

# Underwater sounds, including killer whale and humpback whale vocalizations, recorded in northern Norway in January 2023.

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## Abstract

We publish a dataset of underwater acoustic recordings obtained during the expedition “Orcalize” that took place in Skjervøy in northern Norway from 29<sup>th</sup> December 2022 till 6<sup>th</sup> January 2023. The data contains vocalizations from killer whales and songs from humpback whales which gather in the local fjords during the winter months to feed on herring. We recorded in the band of 20 Hz – 60 kHz with calibrated hydrophones arranged in a compact tetrahedral array that we deployed over board of a motorboat. We describe the instrumentation, the data consolidation and the resulting file format. In addition we release a Jupyter notebook with example python code to load, analyze and export the data and present some highlights of this dataset. In total we provide 17 files of continuous recordings of various length from several minutes to over one hour. The total dataset is about 7 hours 37 minutes long and the memory size is 62.8 GB.

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Filename	short description
2023-01-02--11-09-19--00-14-26	strong clicks
2023-01-02--11-27-50--00-37-57	orca calls, strong clicks
2023-01-02--12-56-55--00-09-08	orca calls
2023-01-03--07-39-15--00-38-26	overlapping humpback whale songs
2023-01-03--09-01-52--00-25-45	big group of orcas, many overlapping calls and bursts
2023-01-04--11-26-33--00-19-19	humpback whale songs
2023-01-04--18-32-15--01-10-44	humpback whale songs, boat, sonar, modem
2023-01-04--20-20-54--00-14-59	orca calls
2023-01-04--20-38-38--00-22-53	strong clicks (clipping)
2023-01-05--09-44-38--00-52-49	humpback whale songs
2023-01-05--10-46-13--00-13-57	humpback whale songs, boat noise
2023-01-05--11-22-21--00-03-25	orca calls
2023-01-05--12-26-21--01-01-32	humpback whale songs
2023-01-06--08-07-48--00-30-11	humpback whale songs
2023-01-06--08-46-51--00-14-38	humpback whale songs
2023-01-06--09-16-18--00-27-41	humpback whale songs

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## Field site

Skjervøy is a small fishing village north east of Tromsø in Norway. During the winter months enormous mass of herring gather in the surrounding fjords for overwintering. This concentration of herring provides a rich food source for marine predators such as orcas, humpback whales, and fin whales, which are known to gather in large numbers in this area. This in turn make the place a famous destination for whale watching tours and scientific observation of these marine mammals.

In January 2023, we performed daily excursions with a small motorboat and recorded the underwater soundscape with the aim to record killer whale and humpback whale vocalizations.

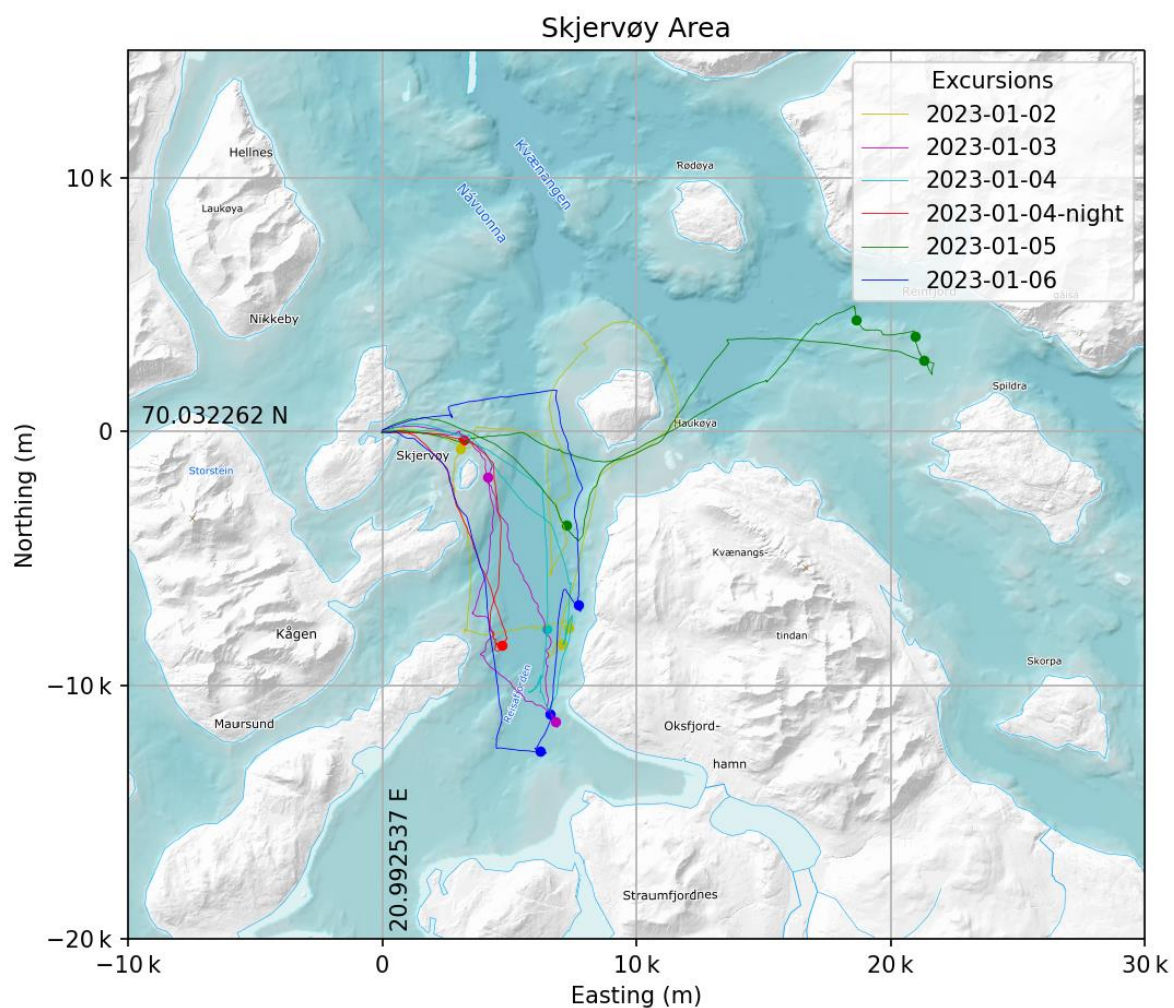


Figure 1. The GPS tracks of the excursions with the boat. The dots mark the positions of the recordings that are included in the publication. The maps are from Norwegian web map services. The projection is stereographic with the origin at the entrance of the harbor of Skjervøy.

## Instrumentation

We used a compact four channel hydrophone array in a tetrahedron structure with ca. 0.7 m side length (Figure 2). We deployed it over board to a depth of ca. 17 m. To dampen the movements of the boat in the waves, we attached 3 kg of weight to the tetrahedron and suspended it with a 5m long elastic rope and curled cables (Figure 2). The hydrophones were of type HTI-92 WB (High Tech Inc. USA) with a nominal bandwidth of 2 Hz – 50 kHz and a specified self-noise 10 dB below "Sea

State 0". Each hydrophone was factory calibrated (-165.5 dB re 1 V /  $\mu\text{Pa}$ ). The hydrophones were customized to run with phantom power of commercial audio recording equipment. We used a Tascam Portacapture X8 recorder to record all four channels simultaneously with 192 kHz sampling rate, and analog bandwidth of 20 Hz - 60 kHz and floating point data format for high dynamic range. An additional channel was used with a microphone to record spoken notifications.



Figure 2. The tetrahedron structure with the four hydrophones mounted inside the corners. The naming convention for the four channels are indicated. The lower three corners are each charged with 1 kg of lead weight. The tetrahedron is suspended with a 5 m long elastic rope to dampen the movements from the surface.

## Highlights

See the Jupyter notebook 'explore.ipynb' for the scripts to generate these examples.

## Humpback whale songs

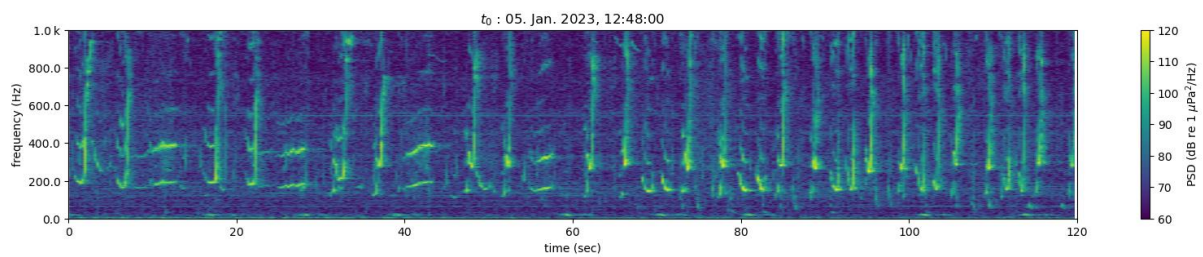


Figure 3. A section of a humpback whale song, characterized by its repetitive patterns of units forming themes.



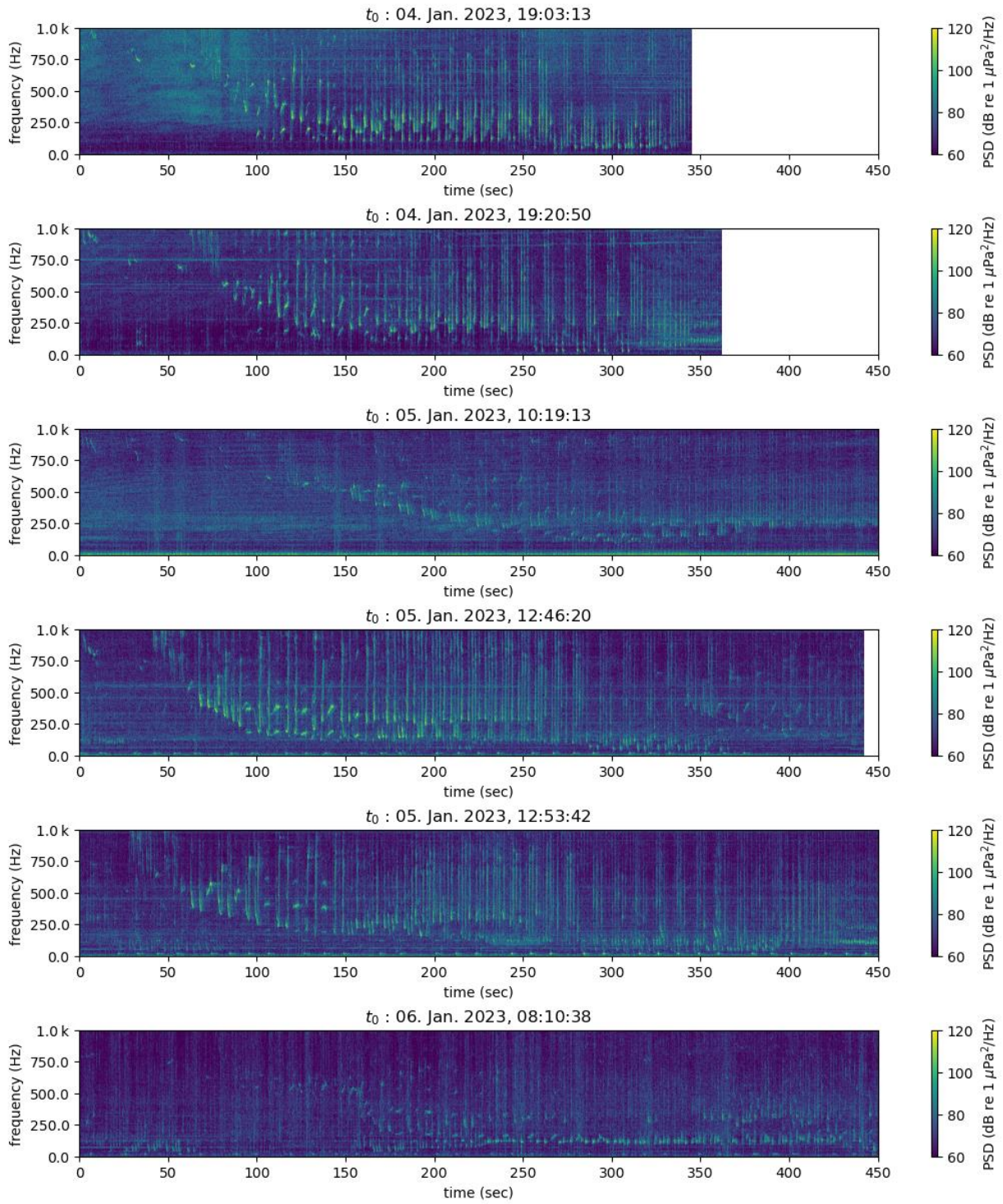


Figure 4. Humpback whale songs recorded on different days and locations.

## Killer whale clicks

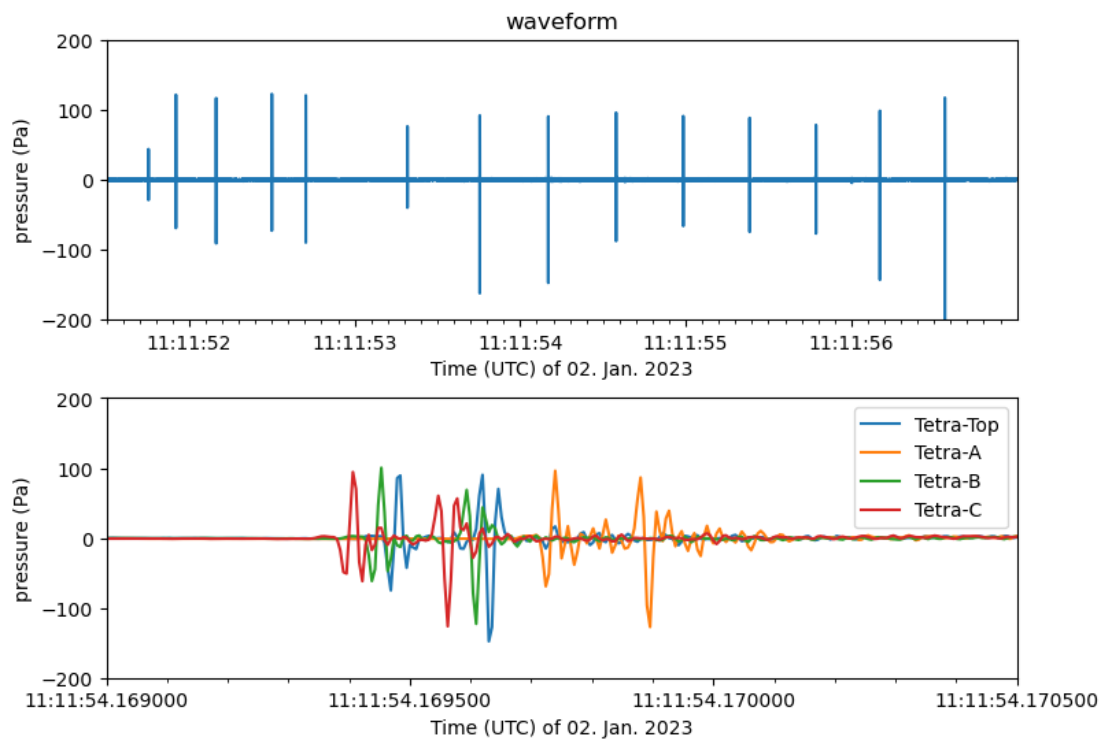


Figure 5. Strong clicks recorded from a close-by killer whale. The click arrives with some time delay at the four hydrophones within the tetrahedron. The double peak could be caused by a surface reflection, therefore the phase reversal.

## Killer whale calls

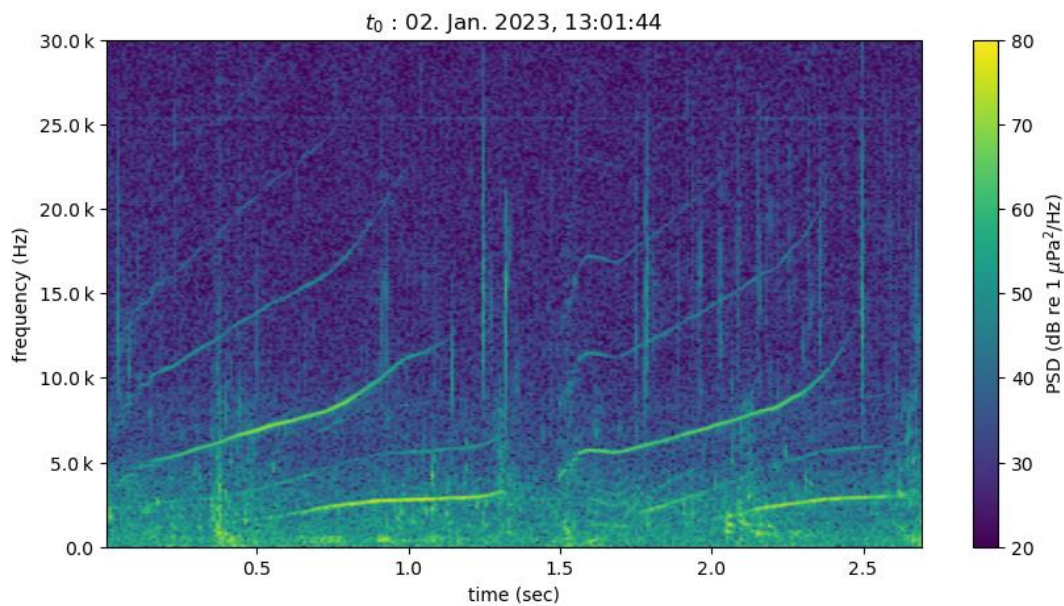


Figure 6. Call-pair from orcas, presumably a call and response from two orcas maintaining vocal contact.



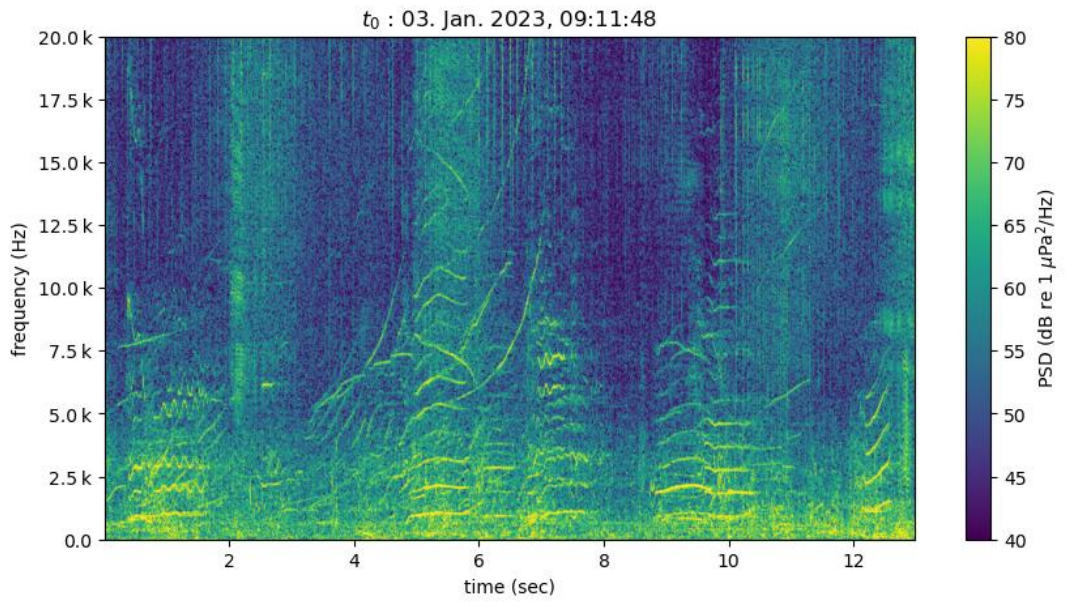


Figure 7. Dense vocalizations from distant orcas that lasts about half an hour.

### Sonar and an unknown acoustic device

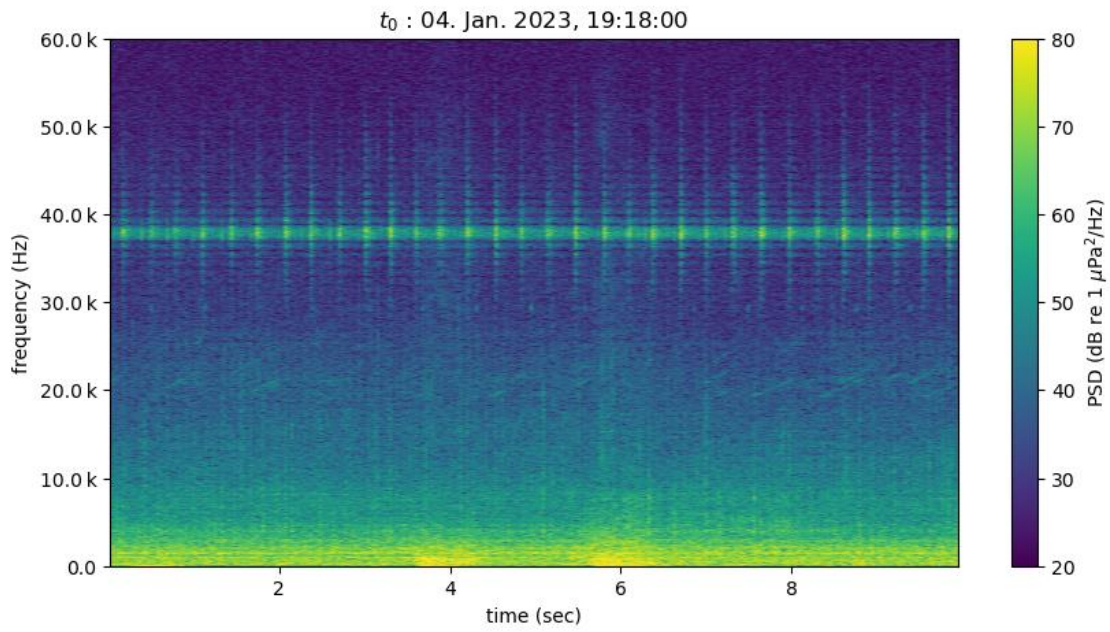


Figure 8. A typical sonar from a fishing vessel.

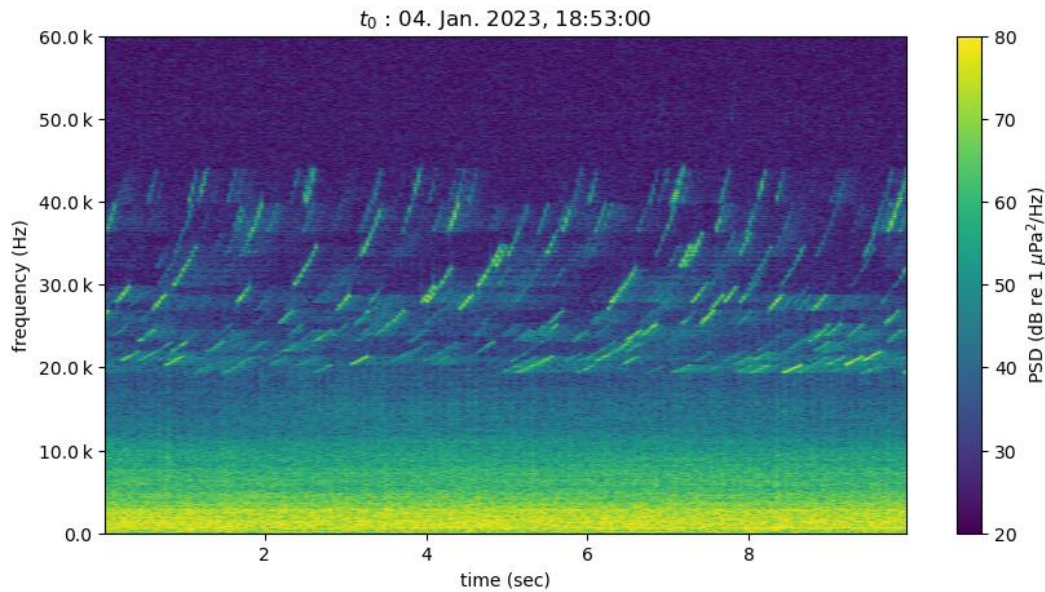


Figure 9. An unknown underwater acoustic device.

## Data management

See the git repository for Jupyter scripts documenting the data management:

<https://gitlab.switch.ch/cetacean-communication/expeditions/orcalize/consolidate.git>

The consolidation (or compilation) process had several steps:

- Omit recordings with bad quality or no animal vocalizations. For example, if the noise from ships are too dominant, or when there is a strong cable strum because the ship drifted to fast in the wind, we do not include the recording in the publication.
- Trim the recordings. In case the recording started when the hydrophones were not yet in the water, or when the recording did not stop at the end and records voices on board of the ship.
- Apply the calibration of the hydrophones and the gain setting of the recorder. This yields a quantitative measurement of sound pressure in the units of Pa.
- The recorder saves separate wav files for every channel, and "rolls over" when the files get too long. We merged all the files of a continuous recording into a single file (HDF5).
- Project the geographic information into local cartesian coordinate system. The geographic GPS tracks in GPX files (Latitude, Longitude) are transformed to a stereographic local coordinate system for easier geometric calculations.

## Filename format

date: year-month-day	time: hour-min-sec	duration: hour-min-sec
2023-01-02--11-09-19--00-14-26.hdf5		

Figure 10: Composition of the filename. The time of the first sample in UTC is always at a boundary of a second. The duration is an integer number of seconds, such that the number of samples in the file is an integer multiple of the sample rate.

## File format

To inspect the hdf5 files, use [HDF VIEW](#).

Object Attribute Info General Object Info

Attribute Creation Order: Creation Order Tracked and Indexed

Number of attributes = 14

Name	Type	Array Size	Value[50](...)
Expedition Name	String...	Scalar	Orcalize
Expedition Description	String...	Scalar	Recording killer whales and humpback whales wit...
Expedition Begin	String...	Scalar	2022-12-29
Expedition End	String...	Scalar	2023-01-08
Expedition Location	String...	Scalar	Skjervoy, northern Norway
Dataset DOI	String...	Scalar	10.5281/zenodo.7657352
Main Institution	String...	Scalar	ETH Zurich
License	String...	Scalar	CC-BY 4.0
Year	String...	Scalar	2023
Author Names	String...	4	Jörg Rychen, Alexander Eckerle, Xintong Liu, Stef...
Author ORCIDs	String...	4	0000-0002-3302-0193, 0000-0002-7839-9459, 0000...
Author Affiliations	String...	4	Institute of Neuroinformatics, University of Zurich, F...
Authors Emails	String...	4	jrychen@ethz.ch, a.eckerle@campus.lmu.de, xintli...
Data Description	String...	Scalar	Underwater acoustic recording and GPS track

Figure 11: Properties on the file level show general data related to the expedition and the data publication itself.

Object Attribute Info General Object Info

Attribute Creation Order: Creation Order Tracked and Indexed

Number of attributes = 17

Name	Type	Array Size	Value[50](...)
Start Time	String, length...	Scalar	2023-01-02T11:09:19.000000+0000
End Time	String, length...	Scalar	2023-01-02T11:23:45.000000+0000
Duration (s)	64-bit floating...	Scalar	866.0
Sample Rate (Hz)	64-bit floating...	Scalar	192000.0
Samples	64-bit integer	Scalar	166272000
Signal	String, length...	Scalar	Sound Pressure
Unit	String, length...	Scalar	Pa
Recorder	String, length...	Scalar	Tascam Portacapture X8
Frequency Band	String, length...	Scalar	20 Hz - 60 kHz
Recorder Gain	String, length...	Scalar	20 dB
Hydrophone Type	String, length...	Scalar	HTI-92-WB / Phantom Power
Array Type	String, length...	Scalar	Tetrahedron
Array Edge Length (m)	64-bit floating...	Scalar	0.7
Array Depth (m)	64-bit floating...	Scalar	17.0
Channels	String, length...	4	Tetra-A, Tetra-B, Tetra-C, Tetra-Top
Hydrophone Serial Numbers	64-bit integer	4	1205018, 1205020, 1205017, 1205019
Hydrophone Sensitivities (dB re 1V/uPa)	64-bit floating...	4	-165.5, -165.4, -165.6, -165.2

Figure 12: Properties of the data table "Signals".

Object Attribute Info General Object Info

Name: Signals

Path: /

Type: HDF5 Dataset

Object Ref: 1670

Dataset Dataspace and Datatype

No. of Dimension(s): 2

Dimension Size(s): 166272000 x 4

Max Dimension Size(s): 166272000 x 4

Data Type: 32-bit floating-point

Miscellaneous Dataset Information

Storage Layout: CHUNKED: 32768 X 4

Compression: 1,258:1GZIP: level = 9,

Filters: SHUFFLE: Nbytes = 4, GZIP, Error detection filter

Storage: SIZE: 2114628200, allocation time: Incremental

Fill value: NONE

Figure 13: Object info of the data table "Signals". The data is in single precision floating point (float32), and the storage is chunked and compressed and includes error detection.



Object Attribute Info General Object Info

Attribute Creation Order: Creation Order Tracked and Indexed

Number of attributes = 17

Name	Type	Array Size	Value[50](...)
Data Type	String, length ...	Scalar	Geographic track of recording location
Start Time	String, length ...	Scalar	2023-01-02T11:09:19.000000+0000
End Time	String, length ...	Scalar	2023-01-02T11:23:45.000000+0000
Duration (s)	64-bit floating-...	Scalar	866.0
Sample Rate (Hz)	64-bit floating-...	Scalar	1.0
Samples	64-bit integer	Scalar	866
Columns	String, length ...	4	X (m), Y (m), Longitude (deg), Latitude (deg)
Global Coordinate System	String, length ...	Scalar	WGS84
Global Coordinate System EPSG Code	String, length ...	Scalar	EPSG 4326
Local Coordinate System Projection	String, length ...	Scalar	Stereographic
Local Coordinate System Origin Latitude (deg)	64-bit floating-...	Scalar	70.032262
Local Coordinate System Origin Longitude (deg)	64-bit floating-...	Scalar	20.992537
Local Coordinate System Origin Description	String, length ...	Scalar	Harbour of Skjervoy
Local Coordinate System Proj4 String	String, length ...	Scalar	+proj=stere +lat_0=70.032262 +lon_0=20.992537 +k=1
Local Coordinate System Units	String, length ...	Scalar	m
Excursion	String, length ...	Scalar	2023-01-02
Mean Position	64-bit floating-...	4	7091.066634348264, -8400.982220594362, 21.177850247

Figure 14: Properties of the data table "Track".

## Ethical statement

We received confirmation from the Norwegian Food Safety Authority that under Norwegian and European legislation related to animal research, neither formal approval nor a license is required for passive acoustic recordings (regulation of 18 June 2015 No 761 concerning the use of animals for scientific purposes § 2, f). The data acquisition is regarded as non-invasive.