A Public Dataset of Annotated Orcinus orca Acoustic Signals for Detection and Ecotype Classification

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# Abstract

Killer whales (Orcinus orca) exhibit significant ecological and genetic diversity, with three primary sympatric populations in the Northeast Pacific: Resident, Bigg’s (Transient), and Offshore. Each population is characterized by distinct foraging habits, social structures, and vocal repertoires, which complicate accurate monitoring and conservation efforts. This dataset, compiled from diverse sources, provides a comprehensive resource for the detection and classification of killer whale vocalizations. The dataset includes annotated acoustic recordings spanning eleven years from various geographical locations within the Northeast Pacific, collected using multiple hydrophone systems. It addresses the challenge of differentiating killer whale calls from other marine species and environmental noise and includes specific instances of confounding signals to enhance model robustness. Detailed annotations capture a broad spectrum of vocalizations and associated metadata, facilitating the development of advanced machine learning models for ecological monitoring. This curated dataset aims to improve the accuracy of killer whale detection algorithms, support conservation efforts, and advance our understanding of killer whale acoustic communication across different populations.

# Background and Summary

Killer whales (*Orcinus orca*) are cosmopolitan, with distinct populations found in every ocean. The killer whale lineage is complex and presently delineated into multiple ecotypes that are genetically distinct (Barrett-Lennard & Ellis, n.d.; Morin et al., 2024) some of which are being named as new species under the genus *Orcinus* (Morin et al., 2024). For consistency, we refer to these lineages as populations, but readers should note that the nomenclature and taxonomy are in flux (Morin et al., 2024). In the Northeast Pacific, killer whales have diverged into genetically and culturally distinct lineages that overlap in distribution. These lineages presently include three sympatric populations that do not interbreed: Resident, Transient or henceforth Bigg’s, and Offshore killer whales (Baird & Stacey, 1988; Balcomb III & Bigg, 1986; J. K. Ford et al., 1998). Of these populations, Southern Resident killer whales (SRKW), are in danger of extinction, and there is international interest in the protection and conservation of these charismatic animals and their habitat.

Each killer whale population is ecologically specialized. They are sympatric populations, therefore, distribution differences are not the distinguishing factor, but food preference and cultural differences appear to be (J. K. B. Ford & Ellis, 2014; Whitehead & Ford, 2018). Resident killer whales including the SRKW and NRKW populations, are obligate teleost fish consumers and are protected federally in Canada. The US. Bigg’s killer whales feed exclusively on marine mammals. Offshore populations are currently of lower conservation concern than some of the Resident populations but are still considered populations at risk. For example, Offshore killer whales travel as large groups and a single catastrophic event such as an oil spill can have negative population consequences (Matkin et al., 2008). Bigg’s killer whales have been low in numbers in the Northeast Pacific until the late 1970s and numbers increased after a ban on killing harbor seals was instated. As a result of apparent prey specializations a decline in prey abundance may cause a decline in Bigg’s killer whales (Blanchet et al., 2021). Offshore, Bigg's, and Northern Residents are all considered "Threatened" under the Species At Risk Act in Canada and Southern Residents that are listed "Endangered".

Within the fish-eating Resident ecotype, the SRKW population ranges in waters off California to the southern end of Alaska, the NRKW population inhabits areas off the Northeast Pacific Ocean from Washington State to the Northern end of Alaska’s panhandle, and the Southern Alaska Residents range from waters off Southeast Alaska (panhandle) to Kodiak Island (Morin et al., 2024). Among mammal-eating Biggs killer whales, the West Coast Bigg's (Biggs) killer whales inhabit waters off California to southeast Alaska, the Gulf of Alaska Biggs population ranges from waters off northern British Columbia to Kodiak Island, and the AT1 sub-population inhabits the northcentral Gulf of Alaska. Individuals from the shark-eating Offshore killer whale population have been sighted from the Aleutian Islands to California.

Each population faces different environmental stressors, with SRKW being especially vulnerable to extinction due to a lack of available food, pollution in their historic summer environment (Stewart et al., 2023), and physical and acoustic disturbance, e.g. masking of foraging and communication signals (Burnham & Vagle, 2023) from transiting vessels (Lacy et al., 2017; Williams et al., 2024). Due to these low numbers, there are significant and sustained efforts to improve the outcome for the SRKW population including reducing competition for salmon through fishing closures, and noise reduction efforts in both US and Canadian waters (Thornton et al. 2022). Critical Habitat designations, as determined by years of visual and acoustic detections of the population, inform these efforts (J. K. B. Ford et al., 2017).

Acoustic detection is achieved by deploying hydrophone(s) (underwater microphone) on the seafloor (either autonomously powered or cabled to shore) to record the soundscape continuously or on duty-cycles, sometimes in areas inaccessible to visual observers. PAM systems can be fully archival (recordings stored onboard for future analysis once retrieved) or transmit data to shore stations (cabled observatories) or via satellite communications (autonomous vehicles), which can enable live listening and detection capabilities. Passive acoustic monitoring generates large volumes of data which are typically too large to examine manually, instead requiring automated processing to produce results within reasonable timeframes. A variety of generalized detection algorithms are available that work reasonably well as binary detectors of killer whale calls (Gillespie et al., 2013; Helble et al., 2012) and neural network based killer whale detectors have been developed (Bergler et al., 2019; Kirsebom et al., 2022). Most of the existing detectors lack the ability to robustly distinguish highly variable killer whale calls with other signals in the same frequency band. While progress has been made in developing automated detection algorithms for killer whale vocalizations, there is a strong need to develop improved classifiers that can distinguish between killer whale calls and calls of species with overlapping sound frequencies, as well as ship noise with tonal elements. Functional species classifiers can assist in the differentiation of calls from different ecotypes and populations.

Killer whale vocalizations can be grouped into three broad categories: echolocation clicks, whistles, and pulsed calls (J. K. Ford, 1987; Janik, 2009). Echolocation clicks are impulsive sounds with the majority of the energy between 20 and 100 kHz, and used in feeding and navigation (Au et al., 2004; Barrett-lennard et al., 1996). Whistles are tonal calls typically used for social communication among individuals within a pod. These whistles are narrow band signals that aid in close-range communication, generally spanning from 0.5 to 25 kHz, and may be involved in coordinating movements and maintaining group cohesion (Riesch et al., 2008; Souhaut & Shields, 2021; Thomsen et al., 2001). Pulsed calls are broadband signals with energy between 500Hz to over 40 kHz (Miller, 2006) and are the most common signal type used for communication by killer whales. They are composed of a series of pulses produced in such rapid succession as to sound tonal with multiple harmonics (Watkins, 1968). Pulsed calls form distinct, complex vocalizations (discrete calls) often characterized by a series of tonal elements that can have one or two overlapping fundamental frequencies (Deecke et al., 2010; J. K. B. Ford, 1991; Yurk et al., 2002) and that vary in contour and amplitude over time (J. K. Ford, 1987). Pulsed calls are primarily used for social communication within and between individuals and groups, serving functions in social cohesion and mating travel and foraging coordination (Deecke et al., 2010; J. K. B. Ford, 1991; Yurk et al., 2002) and conveying social and behavioral cues. Resident killer whales produce calls in higher frequency ranges with significantly higher minimum, peak, and median call frequencies than Biggs killer whales(Filatova et al., 2015; Foote & Nystuen, 2008). The offshore ecotype produces calls with a higher minimum frequency than other ecotypes (Foote & Nystuen, 2008; Madrigal et al., 2021). Such differences contribute to the distinct vocal repertoires and form the motivation for harnessing the power of modern classification methodologies to make the most of acoustic surveys in both archived or near real-time settings.

Accurate machine learning models rely on extensive and well-curated labeled datasets in order to reliably detect and classify killer whales in underwater sound recordings (Gudivada et al., 2017; Priestley et al., 2023). In acoustic ecology, the data used to train machine learning algorithms should represent the full range of the animals' vocalization repertoire, and those vocalizations should remain relatively static over time (Shiu et al., 2020). Many machine learning applications in conservation are targeted at longitudinal datasets to assess changes in occupancy of species on the scale of years or decades (Brookes et al., 2013; Kotila et al., 2023; Myers et al., 2021; Parijs et al., 2009; Pilkington et al., 2023). In species capable of cultural adaptation of their repertoires, including humpback and killer whales, data for machine learning algorithms must then contain signals that were previously heard in the environment (e.g. antiquated song, and killer whale calls from now deceased animals). Furthermore, environmental factors including but not limited to background noise, instrument parameters, and sound propagation conditions can all influence how robust detection and classification algorithms are.

The goal of the curated dataset presented here is to facilitate the construction and evaluation of detectors that are capable of 1) discriminating killer whale calls from other acoustically similar species and 2) discriminating, between the different ecotypes and populations. There are, however, a number of important challenges. First, the data contributed to this effort were amassed from several independent projects each having different goals, using different data collection methods, and annotated to different levels or resolutions. Second it is not always possible to discriminate between killer whale and other species in the frequency ranges considered, notably Pacific white-sided dolphins and humpback whales, even for expert analysts. Within killer whale vocalizations, it is possible to discriminate between ecotypes, populations, and sometimes, pods or maternally related family groups. However, the annotation resolution in the curated dataset varies. Sometimes it is possible to discriminate ecotypes if numerous calls are detected within an encounter, but in some cases no ecotype specific information is present. Nevertheless, the dataset's diverse sources and comprehensive annotations provide a robust starting point for improving detection systems and advancing our understanding of killer whale vocalizations.

# Methods

In this study, we targeted an "ecologically representative" dataset with comprehensive coverage of annotated audio signals spanning the entire vocal repertoire of the three populations of killer whales in the region: Resident, Bigg’s, and Offshore killer whales. Annotations are comprehensive but are not intended to be exhaustive. The dataset encompasses recordings sourced from a variety of geographical locations and varying recording conditions. A critical requirement for the dataset is its capability to facilitate the discrimination of target species vocalizations from those produced by other organisms within the survey area. In particular, humpback whale song units and whistles from other odontocetes, such as Pacific white-sided dolphins are easily confused with the a killer whales pulsed calls. Effort was also made to include anthropogenic noises such as ship propeller cavitation and other abiotic sounds that can sometimes confuse both humans and machine learning models. Therefore, the dataset includes specific instances of a variety of confounding signals to potentially enhance the robustness of any detection and classification algorithm developed with these data.

Building such a dataset is challenging and often cost prohibitive for a single organization. Thus, in this effort we have combined smaller annotated datasets from multiple commercial, non-profit, academic, and governmental organizations to build an ecologically representative annotation dataset. Much of the annotation effort was provided through the Humans and Algorithms Listening and Looking for Orcas (HALLO) project which used a standardized annotation procedure included in Supplemental Information A. The following sections provide detailed information on the 1) Deployment 2) Processing and 3) Annotation procedures. Metadata, where available, is presented in Table 2. While every effort has been made to regularize metadata across the entirety of the dataset, this was not always possible. Rather than exclude data not meeting an arbitrary threshold, we provide as much detail as possible and leave the final decision on which datasets to include or exclude to the user’s discretion.

## Data Records

The dataset contains audio and annotations provided by a collaboration of industry partners, not-for-profits, universities, and governmental organizations (Table 2). These include Orcasound, Ocean Networks Canada (ONC), the Fisheries & Oceans Canada (DFO), JASCO Applied Sciences (JASCO), Saturna Island Marine Research & Education Society (SIMRES), Scripps Institution of Oceanography, and the University of Alaska Fairbanks and North Gulf Oceanic Society (Figure 1). Data were collected using a variety of instruments deployed in the Northeast Pacific from Washington State to Southeast Alaska including AMARs ([https://www.jasco.com](https://www.jasco.com/amar-g4)), AURALs (Multi-Electronique Inc.), Song Meters (SM2Ms, Wildlife Acoustics), Ocean Sonics icListen hydrophones (https://oceansonics.com/products/iclisten-sj9/), High-frequency Acoustic Recording Packages (HARPs; Wiggins et al. 2007) and Ocean Instruments SoundTrap recording hydrophones (https://www.oceaninstruments.co.nz/). Deployment depths ranged from 8 to 253 m. Data coverage varied but covered a 9-year period between May 2013 and April 2023. Deployment, processing, and annotation details for each dataset are provided in the following sections.

To address consistency issues across multiple annotation schemes and annotators, we take a two-step approach. First, we provide the original, raw annotations with explanations from each organization about how the data were processed. These are stored within the ‘Annotations’ folder under each organization’s data. The original annotations often contain considerable information that is beyond the scope of the challenge including a variety of different labels for biologic and anthropogenic sounds and finer resolution on killer whale calls (e.g. matriline or call type). These annotation details may be of interest to those knowledgeable in the field of killer whale acoustics hence their inclusion. Further information about the analysis procedure, where applicable, is stored in the ‘meta’ folder in each organizations data along with any additional deployment information or relevant reports provided by the dataset authors.

To aid in rapid usability we also provide a standardized annotation file collated across all providers (Annotations.csv). The collated annotation file includes standardized annotations from across all datasets with labels described in Technical Validation section (Table 1). Details on how original annotations were standardized to fit the final annotations file are provided in each subsection below. The code used to produce the Annotations.csv is located in the following GitHub repository (<https://github.com/JPalmerK/DCLDE2026>).

### Orcasound

Orcasound is a cooperative hydrophone network and an open-source software & hardware project. Orcasound audio and annotations were compiled from multiple recording efforts spanning from 2017 to 2020. This public dataset includes nine labeling efforts with the 'Pod.Cast' annotation tool, an open-source web app developed by Microsoft Hackathon volunteers to efficiently analyze audio data to detect the presence of killer whale calls (https://ai4orcas.net/portfolio/pod-cast-annotation-system/). Original audio recordings and annotations are accessible via Orcasound's open labeled data bucket. The dataset is organized into annotation rounds that used audio data from various Orcasound locations with a range signal to noise ratios for SRKW calls and background noise characteristics. Full details of Orcasound data are available on the GitHub repositories for these projects (*Orcasound*, n.d.)

**Deployment**

The Orcasound data were gathered from three sites in Washington State, USA: the Orcasound Lab on San Juan Island (Haro Strait), Bush Point on Whidbey Island, and Port Townsend (the latter two sites are within Admiralty Inlet). At each location, low-cost hydrophones were deployed: LabCore-40 or CRT26-08 elements were utilized in Admiralty Inlet, whereas Orcasound Lab tested a wide variety of elements, including HTI 99-MIN, Aquarian AS-1, and ITC1032 models. These hydrophones were deployed in shallow waters (less than 10 meters at low tide) using bespoke, affordable live-streaming equipment (Raspberry Pi with the Pisound ADC HAT [24 bit, stereo, max 192 kHz]) and the orcanode open source code that generates compressed, lossy audio segments in HLS format and uploads it to an open S3 bucket sponsored by Amazon. Hydrophones and recording systems for these projects have not been calibrated.

**Processing**

Audio data were collected in a variety of formats and at multiple sample rates. The majority of the audio data were sampled at 48khz but a strong lowpass filter with a steep roll-off at 16.H5kHz was applied rendering frequencies above this filter unusable. All audio files were pre-processed with an anti-aliasing erfilter diminishing sound intensities at frequencies above 12kHz. Potential SRKWcalls were initially detected by citizen scientists who have access to live-streamed audio recordings. Citizen scientists indicate periods of likely killer whale activity, and those audio files are reviewed by expert analysists and annotated. These files were archived and noted as ‘candidates’ for further analysis (*OrcaHello*, n.d.).

**Annotation**

A subset of Orcasound's open labeled data includes archives that were prepared via the Pod.Cast system. Audio and annotations consist of 9 of the 10 ‘rounds’ of Pod.Cast datasets, each being part of a Google Summer of Code competition. For each 'Round' of data, candidate audio data for SRKW pre-labeled by running an existing classifier with a threshold tuned for high-recall and validated by crowd-sourcing the predictions.

This project's annotations specifically aimed at identifying SRKW, categorizing detections into two classes: SRKW and non-SRKW sounds. The annotation granularity varied between these classes; for confirmed SRKW calls, the start and end times were documented. For non-detections (i.e., 'false positives'), the files were marked as 'FP,' without specifying time or frequency boundaries. Citizen scientist-flagged files underwent expert review to confirm the presence of SRKW calls, noting the call's start and end times. Frequency bounds were not recorded, hence listed as 'NAN' in the frequency columns of the annotation files. Files lacking identifiable SRKW calls were tagged as 'noise,' and all noise labels were reclassified as 'Abiotic' in the Species Class column.

### Ocean Networks Canada

Ocean Networks Canada (ONC) operates cabled underwater observatories in Canadian waters collecting continuous oceanographic data for the benefit of science, society, and industry. Many of their nodes are equipped with calibrated hydrophones (Biffard et al., 2022) to record long term data on changing ocean soundscapes and support research on noise and soniferous animals. Calibration information and other metadata are available on the Ocean Data Portal (*Ocean Networks Canada - Oceans 3.0*, 2024).

**Deployment**

Acoustic data were collected using an Ocean Sonics SC2 (<https://oceansonics.com/>) recording system deployed on the Barkley Canyon Upper Slope platform of ONC’s Northeast Pacific Time-series Underwater Networked Experiments observatory. The hydrophone was mounted 1 m above the sea floor at 168m depth and sampled continuously at 64 kHz. Data that did not contain classified signals were archived after review by regional navies.

**Processing**

The hydrophone sampled at 64 kHz but uses a 25.6 kHz anti-aliasing filter during data collection and digitization, yielding useable information up to 32 kHz bandwidth but with reduced apparent sound intensities above 25.6 kHz. Data were evaluated for the presence of killer whales and other species in three separate efforts with varying protocols for each. All manual annotation was completed initially using JASCO’s PAMLab software. Annotations were produced using a logarithmic spectrogram display with different spectral settings in 4 different bands, enabling multi-species identification across the full bandwidth in a single pass. All visible signals were considered for annotation, and no signal-to-noise ratio threshold was used. Annotations initially made in PAMLab were reviewed for accuracy, signal diversity, and completeness using Raven Pro v 1.6. No automatic detection algorithms were applied during any part of the analysis.

**Annotation**

The annotation effort focused on identifying and categorizing marine mammal presence across a large dataset as well as producing diverse call-level annotations for killer whale classifier development. Data were produced originated from 2013 and 2014. Data from 2013 audio were opportunistically evaluated for the presence of killer whale calls during quality control and assurance checks. The first four days of each month of 2014 data were systematically reviewed by manually scanning all audio files for the presence of marine mammal acoustic signals. All killer whale pulsed calls were classified to ecotype and annotated using bounding boxes for any file containing at least on killer whale call. Whistles were opportunistically annotated while no echolocation clicks were annotated. If signals from other marine mammal species were encountered (e.g. fin whale calls), at least one example per file was annotated with additional examples opportunistically annotated at the analyst’s discretion. Full details of the annotation effort are included in the metadata for these data (README\_BarkleyCanyonAnnotationsCompanionDocument.pdf)

For the purposes of the detection and classification dataset, all annotations indicating the possible presence of killer whales were categorized as ‘KW’ regardless of certainty. Annotations that indicated uncertainty to the species by indicating either possible alternative species or were demarcated with medium or low certainty were defined in the KW\_certain category. Because click annotation varied between groups, click annotations in the ONC data were classified as ‘undetermined biological’ sounds. Killer whale annotations that were paired with other potential species, e.g. “killer whale/white sided dolphin” were similarly classed as undetermined biological sounds. All killer whale annotations containing a “?” were tagged as uncertain.

There were over a hundred different tags for species data in these annotations including all variations of possible confounding species (e.g. killer whale, humpback, or Pacific-white sided dolphin, or unidentified biological sounds). For this dataset any label that contained killer whale possibility was tagged as KW and if other species were listed as alternative possibilities the KW certainty column was set to 0. Calls that were identified as possible humpback whale calls were added to the humpback category The ClassSpecies label for killer whale clicks and buzzes was set to ‘UndBio’ as this was the only dataset that labeled impulsive calls. Should users wish to include clicks in classifiers, they should refer to the original annotations

### Fisheries & Oceans Canada (DFO)

Two groups within DFO provided datasets to the challenge, the Cetacean Research Program and Whale Detection and Localization Program. Data processing methods were consistent across projects within each lab but varied slightly between labs. Exact hydrophone locations are not publicly available for any DFO hydrophone dataset. Instead, general location descriptors are provided. The two DFO datasets are discussed in turn below.

*Cetacean Research Program*

Data from the Cetacean Research Program (CRP) lab consisted of two deployments, one on the continental shelf edge off the west coast of Vancouver Island and another from an instrument deployed on the northern mainland coast of British Columbia. Data were based on approximately 375 days of recording off Vancouver Island and 116 days of recording in northern BC, with the former targeting the winter months. The focus of the original analysis effort that resulted in these datasets was simply to identify which of the recording files contained killer whales calls for use in various habitat studies. The analysis was conducted by using an automated detector with manually identification of all resulting detections. Such a manually annotated dataset may be useful to detector/classifier development efforts.

**Deployment**

Data were collected using AURAL-M2 moored at 114m depth off the northwest coast of Vancouver Island, and an SM2M moored at 35m depth on the Northern mainland coast of BC, respectively. Exact locations were not made available for this competition. The AURAL-M2 sampled audio at 16.4 kHz and the SM2M sampled at 16 kHz.

**Processing**

The raw audio recordings (WAV) were post-processed using the Whistle and Moan Detector in PAMGuard version 1.12.08 (Gillespie et al., 2013) with an FFT length of 512 and 50% overlap (256 samples). The detector was user configured with a high-pass filter of 800 Hz to limit the number of humpback whale detections and lessen the manual validation burden. The SNR detection threshold was set to 6 dB. All detections in the first two seconds of each five minute file were excluded because the detection algorithm produces several false detections within this period.

**Annotation**

All detections including whistles and pulsed calls were aurally and visually reviewed by expert annotators using PAMGuard and identified to species (for biotic) and sound type (for abiotic). Where applicable and as time allowed, detections were also acoustically identified to. Note that files may contain more identifiable calls than the annotations indicate due to false negatives that are inherent when using automated

Note that individual detections may be separate components of the same discrete call (i.e. harmonics or sidebands), thus, not every detection represents a unique vocalization. The PAMGuard Whistle and Moan detector detects individual contours, so all individual harmonics within a call would constitute separate detections if they meet the detector’s criteria (this happens quite frequently). Also, the settings of the detector mean that independent tones (e.g. from multiple individuals) that crossed or overlaped in frequency and time may be detected as a single detection.

*Whale Detection and Localization Program*

Whale Detection and Localization Program (WDL) in collaboration with the Acoustics Program provided data from four deployment locations in Canadian waters, including Carmanah Point, Swanson Channel, and two locations at the southern end of the Strait of Georgia (SOG North and SOG South where north and south are in relation to each other). The annotated dataset spanned 298 days from September 2021 through June 2022.

**Deployment**

Four locations were chosen for the study area: Carmanah Point, Swanson Channel, and southern end of the Strait of Georgia. The exact locations are not disclosed. A SoundTrap ST600 HF (www.oceaninstruments.co.nz) was used at Carmanah Point, while AMAR G4ss (https://www.jasco.com) were used for all other deployments. All deployments were between 3-5 months in duration. Audio data were continuously sampled at either 192 kHz for the SoundTrap or 256 kHz for the AMARs.

**Processing**

Audio recordings were processed with the Whistle and Moan Detector in PAMGuard version 2.02.03 (Gillespie et al., 2013) for the presence of potential killer whale calls. Audio files were downsampled within PAMGuard to 48 kHz, and a weak IIR Butterworth high-pass filter with a threshold of 2 kHz and an order of 1 was applied to reduce background noise in the lower frequency bands. The SNR detection threshold was set to 8 dB. Nominal sensitivities of -164.1 dB and -176.2 dB were used for the AMARs and SoundTrap, respectively. The Whistle and Moan Detector used a minimum frequency threshold of 200 Hz, a maximum frequency threshold of 24 kHz (the Nyquist frequency), and a minimum contour length of 15 time-slices (about 341 milliseconds); otherwise, all other detection settings were kept at their defaults. In the detector's noise and thresholding tab, all boxes except "Run Gaussian Kernel Smoothing" were checked and any input values were kept at their defaults as well. The FFT engine used with the detector used an FFT length of 2048, a hop size of 1024, and a Hann window function, with the same noise parameters as those used with the detector.

**Annotation**

All detections produced by the Whistle and Moan Detector were evaluated for the presence of killer whales and annotated as such using a custom PAMGuard plugin. Detected sounds included whistles and pulsed calls; echolocation clicks were not included as they typically do not trigger the detector due to their short length. As with the Pilkington dataset, which was similarly processed by PAMGuard, a single call can contain multiple detections, typically caused by the presence of harmonics. In this case, 27% of the detections overlapped in time.

### JASCO and Vancouver Frasier Port Authority

The Vancouver Frasier Port Authority (VFPA) in collaboration with JASCO Applied Sciences, collected data from two locations in Haro Strait and Boundary Pass. These data were part of the Enhancing Cetacean Habitat Observation program which aims to improve killer whale acoustic habitat through voluntary vessel speed reductions (Joy et al., 2019).

**Deployment**

AMAR recorders were deployed directly adjacent to the southbound and northbound shipping lanes in Haro Strait (Table 2, Figure 1). Instruments at both locations were deployed and recovered twice. The first deployment extended between July 6th and September 8th 2017. Instruments were deployed and refurbished AMAR’s were re-deployed at the same locations on September 8th and recovered October 26th of the same year. Data from the boundary pass location were collected over the period between September 2018 and April 2019. Deployment depths ranged between 193m to 251m across the three regions.

**Processing**

For all deployments, data were sampled at 256 kHz and killer whale encounters were identified with a proprietary detection algorithm developed by JASCO Applied Science.

**Annotation**

Encounters were manually annotated by expert analysts for the presence of killer whale calls following the HALLO protocol. Expert annotators used Raven Pro to identify killer whale calls and, where possible, classify calls to call type. Annotators also noted the presence of a variety of non-target calls and abiotic sounds including unknown signals, background noise, fish, and potential Pacific-white-sided dolphins.

### JASCO, Vancouver Frasier Port Authority, Ocean Networks Canada

The Strait of Georgia underwater listening station (ULS) is a collaborative project between the Vancouver Fraser Port Authority, Transport Canada, Fisheries and Oceans Canada, Ocean Networks Canada and JASCO Applied Sciences. Data from this hydrophone have been used in evaluating changes in noise levels associated with voluntary vessel slowdowns (Joy et al., 2019).This listening station has been in place since September 2015 and is now in its third year of operation. Data from September 2015 and March 2018 were manually scanned using Raven Pro (v. 1.6) for the presence of killer whales, humpback whales and other signals of interest.

**Deployment**

The ULS is situated on the seabed at approximately 170 m depth approximately 30km west of Vancouver, Canada. The location aims to monitor noise in association with the northbound shipping lane. Synchronized data from four hydrophones are streamed to shore in near real-time via the Victoria Experimental Network Under the Sea (VENUS) Observatory operated by Ocean Networks Canada.

**Processing**

For all deployments, data were sampled at 256 kHz and killer whale encounters were identified with a proprietary detection algorithm developed by JASCO Applied Science.

**Annotation**

Encounters were manually annotated by expert analysts for the presence of killer whale calls following the HALLO protocol (HALLO Annotation Guidelines). Annotators used Raven Pro to identify killer whale calls and, where possible, classify calls to call type. Annotators also noted the presence of a variety of non-target calls and abiotic sounds including unknown signals, background noise, fish, sonar, and potential Pacific-white-sided dolphins.

### SIMRES

The Saturna Island Marine Research and Education Society (SIMRES) maintains several hydrophones along the BC coast as part of the Whale Sound Network. This network collaborates to enable quantification and monitoring of the ocean soundscape. Since 2015, fixed hydrophones have been deployed in Boundary Pass (SIMRES, 2020). The annotated data were collected from the East Point Hydrophone located off the southeasternmost point of Saturnia Island From June through October 2022 (Table 2, Figure 1). These data represent periods when SRKW were both acoustically detected and visually sighted by citizen scientists from the Southern Gulf Islands Whale Sighting Network and student researchers from Simon Fraser University.

The original project goal was to investigate vessel noise impacts on SRKW acoustic behavior in Boundary Pass. The annotated dataset includes 13 hours and 40 minutes of SRKW acoustic activity and call types were identified from all three SRKW pods, J, K, and L. The duration of acoustic events varied and ranged from 5 minutes to 190 minutes.

**Deployment**

An Ocean Sonic’s icListen high-frequency (HF) smart hydrophone (RB9-ETH) with ethernet (<https://oceansonics.com/products/iclisten-sj9/>) was used to collect audio recordings. The shore-cabled hydrophone is located at a depth of 18 m, approximately 120 m from shore, near the commercial shipping channel in Boundary Pass (48.780° N, 123.052° W). Data are continuously sampled at 128 kHz but are down sampled to 64 kHz in the files are provided.

**Processing**

Audio data were not pre-processed with any detection algorithms for this for this study.

**Annotation**

Audio files were manually annotated in Raven Pro v 1.6. All SRKW communication signals including pulsed calls, whistles, buzzes, and rasps were annotated with bounding boxes demarcating the start and end time of the signal as well as the low and high frequencies. When possible, pulsed calls were further classified into the specific call types outlined by Ford (1987). A singular instance or burst of clicks was marked in each audio file to indicate the presence of echolocation but echolocation clicks were not otherwise annotated. The original selection tables also contain annotators comments which may be useful in selecting data to build finer level detection and classification algorithms than outlined here.

Annotated signals were assigned a confidence rating of either ‘low’, ‘medium’, or ‘high’ to specify the level of certainty provided by the annotator. If the call could not be identified, it was left as ‘unknown’. A small number of potential humpback whale calls were also annotated with uncertainty, these have been included in the ‘humpback’ SpeciesClass.

All killer whale annotations were included in the combined annotation dataset regardless of quality. Annotation indicating a low or medium quality were noted as ‘Uncertain” or 0 in the KW\_certain column.

### Scripps Institute of Oceanography

Data from two locations spanning the period 2008-2013 were provided by the Scripps Institute of Oceanography. Data were part of a long-term monitoring project off the Washington Coast and consists of encounters included in previously published work (Leu et al., 2022; Rice et al., 2017).

**Deployment**

High-frequency acoustic recording packages (HARP; Wiggins et al.(2007)) packages were deployed in a nearshore (Cape Elizabeth) and offshore (Quinault Canyon) location. HARPs sampled continuously at 200 kHz. Data from this project represents the most southern locations studied as well as the deepest deployment (1400 m).

**Processing**

Tonal call encounters were identified manually by an expert analyst by reviewing spectrograms in the MATLAB-based software Triton (Rice et al. 2017; <https://github.com/MarineBioAcousticsRC/Triton>). Encounters were annotated and assigned to ecotype where possible based on distinct tonal signals associated with known pods. In a subsequent study (Leu et al., 2022) the tonal annotations were used to run a guided echolocation click detector (SPICE Detector in Triton).

**Annotation**

Original pulsed annotations described in Rice et al. (2017) were not available. As such, data were manually annotated for the presence of killer whale calls using Raven Pro v1.6 (FFT: 19.2 ms, 22.4 Hz). Only calls that could be confidently identified as killer whales were included in the final annotations. Humpback whale calls were added opportunistically and examples of self-noise, tagged as abiotic signals, were included as these signals show structural similarities to biological signals. Killer whale ecotype classes were defined off the original encounter labels (Leu et al., 2022, 2022). Though present in the encounters, echolocation clicks were not labeled during the annotation effort.

### SMRU Consulting

SMRU Consulting in collaboration with the Whale Museum have maintained a cabled hydrophone within SRKW core habitat for nearly two decades. These data have also been used in evaluating then potential benefits of voluntary ship slowdowns (Joy et al., 2019). Data are routinely evaluated for the presence of killer whales and humpback whales. The hydrophone location is also within visual range of the Lime Kiln lighthouse which houses volunteers trained for whale and dolphin identification. Audio files associated with visually confirmed acoustic encounters over several periods from 2016-2021 were provided for the challenge dataset.

**Deployment**

The recording setup consists of a cabled Reson TC4032 hydrophone ~70m from shore mounted to the seafloor at 23m depth. Data were digitized at 250 kHz sample rate, 16 bit depth using a SMRU Consulting data acquisition board and PAMGuard software, stored as wav files and uploaded to a cloud-based systems.

**Processing**

Audio data from the Lime Kiln hydrophone were processed for the presence of biological sounds with the PAMGuard whistle and moan detector (Gillespie et al., 2009) which generated binary detection files.

**Annotation**

PAMGuard binary detection files were inspected in the PAMGuard ViewerMode to view the detections and spectrogram as well as listen to the sound. A detection event was annotated as the time period from the first to last call with no more than 30 minutes between calls. Annotation procedures followed the HALLO protocol.

### University of Alaska Fairbanks

Data contributed by the University of Alaska Fairbanks and North Gulf Oceanic Society are part of a long-term killer whale monitoring project in the Gulf of Alaska. This includes recordings of the southern Alaska resident, Gulf of Alaska Biggs, AT1 Biggs, and offshore killer whale populations from both stationary moorings and focal follows. The metadata folder associated with these data contains three files. The Myers\_DCLDE\_2026\_files.xls file was used to relate filenames, ecotypes, and locations in the original annotation files to the final annotations. It contains three headings, Filename, Ecotype, Population, Location, and UTC. Filename refers to Soundtrap audio file names containing the starttime, UTC is the corrected start time. Location values are abbreviations for Hinchinbroook Entrance (HE), Kachemak Bay (KE), Montague Strait (MS), Resurrection Bay (RS). These represent fixed hydrophone locations. Location values for the focal fallows are labeled ‘field’ in the location column. The Hydrophone locations.xls contain the deployment information for the fixed recorders. 20120114-N\_Matkin\_FY20\_Annual\_Report.pdf contains detailed information about the field recordings and project information. Audio files are organized according to instrument name or ‘field’ for field recordings.

**Deployment**

Recordings of southern Alaska residents were taken with a dipping hydrophone during vessel survey encounters in Prince William Sound and Kenai Fjords (Figure 1) between May and October in 2019, 2020, and 2021. When killer whales were encountered, we photographically identified as many individuals present as possible. We then maneuvered the vessel approximately 500 m in front of the animals, shut off the engine, and collected a field recording. Recordings before June 16th, 2021 were made with a High-Tech, Inc. HTI-96-Min hydrophone deployed at approximately 8 – 10 m depth with a two channel TASCAM DR100 portable digital recorder (sampling rate 24 kHz). Only the first channel was used. Recordings after June 16th, 2021 were made with a Ocean Instruments SoundTrap ST300 hydrophone (sampling rate 24 kHz) deployed at 20 -30 m depth (Table 2).

Biggs or offshore killer whales were rarely encountered during vessel surveys, and Biggs killer whales also vocalize less often than residents (Deecke et al., 2005; Saulitis et al., 2005a) making field recordings difficult to obtain. We therefore contributed recordings from moored hydrophones in which we detected Gulf of Alaska Biggs, AT1 Biggs, or offshore killer whales. Moored hydrophones were deployed in Hinchinbrook Entrance, Montague Strait, Resurrection Bay, and Kachemak Bay (Table 2) beginning in 2016, though for this analysis we included Biggs recordings from June 2019 to May 2021 and offshore recordings from May 2022 and April 2023. Hydrophones were deployed at depths of 25 – 42 m on primarily gravel and sand substrate and were moored approximately 2 m above the seafloor. Moored hydrophones recorded at a 24 kHz sampling rate and were duty cycled (primarily 5 min on, 10 min off) based on battery requirements. All moored hydrophones were Ocean Instruments SoundTrap ST300s, except for the hydrophone in Montague Strait in 2023 which was a model ST600.

**Processing**

All acoustic data from moored hydrophones were processed using the Whistle and Moan Detector in the open-source software package PAMGuard v.1.15.17 (Gillespie et al., 2009). Spectrograms were created with a 1024 Fast Fourier transform length and 50% overlap. The Whistle and Moan detector identified tonal signals in the 700 – 12,000 Hz frequency range with a minimum length of 15 time slices, minimum size of 30 pixels, and that met an 8 dB signal-to-noise ratio threshold. Recordings with at least three detections were manually checked visually and aurally by H. Myers and classified to the population level. Gulf of Alaska Biggs and AT1 Biggs were identified using published call catalogues (Myers et al., 2021; Saulitis et al., 2005b). Offshore killer whale detections were confirmed by J. Pilkington. A small minority of recordings included multiple killer whale populations or killer whale and humpback whale (*Megaptera novaeangliae*) vocalizations; these recordings were not included in the dataset.

**Annotation**

In recordings with killer whales, discrete pulsed calls were manually annotated by H. Myers in Raven Pro v.1.6.5. A bounding box was drawn around each call, and the call start time, end time, low frequency, high frequency, and length were saved in selection tables.

## Technical Validation

All potential killer whale annotations were created by expert analysts at their respective institutes based on a canonical catalogue of killer whale calls (Ford 1987). As with all biological signals, the sound quality of the killer whale vocalisations varied considerably based on the background noise, distance between the animal and the hydrophone, and propagation considerations.

Low SNR detections, as indicated by the reviewing analyst, were not included in the dataset or tagged as uncertain.

Collated annotations covered an approximately 11-year span from May 2011 through April 2023 and were recorded on a variety of instruments including JASCO AMARs, Soundtraps, IC listening devices, and custom-built hydrophones (Table 2).

An annotation file is provided as a CSV that includes links to audio files (Table 1)

## Usage Notes

The intended purpose of this curated dataset is to build classifiers for detecting killer whales and classifying signals to population or ecotype in the Northeastern Pacific. When building detection and classification algorithms, users should consider both their intended applications and potential limitations. For instance, users will immediately note that sample rates differ between each of the contributed datasets and analysis of the annotations will show that down sampling the higher frequency data will limit or exclude some of the higher frequency annotations. Conversely, excluding the lower frequency annotations will result in a much-reduced dataset. The biological implications of the sample rate are also worth noting. Much of the effort in classifying killer whale ecotypes and populations has utilized lower frequency sound <12 kHz (Ford et al. 2022). However, as seen in this dataset, killer whale vocalizations may have fundamental frequencies at or above 20khz. Whether or not the features present at higher frequencies represent useful information for population or ecotype discrimination is yet to be determined.

The audio files presented here are done so in their raw state. They have not been normalized to account for different gain and calibration settings between the various instruments and individual project goals. Researchers wishing to measure received levels should reach out individual data providers directly to determine appropriate calibration offsets. It is also important to note that the sample rate is not always indicative of the useful frequencies. Some groups have applied low-pass filters with cutoff frequencies considerably below Nyquist.

Echolocation clicks in the sound files have not been annotated consistently and are thus not included in the final dataset. However, the presence of echolocation clicks has been noted in some files from JASCO and ONC. See original files for those annotations. As echolocation clicks can be diagnostic of species and potentially ecotype (Leu et al., 2022), further annotation of this dataset could feed into training or validation based on echolocation parameters.

Data for this project represents a large collaboration of groups and institutions and each dataset was processed in accordance with each groups project goals. Post processing of the annotations was done to provide a uniform resource for machine learning algorithms. However, users should consider details from each deployment carefully to determine whether they wish to do any additional post-processing. For example, multiple annotations from the DFO datasets may represent different harmonics of the same call. Alternatively, data derived from ONC projects considered only pulsed calls. Thus, unannotated whistles and echolocation clicks may be present in some files. See individual datasets above for details.

## Code Availability

The R code used to collate data and annotations is available here: https://github.com/JPalmerK/DCLDE2026

# Acknowledgements

# Author Contributions

KJ Palmer collated the final dataset, managed data sharing agreements, produced the collated annotation files, and annotated the SCRIPPS dataset. She also drafted, edited and reviewed the manuscript

Emma Cummings and Alex Harris were expert annotators for the JASCO and Vancouver Port Authority datasets.

K. Frasier provided data and annotations from Scripps Institution of Oceanography and participated in editing the manuscript.

Mike Dowd, Fabio Frazao and Bruno Padovese contributed to the HALLO annotation protocol and participated in data curation throughout the process. He also participated in editing the manuscript.

A. Houweling and Jenn Wladichuck provided the JASCO data and were expert annotators. Additionally, they participated in writing and editing the manuscript.

Jasper Kanes provided data from Ocean Networks Canada and served as expert annotator for the ONC datasets

Oliver S. Kirsebom provided editorial feedback and was involved in the initial inception of the project.

Holger Klink was involved in the project inception provided financial support and editorial input.

Holly Leblond, Lucy Quale, Caitlin O'Neill, Svein Vagle, and Harald Yurk provided data from the DFO Whale and Dolphin Detection and Localization group. Lucy Quale served as the expert annotater. All provided editorial feedback for the manuscript.

Lauren Laturnus served as an expert annotator on the SIMRES data, provided editorial feedback to the manuscript and created Figure 1.

Olivia Murphy served as an expert annotator on the SIMRES data.

Hannah Myers, Craig Matkin, and Dan Olsen provided the University of Alaska Fairbanks data. Additionally, Hannah Meyers served as expert annotator on the University of Alaska Fairbanks data and provided editorial feedback for the manuscript.

J. Pilkington provided data and annotations from the Department of Fisheries and Oceans Cetacean Research Program, participated in writing and editing the manuscript.

Amalis Riera Vuibert served as an expert annotator on the SMRU data

Krista Trounce provided data from the Vancouver Frasier Port Authority and provided editorial feedback on the manuscript.

Scott and Val Viers provided data from Orcasound hydrophones, served as expert annotaters and provided critical feedback to the manuscript.

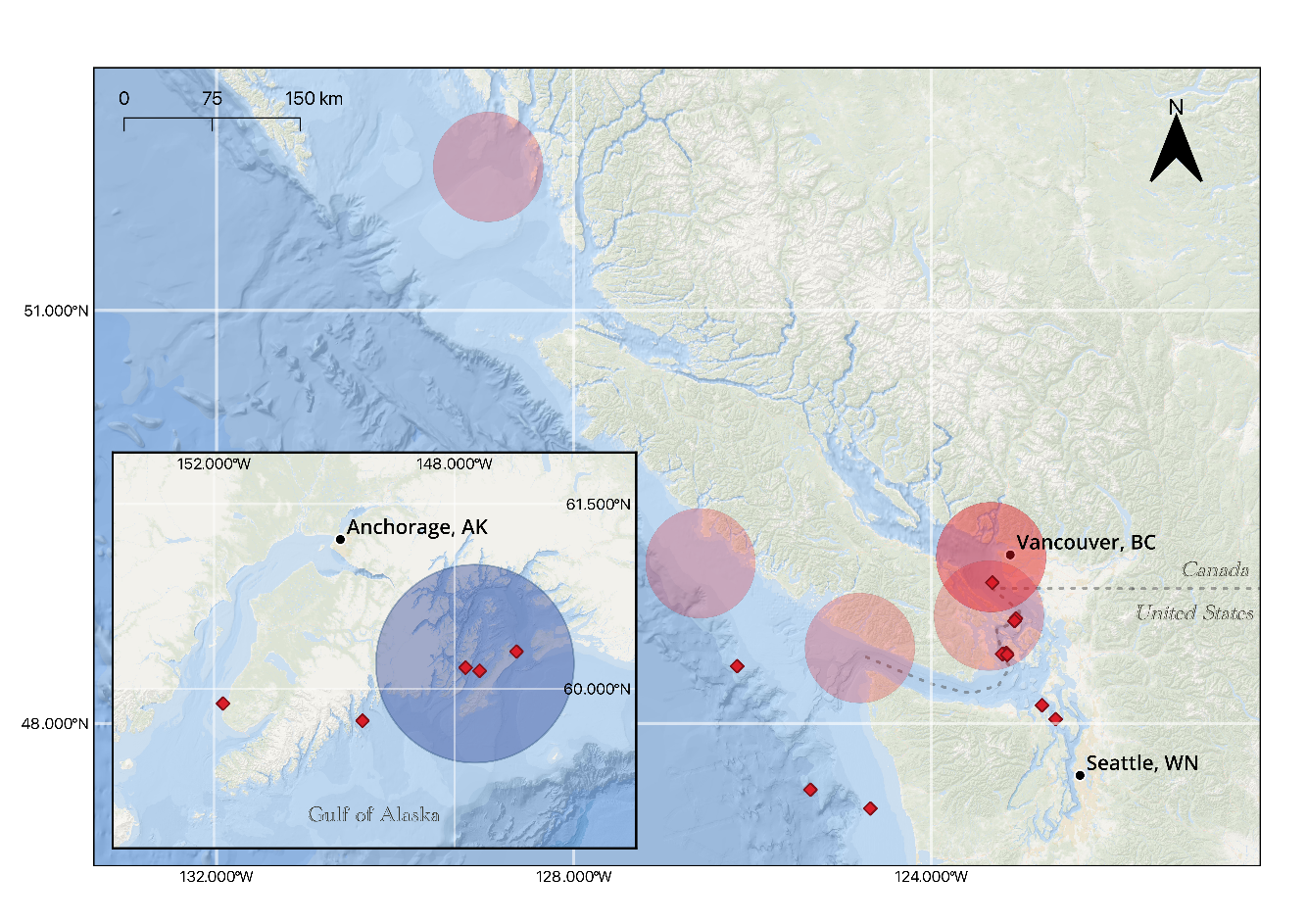
Jason Wood provided data from SMRU Consulting and provided editorial feedback on the manuscript.

Ruth Joy was the benevolent overlord providing financial support of the project, critical feedback at all levels, and a patient ear to gripe at.

# Competing Interests

The authors declare no competing interests.

# Figures



# Figure Legends

Figure 1 Map of study area and hydrophone locations. Points represent data collection sites, transparent circles indicate approximate regions for DFO data collection sites (exact coordinates are not provided) and the blue circle on the inset indicates approximate region of focal follows for University of Alaska field recordings.

# Tables

Table 1 Annotation file descriptors in the pre-cleaned dataset

|  |  |  |
| --- | --- | --- |
| CSV Headings | Contents | Structure |
| **SoundFile** | Name of the audio file from which the annotation was derived | Character string |
| **FilePath** | Full file path to the to the audio file above | Character string |
| **FileBeginSec** | Seconds into the audio file representing the start of the bounding box or detection | Double |
| **FileEndSec** | Seconds into the audio file representing the end of the call annotation | Double |
| **LowFreqHz** | Lower limit of the bounding box or detection, in Hz | Double |
| **HighFreqHz** | Upper limit of the bounding box or detection, in Hz | Double |
| **UTC** | UTC time at the beginning of each annotation (**FileBeginSec**) | Character string ISO formatted date/time |
| **ClassSpecies** | Species or class description with the following options: Killer Whale (**KW**), Humpback Whale (**HW**), Abiotic (**AB**), and Undetermined Biological sound (**UndBio**). | Character string |
| **AnnotationLevel** | Caracter string representing whether the annotation represented a validated **detection, call,** or **file** | Character string |
| **KW** | Indicator of whether or not the annotation denotated that the annotation represented a killer whale call | Bool (0,1) |
| **KW\_certain** | Indicator of whether or not the annotator was certain that the annotation was a KW. This is often represented by a question mark in the annotations. For ONC data, annotators listed all potential species that the thought the call could come from. | Bool (NA,0,1) |
| **Ecotype** | Killer whale ecotype or population represented by the KW annotation, if known. **SRKW**- Southern Resident Killer Whale, **SAR**- Southern Alaska Residents, **NRKW**- Northern Resident Killer Whale, **BKW**- Bigg’s killer whale, or **OKW**- Offshore Killer Whale or blank when no ecotype could be determined | Character string or NA |
| **Data Provider** | Group providing the data | Character string |
| **Dep** | Shorthand for the deployment location | Character string |

Table 2 Deployment summary for the data included in the detection and classification dataset. Annotation start and finish dates represent first and last annotation included in the dataset. Deployment is the name of the deployment location used in the annotations table.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Dataset Provider** | **Location Description** | **Deployment** | **Latitude** | **Longitude** | **Depth (m)** | **Sample Rate (kHz)** | **Hydrophone/Recorder** | **Annotations Start** | **Annotations Finish** |
| Orca Sound | Orcasound Lab | podcast\_round2 | 48.525 | -123.159 | 8 | 32 |  | 2020-09-27 | 2019-07-05 |
|  | Orcasound Lab | podcast\_round3 | 48.525 | -123.159 | 8 | 32 |  | 2020-09-07 | 2017-09-27 |
|  | Orcasound Lab | podcast\_round5 | 48.525 | -123.159 | 8 | 32 |  | 2020-09-08 | 2020-07-25 |
|  | Orcasound Lab | podcast\_round6 | 48.525 | -123.159 | 8 | 32 |  | 2019-07-05 | 2020-09-01 |
|  | Orcasound Lab | podcast\_round7 | 48.525 | -123.159 | 8 | 32 |  | 2017-09-27 | 2020-09-07 |
|  | Port Townsand | podcast\_round9 | 48.135 | -122.760 | 8 | 32 |  | 2020-07-25 | 2020-09-29 |
|  | Bush Point | podcast\_round10 | 48.031 | -122.608 | 12.5 | 32 |  | 2020-09-01 | 2020-09-28 |
|  | Bush Point | podcast\_round11 | 48.031 | -122.608 | 12.5 | 32 |  | 2020-09-05 | 2020-10-18 |
|  | Port Townsand | podcast\_round12 | 48.135 | -122.760 | 8 | 32 |  | 2020-09-29 | 2020-10-08 |
| ONC | Berkley Canyon | Berkley Canyon | 48.426 | 126.174 | 40 | 64 | Ocean Sonics SC2 | 2013-05-20 | 2014-12-04 |
| DFO CRP | West Vancouver Island | WVanIsl | NA | NA | 114 | 16.384 | AURAL-M2 | 2011-05-18 | 2012-05-24 |
|  | Northern Mainland British Colombia | NorthBc | NA | NA | 35 | 16 | SM2M | 2013-10-10 | 2014-02-03 |
| DFO WDLP | Carmanah Point | CarmanahPt | NA | NA | 55 | 192 | SoundTrap 6249 | 2022-03-08 | 2022-06-29 |
|  | Strait of Georgia North 1 | StrGeoN1 | NA | NA | 72 | 256 | AMAR | 2021-09-05 | 2021-10-01 |
|  | Strait of Georgia North 2 | StrGeoN1 | NA | NA | 72 | 256 | AMAR | 2021-11-27 | 2021-11-28 |
|  | Strait of Georgia South 1 | StrGeoS1 | NA | NA | 193 | 256 | AMAR | 2021-11-11 | 2021-11-18 |
|  | Strait of Georgia South 2 | StrGeosS2 | NA | NA | 193 | 256 | AMAR | 2021-09-04 | 2021-09-16 |
|  | Swansen Channel | SwanChan | NA | NA | 245 | 256 | AMAR | 2021-11-13 | 2022-01-09 |
| JASCO/Malahat | Station 3 | Stn\_3 | 48.686 | 123.274 | 237 | 64 | AMAR | 2015-10-14 | 2016-10-08 |
|  | Station 4 | Stn\_4 | 48.507 | 123.211 | 188 | 64 | AMAR | 2015-10-15 | 2017-02-11 |
|  | Station 5 | Stn\_5 | 48.495 | 124.540 | 213 | 64 | AMAR | 2015-10-14 | 2016-02-16 |
|  | Station 6 | Stn\_6 | 48.775 | 123.343 | 74 | 64 | AMAR | 2016-02-16 | 2017-02-10 |
| SIMRES | Tekteksen (East Point), Saturna Island, BC | Tekteksen | 48.780 | 123.052 | 27 | 128 | Ocean Soncics IC Listen | 2022-06-24 | 2022-06-24 |

Table 3 Summary of annotations for each contributor’s detection and classification dataset. CRP indicateds Cetacean Research Program and WDLP indicates Whald and Detection and Localization Program. Detection dataset annotations are divided into killer whale, other or undetermined biological sounds, abiotic sounds, and humpback whales. Population/Ecotype classification task includes annotations for southern resident killer whales (SRKW), Bigg’s, northern resident killer whales (NRKW) and offshore killer whales (OKW)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  | |  | **Species/Class Annotations** | | | | | | | **Ecotype/Population Annotations** | | | | | | |
| **Dataset Provider** | **Dataset name** | | **Detection** | **Annotation Level** | | **KW** | **Und. Bio** | | **Abiotic** | | **HW** | | **SRKW** | **Bigg’s** | | **NRKW** | | **OKW** | |
| Orca Sound | | Podcast 2 | None | | Call (KW)/ File | 435 | | 0 | | 11 | | 0 | 435 | | 0 | | 0 | | 0 |
|  | | Podcast 3 | None | | Call (KW)/ File | 436 | | 0 | | 60 | | 0 | 436 | | 0 | | 0 | | 0 |
|  | | Podcast 5 | None | | Call (KW)/ File | 0 | | 0 | | 31 | | 0 | 0 | | 0 | | 0 | | 0 |
|  | | Podcast 6 | None | | Call (KW)/ File | 151 | | 0 | | 25 | | 0 | 151 | | 0 | | 0 | | 0 |
|  | | Podcast 7 | None | | Call (KW)/ File | 0 | | 0 | | 167 | | 0 | 0 | | 0 | | 0 | | 0 |
|  | | Podcast 9 | None | | Call (KW)/ File | 198 | | 0 | | 89 | | 0 | 198 | | 0 | | 0 | | 0 |
|  | | podcast10 | None | | Call (KW)/ File | 510 | | 0 | | 113 | | 0 | 510 | | 0 | | 0 | | 0 |
|  | | Podcast 11 | None | | Call (KW)/ File | 0 | | 0 | | 118 | | 0 | 0 | | 0 | | 0 | | 0 |
|  | | Podcast 12 | None | | Call (KW)/ File | 54 | | 0 | | 0 | | 0 | 54 | | 0 | | 0 | | 0 |
| ONC | | Berkley Canyon | None | | Call | 1626 | | 9392 | | 156 | | 2946 | 130 | | 834 | | 0 | | 418 |
| DFO CRP | | WVanIsl | Pamguard WM | | Call | 10384 | | 2757 | | 5054 | | 95861 | 48 | | 5336 | | 4558 | | 258 |
|  | | NorthBc | Pamguard WM | | Call | 6886 | | 10696 | | 1178 | | 26058 | 0 | | 2309 | | 3501 | | 947 |
| DFO WDLP | | CarmanahPt | Pamguard WM | | Detection | 2668 | | 33 | | 297 | | 0 | 1610 | | 694 | | 364 | | 0 |
|  | | StrGeoN1 | Pamguard WM | | Detection | 4777 | | 0 | | 190 | | 131 | 4184 | | 593 | | 0 | | 0 |
|  | | StrGeoN1 | Pamguard WM | | Detection | 324 | | 0 | | 1 | | 42 | 0 | | 324 | | 0 | | 0 |
|  | | StrGeoS1 | Pamguard WM | | Detection | 350 | | 0 | | 3 | | 221 | 159 | | 191 | | 0 | | 0 |
|  | | StrGeosS2 | Pamguard WM | | Detection | 2141 | | 0 | | 152 | | 114 | 2070 | | 71 | | 0 | | 0 |
|  | | SwanChan | Pamguard WM | | Detection | 5655 | | 0 | | 383 | | 1660 | 5630 | | 25 | | 0 | | 0 |
| JASCO/Malahat | | Stn\_3 | JASCO | | Call | 7446 | | 3 | | 852 | | 39 | 2574 | | 937 | | 0 | | 0 |
|  | | Stn\_4 | JASCO | | Call | 15788 | | 0 | | 1177 | | 231 | 7647 | | 318 | | 0 | | 0 |
|  | | Stn\_5 | JASCO | | Call | 3039 | | 0 | | 3311 | | 1084 | 395 | | 994 | | 0 | | 0 |
|  | | Stn\_6 | JASCO | | Call | 1333 | | 0 | | 607 | | 26 | 519 | | 242 | | 0 | | 0 |
| SIMRES | | Tekteksen | None | | Call | 3578 | | 21 | | 0 | | 0 | 3418 | | 0 | | 0 | | 0 |

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# Supplemental Information

## HALLO Annotation Guidelines

The following section contains the guidelines provided to expert annotators on the HALLO project for the creation of training and testing datasets. Guidelines were developed with the intention of creating manual annotation using Raven Pro software through the creation of bounding boxes around signals of interest demarking the audio file; lower and upper frequency values; and start and end time in seconds relative to the beginning of the audio file. These guidelines were also used to annotate calls initially detected by PAMGuard whistle moan detection algorithm (e.g. DFO Data). Fragments exported as csv files and classified according to the ‘Sound.ID.Species’. These guidelines have subsequently been updated and are available on the Coastal Marine Science gighub (cite XXX).

**Annotation Guidelines**

* Draw a box specifying the time and frequency boundaries that contain the call/sound
* Assign labels to the box in the 4 label columns (or as many as possible)
* Although the table below contains values for a variety of species for the ‘Sound.ID.Species’ field, our focus remains on Killer whales. Don’t go out of your way to annotate every single dolphin and vessel noise. All labels other than KW are basically there to add a bit of extra information on difficult cases. So, if there are humpback calls sneaking amidst killer whale calls and you think ‘Oh, this could be confusing! I think it’ll be helpful to mark this right here as a humpback’, please go ahead and label it! But you don’t need to chase down every single signal that is not a KW.

|  |  |  |
| --- | --- | --- |
| Label field | Possible values |  |
| Sound\_ID\_Species | KW | Killer whale |
|  | KW? | potential killer whale (if it was unknown but had the potential to be KW, it fell into this category) |
|  | HW | Humpback whale |
|  | HW? | potential humpback whale (certainly not a KW, possibly a HW) |
|  | HW/KW? | either HW or KW, cannot determine |
|  | PWSD | Pacific White Sided Dolphin |
|  | PWSD? | potential Pacific White Sided Dolphin |
|  | KW/PWSD? | either KW or PWSD, too faint or in descript to determine |
|  | GW | Grey Whale |
|  | GW? | potential Grey Whale |
|  | HW/GW? | either HW or GW, cannot determine without further review |
|  | Odontocete | vocalizations from a small unidentified odontocete, not PWSD |
|  | Echolocation | Echolocation clicks that can’t be safely identified as KW |
|  | Odontocete? | potential vocalizations from a small unidentified odontocete, not PWSD |
|  | Rissos | Risso’s Dolphin |
|  | SPW | Sperm Whale |
|  | Vessel Noise | Vessel Noise |
|  | Clang | some metallic-like anthropogenic clang with unknown source |
|  | Mooring | noise likely derived from the instrument’s mooring equipment |
|  | Sonar | Noise likely due to sonar activity |
|  | Unknown | unable to identify or attribute sound to a definitive class |
| KW\_ecotype  (For Killer whales only) | KWSR | Southern Resident Killer Whale |
|  | KWNR | Northern Resident Killer Whale |
|  | KWT | Transient (Bigg’s) Killer Whale |
|  | KWU | Outercoast Transient (Bigg’s) Killer Whale |
|  | KWO | Offshore Killer Whale |
|  | Unknown | unable to identify or attribute sound to a definitive class |
| Pod  (for KWSR only) | J | J pod |
|  | K | K pod |
|  | L | L pod |
|  | Unknown | unable to identify or attribute sound to a definitive class |
|  | K/L | K or L pod (because of the call types they have in common) |
| Call\_Type | S1 | S1 call |
|  | S2 | S2 call |
|  | ... |  |
|  | EL | Echolocation clicks |
|  | Unknown | unable to identify or attribute sound to a definitive class |
| Confidence | High  Medium  Low | Refers to the entry in the field of highest resolution (eg call\_type if there is something in there, otherwise in KW\_ecotype if that’s the last field that has info, etc).  Confidence to be indicated only if the field has no question mark. If there is a question mark, it is assumed that the confidence is very low.  If there is no question mark and confidence level field is blank, it will be assumed to be high. |