FINAL PROGRAM REPORT: SRKW Sighting Compilation 17th Edition

Project Title: Southern Resident Killer Whale Sighting Compilation 1948-2020

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Abstract:

The primary goal of the 17th 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 2020. A total of **2,731** new sightings entries were added: 1,106 records are from 2020, 1,427 records are from 2019, and 299 records are from 2018. 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 compact discs (CDs) of the **110,352** records in the sightings database in both MS Access and MS Excel. This project was funded with resources from NOAA Contract #1305M318DNFFP0011 and The Whale Museum.

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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.* 2014-2018b, Abdel-Raheem *et al.* 2019) with the 17th edition covering sightings from 1948 through December 2020. 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 e-mail 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.* 2020); 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 the Coastal Ocean Research Institute's B.C. Cetaceans Sightings Network (BCCSN), a primarily opportunistic sightings database from 1975-2020.

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 the 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.

Included with this report is a compact disc (CD) of the entire Sighting Compilation database in MS Access (Appendix I) and MS Excel (Appendix II).

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.* 2014-2018b, Abdel-Raheem *et al.* 2019). The specific objectives of this contract were to continue to compile SRKW sightings information through 2020, process it for accuracy and completeness, and integrate it with the existing dataset.

Changes to the 2019 Orca Master Dataset

This is an update to the 2019 OM report, however, 2019 data were very incomplete and not fully scrubbed at the time of submission. Additionally, many partners provided their data late in the 2019 season for inclusion in the last report, and so they were instead included here. BCCSN is one partner which provided data from 2018-2020, and so some 2018 reports are included in the 2019-2020 data set. Approximately half of the new data presented here (n = 1,427 records) are from 2019, whereas the remaining half is from 2020 (n = 1,106) and a few from 2018 (n = 299). A few months of 2020 data from Orca Network were not submitted in time for inclusion into the current report, but will be included in next year's report.

Data analysis was conducted using R version 4.0.1 (RStudio Team, 2020). The full OM data set (n = 110,352 records) were read into R as a comma-separated values (.csv) file for processing. Pod information from "Pod" and "LikelyPod" columns were consolidated, where any data in the "LikelyPod" columns was prioritized over data in the "Pod" column as data in "LikelyPod" have been scrubbed prior to data export. This consolidation was used to update Fig. 4 (Annual & Monthly SRKW Arrival & Departure chart). The primary differences between past versions of Fig. 4 and the current is a greater resolution of pod occurrence. However, the primary residence/occupancy patterns have not changed greatly from past reports to the current.

Additionally, Figs. 5 and 6 were also fully generated in R ver. 4.0.1. Data for Puget Sound and the Central Salish Sea were filtered from the full OM data set where any data that was reported in quadrants south of Admiralty Inlet (Quadrant ≥ 365) were assigned to Puget Sound, and any quadrants north of Admiralty Inlet (Quadrant < 365) were assigned to the Central Salish Sea. This regional designation is consistent with how the overall Salish Sea region was subdivided for past versions of this report. The count data displayed by the bars are the number of "whale days" in which at least one report of SRKW was made. This method is used to smooth the data and account for reporter effort. This effort-correction method is also identical to past submissions of the OM report. Decadal means were calculated for all "whale days" by month in a given decade. This method is also identical to past OM report submissions.

Ultimately, the primary differences in data analysis and generation lie with the methods used. In the past, data analysis and figure compilation was done in disparate excel workbooks and data were difficult to maintain long-term. As a consequence, some data may have been lost due to errors inherent to manual data entry methods, and this is the primary cause of any differences across figures in historical reports and current. We hope that this new method will decrease any errors and facilitate more consistent reporting in the future.

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 17th 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 17th 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 e-mail 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 are 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 on while on commercial whale watching trips. However, relationships with whale watch operators has 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. SRKW were either not sighted by the single operator in 2019 or any SRKW sightings were not shared with TWM for inclusion in the OM dataset and report. Whale watch data were collected by boat captains and/or naturalists and provide 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. As noted, 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). 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 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 2 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 the Coastal Ocean Research Institute, and annual data exchanges are expected to continue. This report incorporates BCCSN's sighting records of SRKWs from the 2018-2020 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 number of existing records.

Data Source	Years	Description	Location Record	Source Code	No. of Records
TWM Sightings Archive	1948-2020 Year-round	Sighting records reported by public and reliable observers to TWM	Locations given in descriptive terms and matched to TWM Quadrants	TWM-SA-Pub	17,440
				TWM-SA-Rel	20,870
				TWM-SA-WW	9,863
				TWM-HYD-Pub	1,342
				TWM-HYD-Rel	3,704
				Total TWM-SA Records	53,219
Pager	1997-2007 Summers	Whale watch pager system	Pager coordinates matched to TWM quadrants	TWM-Pager	18,893
Soundwatch	1998-2020 Summers	Sightings observed by Soundwatch personnel recorded every ½ hour on the water	Coordinates matched to TWM quadrants	TWM-SW	14,045
Lime Kiln Station	1991 and 1994-2020 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	2008-18 Summers	Satellite GPS tracking units used by various researchers	Lat/long tracks of boats following whales	SPOT	8,892
BCCSN	1975-2020 Year-round	Sightings reported by public to BCCSN	Locations provided in descriptive terms and coordinates then matched to TWM Quadrants	BCCSN	12,170

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 simply 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 was 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, many times TWM staff member recording the data is aware of what pod(s) is (are) in the area at that time (or has some other access to this information). 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". Non-directional 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 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

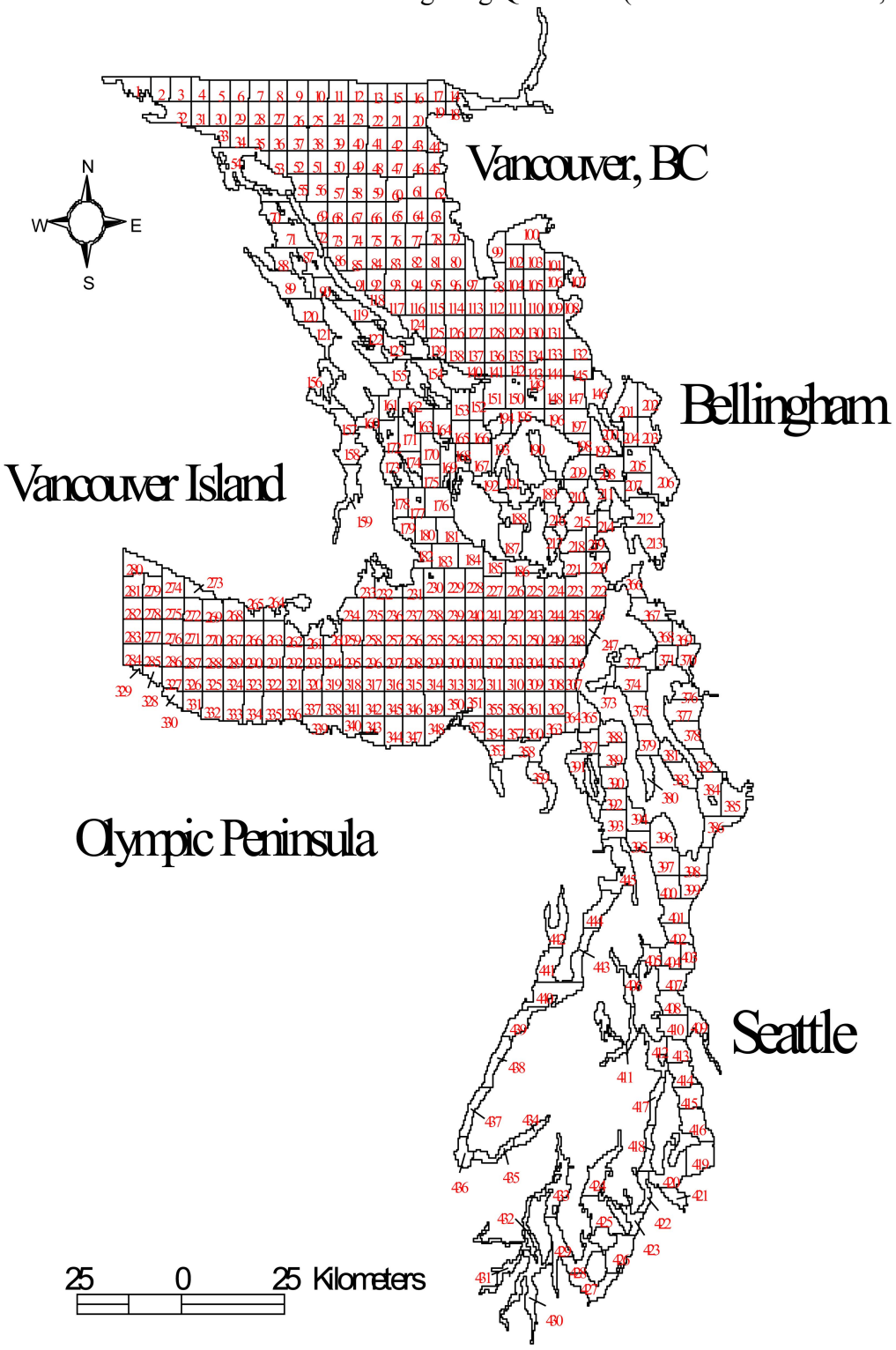
Source is the original data source for the record as identified in Table 1. TWM-SA for Museum sighting archive; TWM-HYD for all reports of acoustic detections via the various hydrophone arrays; TWM-Pager for pager data; TWM-SW for Soundwatch data; TWM-Otis for Dr. Otis' Lime Kiln data; SPOT for SPOT 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	03/07/2019
Time1	Time	hh:mm	Time of observation	13:00
Time2	Long Integer	hhmm	Time of observation	1300
Month	Long Integer	mm	Month of observation	03
Day	Long Integer	dd	Calendar day of observation	07
Year	Long Integer	yyyy	Year of observation	2019
Pod	Text		Pod identity: J	*J-Pod members (inc. L-87 as of mid-summer 2010)*
			K	*K-Pod members (inc. L-87 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*
			L11s	*Specifically L-25, L-41, L-77, and L-94*
			Lm	*Main part of L-pod excluding L12 subpod*
			SRs	*Known Southern Residents but unknown pod*
			Orcas	*Pod identification not known*
			J?/K?/L?	*Uncertain pod identification*
LikelyPod	Text		Likely Pod or Ecotype	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	

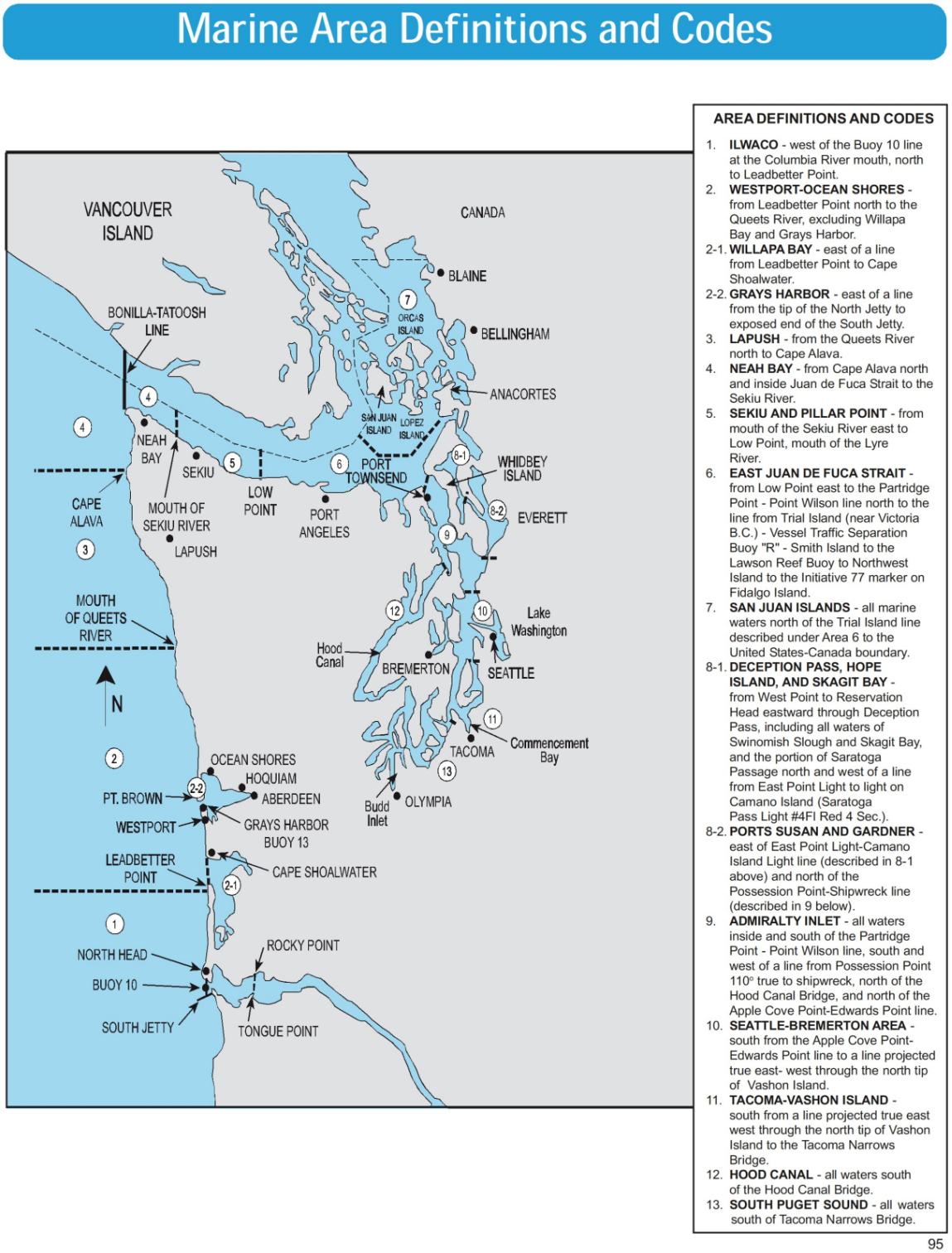
UTMy	Double	WGS84 UTM Zone 10 N		
Source	Text	Source data for record	TWM-SA-Pub	*Public info from TWM Sighting Archive*
			TWM-SA-Rel	*Reliable info rom TWM Sighting Archive*
			TWM-SA-WW	*Info obtained from WW vessels and charters*
			TWM-HYD-Pub	*Public info from hydrophone arrays*
			TWM-HYD-Rel	*Reliable info from hydrophone arrays*
			TWM-Pager	*Whale watch pager data*
			TWM-SW	*Soundwatch observation*
			TWM-Otis	*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)



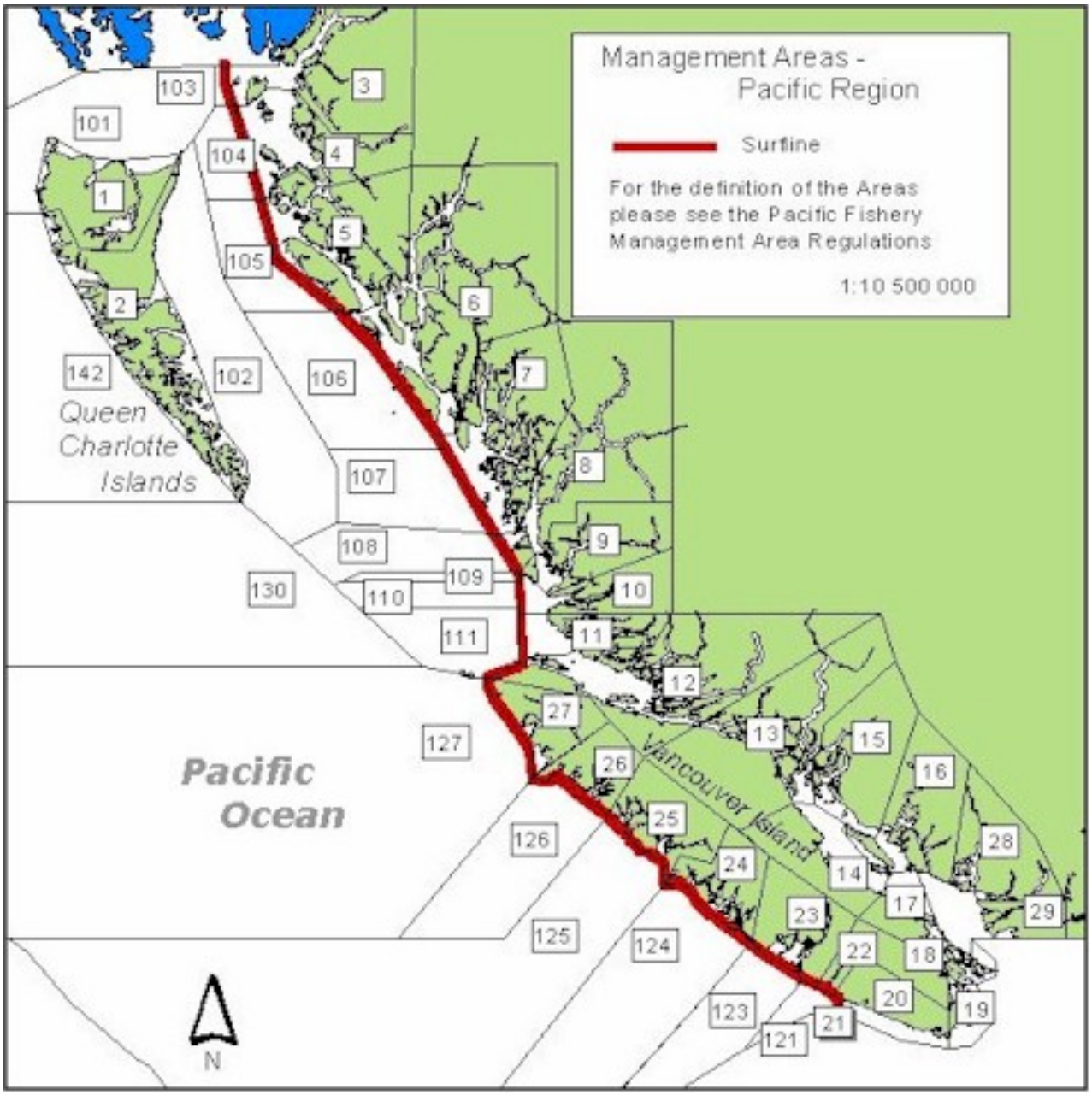
Note: This map is formatted to print on 11 x 17 paper. Please view file *TWMQuads.doc* included on this CD for viewing and printing options.

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 Juans.

Figure 4: Monthly Scale Pod Occurrence in the Inland Waters (1976-2020). This figure is best observed in a separate image viewer.

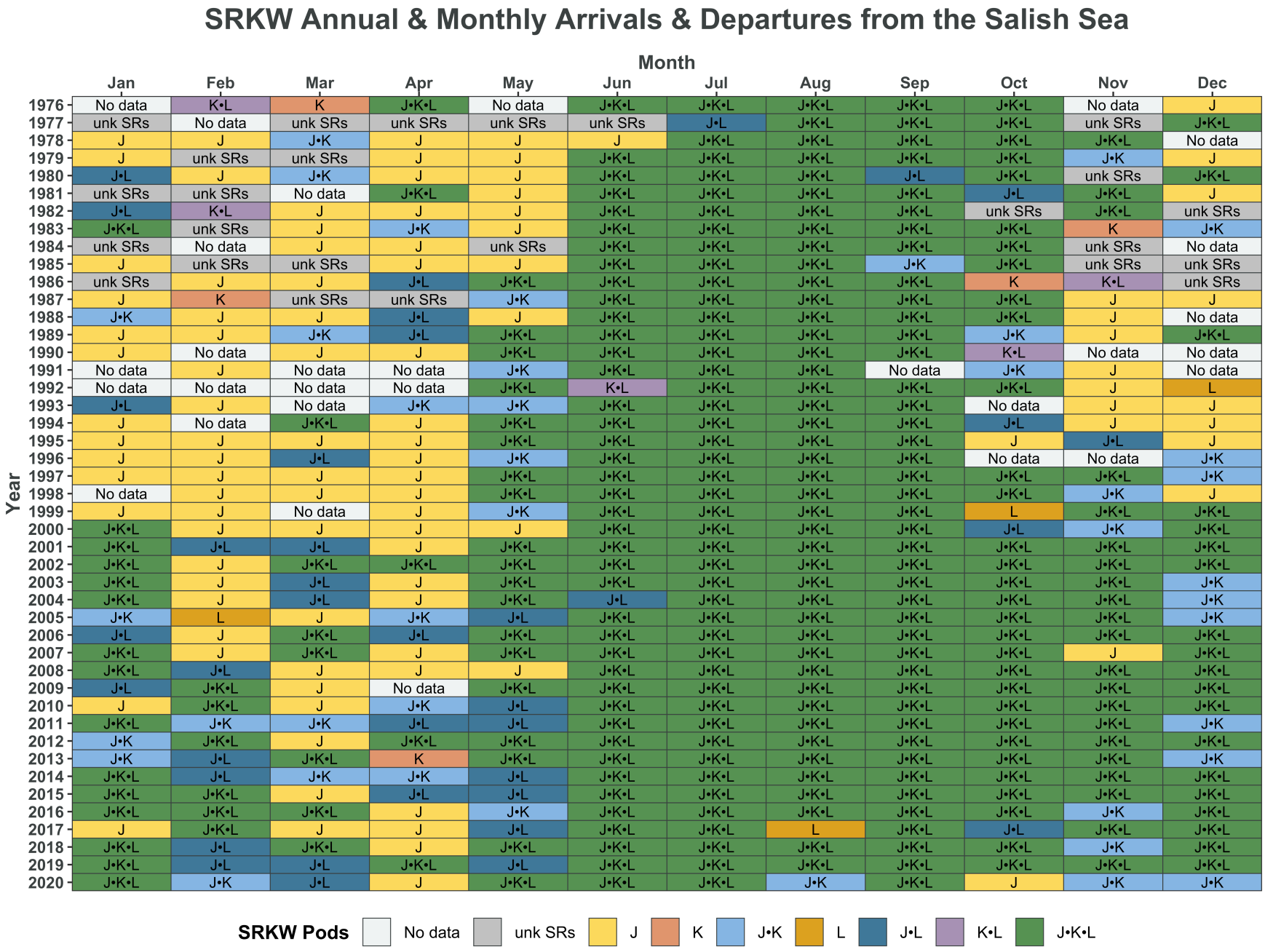


Figure Credit: S. Abdel-Raheem, TWM

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 2020 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/Month SRKW Detected in the Central Salish Sea. The decadal means are also included to highlight long-term trends. These figures are best observed in a separate image viewer.

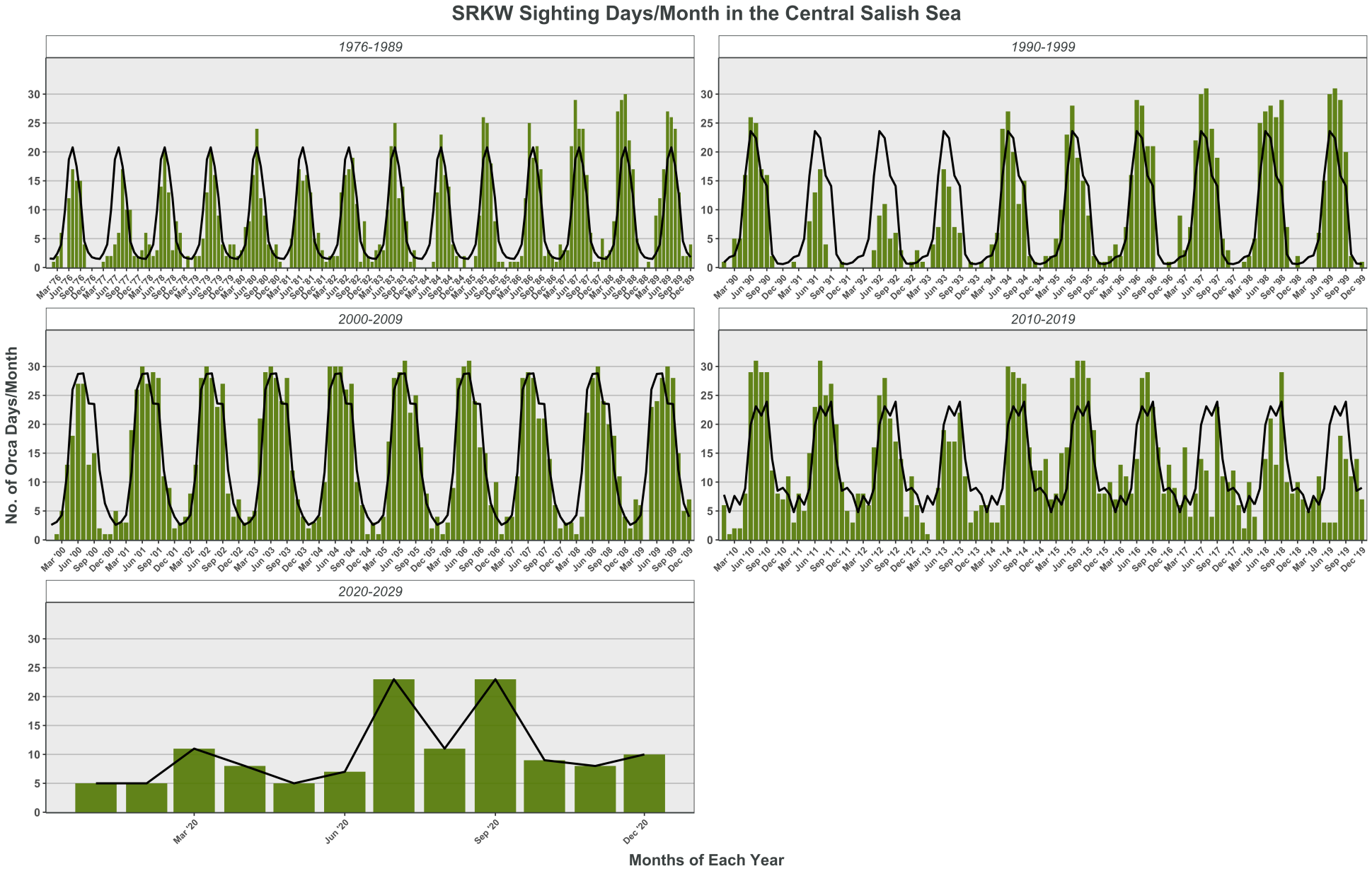


Figure Credit: S. Abdel-Raheem, TWM

Figure 6: Days/Month SRKW Detected in Puget Sound. The decadal means are also included to highlight longer term trends. These figures are best observed in a separate image viewer.

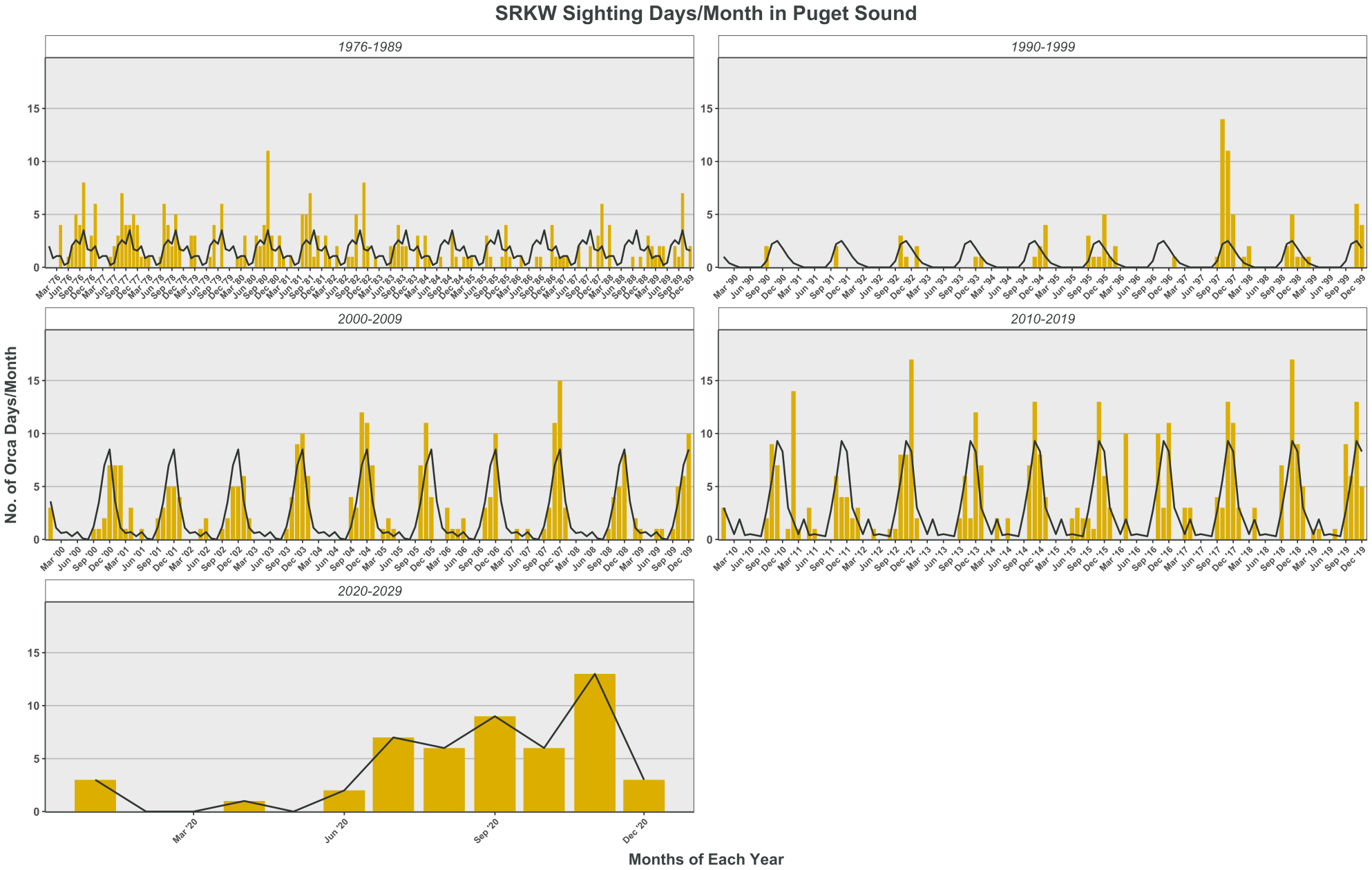


Figure Credit: S. Abdel-Raheem, TWM

SRKW 2020 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 also where people were most likely to view and report any SRKWs. 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 2019 through 2020. Each circle is atop the centroid of a quadrant, and its size is proportional to the number of reports for that quadrant. This figure is best observed in a separate image viewer.

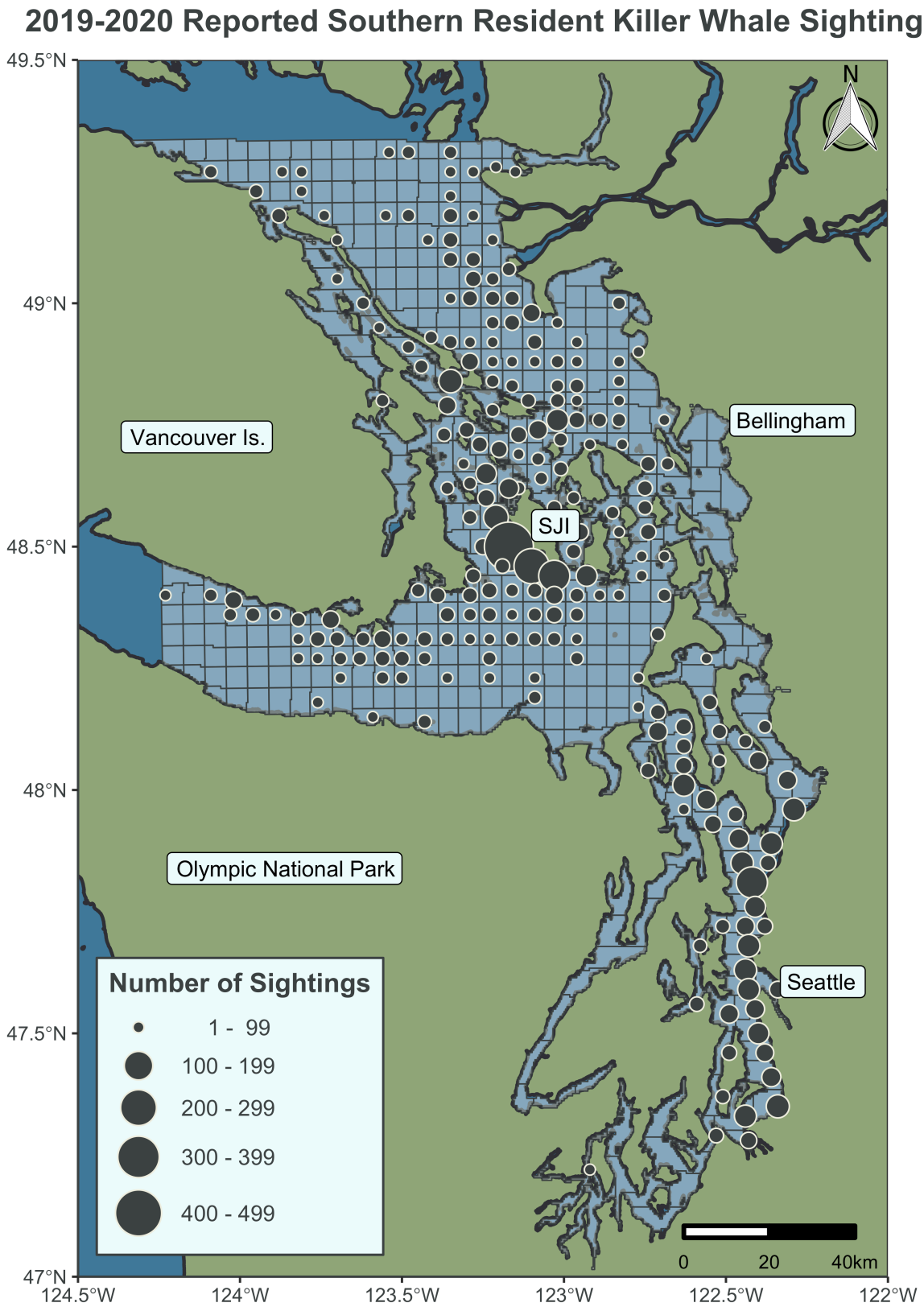


Figure Credit: S. Abdel-Raheem, TWM

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. 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, non-profit 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.* 2018a). 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 **110,352** sighting records of SRKWs 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 on CD to NOAA's Northwest Fisheries Science Center and the Northwest Regional Office, Protected Resources Division.

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List of Appendices

Appendix I MS Access Sighting Compilation Database.

Appendix II MS Excel Sighting Compilation Database.

Hi-Resolution .png files of Figures 4, 5, 6, and 7.