ECHO Program

Summary report: 2021 voluntary vessel slowdown at Swiftsure Bank

Vancouver Fraser Port Authority

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Executive summary

This report summarizes the development, implementation and results of the 2021 voluntary vessel slowdown at Swiftsure Bank. The slowdown was coordinated and implemented by the Vancouver Port Authority-led Enhancing Cetacean Habitat and Observation (ECHO) Program, with the ECHO Program's vessel operators committee and advisory working group members providing valuable input and advice throughout.

Swiftsure Bank is critical habitat for endangered southern resident killer whale (SRKW) and overlaps with the commercial shipping lanes in both Canadian and US waters. Historical data indicates that SKRWs are most frequently detected at Swiftsure Bank between June and October.

The ECHO Program voluntary slowdowns in Haro Strait and Boundary Pass between 2017 and 2020 and outbound at Swiftsure Bank in 2020 demonstrated that reducing the speeds of vessels can be effective in reducing the underwater noise generated at the vessel source and total underwater noise in nearby habitats, which may benefit the behaviour and feeding success of the southern resident killer whales.

As new Fisheries and Oceans Canada research became available indicating the importance of Swiftsure Bank as a key SRKW foraging habitat, the voluntary slowdown at Swiftsure Bank was trialed in 2020. The trial aimed to evaluate the level of voluntary transboundary participation that could be achieved in these un-piloted waters, and the potential reduction in underwater noise. Following a successful voluntary outbound slowdown trial for a three-month period in 2020, the slowdown was undertaken again in 2021.

When safe and operationally feasible to do so, outbound vessels were encouraged to voluntarily slowdown from JA buoy to the end of the traffic separation scheme between July 1 and October 31, 2021. Vehicle carriers, passenger (cruise) vessels and container ships were encouraged to transit at 14.5 knots or less speed through water while bulk cargo vessels, tankers and government vessel operators were asked to transit at 11 knots or less speed through water.

Eighty one percent of outbound ship transits (1,589 of 1,973) participated in the slowdown by achieving their respective target speeds within one knot.

Scientific evidence shows that deep sea vessels are quieter at source when they slow down. Seasonal fluctuations in sound levels at the DFO hydrophone beneath the outbound shipping lane at Swiftsure Bank pose a challenge to evaluating the 2021 summer/fall slowdown period against a spring baseline/control. Further investigation of this seasonal variability is required to understand and assess the acoustic benefits of the slowdown.

Marine mammal observations were conducted by Pacheedaht First Nation's vessel and trained crew who undertook 27 marine mammal observation field excursions totaling 68 hours of survey transects between June and November 2021. The observers recorded 79 sightings of an estimated 128 animals, two of which were killer whales that were observed on two separate occasions. In addition, the B.C. Cetacean Sightings Network received 21 reports of humpbacks, killer whales and unidentified whale species sightings in the Swiftsure Bank area during the slowdown period.

The results of the 2021 vessel slowdown at Swiftsure Bank further demonstrates that voluntary measures are an effective way of managing threats to at-risk whales. High transboundary voluntary participation rates were achieved in non-piloted waters and slower ship speeds are known to reduce underwater noise generated at the vessel source.

Future vessel slowdowns in this area will build on the learnings of this slowdown and other ECHO Program slowdown initiatives to date.

1. Background

The voluntary vessel slowdown trial at Swiftsure Bank was coordinated and implemented by the Enhancing Cetacean Habitat and Observation (ECHO) Program, with input from the program's vessel operators committee and advisory working group members, and Pacheedaht First Nation providing valuable input and advice throughout the development, implementation and evaluation of the slowdown.

The purpose of the slowdown was to help reduce underwater vessel noise impacts in the vicinity of Swiftsure Bank (Figure 1), a known foraging area of importance to the southern resident killer whale (SRKW). Data collection and analysis was undertaken to help measure the level of voluntary vessel participation and speeds achieved, as well as to monitor underwater noise levels during the slowdown.

The slowdown trial took place between June 1 and October 31, 2021 and involved voluntary speed reductions for large commercial vessels transiting the outbound shipping lane in the Swiftsure Bank area (Figure 1).

1.1. The ECHO Program

The ECHO Program is a Vancouver Fraser Port Authority-led initiative aimed at better understanding and reducing the effects of large commercial vessel-related activities on at-risk whales throughout the southern coast of British Columbia (B.C.).

The geographic scope of the port authority's jurisdiction is limited; therefore, to adequately understand and address the cumulative effects of commercial ship activity on whales regionally, a collaborative approach is required. To this end, since 2014 the port authority has been collaborating with an advisory working group and technical committees made up of Canadian and U.S government agencies, marine transportation industries, Indigenous communities, conservation and environmental groups, and scientists to advance ECHO Program projects within the Salish Sea. The long-term goal of the program is to quantifiably reduce threats to at-risk whales as a result of large commercial vessel-related activities.

1.2. Context for the voluntary vessel slowdown

A number of 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 southern resident killer whale, with a population of 73 individuals as of December 31, 2021 (Center for Whale Research, 2022). 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 shipping traffic is a priority focus area for the ECHO Program.

Fisheries and Oceans Canada's recovery strategy (Fisheries and Oceans Canada 2011; 2016; 2017) designates much of the Salish Sea as SRKW critical habitat—the habitat necessary for the survival or recovery of the species. Under the *Endangered Species Act*, critical habitat has also been designated in much of the U.S. waters of the Salish Sea. Killer whales use sound to navigate, communicate and locate prey via echolocation, and underwater noise generated by vessels can impede these functions.

In May 2019, the Government of Canada entered into a first-of-its-kind *Species at Risk Act*, Section 11 conservation agreement with Vancouver Fraser Port Authority, Pacific Pilotage Authority and five marine transportation industry partners to support the recovery of the SRKW. The agreement formalizes the role of the ECHO Program and the participation of the marine industry and government to continue working collaboratively over a five-year term, with a focus on reducing acoustic and physical disturbance of large commercial vessels operating in southern resident killer whale critical habitat.

Since 2018, scientists from the Department of Fisheries and Oceans (DFO) have been conducting extensive studies on the habitat use and behavior of SRKW at key locations throughout critical habitat, including Swiftsure Bank. Preliminary study results highlighting Swiftsure Bank as an important SRKW foraging area were presented to the ECHO Program advisory working group in late 2019, prompting a decision to undertake the slowdown trial in 2020. In early 2021, DFO published a Science Advisory Report on areas for mitigation of vessel related threats to survival and recovery for southern resident killer whales (Fisheries and Oceans Canada, 2021). The report confirmed that Swiftsure Bank is an important foraging area for SRKW.

Results from previous voluntary vessel slowdowns in Haro Strait and Boundary Pass between 2017 and 2020 and the Swiftsure Bank slowdown trial in 2020 demonstrated that reducing ship speeds is an effective way of reducing both the underwater noise generated at the ship source (MacGillivray et al, 2018a; JASCO, 2021) and total underwater noise in nearby habitats, which is in turn predicted to benefit the behaviour and feeding success of the southern resident killer whale (SMRU, 2018b, 2019a, 2019b).

Throughout this report, vessel types are grouped together based on business sector, cargo type and vessel size and shape. Bulker refers to bulk carriers and general cargo vessels carrying bulk, breakbulk and project cargo. Tanker refers to tanker vessels carrying liquid bulk cargo. Other includes yachts, tugs, government vessels and heavy lift vessels. Due to COVID-19, cruise ships were not permitted at Canadian ports, however, US cruise traffic resumed in mid-summer 2021. Cruise vessels are referred to as passenger vessels in this report.

1.3. Development of the slowdown parameters

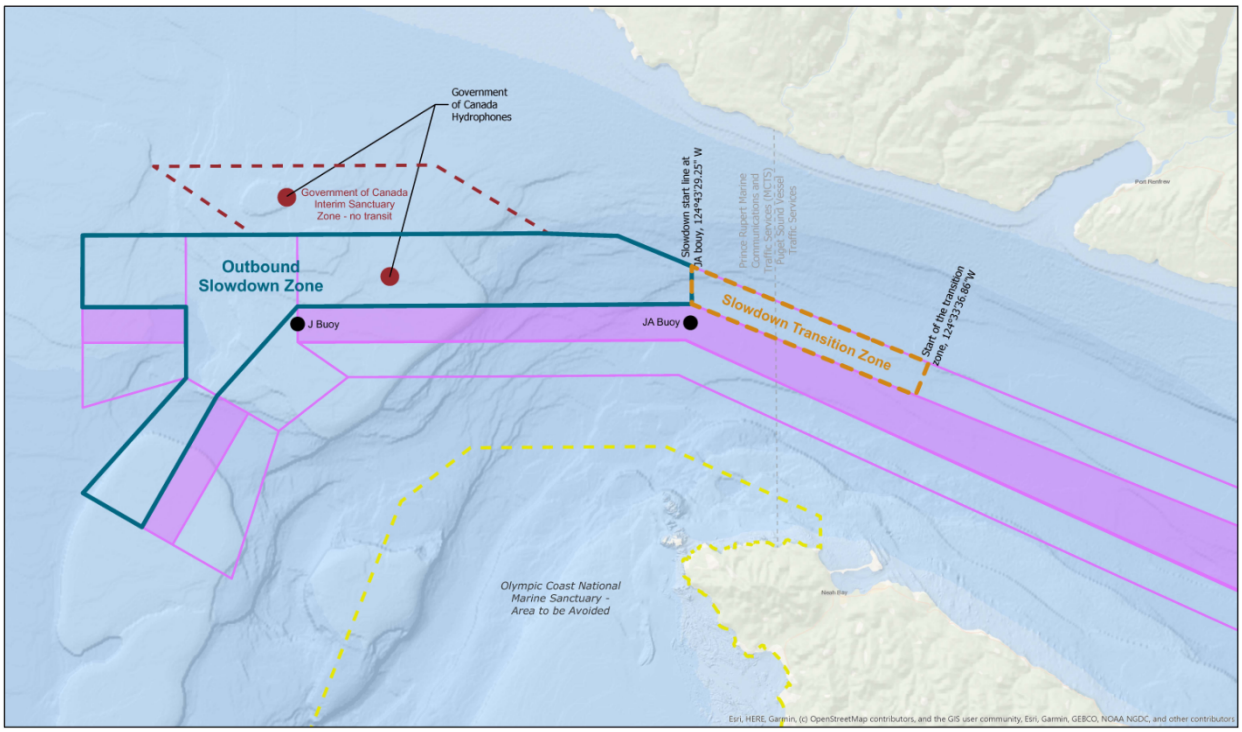
1.3.1. Slowdown area

Preliminary results of a study undertaken by Fisheries and Oceans Canada identified the bathymetric feature of Swiftsure Bank, where the Pacific Ocean floor rises quickly at the mouth of the Strait of Juan de Fuca, as an important foraging habitat for SRKW. The international shipping lanes for vessels entering and exiting the Salish Sea from ports in British Columbia and Washington State directly overlap the Swiftsure Bank area. The outbound shipping lane is located in Canadian waters, whereas the inbound shipping lane is in U.S. waters. Pilotage is mandatory in the interior coastal waters, however, in the Strait of Juan de Fuca and the Swiftsure Bank area, pilotage is not required.

The Swiftsure Bank slowdown took place in the outbound shipping lane between JA buoy and the end of the traffic separation scheme (defining the deep-sea vessel traffic lanes) as shown in Figure 1. The distance of the slowdown area was 17 nautical miles via the west exit, or 20 nautical miles via the southern exit. A transition zone was defined before the slowdown area to encourage vessel operators to slow down to the appropriate target speed prior to entering the slowdown area.

The Swiftsure Bank slowdown was advanced within the traditional marine territory of the Pacheedaht First Nation. Pacheedaht First Nation participates as a member of the ECHO Program advisory working group and was engaged throughout the process of setting the parameters for the slowdown.

Figure 1: 2021 Swiftsure Bank voluntary vessel slowdown area



Source: Vancouver Fraser Port Authority

1.3.2. Slowdown speeds

For simplicity of communications, the 2021 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, vehicle carriers and container vessel operators were encouraged to transit the slowdown area at 14.5 knots or less speed through water. Bulkers, tankers and government vessel operators were asked to transit at 11 knots or less speed through water, which is half a knot slower than the 2020 target speed for the Swiftsure Bank slowdown area.

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 at the target speeds of 14.5 and 11 knots was estimated to add between 10 and 29 minutes to the total transit time, depending on the vessel type. These calculations are based on vessels using the longer route (20 nautical miles) via the southern exit and represent worst case delays.

Table 1: Predicted average increases in transit time due to 2021 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)
Bulker	11	12.0	10
Car carrier	14.5	16.7	13
Container	14.5	16.6	13
Passenger	14.5	20.3	29
Tanker	11	13.5	23

1.3.3. Start and end dates

The Swiftsure Bank slowdown began on June 1 and continued until October 31, 2021. The 2021 slowdown was two months longer than the 2020 slowdown trial, which ran between August and October.

The start and end of the slowdown was communicated to mariners through a Navigational Warning (NAVWARN) from Canadian Coast Guard and a Marine Safety Information Bulletin and Notice to Mariners from the US Coast Guard. Key partners, Canadian and US shipping associations and agents, and Canadian and US pilots were informed of the slowdown start via the ECHO Program newsletter distribution list and webpage.

2. Implementation

The implementation of the voluntary vessel slowdown required the preparation and distribution of information, communication and engagement with stakeholders, the use of Automatic Identification System (AIS) data to monitor vessel participation, and hydrophones to monitor underwater noise. The following sections provide further details on the implementation of the 2021 voluntary vessel slowdown.

2.1. Engagement and communications

The ECHO Program advisory working group convened five times in 2021 to share input and advice during the development, implementation, and evaluation phases of the slowdown. The ECHO Program vessel operators committee convened five times throughout the year to assist in the development of parameters for the 2021 slowdown and support monitoring of participation.

A list of the advisory working group and vessel operators committee members can be found here.

Several communication tools including background documents, maps, presentations and a webpage were developed and made available to raise awareness about the 2021 voluntary vessel slowdown. An instructional handout was also prepared for ship crew. The handout described the slowdown instructions in English and was also translated into eight languages including Chinese (simplified and traditional), French, Greek, Japanese, Korean, Spanish, and Tagalog. Email newsletters from the ECHO Program were sent bi-weekly throughout the slowdown to provide updates on whale presence and participation rates.

Certificates of appreciation and letters of thanks were provided to each organization that supported, or participated in, the 2021 ECHO Program initiatives.

2.2. Monitoring

Automatic Identification System (AIS) data provided by Canadian Coast Guard includes information such as vessel type, name, speed over ground and draught on each AIS-enabled vessel transiting the slowdown area. These data, corrected to speed through water using a tidal current model, were used by JASCO Applied Sciences to calculate speed through water for each vessel pass. These speed through water values were used to evaluate participation in the Swiftsure Bank voluntary vessel slowdown.

Fisheries and Oceans Canada has maintained autonomous hydrophones at Swiftsure Bank since 2018, which are typically retrieved and redeployed approximately every three months (with some deviation in timelines due to COVID-19). The DFO hydrophone used to monitor ambient noise before and during the slowdown was located below the outbound shipping lane at an approximate depth of 75 metres as shown on Figure 1.

To better understand the presence and behaviour of whale species in both Swiftsure Bank and the Strait of Juan de Fuca, the ECHO Program supported Pacheedaht First Nation to undertake marine mammal observations in both regions between June and November 2021. The results of these monitoring activities are described in the sections below.

3. Evaluation and results: industry participation

The Swiftsure Bank slowdown evaluated both intent to participate as well as the achievement of speed through water (STW) targets by outbound vessels.

3.1. Intent to participate by company

Prior to, and during the slowdown period, shipping associations and shipping agents disseminated communication materials about the Swiftsure Bank slowdown to their members and encouraged participation. Canadian and U.S. ship owners and operators transiting the area were asked to confirm their intent to participate in the voluntary slowdown. A list of the companies who confirmed their intent to participate in the slowdown can be found in Appendix A.

3.2. Intent to participate by transit

Although the Swiftsure Bank slowdown is in non-piloted waters, learnings from the Haro Strait and Boundary Pass slowdown indicate that the pilot is extremely valuable in supporting clear communications with international masters and crew.

Prior to disembarking outbound vessels, both the BC Coast Pilots and Puget Sound Pilots described the Swiftsure Bank slowdown to the master and crew, distributed the translated instructional handout, and requested the master's intent to participate.

The BC Coast Pilots and Puget Sound Pilots then communicated the vessel's intent to participate or not with their respective Coast Guards. Canadian and US 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 Systems (MCTS) collated and relayed the following information to the ECHO Program via an online data collection tool:

- Vessel name
- Date and time of transit
- Was the vessel aware of the slowdown?
- Did the vessel intend to participate in the slowdown?
- Based on a high-level review of AIS and radar data, did it appear as though the vessel participated?

Prince Rupert MCTS recorded a vessel's intention to participate or not for 1,512 of the total 1,973 vessel transits (76%). Of these 1,512 transits, 1,344 captains (89%) expressed their intent to participate in the slowdown trial.

Table 2: Intent to participate responses by vessel type

Vessel Type	Expressed an intention to slowdown	
Bulker	90%	546 of 608
Car Carrier	81%	116 of 144
Container	89%	361 of 406
Tanker	92%	183 of 198
Passenger	91%	81 of 89
Other	85%	57 of 67
All Vessels	**89%**	**1,344 of 1,512**

3.3. Calculated vessel speeds and participation rates

Speed through water (STW) is used to evaluate slowdown participation. Canadian Coast Guard provided AIS data which included vessel position and speed over ground for each AIS-enabled vessel transiting the slowdown area. Using several locations from the DFO 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 STW value. A mean STW value was then calculated on a per-transit basis over the entire slowdown area.

Owing to the momentum of the vessel combined with tidal currents and wind, the STW 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.

For each transit, mean STW values were compared to the speed targets for each vessel category. Based on the mean STW values, 81% (1,589 of 1,973) of all vessels were able to transit within 1 knot of their respective target speeds. Fifty nine percent (1,156 of 1,973) of vessels were able to transit at or below the target speed for their vessel type.

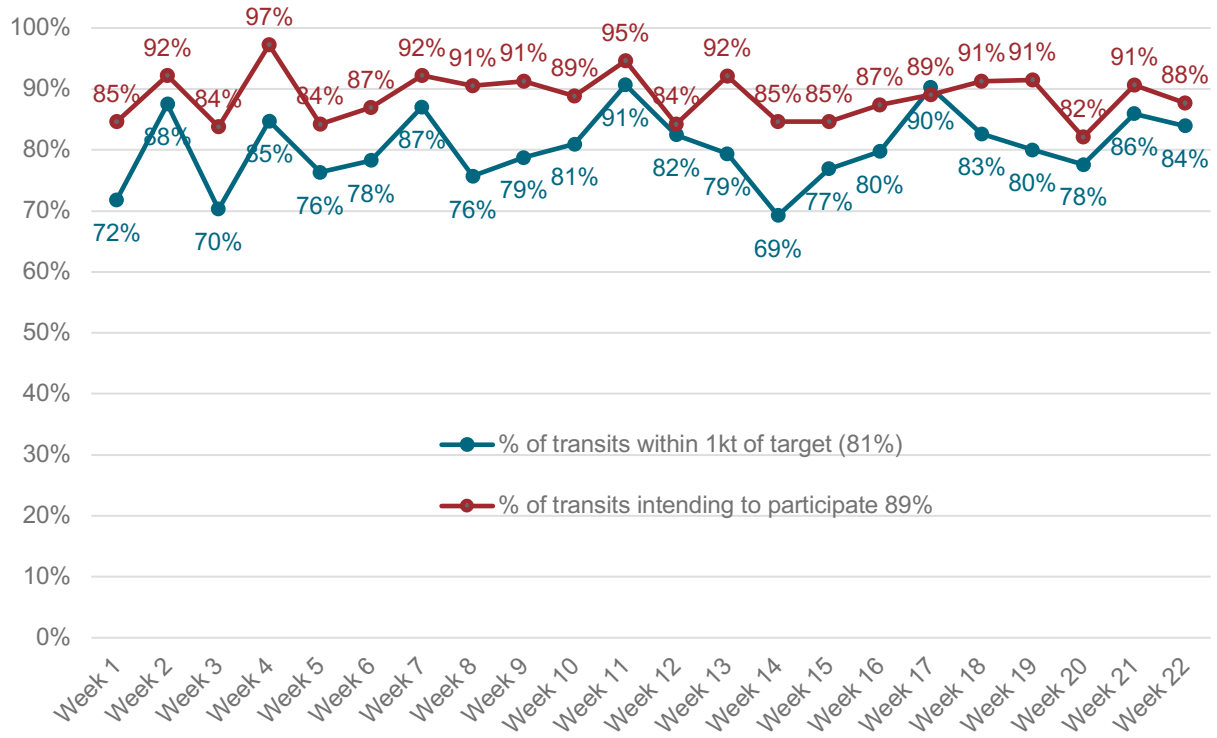
Table 3 provides details of the STW achievement rates by vessel type. Figure 2 provides an overview of how the calculated STW participation and the transit intent to participate rates varied by week.

Table 3: Calculated speed through water participation by vessel type

Vessel Type	Swiftsure Bank slowdown trial participation	
	Met speed through water target within 1 knot	Met speed through water target
Bulker	571 of 733 (78%)	375 of 733 (51%)
Vehicle Carrier	118 of 163 (72%)	97 of 163 (60%)
Container	421 of 498 (85%)	357 of 498 (72%)
Passenger	84 of 101 (83%)	62 of 101 (61%)
Tanker	196 of 228 (86%)	124 of 228 (54%)
Other	199 of 250 (80%)	141 of 250 (56%)
All Vessels	**1589 of 1973 (81%)**	**1156 of 1973 (59%)**

Prince Rupert MCTS captured data on the vessel's most recent port of call prior to transiting outbound through Swiftsure Bank, either Canada or US. Where vessel origin could be determined, a slightly higher percentage of vessels participated within one knot of the target speed after departing a Canadian port of call (83%) versus vessels departing from a US port of call (80%).

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



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

3.4. Speed reductions

Mean vessel speed over a 10 nautical mile control area in the Strait of Juan de Fuca, leading up to the slowdown transition area, was compared to the mean achieved speeds in the Swiftsure Bank slowdown area. This analysis was undertaken for all 1,973 outbound vessels with valid AIS vessel tracks, regardless of whether the vessel expressed an intent to participate.

All vessel types showed a reduction in mean speed within the slowdown area compared to the control area, with passenger vessels demonstrating the greatest reduction, achieving an average 3.7 knot speed reduction. On average, vessels transited 1.7 knots slower in the 2021 slowdown area compared to the control area as shown in Table 4. The average reduction seen in 2020 was 1.4 knots. The improvement seen in 2021 is due in part to the reduced target speed through the water from 11.5 knots to 11 knots for the slower vessel types, however the average speed overall was 0.2 knots lower in 2021.

Table 4: Change in mean speed through water by vessel type during slowdown

Vessel type	AIS transits	Mean speed through water (knots)		Speen reduction (knots)
		SJDF control area	Swiftsure Bank slowdown area	
Bulk Carrier	733	12.1	11.1	1.0
Vehicle Carrier	163	17.1	14.6	2.5
Container	498	15.6	13.7	1.9
Passenger	101	17.7	14.0	3.7
Tanker	228	12.9	10.8	2.1
Other	250	11.9	10.9	1.0
All vessels 2021	**1,973**	**13.8**	**12.1**	**1.7**
All vessels 2020	1,044	13.7	12.3	1.4

4. Evaluation and results: acoustics

The potential acoustic benefit of the Swiftsure Bank slowdown was intended to be evaluated using a hydrophone deployed beneath the outbound shipping lane in the Swiftsure Bank slowdown area (Figure 1). This hydrophone was deployed by Fisheries and Oceans Canada and has been collecting data on a near-continuous basis (with some COVID-19 related service disruptions) since 2018. The results analyzed for this, and other underwater noise reduction initiatives conducted in the Salish Sea in 2021, will be presented in a technical report to be published by DFO in the fall of 2022. Recorded noise levels from the hydrophone were provided to the Vancouver Fraser Port Authority for review, and acoustic information is discussed below.

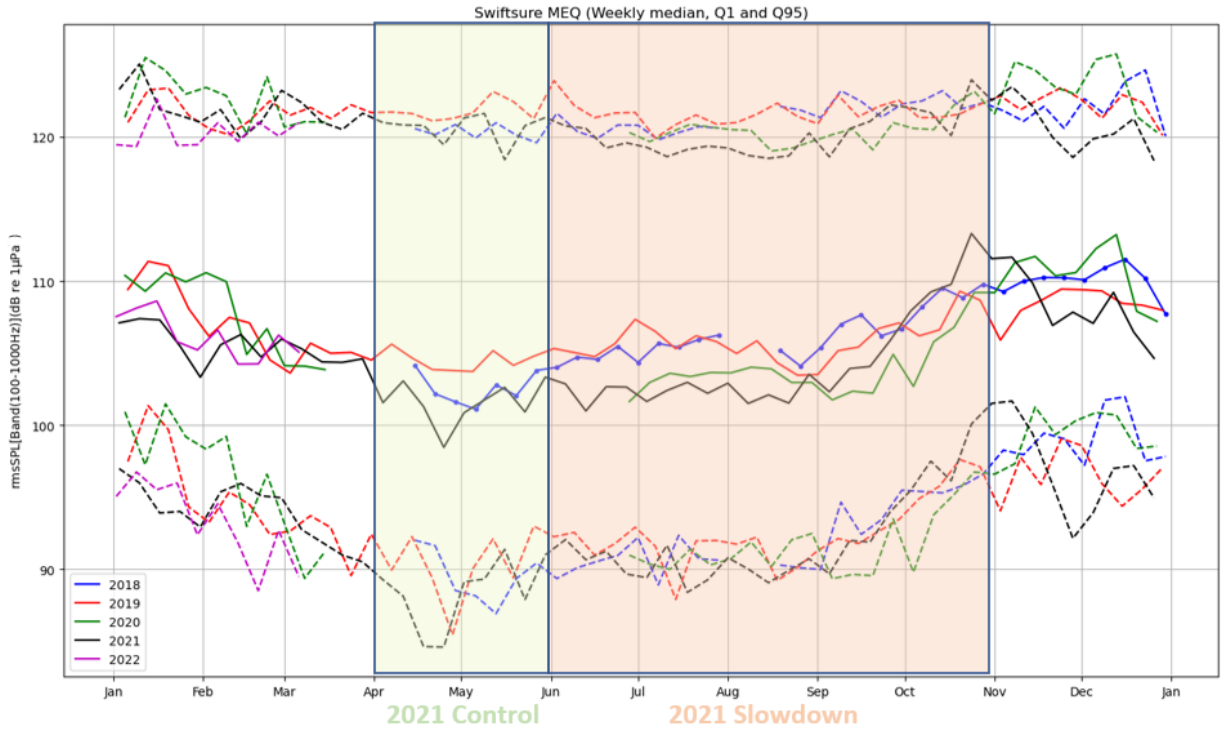
Evaluation of the Swiftsure Bank slowdown trial in 2020 (Burnham et al., 2021) included comparison of noise levels during the slowdown (August to October 2020) against a control period of late June and July 2020. These results indicated a broadband noise reduction of approximately 2 dB during the 2020 slowdown trial. The 2021 slowdown anticipated similar noise reduction results.

In 2021, the slowdown began on June 1 and continued through to October 31, with a control period of April-May 2021. Contrary to expectations, initial evaluation of acoustic results indicated that noise levels increased at the Swiftsure Bank hydrophone over the course of the 2021 slowdown, when compared to the control period. Noise levels, particularly in the lowest frequency bands, increased steadily each month from April through to November. Further investigation of these results is underway. As a first step to evaluate this unexpected result, a plot of weekly sound pressure levels collected from initial deployment of this DFO hydrophone under the outbound shipping lane in April 2018 to the most recent retrieval in March 2022 was conducted. Figure 3 provides a plot of these data for the frequency range of 100 – 1,000 Hz (a range normally indictive of vessel traffic) with each year of the deployment displayed in a different colour.

In Figure 3, the root mean squared sound pressure level received at the hydrophone, measured in dB re 1 µPa is plotted on the Y axis, and the month of each year is plotted on the X axis. The highest dotted lines are the Q95 levels (the 5% noisiest sound levels), the solid lines represent the median or 50% sound levels, and the lowest dotted lines represent the Q1 levels (quietest 1% sound levels). Of note is the seasonal variation in these sound levels over each year, where noise levels are lowest in April/May, somewhat level from June through August, then begin to increase through September and October, peaking in the winter months of November through January, before decreasing again in the spring. These seasonal sound level fluctuations were seen in the majority of frequency ranges, for all years measured,

regardless of whether an ECHO Program voluntary vessel slowdown was in place. Of note, Figure 3 also indicates that for the two years for which slowdowns were in place (2020 in green, and 2021 in black), median and Q95 noise levels were lower than in the years there was no slowdown in place (2018 in blue and 2019 in red).

Figure 3: DFO hydrophone sound pressure levels for 2018-2022 – frequency range 100-1,000 Hz



Source: Fisheries and Oceans Canada, modified to show control and slowdown periods

Further understanding of the seasonal fluctuations in noise levels measured at the Swiftsure Bank hydrophone will be required before a determination of the acoustic benefits of the slowdown can be evaluated. Factors which could be contributing to these seasonal fluctuations may include: water temperature and salinity affecting how sound travels from the ship to the hydrophone in winter versus summer; weather effects contributing to higher noise levels in winter (wind, rain, wave); the relationship between current and received noise at the hydrophone; and potential changes in vessel traffic density and routes (closer transits to the hydrophone increase received sound levels). Such seasonal variations may indicate that the selection of a spring “control” period may not be appropriate for evaluating the acoustic benefits of the voluntary vessel slowdown at Swiftsure Bank.

The location of the hydrophone in the outbound shipping lane at Swiftsure Bank, positioned on a bathymetric high where the open ocean meets the mouth of the Strait of Juan de Fuca, poses significantly different acoustic conditions than those of the confined waters of the ECHO Program slowdowns in Haro Strait and Boundary Pass. These differences indicate that the methods of evaluating the acoustic benefits of the slowdowns in Haro Strait and Boundary Pass, may not be appropriate for Swiftsure Bank. Fisheries and Oceans Canada and the ECHO Program will continue to work together to investigate how best to evaluate the acoustic benefits of the slowdown in this unique area.

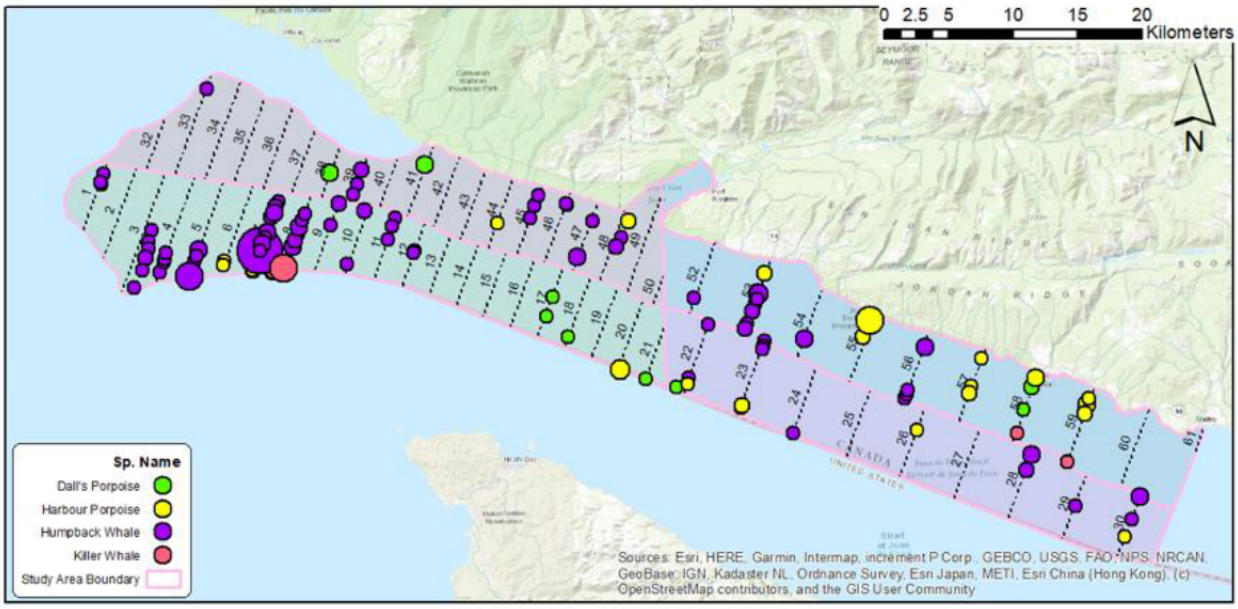
5. Evaluation and results: marine mammal presence

In both 2020 and 2021, Pacheedaht First Nation, in collaboration with the ECHO Program and consultants Seaview Marine Sciences and SMRU Consulting, gathered marine mammal observations in the Strait of Juan de Fuca and Swiftsure Bank during the Swiftsure Bank slowdown. ECHO Program consultants provided in-person marine mammal observer training to the Pacheedaht First Nation crew and designed a detailed 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 61 line transects.

For the 2021 Swiftsure Bank slowdown season, the *Seafoam Spirit* crew undertook 27 marine mammal observation field excursions for a minimum of 68 hours of survey transects between June and October 2021. The crew recorded 79 sightings of an estimated 128 animals, two of which were killer whales and were observed on two separate occasions. During both sightings of killer whales, the ecotype could not be determined. Humpback whales were the most frequently observed animal during the study, followed by harbor porpoise.

Figure 4 shows all the cetacean sightings observed during line transect surveys undertaken by the Pacheedaht First Nation crew in both 2020 and 2021. Due to low SRKW sightings in 2021, both 2020 and 2021 data is included in Figure 4. The different sizes and colours of circles shown on Figure 4 represent the number of sightings recorded, by species. The complete report on marine mammal surveys and observations (Hall et al., 2022) can be found in Appendix B.

Figure 4: Cetacean sightings by Pacheedaht First Nation crew – combined 2020 and 2021

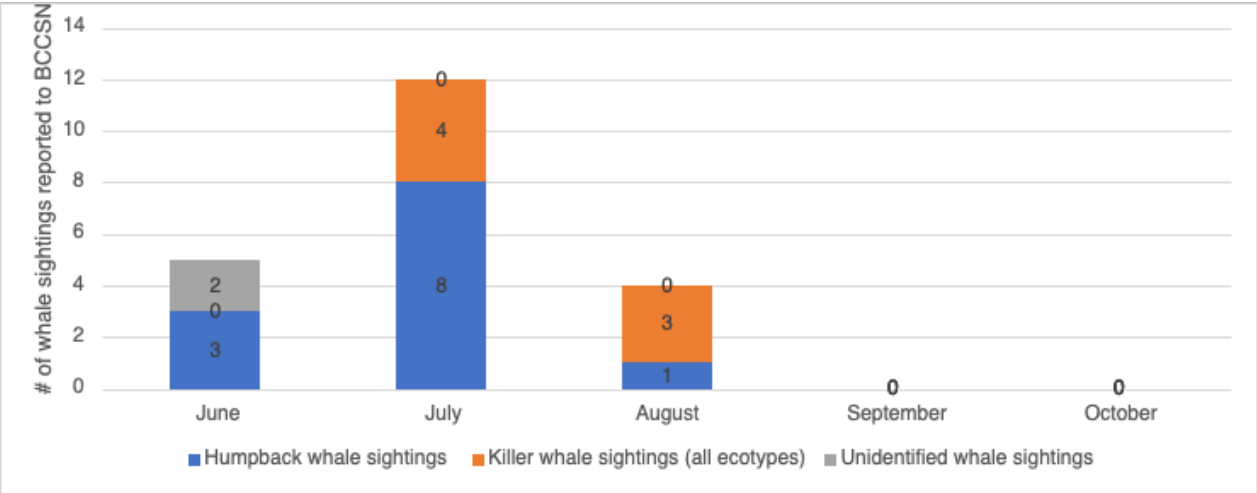


Source: Seaview Marine Services/ SMRU Consulting

The number of marine mammal sightings in 2021 is a notable reduction in sightings from 2020, despite almost double the survey hours. For comparison, in 2020, there were 17 sightings of killer whales, 4 of which were confirmed to be SRKW. In 2021, of the killer whales visually sighted, none were confirmed to be SRKWs. It should be noted that an absence of observations does not necessarily indicate an absence of whales in the area. Several recommendations are provided in Appendix B to modify the survey plan in future years to increase the focus on detecting killer whales, including increasing survey effort on the western portion of the survey area in 2022.

In addition to the Pacheedaht First Nation study, the B.C. Cetacean Sightings Network (BCCSN) collects citizen scientist reports of opportunistic whale sightings. Between June 1 and October 31, 2021, the BCCSN received 21 reports of humpbacks, killer whale and unidentified whale species sightings in the Swiftsure Bank area. Based on these citizen science reports, an estimated 265 individual cetaceans were observed. Figure 5 shows a breakdown of the sightings by month and by species.

Figure 5: Cetacean count from B.C. Cetacean Sightings Network – Swiftsure Bank 2021



Source: Ocean Wise Research Institute and Fisheries and Oceans Canada. Data not corrected for observer effort. Used with permission.

Of the estimated 265 marine mammals reported to the BCCSN, about 75% of these individual whales observed were killer whales (198 of 265) and about 55% of them were reported to be southern resident killer whales (143 of 265). 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.

6. Key findings and conclusions

The 2021 Swiftsure Bank slowdown parameters were developed by working closely with members of the ECHO Program's advisory working group and vessel operators committee, and the slowdown was coordinated and managed by the ECHO Program team. The slowdown was conducted between June 1 and October 31, 2021, over an approximately 20 nautical mile area over Swiftsure Bank, key foraging habitat for southern resident killer whales. The goal of the 2021 slowdown was to reduce underwater noise and provide benefit to SRKW in this important feeding area.

The key findings of the 2021 voluntary vessel slowdown are:

- 81% of all outbound transits came within one knot of the vessel-specific speed through water targets
- Significant scientific evidence indicates that deep sea vessels are quieter when they slow down. Seasonal fluctuations in sound levels at the DFO hydrophone located under the outbound shipping lane over Swiftsure Bank, however, require further investigation before a true assessment of the benefit to ambient noise resulting from the Swiftsure Bank slowdown can be evaluated.
- Between June and October 2021, 27 marine mammal observation field excursions totaling 68 hours of survey transects were undertaken and, marine mammal observers recorded 79 sightings of an estimated 128 animals, two of which were killer whales that were observed during two separate events.

The following conclusions and recommendations are made regarding the 2021 slowdown at Swiftsure Bank:

- High transboundary voluntary participation rates were achieved in these non-piloted waters despite the uncertainties of the global COVID-19 pandemic
- Assessment of underwater noise using a spring control period compared to the summer/fall slowdown period may not be an appropriate means of evaluating acoustic benefits of the slowdown over Swiftsure Bank.
- Additional investigation is recommended to understand natural seasonal fluctuations in sound levels in order to properly quantify the potential benefit of the slowdown to ambient noise.

7. References

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Appendix A

List of organizations that confirmed their intent to participate in the ECHO Program's 2021 Haro Strait and Boundary Pass slowdown

ACGI Shipping Inc.
Amix Marine Services
Canpotex Shipping Service
CMA CGM
Colley West Shipping Ltd
COSCO Shipping Lines (Canada) Inc.
CSL Americas
Evergreen Shipping Agency (America) Corp
Fairmont Shipping (Canada) Ltd
Fednav Limited
Fisheries and Oceans Canada
G2 Ocean
GFY Marine Group Inc.
Hapag-Lloyd
HMM America Shipping Agency, Inc.
Kirby Offshore Marine
LBH Shipping Canada Inc.
Ledcor Resources & Transportation
Maersk Line
Mason Agency Ltd.
Mclean Kennedy Inc.
MOL (Americas) LLC
MOL Chemical Tankers
MOL Chemical Tankers America Inc
MONTSHIP INC.
MSC Geneva S.A.
MSC MEDITERRANEAN SHIPPING COMPANY
Navitrans Shipping Agencies West Inc.
Neptune Bulk Terminals (Canada) Ltd.
Nickel Bros Industrial Ltd
"K" Line
NOAA Olympic Coast National Marine Sanctuary
NORTON LILLY
Oak Maritime
Ocean Network Express (Canada) Inc
Ocean Network Express Inc
Oldendorff Carriers
OOCL (CANADA) INC
Pacific Basin Shipping (Canada) Ltd.
Pacific Northwest Ship & Cargo Services
Pinnacle Renewable Energy
Ravensdown Shipping Services Pty Ltd
RCI
Robert Reford
SAAM Towage
Saga Welco AS
Saturna Cetacean Sighting Network
Seaspan ULC
Seaward Engineering and Research LTD.
Swire Bulk Pte Ltd
Teekay
Trans Mountain
Ocean Tugs
Trans-Oceanic Shipping
V.Ships USA LLC (Boston)
Valles Steamship (Canada) Ltd
VANCOUVER ISLAND AGENCIES
Varamar Group
SM Line Corporation
Westward Shipping Ltd
Westwood Shipping Lines
Wheelhouse Shipping Agency Ltd.
Wilhelmsen Ships Service
Yang Ming Shipping(Canada) Ltd.
Zim Integrated Shipping Services

Appendix B

Marine Mammal Survey 2021- Pacheedaht First Nation and ECHO Program

Marine Mammal Survey 2021
Pacheedaht First Nation and ECHO Program

Prepared for the ECHO Program

[February, 2022]

SMRU Consulting North America

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Canada

Marine Mammal Survey 2021
Pacheedaht First Nation and ECHO Program

February 2022

Prepared by Sea View Marine Sciences and SMRU Consulting NA

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Hall, A., Carrières C., Ogilvie, M., Harris, A., Hall, C., Gatzke, K., Tollit, D. 2022. Marine Mammal Survey 2021 - Pacheedaht First Nation and ECHO Program. Prepared by Sea View Marine Sciences and SMRU Consulting NA for Vancouver Fraser Port Authority. 51p.

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Acknowledgements

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1 Introduction

Northeast Pacific southern resident killer whales (*Orcinus orca*) are one of four populations of killer whales that inhabit the Pacific waters of British Columbia (BC). These whales inhabit both Canadian and United States (US) waters. Throughout the year, southern resident killer whales range from California to Alaska but spend much of their time in the inland waters of BC and Washington State. The transboundary region of these inland waters is 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 45 years. As of 1 July 2021, there were 74 southern resident killer whales (CWR 2021a). This community is composed of three pods known as J (N=24), K (N=17), and L (N=33) (CWR 2021a). They were listed as *Endangered* under the Species At Risk Act in 2003 in Canada (GoC 2021), and the Endangered Species Act in the USA in 2005 (NOAA 2021a).

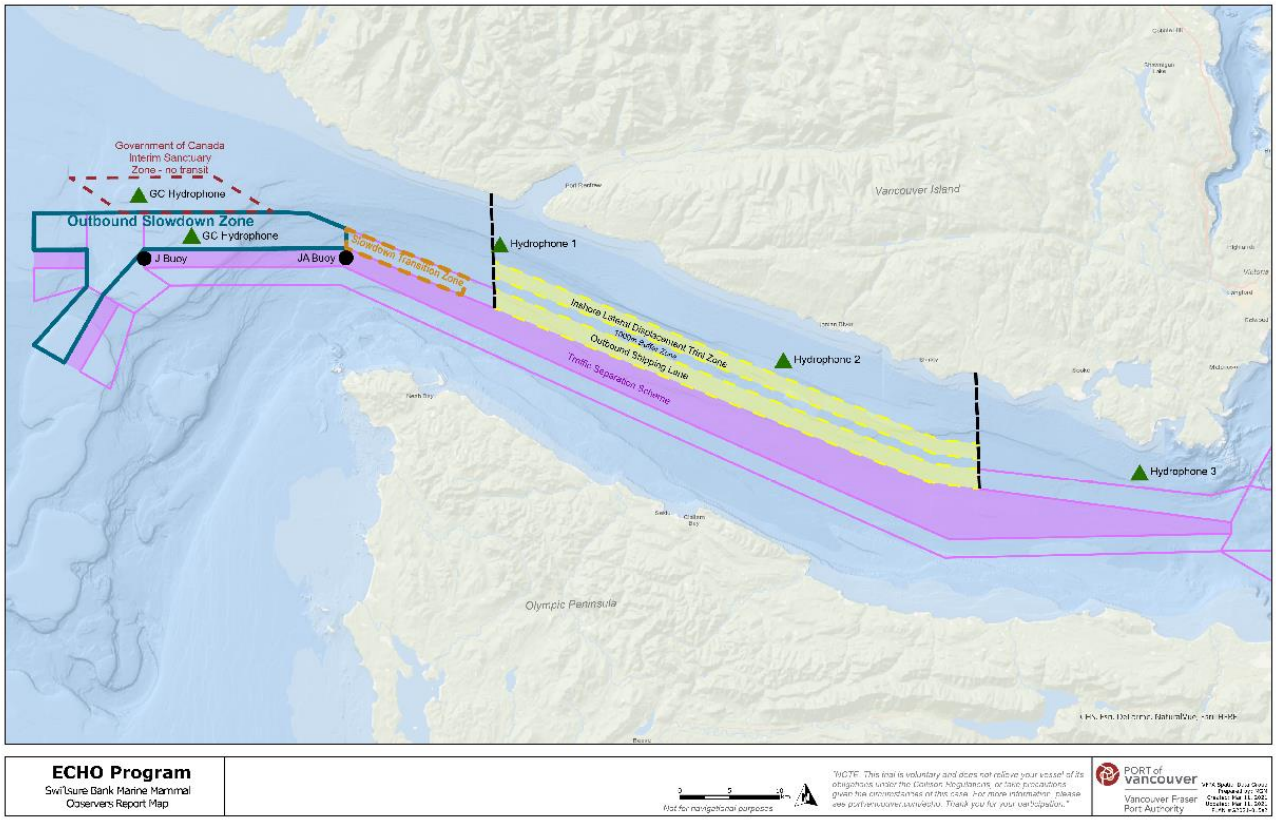
The international focus on this endangered population prompted conservation actions in both Canada and the US. These actions have been focussed on addressing the known threats which have been recognised to include (in no particular order): environmental contamination, underwater anthropogenic noise, physical disturbance from boats, and reduced availability or quality of prey, in particular their preferred prey, chinook salmon (*Oncorhynchus tshawytscha*) (DFO 2017b). Management measures implemented in Canadian waters of the Salish Sea included fishery closures, implementation of Interim Sanctuary Zones in the Gulf Islands and at Swiftsure Bank, and mandatory vessel approach distances (DFO 2020, DFO 2021). 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 1.2). Conservation measures have also been enacted in the US, including implementation of Recovery Plan actions (NOAA 2021b), development of the National Oceanic and Atmospheric Administration (NOAA) Fisheries - Species in the Spotlight 5-Year Priority Action Plan (NOAA 2021b), and a new Washington State Governor's Task Force directed to identify immediate and long-term actions to benefit southern resident killer whales (NOAA 2021b).

While conservation actions were implemented with the goal of reducing some of the known threats to individual, and subsequently population survival, it was also recognised that spatial and temporal gaps in scientific understanding remained. Spatial and temporal gaps are most prevalent along the Pacific coasts of California, Oregon, Washington, and in Canada within the westernmost regions of the Salish Sea. The westernmost region of the Salish Sea lies within Juan de Fuca Strait which connects the inland waters of Washington and British Columbia to the open Pacific Ocean (Figure 1). At approximately 156 kilometres (km) in length (Thomson 1991), the strait provides increasingly sheltered passage from the expanse of the Pacific Ocean to coastal regions for whales and ships alike. The western extent is a remote expansive channel with increasing depths that are 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 1991). The western Salish Sea 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 Juan de Fuca Strait 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 is not well understood, but likely includes foraging, 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 scientific knowledge for this region, the species diversity of this region is well understood.

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. 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 Juan de Fuca Strait 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 2021 field season.

Figure 1. Juan de Fuca Strait and Swiftsure Bank region with Traffic Separation Scheme, DFO hydrophones and boundaries of the 2021 ECHO Program noise reduction measures, including the voluntary slowdown zone in the outbound traffic lane that crosses onto Swiftsure Bank.



Objectives

The objective of the 2021 effort was to build upon the initial marine mammal distribution study conducted in 2020, and to better understand marine mammal presence and habitat use, with a focus on southern resident killer whales in the western Strait of Juan de Fuca (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 whale's critical habitat.

1.1 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 Juan de Fuca Strait (Figure 1). This slowdown was conducted in an attempt to reduce acoustic disturbance from large commercial vessels in key southern resident killer whale feeding areas. In 2017, the ECHO Program led a research trial to evaluate how slowing vessels down might decrease underwater noise and how this could potentially affect the behaviour and foraging of southern resident killer whales in Haro Strait.

The Haro Strait trial found that reducing vessel speed was an effective way of reducing underwater vessel noise as well as reducing the total underwater noise in nearby habitats which may ultimately be a benefit to the foraging success for southern resident killer whales (ECHO 2018), as well as other marine mammal species. In addition to the 2020 voluntary vessel slowdown research trial in the Swiftsure Bank area, another voluntary inshore lateral displacement initiative for tugboat operators was also conducted in the Strait of Juan de Fuca. These two initiatives were a continuation of the ECHO Programs' efforts which collectively 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 2021a). The ECHO Program also supports other threat-reduction projects for whales in BC related to reducing physical disturbances and environmental contaminants (ECHO 2021a). ECHO Program conservation actions related to southern resident killer whales continued in 2021.

The voluntary Swiftsure Bank slowdown and the Juan de Fuca Strait lateral displacement was in effect from 1 June 2021 through to 31 October 2021 (ECHO 2021b). The Swiftsure Bank Slowdown requested that large commercial ships transiting outbound from Juan de Fuca Strait voluntarily slow the vessels speed during the transit from the JA Buoy to the end of the traffic separation scheme (Figure 1) – a distance that ranged from 17 – 20 nautical miles (32 – 37 km) (ECHO 2021c). The recommended vessel speed targets were:

- 14.5 knots or less through the water for vehicle carriers, cruise ships and container vessels
- 11 knots or less through the water for bulkers, tankers and government vessels (ECHO 2021).

In addition to the voluntary slowdown trial, there was also an effort to further reduce underwater noise in proximity to killer whale habitats from tugboats. The Juan de Fuca Strait inshore lateral displacement initiative aimed to reduce underwater noise by increasing the distance between killer whales and tugboats. Tugboats transiting in the Canadian inshore area of Juan de Fuca Strait 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 2021b). Tugboats were encouraged to participate whether or not they were engaged in towing a barge (ECHO 2021b).

The ECHO Program was also seeking to better understand the presence and behaviour of other whale species at both Swiftsure Bank and in western Juan de Fuca Strait. The ECHO Program partnered with Pacheedaht First Nation, near Port Renfrew, to help achieve this goal. The focus of this effort at Swiftsure Bank and in western Juan de Fuca Strait was on 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 second year of marine mammal surveys and combines systematic survey data collected during the first year of this partnership (see Hall et al. 2021).

1.2 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 Juan de Fuca Strait 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 2020, and as a new course for new participants in 2021. 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 2020 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, interim sanctuary zone, and whale hot spot areas.

The marine mammal survey was based on the Distance-based stratified survey design of 2020, 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 study, the survey area was divided into four strata.

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 2021, 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 (QA & QC). 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 2021 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 six members and representatives of the Pacheedaht First Nation on 2-3 June 2021 and 16 June 2021. The training was based on 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 Soule Creek Lodge in Port Renfrew, British Columbia on 2-3 June 2021. The at-sea components were held on 16 June 2021 aboard the Pacheedaht First Nation's vessel the *Seafoam Spirit* in Juan de Fuca Strait (Figure 1).

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, Interim Sanctuary Zones, 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

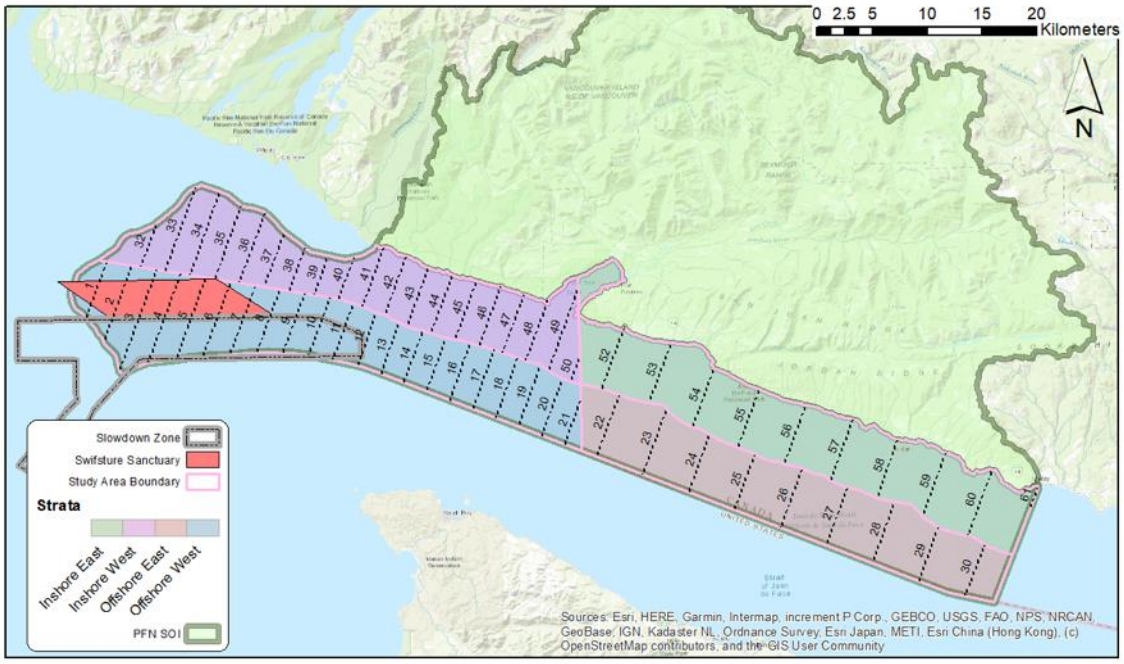
The at-sea component provided an opportunity to implement the training module information into practice during marine mammal sightings, data collection, reporting, and field practices that in 2021 also included COVID-19 safety protocols. The at-sea component included theoretical and practical components 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. Four 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 2021.

Task 2 – Marine mammal survey

The marine mammal survey of 2021 used the same Distance-based stratified survey design as in 2020 (Hall et al. 2021) 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 Statement of Interest (SOI) in four strata (Figure 2) and took into account potential safety aspects regarding survey designs that include commercial shipping lanes, the Interim Sanctuary Zone, whale hot spot areas and vessel etiquette for other researchers that may be operating in the same region.

As in 2020, the goal following stakeholder input 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 2021 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.

Figure 2. 2021 Marine mammal survey design for the Pacheedaht marine territory in the Statement of Interest and other key features.



As previously described for the 2020 marine mammal survey (Hall et al. 2021), the 2021 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 Juan de Fuca Strait), Offshore east (Offshore east stratum in Juan de Fuca Strait), Inshore west (Inshore west stratum in Juan de Fuca Strait and the northern waters of Swiftsure Bank area) and Offshore west (Offshore west stratum in Juan de Fuca Strait 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 strata (Inshore east, Offshore east, Inshore west, and Offshore west) (Figure 2).

The study area intersected with the regions demarcated for the ECHO Program inshore lateral displacement area and Swiftsure Bank Slowdown Trial area, the Transport Canada ordered Interim Sanctuary Zone at Swiftsure Bank and the Transport Canada separation scheme for inbound and outbound deep-sea traffic (Figures 1 and 2).

The study area encompassed 1038.6 square kilometres (km^2) of western Juan de Fuca Strait 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. The field notebook information was cross-referenced with the captains' logbook in order to determine specific details of the timing of the daily work schedule (e.g., daily departure and arrival times).

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 2021, 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 photographs 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 2021 field season based on feedback from the Pacheedaht field team communicated during in-person meetings. Communication was maintained via email, phone, text, and in-person visits in Port Renfrew, Metchosin, and View Royal, BC throughout the field season. Weekly communications included: weather forecasts, tentative survey schedules, survey sightings, field equipment, and data recording. Two additional in-person meetings were held at the Pacheedaht First Nation Office on 26 July and 23 November 2021, and an additional in-person meeting was held in View Royal on 9 November 2021, with the field crew and the Sea View Marine Sciences team. A third meeting was planned for late 2021 at the Pacheedaht First Nation but had to be rescheduled several times due to extreme weather events and road closures.

Task 4 - Data analysis and reporting.

Transect data recorded in Transect Pro software (Wernicke and Hall 2015), and provided by the Porpoise Conservation Society were uploaded to the shared Google Drive. Daily database files were downloaded and exported to MS Excel for review and analysis. Marine mammal location data were visualised in ArcGIS 10.7.1. The data were compiled and summarised for reporting (see Section 3).

Photographic data were uploaded to the shared OneDrive by the Pacheedaht field team members and downloaded by 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 processed using photo-identification to identify ecotype and individual when possible. Any potential southern resident killer whales were compared to the Centre for Whale Research Orca Survey Guide, previous Sea View Marine Sciences photographs and on-line photographs (e.g., CWR 2021b) for individual whale identification.

3 Results

3.1 Field Effort

The 2021 marine mammal field effort was conducted with line transect surveys conducted 19 June – 8 October 2021, during which time a total of 280 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 1584.3 km, for a minimum on-effort time duration of 68.2 hours (h). Based on the captains' logbook information, the total at-sea field team effort for the 2021 field season for both systematic line transect surveys and opportunistic data collection was 5591.6 km and 171.7 h at sea.

Twenty-three percent (n=65) of transects were undertaken in the Offshore west stratum (i.e., Swiftsure Bank), 34% (n=96) in the Inshore west (western Juan de Fuca Strait study area, while 16% (n=44) and 27% (n=75) of transects were completed through Offshore east and Inshore east strata (i.e., eastern Juan de Fuca Strait strata of study area), respectively. This apportioning of survey effort aimed to better balance the Inshore west strata under-sampled in 2020 (see Hall et al. 2021). The overall ratio of effort comparing western strata with eastern strata in 2021 was 1.35:1.

Table 1. Line transects completed during the 2021 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	3	21	5	42	6
2	3	22	6	43	6
3	3	23	5	44	5
4	3	24	5	45	6
5	3	25	6	46	6
6	3	26	4	47	6
7	3	27	4	48	8
8	3	28	5	49	8
9	3	29	4	50	9
10	3	30	5	52	10
11	3	32	3	53	9
12	3	33	3	54	5
13	3	34	2	55	8
14	2	35	1	56	8
15	3	36	1	57	7
16	3	37	1	58	7
17	3	38	7	59	7
18	3	39	6	60	7
19	3	40	6	61	7
20	4	41	6		

The 2021 field effort consisted of 27 field excursions that included either or both line transect surveys and opportunistic data collection. Several field excursions were terminated early or cancelled entirely due to illness, statutory holidays, weather changes, deteriorating sea conditions, and National Aboriginal Day. On four of 27 excursions, some data were compromised by technical issues related to the Global Positioning System (GPS) unit, nevertheless in total, 27 line transect surveys resulted in systematic (i.e., on-effort) marine mammal data (Table 2). Sixteen of the 27 on-effort days also resulted in the collection of opportunistic data (Table 2).

During the 2021 field season, each line transect was completed at least once (Table 1). This resulted in a completion rate of 100%, with Transects 1-30, 32-50, and 52-61 being conducted between one and ten times (i.e., replicates) during the 2021 field 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 field season.

In some cases, surveys were constrained by crew obligations, illness, and weather changes. Thus, the effort per excursion varied from two transect lines, when the field work was interrupted due to sea conditions or illness, to up to sixteen transect lines in multiple strata being completed in a single excursion (Table 2). More effort was expended in the inshore waters than the offshore waters, with both the eastern and western strata sampled throughout the June – October field season (Tables 1 and 2).

Table 2. 2021 Field excursion and systematic data collection summary.

Excursion Number	Date	Stratum	Transect Lines
1	19-Jun-21	Inshore West, Inshore East	38-50, 52-54
2	20-Jun-21	Offshore West	1-10
3	22-Jun-21	Inshore East	55-61
4	23-Jun-21	Offshore West, Offshore East	11-24
5	24-Jun-21	Offshore East, Inshore West, Inshore East	25-30, 48, 59-61
6	25-Jun-21	Offshore West	1-13
7	26-Jun-21	Offshore West, Offshore East	13-17, 19-25, 27-28
8	28-Jun-21	Inshore West	38-49
9	29-Jun-21	Inshore West, Inshore East	50, 52-56
10	5-Jul-21	Inshore West, Inshore East	38-50, 52
11	6-Jul-21	Offshore West, Offshore East	20-30
12	8-Jul-21	Offshore West	1-8
13	9-Jul-21	Offshore West, Inshore West	9-12, 38-48
14	13-Jul-21	Inshore West, Inshore East	49-50, 52-53, 55-58, 60-61
15	16-Jul-21	Offshore West, Offshore East	17-26, 28-30
16	30-Jul-21	Inshore West	32-34
17	4-Aug-21	Inshore West, Inshore East	49-50, 52-53, 57-61
18	5-Aug-21	Offshore West	15, 18
19	6-Aug-21	Inshore West	32-47
20	7-Aug-21	Offshore East, Inshore West, Inshore East	26-30, 48-50, 52-55
21	11-Aug-21	Offshore West, Inshore West, Inshore East	16, 42-59
22	17-Aug-21	Inshore East	55-61
23	18-Aug-21	Offshore West, Offshore East, Inshore East	21-22, 49-50, 52-53, 55-56
24	19-Aug-21	Offshore East, Inshore West, Inshore East	22-25, 30, 48, 55-61
25	13-Sep-21	Inshore West	32-33
26	22-Sep-21	Inshore West, Inshore East	50, 52-54, 56-61
27	8-Oct-21	Inshore West, Inshore East	38-43, 45-50, 52

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

3.2 Systematic Line Transect Data

A minimum of seven marine mammal species were observed during the on-effort component of the 2021 line transect surveys (Appendix B). These included California sea lions, Dall's porpoises, harbour porpoise, harbour seals, humpback whales, killer whales, and Steller sea lions (Appendix B). Pinniped data are not presented in this report, but the systematic and opportunistic data collected on pinnipeds are included in Appendices B and C.

A list of cetacean species sighted per week is summarized in Table 3, with five weeks of no effort during the 2021 field season, therefore no sightings.

Table 3 . Total number of cetacean species sightings summarized by week during line transect surveys June through October 2021.

Week Number	2021 Survey Dates	Number of Transects	DP	HP	HB	KW	Total Number Species
1	Jun 19-25	70	0	0	24	0	1
2	Jun 26-Jul 2	33	0	0	0	0	0
3	Jul 3-9	48	0	0	15	0	1
4	Jul 10-16	23	5	5	11	0	3
5	Jul 17-23	NA	NA	NA	NA	NA	NA
6	Jul 24-30	3	0	0	0	0	0
7	Jul 31-Aug 6	27	10	0	0	0	1
8	Aug 7-13	21	0	11	11	0	2
9	Aug 14-20	29	0	15	6	0	2
10	Aug 21-27	NA	NA	NA	NA	NA	NA
11	Aug 28-Sep 3	NA	NA	NA	NA	NA	NA
12	Sep 4-10	NA	NA	NA	NA	NA	NA
13	Sep 11-17	2	0	0	1	0	1
14	Sep 18-24	10	0	4	6	2	3
15	Sep 25-Oct 1	NA	NA	NA	NA	NA	NA
16	Oct 2-8	14	0	0	2	0	1
Total		280	15	35	76	2	

All transect data included.
DP – Dall's porpoise
HP – Harbour porpoise
HB – Humpback whale
KW – Killer whale
NA – Not Applicable as no field effort

A variety of different behaviours and species were observed during each day of the systematic on-effort survey in 2021, 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) (Appendix B). The duration of encounters was not recorded during the line transect surveys as the transect surveys were conducted in passing mode (i.e., the vessel proceeded along the survey line and did not deviate from the course when marine mammals were sighted). Similarly, a summary of vessels during each encounter was not recorded as the field teams' focus was on marine mammal data collection.

During the on-effort line transect surveys, there was a total of 79 cetacean sightings of an estimated 128 animals (Table 4). Of the 128 cetacean sightings, humpback whales were the most numerically abundant and most often encountered species in terms of the total estimated number of animals (n=76) and the number of sightings (n=51) (Table 4). Harbour porpoise and Dall's porpoise were the next most frequently observed cetaceans in terms of the estimated total numbers of animals and the number of sightings during the 2021 field season (Table 4). Killer whales were the least frequently observed cetacean with only two encounters during the on-effort component (i.e., line transects) of the 2021 field season (Table 4).

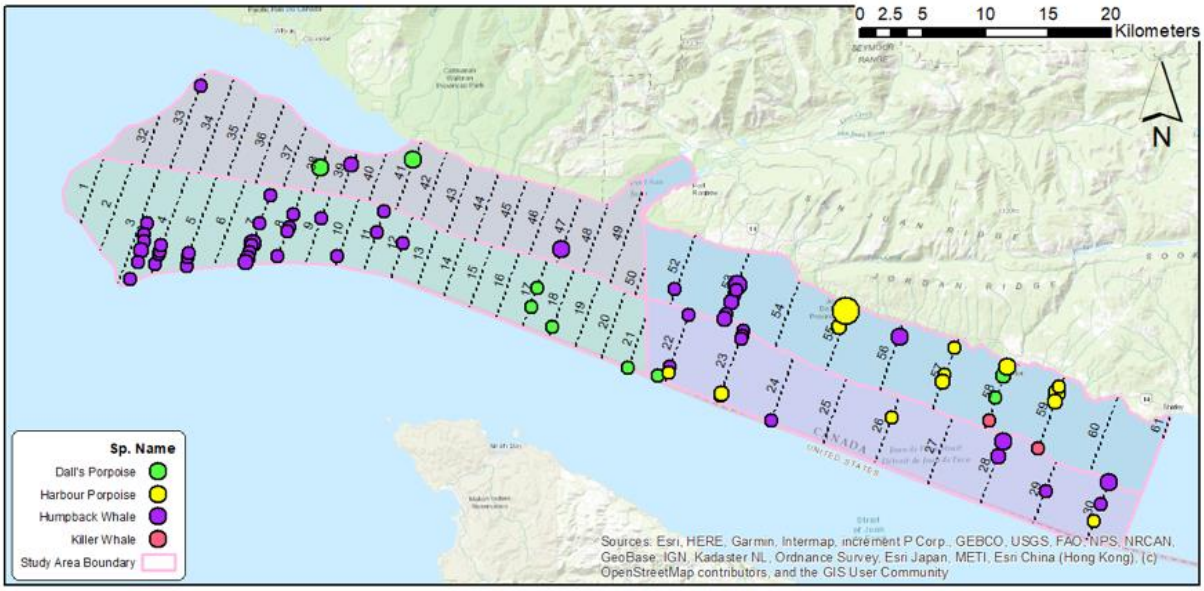
As noted, humpback whales were the most frequently encountered cetacean, with this species observed throughout the 2021 field season, though more sightings were recorded June through mid-August than the remainder of the survey season (Table 3). Killer whales were the least frequently encountered cetacean during the line transect surveys with only two occurrences of single animals (ecotype unknown) both observed on 22 September 2021 (Tables 3 and 4). The ecotype could not be determined in the field, and photographs were not available.

Table 4. Cetacean species line transect data summary with the estimated total number of animals observed and the total number of sightings per species 19 June through 8 October 2021.

Species	Estimated Total Number Animals	Total Number of Sightings
Dall's Porpoise	15	9
Harbour Porpoise	35	17
Humpback Whale	76	51
Killer Whale (Ecotype Unknown)	2	2
Total	128	79

Locations of on-effort cetacean line transect sightings data are presented in Figure 3. Humpback whales and Dall's porpoise were observed in all four strata, harbour porpoise and killer whales (ecotype unknown) were only observed on-effort in the eastern two strata (Figure 3).

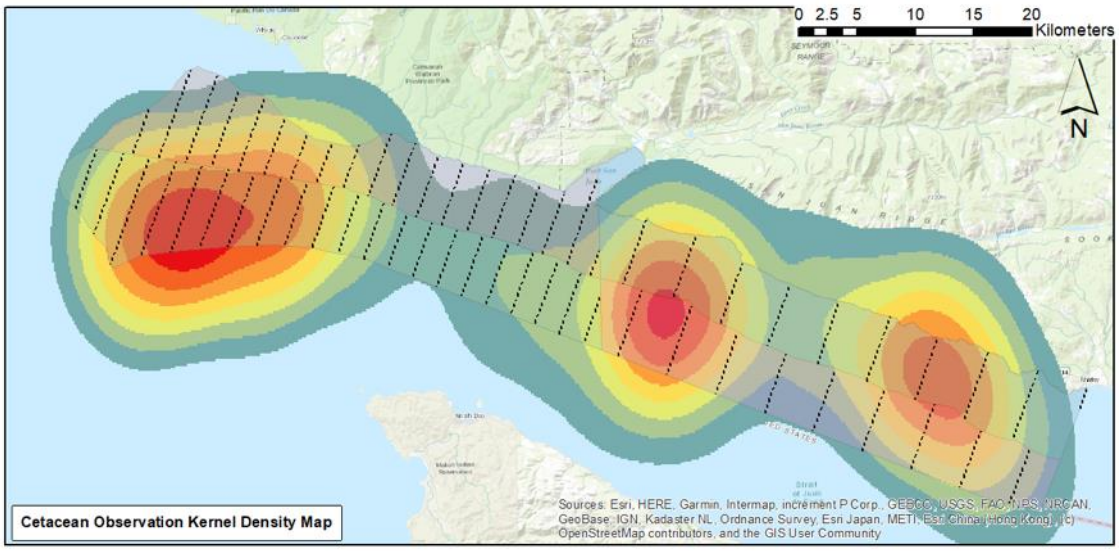
Figure 3. 2021 Marine Mammal Survey - All on-effort cetacean sightings.



Symbol sizes are proportional to group size (min. 1, max. 10)

A simple kernel heat map of cetacean sightings is provided in Figure 4. These highlight the numerical non-effort corrected hotspot of sightings for all cetaceans located in the Offshore west (Swiftsure Bank) stratum, central study area, and inshore east stratum. These overlap with the commercial shipping lane slowdown area, and to a lesser extent the Interim Sanctuary Zone area and are dominated by the humpback whale sightings data in the western and central hot spots, and by harbour porpoise sightings in the easternmost hot spot. However, as documented earlier, it should be noted that these heat maps have not been effort corrected, and that survey effort was unequal amongst strata. To provide an estimate of relative importance across the four strata, combined systematic survey data for both 2020 and 2021 were used to provide numbers of each cetacean species per 100 km of strata surveyed.

Figure 4. 2021 Marine Mammal Survey - Kernel heat map of all on-effort cetacean sightings (not effort corrected).



3.3 2021 Opportunistic Observational Data – Only Cetaceans

In addition to the systematic line transect survey data, opportunistic (off-effort) data were collected during the 2021 field season (Appendix C). Between 19 June and 8 October 2021, there were an additional 56 sightings of at least six cetacean species, opportunistically observed while off-effort (Table 5, Appendix C). The complete list of all marine mammal sightings from off-effort periods is presented in Appendix C, however this section of the report focusses only on the 129 cetaceans and includes: Dall's porpoise, grey whales, harbour porpoise, humpback whales, killer whales, and a Pacific white-sided dolphin (Table 5).

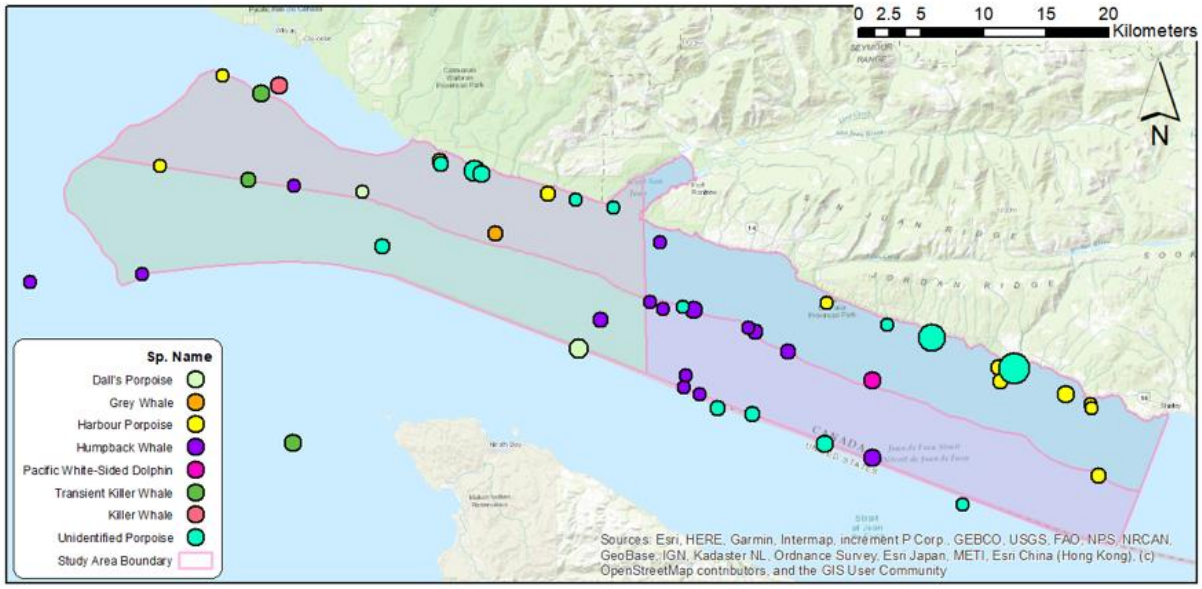
The actual number of observed cetaceans is greater than that reported here due to inconsistencies with data recording during the 2021 season (Appendix C). However, as with the on-effort line transect data, humpback whales and harbour porpoise were again the most frequently sighted cetaceans (Table 5). There was also an equal number of sightings of unidentified porpoise species (Table 5). There were however more sightings of killer whales while off-effort than while on-effort (Tables 4 and 5).

The opportunistic cetacean data were distributed in each stratum, with many observations located along the margins of the strata and two sightings well beyond the study area boundary (Figure 5). Killer whales were opportunistically sighted in the western Offshore stratum of the study area and in the waters south of the study area (Figure 5). Three of the four sightings were of transient killer whales, with the remaining sighting of an unknown ecotype. In 2021, there were no confirmed southern resident killer whale sightings while off-effort.

Table 5. Opportunistic cetacean species observations with the estimated total number of animals and total number of sightings during the 2021 field season.

Species	Estimated Number of Animals	Number of Sightings
Dall's Porpoise	6	2
Grey Whale	3	2
Harbour Porpoise	29	15
Humpback Whale	27	17
Killer Whale	14	4
Pacific White-sided Dolphin	1	1
Unidentified Porpoise	49	15
Total	129	56

Figure 5. Opportunistic cetacean sighting locations during the 2021 marine mammal survey.



Symbol sizes are proportional to group size (min. 1, max. 20)

3.4 2021 On- and Off-Effort Observational Data

Taking into account the on- and off-effort data collection (i.e., systematic and opportunistic data), thirteen of the total 27 days of effort resulted in neither a killer whale nor humpback whale sighting. Days of no on-effort killer whale or humpback whale sightings were:

- 22-24, 26, and 28-29 June,
- 5-6, 9, 13, and 30 July, and
- 5 and 17 August.

Humpback whales were sighted on 13 of the 27 survey days, while killer whales were sighted only on three of the survey days (Table 6). Killer whales were observed in the study area in July, August, and September 2021, while humpback whales were observed in each month of the survey (Table 6). Two of the 27 days of survey resulted in both species being positively identified on the same day (8 July and 22 September) (Table 6). Transient killer whales were observed actively foraging when sighted in July 2021 (Table 7).

Table 6. Summary of humpback and killer whale sightings days during the 2021 field season. Numbers represent the number of sightings during both systematic (line transect) and opportunistic data collection.

Excursion Number	Date	Humpback Whales	Killer Whales	Data Type
1	19-Jun-21	4	0	Systematic
2	20-Jun-21	6	0	Systematic
3	25-Jun-21	14/2	0	Systematic / Opportunistic
4	08-Jul-21	15/1	0/6	Systematic / Opportunistic
5	16-Jul-21	11	0	Systematic
6	04-Aug-21	0/2 + calf	0	Systematic / Opportunistic
7	06-Aug-21	0	0/7 + calf	Systematic / Opportunistic
8	07-Aug-21	0/3	0	Systematic / Opportunistic
9	11-Aug-21	11/3	0	Systematic / Opportunistic
10	18-Aug-21	0/6	0	Systematic / Opportunistic
11	19-Aug-21	6/8	0	Systematic / Opportunistic
12	13-Sep-21	1/1	0	Systematic / Opportunistic
13	22-Sep-21	8/1	2	Systematic / Opportunistic
14	8-Oct-21	1	0	Systematic

Table 7. Summary of all killer whale sightings during line transects and opportunistic sightings in 2021.

Date	Survey Type or Transect Number	Species	Behaviour	Group Size
08-Jul-21	Opportunistic	Transient Killer Whale	Breach and Blow	2
08-Jul-21	Opportunistic	Transient Killer Whale	Feeding	4
06-Aug-21	Opportunistic	Killer Whale (Ecotype Unknown)	Swimming	4
06-Aug-21	Opportunistic	Transient Killer Whale	Surfaced	3 + calf
22-Sept-21	3	Killer Whale (Ecotype Unknown)	Surfaced	1
22-Sept-21	4	Killer Whale (Ecotype Unknown)	Surfaced	1

3.4.1 Killer Whale Ecotype Identification

Photo-identification of killer whale ecotype was possible for only two of the three days of killer whale observations because photographs were only taken these two days. Based on photographic analyses for 8 July and 6 August 2021, both of these sightings were of transient killer whales (Table 8). On 8 July 2021, a male killer whale was identified as T49C (Figure F). It is also likely that the killer whales observed on 22 September 2021 were also the transient ecotype based on the timing of the observations of two single animals, more than about 40 minutes apart (Appendix B). However, without photographs this cannot be confirmed.

Table 8. Killer whale sightings photograph analysis for ecotype.

Date	Data Type	Photo Taken	Ecotype	Stratum
8-Jul-21	Opportunistic	Yes	Transient	NA
8-Jul-21	Opportunistic	No	Transient	NA
6-Aug-21	Opportunistic	No	Unknown	NA
6-Aug-21	Opportunistic	Yes	Transient	NA
22-Sep-21	Systematic	No	Unknown	Offshore West
22-Sep-21	Systematic	No	Unknown	Offshore West

3.4.2 Killer Whale and Humpback Whale Spatial Distribution

One sighting of transient killer whales was well beyond the study area boundary, with the other sightings in the western and eastern regions of the study area (Figures 3, 5 and 6). Humpback whales were observed in all four strata, with the fewest observations in the Inshore west stratum (Figures 3, 5 and 7).

Figure 6. 2021 Marine Mammal Survey killer whale (transient and unknown ecotype from on- and off-effort data).

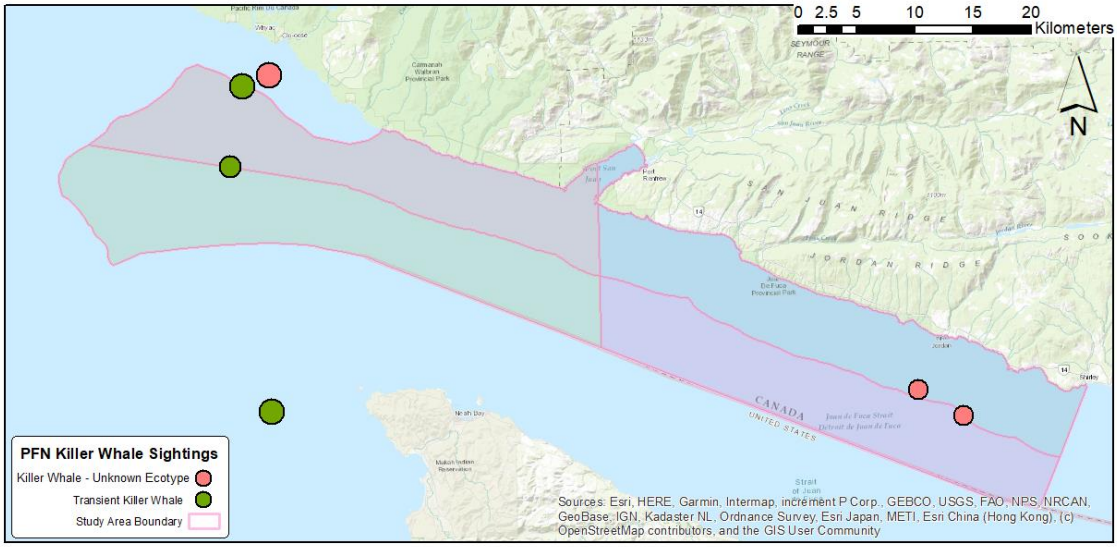
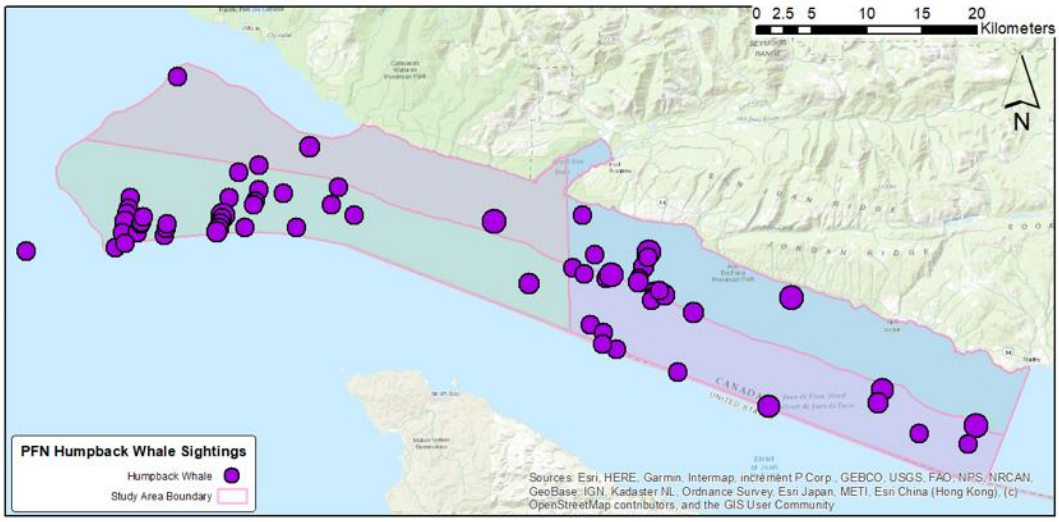


Figure 7. 2021 Marine Mammal Survey - humpback whale sightings from on- and off-effort data sources.



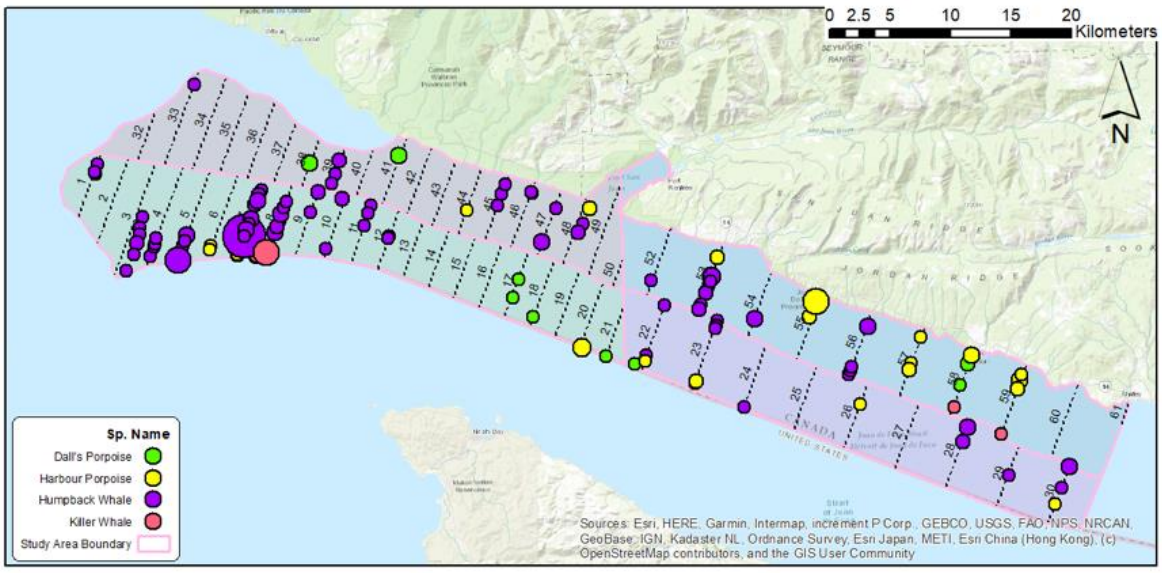
Symbol sizes are proportional to group size (min. 1, max. 5)

3.5 Combined 2020 and 2021 Systematic Cetacean Data Summary

3.5.1 Combined Systematic Cetacean Sightings Distribution Data 2020 and 2021

Review of the combined cetacean sightings data for 2020 and 2021 indicates that humpback whales were observed throughout the study area, with a concentration of sightings in the western Offshore stratum, and few sightings in the westernmost region of the western Inshore and the central eastern Offshore (Figure 8). Harbour porpoise were generally observed in the eastern strata, whereas Dall's porpoise were observed more in the western strata (Figure 8). Killer whales were infrequently observed compared to the other cetacean species (Figure 8).

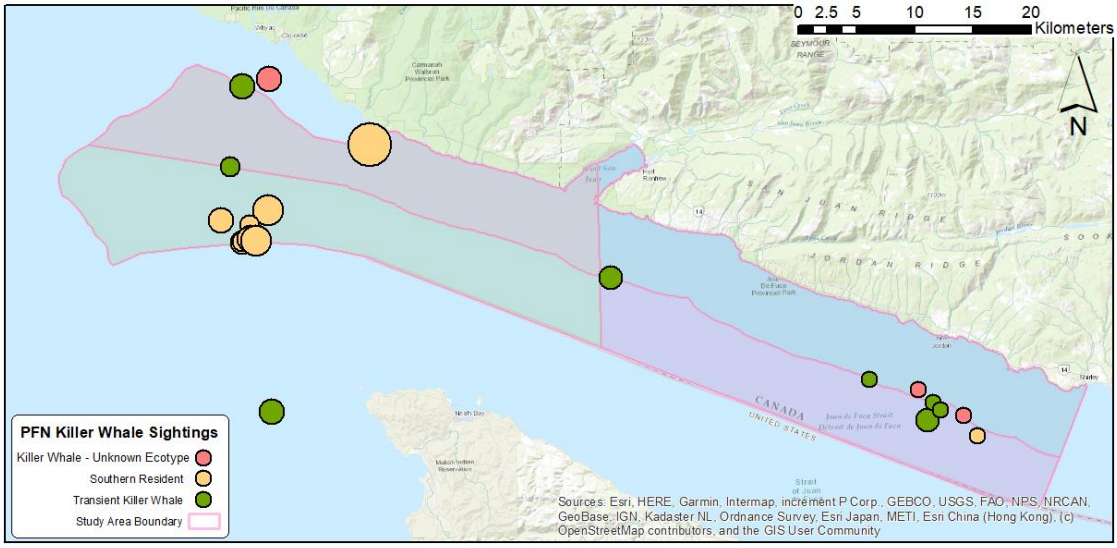
Figure 8. Combined cetacean systematic sightings data for 2020 and 2021 across study area.



Symbol sizes are proportional to group size (min. 1, max. 20)

In the combined 2020 and 2021 killer whale sightings data, this species (all ecotypes) was observed in all the eastern and western regions, as well as beyond the study (Figure 9). Southern resident killer whales were most often sighted in the Offshore west stratum (Swiftsure Bank).

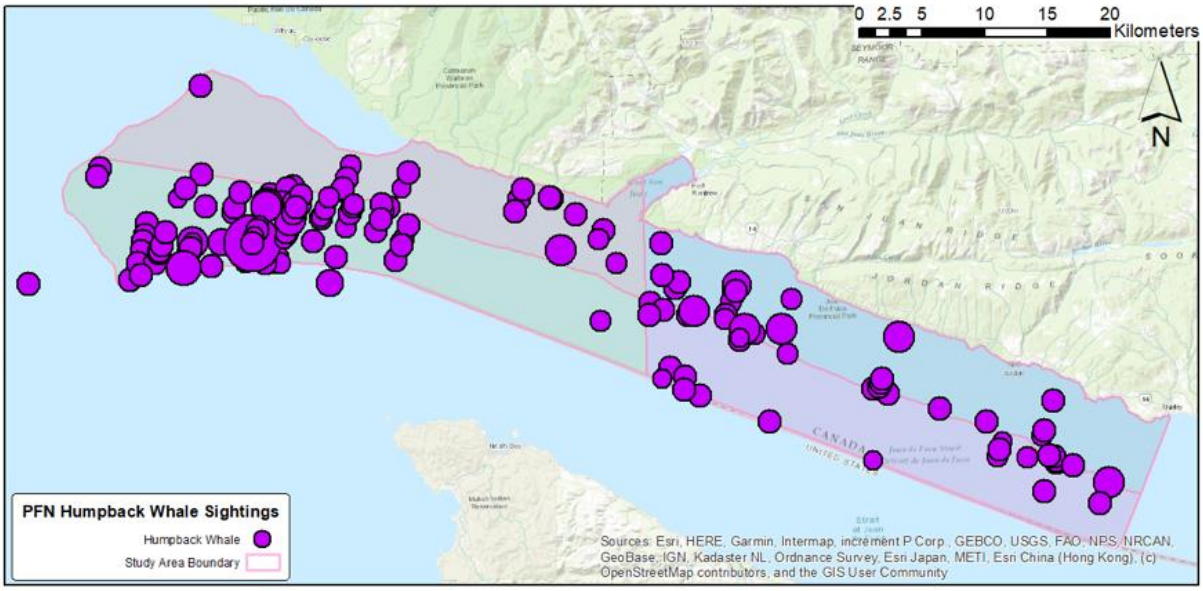
Figure 9. Combined killer whale systematic sightings data (all ecotypes) for 2020 and 2021.



Symbol sizes are proportional to group size (min. 1, max. 7)

In the combined 2020 and 2021 humpback whale sightings data, this species was also observed in all four strata, with a clear concentration of sightings in the western Offshore stratum (Figure 10).

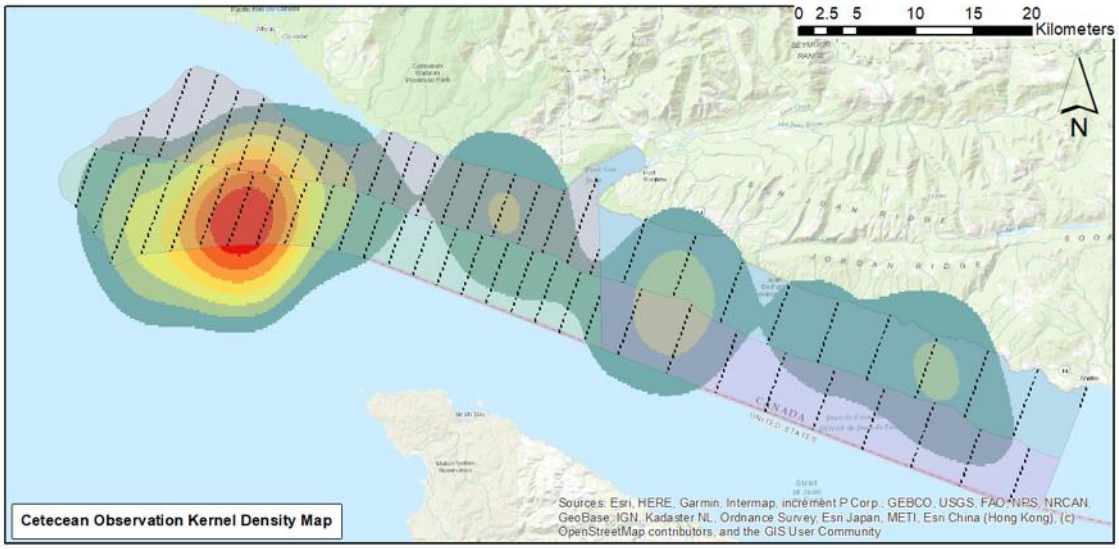
Figure 10. Combined humpback whale systematic sightings data for 2020 and 2021.



Symbol sizes are proportional to group size (min. 1, max. 10)

Combining the cetacean systematic (non-effort corrected) sightings for 2020 and 2021 indicates that the highest density of observations occurs in the Offshore west stratum, with additional habitats being used more frequently across all species in the central and inshore regions (Figure 11). A total of 159 cetaceans were sighted in the Offshore west stratum, just 31 in the Inshore West stratum, 50 in the Offshore east stratum and 89 in the Inshore east stratum. However, analysis correcting for line transect sightings effort within each stratum presents a different picture (see section 3.5.2).

Figure 11 Cetaceans (kernel heat map of all on-effort sightings – not effort corrected) for 2020 and 2021.



3.5.2 Effort-Corrected Systematic Cetacean Sightings Data - Survey Effort 2020 and 2021

The number of animals observed per hundred kilometres of survey was calculated based on the systematic effort and systematic line transect cetacean sightings for 2020 and 2021 (Table 9). When correcting for level of effort, there was a greater number of animals observed on-effort in 2020 than 2021 for all species of cetacean, except Dall's porpoise (Table 9). While 2020 sightings were only 1.7 times higher for harbour porpoise, killer whale and humpback whale sightings were nearly 20 and 5 times higher, respectively.

Overall, humpback whales were sighted most often at a rate of 10.2 animals per 100 km effort, followed by harbour porpoise at 2.7 animals per 100 km effort (Table 9). Dall's porpoise had the lowest encounter rate of focused species per 100 km effort at 0.7 (Table 9). Killer whales had a higher encounter rate (0.8) than Dall's porpoise, noting data combined sightings of all ecotypes including southern resident killer whale, transient killer whale and unknown killer whale ecotypes (Table 9).

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

	2020			2021			2020 and 2021		
Species Name	#	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	230	2257.3	10.19
Killer Whale	17	673	2.53	2	1584.3	0.13	19	2257.3	0.84
Harbour Porpoise	26	673	3.86	35	1584.3	2.21	61	2257.3	2.70
Dall's Porpoise	0	673	0.00	15	1584.3	0.95	15	2257.3	0.66
Unidentified Whale	7	673	1.04	0	1584.3	0.00	7	2257.3	0.31

When combined 2020 and 2021 data were partitioned by stratum, the Offshore west stratum had the highest amount of completed survey transect lines (771 km, 34.7%), followed by Inshore west (716 km, 32.3%), then Inshore east (405 km, 18.2%), and finally Offshore east (328 km, 14.8%). The overall ratio of effort comparing western strata with eastern strata was 2:1, as planned in scoping.

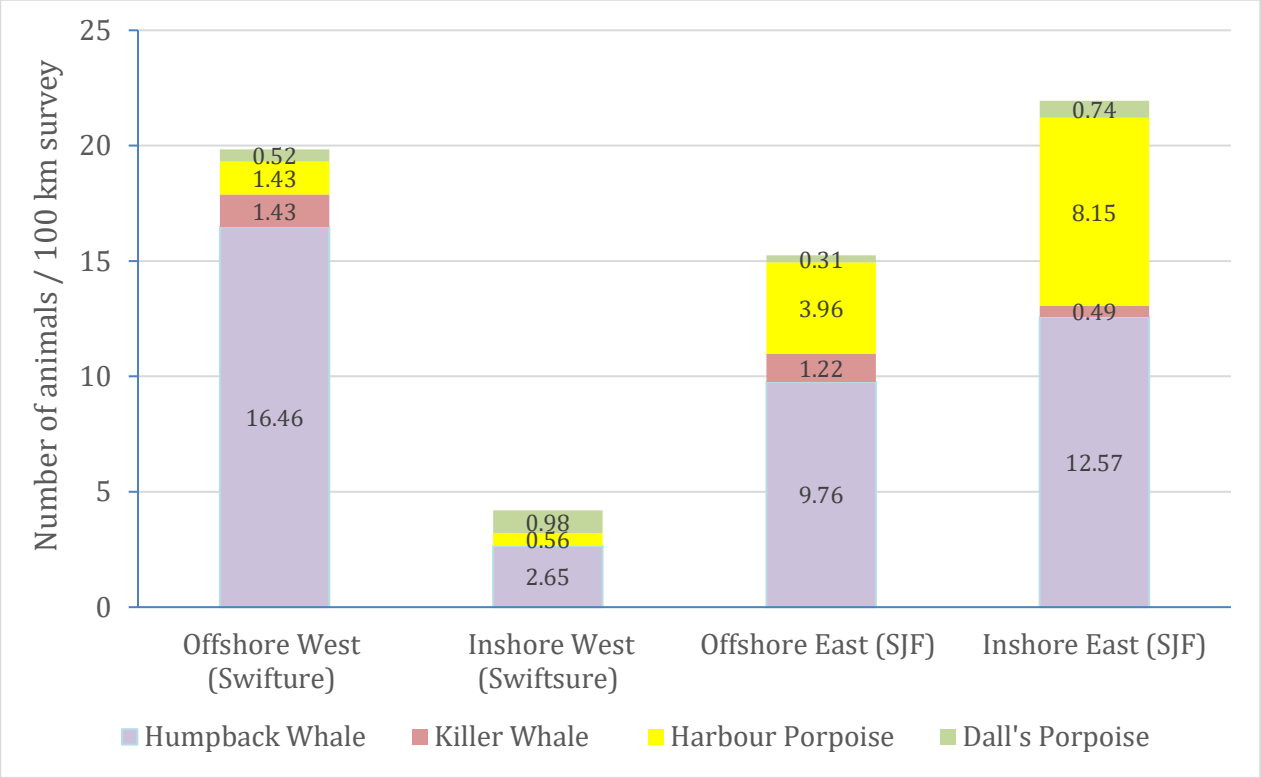
Taking effort per stratum into account, the three highest species sightings rates were humpback whales in the western Offshore stratum (16.5 per 100 km), the eastern Inshore stratum (12.6 per 100 km) and the eastern Offshore stratum (9.8 per 100 km) (Table 10, Figure 12). The next highest sighting rate was harbour porpoise with 8.2 animals seen per 100 km in the eastern Inshore stratum (Table 10). Harbour porpoise rates were ~50% lower in the eastern Offshore strata and even lower in both the western Offshore and Inshore strata (Table 10, Figure 12). Killer whales (all ecotypes combined) rates were highest in the western Offshore stratum followed by the eastern Offshore stratum (Table 10, Figure 12). No killer whales were observed on-effort in the western Inshore stratum, but this region saw the highest rate of Dall's porpoise sightings (Table 10, Figure 12).

Table 10. Effort corrected cetacean species sightings of number of animals (#) per hundred kilometres for each stratum for 2020 and 2021 combined on-effort 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	16.46	2.65	9.76	12.57
Killer Whale	1.43	0	1.22	0.49
Harbour Porpoise	1.43	0.56	3.96	8.15
Dall's Porpoise	0.52	0.98	0.31	0.74
Unidentified Whale	0.78	0.14	0	0

When effort corrected sighting rates were accumulated across these four cetacean species, the eastern Inshore stratum of the Strait of Juan de Fuca 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 five-fold lower than observed for the eastern inshore stratum (Figure 12).

Figure 12. Effort corrected cetacean species sightings of number of animals (#) per hundred kilometres for each stratum for 2020 and 2021 combined on-effort 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 the Strait of Juan de Fuca and at Swiftsure Bank through partnership with Pacheedaht First Nation during the summer and autumn months in 2021. Scientific survey design, training, support and 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 Juan de Fuca Strait 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 demarked for the ECHO Program Lateral Displacement and Swiftsure Bank Slowdown Trial, and the Transport Canada ordered Interim Sanctuary Zone at Swiftsure Bank (Figures 1 and 2). Stakeholders agreed a stronger survey effort (2:1) should be devoted to Swiftsure Bank (western) area.

Marine mammal observer (MMO) training was provided by Sea View Marine Sciences to six representatives of the Pacheedaht First Nation on 2-3 June 2021 and 16 June 2021. In total, four 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 2021. Two 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. Season 2021 has seen more than a two-fold increase in effort from 2020 (Hall et al. 2021) and an improvement in the quality of data collected. It has been a successful second season and it is expected for this program to keep improving over time. This year, the field effort was weighted toward the summer months, June through mid-August, with less effort between mid-August and early October, and no effort from mid-October to the end of the survey season.

Of the accumulated 280 transects undertaken, 57% were those west of Port Renfrew towards the Swiftsure Bank area (23% offshore strata, 34% inshore strata). As planned, fewer transects were conducted across the Offshore east (16%) and Inshore east (27%) strata, the survey region east of Port Renfrew. Systematic survey effort focused on Inshore west due to under sampling of this stratum in 2020. The overall ratio of effort comparing western strata with eastern strata in 2021 was 1.35:1.

During the 2021 on-effort line transect surveys, there was a total of 79 cetacean sightings of an estimated 128 animals (Table 4). Of the 128 cetacean sightings, humpback whales were the most numerically abundant and most often encountered species (especially in the early summer) in terms of the total estimated number of animals (n=76) and the number of sightings (n=51) (Table 4). Harbour porpoise and Dall's porpoise were the next most frequently observed cetaceans in terms of the estimated total numbers of animals and the number of sightings during the 2021 field season (Table 4). Killer whales were the least frequently observed cetacean with only two encounters during the on-effort component (i.e., line transects) of the 2021 field season. There were an additional four opportunistic killer whale sightings across two days, of which three sightings were confirmed as the transient ecotype using photo-identification. There were no confirmed sightings of southern resident killer whales in 2021, however not all observations could be determined to ecotype as photographs were not available for all encounters.

Locations of on-effort cetacean sightings for 2021 presented in Figures 3 and 4 highlight the numerical (non-effort corrected) hotspot for cetaceans, 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 Government of Canada's Swiftsure Bank Interim Sanctuary Zone. Secondary hotspots were located in the eastern strata. However, as documented earlier, it should be noted that survey effort was also weighted towards the inshore strata (27-34%) compared to the offshore strata (16-23%).

To take into account differences in survey effort by year and across different strata, the number of animals observed per hundred kilometres was calculated based on all systematic effort for 2020 and 2021 (Tables 9 and 10). There were a greater number of animals observed per 100 km on-effort in 2020 than 2021 for all species of cetacean, except Dall's porpoise (Tables 9 and 10). Killer whale sightings rates per 100 km effort were nearly twenty-fold higher in 2020 and humpback whale sightings rates per 100 km effort five-fold higher in 2020 (Tables 9 and 10). Overall, humpback whales were sighted most often at a rate of 10 animals per 100 km effort, followed by harbour porpoise at 2.7 animals per 100 km effort and killer whales (all ecotypes) at 0.84 animals per 100 km effort (Table 9).

Across strata, the highest effort-corrected species sightings rate (16.5 per 100 km) was found to be of humpback whales in the western Offshore stratum (Table 10). The next highest sightings rates were also of humpbacks whales in the eastern Inshore (12.6 per 100 km) and eastern Offshore (9.8 per 100 km) strata (Table 10). This was followed by the harbour porpoise sightings rate at 8.2 animals seen per 100 km within the eastern Inshore stratum (Table 10). Harbour porpoise rates were ~50% lower in the eastern Offshore stratum and even lower in both the western Offshore and Inshore strata (Figure 12). Killer whale (all ecotypes) sighting rates were highest in the western Offshore stratum followed by the eastern Offshore stratum (Figure 12). No killer whales were observed on-effort in the western Inshore stratum, but this region saw the highest rate of Dall's porpoise sightings (Figure 12). The eastern Inshore stratum of the Strait of Juan de Fuca had the highest overall sightings rates across these four species (reflecting higher rates of both humpback whale and harbour porpoise), followed by the western Offshore stratum (largely dominated by humpback whale sightings) that encompasses the ECHO Program vessel slowdown zone (Figures 2 and 12). The western Inshore stratum clearly had the lowest overall sightings rates (particularly notable for humpback whales), with a combined species sightings rate approximately five-fold lower than observed for the eastern Inshore stratum and more than four-fold lower than western Offshore stratum.

Survey data collected in the summer and early fall of 2020 and 2021 highlight inter-annual differences and spatial distribution differences across multiple cetacean species. Humpback whales dominate the study area of interest, particularly early in the season, with effort corrected sightings rates highest in the stratum that overlaps the current Swiftsure Bank ECHO Program vessel slowdown zone. Southern resident killer whales were sighted in 2020, but were not positively identified in 2021, despite more than 27 surveys and more than 60 hours of on-effort line transect time and a clear overall improvement in field effort from 2020.

5 Recommendations

Review of the 2021 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.
- Designating a member of the Pacheedaht field crew as a Team Lead position that carries specific roles and responsibilities.
- Consistency in data collection across all field team members.
- 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 the entire field crew and support team members.
- Strict adherence to data collection protocols and conventions.
- Revisions to field plans to offset data deficiencies or gaps that resulted from the 2020 -2021 seasons.
- Ensure photographs are taken for as many encounters as possible - especially for killer whale encounters.
- Storage and processing of only clear photos of marine mammals.
- Continuing to provide table headings in the field notebook for opportunistic data collection to ensure consistency and accuracy.
- Continue to work with Pacheedaht field team on species identification to reduce the number of "unknown" species in the data set.
- Continue to work with Pacheedaht field team on timely data transfer, particularly photographs.
- Apply for a DFO SARA permit to approach killer whales closer than 400 m to increase chance of ecotype identification.

Modifying some of the 2021 season's practices and improving communication with Pacheedaht crew is expected to further increase the quality of data collected which will allow for a better appreciation of marine mammal presence in the area.

In order to increase focus on detecting killer whales in relevant zones of interest, such as the ECHO Program Slowdown Zone and current and proposed Interim Sanctuary Zones, a more intense survey effort could be considered in 2022 covering only the western strata or by adapting the survey design to emphasize strata of interest. This should ideally be cross-referenced with other Pacheedaht areas of marine mammal interest within the SOI. Lastly, recognition of the success of the 2021 field team success and as much as possible, maintain continuity with interested members of the field team into 2022 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. Decide transect route with captain.
3. Start yellow book data (date, crew, sea state, weather, survey goal for the day).
4. Calibrate distance estimations and zero protractors before starting line transects to help get everyone adjusted.
5. Turn on the tablet, plug in GPS, turn on Transect Pro X software.
6. If GPS becomes unplugged, must press disconnect on the tablet in Transect Pro X, then plug the GPS back in, press reconnect on the software
    a. Bring backup data sheets & yellow book (for opportunistic sightings and notes)
7. Launch software a few minutes before beginning survey to get ready- decide who will be observer/ data collector. Observer and data collector should rotate positions each line.
8. If the previous days transect data are visible, you need to reset the database.
9. Confirm start of transect line with Captain.
10. Begin On Effort until Captain ends the line.
    a. Boats and other vessels will be noted in the Notes section, but animals take priority over boats for data entry. Can always add in the boat's info later in the day.
11. End the transect.
12. Repeat until the end of the day.
13. When you are finished your last line of the day, create a backup of the days data.
14. At the end of the day, review data in Transect Pro and Yellow book. Make sure all are correct and complete.
15. Bring the tablets back somewhere with WIFI. Transfer the data and scan of the yellow book onto OneDrive- folders for each!
16. Review photographs, delete unnecessary ones, load Photo-ID photographs into folder as well- include notes with them from which trip/ where they were taken.
17. Text Anna with a quick update on the trip including who was there, how many lines were completed, which lines were done, and the plan for the next survey day.
18. 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)- contains all backup files.
19. Copy & Paste that data file from the "Backup" file to the "Transfer Files here" folder so that we can then find the data.

Appendix B: Daily marine mammal species encounters, locations, estimated group sizes, behavioural states during observations, and information on weather and sea state during on-effort survey conditions in 2021

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2021-06-19 09:46:39	48.588	124.795	SSL	1	No Data	Overcast	2
2021-06-19 12:34:38	48.511	124.546	HB	4	BLOW	Overcast	No Data
2021-06-19 13:00:50	48.532	124.495	HS	2	No Data	No Data	No Data
2021-06-20 13:26:43	48.534	124.871	HB	1	BLOW	PCPS	3
2021-06-20 13:30:31	48.520	124.879	HB	4	BLOW	Sunny	3
2021-06-20 13:41:06	48.510	124.852	HB	1	SURFACE	PCPS	3
2021-06-25 09:55:48	48.495	125.011	HB	1	BLOW	No Data	No Data
2021-06-25 10:21:38	48.494	125.007	HS	1	ROLLING-KELP	No Data	No Data
2021-06-25 11:15:17	48.504	124.950	HB	1	BUBBLE-FEED	Sunny	2
2021-06-25 11:17:09	48.510	124.949	HB	1	BLOW	Sunny	2
2021-06-25 11:18:04	48.513	124.948	HB	1	OTHER	No Data	No Data
2021-06-25 11:22:40	48.528	124.939	SSL	1	FAST-SURFACE	Sunny	2
2021-06-25 11:23:43	48.532	124.937	SSL	1	FAST-SURFACE	Sunny	2
2021-06-25 12:03:32	48.514	124.882	SSL	1	SURFACE	Sunny	1
2021-06-25 12:04:25	48.518	124.880	HB	1	BLOW	Sunny	1
2021-06-25 12:15:25	48.554	124.859	HB	1	BREACH	Sunny	2
2021-06-25 12:48:21	48.542	124.833	SSL	1	SURFACE	Sunny	1
2021-06-25 12:49:19	48.540	124.834	HB	1	FAST-SURFACE	Sunny	2
2021-06-25 12:58:25	48.531	124.839	HB	1	FAST-SURFACE	Sunny	2
2021-06-25 13:03:41	48.528	124.841	HB	1	SURFACE	Sunny	2
2021-06-25 13:27:28	48.537	124.804	HB	1	BREACH	No Data	No Data
2021-06-25 13:28:31	48.540	124.802	SSL	1	FAST-SURFACE	No Data	No Data
2021-06-25 13:51:31	48.509	124.788	HB	1	BREACH	No Data	No Data
2021-06-25 14:06:03	48.526	124.745	HB	1	BREACH	No Data	No Data
2021-06-25 14:10:13	48.541	124.737	HB	1	BREACH	No Data	No Data
2021-06-25 14:22:31	48.518	124.717	HB	1	BREACH	Sunny	2
2021-06-26 09:37:28	48.465	124.619	HS	1	RESTING	Sunny	2
2021-06-26 09:39:55	48.473	124.613	HS	1	SURFACE	Sunny	2
2021-06-28 11:39:36	48.541	124.528	SSL	1	FAST-SURFACE	Sunny	1
08-07-2021 10:53	48.535	124.992	HB	1	FAST-SURFACE	PCPS	1
08-07-2021 10:54	48.531	124.993	HS	1	SWIM	PCPS	1
08-07-2021 10:55	48.527	124.995	HB	1	BLOW	PCPS	1
08-07-2021 10:56	48.522	124.996	HB	1	BLOW	PCPS	1
08-07-2021 10:58	48.516	124.999	HB	2	BLOW	PCPS	1
08-07-2021 11:01	48.507	125.002	HB	1	BLOW	PCPS	1
08-07-2021 11:11	48.506	124.984	HB	1	FLUKE	PCPS	1
08-07-2021 11:13	48.513	124.980	HB	1	BLOW	PCPS	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
08-07-2021 11:13	48.515	124.979	HB	1	SURFACE	PCPS	1
08-07-2021 11:15	48.519	124.977	HB	1	SURFACE	PCPS	1
08-07-2021 13:38	48.513	124.882	HB	1	BREACH	PCPS	2
08-07-2021 13:39	48.509	124.884	HB	2	SURFACE	PCPS	1
08-07-2021 13:40	48.506	124.887	HB	2	BLOW	PCPS	1
09-07-2021 9:32	48.540	124.737	HS	1	SURFACE	Fog	1
2021-07-16 09:06:12	48.334	123.964	HB	4	BLOW	PCPS	1
2021-07-16 09:11:31	48.319	123.973	HB	1	BLOW	PCPS	1
2021-07-16 09:31:48	48.329	124.032	HB	1	BLOW	PCPS	1
2021-07-16 09:46:42	48.366	124.076	HB	3	BLOW	Overcast	1
2021-07-16 09:49:48	48.355	124.082	HB	2	BLOW	Overcast	1
2021-07-16 10:34:23	48.385	124.195	HP	1	SURFACE	PCPS	1
2021-07-16 11:34:54	48.404	124.379	HP	1	FAST-SURFACE	PCPS	1
2021-07-16 11:35:38	48.405	124.378	HP	2	FAST-SURFACE	PCPS	1
2021-07-16 11:52:10	48.446	124.355	HS	1	SURFACE	PCPS	1
2021-07-16 12:10:34	48.419	124.445	DP	1	FAST-SURFACE	PCPS	1
2021-07-16 12:25:12	48.421	124.434	HP	1	FAST-SURFACE	PCPS	1
2021-07-16 12:35:26	48.425	124.477	DP	1	FAST-SURFACE	PCPS	0
2021-07-16 13:47:03	48.456	124.558	DP	1	WAKE	PCPS	1
2021-07-16 13:58:27	48.470	124.580	DP	1	SURFACE	PCPS	1
2021-07-16 14:02:04	48.484	124.573	DP	1	FAST-SURFACE	PCPS	1
2021-08-04 10:22:04	48.397	124.083	DP	1	FAST-SURFACE	Sunny	1
2021-08-04 10:27:17	48.413	124.074	DP	2	FEEDING	Sunny	1
06-08-2021 10:54	48.610	124.881	USL	1	SURFACE	Overcast	2
06-08-2021 12:41	48.573	124.804	DP	3	FAST-SURFACE	Overcast	1
06-08-2021 13:24	48.578	124.704	DP	4	FAST-SURFACE	Overcast	1
07-08-2021 12:40	48.307	123.981	HP	1	FAST-SURFACE	Fog	1
2021-08-11 11:11:25	48.483	124.358	HB	5	BLOW	Sunny	No Data
2021-08-11 11:13:23	48.476	124.361	HB	1	BREACH	Sunny	1
2021-08-11 11:15:00	48.471	124.365	HB	2	BREACH	Sunny	1
2021-08-11 11:17:36	48.462	124.370	HB	1	BLOW	Sunny	1
2021-08-11 11:18:26	48.459	124.372	HB	2	BLOW	Sunny	1
2021-08-11 12:09:59	48.460	124.244	HP	1	FAST-SURFACE	Sunny	1
2021-08-11 12:12:51	48.451	124.249	HP	2	FAST-SURFACE	Sunny	1
2021-08-11 12:14:10	48.447	124.251	HS	1	SLOW-ROLLING	Sunny	1
2021-08-11 12:55:07	48.428	124.195	HS	1	RESTING	Sunny	0
2021-08-11 13:08:17	48.434	124.126	HP	1	FAST-SURFACE	Sunny	0
2021-08-11 13:13:40	48.415	124.137	HP	1	FAST-SURFACE	Sunny	0
2021-08-11 13:14:59	48.410	124.140	HP	2	FAST-SURFACE	Sunny	0
2021-08-11 13:48:02	48.400	124.017	HP	3	FEEDING	PCPS	1
2021-08-17 10:09:01	48.393	124.020	HP	2	FAST-SURFACE	Sunny	1

Date and Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Beaufort Scale
2021-08-17 10:21:34	48.419	124.070	HP	1	SURFACE	PCPS	1
2021-08-18 10:16:22	48.462	124.242	HP	10	SURFACE	Overcast	2
19-08-2021 10:47	48.404	124.015	HP	1	FAST-SURFACE	PCPS	1
19-08-2021 11:24	48.419	124.071	HP	1	FAST-SURFACE	PCPS	1
19-08-2021 13:27	48.385	124.325	HB	1	FAST-SURFACE	PCPS	1
19-08-2021 13:55	48.450	124.352	HB	1	FAST-SURFACE	PCPS	2
19-08-2021 13:56	48.446	124.354	HB	1	BLOW	PCPS	1
19-08-2021 13:57	48.444	124.355	HB	1	BLOW	PCPS	1
19-08-2021 14:25	48.425	124.432	HB	1	FAST-SURFACE	PCPS	1
19-08-2021 14:38	48.462	124.411	HB	1	FAST-SURFACE	PCPS	1
13-09-2021 12:04	48.633	124.932	HB	1	SURFACE	PCPS	1
22-09-2021 10:11	48.360	124.039	KW	1	SURFACE	Overcast	1
22-09-2021 10:36	48.419	124.070	HP	4	FEEDING	Overcast	1
22-09-2021 10:51	48.381	124.091	KW	1	SURFACE	Overcast	1
22-09-2021 11:24	48.443	124.185	HB	4	FAST-SURFACE	Overcast	1
22-09-2021 12:42	48.479	124.359	HB	1	BLOW	Overcast	2
22-09-2021 13:08	48.488	124.420	HS	1	RESTING	Overcast	1
22-09-2021 13:10	48.481	124.425	HB	1	FLUKE	Overcast	1
2021-10-08 09:45:38	48.575	124.771	HB	2	FLUKE	PCPS	3
2021-10-08 13:36:07	48.553	124.457	CSL	1	SWIM	Overcast	2

CSL – California sea lion
DP – Dall's porpoise
HP – Harbour porpoise
HS – Harbour seal
HB – Humpback whale
KW – Killer whale (ecotype unknown?)
SSL – Steller sea lion
USL – Unidentified sea lion
PCPS – Partly cloudy partly sunny

Appendix C: 2021 Opportunistic Marine Mammal Sightings Data

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
20-Jun	1219	48.565	124.913	SSL	1	Surfaced	Fog and sun	1
22-Jun	1317	48.375	123.926	SSL	2	Surfaced	Fog and sun	2
25-Jun	0800	48.523	124.617	GW	1	Foraging	Sunny	1
25-Jun	1020	48.493	125.120	HB	1	Blow	Sunny	1
25-Jun	1231	48.560	124.834	HB	1	Surfaced	Sunny	1
25-Jun	1336	48.550	124.760	SSL	2	Surfaced	Sunny	1
25-Jun	1512	48.528	124.618	HS	1	Surfaced	Sunny	1
26-Jun	1211	48.467	124.416	UP	2	Surfaced	Sunny	1
26-Jun	1252	48.394	124.381	UP	1	Surfaced	Sunny	1
26-Jun	1414	48.320	124.120	UP	15	Surfaced	Sunny	0
28-Jun	0816	48.542	124.487	HS	1	Hauled out	Sunny	1
28-Jun	0820	No Data	No Data	GW	1	Blow	Sunny	1
28-Jun	1044	48.549	124.537	USL	1	Fast surfacing	Sunny	1
28-Jun	1058	NA	No Data	USL	2	Fast surfacing	Sunny	1
29-Jun	1050	48.460	124.240	USL	1	Fast surfacing	Sun and cloud	1
05-Jul	0815	48.540	124.489	UP	6	Surfaced	Fog and sun	1
05-Jul	0847	48.568	124.638	UP	3 + calf	Surfaced	Fog and sun	1
05-Jul	1100	48.566	124.631	UP	3	Surfaced	Fog and sun	1
06-Jul	1247	48.411	124.213	PWSD	1	Bow riding	Fog and sun	3
08-Jul	0843	48.546	124.529	UP	2	Surfaced	Fog and sun	1
08-Jul	0907	48.574	124.675	UP	2	Surfaced	Fog and sun	1
08-Jul	0919	48.515	124.739	UP	2	Surfaced	Fog and sun	1
08-Jul	0929	48.592	124.827	USL	1	Surfaced	Fog and sun	1
08-Jul	1107	48.498	124.999	HB	2	Blow	Fog and sun	1
08-Jul	1234	48.565	124.883	TKW	4	Breach and Blow	Fog and sun	1
08-Jul	1303	48.375	124.839	TKW	20	Feeding	Fog and sun	1
09-Jul	0830	48.539	124.532	HS	1	Hauled out	Fog and overcast	1
09-Jul	1344	48.547	124.469	USL	1	Surfaced	Fog and overcast	1
16-Jul	0814	48.578	124.431	HS	3	Surfaced	Sun and cloud	1
16-Jul	1050	48.366	124.267	UP	2	Surfaced	Sun and cloud	1
16-Jul	1142	48.389	124.344	UP	5	Surfaced	Sun and cloud	1
16-Jul	1312	48.439	124.529	DP	10	Surfaced	Sun and cloud	1
30-Jul	0919	48.540	124.501	HS	1	Hauled out	Fog and sun	2
04-Aug	949	48.390	123.979	HP	1	Foraging	Sunny	0
04-Aug	1030	48.419	124.072	HP	2	Foraging	Sunny	1
04-Aug	1042	48.408	124.076	HP	2 + calf	Foraging	Sunny	1
04-Aug	1106	48.420	No Data	HB	2	Spy hopping and fluking	Sunny	1
06-Aug	0839	48.551	124.559	HP	1	Surfaced	Overcast	1
06-Aug	0844	48.557	124.585	USL	2	Surfaced	Overcast	1
06-Aug	0857	48.576	124.676	HP	1	Surfaced	Overcast	1

Date	Time	Latitude	Longitude	Species	Group Size	Behaviour	Weather	Sea State (Beaufort Scale)
06-Aug	0858	48.580	124.686	USL	1	Surfaced	Overcast	1
06-Aug	0953	48.576	124.978	HP	1	Surfaced	Overcast	1
06-Aug	1017	48.640	124.909	HP	4	Surfaced	Overcast	1
06-Aug	1042	48.627	124.868	KW	4	Swimming	Overcast	No Data
06-Aug	1125	48.627	124.868	TKW	3+calf	Surfaced	Overcast	1
06-Aug	1248	48.555	124.760	DP	20	Surfaced	Overcast	1
06-Aug	1519	48.544	124.479	HS	1	Hauled out	Overcast	1
07-Aug	1202	48.362	124.658	HP	2	Surfaced	Fog	1
07-Aug	1210	48.338	123.973	HP	3	Surfaced	Fog	1
07-Aug	1409	48.355	124.216	HB	2	Surfaced	Fog	1
11-Aug	1017	48.459	124.505	HB	1	Fluking	Sunny	1
11-Aug	1032	48.471	124.451	HB	1	Surfaced	Sunny	2
11-Aug	1055	48.520	124.400	HS	2	Surfaced	Sunny	2
11-Aug	1205	48.472	124.270	USL	10	Surfaced	Sunny	2
11-Aug	1247	48.441	124.148	UP	1	Surfaced	Sunny	No Data
11-Aug	1300	48.436	124.151	UP	1	Surfaced	Sunny	1
17-Aug	0839	48.468	124.261	HP	2	Surfaced	Sun and cloud	2
17-Aug	0859	48.418	124.077	HP	3	Surfaced	Sun and cloud	2
17-Aug	0905	48.397	124.005	HP	1	Surfaced	Sun and cloud	2
17-Aug	0907	48.387	123.978	HP	15	Surfaced	Sun and cloud	2
17-Aug	0929	48.375	123.925	HS	3	Surfaced	Sun and cloud	2
18-Aug	0856	48.577	124.282	HP	1	Surfaced	Fog and sun	2
18-Aug	1108	48.309	124.290	USL	4	Hauled out	Fog and sun	2
18-Aug	1209	48.465	124.404	HB	1	Blow and fluking	Fog and sun	2
18-Aug	1236	48.418	124.415	HB	1	Surfaced	Fog and sun	2
18-Aug	1259	48.466	124.437	HB	1	Surfaced	Fog and sun	2
18-Aug	1409	48.556	124.453	HS	1	Surfaced	Fog and sun	2
19-Aug	833	48.514	124.439	HB	1	Surfaced	Fog and sun	1
19-Aug	1236	48.451	124.196	UP	2	Surfaced	Fog and sun	1
19-Aug	1343	48.433	124.304	HB	2	Surfaced and fluking	Fog and sun	2
19-Aug	1351	48.448	124.339	HB	1	Blow and fluking	Fog and sun	2
19-Aug	1353	48.451	124.346	HB	1	Blow	Fog and sun	2
19-Aug	1414	48.404	124.400	HB	1	Fluking	Fog and sun	2
19-Aug	1417	48.409	124.417	HB	1	Breach	Fog and sun	2
22-Sep	0822	No Data	No Data	HB	6	Blow and fluking	Sun and cloud	1
22-Sep	0918	No Data	No Data	HP	12	Feeding	Sun and cloud	1
22-Sep	1031	48.417	124.060	UP	1	Feeding	Sun and cloud	1

CSL – California sea lion
DP – Dall's porpoise
HP – Harbour porpoise
HS – Harbour seal
HB – Humpback whale
KW – Killer whale (ecotype unknown?)

PWSD – Pacific white-sided dolphin
SSL – Steller sea lion
USL – Unidentified sea lion
TKW – Transient killer whale
UP – Unidentified porpoise

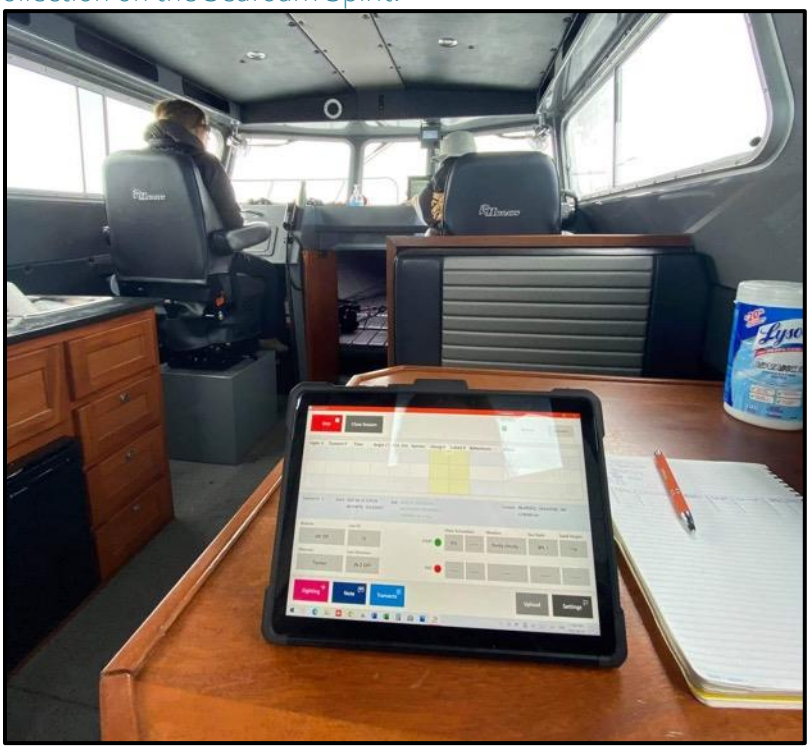
Appendix D: 2021 Field Photographs

A – Pacheedaht First Nation field crew getting the Seafoam Spirit ready for the 2021 season.

B – Motor off while Pacheedaht First Nation field crew waits for a humpback whale to inspect the vessel.

C – Pacheedaht First Nation field crew on the watch.

D – Set-up for data collection on the Seafoam Spirit.



E – Group of three transient killer whales 8 July 2021.

F – Transient killer whales (male identified as T49C) photographed 8 July 2021.

G – Opportunistic killer whale sighting on 6 August 2021.

H – Humpback whale spyhopping – opportunistic sighting on 4 August 2021.

I – Humpback whale blowing – opportunistic sighting on 4 August 2021.

J – Humpback whale pectoral fin – opportunistic sighting on 4 August 2021.

K – Humpback whale diving 25 June 2021.

L – Humpback whale fluking 25 June 2021.

M – Humpback whales swimming 20 June 2021.

N – Steller and California sea lions hauled out on rocks – opportunistic sighting 16 August 2021.

O – Harbour seals hauled out on rocks at low tide – opportunistic sighting 17 August 2021.

P – Nearshore habitat used by black bears 29 June 2021.

Q – Juvenile brown pelican (*Pelecanus occidentalis*) on 9 July 2021.