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PODS: Two Decades of Ship-Based Surveys Inform Expansion of Critical Habitat Designation for Southern Resident Killer Whales (*Orcinus orca ater*)

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Plain Language Summary

Three distinct killer whale subspecies coexist in the northeastern Pacific Ocean: resident killer whales (*Orcinus orca ater*), Bigg's killer whales (*Orcinus orca rectipinnus*), and offshore killer whales (*Orcinus orca orca*). These subspecies differ in diet, social structure, appearance, and behavior. Southern Resident killer whales (SRKW) are a distinct population segment of the resident killer whale subspecies; they inhabit the coastal waters of Washington, Oregon, California, and British Columbia, Canada.

In 2005, SRKW were listed as endangered under the U.S. Endangered Species Act. At the time of listing, we did not know enough about them to designate Critical Habitat beyond the inland waters of the Salish Sea. To address this data gap, we conducted Pacific Orca Distribution Surveys from 2004 to 2021 to document SRKWs' winter range, as well as to improve our understanding of their behavior and habitat use outside of the Salish Sea.

This report summarizes the methods and results of these surveys and discusses how they were integral to the revision of Critical Habitat to include the coastal waters of Washington, Oregon, and California.

Links used in this section:

- List of Marine Mammal Species: https://marinemammalscience.org/science-and-publications/list-marine-mammal-species-subspecies/
- NOAA Southern Resident killer whale management actions: https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/southern-resident-killer-whale-orcinus-orca
- SRKW Critical Habitat revision: https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/critical-habitat-southern-resident-killer-whales

Acknowledgments

We are grateful to the officers and crews of the NOAA Ships *McArthur II* and *Bell M. Shimada* for their support over many years. Their expertise was essential to the success of these surveys. The accomplishments of these surveys would not have been possible without the dedication and hard work of the research team participants (Appendix B). Many people from the Northwest Fisheries Science Center provided logistical and analytical support for these surveys, including Jen Zamon, Damon Holzer, Rick Brown, Kim Parsons, Jennifer Hemplemann, Nick Adams, Brian Bill, Vera Trainer, Bill Peterson, Dezhang Chu, Lawrence Hufnagle, and Mike Ford.

Introduction

The Southern Resident killer whale (SRKW) distinct population segment was listed as endangered under the Endangered Species Act (ESA) on 18 November 2005 (USOFR 2005). The initial Critical Habitat designation did not include coastal waters outside the Salish Sea, even though Southern Resident killer whale range extends from central California to southeastern Alaska. At the time of listing, available data on winter coastal distribution, diet, and habitat use were inadequate. To obtain location data necessary to revise the Critical Habitat designation, as well as obtain other information on behavior and prey selection, Pacific Orca Distribution Surveys (PODS) were conducted from 2004 to 2021. Here we report on survey objectives, methods, and results of these surveys.

Most of these data have been previously synthesized and presented in publications (Hanson et al. 2021, Bliss et al. 2024) or for management actions (NMFS 2021). This report represents the only comprehensive documentation of the two decades of survey methods, effort, and killer whale encounters, and provides an important context for those publications.

Survey Objectives

The primary objective of PODS was to locate Southern Resident killer whales to better document their winter range as well as improve understanding of their behavior and habitat use outside of the Salish Sea. Secondary objectives included photo identification, behavioral observations, collection of biological samples, and acoustic study of sounds produced by cetaceans in this area during the winter. In addition, other biological and oceanographic data were collected to better characterize their environment.

Study Area

The PODS study area included the shelf waters of California, Oregon, Washington, and British Columbia, as well as inland waters of the Salish Sea in some years. It extended from Monterey Bay, California, north to Tofino, British Columbia, Canada (lat 36.6°N, long 121.9°W to lat 49.15°N, long 125.9°W) and was based on previous sightings of SRKW.

Survey Platforms

PODS sailed aboard the NOAA Ship *MacArthur II* (hereafter, "*Mac II*") in 2004, 2006, 2007, 2008, and 2009. Following the retirement of this vessel, PODS sailed aboard the NOAA Ship *Bell M. Shimada* (hereafter, "*Shimada*") in 2012, 2013, 2015, 2016, and 2021.

Methods

When no prior information was available regarding SRKW locations, line-transect survey methods were used to search for and locate SRKW. This approach was consistent with the Southwest Fisheries Science Center's (SWFSC) approach for estimating cetacean abundance (Kinzey et al. 2000). A set of predetermined track lines (Figure 1) was established prior to the survey to cover the portion of the study area with the highest probability of encountering SRKW based on previous sightings. It was often necessary to modify these track lines and methods due to weather conditions (e.g., rain and fog) and/or other considerations.

In all years, both visual and acoustic methods were used to locate SRKW at sea. In 2012, satellite telemetry was added as a tool to locate SRKW, but successful deployment of a telemetry tag did not occur until the end of the survey. From 2013–16, satellite tag-derived locations were available throughout the surveys, resulting in less time spent on the predetermined track lines and more time spent with SRKW.

Survey Effort

To summarize survey effort for all years, we generated time-density maps for the entire study area using ship tracks and a 5 × 5 km grid. The 5 × 5 km grid was developed for the analysis of satellite telemetry data from SRKW in the same study area (Hanson et al. 2018). The

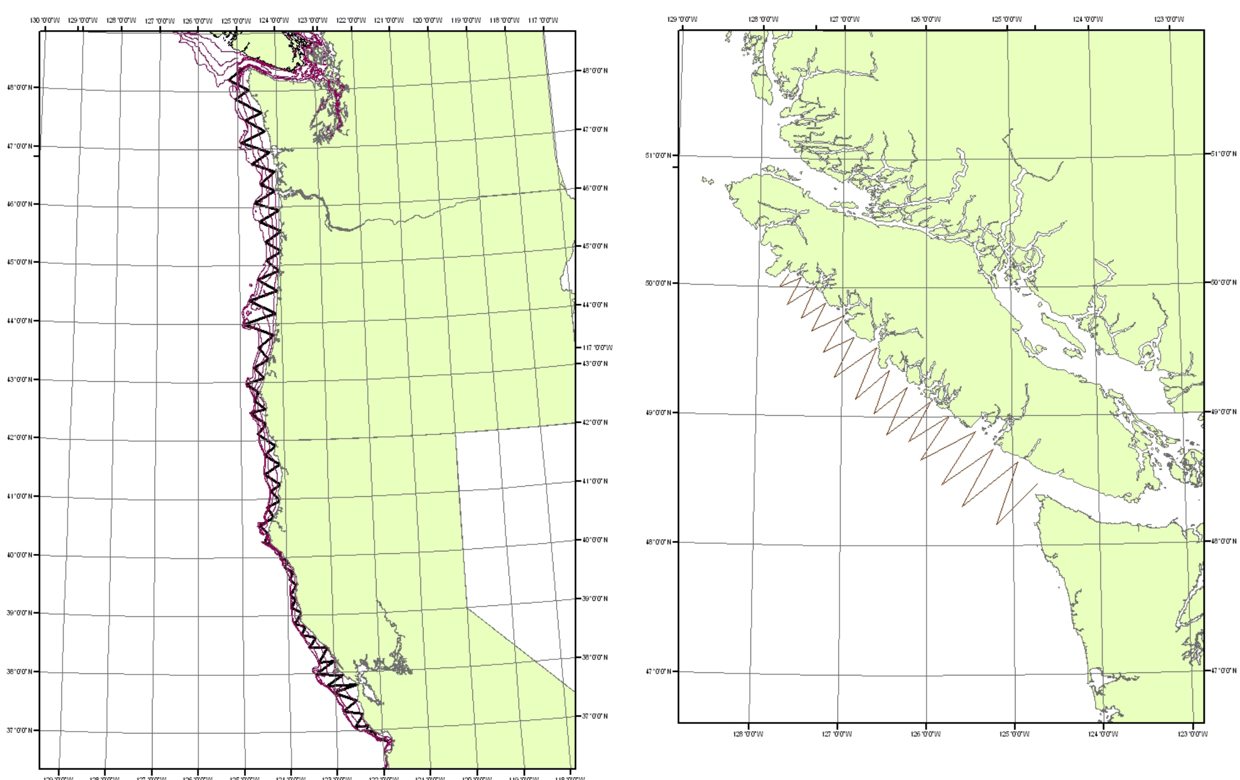

Figure 1. Planned survey track lines for PODS in (left) U.S. waters and the Salish Sea, and (right) along the west coast of Vancouver Island, Canada.

amount of time in each grid square was calculated in minutes for total survey effort, visual time with killer whales, and acoustic time with killer whales. Maps for the 2004 survey were generated separately, since it was the only year that there was survey effort in California.

Surveys were further separated into two time periods to reflect the knowledge gleaned from satellite tracking: Period 1 (2006–12) and Period 2 (2013–21).

Visual methods

When searching for SRKW, ships traveled at approximately 10 kn along the designated track line. A daily watch for marine mammals was maintained during daylight hours (approximately 0700 to 1800) by scientific observers on the flying bridge, except when the ship was stopped to conduct other sampling operations, or when precluded by weather. A team of three observers searched for marine mammals with 25 × 150 stanchion-mounted binoculars (hereafter, "Big Eyes"), 7 × 50 hand-held binoculars, and the unaided eye. The two outboard observers scanned from 10° across the track line to 90° abeam with the Big Eyes. The two observers reported sighting angle using the azimuth incorporated into the binocular mount (this azimuth was calibrated to zero at the beginning of the cruise). The recorder monitored the entire 180° field of view with 7 × 50 binoculars and the unaided eye. Sighting conditions, observer rotations, cetacean sightings, and other required information were entered into a computer, using the program WinCruz (R. Holland, SWFSC). The computer was connected to the ship's GPS so that each sighting was associated with a specific date, time, course, speed and position. Observers worked for 30 minutes at each of the three stations and rotated through the three positions for a total of 1.5 hours on the flybridge, with an hour break between sets of rotations to minimize observer fatigue.

If poor weather conditions (sea state greater than Beaufort 5, rain, or fog) precluded observations with the Big Eyes, then a two-observer watch was maintained on either the flybridge or bridge with 7 × 50 binoculars or the unaided eye. In this case, one of the two observers, instead of a dedicated data-entry person, entered sighting data into the computer.

When killer whales were sighted, the marine mammal observer team requested the vessel be maneuvered to approach the group to begin a killer whale encounter. During these encounters, flybridge observers went off search effort to allow the ship to approach. Upon close approach, the observers made estimates of group size and killer whale ecotype. When conditions allowed, photographs, behavioral data, and biological samples were collected. These are described below in <u>Killer whale encounters</u>. When the small boat was launched, a separate watch on the flybridge was established to maintain visual contact with the killer whales. Depending on the duration and end location of the small boat operations, the survey vessel track line was either resumed at the point of initial departure from the line, or the survey vessel intersected the track line at the closest point, while ensuring that survey of previously sampled track line was not repeated.

Passive acoustic methods

Passive acoustic monitoring was conducted during both daytime and nighttime hours, primarily using towed hydrophone arrays to aid in locating killer whales when visual observations were limited or not possible. Sonobuoys were also used when towed array deployment was not feasible, such as during oceanographic operations, or in 2021 when staffing was reduced due to COVID-19 restrictions. The acoustic survey team was comprised of bio-acousticians who had extensive experience detecting, tracking, and identifying cetacean species in the northeastern Pacific Ocean.

The towed system consisted of two hydrophones arrays: a two-element array (Array A) and a five-element array (Array B), or Array B and a five-element oil-filled array. Array A consisted of two elements with 3.15 m spacing and approximately 330 m of deployed length of the cable. The elements for Array A had an effective (i.e., flat) frequency response of 100 Hz–40 kHz. Array A was the primary array deployed (i.e., day and night) during normal survey mode. Array B consisted of five elements: two paired mid-frequency phones at either end with 3 m spacing between each element in the pair, and a single hydrophone near the middle (330 m from the end pair and 130 m from the first pair), for a total aperture of 660 m (between the first and last pair). The last element of Array B consisted of a broadband, high-frequency element with a flat frequency response up to 200 kHz. Array B was intended to complement Array A during nighttime encounters with resident killer whales in order to improve tracking capabilities (i.e., to disambiguate left/right detections). Starting in 2013, the oil-filled array was used along with Array B. The oil-filled array consisted of three mid-frequency hydrophones (1, 3, and 5) and two high-frequency hydrophones (2 and 4), and spacing was either 0.5 or 1.5 m between pairs of hydrophones with approximately 300 m of cable (Rankin et al. 2013).

For array recordings, the software package `ISHMAEL` (Mellinger 2001) was used to record and process acoustic data during real-time monitoring and localization in earlier years. Generally, data were sampled and recorded at 96 kHz for both arrays. Two channels were recorded when Array A was deployed, and five channels (two from Array A and three from Array B) were recorded when both arrays were deployed. Recordings were made continuously at ten-minute intervals, with most start times aligned on the hour and every ten minutes after the hour. The software package `Whaletrack II` (G. Gailey, TAMUG, Texas) was used to plot bearings and/or location estimates passed from `ISHMAEL`. In later years (2012 and after), `PAMGUARD` (D. Gillespie, University of St. Andrews, United Kingdom) was used—in combination with `ISHMAEL`, or on its own—to record and process acoustic data during real-time monitoring and localization.

In all years, type AN/SSQ-57B USN or -53F DIFAR sonobuoys (effective audio frequency response from 10 Hz up to 20 kHz) transmitting at various radio frequencies (in the MHz range) were deployed for real-time acoustic monitoring when the towed arrays could not be used (for example, during oceanographic sampling, small boat launching and recovering, and array repairs). Sonobuoys are self-contained units that automatically power up upon contact with water and transmit sounds via surface radio antenna. All sonobuoys were set at 90 m hydrophone deployment depths, typically for eight hours of operating life (auto-scuttle setting). The sonobuoy radio signals were received by a mast-mounted antenna connected to an ICOM IC-PCR1000 receiver that was controlled through a PC-based software interface. Acoustic signals from the receiver were recorded to a hard drive using `ISHMAEL` and an NI 6062E DAQ card or the internal PC sound card.

In 2021, only sonobuoys were used instead of a towed array for acoustic monitoring, in part due to staffing limitations during the COVID-19 pandemic. That year, the survey occurred in October and, based on previous sightings, was located near the commercial shipping lanes at the western entrance to the Strait of Juan de Fuca. The towed arrays reduce the maneuverability of the survey vessel, limiting their usefulness in this location.

If killer whale sounds were detected at night, the bio-acoustician on watch would attempt to localize and track the signals in real time. Killer whale discrete calls were compared to a catalog of pod- and population-specific pulsed calls to determine the killer whale ecotype and population (Ford 1987). If SRKW were detected, effort was made to remain with the whales until daybreak, when visual observers could locate the whales. During all killer whale sightings and encounters, bio-acousticians continued localizing killer whale sounds to aid in maintaining contact with the focal whales and monitoring acoustic behavior.

Killer whale encounters

When killer whales were encountered, both visual and acoustic data were used to identify the ecotype, community, and pods or individuals present. If weather conditions prevented small boat operations, photographs, acoustic recordings, and behavioral data were collected from the ship during encounters.

When weather conditions allowed, a small boat was deployed to conduct focal follows, photograph individual whales, and collect biological samples—including prey and fecal samples—using methods described in Hanson et al. (2010). Skin and blubber biopsy samples were also collected using methods described in Krahn et al. (2009). In 2012, 2013, 2015, and 2016, Low Impact Minimal Percutaneous External-electronics Transmitting (LIMPET) satellite telemetry tags, developed by Wildlife Computers, Inc. (Redmond, Washington), were also deployed during small boat operations. More information on the LIMPET tag deployments can be found in Hanson et al. (2018) and Schorr et al. (2022).

Oceanography

A Sea-bird Electronics Thermosalinograph (TSG) sampled surface water temperature and salinity continuously during the entire cruise track. The data from the TSG and from a GPS were continuously recorded by the ship's Scientific Computing System (SCS). TSG information was also used in the field by the oceanographer to record latitude, longitude, surface water temperature, and salinity during expendable bathythermograph (XBT) casts, surface water sampling, and connectivity–temperature–depth (CTD) casts.

XBTs were deployed at 0900, 1200, and 1500 hours to provide water temperature profiles. In the event that a CTD cast was cancelled due to inclement weather or because the ship was tracking killer whales, an XBT was also deployed when the surface water sample was collected at 1800. In later years, XBTs were not deployed when the ship was in shallow water (< ~100 m) or while transiting in Haro Strait and the Strait of Juan de Fuca. For XBT deployments, Sippican Deep Blue probes were used, and data were transmitted to the Shipboard Environmental Data Acquisition System.

Surface water samples for chlorophyll-a analysis were collected at 0600, 0900, 1200, 1500, and 1800 hours local ship time, and at other times under the discretion of the Chief Scientist (e.g., surface water samples were also taken every hour when in the presence of SRKW in some years). The surface water samples were collected in a bucket deployed over the side of the ship. Immediately following bucket sampling, a 50 mL sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in a Ziploc freezer bag until sample analysis, which occurred on the ship within 1–2 weeks of collection or within 1–2 weeks of returning to NWFSC in Seattle, depending on the availability of staff each year. For extraction, the filters were placed in culture tubes with 8 mL of 90% (v/v) acetone and stored in the freezer for a minimum of 2 hours. The tubes were then allowed to equilibrate with room temperature, and fluorescence was measured using a Turner Designs 10-AU Digital Field Fluorometer.

A CTD profile was conducted each evening one hour after sunset, weather and sufficient depth permitting. CTD data and seawater samples were collected using a SeaBird 9/11+ CTD with a 12 place rosette and Niskin bottles. All casts were to 1,000 m (depth permitting), with the descent rate set at 30 m/min for the first 100 m of the cast, then 60 m/min after that, including the upcast between bottles. Niskin bottle water samples were collected at 12 standard depths (0, 10, 20, 30, 40, 50, 75, 100, 150, 200, 500, and 1,000 m), or to within 10 m of the bottom. For each cast, water samples were collected for chlorophyll-a analysis at all depths to 200 m. Immediately following sampling, a 50 mL sample of the water was filtered onto a 2.5 cm GF/F filter. All filters were wrapped in foil, labeled, and stored frozen in a Ziploc freezer bag until sample analysis, which occurred on the ship within 1–2 weeks of collection or within 1–2 weeks of returning to NWFSC in Seattle, depending on staff availability each year. Chlorophyll-a extraction and analysis were conducted using the same protocol as above. Water samples for salinity analysis were collected at 100, 500, and 1,000 m (or to within 10 m of the bottom). Three additional salt samples were collected every other day so that the depths sampled were 30, 100, 150, 200, 500, and 1,000 m. Water samples for salinity analysis were stored upright at ambient room temperature. Salinity samples were processed at the University of Washington (UW) Marine Chemistry Laboratory in Seattle within a few months after the cruise (except for samples from 2004, which were analyzed while on the ship). Water samples (approximately 40 mL) for nutrient analysis from each of the 11 depths up to 500 m were transferred into pre-rinsed (10% HCl and H_2O) vials and frozen upright. Nutrient samples were processed within 1 year after the cruise at the UW Marine Chemistry Laboratory in Seattle (except for samples from 2004, which were analyzed with samples collected in 2006).

A detailed summary of oceanographic sampling can be found in Appendix A.

Ancillary Projects

In some years, additional projects were undertaken with collaborators during surveys. These included seabird surveys, juvenile salmon sampling, plankton sampling, active acoustic surveys, and eDNA sampling. These were components of larger projects or pilot studies, and the results are not included here.

Permits

All marine mammal work was conducted under NMFS permits #781-1824, #16163, and #21348 in U.S. waters, and MML 2008-03/SARA 84, MML 2012-03/SARA 84, XMMS 8 2014, and XMMS 4 2020 in Canadian waters. All activities in Olympic Coast National Marine Sanctuary were conducted under semi-annual permits.

Results

Surveys varied in length from 10–21 days due to ship time constraints, and occurred in the months of February and March in all years except 2007 (May) and 2021 (October). Initially, predetermined track lines were chosen to cover the continental shelf from central California to Vancouver Island, but search effort was modified since SRKW were not found equally across the study area. Most SRKW encounters were along the Washington coast and within 20 km of shore. Table 1 summarizes the survey methods used each year to locate SRKW.

The first survey in 2004 was the only one that extended south into California. For that reason, survey effort was summarized separately for this year. There were 390 hours of survey effort along the cruise track, eight hours visually tracking killer whales, and 18 hours of acoustic tracking of killer whales (Figure 2).

Table 1. Summary of yearly PODS dates and survey methods.

Year	Month	Duration	Visual	Acoustic	Satellite Telemetry
2004	February	18 days	Standard	Towed array	No
2006	March	18 days	Standard	Towed array	No
2007	May	13 days	Standard	Towed array	No
2008	March	10 days	Standard	Towed array	No
2009	March	17 days	Standard	Towed array	No
2012	February	19 days	Standard	Towed array	No
2013	March	10 days	Standard	Towed array	Yes
2015	February	20 days	Standard	Towed array	Yes
2016	February	20 days	Standard	Towed array	Yes
2021	October	14 days	Modified	Sonobuoy only	No

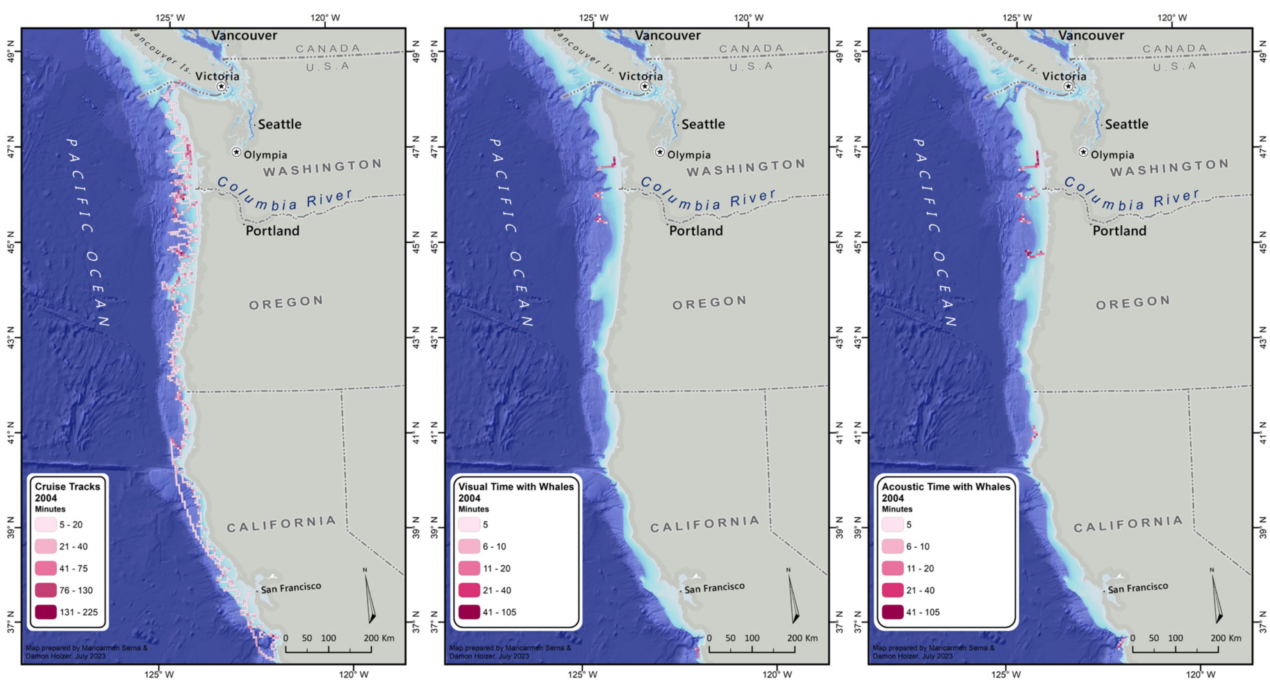

Figure 2. 2004 PODS time with whales compared to total survey effort. There were 390 hours of total survey effort (left), 8 hours of visual time spent with killer whales (center), and 18 hours of acoustic time spent with killer whales (right).

From 2006 to 2012 (Period 1), standard visual and acoustic survey methods were used to locate killer whales in Oregon, Washington, and British Columbia, resulting in 1,669 hours of survey along the cruise track, 108 hours visually tracking killer whales, and 205 hours acoustically tracking killer whales (Figure 3).

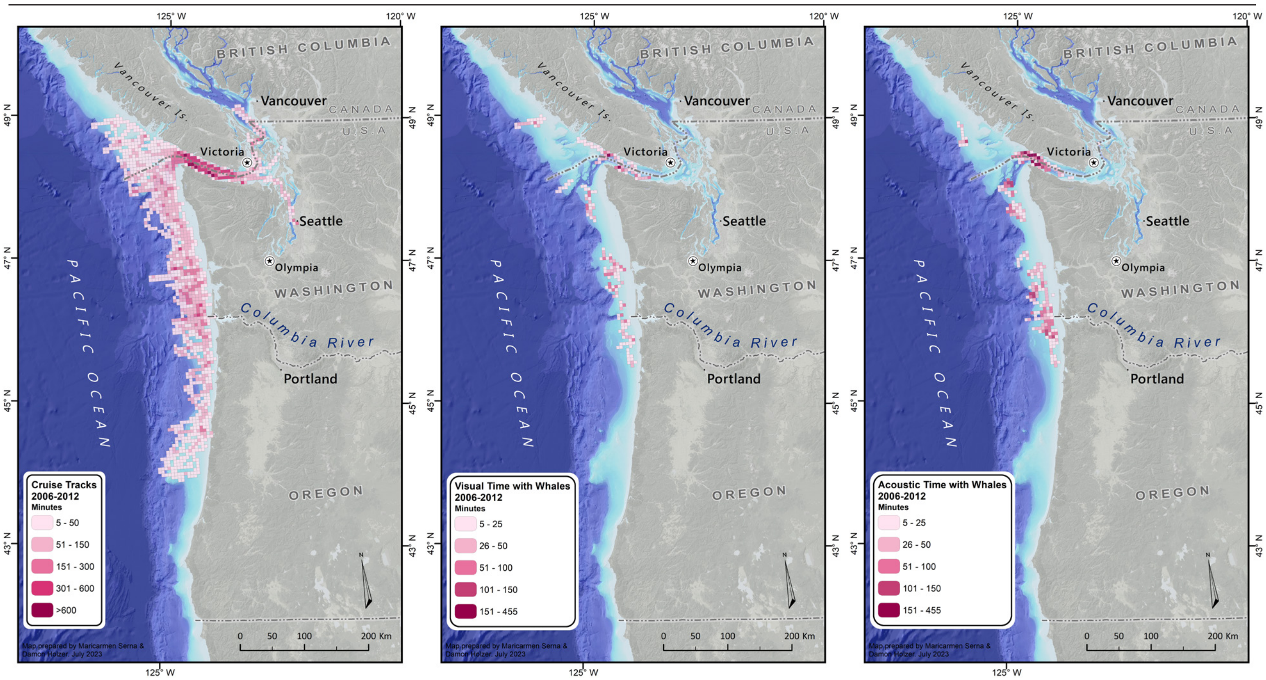

Figure 3. Period 1 (2006–12) PODS time with whales compared to total survey effort. There were 1,669 hours of total survey effort (left), 108 hours of visual time spent with killer whales (center), and 205 hours of acoustic time spent with killer whales (right).

Period 2 (2013–21) represented a shift in survey effort, with the additional knowledge from satellite telemetry allowing us to more rapidly locate SRKW. Satellite tags were deployed from a small boat on adult male SRKWs in the Salish Sea near the end of the year previous to a scheduled survey to increase the probability the tag was still transmitting the whale's location at the start of the survey (Hanson et al. 2018). In 2013, 2015, and 2016, a second tag was deployed when whales were located on the survey. The inclusion of satellite telemetry and improved understanding of SRKW occurrence in the study area reduced the time we searched for killer whales, both visually and acoustically, and increased the time we were able to spend with killer whales between Periods 1 and 2 (Table 2). In Period 2, the time spent visually (289 hr) and acoustically (343 hr) tracking killer whales increased, despite fewer hours of survey effort (1,444 hr) on the cruise track (Figure 4).

Table 2. Search effort compared to time spent with killer whales, in hours, in Period 1 (2006–12) and Period 2 (2013–21). *TWW* = time with whales.

	Visual effort	Visual TWW	Percentage of survey	Acoustic effort	Acoustic TWW	Percentage of survey
Period 1	846 hr	108 hr	12.7%	1,568 hr	205 hr	13.1%
Period 2	546 hr	289 hr	52.9%	858 hr	343 hr	40.0%

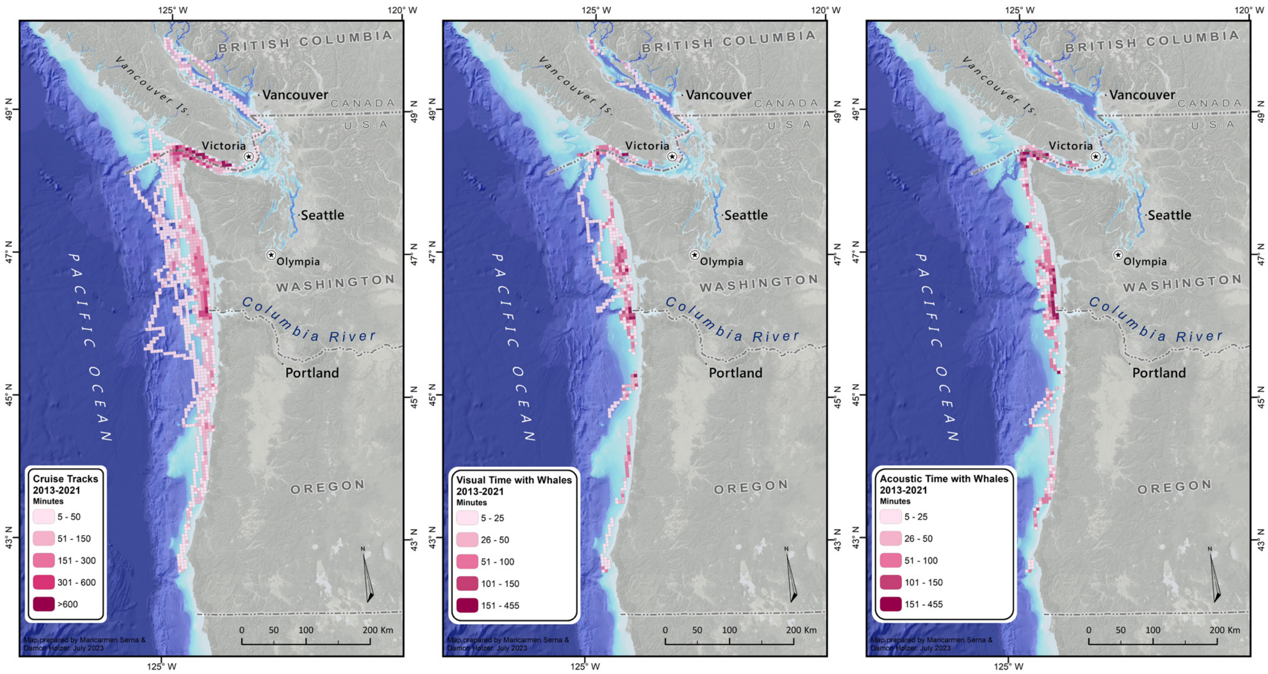

Figure 4. Period 2 (2013–21) PODS time with whales compared to total survey effort. There were 1,444 hours of total survey effort (left), 289 hours of visual time spent with killer whales (center), and 343 hours of acoustic time spent with killer whales (right).

Acoustic survey effort was conducted 24 hours per day and only briefly interrupted by extreme weather conditions, fishing gear interactions, shipping traffic, and daily oceanographic operations. The exception was in 2021, when 54 sonobuoys were deployed in lieu of the towed arrays to aid in locating and tracking SRKW (Figure 5).

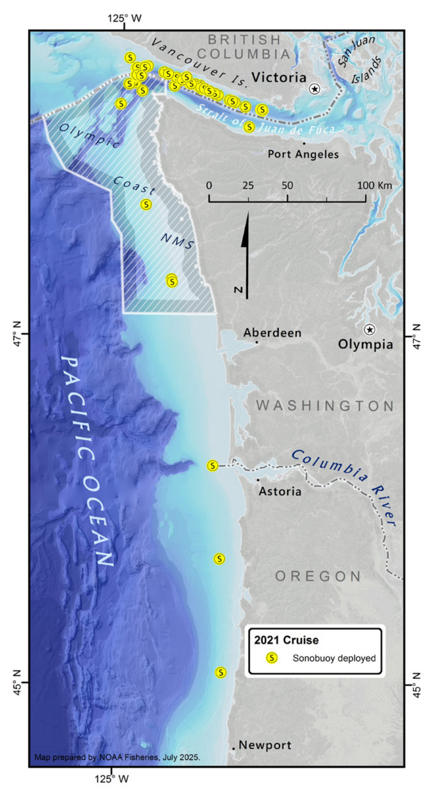

Figure 5. Locations of sonobuoys ($n = 54$) deployed during the 2021 PODS survey.

Weather conditions, including sea state, swell, and visibility, were the most common factors limiting visual surveys and small boat operations during killer whale encounters. Table 3 summarizes, for each year, the number of days with conditions sufficient for visual surveys, the number of kilometers surveyed, the number of cetacean sightings, and the number of killer whale encounters.

SRKW were sighted in all years except 2007, which was the only survey in the month of May.

Resident, Bigg's, and offshore killer whales were encountered during surveys, especially during Period 1, when more time was spent searching for SRKW and less on focal observations with SRKW. Bigg's killer whales were encountered throughout the study area in 2004 and Period 1. Northern Resident killer whales (NRKW)

Table 3. Summary of PODS visual effort.

Year	Visual effort (days)	Visual effort (km)	Number of cetacean sightings	Number of killer whale encounters
2004	15	1,556.8	128	5
2006	16	2,227.8	94	8
2007	13	2,296.2	91	2
2008	8	1,223.1	45	3
2009	15	2,083.5	76	9
2012	18	1,991.5	81	4
2013	8	620.3	56	8
2015	19	1,631.1	145	15
2016	18	1,762.1	152	10
2021	12	834.9	145	7

were encountered along the Washington coast, especially in 2006, and as far south as Westport, Washington, in 2012. In Period 2, most encounters were with SRKW, except for one encounter with offshore killer whales in 2013 and two Bigg's killer whale encounters in 2016.

Time spent with SRKW during PODS allowed for visual and acoustic behavioral observations outside of the Salish Sea. Behavior was variable between years. For example, in February 2015, foraging was often observed and prey samples were collected. In contrast, little foraging was observed along the Washington coast during daylight hours in February 2016. Instead, SRKW were observed travelling in two tight groups for multiple days. Observed behavior was also different compared to other studies conducted in the Salish Sea. For example, vocalization rate from 2013, 2015, and 2016 surveys was consistently lower than that observed in the Salish Sea during the summer (Holt et al. 2009, Hanson et al. 2018). Further details on killer whale encounters can be found in Table 4.

In all years, the small boat was deployed to conduct photo identification of killer whale groups. Starting in 2009, the NWFSC small boat RV *Phocoena II* was deployed. The *Phocoena II* is outfitted to conduct focal follows to collect prey and fecal samples from SRKW using methods described in Hanson et al. 2010. Effort from these follows (2009–21) is summarized using the methods described previously for all survey effort (Figure 6).

Sightings of other cetacean species varied across years, depending on location and timing of surveys. Grey whales (*Eschrichtius robustus*), humpback whales (*Megaptera novaeangliae*), Dall's porpoises (*Phocoenoides dalli*), and harbor porpoises (*Phocoena phocoena*) were the most sighted species. All cetacean sightings other than killer whales are summarized in Table 5.

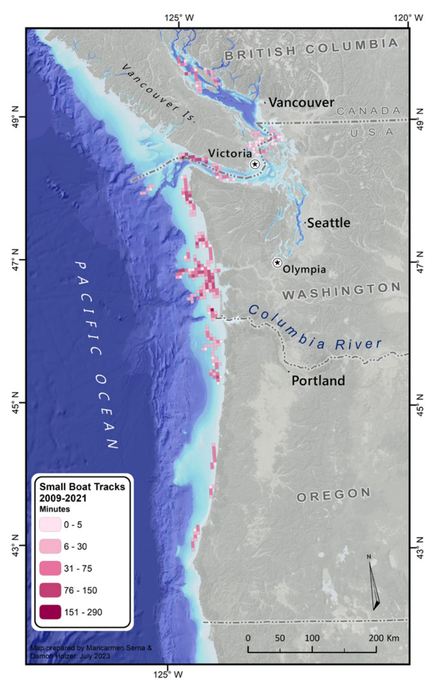

Figure 6. Small boat effort (176 hr) from 2009–21.

Table 4. Summary of all killer whale encounters during PODS. Whale types: *OKW* = offshore killer whale, *TKW* = Bigg's (transient) killer whale, *SRKW* = Southern Resident killer whale, *NRKW* = Northern Resident killer whale. Encounter duration is in hours:minutes. Encounter locations: *CA* = California, *OR* = Oregon, *WA* = Washington, *JF* = Strait of Juan de Fuca, *WVI* = West Vancouver Island, *NGS* = Northern Georgia Strait, *CR* = off the Columbia River.

Date	Whales present	*n*	Duration	Location	Vessel	Biopsy samples	Satellite tags	Prey samples	Fecal samples
05 Mar 2004	OKW	7	0:55	CA	Ship				
08 Mar 2004	TKW	6	3:00	CA	Ship				
11 Mar 2004	TKW	3	1:00	OR	Ship				
12 Mar 2004	TKW	7	2:50	OR	Ship				
13 Mar 2004	SRKW	35	1:20	WA	Small boat				
14 Mar 2006	TKW	6	1:21	WA	Ship				
18 Mar 2006	SRKW	24	5:07	JF	Small boat				
18 Mar 2006	SRKW	24	6:33	JF	Ship				
20 Mar 2006	NRKW	25	2:52	WA	Small boat				
27 Mar 2006	NRKW	42	8:37	WA	Ship				
28 Mar 2006	NRKW	42	2:59	WA	Ship				
30 Mar 2006	SRKW	40	3:03	CR	Small boat				
31 Mar 2006	NRKW	5	1:00	WA	Ship				
05 May 2007	NRKW	15	7:52	WVI	Small boat				
13 May 2007	TKW	12	2:00	JF	Small boat	3			
18 Mar 2008	TKW	3	0:40	WA	Ship				
22 Mar 2008	TKW	3	2:18	WA	Small boat				
25 Mar 2008	SRKW	25	9:27	JF	Small boat	1			
26 Mar 2009	SRKW	40	9:11	WA	Small boat	1		2	
27 Mar 2009	SRKW	40	16:42	WA	Small boat				
28 Mar 2009	TKW	30	6:10	WA	Small boat				
29 Mar 2009	TKW	10	3:50	WA	Small boat				
31 Mar 2009	TKW	6	—	WA	Ship				
04 Apr 2009	TKW	5	1:31	WA	Small boat				
05 Apr 2009	TKW	4	3:52	WA	Small boat				
06 Apr 2009	TKW	15	3:33	OR	Small boat	1	1		
08 Apr 2009	TKW	5	1:55	WA	Small boat	1	1		
20 Feb 2012	SRKW	25	6:48	JF	Small boat		1		
22 Feb 2012	UNK	5	—	JF	Ship				
27 Feb 2012	NRKW	10	—	JF	Ship				
04 Mar 2012	NRKW	5	2:16	WA	Small boat	1			
02 Mar 2013	SRKW	56	5:28	OR	Small boat		1		3
03 Mar 2013	SRKW	56	5:29	OR	Small boat				4
04 Mar 2013	SRKW	56	7:50	OR	Small boat	4		7	1
05 Mar 2013	SRKW	56	3:55	WA	Small boat			3	1
06 Mar 2013	SRKW	56	5:22	WA	Small boat				6
07 Mar 2013	SRKW	56	6:53	WA	Small boat			2	4
08 Mar 2013	OKW	25	6:50	WA	Small boat	4	2	1	
09 Mar 2013	SRKW	56	6:18	WA	Small boat	1		11	2

Table 4 (continued). Summary of all killer whale encounters during PODS.

Date	Whales present	*n*	Duration	Location	Vessel	Biopsy samples	Satellite tags	Prey samples	Fecal samples
13 Feb 2015	SRKW	26	3:38	NGS	Small boat	2		1	
14 Feb 2015	SRKW	26	2:34	NGS	Small boat			1	
15 Feb 2015	SRKW	26	6:54	NGS	Small boat				
17 Feb 2015	SRKW	43	6:17	WA	Small boat	2	1	4	
18 Feb 2015	SRKW	43	3:55	WA	Small boat				4
19 Feb 2015	SRKW	43	7:20	CR	Small boat				1
21 Feb 2015	SRKW	43	1:43	OR	Small boat				
23 Feb 2015	SRKW	43	4:36	OR	Small boat			1	2
24 Feb 2015	SRKW	43	7:48	OR/WA	Small boat			3	2
25 Feb 2015	SRKW	53	7:03	WA	Small boat				3
26 Feb 2015	SRKW	53	7:36	WA	Small boat			5	
28 Feb 2015	SRKW	25	7:42	WA	Small boat			6	1
01 Mar 2015	SRKW	10	4:00	WA	Small boat			3	
23 Feb 2016	SRKW	35	1:42	WA	Small boat		1		
24 Feb 2016	SRKW	35	3:34	WA	Small boat				
25 Feb 2016	SRKW	35	3:33	CR	Small boat				4
26 Feb 2016	SRKW	54	6:02	WA	Ship				
27 Feb 2016	SRKW	54	3:38	WA	Ship				
01 Mar 2016	SRKW	26	0:49	JF	Ship				
02 Mar 2016	SRKW	26	3:27	JF	Ship				
03 Mar 2016	TKW	3	1:06	JF	Ship				
04 Mar 2016	SRKW	26	1:00	JF	Small boat				
07 Mar 2016	SRKW	26	11:10	WA	Ship				
09 Mar 2016	TKW	8	1:27	WA	Ship				
17 Oct 2021	SRKW	74	7:27	JF	Ship				
18 Oct 2021	SRKW	74	3:45	JF	Small boat			4	2
19 Oct 2021	SRKW	25	5:00	JF	Ship				
20 Oct 2021	SRKW	24	1:27	JF	Small boat			1	
22 Oct 2021	SRKW	25	4:06	JF	Small boat				5
24 Oct 2021	SRKW	25	2:52	JF	Ship				
27 Oct 2021	SRKW	25	2:29	JF	Ship				

Table 5. Yearly summary of cetacean sightings (other than killer whales) during PODS.

Species	2004	2006	2007	2008	2009	2012	2013	2015	2016	2021
Gray whale (*Eschrichtius robustus*)										
Sightings	43	40	0	9	20	1	23	57	45	1
Animals	69	81	0	17	37	2	37	100	60	1
Humpback whale (*Megaptera novaeangliae*)										
Sightings	0	5	33	2	8	0	5	1	8	126
Animals	0	9	73	2	12	0	6	2	10	371
Fin whale (*Balaenoptera physalus*)										
Sightings	1	0	2	1	0	0	1	11	0	0
Animals	1	0	5	6	0	0	1	21	0	0
Minke whale (*Balaenoptera acutorostrata*)										
Sightings	0	2	1	0	0	0	0	0	0	0
Animals	0	2	1	0	0	0	0	0	0	0
Sperm whale (*Physeter macrocephalus*)										
Sightings	0	1	0	0	0	0	0	1	0	0
Animals	0	1	0	0	0	0	0	2	0	0
Unidentified whale										
Sightings	4	8	38	13	14	1	4	35	21	9
Animals	8	8	64	20	19	2	4	54	23	11
Dall's porpoise (*Phocoenoides dalli*)										
Sightings	6	14	13	4	6	39	0	8	11	1
Animals	116	48	56	5	30	135	0	25	27	6
Harbor porpoise (*Phocoena phocoena*)										
Sightings	12	10	1	9	18	28	14	8	46	0
Animals	14	13	1	15	29	52	33	33	88	0
Unidentified porpoise										
Sightings	0	0	1	0	1	1	0	0	1	0
Animals	0	0	1	0	1	2	0	0	1	0
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)										
Sightings	23	5	0	1	0	2	0	1	1	0
Animals	497	63	0	5	0	11	0	10	40	0
Northern right whale dolphin (*Lissodelphis borealis*)										
Sightings	3	0	0	0	0	0	0	1	0	0
Animals	76	0	0	0	0	0	0	50	0	0
Risso's dolphin (*Grampus griseus*)										
Sightings	1	0	0	0	0	0	0	1	0	0
Animals	4	0	0	0	0	0	0	18	0	0
Unidentified dolphin										
Sightings	4	0	0	2	0	1	0	1	1	0
Animals	14	0	0	132	0	1	0	250	1	0

Discussion

PODS were successful in locating SRKW during winter months despite the large study area (approximately 50,000 km^2), the small population size of SRKW, and winter conditions (e.g., weather, short days), and highlighted the seasonal importance of the nearshore waters of the Washington coast, especially adjacent to the Columbia River and the Strait of Juan de Fuca.

The objective of PODS was to locate SRKW to a) better document their winter range, and b) improve our understanding of their behavior and habitat use in these areas. PODS were initially modeled after previous NMFS shipboard surveys that utilized line-transect methods to estimate cetacean population size and range, but winter conditions (bomb cyclones, snow, low visibility, and low-pressure systems) required modifications to those methods. For the stated objective, these modified visual and acoustic survey methods were sufficient to locate killer whales and were most effective when combined with satellite telemetry.

An analysis of data from the 2006, 2008, 2009, and 2012 surveys found that resident killer whale occurrence was associated with moderate temperature and salinity, and more associated with distance from shore than other piscivorous cetaceans (Bliss et al. 2024). The majority of sightings during these years were along the Washington coast, despite effort throughout the study area (Bliss et al. 2024).

The addition of satellite telemetry further refined search efforts and provided additional evidence that SRKW occurrence was not equal throughout the study area (NMFS 2021). SRKW showed a preference for waters between 18 m and 54 m depth and within 34 km of shore (Hanson et al. 2017). These findings also identified high-use areas primarily off the Washington coast, similar to Bliss et al. (2024).

When a satellite tag was transmitting concurrently with a survey, search time was reduced; this allowed us to spend more time with SRKW to collect prey and feces to provide critical information on winter diet, as reported in Hanson et al. (2021). Their analysis of SRKW diet from October to May 2004–17 demonstrated that Chinook salmon was an important year-round prey item, although fecal samples indicated a broader diet (Hanson et al. 2021). This analysis also provided additional evidence of the seasonal importance of Columbia River Chinook salmon and filled an important data gap of SRKW seasonal diet outside of the Salish Sea.

Subsequent analysis of biopsy samples collected during PODS also provided additional information on the diet of SRKW. Quantitative fatty acid signature analysis (QFASA) of these samples integrates dietary patterns over longer temporal scales (weeks to months). Results confirm the importance of Chinook salmon to SRKW, but suggest their diet may be more diverse than previously thought from prey and fecal sample analysis alone (Remili et al. in review).

Encounters with other piscivorous killer whales, including NRKW, along the Washington coast provide additional evidence that competition with other fish-eating killer whales may impact SRKW (Emmons et al. 2021, Hanson et al. 2021). During a PODS encounter with offshore killer whales (OKW) near Grays Harbor Canyon, prey remains were identified as Chinook salmon, even though sharks have been reported to be the primary prey of OKW in other parts of their range (Wright et al. 2025). This encounter is described further in Schorr et al. (2022).

The most commonly encountered species, other than killer whales, were gray whales, humpback whales, harbor porpoises, and Dall's porpoises. These sightings indicate that, despite the many individuals known to undertake large seasonal migrations (Poole 1984, Calambokidis et al. 2001), some humpback and gray whales are found throughout the year along the Washington coast. While conditions and resulting survey effort modifications did not provide sufficient data to estimate how many individuals remain on the Washington coast, Bliss et al. (2024) describe habitat associations of these species in the California Current in the low-productivity downwelling season.

PODS were one component of an integrated approach that included passive acoustic monitoring and satellite telemetry to address the data gap of winter distribution and habitat use of SRKW, refine the Critical Habitat designation, and better understand the diet of SRKW in different seasons throughout their range. Data collected during surveys provided necessary information on habitat use, locations of foraging and predation events, and the species and salmon stocks that SRKW eat in their outer coast habitat, and were integral to the revision of their Critical Habitat (NMFS 2021). The success of these collective winter observations of SRKW was made possible by the capabilities of large ocean-going vessels in combination with satellite telemetry information, which maximized the limited available time at sea and reduced the challenges of locating SRKW in winter months.

Recent studies have shown that SRKW occurrence patterns are shifting (Olson et al. 2018). While most of these documented shifts have been in the Salish Sea (Ettinger et al. 2022, Shields et al. 2023), passive acoustic monitoring along the Washington coast suggests decreasing seasonal occurrence near the Columbia River and increasing year-round occurrence at the west entrance of the Strait of Juan de Fuca (Hanson et al. in prep.), which has common foraging areas for SRKW (Stredulinsky et al. 2023). These recent shifts warrant continued use of surveys and emerging technologies to monitor SRKW movements, behavior, and foraging ecology outside of the Salish Sea.

References

Bliss, L. M., J. E. Zamon, G. K. Davoren, M. B. Hanson, D. P. Noren, C. K. Emmons, and M. M. Holt. 2024. Habitat associations of marine predators in the northern California Current during the low productivity downwelling season. Frontiers in Marine Science 11:13554399.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. R. Urban, J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, and 13 coauthors. 2001. Movements and population structure of hump-back whales in the North Pacific. Marine Mammal Science 17(4):769–794.

Emmons, C. K., M. B. Hanson, and M. O. Lammers. 2021. Passive acoustic monitoring reveals spatiotemporal segregation of two fish-eating killer whale *Orcinus orca* populations in proposed critical habitat. Endangered Species Research 44:253–261.

ESA (Endangered Species Act of 1973). 1973. U.S. Code, title 16, sections 1531–1544.

Ettinger, A. K., C. J. Harvey, C. K. Emmons, M. B. Hanson, E. J. Ward, J. K. Olson, and J. F. Samhouri. 2022. Shifting phenology of an endangered apex predator mirrors changes in its favored prey. Endangered Species Research 48:211–223.

Ford, J. K. B. 1987. A catalogue of underwater calls produced by killer whales (*Orcinus orca*) in British Columbia. Canadian Data Report of Fisheries and Aquatic Sciences 633:1–165.

Hanson, M. B., R. W. Baird, J. K. B. Ford, J. Hempelmann-Halos, D. M. Van Doornik, C. R. Candy, C. K. Emmons, G. S. Schorr, B. Gisborne, K. L. Ayres, and 5 coauthors. 2010. Species and stock identification of prey consumed by endangered Southern Resident killer whales in their summer range. Endangered Species Research 11:69–82.

Hanson, M. B., C. K. Emmons, M. J. Ford, M. Everett, K. Parsons, L. K. Park, J. Hempelmann, D. M. V. Doornik, G. S. Schorr, J. Jacobsen, and 5 coauthors. 2021. Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. PLOS ONE 16(3):e0247031.

Hanson, M. B., E. J. Ward, C. K. Emmons, M. M. Holt, and D. M. Holzer. 2017. Assessing the movements and occurrence of Southern Resident killer whales relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest. Northwest Fisheries Science Center, Seattle.

Hanson, M. B., E. J. Ward, C. K. Emmons, and M. M. Holt. 2018. Modeling the occurrence of endangered killer whales near a U.S. Navy Training Range in Washington State using satellite-tag locations to improve acoustic detection data. Northwest Fisheries Science Center, Seattle.

Hanson, M. B., C. K. Emmons, E. J. Ward, M. M. Holt, J. A. Nystuen, and M. O. Lammers. In preparation. Long-term autonomous passive acoustic monitoring shows shift in the coastal occurrence patterns of endangered fish-eating killer whales. Northwest Fisheries Science Center, Seattle.

Holt, M. M., D. P. Noren, V. Veirs, C. K. Emmons, and S. Veirs. 2009. Speaking up: Killer whales (*Orcinus orca*) increase their call amplitude in response to vessel noise. The Journal of the Acoustical Society of America 125(1):EL27–EL32.

Kinzey, D., P. A. Olson, and T. Gerrodette. 2000. Marine mammal data collection procedures on research ship line-transect surveys by the Southwest Fisheries Science Center. U.S. Department of Commerce, NOAA Administrative Report LJ-00-07C.

Krahn, M. M., M. B. Hanson, G. S. Schorr, C. K. Emmons, D. G. Burrows, J. L. Bolton, R. W. Baird, and G. M. Ylitalo. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in "Southern Resident" killer whales. Marine Pollution Bulletin 58(10):1522–1529.

Mellinger, D. K. 2001. Ishmael 1.0 User's Guide. U.S. Department of Commerce, NOAA Technical Memorandum OAR PMEL-120. Available: repository.library.noaa.gov/view/noaa/11056 (May 2026).

NMFS (National Marine Fisheries service). 2021. Revision of the Critical Habitat Designation for Southern Resident Killer Whales: Final Biological Report (to accompany the Final Rule). National Marine Fisheries Service, Seattle.

Olson, J. K., J. Wood, R. W. Osborne, L. Barrett-Lennard, and S. Larson. 2018. Sightings of Southern Resident killer whales in the Salish Sea 1976–2014: The importance of a long-term opportunistic dataset. Endangered Species Research 37:105–118.

Poole, M. 1984. Migration corridors of gray whales along the Central California coast, 1980–1982. Pages 389–407 in M. L. Jones, S. L. Swartz, and S. Leatherwood, editors. The gray whale. Academic Press, New York.

Rankin, S., J. Barlow, Y. Barkley, and R. Valtierra. 2013. A guide to constructing hydrophone arrays for passive acoustic data collection during NMFS shipboard cetacean surveys. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-511.

Remili, A., D. P. Noren, P. Chittaro, M. B. Hanson, G. M. Ylitalo, C. K. Emmons, S. M. O'Neill, A. Chappell, I. R. Schultz, C. Gallilee, and 2 coauthors. In review. Diet composition of Southern Resident Killer Whales (*Orcinus orca ater*) estimated by quantified fatty acid signature analysis.

Schorr, G. S., M. B. Hanson, E. A. Falcone, C. K. Emmons, S. M. Jarvis, R. D. Andrews, and E. M. Keen. 2022. Movements and diving behavior of the Eastern North Pacific offshore killer whale (*Orcinus orca*). Frontiers in Marine Science 9:854893.

Stredulinsky, E. H., S. Toews, J. Watson, D. P. Noren, M. M. Holt, and S.J. Thornton. 2023. Delineating important killer whale foraging areas using a spatiotemporal logistic model. Global Ecology and Conservation 48:e02726. DOI: 10.1016/j.gecco.2023.e02726

USOFR (U.S. Office of the Federal Register). 2005. 50 CFR Part 224: Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales, final rule. Federal Register 70:222(18 November 2005):69903–69912.

Wright, B. M., D. Olsen, B. Gisborne, A. D. Schulze, M. H. Wetklo, G. M. Ellis, C. O. Matkin, J. K. B. Ford, and T. Doniol-Valcroze. 2025. Dietary specialization on elasmobranchs and seasonal foraging patterns of offshore killer whales *Orcinus orca* in the northeastern Pacific. Marine Ecology Progress Series 763:171–196.

Appendix A

Table A-1. PODS oceanography sample collection.

Sampling	2004	2006	2007	2008	2009	2012	2013	2015	2016	2021
CTD casts	9	7	10	6	6	7	7	17	0	0
CTD chlorophyll samples	83	67	93	57	58	69	50	129	0	0
CTD nutrient samples	86	67	100	60	62	74	50	132	0	0
CTD salinity samples	25	24	30	22	25	30	8	32	0	0
Bucket-collected surface samples	90	96	68	46	84	78	88	96	86	0
Surface chlorophyll samples	90	96	68	46	84	78	88	96	95[a]	0
Surface nutrient samples	0	0	0	0	0	0	0	0	95[b]	0
XBT drops	56	53	37	25	34	25	22	62	43	0

[a] In 2016, a subset of duplicate samples was collected to compare data from surface water collected using the bucket method to data from water collected via the ship inlet source (inlet samples [#31–43] are labeled with a *B* in the data sheets).

[b] In 2016, surface water nutrient samples were collected using the bucket method in lieu of conducting CTD casts, due to a staffing shortage. A subset of duplicate samples was collected to compare data from surface water collected using the bucket method to data from water collected via the ship inlet source (inlet samples [#31–43] are labeled with a *B* in the data sheets).

Appendix B

PODS Scientific Participants

Chief scientist

Brad Hanson

Visual observers

Brad Hanson	Dawn Noren	Candice Emmons
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Allan Ligon	Amy Kennedy	Daniel Webster
Brenda Rone	Jeff Foster	Dawn Breese

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Killer whale ID specialists

David Ellifrit	Candice Emmons

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Jeff Foster		

Oceanography lead

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Oceanographers

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Toby Auth	Tracy Shaw	Alyssa Hopkins
Andrea Goodmansen	Tamara Fraser	

Seabird lead

Jen Zamon

Seabird observers

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Troy Guy	Brendan Courtot	Elizabeth Phillips
Terry Hunfield	Ryan Merrill	Ignacio Vilchis

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NOAA Technical Memorandum NMFS-NWFSC-

207 **Holt, M. M., C. K. Emmons, R. P. Dziak, D. K. Mellinger, and S. M. Haver. 2026.** Underwater Acoustic Monitoring Desktop Study: A Collaborative Initiative Between Port of Seattle (PoS) and the National Oceanic and Atmospheric Administration (NOAA). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-207. https://doi.org/10.25923/g589-6539

206 **Somers, K. A., K. E. Richerson, and V. J. Tuttle. 2026.** Estimated Discard and Catch of Groundfish Species in the 2024 U.S. West Coast Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-206. https://doi.org/10.25923/c8cz-tk83

205 **Keller, A. A., V. H. Simon, D. L. Draper, A. C. Chappell, K. L. Bosley, J. C. Buchanan, P. H. Frey, J. H. Harms, and M. A. Head. 2026.** The 2019 U.S. West Coast Bottom Trawl Survey of Groundfish Resources off Washington, Oregon, and California: Estimates of Distribution, Abundance, and Length Composition. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-205. https://doi.org/10.25923/w111-ja31

204 **Gaydos, J. K., H. H. Nollens, C. F. Lo, M. B. Hanson, K. Haman, M. Weiss, D. Giles, S. J. Thornton, T. R. Robeck, and C. Dold. 2026.** Remotely Sensed Metrics for Evaluating Wild Killer Whale Health. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-204. https://doi.org/10.25923/jftd-d217

203 **Somers, K. A., K. E. Richerson, and V. J. Tuttle. 2025.** Fishing Effort in the 2002–23 U.S. Pacific Coast Groundfish Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-203. https://doi.org/10.25923/1rck-7159

202 **Sol, S. Y., P. M. Nicklason, B. F. Anulacion, and R. B. Johnson. 2025.** Use of Non-Native Columbia River American Shad (*Alosa sapidissima*) as an Alternative Fishmeal Source for Juvenile Sablefish (*Anoplopoma fimbria*). U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-202. https://doi.org/10.25923/8dcv-5t90

201 **WC Chinook Salmon Status Review Team. 2025.** Biological Status of the Washington Coast Chinook Salmon Evolutionarily Significant Unit: Report of the Status Review Team. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-201. https://doi.org/10.25923/1713-1129

200 **Steiner, E., A. Phillips, and A. Chen. 2025.** Economic Status of the Pacific Hake Fishery, 2009–23. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-200. https://doi.org/10.25923/gcr3-ph80

199 **Somers, K. A., K. E. Richerson, V. J. Tuttle, and J. T. McVeigh. 2024.** Estimated Discard and Catch of Groundfish Species iin the 2023 U.S. West Coast Fisheries. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-199. https://doi.org/10.25923/mxc3-9934

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