FINAL PROGRAM REPORT: SRKW Sighting Compilation 19th Edition

Project Title: Southern Resident Killer Whale Sighting Compilation 1948-2022

Authors/ Organization: Alexis Haifley
Data & GIS Analyst – Sightings Network Coordinator
The Whale Museum
P.O. Box 945, Friday Harbor, WA 98250
Email: alexis@whalemuseum.org

Project Data and Description Prepared By:
Alexis Haifley, Salma Abdel-Raheem, Jennifer Olson, Dr. Jason Wood, Dr. Richard Osborne, and Dr. Robert Otis under the auspices of The Whale Museum.

Contract Number: #1305M318DNFFP0011
Date: June 1, 2023

Abstract:

The primary goal of the 19th Edition of the Southern Resident Killer Whales (SRKW) Sightings Compilation is to update and re-integrate available sightings data on the SRKW from the inland marine waters of Washington State and Southern British Columbia. This edition includes data from 1948 through 2022. A total of 1,932 new sightings entries were added for 2022, which constitutes a 46% increase in sightings reports from 2021. Information processed for this database comes from identified SRKW sighting sources that have been systematically evaluated for accuracy and integrated into a uniform dataset in MS Access. Normalized spatial locations have been translated into latitude and longitude, UTM coordinates, and WDFW/DFO Fisheries reporting areas. The six primary data sources for this database are:

1. The Whale Museum's sighting archives (which includes sightings from Museum affiliated researchers, naturalists, and whale watch companies; Orca Network sightings posted on the internet; and sightings reported via The Whale Museum's Whale Hotline)
2. Commercial whale watch pager system reports
3. Soundwatch Boater Education program data
4. A longitudinal dataset from Lime Kiln Point State Park
5. SPOT recorder data
6. BCCSN data.

This database is updated on an annual basis by staff and affiliated researchers. Included with this report are the 113,126 records in the sightings database which are added in the appendices as both MS Access and MS Excel format. This project was funded with resources from NOAA Contract #1305M318DNFFP0011 and The Whale Museum.

Table of Contents

Executive Summary

The primary goal of the present report is to update the SRKW Sighting Compilations (Osborne et al. 2004, 2006, 2007, Traxler et al. 2008-2011, Charapata et al. 2012, Olson et al. 2013-2018b, Abdel-Raheem et al. 2019-2020, Haifley et al. 2021) with the 19th edition covering sightings from 1948 through December 2022. The goal of this report is to provide a data update to the 1305M318DNFFP0011 contract report.

The primary data source in the SRKW Sighting Compilation is The Whale Museum's (TWM) sighting archives (TWM-SA) of year-round public sightings reported to The Whale Hotline or directly provided to Museum staff through several different channels (Balcomb et al. 1980, Heimlich-Boran 1988, Felleman et al. 1991, Osborne 1991, 1999, Olson 1998, Osborne et al. 2007; Olson et al. 2014-2018b, Abdel-Raheem et al. 2019). These channels include sighting compilations from the following: affiliated naturalists, scientists, commercial whale watch vessels, Orca Network email postings (www.orcanetwork.org), hydrophone detections from listeners to the Salish Sea Hydrophone Network (http://seasound.org and http://www.orcasound.org), and reliable reports from independent investigators and whale watchers. Other more systematic data sources collected during the summer season include: Dr. Robert Otis' longitudinal dataset from Lime Kiln Point State Park (Osborne 1999, Osborne et al. 2004, 2006, 2007, Traxler et al. 2008-2011, Charapata et al. 2012, Olson et al. 2014-2018b), Soundwatch Boater Education and Monitoring Program's 30-minute samples during on-water vessel patrols (Koski et al. 2004, 2006-2011, Eisenhardt et al. 2012-2013, Eisenhardt and Koski 2014, Seely 2015-2016, Seely et al. 2017, Shedd et al. 2018-19, Frayne et al. 2021); and information from SPOT (satellite personal GPS) systems used by various whale watch and research boats from 2008-2018. A final source includes SRKW sightings via collaboration with Ocean Wise's Coastal Ocean Research Institute's B.C. Cetaceans Sightings Network (BCCSN), a primarily opportunistic sightings database from 1975-2022.

The Whale Museum's sightings archive data was collected in a fashion that is not subject to a uniform test of reliability due to the variation of sighting platforms, observers, and their qualifications (Heimlich Boran 1988, Osborne 1991, 1999, Olson 1998). However, summer datasets from Lime Kiln Point State Park, TWM's Soundwatch Program, and the commercial pager records are systematic enough to use as homogeneous samples on their own for some statistical considerations (Hauser 2006, Hauser et al. 2006). Outside of the summer season, there are great sampling biases regarding the number of observers, number of observers actively searching for whales, period of daylight, and visibility in terms of sea surface and atmospheric conditions. It is also important to note that TWM has increased its efforts to collect sightings data over the years by recruiting new sources, many of which overlap in coverage area. Though all the data has been given with a point source, killer whale movements cover large areas and original location sources are often approximate. Data, however, are considered to be accurate within a ± 1-kilometer range for use in a standard GIS analysis.

Project Goal and Objectives

The primary goal of this contract report is to update the historical SRKW Sightings Compilation and spatial database for the inland marine waters of Washington State and Southern British Columbia so that scientists and managers have a reliable, up-to-date spatial dataset on the movement patterns of SRKW that is uniform between studies (Osborne et al. 2004, 2006, 2007, Traxler et al. 2008-2011, Charapata et al. 2012, Olson et al. 2013-2018b, Abdel-Raheem et al. 2019, Haifley et al. 2021). The specific objectives of this contract were to continue to compile SRKW sightings information through 2022, process it for accuracy and completeness, and integrate it with the existing dataset.

Data Sources

Data source information, including a basic description of the dataset, periods of coverage, locations, and numbers of records, are reported in Table 1 for each of the five datasets comprising the 19th edition of the SRKW Sighting Compilation. In Table 2, each field in the database is described and classified in terms of the data type, its format and its rules for entry.

I) The Whale Museum Sightings Archive (TWM-SA)

The Whale Museum (TWM) has long maintained an archive of marine mammal sightings (Boran 1980, Osborne 1991, 1999). The first data source used for the SRKW Sighting Compilation 19th Edition is TWM's Sighting Archives (TWM-SA). These sightings are reported to TWM through several channels, including:

- The Whale Hotline (a phone recording for public sightings)
- TWM's online reporting system (http://hotline.whalemuseum.org)
- E-mail via TWM's website (hotline@whalemuseum.org)
- TWM staff, interns, and visitors
- Orca Network (an email list service based on Whidbey Island)
- Eyewitness reports from affiliated researchers
- Logbooks from shipboard naturalists on commercial whale watch boats
- Hydrophone detections from listeners to the Salish Sea Hydrophone Network (http://seasound.org and http://www.orcasound.org) or from collaborating acousticians.

Sightings are recorded on data or MS Excel sheets that are either created and distributed by TWM to affiliated data partners or are created by and provided to TWM by the affiliated partner. All data provided to TWM is processed for consistency and then entered into a Microsoft Access database. TWM-SA records are identified as from a public source (TWM-SA-Pub) if the observer is not known to TWM staff or as reliable (TWM-SA-Rel) if the observer is known to be experienced or professional. The TWM-SA provides the only year-round source for the Orca Master dataset and is primarily composed of opportunistic reports. The remaining sighting datasets, which are incorporated in this master database, are primarily focused on the six months of summer (April-September).

Historically, TWM has partnered with many whale watch operators and their naturalists to collect and share any sightings observed while on commercial whale watching trips. However, relationships with whale watch operators have greatly changed in the last few years. For instance, sightings reports were provided by a single whale watch company for the 2019 season, but none reported any sightings in 2020. Therefore, SRKW were either not sighted by a single operator in 2019 or any SRKW sightings were not shared with TWM for inclusion in the OM dataset and report. Whale watch data collected by boat captains and/or naturalists provided reliable information on location, pod(s), and direction of travel. Although considered to be "reliable," the source code "TWM-SA-WW" was assigned to these records in order to better track the number of sightings received by this method.

II) TWM in conjunction with Whale Watch Operators' Pager System (TWM-Pager)

The second data source comes from the whale watch operators' pager system previously operated by Sea Coast Expeditions and later acquired by Orca Spirit Adventures Group of Victoria, B.C. Observations of whale movements were systematically collected by members who were searching from land and on water for the SRKW. This sometimes included a paid shore observer on Mt. Douglas on Vancouver Island. As pages were sent out, information on whale locations and pod identity were recorded by Lime Kiln Lighthouse interns or TWM staff/volunteers in a notebook. In some years, Sea Coast Expeditions personnel kept records of the pages and sent copies of them to TWM at the end of the year, but this practice was discontinued in 2003. After 2003, TWM shifted to recording the pages separately in our own set of notebooks as sightings occurred throughout the summer. The notebooks and photocopies were then digitized into a MS Excel spreadsheet, and entered into the database. The pager data were available during the months of the whale watch season, May through October. This data source was suspended after the 2007 season.

III) TWM's Soundwatch Boater Education Program (TWM-SW)

The third data source is provided by TWM's Soundwatch Boater Education and Monitoring program, which distributes educational literature to private whale watch vessels and also collects data on vessel traffic patterns around whales (Koski 2004, Koski and Osborne 2005, Koski 2006-2011, Eisenhardt 2012-2013, Eisenhardt and Koski 2014, Seely 2015-2016, Seely et al. 2017, Shedd et al. 2018-19, Frayne et al. 2020-2022). Every half hour (30 minutes), Soundwatch personnel count boats around the SRKW noting the time, GPS location, pod and direction of the animals. These data were collected on field data sheets or Android data loggers and then entered into an MS Access database. Soundwatch data are only available during the regular whale watch season (May-September). Any similar sighting information obtained from the Cetus Society's Straitwatch Boater Education program were also included with the Soundwatch data.

IV) TWM in conjunction with Dr. Otis' Research at Lime Kiln State Park (TWM-Otis)

The fourth source of data is a longitudinal dataset collected by Dr. Robert Otis from Lime Kiln Point State Park. During 1990 to 2020, from late May until early August, Dr. Robert Otis has recorded data about the whales as they pass by the park in the hours between 9:00 A.M. and 5:00

P.M. This represents a very important summertime control dataset that establishes a uniform observer effort and helps identify detailed pod movements in a portion of Haro Strait (Osborne et al. 2004, Koski and Osborne 2005).

V) TWM in conjunction with researchers using SPOT Satellite Data (SPOT)

A fifth data source was the Satellite Personal Tracker or SPOT recorders from May-October. The SPOT data recorders have been used for seven consecutive years. The SPOT devices record a position every 10 minutes when the appropriate button is pushed. Location data were sent via satellite link to the SPOT website (http://www.findmespot.com/en/) from which they were downloaded. Boat logs from the reporting party were reviewed to ensure that any coordinates incorporated into the Orca Master Dataset occurred when whales were present. Historically, the SPOT recorders generate accurate lat/long coordinates and have proven to be a useful source for tracking movement patterns of boats following the whales. TWM collected the SPOT trackers in 2019, and has not since found willing and able researchers/individuals, who regularly go out to observe the SRKWs, to carry the SPOT trackers. We have suspended this method of data collection in the last 3 seasons and it is unknown when/if we will resume this method of data collection.

VI) TWM in conjunction with the B.C. Cetacean Sightings Network (BCCSN)

The sixth and final source of data comes from a continued collaboration with the B. C. Cetaceans Sightings Network (BCCSN). These data were acquired via collaboration with Ocean Wise's Coastal Ocean Research Institute and annual data exchanges are expected to continue. This report incorporates BCCSN's sighting records of SRKWs from the 2018-2022 seasons. Like much of TWM's sighting archives, data obtained from BCCSN were collected opportunistically with limited knowledge of the temporal or spatial distribution of observer effort. As a result, absence of sighting reports at any location does not demonstrate absence of SRKWs.

Table 1: Description of data sources with numbers of existing records.

Data Source	Years	Description	Location Record	Source Code	No. of Records
TWM Sightings Archive	1948-2021 Year-round	Sightings records reported by public and reliable observers to TWM	Locations given in descriptive terms and matched to TWM quadrants	TWM-SA-Pub	18,004
				TWM-SA-Rel	21,894
				TWM-SA-WW	9,868
				TWM-HYD-Pub	1,342
				TWM-HYD-Rel	3,856
				Total TWM-SA Records	54,964
Pager	1997-2007 Summers	Whale watch pager system	Pager coordinates matched to TWM quadrants	TWM-Pager	18,893
Soundwatch	1998-2022 Summers	Sightings observed by Soundwatch personnel recorded every ½ hour on the water	Coordinates matched to TWM quadrants	TWM-SW	15,518
Lime Kiln Station	1991 and 1994-2021 Summers	Sightings by Dr. Robert Otis, Ripon College: May-Aug Daily 9AM-5PM	Lime Kiln study area is TWM Quadrant 181	TWM-Otis	2,024
SPOT	2008-2018 Summers	Satellite GPS tracking units used by various researchers	Lat/long tracks of boats following whales	SPOT	8,892
BCCSN	1975-2021 Year-round	Sightings reported by public to BCCSN	Locations provided in descriptive terms and coordinates then matched to TWM Quadrants	BCCSN	12,835

Field Descriptions

Table 2 provides an outlined description of the fields included in the Orca Master Dataset. The following is a detailed description of each field.

I) Temporal Data

Date information is included in a short date field and split out to month, day, and year to simplify data queries.

Time is included both as a short time (*Time1*) field and as an integer (*Time2*) to accommodate different types of software that might be used in the analysis of these data.

II) Species Data

Pod identity is included where known. When pod identity is not known "Orcas" is listed as the pod. Unknown or questionable pods may not be Southern Residents, but known sightings of transients, offshores, and northern resident orcas have not been included in this dataset. In spite of this effort to exclude other ecotypes, there are likely some records in the dataset that are not Southern Residents.

LikelyPod is a field that was added in 2009 in an effort to more accurately designate ecotypes in this dataset. It has always been customary to report sightings "as is" when they come in. However, often TWM staff member(s) recording these data are aware of what pod(s) is (are) in the area at that time (or can verify the report using other sources). This column allows this information to be added, thereby making the final dataset more accurate without altering the original data.

III) Spatial Data

Direction is the heading of the whales at the time of observation and is indicated as a text field with N for north, E for east, etc. Whale turnarounds are indicated by the word "then" as in "N then S". Nondirectional behavior is listed as "mill." Whale groups that have split and are going in different directions are indicated by the word "and" for example, "N and S", or other appropriate directions.

Location is described in 4 distinct ways: TWM Quadrants, WDFW/DFO Fishery Areas, UTMx/y coordinates, and latitude/longitude. All of the location data from each of the data sources was matched from their original description to the Museum's quadrant system (Figure 1, Heimlich-Boran 1988, Olson 1998, Osborne 1999). It is important to note that the quadrants only extend about 2/3 of the way out the Strait of Juan de Fuca and as far north as Burrard Inlet. Any whale sightings outside of these areas will have an assigned fish area but not a quadrant. As the UTM coordinates and lats/longs are derived from the quadrant system (they are the centroid for those quadrants), those sightings without a quadrant will also not have UTM coordinates and lats/longs. In recent years GPS and other spatial technologies have become more widespread.

Some data partners collect location data using personal GPS devices, and so GPS lats/longs that were reported were included in the "ActLat" and "ActLong" columns.

The location data for the Sighting Archive data originally consisted of descriptions of the area where the animals were seen, usually referring to a point on land. Locations from the Pager data were reported on a grid system used by the whale watch operators. All anecdotal location data were matched from the original description, often referring to a point on land, to the TWM quadrant that was adjacent to the land-based sighting. Hydrophone detections were ascribed to the quadrant containing the hydrophone. SPOT data generates actual latitudes and longitudes that spatially joined to Quads/Fish Areas and then to Lat/Long/UTMx/y representing the centroid for that quadrant. BCCSN data were also reported in latitudes and longitudes that were spatially joined to Quads/Fish Areas and then to Lat/Long/UTMx/y representing the centroid for that quadrant. Pager data were transformed into quadrants as well as latitude and longitude and UTM coordinates by digitizing the quadrant map and developing a computer program to perform the needed interpolations and transformations (V. Veirs, pers. comm.). The quadrant results were checked against the earlier work of Jean Olson to ensure accuracy (Olson et al. 2001). Additionally, all observations were assigned to fishery management areas to facilitate larger groupings of data. All U.S. sightings are assigned to Washington Department of Fish and Wildlife (WDFW) fish areas (Figure 2). All B.C. sightings are assigned to the Department of Fishery and Oceans Canada (DFO) fish areas (Figure 3). The letter "C" is appended to the DFO fish areas to indicate that the sighting is in Canadian waters.

IV) Source Data

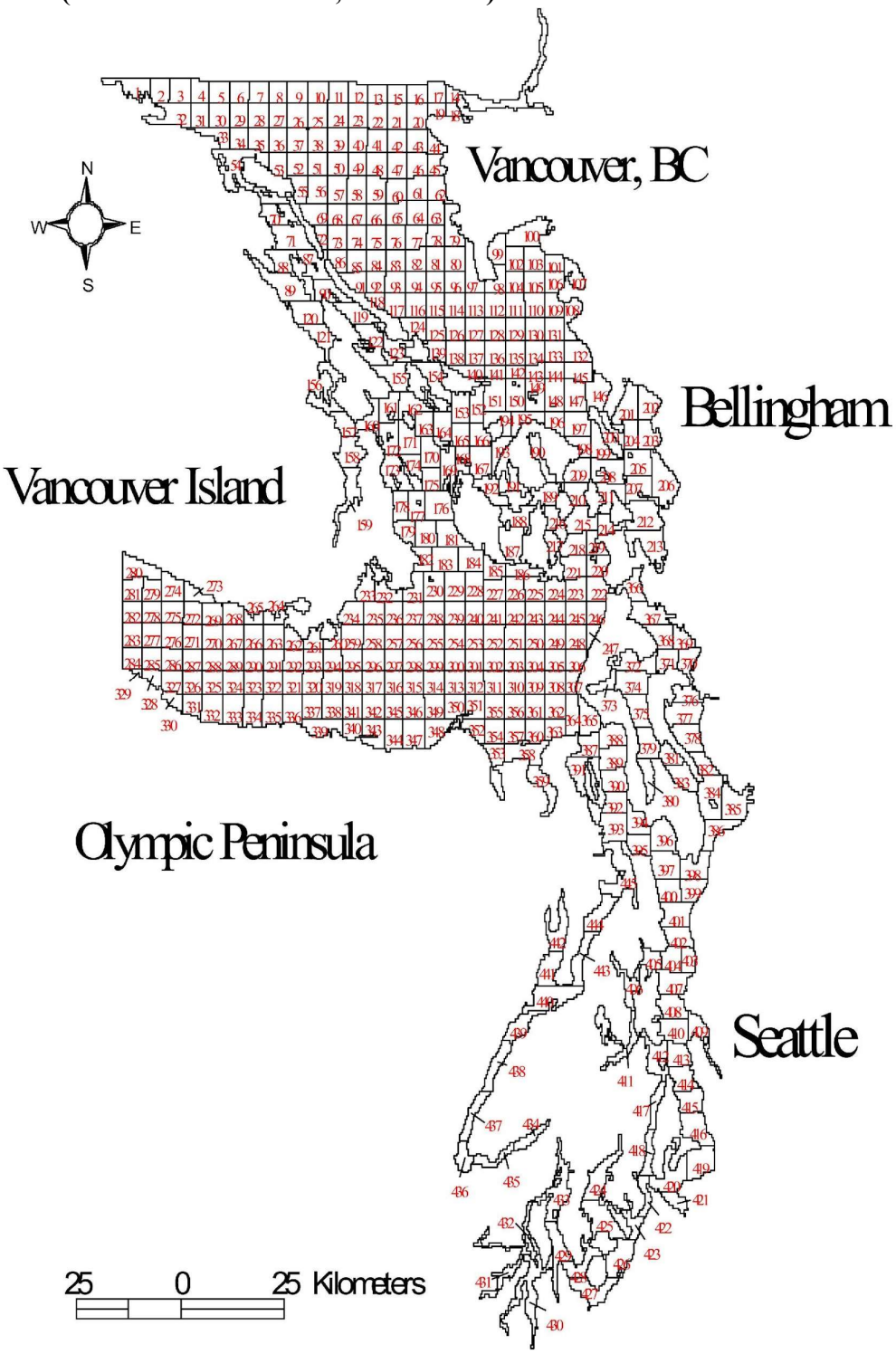
Source is the original data source for the record as identified in Table 1. TWM-SA for Museum sighting archive; TWM-HYD for all reports of acoustic detections via the various hydrophone arrays; TWMPager for pager data; TWM-SW for Soundwatch data; TWM-Otis for Dr. Otis' Lime Kiln data; SPOT for SPOT data; and BCCSN for BCCSN data.

Table 2: Descriptions of the data fields in the Orca Master Dataset.

FIELD	Type	Format	Description		Format Example /Rules of Entry
Date	Date	mm/dd/yyyy	Date of observation		7/2/2021
Time1	Time	hh:mm	Time of observation		13:00
Time2	Long Integer	hhmm	Time of observation		1300
Month	Long Integer	mm	Month of observation		07
Day	Long Integer	dd	Calendar day of observation		02
Year	Long Integer	yyyy	Year of observation		2021
Pod	Text		Pod identity	J	*J-Pod members (including L-87 as of mid-summer 2010)*
				K	*K-Pod members (including L-87 from 2007-mid-summer 2010)*
				L	*L-Pod members*
				JKL	*J, K, and L-pod members traveling together*
				Jp/Kp/Lp	*Part of J, K, and/or L pod in the area*
				L12s	*L12 subpod*
				L11a	*Specifically L-25, L-41, L-77, and L-94*
				Lm	*Main part of L-pod without the L12 subpod*
				SRs	*Known Southern Residents but unknown pod*
				Orcas	*Pod identification not known*
				J?/K?/L?	*Uncertain pod identification*
Likely Pod	Text		Likely Pod or Ecotype identity		Same as "Pod" but includes possible transient ecotype sightings designated as "Ts"
Dir	Text		Direction whales seen heading	N	North
				N then S	*Whale turnaround*
				Mill	*Non-directional/ milling*
				N and S	*Whales split – going different directions*
FishArea	Text		WDFW Fish Areas-US DFO Fish Areas-BC		WDFW Fish areas 1-13 *Figure 2* DFO Fish Areas 12C-29C *Figure 3*
Quadrant	Long Integer		TWM Quadrants		TWM Quadrants 1-445 *Figure 1*
Lat	Double		Latitude of quadrant centroid		In decimal degrees
Long	Double		Longitude of quadrant centroid		In decimal degrees
UTMx	Double		WGS84 UTM Zone 10 N		
UTMy	Double		WGS84 UTM Zone 10 N		

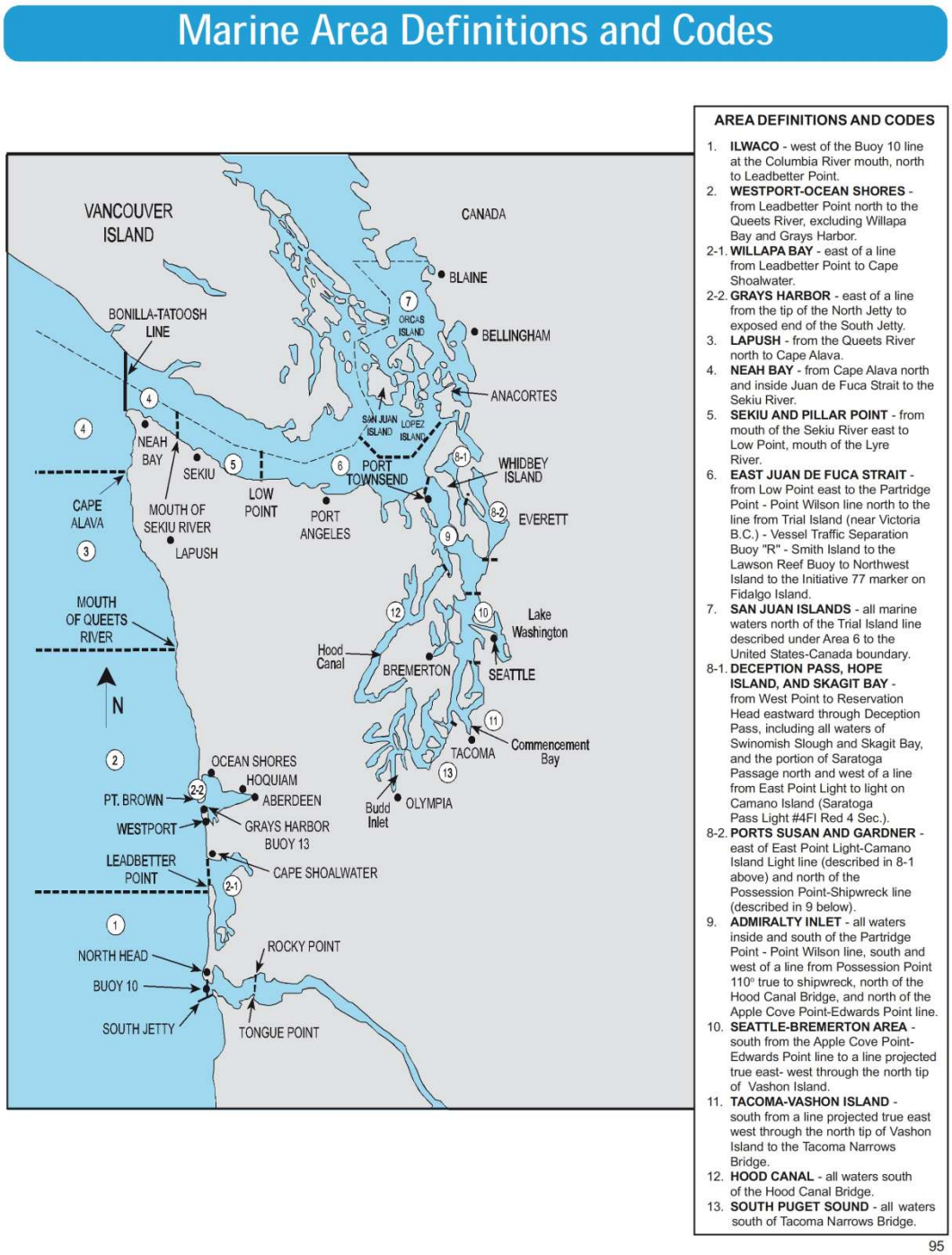
Source	Text	Source data for record	TWM-SA-Pub	*Public info from TWM Sighting Archive*
			TWM-SA-Rel	*Reliable info from TWM Sighting Archive*
			TWM-SA-WW	*Info obtained directly from WW vessels and charters*
			TWM-HYD-Pub	*Public info from hydrophone arrays*
			TWM-HYD-Rel	*Reliable info from hydrophone arrays*
			TWM-Pager	*Whale watch pager data*
			TWM-SW	*Soundwatch observations*
			TWM-Otis	*Dr. Otis data from Lime Kiln State Park*
			SPOT	*Combined SPOT data from various vessels*
			BCCSN	*BCCSN data*
ActLat	Double	GPS latitude reported		In decimal degrees
ActLong	Double	GPS longitude reported		In decimal degrees

Figure 1. The Whale Museum marine mammal sighting Quadrants (Heimlich-Boran 1988, Olson 1998)



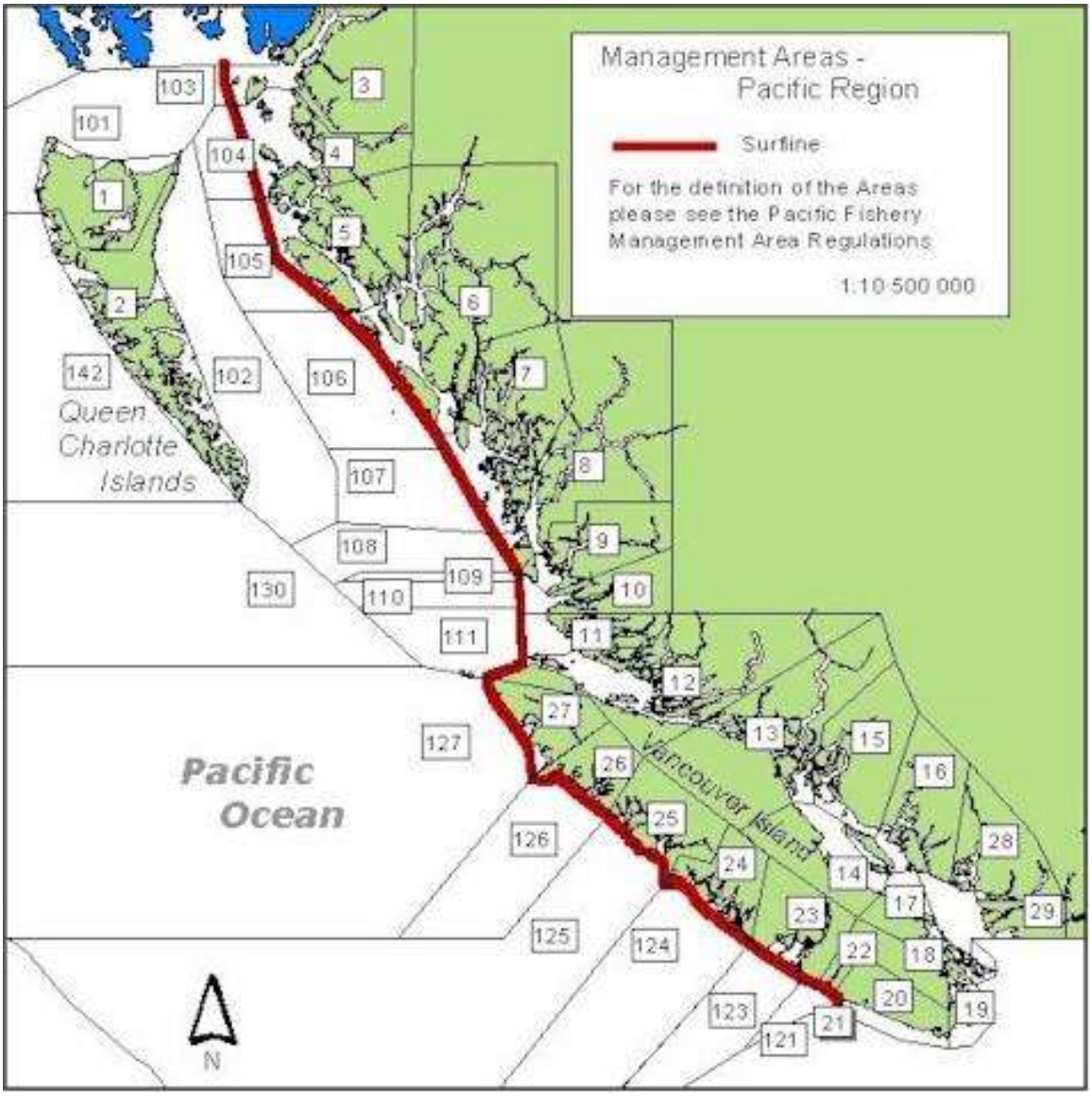
Note: This map is formatted to print on 11 x 17 paper.

Figure 2. Washington Department of Fish and Wildlife fishery management areas



Source: Washington Department of Fish and Wildlife, Sport Fishing Rules 2004/2005 Pamphlet edition. http://wdfw.wa.gov/

Figure 3. Department of Fisheries and Oceans Canada fishery management areas.



Source: Fisheries and Oceans Canada, www.pac.dfo-mpo.gc.ca/ops/fm/Areas/areamap_e.htm

Project Results

Recent Temporal Trends in SRKW Habitat Use

There are three primary annual habitat-use patterns that SRKWs exhibit: 1) summer (June - August) primarily centered in the straits around the San Juan Islands; 2) fall/winter (September - January) a variation on summer with extended excursions into Puget Sound and short trips to the outer coast; and 3) winter/spring (Feb-May) extended excursions outside the Salish Sea along the outer coast, particularly for K and L pods (Heimlich-Boran 1988, Osborne 1999, Hauser 2006, Hauser et al. 2006).

The most basic underlying pattern is reported SRKW presence or absence from the inland waters of the Salish Sea. This is illustrated in Figure 4, where pod detection is color-coded in a matrix of months-by-years. Figure 4 shows the nearly year-round occurrence of J Pod, and the continuous monthly presence of the entire population (J, K, and L pods) in the inland waters during the summer and fall months. The trend in this pattern since the winter of 1999-2000 is for K and L Pods to increase the number of months they are detected in the inland waters by staying in the Salish Sea through the fall and into the early winter, before completely exiting the inland waters for months at a time in late winter. In the most recent decade, however, there have been some noted absences of J pod. In 2009 none of the three pods were reported in the month of April. Similarly, 2017 marked the first time since the start of this database that J pod was not sighted in the inland waters during the month of August. The year 2018, marked the first time since the start of this database that J pod was not sighted in the inland waters of the Central Salish Sea during the months of April or May (Fig. 5). During August of 2020, the SRKWs were never visually reported on the West side of San Juan Island, however, upon compilation of the data J pod was reported on the Lime Kiln Hydrophone Array (Quad 181) and Southern Residents were reported elsewhere in the Salish Sea. Although very little to no variation is observed in the monthly/annual SRKW arrivals and departures from the Salish Sea as a whole, we believe that there may be some localized changes in their residency and habitat use within their preferred seasonal habitats. It could potentially be informative to assess SRKW observations within specific quadrants, particularly the west side of San Juan Island, to better determine any major changes in their distribution. The SRKWs are sighted and reported all throughout the Salish Sea and have been anecdotally known to spend more time in northern Canadian waters whereas historically they were commonly observed in and around the waters of the San Juan’s.

Figure 4: Monthly Scale Pod Occurrence in the Inland Waters (1976-2022).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	No data	K·L	K	J·K·L	No data	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	No data	J
1977	unk SRs	No data	unk SRs	unk SRs	unk SRs	unk SRs	J·L	J·K·L	J·K·L	J·K·L	unk SRs	J·K·L
1978	J	J	J·K	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	No data
1979	J	unk SRs	unk SRs	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K	J
1980	J·L	J	J·K	J	J	J·K·L	J·K·L	J·K·L	J·L	J·K·L	unk SRs	J·K·L
1981	unk SRs	unk SRs	No data	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·L	J·K·L	J
1982	J·L	K·L	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	unk SRs	J·K·L	unk SRs
1983	J·K·L	unk SRs	J	J·K	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	K	J·K
1984	unk SRs	No data	J	J	unk SRs	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	unk SRs	No data
1985	J	unk SRs	unk SRs	J	J	J·K·L	J·K·L	J·K·L	J·K	J·K·L	unk SRs	unk SRs
1986	unk SRs	J	J	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	K·L	K·L	unk SRs
1987	J	K·L	unk SRs	unk SRs	J·K	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J	J
1988	J·K	J	J	J·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J	No data
1989	J	J	J·K	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K	J	J·K·L
1990	J	No data	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	K·L	No data	No data
1991	No data	J	No data	No data	J·K	J·K·L	J·K·L	J·K·L	No data	J·K	J	No data
1992	No data	No data	No data	No data	J·K·L	K·L	J·K·L	J·K·L	J·K·L	J·K·L	J	L
1993	J·L	J	No data	J·K	J·K	J·K·L	J·K·L	J·K·L	J·K·L	No data	J	J
1994	J	No data	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·L	J	J
1995	J	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J	J·L	J
1996	J	J	J·L	J	J·K	J·K·L	J·K·L	J·K·L	J·K·L	No data	No data	J·K
1997	J	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
1998	No data	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K	J
1999	J	J	No data	J	J·K	J·K·L	J·K·L	J·K·L	J·K·L	L	J·K·L	J·K·L
2000	J·K·L	J	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·L	J·K	J·K·L
2001	J·K·L	J·L	J·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2002	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2003	J·K·L	J	J·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
2004	J·K·L	J	J·L	J	J·K·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
2005	J·K	L	J	J·K	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
2006	J·L	J	J·K·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2007	J·K·L	J	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J	J·K·L
2008	J·K·L	J·L	J	J	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2009	J·L	J·K·L	J	No data	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2010	J	J·K·L	J	J·K	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2011	J·K·L	J·K	J·K	J·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
2012	J·K	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2013	J·K	J·L	J·K·L	K	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K
2014	J·K·L	J·L	J·K	J·K	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2015	J·K·L	J·K·L	J	J·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2016	J·K·L	J·K·L	J·K·L	J	J·K	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K	J·K·L
2017	J	J·K·L	J	J	J·L	J·K·L	J·K·L	L	J·K·L	J·L	J·K·L	J·K·L
2018	J·K·L	J·L	J·K·L	J	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K	J·K·L
2019	J·K·L	J·L	J·L	J·K·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L	J·K·L
2020	J·K·L	J·K	J·L	J	J·K·L	J·K·L	J·K·L	J·K	J·K·L	J	J·K	J·K
2021	J·K·L	J·K·L	J	J	No data	J	J·K·L	J·L	J·K·L	J·K·L	J·K·L	J·K·L
2022	J·L	J	J	J	J	J·L	J·K·L	J·K·L	J·K·L	J	J·K·L	J·K

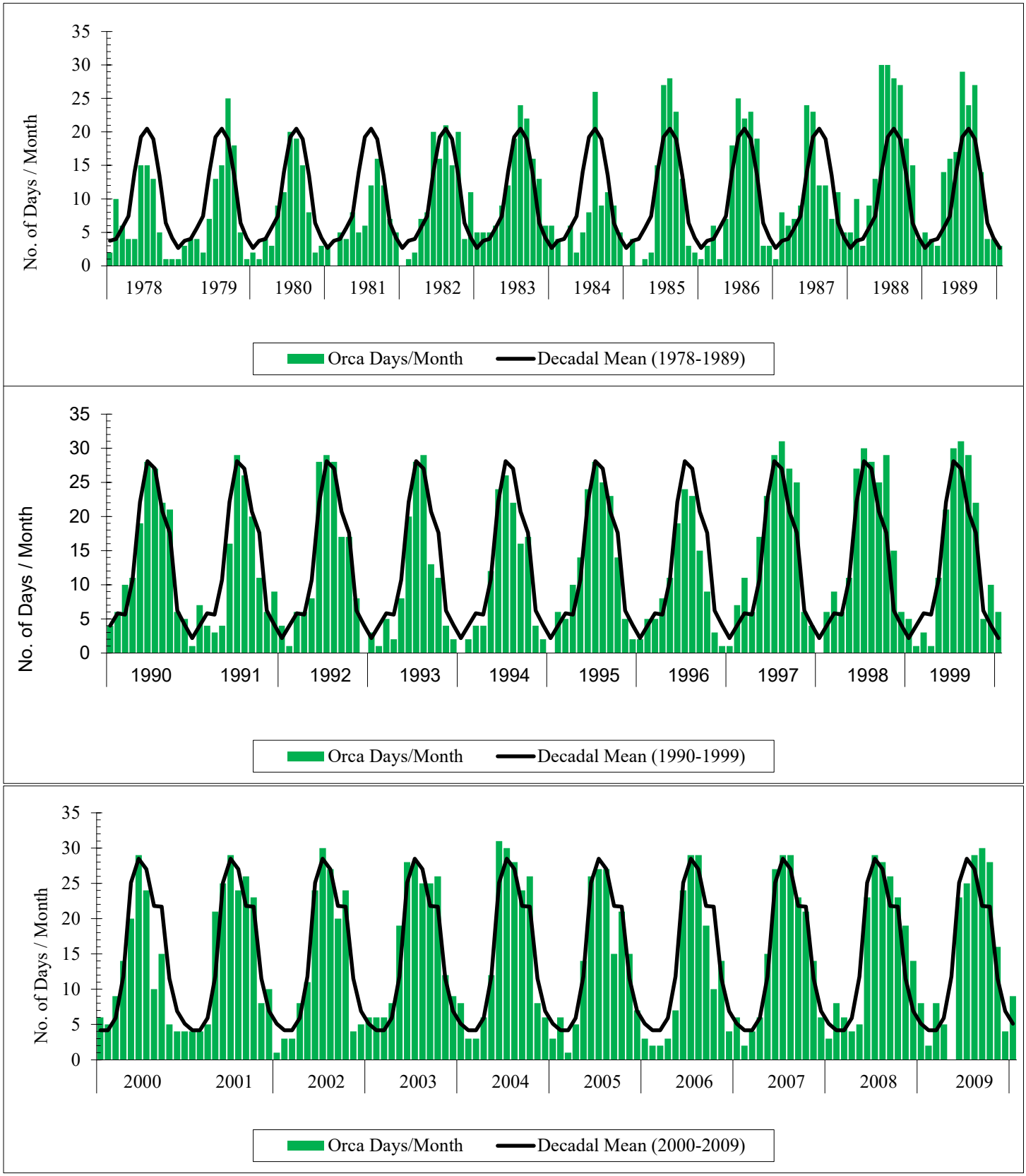
No data
Unk SRs
J Pod
K Pod
L Pod
J & K Pod
J & L Pod
K & L Pod
J, K, L Pod

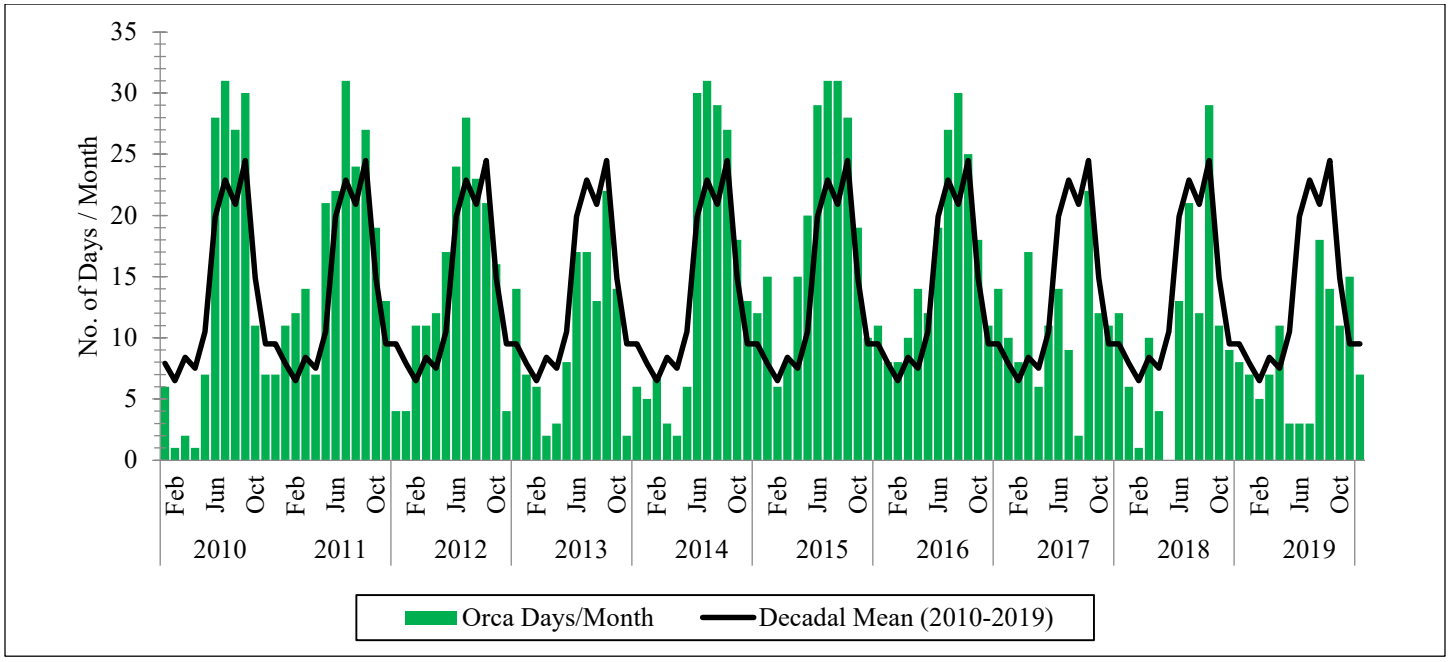
SRKW Habitat Use Comparison and Decadal Means: Central Salish Sea vs. Puget Sound

In Figures 5 and 6, the seasonal occurrence patterns of SRKW in the Central Salish Sea (Figure 5) and Puget Sound (Figure 6) are illustrated (after Osborne 1999). In these figures, the number of days per month SRKW were detected from 1978 to 2022 were plotted relative to their respective decadal (10- year) means of occurrence for each month. Only confirmed sightings of SRKW were included in these figures. For the Central Salish Sea, SRKW show an overall pattern of increased occurrence during the summer months that is fairly consistent across the decades. In recent years (e.g., 2013-2014, 2017-2019), a trend of reduced occurrence in the spring months may be emerging with some years (e.g., 2017-2019) showing reduced occurrence throughout the summer months as well.

SRKW occurrence in Puget Sound proper follows a pattern of reduced presence in the spring and summer and an increasing occurrence in the late fall and early winter. This fall/winter pattern seems to have become established after a sub-group of L Pod was trapped in Dyes Inlet in 1997. In 2010 and 2011, the numbers of days with SRKW in Puget Sound were essentially absent except for the fall/winter pattern (Figure 6). In 2019, SRKW sightings in Puget Sound followed the decadal mean fairly closely with deviations from the decadal mean most prominent in September, where the number of days detected was well above the decadal mean (Fig. 6).

Figure 5: Days/Months SRKW Detected in the Central Salish Sea. The decadal means are also included to highlight long-term trends.




No. of Days / Month
0
5
10
15
20
25
30
35
Feb
Jun
Oct
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Orca Days/Month
Decadal Mean (2010-2019)

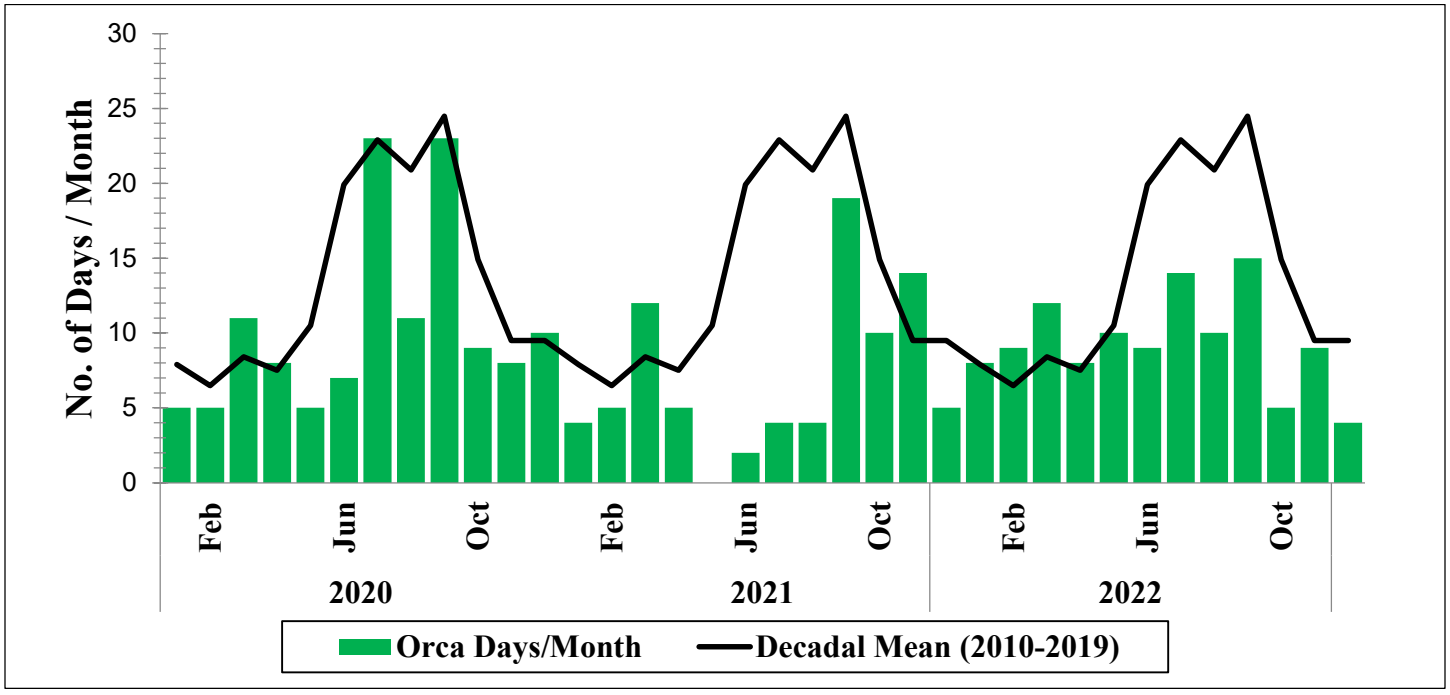
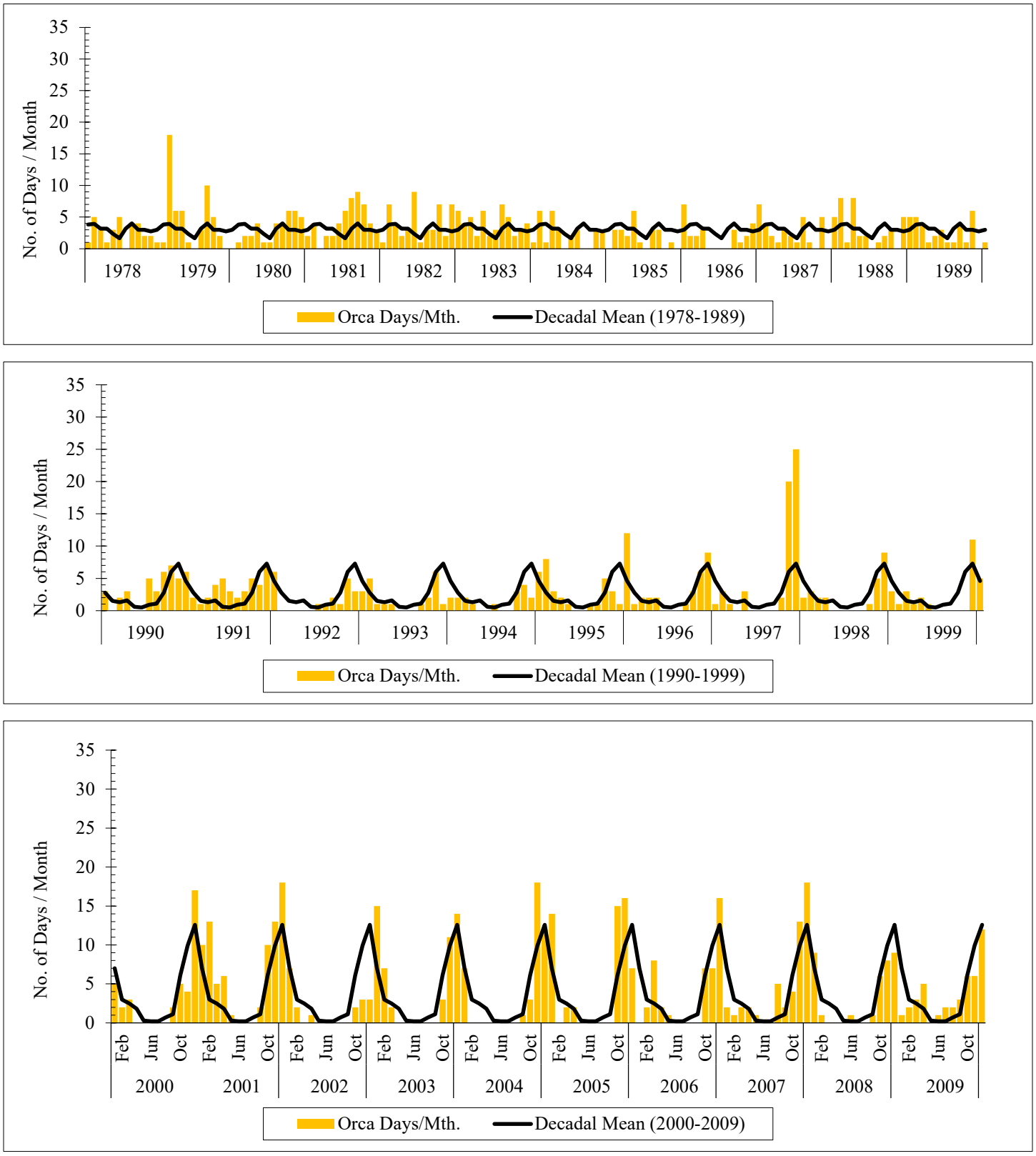
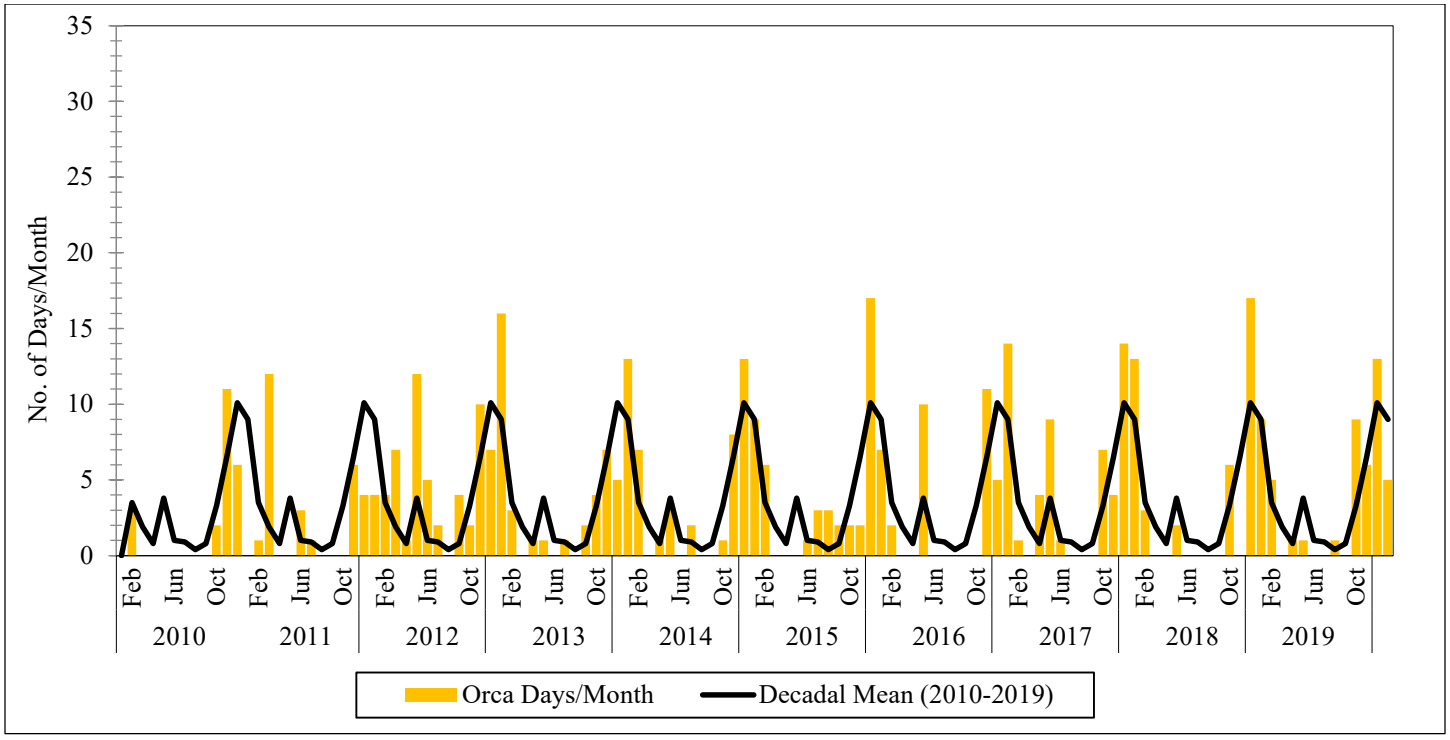
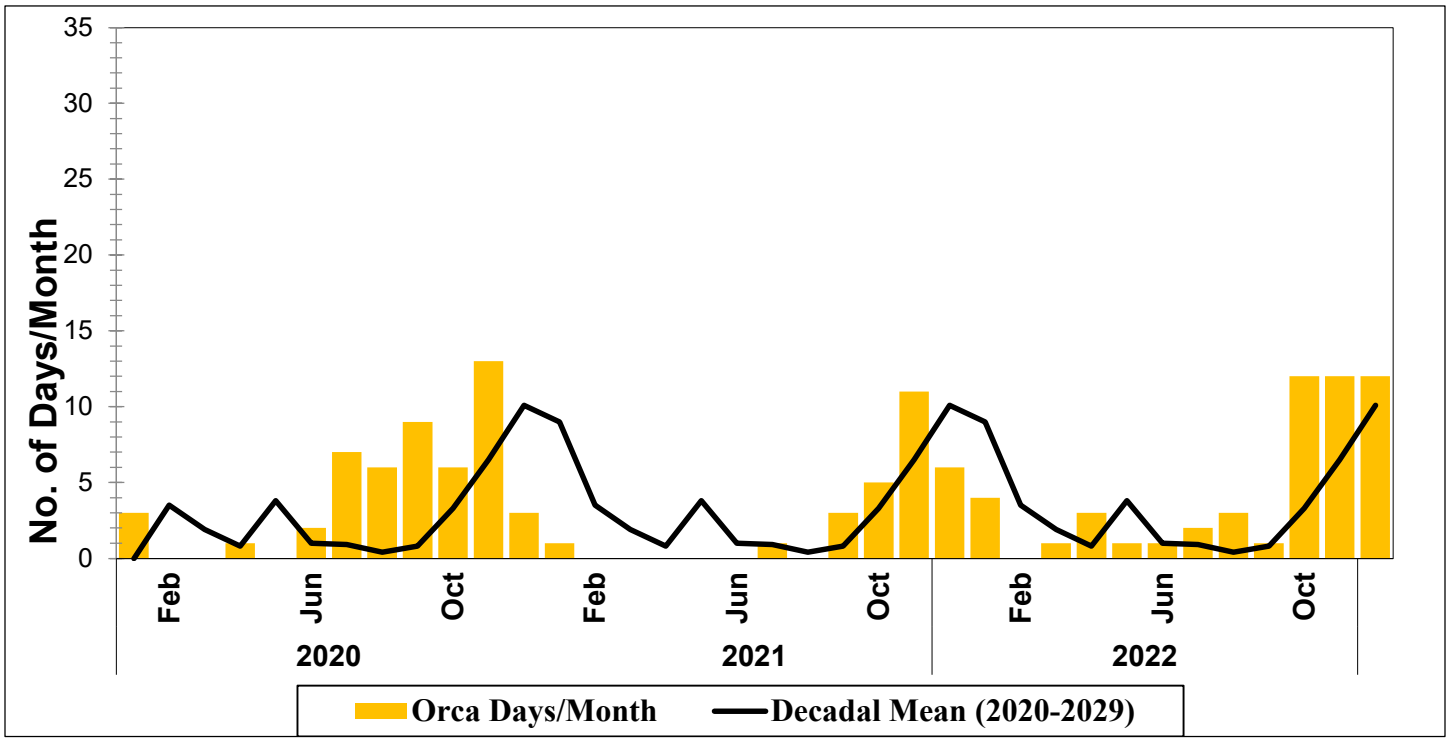

No. of Days / Month
0
5
10
15
20
25
30
Feb
Jun
Oct
2020
2021
2022
Orca Days/Month
Decadal Mean (2010-2019)

Figure 6: Days/Month SRKW Detected in Puget Sound. The decadal means are also included to highlight longer term trends.



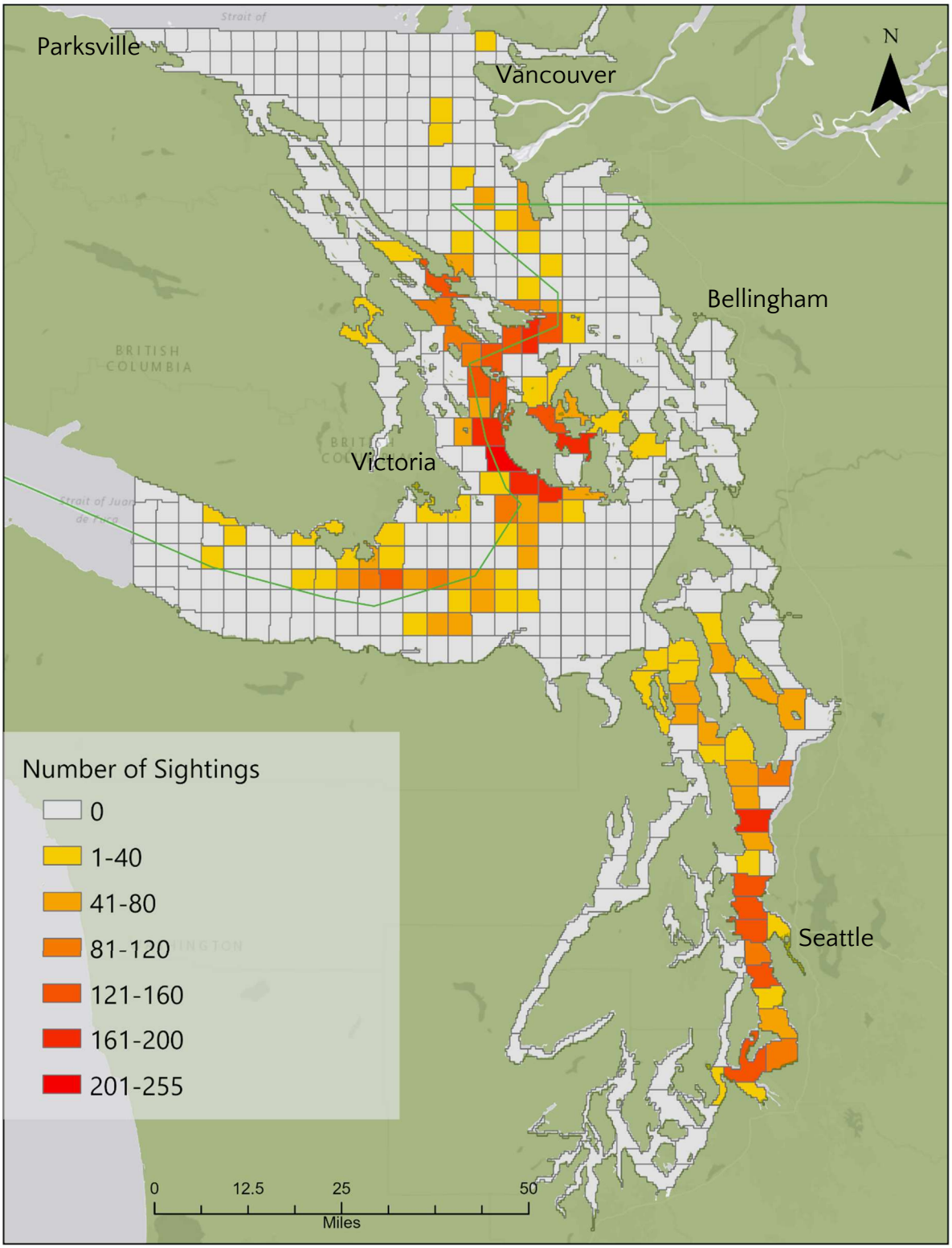

No. of Days/Month
35
30
25
20
15
10
5
0
Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct Feb Jun Oct
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Orca Days/Month
Decadal Mean (2010-2019)


No. of Days/Month
35
30
25
20
15
10
5
0
Feb Jun Oct Feb Jun Oct Feb Jun Oct
2020 2021 2022
Orca Days/Month
Decadal Mean (2020-2029)

SRKW 2022 Sighting Summary

Figure 7 depicts new SRKW sightings included in this report. Reports were tallied for each quadrant and then depicted on the map at the centroid of each quadrant. The larger the size of the symbol, the greater the number of sightings in that quadrant. All new reports to this dataset were included in this map, and therefore is not just indicative of where the whales were found most often, but where people were most likely to view and report any SRKW. The figure emphasizes the importance of Haro Strait as well as the use of the corridor south of Admiralty Inlet and north of Vashon Island in Puget Sound proper. This is likely driven by late fall/early winter excursions by the SRKW into the Puget Sound to feed on chum salmon run.

Figure 7. Map depicting the number of SRKW sightings reported by quadrant in 2022.



Note: Each quadrant is filled in with a color corresponding to the number of sightings reported for that area. The warmer the gradient, the higher sightings reported.

Presentations of Findings and Works in Progress

Preliminary presentations of this dataset were made at the NOAA-sponsored SRKW Workshops in 2004 and 2006. The Orca Master Sightings data was also used in a three-part series of workshops related to Southern Resident killer whale and salmon fishery interactions sponsored by NOAA and DFO. Two of the workshops took place in Seattle, WA in September 2011 and January 2012. The third workshop took place in Vancouver, Canada in September 2012. Since 2016, presentations of this dataset have been made biannually at TWM's Marine Naturalist Training Program and at TWM's Research Symposiums. In 2018, long-term trends highlighted by this dataset were also presented by TWM at the 30th Salish Sea Ecosystem Conference in Seattle, WA.

Data from Orca Master have been shared with countless U.S. and Canadian management agencies, nonprofit researchers, private consultants, schools, tribes, and college students. This dataset is increasingly used for environmental impact assessments. For example, The Whale Museum, as part of a contract with the Snohomish County Public Utility District, conducted a historical review of the usage of Admiralty Inlet by Southern Resident killer whales that was based mostly on the Orca Master Dataset (Wood et al. 2009). In addition, as part of thirteen contracts with the Washington State Ferries, one contract with the U.S. Department of the Navy, one contract with AECOM / NOAA Fisheries, and one contract for Hart Crowser, The Whale Museum conducted historical reviews of SRKW usage of the Seattle, Anacortes, Bremerton, Vashon/Southworth, Coupeville, Edmonds, Mukilteo, Port Angeles, Henderson Bay, and Possession Sound/Port Gardner areas that were based on the Orca Master dataset (Olson and Wood 2014a-c; Olson and Wood 2015; Olson 2017a-d; Olson 2018a-b, Abdel-Raheem 2020, 2021).

A manuscript summarizing the overall trends and importance of this dataset was published by TWM staff in *Endangered Species Research* which has also been made available for Governor Inslee's SRKW Task Force (Olson et al. 2018). This manuscript includes the addition of an effort corrected relative density estimate to account for some of the geographical biases in the Orca Master Dataset. This dataset has also been incorporated into three completed master's thesis projects (Olson 1998, Hauser 2003, McCluskey 2006) and two doctoral dissertations (Osborne 1999, Giles 2014). Peer reviewed publications directly utilizing this dataset have been written by Donna Hauser (Hauser et al. 2006, 2007), Deborah Giles (Giles and Koski 2012) and Monika Wieland Shields (Shields et al. 2018).

Summary Copy of Data

The primary products of this contract are the 113,126 sighting records of SRKW that have been systematically assessed and integrated into a single spatial database available in MS Access and MS Excel format (Appendices I & II). This information has been provided via Google Drive and Box to NOAA's Northwest Fisheries Science Center and the Northwest Regional Office, Protected Resources Division.

Acknowledgements

The Whale Museum staff administered grant funds, including accounting and disbursements, from award #1305M318DNFFP0011, and undertook the bulk of sighting recording, compilation and assessment. Individuals outside of The Whale Museum staff who made major contributions to the compilation and assessment of the 2022 database include: Jeanne Hyde, Jason Wood of SMRU Consulting, Rick Huey of WSDOT, Susan Berta and Howard Garrett of Orca Network, and Mark and Maya Sears. Special thanks to the primary contributors of our most systematic datasets: Dr. Bob Otis of Ripon College, Alanna Frayne of Soundwatch, Orca Spirit Adventures Group, and Monika Wieland of Orca Behavior Institute. Thank you to Lauren Dares, Jessica Torode, and Dr. Chloe Robinson BCCSN for their continued collaboration with annual data exchanges.

References

Abdel-Raheem, S.T. 2021. Marine Mammal Sighting Report for Possession Sound/Port Gardner. Contract Report to Hart Crowser div. of Haley and Aldrich. 30p.

Abdel-Raheem, S.T. 2020. Marine Mammal Sighting Report for Henderson Bay. Contract Report to Washington State Department of Transportation, 36p.

Abdel-Raheem, S.T., Olson, J. K., Wood, J., and R. W. Osborne, 2019. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-20202. Final Contract Report #1305M318DNFFP0011, NWFSC, NMFS, NOAA, Seattle, WA, 27p.

Balcomb, K.C., J.R. Boran, R.W. Osborne, and N.J. Haenel, 1980. Observations of Killer Whales (Orcinus orca) in Greater Puget Sound. State of Washington, NTISPB80-224728, U.S. Dept. of Commerce, Springfield, VA.

Boran, J.R., 1980. The Whale Hotline. Cetus Vol. 2, No. 2, pp. 4-5

Charapata, P., A. Traxler, J. Wood and R.W. Osborne. 2012 Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-1989. Final Contract Report # RA133F-12-CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 25p.

Eisenhardt, E., 2012. Final Program Report: Soundwatch Public Outreach/Boater Education Project2012. NOAA Contract # AB133F-07-CN-0221. The Whale Museum, Friday Harbor, WA.

Eisenhardt, E., 2013. Final Program Report: Soundwatch Public Outreach/Boater Education Project2013. NOAA Contract # RA133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Eisenhardt, E. and K. Koski. 2014. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2014. NOAA Contract # RA133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Felleman, F.L., J.R. Heimlich-Boran, and R.W. Osborne, 1991. Feeding Ecology of the Killer Whale, (Orcinus orca). In: K.W. Pryor and K.S. Norris (Eds.), Dolphin Societies: Discoveries and puzzles, Berkeley, University of California Press, 113-147.

Frayne, A., Shedd, T., E. Seely, and R. Osborne. 2020. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2018. NOAA Contract #1305M318DNFFP0011. The Whale Museum, Friday Harbor, WA.

Giles, Deborah A. 2014. Southern Resident Killer Whales (*Orcinus orca*): The evolution of adaptive management practices for vessel-based killer whale watching in the Salish Sea, A novel noninvasive method to study southern resident killer whales (*Orcinus orca*) and vessel compliance with regulations, and The effect of vessels on group cohesion and behavior of southern resident killer whales (*Orcinus orca*). Doctoral thesis, Dept. Geography, University of California Davis, Davis, CA, 125 p.

Giles, Deborah A., and K.L. Koski, 2012. Managing Vessel-Based Killer Whale Watching: A Critical Assessment of the Evolution from Voluntary Guidelines to Regulations in the Salish Sea, Journal of International Wildlife Law & Policy, 15:2, 125-151.

Haifley, A. Abdel-Raheem, S.T., Olson, J. K., Wood, J., and R. W. Osborne, 2022. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2022. Final Contract Report #1305M318DNFFP0011, NWFSC, NMFS, NOAA, Seattle, WA, 27p.

Haifley, A. Abdel-Raheem, S.T., Olson, J. K., Wood, J., and R. W. Osborne, 2021. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2022. Final Contract Report #1305M318DNFFP0011, NWFSC, NMFS, NOAA, Seattle, WA, 27p.

Hauser, D.D.W., 2003. Seasonal Habitat Use, Including Areas of Pod Overlap and Specialization by Southern Resident Killer Whales (Orcinus orca) in Washington State and British Columbia. Student paper, Field Methods in Marine Mammalogy, University of Washington Friday Harbor Laboratories, Friday Harbor, WA, 24 p.

Hauser, D.D.W, 2006. Summer space-use of Southern Resident killer whales (Orcinus orca) within Washington and British Columbia inshore waters. M.S. Thesis, University of Washington, 116 p.

Hauser, D. D. W., G. R. VanBlaricom, E. E. Holmes and R.W. Osborne, 2006. Evaluating the use of whale watch data in determining killer whale (Orcinus orca) distribution patterns. J. Cetacean Research and Management (8)3: 273-281.

Hauser, D. D. W., M. Logsdon, E. E. Holmes G. R. VanBlaricom, and R.W. Osborne, 2007. Summer distribution patterns of Southern Resident killer whales (Orcinus orca): core areas and spatial segregation of social groups. Marine Ecology Progress Series, 351:301-310.

Heimlich-Boran, J.R., 1988. Behavioral Ecology of Killer Whales (Orcinus orca) in the Pacific Northwest. Canadian Journal of Zoology 66:565-579.

Koski, K., 2004. Final Program Report: Soundwatch Public Outreach/Boater Education Project 1998-2003. NOAA Contract # AB133F-03-SE-1126. The Whale Museum, Friday Harbor, WA.

Koski, K.L., and R.W. Osborne, 2005. The evolution of adaptive management practices for vessel-based wildlife viewing in the boundary waters of British Columbia and Washington State. Proceedings of the Puget Sound / Georgia Basin Ecosystem Conference 2005, Puget Sound Water Quality Action Team (www.psat.wa.gov/Publications/05_proceedings/index.html.).

Koski, K., 2006. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2004-2005. NOAA Contract # AB133F-04-SE-0835. The Whale Museum, Friday Harbor, WA. NWFSC, NMFS, NOAA, Seattle, WA, 25 p.

Koski, K., 2007. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2006. NOAA Contract # AB133F-04-SE-0653. The Whale Museum, Friday Harbor, WA.

Koski, K., 2008. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2007. NOAA Contract # AB133F-04-SE-0653. The Whale Museum, Friday Harbor, WA.

Koski, K., 2009. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2008. NOAA Contract # AB133F-07-CN-0221. The Whale Museum, Friday Harbor, WA.

Koski, K., 2010. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2009. NOAA Contract # AB133F-07-CN-0221. The Whale Museum, Friday Harbor, WA.

Koski, K., 2010. NOAA Contract # AB133F-07-CN-0221 Final Program Report: Soundwatch Public Outreach/Boater Education Project 2010. The Whale Museum, Friday Harbor, WA.

Koski, K., 2011. NOAA Contract # AB133F-07-CN-0221 Final Program Report: Soundwatch Public Outreach/Boater Education Project 2011. The Whale Museum, Friday Harbor, WA.

McCluskey, S.M., 2006 Space Use Patterns and Population Trends of Southern Resident Killer Whales (*Orcinus orca*) in Relation to Distribution and Abundance of Pacific Salmon

(Oncorhynchus spp.) in the Inland Marine Waters of Washington State and British Columbia. M.S. Thesis, The University of Washington

Olson, J. M., 1998.Temporal and spatial distribution patterns of sightings of Southern Community and transient orcas in the inland waters of Washington and British Columbia. M.S. Thesis, Huxley College of Environmental Studies, Western Washington University, Bellingham, WA.

Olson, J. K. 2017a. Marine Mammal Sighting Report for the Mukilteo Multimodal Project. Contract Report to U. S. Department of the Navy, 20p.

Olson, J. K. 2017b. Marine Mammal Sighting Report for Puget Sound and Seattle Trestle Project Zones of Influence. Contract Report to Washington State Ferries, 19p.

Olson, J. K. 2017c. Marine Mammal Sighting Report for Puget Sound and Bremerton Ferry Wingwalls Replacement Project. Contract Report to Washington State Ferries, 19p.

Olson, J. K. 2017d. Marine Mammal Sighting Report for Puget Sound and Edmonds Pile Reset Monitoring Project. Contract Report to Washington State Ferries, 19p.

Olson, J. K. 2018a. Marine Mammal Sighting Report for NWFSC Mukilteo Research Station Upgrade. Contract Report to AECOM Impact Assessment and Reporting, 21p.

Olson, J. K. 2018b. Marine Mammal Sighting Report for Puget Sound and Seattle Trestle Project Zones of Influence (2018 Update). Contract Report to Washington State Ferries, 19p.

Olson, J. K. and J. Wood. 2014a. Marine Mammal Sighting Report for Rosario Strait and Anacortes Tieup Slip Project Zones of Influence. Contract Report to Washington State Ferries, 20p.

Olson, J. K., and J. Wood. 2014b. Marine Mammal Sighting Report for Southworth Trestle Project and Vashon Seismic Retrofit Zones of Influence. Contract Report to Washington State Ferries, 20p.

Olson, J. K., and J. Wood. 2014c. Marine Mammal Sighting Report for Coupeville Ferry Terminal Towers Replacement Project. Contract Report to Washington State Ferries, 20p.

Olson, J. K., and J. Wood. 2015. Marine Mammal Sighting Report for Port Angeles Pier and Trestle Project. Contract Report to U. S. Department of the Navy, 14p.

Olson, J. M., R.W. Osborne, and K.L. Koski, 2001. GIS plots of five seasons of killer whale movement patterns using commercial whale watch sighting network data. Abstract, Remote Sensing Workshop, Fourteenth Biennial Conf. on the Biol. Mar. Mammal., Vancouver, B.C.

Olson, J. K., R. W. Osborne, K. Bennett, and E. Eisenhardt. 2014. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2013. Final Contract Report # RA133F-12- CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 25p.

Olson, J. K., R. W. Osborne, and K. Bennett. 2015. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2014. Final Contract Report # RA133F-12-CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 24p.

Olson, J. K., R. W. Osborne, and K. Bennett. 2016. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2015. Final Contract Report # RA133F-12-CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 23p.

Olson, J. K., R. W. Osborne, and K. Bennett. 2017. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2017. Final Contract Report # RA133F-12-CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 24p.

Olson, J. K., J. Wood, R. W. Osborne, L. Barrett-Lennard, and S. Larson. 2018a. 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.

Olson, J. K., R. W. Osborne, and K. Bennett. 2018b. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-2016. Final Contract Report # RA133F-12-CQ-0057, NWFSC, NMFS, NOAA, Seattle, WA, 24p.

Osborne, R.W., 1991. Trends in killer whale movements, vessel traffic, and whale watching in Haro Strait. Proceedings of Puget Sound Research '91, Seattle, WA, Puget Sound Water Quality Authority, pp.672-688.

Osborne, R.W., 1999.A historical ecology of Salish Sea resident killer whales (Orcinus orca) with implications for management. Doctoral thesis, Dept. Geography, University of Victoria, Victoria, B.C., 262 p.

Osborne, R.W., J.M. Olson, and R.E. Tallmon, 2001. Southern Resident killer whale habitat use at different time scales using sighting and photo-identification records. Abstract, Fourteenth Biennial Conf. on the Biol. Mar. Mamm., Vancouver, B.C.

Osborne, R.W., R.E. Tallmon, J. Olson and R.E. Otis, 2004. Southern Resident Killer Whale Sighting Compilation 1990-2003. Final contract report # AB133F-03-SE, NWFSC, NMFS, NOAA, Seattle, WA, 14 p.

Osborne, R.W., R.Tallmon, A.Traxler, K.Koski, D. Hauser, R.Otis and J.Slocomb, 2006. Southern Resident Killer Whale Sighting Compilation 2nd Edition (1990-2005). Final contract report #s AB133F-04-SE-1576 & AB133F-05-SE-5915, NWFSC, NMFS, NOAA, Seattle, WA, 21p.

Osborne, R.W., A. Traxler, R.Tallmon, K. Koski, and R.Otis, 2007. Southern Resident Killer Whale Sighting Compilation 3rd Edition (1990-2006). Final contract report #s AB133F-06-SE-4956, NWFSC, NMFS, NOAA, Seattle, WA, 17p.

RStudio Team. 2020. RStudio: Integrated Development Environment for R. RStudio, PBC, Boston, MA URL <http://www.rstudio.com/>.

Seely, Elizabeth. 2015. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2015. NOAA Contract # RA-133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Seely, Elizabeth. 2016. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2016. NOAA Contract # RA-133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Seely, E., S. Youngstrom, and R. Osborne. 2017. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2017. NOAA Contract # RA-133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Shedd, T., E. Seely, and R. Osborne. 2018. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2018. NOAA Contract # RA-133F-12-CQ-0057. The Whale Museum, Friday Harbor, WA.

Shedd, T., E. Seely, and R. Osborne. 2019. Final Program Report: Soundwatch Public Outreach/Boater Education Project 2018. NOAA Contract #1305M318DNFFP0011. The Whale Museum, Friday Harbor, WA.

Traxler, A., R.W. Osborne, V. Veirs, K.Koski, and R.Otis, 2008. Southern Resident Killer Whale Sighting Compilation 4th Edition (1990-2007). Final contract report #s AB133F-07-CN-0221, NWFSC, NMFS, NOAA, Seattle, WA, 17p.

Traxler, A., J. Wood, R.W. Osborne, V. Veirs, K.Koski, and R.Otis, 2009. Southern Resident Killer Whale Sighting Compilation 5th Edition (1990-2008). Final contract report #s AB133F-07-CN-0221, NWFSC, NMFS, NOAA, Seattle, WA, 20p.

Traxler, A., J. Wood, R.W. Osborne, V. Veirs, K.Koski, and R.Otis, 2010. Southern Resident Killer Whale Sighting Compilation 6th Edition (1990-2009). Final contract report #s AB133F-07-CN-0221, NWFSC, NMFS, NOAA, Seattle, WA, 22p.

Traxler, A., J. Wood, S. Brager, 2011. Southern Resident Killer Whale Sighting Compilation 7th Edition (1990-2010). Final contract report #s AB133F-07-CN-0221, NWFSC, NMFS, NOAA, Seattle, WA, 25p.

Traxler, A., and Osbourne, R. 2013. Southern Resident Killer Whale Sighting Compilation – Historical Database 1948-1989. Final Contract Report # AB133F-07-CN-0221, NWFSC, NMFS, NOAA, Seattle, WA, 20p.

Veirs, Scott. 2012. “Canadian Sonar in U.S. Waters”. Orcasound.net. February 6, 2012. Wordpress. April 26, 2013. http://www.orcasound.net/wp/2012/02/06/canadian-sonar-in-us-critical-habitat/

Shields, M. W., J. Lindell, J. Woodruff. 2018. Declining spring usage of core habitat by endangered fisheating killer whales reflects decreased availability of their primary prey. Pacific Conservation Biology. https://doi.org/10.1071/PC17041;

Wood, J.W., Tollit, D., Berta, S. and H. Garrett, 2009. Review of historical information and site-specific synthesis. Contract Report to Snohomish Public Utility District for the Snohomish PUD Admiralty Inlet Pilot Project: Marine Mammal Pre-Installation Study. Snohomish PUD, Everett, WA. 21p.

List of Appendices

Appendix I MS Excel Sighting Compilation Database.

Appendix II GIS Monthly Sightings Map for 2022.