.476	-124.611	HB	1	BLOW	Sunny	0
2022-10-08 11:23	48.456	-124.590	HB	1	BLOW FLUKE	No Data	No Data
2022-10-08 11:24	48.459	-124.588	HB	2	BLOW	Sunny	2
2022-10-08 11:30	48.474	-124.579	HB	1	BLOW	Sunny	2
2022-10-08 12:53	48.446	-124.499	HB	1	BLOW	Sunny	2
2022-10-08 13:16	48.492	-124.417	HB	1	FLUKE BLOW	Sunny	1
2022-10-08 13:43	48.486	-124.463	HB	2	BLOW	Sunny	0
2022-10-08 13:45	48.478	-124.467	HB	2	BLOW	Sunny	1
2022-10-09 8:42	48.565	-124.712	HP	1	BLOW	No Data	No Data
2022-10-09 11:08	48.437	-124.255	HP	2	SLOW-ROLLING SURFACE	Sunny	0
2022-10-09 11:11	48.428	-124.260	HB	1	SURFACE	Sunny	0
2022-10-09 11:13	48.423	-124.263	HB	2	FLUKE BLOW	Sunny	0
2022-10-09 11:51	48.501	-124.347	HP	1	FAST-SURFACE	Sunny	0
2022-10-09 11:56	48.490	-124.354	SRKW	2	BLOW BREACH	Sunny	0
2022-10-09 12:01	48.475	-124.362	HB	1	BLOW	Sunny	0
2022-10-09 12:03	48.469	-124.366	HB	1	BLOW	Sunny	0
2022-10-09 12:04	48.465	-124.368	HB	2	BLOW SURFACE	Sunny	0
2022-10-09 12:22	48.487	-124.420	HB	1	FLUKE	No Data	No Data
2022-10-11 8:16	48.295	-123.987	HB	1	SURFACE BLOW	Sunny	2
2022-10-11 9:40	48.383	-124.132	HB	1	FLUKE	Sunny	1
2022-10-11 9:41	48.381	-124.132	HB	3	BOW	Sunny	0
2022-10-11 9:45	48.373	-124.137	HB	1	SURFACE BLOW	Sunny	0

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-10-11 12:04	48.426	-124.368	HB	1	BLOW	Sunny	1
2022-10-11 12:40	48.458	-124.459	HB	1	BLOW SURFACE	Sunny	1
2022-10-11 12:42	48.454	-124.462	HB	1	BLOW	Sunny	1
2022-10-11 12:47	48.442	-124.469	HB	1	BLOW	Sunny	1
2022-10-12 8:25	48.387	-123.957	HB	3	SURFACE	Sunny	1
2022-10-12 8:37	48.351	-123.979	HB	1	BLOW	Sunny	3
2022-10-12 8:38	48.347	-123.982	HB	1	BREACH	Sunny	4
2022-10-12 9:11	48.418	-124.072	HP	2	SURFACE	Sunny	1
2022-10-12 9:12	48.414	-124.072	HB	2	BLOW	Sunny	1
2022-10-12 10:22	48.423	-124.263	HB	1	BLOW	No Data	2
2022-10-12 10:59	48.449	-124.312	HB	1	BREACH	Sunny	3
2022-10-12 11:00	48.445	-124.315	KW	2	SURFACE	Sunny	3
2022-10-12 11:49	48.471	-124.431	HB	1	SURFACE	Sunny	2
2022-10-13 11:23	48.560	-124.856	HB	1	BLOW	Sunny	2
2022-10-13 11:26	48.556	-124.858	HB	4	BLOW BREACH	Sunny	2
2022-10-13 11:27	48.554	-124.859	HB	2	BLOW	Sunny	2
2022-10-13 11:28	48.552	-124.860	HB	6	BLOW BREACH	Sunny	2
2022-10-13 11:30	48.549	-124.862	HB	2	BLOW	Sunny	2
2022-10-13 11:31	48.545	-124.865	HB	4	BLOW FLUKE	Sunny	2
2022-10-13 11:35	48.538	-124.868	HB	1	BLOW SURFACE	Sunny	2
2022-10-13 11:36	48.535	-124.870	HB	2	BLOW FLUKE	Sunny	2
2022-10-13 11:43	48.522	-124.877	HB	3	FLUKE BLOW	Sunny	2
2022-10-13 11:58	48.507	-124.855	HB	3	BLOW	No Data	No Data
2022-10-13 11:59	48.509	-124.853	HB	3	BLOW FLUKE	No Data	No Data
2022-10-13 11:59	48.510	-124.853	HB	2	BLOW FLUKE	No Data	No Data
2022-10-13 12:00	48.511	-124.853	HB	1	BLOW FLUKE	Sunny	2
2022-10-13 12:04	48.518	-124.848	HB	6	BLOW	Sunny	3
2022-10-13 12:05	48.520	-124.848	HB	2	BLOW FLUKE	Sunny	3
2022-10-14 10:11	48.479	-124.543	HB	1	FLUK BLOW	Sunny	2
2022-10-14 10:39	48.536	-124.598	HB	1	BLOW	Fog	2
2022-10-14 13:39	48.568	-124.806	SRKW	3	BLOW SURFACE	Sunny	2
2022-10-14 13:43	48.562	-124.809	SRKW	2	BLOW	PCPS	2
2022-10-14 13:46	48.558	-124.812	SRKW	3	BLOW SURFACE	Sunny	2
2022-10-14 13:47	48.558	-124.812	SRKW	1	BLOW	No Data	No Data
2022-10-14 13:53	48.556	-124.813	SRKW	4	BLOW SURFACE	No Data	No Data
2022-10-17 12:52	48.509	-124.689	SRKW	8	SURFACE	Overcast	0
2022-10-17 13:01	48.509	-124.691	SRKW	2	SWIM	No Data	No Data

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2022-10-17 13:25	48.496	-124.660	SRKW	5	TRAVEL	No Data	No Data
2022-10-29 9:06	48.427	-124.367	HB	2	BLOW SURFACE	Overcast	No Data
2022-10-29 10:08	48.478	-124.468	HB	1	SURFACE	Overcast	2
2022-10-29 11:33	48.504	-124.486	HB	1	SURFACE FLUKE	Overcast	2

DP – Dall's porpoise
GW – Grey whale
HP – Harbour porpoise
HB – Humpback whale
KW – Killer whale (ecotype unknown)
SRKW– Killer whale (southern resident killer whale)
TKW– Killer whale (transient killer whale)
UP – Unidentified porpoise
PCPS – Partly cloudy partly sunny

Appendix C: 2022 Opportunistic Cetacean Sightings Data.

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-06-24	941	48.504	-125.000	HB	3	Surfacing and Blowing	PCPS	1
2022-06-24	941	48.504	-125.000	KW	3	Surfacing and Blowing	Sunny	1
2022-06-24	945	48.504	-125.000	HB	9	Blowing and Fluking	Sunny	1
2022-06-24	1140	48.505	-124.871	HB	1	Surfacing, Blowing, Breaching	Sunny	No Data
2022-06-25	744	48.599	-124.735	HB	2	Blowing and Fluking	Sunny	1
2022-06-25	801	48.615	-124.812	KW	2	Surfacing	Sunny	1
2022-06-25	840	48.585	-124.978	UP	3	No Data	Sunny	1
2022-06-29	721	48.523	-124.450	HP	3	Fast Surfacing	PCPS	0
2022-06-29	740	48.451	-124.269	HP	3	Fast Surfacing	PCPS	0
2022-06-29	755	48.394	-124.120	SRKW	16	Surfacing and Blowing	PCPS	0
2022-06-29	924	48.350	-124.020	HP	7	Fast Surfacing	PCPS	0
2022-06-29	941	48.176	-124.080	HP	1	Fast Surfacing	PCPS	1
2022-06-29	943	48.322	-124.091	HP	1	Fast Surfacing	PCPS	1
2022-06-29	1044	48.414	-124.248	HP	7	Fast Surfacing	PCPS	1
2022-06-29	1056	48.405	-124.314	HB	1	Surfacing and Blowing	PCPS	0
2022-07-07	1151	48.512	-125.026	HB	8	Breaching and Blowing	PCPS	1
2022-07-07	1243	48.413	-124.996	HB	3	Blowing	PCPS	1
2022-07-07	1358	48.506	-124.900	HB	15	Fluking and Breaching	PCPS	1
2022-07-07	1443	48.505	-124.854	HB	1	Blowing	PCPS	1
2022-07-07	1445	48.504	-124.842	HB	3	Blowing and Slow Rolls	PCPS	1
2022-07-07	1510	48.538	-124.765	HB	4	Blowing	PCPS	1
2022-07-07	1530	48.503	-124.773	HB	1	Blowing	PCPS	1
2022-07-09	932	48.454	-124.327	HP	1	Fast Surfacing	Overcast	0
2022-07-09	937	48.376	-124.317	HP	2	Fast Surfacing	Overcast	0
2022-07-09	1201	48.347	-123.995	HP	1	Fast Surfacing	Overcast	1
2022-07-11	928	48.541	-124.495	HP	3	Fast Surfacing	Sunny	2
2022-07-11	930	48.545	-124.519	HP	1	Fast Surfacing	Sunny	2
2022-07-11	937	48.554	-124.564	HP	3	Fast Surfacing	Sunny	2
2022-07-11	1010	48.611	-124.816	HP	1	Fast Surfacing	Sunny	2
2022-07-11	1024	48.613	-124.939	HB	1	Blowing	Sunny	1
2022-07-11	1040	48.575	-124.973	HP	1	Fast Surfacing	Sunny	1
2022-07-11	1154	48.626	-124.861	HP	2	Fast Surfacing	Sunny	1

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-07-11	1217	48.562	-124.867	HB	3	Blowing and Fast Surfacing	Sunny	1
2022-07-11	1403	48.525	-124.668	HB	1	Breaching	Sunny	3
2022-07-17	927	48.505	-124.868	HB	1	Fast Surfacing	Overcast	1
2022-07-17	947	48.557	-124.825	HB	1	Breaching	Overcast	1
2022-07-17	1003	48.519	-124.815	HB	1	Breaching	Overcast	1
2022-07-17	1226	48.469	-124.633	UP	3	Fast Surfacing	Overcast	2
2022-07-21	1057	48.380	-124.210	HB	3	Breaching	Foggy and Overcast	2
2022-07-21	1114	48.368	-124.251	HB	1	Blowing	Foggy and Overcast	2
2022-07-21	1117	48.371	-124.263	HB	2	Blowing	Foggy and Overcast	2
2022-07-23	925	48.486	-124.489	GW	2	Blowing	Overcast	1
2022-07-23	1050	48.424	-124.274	HB	2	Blowing	Overcast	1
2022-07-23	1110	48.464	-124.240	HP	1	Fast Surfacing	Overcast	1
2022-08-04	836	48.454	-124.210	UP	1	Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	853	48.405	-124.022	HP	1	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	854	48.401	-124.013	HP	1	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	858	48.387	-123.969	HP	3	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	939	48.389	-123.973	HP	1	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	943	48.400	-124.005	HP	1	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	1004	48.364	-124.055	HP	3	Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	1047	48.395	-124.162	HB	4	Fast Surfacing	Foggy, Rainy and Overcast	1

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-08-04	1049	48.400	-124.182	HB	1	Blowing	Foggy, Rainy and Overcast	1
2022-08-04	1052	48.404	-124.204	HB	5	Blowing and Fast Surfacing	Foggy, Rainy and Overcast	1
2022-08-04	1138	48.423	-124.274	HB	3	Blowing and Resting	Foggy, Rainy and Overcast	1
2022-08-04	1139	48.423	-124.276	HB	1	Fluking	Foggy, Rainy and Overcast	1
2022-08-04	1141	48.425	-124.281	HB	4	Fast Surfacing and Fluking	Foggy, Rainy and Overcast	1
2022-08-04	1146	48.433	-124.306	HB	8	Fast Surfacing and Fluking	Foggy, Rainy and Overcast	1
2022-08-04	1148	48.436	-124.314	HB	2	Fast Surfacing and Fluking	Foggy, Rainy and Overcast	1
2022-08-05	1157	48.423	-124.275	HB	4	Fast Surfacing	Sunny and Foggy	0
2022-08-05	1200	48.430	-124.296	HB	6	Fluking, Surfacing and Blowing	Sunny and Foggy	1
2022-08-05	1217	48.389	-124.321	HB	3	Surfacing	Sunny and Foggy	1
2022-08-05	1241	48.454	-124.357	HB	2	Fluking and Surfacing	Sunny and Foggy	1
2022-08-05	1246	48.461	-124.394	HB	1	Surfacing	Sunny and Foggy	1
2022-08-05	1310	48.426	-124.460	HP	1	Surfacing	Sunny and Foggy	1
2022-08-05	1426	48.496	-124.530	HB	1	Fluking	Sunny and Foggy	2

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-08-05	1513	48.512	-124.538	HB	1	Surfacing	Sunny and Foggy	2
2022-08-07	915	48.533	-124.526	HB	1	Breaching	Sunny	2
2022-08-07	920	48.524	-124.521	HB	55	Blowing	Sunny	2
2022-08-07	931	48.541	-124.654	HB	2	Blowing	Sunny	2
2022-08-07	939	48.544	-124.700	HB	1	Blowing	Sunny	2
2022-08-07	1202	48.560	-124.990	HB	2	Breaching and Blowing	Sunny	2
2022-08-07	1352	48.505	-124.880	HB	1	Blowing	Sunny	2
2022-08-07	1354	48.504	-124.874	HB	2	Blowing	Sunny	2
2022-08-07	1355	48.504	-124.868	HB	2	Blowing	Sunny	2
2022-08-07	No Data	48.550	-124.733	HB	2	Fast Surfacing	Sunny	2
2022-08-11	1129	48.577	-124.957	HP	1	Fast Surfacing	Sunny and Foggy	1
2022-08-11	1228	48.638	-124.891	HP	1	Fast Surfacing	Sunny and Foggy	1
2022-08-13	1035	48.564	-124.891	HP	1	Fast Surfacing	Rainy, Cloudy and Foggy	2
2022-08-13	1356	48.624	-124.951	HB	2	Fast Surfacing	Rainy, Cloudy and Foggy	2
2022-08-13	1359	48.633	-124.953	HB	1	Blowing and Fast Surfacing	Rainy, Cloudy and Foggy	1
2022-08-13	1453	48.638	-124.893	HP	2	Fast Surfacing	Rainy, Cloudy and Foggy	1
2022-08-14	914	48.547	-124.558	HP	1	No Data	Sunny	1
2022-08-14	1226	48.444	-124.532	HB	1	Blowing and Breaching	Sunny	1
2022-08-14	1332	48.421	-124.436	HB	1	Surfacing	Sunny	1
2022-08-14	1358	48.421	-124.436	HB	2	Fast Surfacing	Sunny	2
2022-08-14	1417	48.422	-124.435	HB	1	Surfacing	Sunny	2
2022-08-15	1139	48.360	-124.287	HB	1	Fluking	Sunny	2

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-08-15	1157	48.399	-124.177	HB	1	Fluking	Sunny	3
2022-08-15	1236	48.353	-124.995	HB	1	Surfacing	Sunny	3
2022-08-15	No Data	48.492	-124.295	HB	2	Surfacing	Sunny	2
2022-08-16	1016	48.453	-124.349	HB	1	Surfacing	Sunny and Foggy	2
2022-08-16	1018	48.449	-124.341	HB	4	Fluking	Sunny and Foggy	2
2022-08-16	1019	48.443	-124.324	HB	4	Fluking	Sunny and Foggy	2
2022-08-17	934	48.524	-124.502	HP	1	Fast Surfacing	Sunny and Foggy	1
2022-08-18	1137	48.406	-124.208	TKW	4	Fast Surfacing and Spy hopping	Sunny	0
2022-08-18	1146	48.388	-124.097	HB	3	Surfacing	Sunny	0
2022-08-18	1150	48.391	-124.099	TKW	4	Tail Lob	Sunny	0
2022-08-18	1200	48.418	-124.072	HP	3	Fast Surfacing	Sunny	0
2022-08-18	1230	48.370	-124.250	HB	1	Blowing	Sunny	0
2022-08-18	1420	48.424	-124.267	HB	5	Surfacing and Blowing	Sunny	0
2022-08-18	1450	48.418	-124.371	HB	1	Blowing	Sunny	0
2022-08-18	1454	48.432	-124.363	HB	1	Fluking and Blowing	Sunny	0
2022-08-18	No Data	48.458	-124.376	HB	1	Blowing	Sunny	1
2022-08-18	No Data	48.483	-124.357	HB	1	Blowing	Sunny	1
2022-08-18	No Data	48.485	-124.301	HB	1	Blowing	Sunny	1
2022-08-18	No Data	48.480	-124.425	HB	5	Blowing and Fast Surfacing	Sunny	1
2022-08-18	No Data	48.437	-124.318	HB	30	Blowing and Fast Surfacing	Sunny	1
2022-08-18	No Data	48.387	-124.142	HB	1	Fast Surfacing	Sunny	0
2022-08-18	No Data	48.415	-124.262	HB	1	Fluking	Sunny	0
2022-08-18	No Data	48.421	-124.262	HB	5	Fluking and Blowing	Sunny	1

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2022-08-18	No Data	48.436	-124.253	HB	3	Fluking and Blowing	Sunny	1
2022-08-18	No Data	48.409	-124.206	HB	4	Fluking and Blowing	Sunny	0
2022-08-18	No Data	48.487	-124.420	HB	3	Surfacing	Sunny	1
2022-08-18	No Data	48.468	-124.398	HB	2	Surfacing	Sunny	1
2022-08-18	No Data	48.449	-124.183	HP	1	Surfacing	Sunny	0
2022-08-19	944	48.576	-124.679	HB	1	Blowing	Overcast, Sunny and PSPC	1
2022-08-19	1537	48.508	-124.468	HB	1	Blowing	PSPC	1
2022-08-20	732	48.490	-124.366	HP	1	Fast Surfacing	PSPC	1
2022-08-20	830	48.359	-124.038	HB	1	Blowing	PSPC	3
2022-08-20	1014	48.358	-124.040	HB	4	Blowing	PSPC	2
2022-08-20	1019	48.371	-124.071	HB	1	Blowing	PSPC	2
2022-08-20	1147	48.364	-124.251	HB	1	Blowing	PSPC	2
2022-08-20	1219	48.453	-124.350	HB	1	Fluking	PSPC	2
2022-08-20	1250	48.392	-124.340	HB	4	Blowing	PSPC	2
2022-08-20	1256	48.403	-124.380	HB	1	Fluking	PSPC	2
2022-08-20	1259	48.409	-124.377	HB	8	Blowing	PSPC	2
2022-08-20	1351	48.425	-124.452	HB	1	Breaching	PSPC	2
2022-08-21	831	48.585	-125.005	HP	1	Fast Surfacing	Overcast and PSPC	0
2022-08-21	1241	48.529	-124.874	HB	2	Blowing	Overcast and PSPC	0
2022-08-21	1256	48.504	-124.869	HB	2	Blowing	Overcast and PSPC	0
2022-08-21	1323	48.554	-124.826	HP	1	Fast Surfacing	Overcast and PSPC	1
2022-08-22	741	48.539	-124.672	SRKW	6	Feeding and Swimming	PSPC and Foggy	0
2022-08-22	749	48.541	-124.692	SRKW	10	Fluking, Breaching and Blowing	PSPC and Foggy	0
2022-08-22	759	48.542	-124.704	SRKW	19	Breaching, Feeding, Fluking and Reproduction	PSPC and Foggy	0
2022-08-22	902	48.597	-124.855	HB	1	Blowing and Fluking	PSPC and Foggy	1
2022-08-22	1016	48.640	-124.909	HP	1	Fast Surfacing	PSPC and Foggy	1

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-08-22	1133	48.606	-124.822	HB	1	Fast Surfacing and Fluking	PSPC and Foggy	1
2022-08-22	1311	48.545	-124.723	HP	1	Fast Surfacing	PSPC and Foggy	1
2022-08-22	1352	48.521	-124.713	HB	1	Blowing	PSPC and Foggy	1
2022-08-31	938	48.439	-124.471	HB	1	Blowing	Sunny and Foggy	2
2022-08-31	1047	48.398	-124.339	HB	1	Blowing	Sunny and Foggy	2
2022-08-31	1049	48.389	-124.394	HB	1	Surfacing	Sunny and Foggy	2
2022-09-02	1027	48.632	-124.900	HP	2	Fast Surfacing	Foggy and Sunny	0
2022-09-03	916	48.317	-124.073	HB	1	Fluking	Overcast and Foggy	2
2022-09-03	952	48.318	-124.077	HP	1	Fast Surfacing	Overcast and Foggy	2
2022-09-03	1401	48.433	-124.204	HP	6	Fast Surfacing	Overcast and Foggy	2
2022-09-03	1422	48.406	-124.318	HB	8	Fast Surfacing, Fluking and Blowing	Overcast and Foggy	2
2022-09-03	1444	48.426	-124.341	HB	1	Blowing	Overcast and Foggy	2
2022-09-03	1446	48.431	-124.360	HB	11	Surfacing	Overcast and Foggy	2
2022-09-03	1448	48.375	-124.399	HB	5	Surfacing	Overcast and Foggy	2
2022-09-03	1452	48.469	-124.461	HB	2	Surfacing and Fluking	Overcast and Foggy	2

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2022-09-03	1455	48.481	-124.419	HB	1	Blowing	Overcast and Foggy	2
2022-09-03	1458	48.511	-124.444	HP	1	Surfacing	Overcast and Foggy	2
2022-09-04	956	48.550	-124.571	HP	2	Fast Surfacing	Foggy, Overcast and Rainy	2
2022-09-04	1144	48.476	-124.464	HB	2	Fast Surfacing and Blowing	Foggy, Overcast and Rainy	2
2022-09-04	1226	48.480	-124.359	HP	2	Fast Surfacing	Foggy, Overcast and Rainy	2
2022-09-04	1355	48.497	-124.531	HB	1	Fast Surfacing and Fluking	Foggy, Overcast and Rainy	2
2022-09-04	1437	48.495	-124.522	HB	1	Blowing	Foggy, Overcast and Rainy	2
2022-09-04	1445	48.500	-124.487	HB	1	Fast Surfacing and Blowing	Foggy, Overcast and Rainy	2
2022-09-06	817	48.360	-123.907	HB	1	Surfacing	Sunny	0
2022-09-06	1142	48.471	-124.445	HB	30	Fluking, Blowing and Surfacing	Sunny	1
2022-09-06	1203	48.424	-124.445	HB	4	Fluking and Blowing	Sunny	1
2022-09-06	1235	48.457	-124.492	HB	1	Surfacing	Sunny	1
2022-09-06	1420	48.499	-124.562	KW	6	Surfacing	Sunny	1
2022-09-06	1433	48.522	-124.502	HB	6	Surfacing	Sunny	1
2022-09-07	713	48.489	-124.383	HB	3	Blowing and Fast Surfacing	Sunny	1
2022-09-07	722	48.481	-124.294	HP	2	Fast Surfacing	Sunny	1
2022-09-07	851	48.474	-124.453	HB	1	Surfacing	Sunny	2
2022-09-07	912	48.510	-124.507	HB	1	Breaching	Sunny	2
2022-09-07	914	48.513	-124.522	HB	1	Fluking and Blowing	Sunny	2
2022-09-07	923	48.515	-124.512	HB	1	Surfacing	Sunny	3
2022-09-07	923	48.515	-124.512	KW	1	Surfacing	Sunny	3
2022-09-09	715	48.525	-124.514	HB	1	Surfacing	Sunny	2
2022-09-09	1200	48.447	-124.552	HB	2	Blowing	Sunny	2
2022-09-09	1227	48.517	-124.542	HB	1	Blowing	Sunny	3
2022-09-09	1303	48.446	-124.553	HB	1	Surfacing	Sunny	2

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2022-09-09	1334	48.498	-124.499	SRKW	4	Blowing and Breaching	Sunny	2
2022-09-09	1336	48.501	-124.497	SRKW	3	Spy Hopping and Fluking	Sunny	2
2022-09-09	1352	48.526	-124.500	SRKW	2	Surfacing and Blowing	Sunny	2
2022-09-09	1355	48.521	-124.504	SRKW (putative)	1	Blowing	Sunny	2
2022-09-09	1359	48.512	-124.510	SRKW	4	Blowing	Sunny	2
2022-09-09	1403	48.505	-124.515	SRKW	2	Blowing	Sunny	2
2022-09-09	1403	48.503	-124.517	SRKW	1	Breaching	Sunny	2
2022-09-09	1404	48.501	-124.519	SRKW	4	Blowing	Sunny	2
2022-09-09	1415	48.300	-124.304	SRKW	4	Surfacing	Sunny	2
2022-09-10	853	48.356	-124.346	HB	3	Blowing	Sunny	4
2022-09-10	1000	48.373	-124.364	HB	10	Blowing and Breaching	Sunny	5
2022-09-10	1010	48.366	-124.240	HB	1	Breaching	Sunny	5
2022-09-11	1019	48.466	-124.628	HB	1	Blowing	Sunny	0
2022-09-11	1131	48.498	-124.761	HB	1	Surfacing	Sunny	1
2022-09-11	1140	48.524	-124.747	HB	3	Fast Surfacing and Blowing	Sunny	1
2022-09-11	1352	48.513	-124.809	HB	14	Blowing	Sunny	1
2022-09-11	1406	48.522	-124.854	HB	7	Surfacing and Blowing	Sunny	1
2022-09-12	723	48.548	-124.546	TKW	5	Fast Surfacing	Sunny and Cloudy	0
2022-09-12	1330	48.591	-124.744	HB	1	Fast Surfacing and Feeding	Sunny and Cloudy	0
2022-09-12	1334	48.583	-124.712	UW	1	Blowing	Sunny and Cloudy	0
2022-09-15	750	48.637	-124.911	HB	2	Fast Surfacing	Foggy	0
2022-09-15	830	48.583	-124.728	HP	4	Fast Surfacing	Foggy	1
2022-09-15	1052	48.528	-124.841	HB	5	Blowing	Foggy	0
2022-09-15	1106	48.516	-124.841	HB	1	Blowing	Foggy	0
2022-09-15	1144	48.532	-124.809	SRKW	5	Fast Surfacing	Foggy	1
2022-09-15	1154	48.534	-124.811	SRKW	14	Blowing, Fast Surfacing, Breaching and Spy Hopping	Foggy	1
2022-09-15	1203	48.534	-124.806	SRKW	2	Slow Rolling	Foggy	0
2022-09-15	1205	48.538	-124.804	SRKW	1	Breaching and Slow Rolling	Foggy	1
2022-09-15	1207	48.539	-124.803	SRKW	1	Blowing and Fast Surfacing	Foggy	1

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2022-09-15	1211	48.540	-124.804	SRKW	9	Swimming, Fluking and Blowing	Foggy	1
2022-09-15	1445	48.537	-124.584	HB	1	Blowing	Foggy	2
2022-09-16	932	48.583	-124.701	GW	1	Blowing, Feeding and Surfacing	Sunny	1
2022-09-16	958	48.615	-124.799	GW	1	Surfacing	Sunny	1
2022-09-16	1033	48.559	-124.844	HB	8	Blowing	Sunny	2
2022-09-17	755	48.513	-124.467	HB	1	Blowing	Sunny	2
2022-09-17	807	48.502	-124.466	SRKW	30	Feeding, Slow Rolling, Breaching, Surfacing and Blowing	Sunny	2
2022-09-17	807	48.502	-124.466	HB	2	Surfacing, Blowing, Slow Rolling	Sunny	2
2022-09-17	825	48.478	-124.483	SRKW	1	Surfacing	Sunny	2
2022-09-17	929	48.443	-124.512	SRKW	5	Surfacing	Sunny	2
2022-09-17	1058	48.454	-124.357	HB	1	Blowing	Sunny	0
2022-09-17	1059	48.453	-124.352	HB	1	Blowing	Sunny	0
2022-09-17	1244	48.463	-124.238	HP	4	Fast Surfacing	Sunny	0
2022-09-18	804	48.441	-124.155	HB	1	Blowing	Sunny	1
2022-09-18	857	48.416	-124.039	HP	20	Fast Surfacing	Sunny	0
2022-09-18	919	48.359	-124.946	HB	23	No Data	Sunny	1
2022-09-18	1003	48.363	-124.938	HB	2	Blowing and Surfacing	Sunny	2
2022-09-18	1005	48.353	-124.055	HB	4	Blowing	Sunny	2
2022-09-18	1056	48.364	-124.055	HB	2	Blowing	Sunny	2
2022-09-18	1056	48.366	-124.059	HB	3	Blowing	Sunny	2
2022-09-18	1058	48.397	-124.065	HB	3	Blowing and Surfacing	Sunny	2
2022-09-18	1153	48.388	-124.147	HB	2	Surfacing	Sunny	1
2022-09-18	1202	48.412	-124.232	HB	1	Blowing	Sunny	1
2022-09-18	1209	48.413	-124.232	HB	1	Blowing	Sunny	1
2022-09-18	1213	48.414	-124.232	HB	2	Blowing	Sunny	1
2022-09-18	1217	48.414	-124.238	HB	1	Fluking	Sunny	1
2022-09-18	1232	48.433	-124.302	HB	1	Blowing	Sunny	2
2023-09-19	1159	48.443	-124.164	HB	9	Blowing	Sunny	2
2023-09-19	1207	48.462	-124.237	HP	1	Surfacing	Sunny	2
2023-09-19	1258	48.446	-124.488	HB	1	Blowing	Sunny	2
2023-09-19	1326	48.469	-124.495	KW	1	Surfacing	Sunny	2
2022-09-20	900	48.574	-124.953	KW	5	Surfacing	No Data	2
2022-09-20	914	48.576	-124.957	HB	2	Blowing	No Data	2
2022-09-20	1339	48.558	-124.818	HB	19	Blowing	No Data	2
2022-09-21	816	48.505	-124.869	UW	1	Blowing	Sunny	2
2022-09-21	818	48.504	-124.883	HB	4	Blowing	Sunny	2

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-09-21	821	48.503	-124.901	HB	2	Blowing	Sunny	2
2022-09-21	852	48.563	-124.868	HB	2	Blowing and Surfacing	Sunny	2
2022-09-21	928	48.505	-124.869	HB	9	Blowing	Sunny	2
2022-09-21	1045	48.538	-124.774	HB	1	Blowing	Sunny	3
2022-09-22	743	48.495	-124.416	KW	1	Blowing and Surfacing	Overcast	1
2022-09-22	806	48.494	-124.352	HB	2	Blowing	Overcast	1
2022-09-22	903	48.476	-124.273	HP	11	Feeding, Swimming and Surfacing	Overcast	2
2022-09-22	906	48.474	-124.269	HP	5	Swimming and Eating	Overcast	2
2022-09-22	930	48.408	-124.215	HB	75	Blowing, Fluking and Breaching	Overcast	2
2022-09-23	720	48.497	-124.401	HB	1	Fluking	No Data	0
2022-09-23	723	48.474	-124.372	HB	12	Blowing and Fluking	No Data	0
2022-09-23	725	48.466	-124.356	HB	2	Surfacing	No Data	0
2022-09-23	726	48.459	-124.400	HB	3	Blowing	No Data	0
2022-09-23	728	48.455	-124.331	HB	5	Fluking	No Data	0
2022-09-23	729	48.449	-124.317	HB	2	Surfacing	No Data	0
2022-09-23	730	48.447	-124.312	HB	3	Blowing	No Data	0
2022-09-23	731	48.442	-124.299	HB	16	Blowing, Surfacing and Surfacing	No Data	0
2022-09-23	733	48.367	-124.284	HB	3	Blowing	No Data	0
2022-09-23	736	48.429	-124.261	HB	4	Blowing and Fluking	No Data	0
2022-09-23	741	48.411	-124.211	HB	6	Blowing and Fluking	No Data	0
2022-09-23	743	48.406	-124.197	HB	11	Blowing and Fluking	No Data	0
2022-09-23	746	48.396	-124.167	HB	4	Blowing and Fluking	No Data	0
2022-09-23	749	48.391	-124.151	HB	2	Blowing and Surfacing	No Data	1
2022-09-23	832	48.371	-124.078	HB	3	Blowing	No Data	0
2022-09-23	918	48.344	-124.983	HB	1	Blowing	No Data	0
2022-09-23	1104	48.400	-124.156	HB	2	Fluking and Blowing	No Data	0
2022-09-23	1107	48.398	-124.186	HB	3	Blowing and Fluking	No Data	0
2022-09-23	1152	48.419	-124.263	HB	7	Blowing	No Data	1
2022-09-23	1159	48.431	-124.301	HB	2	Blowing and Surfacing	No Data	1
2022-09-23	1246	48.456	-124.362	HB	2	Blowing and Fluking	No Data	1
2022-09-23	1246	48.456	-124.369	HB	2	Surfacing	No Data	1
2022-09-23	1337	48.512	-124.466	HB	1	Surfacing	No Data	1
2022-09-26	726	48.572	-124.670	HB	1	Blowing	Sunny and Cloudy	2
2022-09-26	732	48.578	-124.708	GW	1	Fluking and Surfacing	Sunny and Cloudy	2

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-09-26	826	48.564	-124.691	HB	2	Blowing	Sunny and Cloudy	2
2022-09-26	844	48.547	-124.568	HB	2	Breaching	Sunny and Cloudy	1
2022-09-26	853	48.534	-124.538	HB	1	Blowing and Fluking	Sunny and Cloudy	3
2022-09-26	900	48.527	-124.507	HB	2	Fluking and Blowing	Sunny and Cloudy	3
2022-09-29	1002	48.540	-124.488	HP	3	Surfacing	Foggy and Sunny	1
2022-09-29	1400	48.548	-124.469	UW	1	Surfacing	Foggy and Sunny	2
2022-10-01	725	48.490	-124.435	HB	3	Surfacing	No Data	1
2022-10-01	729	48.482	-124.425	KW	2	Surfacing	No Data	1
2022-10-01	729	48.477	-124.398	HB	20	Surfacing, Blowing and Fluking	No Data	1
2022-10-01	745	48.475	-124.393	TKW	4	Blowing and Surfacing	No Data	1
2022-10-01	807	48.456	-124.353	HB	3	Surfacing	No Data	1
2022-10-01	823	48.425	-124.804	HB	1	Fluking and Surfacing	No Data	1
2022-10-01	848	48.323	-124.048	HP	3	Fast Surfacing	No Data	1
2022-10-01	912	48.344	-124.998	HB	1	Fluking and Surfacing	No Data	2
2022-10-01	1015	48.357	-124.301	HB	2	Breaching	No Data	2
2022-10-01	1204	48.454	-124.309	HB	1	Blowing	No Data	2
2022-10-01	1301	48.462	-124.393	HB	11	Blowing, Fluking and Surfacing	No Data	3
2022-10-01	1447	48.463	-124.458	HB	1	Blowing and Fluking	No Data	2
2022-10-02	723	48.477	-124.417	HB	2	Fluking	Sunny	1
2022-10-02	918	48.061	-124.132	HP	2	Surfacing	Sunny	0
2022-10-02	1049	48.425	-124.278	HB	2	Blowing, Resting and Surfacing	Sunny	2
2022-10-02	1102	48.431	-124.295	HB	10	Blowing and Surfacing	Sunny	2
2022-10-02	1126	48.391	-124.321	HB	7	Blowing and Surfacing	Sunny	2
2022-10-02	1212	48.479	-124.467	HB	3	Blowing and Surfacing	Sunny	2

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-10-02	1301	48.495	-124.522	HB	1	Blowing	Sunny	2
2022-10-02	1302	48.496	-124.531	HB	1	Blowing	Sunny	2
2022-10-02	1409	48.541	-124.570	HB	2	Blowing and Surfacing	Sunny	2
2022-10-04	723	48.513	-124.534	HB	11	Fluking and Surfacing	Light Fog	2
2022-10-04	757	48.455	-124.584	HB	1	Surfacing and Blowing	Light Fog	2
2022-10-04	947	48.527	-124.680	HP	2	Fast surfacing	Light Fog	1
2022-10-04	947	48.527	-124.680	HB	1	Fluking and Blowing	Light Fog	1
2022-10-04	1102	48.507	-124.845	HB	20	Fluking	Light Fog	0
2022-10-04	1104	48.506	-124.850	SRKW	3	Breaching, Feeding, Fluking and Surfacing	Light Fog	0
2022-10-04	1108	48.506	-124.855	HB	7	Logging, Feeding	Light Fog	0
2022-10-04	1128	48.508	-124.854	SRKW	1	Surfacing	Light Fog	No Data
2022-10-04	1129	48.510	-124.853	SRKW	1	Surfacing	Light Fog	No Data
2022-10-04	1131	48.511	-124.853	SRKW	8	Blowing and Surfacing	Light Fog	No Data
2022-10-04	1131	48.515	-124.851	SRKW	1	Fluking	Light Fog	No Data
2022-10-04	1131	48.516	-124.850	SRKW	5	Breaching and Blowing	Light Fog	No Data
2022-10-04	1134	48.522	-124.849	SRKW	4	Surfacing and Blowing	Light Fog	0
2022-10-04	1136	48.522	-124.848	SRKW	1	Fluking and Blowing	Light Fog	0
2022-10-04	1145	48.523	-124.848	SRKW	15	Breaching and Fluking	Light Fog	0
2022-10-04	1158	48.507	-124.827	HB	4	Fluking and Surfacing	Light Fog	0
2022-10-04	1220	48.524	-124.850	SRKW	8	Fluking and Blowing	Light Fog	0
2022-10-04	1236	48.525	-124.853	HB	4	Breaching	Light Fog	0
2022-10-04	1252	48.525	-124.855	SRKW	1	Blowing and Surfacing	Light Fog	No Data
2022-10-04	1253	48.526	-124.853	SRKW	1	Surfacing	Light Fog	No Data
2022-10-04	1423	48.559	-124.716	GW	1	Surfacing	Light Fog	0
2022-10-04	1436	48.548	-124.578	HB	2	Blowing	Light Fog	0
2022-10-04	1439	48.544	-124.541	HB	4	Fluking and Blowing	Light Fog	1
2022-10-04	1442	48.504	-124.916	HB	2	Surfacing	Light Fog	0
2022-10-04	1445	48.545	-124.475	HB	6	Blowing	Light Fog	1
2022-10-04	1455	48.531	-124.906	HB	1	Surfacing	Light Fog	0
2022-10-05	717	48.551	-124.572	HB	8	Breaching	Foggy and PSPC	1
2022-10-05	722	48.555	-124.650	HB	1	Breaching	Foggy and PSPC	1
2022-10-05	732	48.554	-124.704	KW	2	Fluking	Foggy and PSPC	0
2022-10-05	734	48.554	-124.704	HB	2	Tail Lobbing	Foggy and PSPC	0

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-10-05	744	48.563	-124.741	HB	1	Breaching	Foggy and PSPC	0
2022-10-06	741	48.527	-124.463	HP	1	Surfacing	Sunny	2
2022-10-06	815	48.466	-124.403	HB	8	Surfacing	Sunny	0
2022-10-06	907	48.450	-124.313	HB	2	No Data	Sunny	0
2022-10-06	1107	48.414	-124.051	HP	12	Fast surfacing	Sunny	0
2022-10-06	1108	48.410	-124.037	HP	7	Fast surfacing	Sunny	0
2022-10-06	1114	48.401	-124.017	HP	4	Fast surfacing	Sunny	0
2022-10-06	1224	48.353	-124.939	HB	1	Surfacing	Sunny	2
2022-10-06	1301	48.301	-124.003	HB	1	Blowing and Fluking	Sunny	3
2022-10-06	1333	48.390	-124.119	HB	3	Blowing and Fluking	Sunny	2
2022-10-06	1404	48.471	-124.371	HB	3	Fluking, Blowing and Surfacing	Sunny	1
2022-10-07	719	48.494	-124.457	HB	2	Blowing	PSPC	0
2022-10-07	721	48.473	-124.457	HB	4	Blowing and Surfacing	PSPC	0
2022-10-07	722	48.462	-124.457	HB	1	Blowing	PSPC	0
2022-10-07	758	48.420	-124.389	HB	8	Blowing	PSPC	0
2022-10-07	802	48.454	-124.354	HB	1	Breaching	PSPC	0
2022-10-07	846	48.430	-124.297	HB	3	Blowing	PSPC	2
2022-10-07	1143	48.397	-124.018	HP	3	Surfacing	PSPC	0
2022-10-07	1153	48.414	-124.054	HP	1	Travelling	PSPC	0
2022-10-07	1243	48.475	-124.326	HB	2	Breaching	PSPC	2
2022-10-07	1248	48.487	-124.351	HB	6	Blowing and Surfacing	PSPC	2
2022-10-07	1250	48.499	-124.375	HB	2	Blowing	PSPC	2
2022-10-08	731	48.545	-124.531	HP	2	Surfacing	Sunny	1
2022-10-08	741	48.559	-124.602	HP	3	Surfacing	Sunny	0
2022-10-08	938	48.497	-124.530	HB	5	Surfacing	Sunny	0
2022-10-08	938	48.497	-124.530	SRKW	2	Surfacing	Sunny	0
2022-10-09	715	48.354	-124.526	HP	1	Surfacing	Sunny	2
2022-10-09	820	48.584	-124.714	GW	1	Blowing	Sunny	1
2022-10-09	905	48.572	-124.651	HP	3	Surfacing	Sunny	1
2022-10-09	935	48.530	-124.673	HB	2	Surfacing	Sunny	2
2022-10-09	1015	48.461	-124.393	HB	4	Blowing and Fluking	Sunny	1
2022-10-09	1118	48.425	-124.280	HB	2	Blowing, Fluking and Surfacing	Sunny	0
2022-10-11	804	48.355	-124.050	HB	1	Blowing	Sunny	1
2022-10-11	812	48.312	-124.006	HB	2	Blowing	Sunny	1
2022-10-11	918	48.365	-124.078	KW	1	Surfacing	Sunny	0
2022-10-11	939	48.383	-124.128	HB	1	Fluking	Sunny	1
2022-10-11	1031	48.411	-124.230	KW	4	Surfacing	Sunny	1

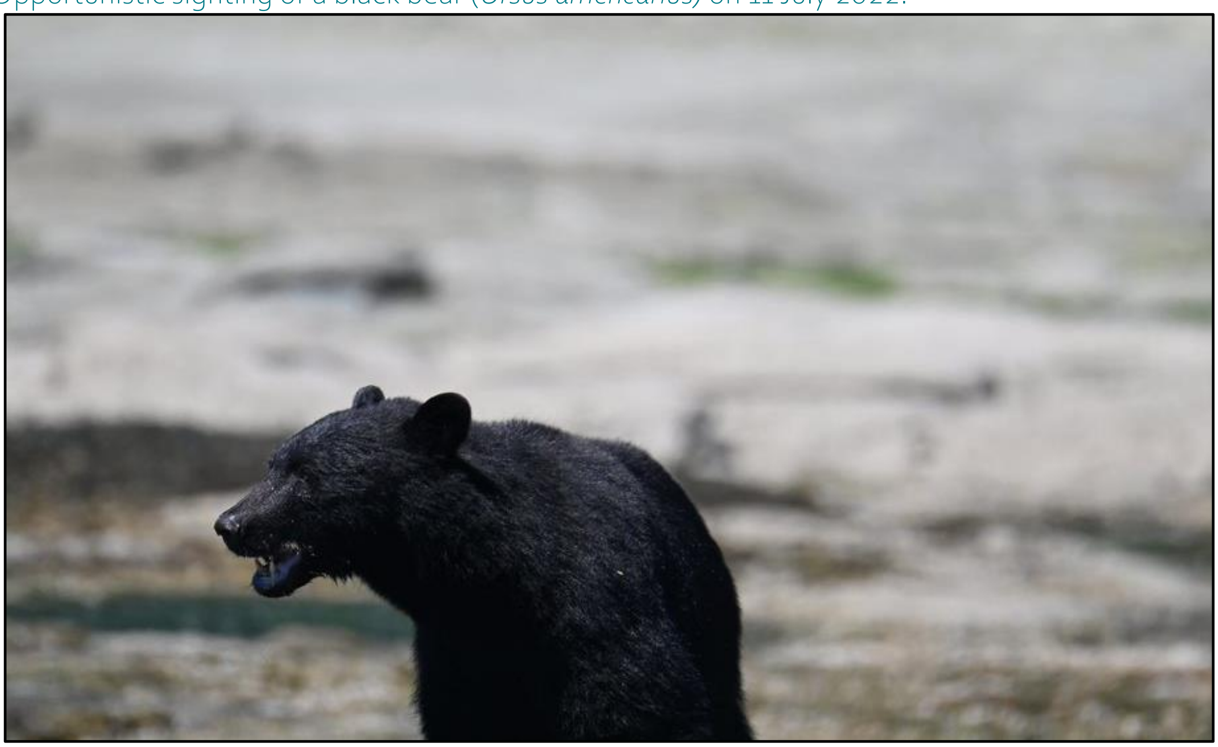
Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
2022-10-11	1036	48.413	-124.236	KW	4	Surfacing, Breaching and Feeding	Sunny	1
2022-10-11	1050	48.421	-124.425	KW	4	Tail Slapping, Fluking, Breaching	Sunny	No Data
2022-10-11	1120	48.377	-124.283	HB	2	Surfacing	Sunny	1
2022-10-11	1149	48.435	-124.312	HB	2	Surfacing and Blowing	Sunny	1
2022-10-11	1216	48.412	-124.405	HB	1	Fluking and Surfacing	Sunny	1
2022-10-12	809	48.540	-124.455	HB	1	Fluking	Sunny	3
2022-10-12	1039	48.470	-124.260	HP	1	Surfacing	Sunny	1
2022-10-12	1204	48.507	-124.465	HB	1	Blowing and Surfacing	Sunny	3
2022-10-13	738	48.573	-124.735	HP	1	Surfacing	Sunny	0
2022-10-13	750	48.568	-124.761	UW	1	Blowing	Sunny	1
2022-10-13	1210	48.527	-124.840	SRKW	4	Surfacing	Sunny	3
2022-10-13	1305	48.527	-124.810	HB	2	Blowing	Sunny	2
2022-10-13	1312	48.511	-124.819	HB	1	Blowing	Sunny	2
2022-10-13	1314	48.506	-124.822	HB	2	Blowing	Sunny	2
2022-10-13	1402	48.499	-124.757	HB	2	Blowing	Sunny	2
2022-10-14	931	48.511	-124.589	HB	2	Fluking and Surfacing	Sunny	1
2022-10-14	1018	48.497	-124.533	HB	2	Blowing	Sunny	2
2022-10-14	1026	48.511	-124.565	HB	2	Resting	Sunny	2
2022-10-14	1134	48.570	-124.699	GW	2	Blowing	Sunny	2
2022-10-15	850	48.393	-124.093	HB	5	Blowing and Surfacing	No Data	5
2022-10-16	1135	48.445	-124.330	HB	1	Blowing and Fluking	Sunny and PSPC	2
2022-10-17	754	48.623	-124.851	HB	1	Surfacing	Overcast	1
2022-10-17	1111	48.584	-124.713	GW	1	Blowing	Overcast	0
2022-10-29	1006	48.476	-124.455	HB	3	Blowing	Foggy	2

DP – Dall's porpoise
GW – Grey whale
HP – Harbour porpoise
HB – Humpback whale
KW – Killer whale (ecotype unknown)
SRKW – Southern resident killer whale
TKW – Transient killer whale
UP – Unidentified porpoise
PCPS – Partly cloudy partly sunny

Appendix D: 2022 Field Photographs

A – Steller sea lions (*Eumetopias jubatus)* hauled out south of Port Renfrew, BC on 16 June 2022.

B – Opportunistic sighting of a black bear (*Ursus americanus)* on 11 July 2022.



C – Breaching humpback whale (*Megaptera novaeangliae)* on 21 July 2022.

D – Pod of southern resident killer whales (*Orcinus orca)* on 22 August 2022.

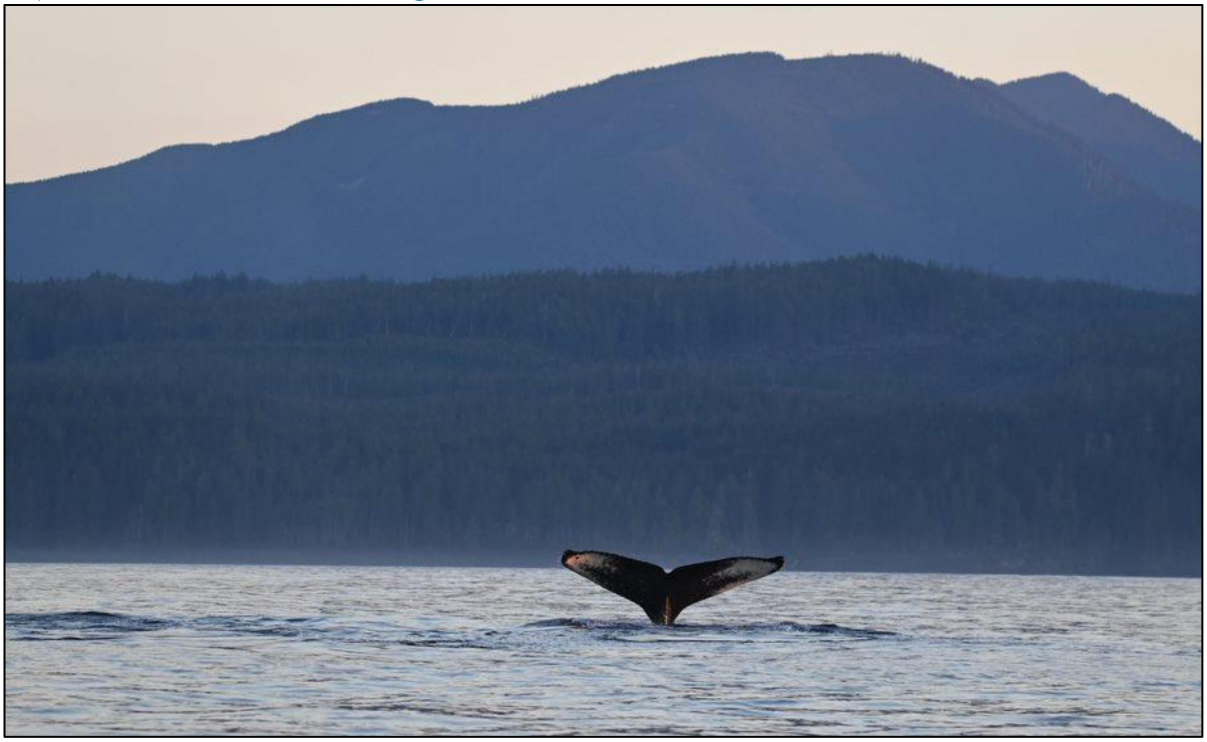
E – Adult male southern resident killer whale exhibiting reproductive behaviour on 17 September 2022.

F – Southern resident killer whale tail slapping on 17 September 2022.

G – Humpback whale (2021 calf of BCX0470) fluking on 23 September 2022.

H – Grey whale (*Eschrichtius robustus)* near Carmanah Point on 26 September 2022.

I – Humpback whale (BCY0329) fluking on 01 October 2022.



J – Group of three southern resident killer whales on 04 October 2022.

K – Three humpback whales foraging in close proximity on 04 October 2022.

L – Male southern resident killer whale travelling towards a commercial fishing vessel near Swiftsure Bank on 04 October 2022.

M – Two sea otters (*Enhydra lutris)* rafting together on 16 October 2022.

N – Humpback whale breaching on 18 October 2022.