High resolution acoustic recordings of wild free-ranging short-beaked common dolphins for etho-acoustical and repertoire studies

Loïc Lehnhoff[1,2,3,*], Hervé Glotin[2,3,*], Yves Le Gall[4], Eric Menut[4], Hélène Peltier[5], Jérôme Spitz[5], Olivier Van Canneyt[5], and Bastien Mérigot[1,3,*]

[1]MARBEC, Univ Montpellier, CNRS, IFREMER, IRD, Sète, France
[2]Université de Toulon, Aix Marseille Univ, CNRS, LIS DYNI, Toulon, France
[3]Centre international. d'IA en Acoustique Naturelle (CIAN), France
[4]French Research Institute for Exploitation of the Sea (IFREMER), Centre Bretagne, Plouzané, France
[5]Observatoire Pelagis, La Rochelle Université, CNRS, La Rochelle, France
[*]These authors contributed equally to this work.

Correspondence: Loïc Lehnhoff (loic.lehnhoff@gmail.com)

Abstract. Dolphins are highly vocal cetaceans with a complex acoustic repertoire. These marine mammals rely heavily on sound for critical activities: echolocation clicks for navigation and prey detection, whistles for social communication, and pulsed sounds for less well-documented purposes. Understanding their acoustic behaviour is essential for insights into their ecology, social structure, and responses to anthropogenic noise. However, to date, there is a lack of open-access datasets

5 of acoustic recordings of wild free-ranging short-beaked common dolphins (*Delphinus delphis*), coupled with ~~observations~~ observational data. Here, we present a new dataset (DOI: 10.5281/zenodo.14637674, Lehnhoff (2025)) of high resolution acoustic recordings of (*D. delphis*) observed during various behavioural states, including foraging, travelling, socializing, milling, and attraction to the boat. The dataset was collected in the northern Bay of Biscay, France, from summers of 2020 to 2022 during surveys conducted as part of the DOLPHINFREE project. ~~The dataset contains acoustic recordings of wild~~

10 ~~free-ranging short-beaked common dolphins (*Delphinus delphis*) observed during various behavioural states, including foraging, travelling, socializing, milling, and attraction to the boat.~~ Audio recordings were performed during opportunistic encounters using two devices: a single high-quality hydrophone (sampling rate: 512 kHz, bit-depth: 32 bits) and a compact array of four hydrophones (256 kHz to 512 kHz, 16 to 24 bits) for localization purposes. The dataset comprises over 400 minutes of unedited audio recordings of *D. delphis* accompanied by visual observations. In total, we identified about 68,000 echolocation clicks,

15 4,600 whistle contours, and more ~~that~~ than 350 pulsed sounds. This comprehensive resource is ~~valuable~~ invaluable for detailed studies of the acoustic repertoire of ~~common dolphins and their two-dimensional movements~~ (*D. delphis*), coupled with behavioural studies or analyses of the directionality of their acoustic emissions.

Keywords: etho-acoustic, bio-acoustic, cetaceans, echolocation click, whistle, buzz, burst pulse, *Delphinus delphis*

1 Introduction

20 ~~The study of the sounds emitted by cetaceans represents a field of research with numerous applications, including the investigation of social interactions, behavioural patterns, localisation (including trajectory reconstruction) and the identification of these animals (e.g. Caldwell and Caldwell, 1968; Overstrom, 1983; Poupard et al., 2019; Halkias et al., 2013). Cetaceans have different and distinctive vocal repertoires between species, populations (e.g. Ansmann et al., 2007) or even between individuals within a single group (e.g. Fearey et al., 2019; Cones et al., 2023).~~ This data descriptor makes available a bio-acoustic dataset of au-

25 dio recordings of wild, free-ranging short-beaked common dolphins (*Delphinus delphis*) collected at sea. ~~Comparable~~ These recordings are accompanied by visual observations, providing a comprehensive contextual framework for each file. Comparable audio datasets are available for other delphinid species (e.g. Di Nardo et al., 2023). However, to date, there is a lack of open-access datasets of acoustic recordings of *D. delphis*. ~~The present study proposes a high-sampling, high-resolution audio dataset accompanied by visual observations, providing a comprehensive contextual framework for each recording.~~

30 Short-beaked common dolphins emit sounds that are similar to those of other delphinid species. ~~Acoustic signals emitted by delphinid species, including short-beaked common dolphins, can~~ These acoustic signals can usually be divided into three main categories: echolocation clicks, whistles and rapid sequences of clicks (or pulsed sounds, often referred to as buzzes and/or burst-pulses, Jones et al. (2020)). ~~The echolocation clicks of these animals are short broadband pulses, which enable dolphins to effectively navigate their surrounding environment and to recognise the nature of objects (Norris et al., 1961; Tyack, 1986; Au, 1993)~~

35 ~~.~~

Echolocation clicks are short (typically <100 μs), broadband (ranging from 20 kHz to over 150 kHz, Henderson et al. (2012)) pulses used primarily for navigation, prey detection and object recognition (Au, 1993; Tyack, 1986; Norris et al., 1961). For *D. delphis*, these clicks have been the most frequently observed when the animals are travelling (e.g. Henderson et al., 2012).

Whistles are narrow-band, frequency-modulated ~~signals~~ tonal sounds (usually between 5 kHz to 25 kHz) that are thought to

40 be used for inter-individual communication (Caldwell and Caldwell, 1968; Au and Hastings, 2008), individual identification (signature whistles~~) (Sayigh, 1992)~~, Sayigh (1992)) and coordination of group movements (Lammers and Au, 2003; Branstetter et al., 2012). ~~Finally, these dolphins also emit rapid sequences of clicks, that form an other form of communication: pulsed sounds. Buzzes have been linked to hunting behaviours (Wisniewska et al., 2014; Ridgway et al., 2015), while~~ The whistle repertoire of *D. delphis* is well-described (e.g. Ansmann et al., 2007; Pagliani et al., 2022). However, there have been recent

45 advances, with the formal identification of signature whistles for this species (Fearey et al., 2019; Cones et al., 2023; Agafonov et al., 2024), showing the importance of these signals in social interactions.

Pulsed sounds (Herman and Tavolga, 1980), including burst-pulses ~~are frequently observed during social interactions (Overstrom, 1983; . The distinction between these signals~~ and buzzes, are rapid sequences of clicks whose function remains a subject of debate (Ridgway et al., 2015). The classification of these sounds can be complex, as they form a graded continuum between clicks and

50 whistles (Murray et al., 1998). Usually, their categorisation is based on ~~their~~ the inter-click interval ~~(ICI) (Martin et al., 2019). However, the function of these pulsed signals remains subject to debate (Ridgway et al., 2015)~~(Martin et al., 2019). Buzzes are characterised by very short ICIs and high repetition rates, they are typically associated with the terminal phase of prey

capture (Wisniewska et al., 2014; Ridgway et al., 2015), while burst-pulses are more variable and are frequently observed during close-range social interactions such as agonistic or intimate encounters (Overstrom, 1983; Lammers et al., 2006).

55   The dataset that we provide is extracted from audio recordings collected during surveys at sea performed ~~in the frame of the~~ during the DOLPHINFREE project off the coast of Penmarc'h, Brittany, France in 2020, 2021 and 2022. The aim ~~was to~~ of this project was to create a bio-inspired acoustic signal to reduce the risk of fishery bycatch of (*D. delphis*) (Lehnhoff et al., 2022). To that end, surveys were conducted in order to visually and acoustically assess the behavioural responses of wild, free-ranging common dolphins to ~~a~~ the bio-inspired acoustic signal (co-created by University of Montpellier and IFREMER), emitted by

60   the version 1 of the CETASAVER-DOLPHINFREE beacon (OCTech company)~~, the purpose of which is to reduce the risks of fishery bycatch (Lehnhoff et al., 2022). Therefore, acoustic recordings were~~.

These surveys generated a large volume of acoustic recordings made with and without the activation of the beacon, but also in presence/absence of a fishing net, and depending on the behavioural state of the dolphins (i.e. foraging, travelling, socialising, milling, attraction to the boat), in order to assess the acoustic activities of the animals in different conditions. Only

65   the acoustic recordings collected before the beacon was turned ON are made available, as (i) the DOLPHINFREE signals are protected by intellectual property rights (property of the University of Montpellier and IFREMER), and (ii) in order to deliver data that ~~is~~ are not dependent on the activation of the device, enabling the study of the natural behaviour of the dolphins during the different states cited above.

~~This data descriptor therefore presents a selection of the acoustic data collected during the DOLPHINFREE surveys, together~~

70   ~~with the visual observations performed at the same times. Two types of devices were used to make acoustic recordings (see detailed specifications in the Materials and Methods section): (i) a single Ocean Sonics icListen~~ The study of the sounds emitted by cetaceans represents a field of research with numerous applications, including the investigation of social interactions, behavioural patterns, localisation (including trajectory reconstruction) and the identification of these animals (e.g. Caldwell and Caldwell, 1. With this dataset, we hope to provide high-quality ~~hydrophone deployed from an observation boat, and (ii) a custom-made~~

75   ~~antenna (TETRA), which is a compact tetrahedral array made of 4 hydrophones, suspended under a buoy (see fig 3) . The aim of the recordings made using the icListen hydrophone was to record the signals of dolphins from the observation boat to access their acoustic behaviour, while the aim of the recordings made with the TETRA antenna was more dedicated to studying the movements of the dolphins in two dimensions during the surveys. As these devices were not designed for the same purposes, they were often deployed during different sequences. In total, 275 and 162 minutes of active recording made with the icListen~~

80   ~~hydrophone and the TETRA antenna, respectively, are made available. For these recordings, visual observations confirmed the presence of dolphins around the hydrophones. These data provide a wide panorama of the signals that short-beaked common dolphins can emit: echolocation clicks, whistles, pulsed sounds and probable bi-phonations (Jones et al., 2020) can be found in the dataset.~~

~~This dataset provides complete~~ audio recordings of ~~encounters with wild~~ free-ranging short-beaked common dolphins~~at sea,~~

85   ~~in the Bay of Biscay,~~ which should be of interest for the study of the acoustic repertoire of these animals, their ~~whistles, their acoustic behaviours , their localisation using acoustic signals as well as tasks of whistle detection~~ acoustic behaviours and the directionality of their acoustic emissions.

~~Typical example of the experimental layout during the DOLPHINFREE surveys. *Aerial image captured by a DJI Phantom drone piloted by B. Mérigot.*~~

2 Material and surveys

2.1 Study area

~~Non-systemic~~ Non-systematic scientific surveys were ~~carried out at sea to find dolphins in opportunistic encounters~~ conducted at sea, from semi-rigid pneumatic boats carrying visual observers off the coast of Penmarc'h, Brittany, France (see Figure 1). ~~Wild dolphins are frequently sighted in this area~~, The area was chosen as it is locally known for its frequent sightings of free-ranging dolphins, which have been observed just a few nautical miles off the coast, thereby facilitating opportunistic encounters. In addition, the occurrence of dolphin strandings in the area (Peltier et al., 2020), contributed to the selection of this site. Surveys were performed ~~on~~ during the period of 11–17 July 2020, 9–18 July 2021 and 16–24 July ~~2022~~ 2022. They were only conducted when the weather conditions allowed visual sightings of the dolphins and the identification of their behaviours ~~from semi-rigid pneumatic boats carrying visual observers: with a wind~~, under wind conditions $\leq$ 10 knots and a swell $\leq$ 1 m.
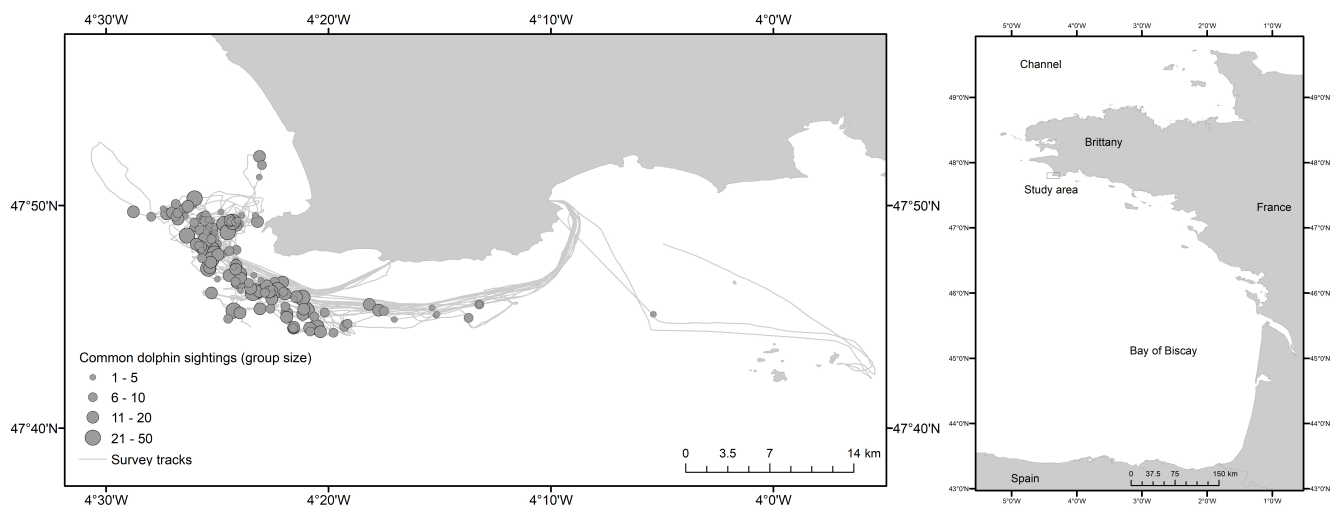
Figure 1. Map of dolphins encountered during the 2020, 2021 and 2022 DOLPHINFREE surveys conducted at sea off the coast off Penmarc'h, Brittany, France.

2.2 Acoustic devices

Two types of devices were used to make acoustic recordings: (i) a single Ocean Sonics icListen HF hydrophone, and (ii) a custom-made compact 4-hydrophone tetrahedral array (TETRA). The objective of the audio monitoring made using the HF hydrophone was to record the acoustic signals emitted by dolphins at close range from the observation boat. These signals

could then be directly correlated with visual observation of the behaviours of the dolphins. The recordings made using TETRA were dedicated to the study of the angular movements of the dolphins during the surveys. As these devices were not designed for the same purposes, they were often deployed during different recording sequences.

2.2.1 Main hydrophone

The Ocean Sonics icListen HF hydrophone (see appendix B2 for technical details) was used during surveys at sea in order to record short-beaked common dolphins acoustic signals. This high-frequency hydrophone was used to record sounds on one channel, with a sampling rate of 512 kHz and an audio bit-depth of 32-bits. When the observation boat was stationary (engine off), this hydrophone was deployed from one side of the boat and positioned at -3 m underwater. These ~~parameters~~ procedures allow for a high quality sampling of the raw acoustic signals in the vicinity of the boat~~, without any computational processing~~.

2.2.2 Compact hydrophone array

A custom-made prototype of a compact array of 4 hydrophones was deployed during the surveys. The device (hereafter called TETRA, Figure 2) has a tetrahedral shape, with one hydrophone at each one of its apexes: one CR3 spherical hydrophone with linear frequency range up to 180 kHz, and three SQ26 cylindrical hydrophones with satisfactory responses up to 50 kHz (see appendix B3 & B4 for technical details). The array is made of PVC tubes joined by 3D-printed parts ~~,~~ and connected to a QHB motherboard, made by the SMIoT laboratory (Barchasz et al., 2020), University of Toulon, France (technical specifications available online here).

~~Annotated photo of the TETRA antenna used during the 2021 and 2022 surveys of the DOLPHINFREE project. TETRA's sides are ≈90 cm in length.~~ *~~Photograph taken by L. Lehnhoff before the surveys.~~*

This array was used in 2021 and 2022 to record audio on 4 channels at 256 kHz to 512 kHz, with a bit-depth of 16 to 24 bits, depending on survey sessions. Its materials and its size (about 90 cm in length) make it a compact, portable and practical device. Once in the water, it is left to drift freely under a buoy at -3 m underwater, and is monitored by observers onboard. Consequently, when both recording devices were deployed, audio recordings made with TETRA might differ from those of the icListen hydrophone, due to the distance between the two devices. It should also be noted that this version of TETRA was an initial prototype, which has since been improved in subsequent versions (see Glotin et al. (2024)).
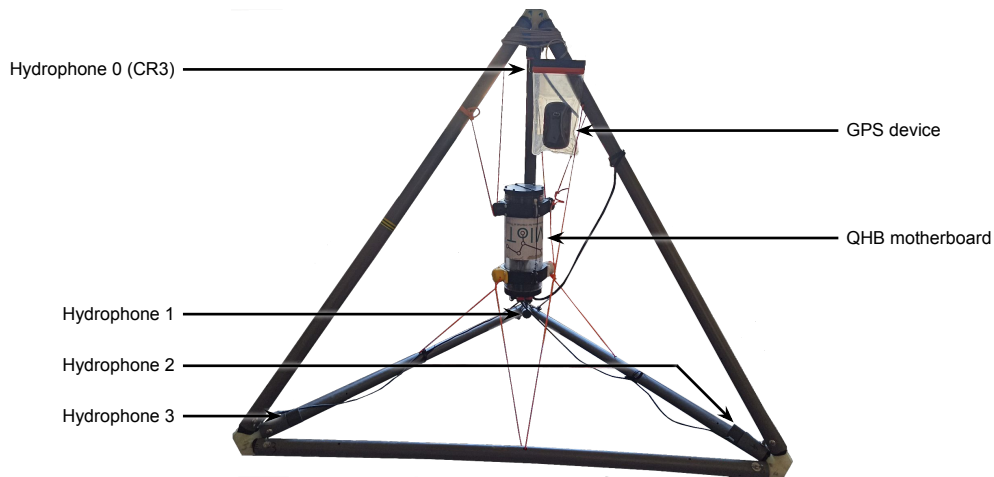
Figure 2. Annotated photo of the TETRA antenna used during the 2021 and 2022 surveys of the DOLPHINFREE project. TETRA's sides are ≈90 cm in length. *Photograph taken by L. Lehnhoff before the surveys.*

2.3 Survey design

During the surveys, two to three people were present on board to navigate, to deploy the acoustic equipment, and to take notes of the visual observations made on the observed groups of dolphins (see Figure 3). A group of dolphins was defined as any number of animals observed within five body lengths of another conspecific, moving and behaving in the same pattern (Shane, 1990; Stockin et al., 2008; Filby et al., 2013). The distances of each group of dolphins from the boat were initially estimated using rangefinder binoculars (Bushnell Fusion 10×42) that enabled visual observers to get accustomed to estimating distances at sea. Once the observers were used to estimating distances, the binoculars were set aside as this allowed for quicker visual observations, which was a more pragmatic approach.
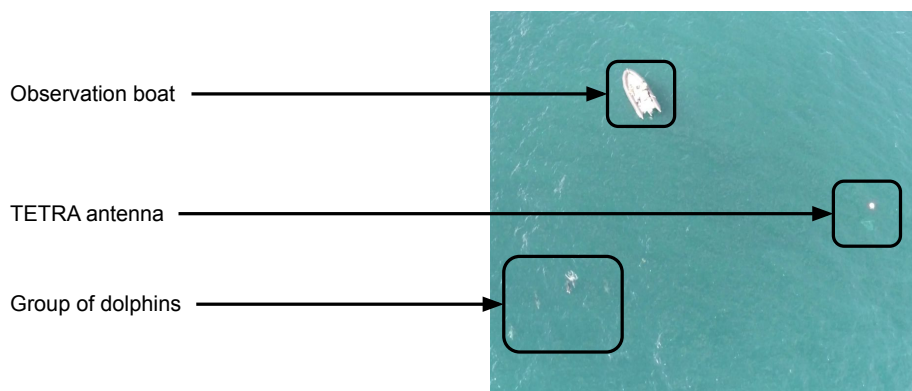
Figure 3. Experimental layout during the DOLPHINFREE surveys. *Image captured by a DJI Phantom drone piloted by B. Mérigot.*

The DOLPHINFREE surveys required a group of dolphins to show a constant behavioural state (defined in Table 1) for at least 1 min one minute of observation. Meaning that the observers waited until the dolphins presented a homogeneous behavioural state before starting to record. As soon as this condition was met, the boat was stopped, the engine and sonar were switched off. Then, the recording devices were set: the icListen hydrophone at -3 m from one of the sides of the boat, and the TETRA antenna at -3 m under a buoy left to drift from the other side of the boat. However, it should be noted that the TETRA antenna was only deployed when drift conditions enabled the observers on board to maintain visual contact with the buoy.

Table 1. Definitions of behavioural states of common dolphins recorded in 2020, 2021 and 2022 (according to (Van Canneyt et al., 2006; Berg Soto et al., 2013; Filby et al., 2013), from (Lehnhoff et al., 2022)).

State	Definition
Foraging	Dolphins involved in any effort to pursue, capture and/or consume prey, as defined by observations of two or more of the following: fish chasing; erratic movements at the surface; multi-directional diving; coordinated deep diving; and rapid circle swimming. Preys and hunting birds often observed at the surface.
Travelling	Dolphins engaged in persistent, directional movement making noticeable headway along a specific compass bearing. Group spacing varied and individuals swam with short (<20 s), relatively constant dive intervals.
Socialising	Animals were involved in active surface behaviour (frequent surfacing and breaching) that included physical interactions among group members and sometimes aerial behaviour.
Milling	Dolphins showed little movement, tended to remain in the same place and either spent floating at the surface or surfaced asynchronously.
Attraction	Dolphins came towards the boat and swam at a few metres along it, following its direction.

As stated in the Introduction section, only the recordings made before the emission of signals by the DOLPHINFREE acoustic beacon are available here. However, other signals were tested during part of the surveys: classical music pieces, whistles of orcas. The audio recordings of these sequences are fully available. In addition, during some surveys, a fishing net was set underwater to simulate the conditions in which bycatch occur occurs. The distribution of audio files according to the behaviour observed and the presence or absence of a fishing net is presented in Figure 4. Four fishing nets were utilised during the course of the surveys. While they do not constitute an exhaustive sample of all the existing nets deployed by fishermen, they still represent a diverse sample of fishing gears. The technical specifications of these nets are provided in appendix B1.
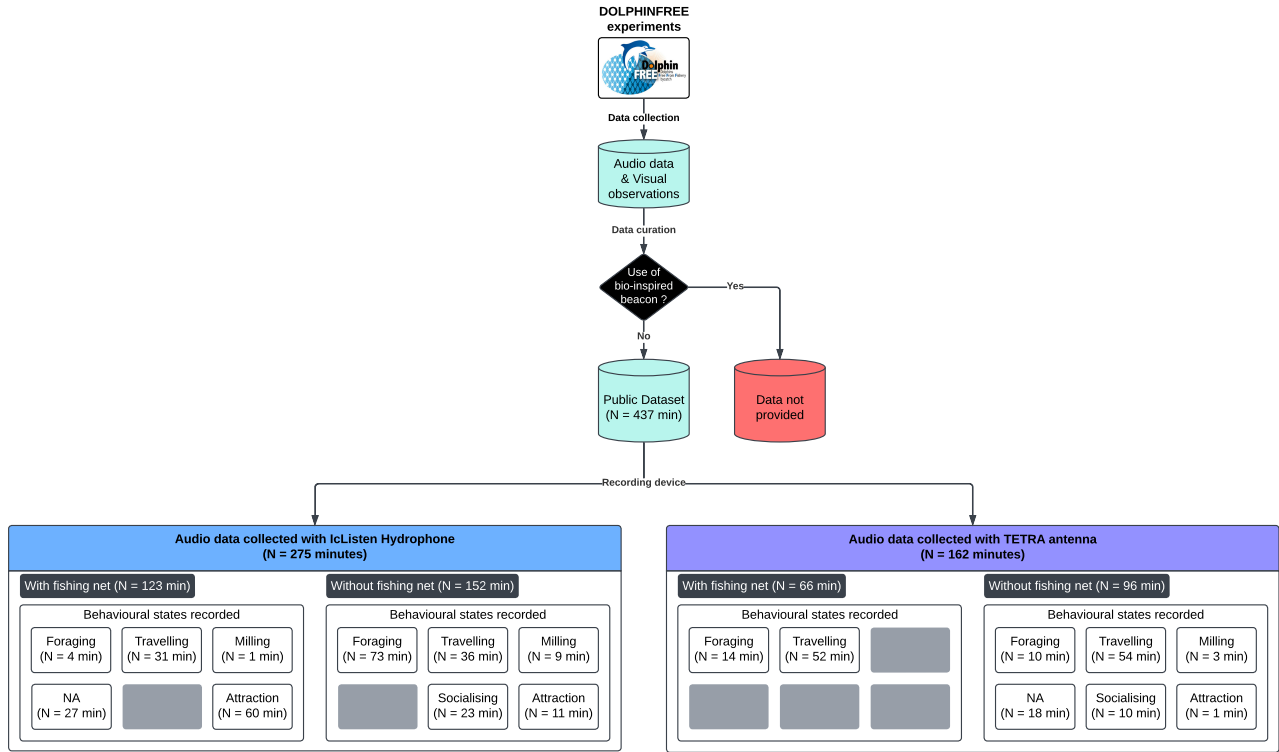
Figure 4. Diagram illustrating the distribution of data collected as part of the DOLPHINFREE surveys, with a focus on the data made available depending on the presence of a fishing net, and the observed behavioural state of the dolphins.

3 Data & methods

This section describes the files and data types that will be found in the dataset (DOI: 10.5281/zenodo.14637674, Lehnhoff (2025)) that is made available.

3.1 ~~Audio files~~

~~These are raw files obtained from the recording of wild free-ranging short-beaked common dolphins during the DOLPHINFREE surveys. There are 275 unedited 1-minute files of audio recordings made using the icListen hydrophone. These files have a sampling rate of 512 kHz with 32-bits resolution on 1 channel.~~

~~As the tetrahedral hydrophone array (TETRA) is a custom-made device, we experimented with different configurations of its QHB motherboard, leading to audio recordings made with varying parameters. In total, 117 files are available, which cumulated, add up to 162 minutes of audio data. Files obtained from the TETRA antenna were recorded on 4 channels~~

3.1 Observation notes

165

Observation data was were collected manually during the surveys, following a custom-made data table (see appendix A). Then, notes were standardised and associated with each audio file independently. These visual observations are available as .xlsx files, distinct for each year and acoustic recording device. Each file contains the values described in Table 2). . Animals within a group often exhibited the same behavioural state (as defined in Table 1). Behavioural states were relatively easy to identify
170 and distinct from each other. However in some cases, the dolphins may have changed their behaviour within the observational window, exhibited different behavioural states within the same group, or displayed two different states simultaneously (notably attraction to the boat and socialising, during our surveys). To take these cases into account, the behavioural states were recorded as a percentage of the behaviours observed each minute. In addition, each observation was associated with the name of the observer to help identify potential biases.

Table 2. ~~Signification~~ Description of column ~~names~~ headers in visual observation data (XLSX) files ~~of visual observations~~.

Column name	Signification	Value format
audio_file	Name of the wavefile.	[date]_[time].wav
datetime_utc	Start date and time of recording.	YYYY-MM-DD HH:MM:SS
observers	Names of observers taking notes.	firstname_lastname
ID_group	Identification number of a group of dolphin.	Integer
ID_sequence	Identification number of each survey sequence.	Integer
group_size	Number of individuals in group.	Integer
fishing_net	Presence/absence of a fishing net.	"present" or "absent"
fishing_net_type	When present, type of fishing net deployed.	"type_of_net"
~~behaviour~~ percent_[behaviour]	~~Observed behavioural state of the group of dolphins.~~ % of observed behaviour as defined in Table 1	~~see Table 1~~ Integer
behavioural_event	Special behavioural events.	jumps, spyhopping, ...
distance	Distance from the boat to the closest visible dolphin.	Integer
group_clustering	Aspect of the spacing between individuals.	"compact" or "scattered"
direction	General direction in which the group is heading.	"continuous" or "variable"
speed	Average speed of the animals (slow/fast threshold: $\approx$10 kn).	"slow", "variable" or "fast".
diving_time	Average diving time of the animals (normal/long threshold: 2 min).	"normal", "variable" or "long"
activation_sequence	Experimental treatment (relative to the emission of signals).	"before", "during", "after" or "control"
signal	Type of signal loaded in the emitter.	see **signal_codes.txt** file
sonar_noise	Indicates if a sonar was unintentionally recorded.	0 (No), 1 (Yes)
special_observations	Any additional observation	Notes

3.2 Audio files

These are raw files obtained from the recording of wild free-ranging short-beaked common dolphins during the DOLPHINFREE surveys. There are 275 unedited 1-minute files of audio recordings made using the icListen hydrophone. These files have a sampling rate of 512 kHz with 32-bits resolution on 1 channel.

As the tetrahedral hydrophone array (TETRA) is a custom-made device, we experimented with different configurations of its QHB motherboard, leading to audio recordings made with varying parameters. Overall, 117 files are available, which in total add up to 162 minutes of audio data. Files obtained from the TETRA antenna were recorded on 4 channels (corresponding to

its 4 hydrophones) and have varying sampling rates (256 kHz or 512 kHz), bit-depth resolutions (16 to 24 bits) and durations (15 s to 120 s).

For the acoustic data recorded from both recording devices, we recommend the application of a high-pass filter for the study of echolocation clicks, in order to avoid background noises (such as waves and boat engines), as both devices were deployed only a few meters below the water surface. Visual observations confirmed dolphin presence in all the recordings provided. These data contain a wide panorama of the signals that short-beaked common dolphins can produce: echolocation clicks, whistles, pulsed sounds and probable bi-phonations (Jones et al., 2020).

3.3 Whistle contour annotation

The shapes of whistles can be linked to specific behaviours and contexts (Lehnhoff et al., 2022) or directly to individuals (i.e. signature whistles (Caldwell and Caldwell, 1965)). However, the extraction of whistle contours represents a challenging task, for which a variety of automated methods have been developed (e.g. using modelling (Halkias and Ellis, 2006; Roch et al., 2011), pitch-tracking (Baumgartner and Mussoline, 2011), or deep learning (Conant et al., 2022; Li et al., 2023) techniques).

We used a semi-automated method (Lehnhoff et al., in review.a) to annotate the contour of whistles from audio ~~recording~~ recordings made using the IcListen hydrophone. The spectrograms used for the annotations were generated using the following parameters: 96,000 Hz sampling rate, 1024 samples (11 ms) frame size, 512 samples (5 ms) hop length, on a linear frequency scale. These annotations were then manually verified and corrected using PyAVA (Lehnhoff, 2022), a custom-made annotation tool for whistle contours. These results are made available as .json files in the **Whistle_annotations** ~~in~~ folder within the dataset.

3.4 Other data

A **README.md** file is available in the parent folder of the dataset and describes the structure of the dataset, with usage notes and links to academic papers produced using its data.

The **Tetra\Hydro_coordinates** folder contains the .csv files giving the measured coordinates of the 4 hydrophones of the tetrahedral antenna in 2021 and 2022. These coordinates are needed to determine the angle of arrival of the signals detected using the hydrophones.

4 Results & output data

Some analyses were already conducted on this dataset and are published/in review/submitted in 3 different scientific papers. These papers show an increase in the acoustic activity of common dolphins in response to the DOLPHINFREE bio-inspired acoustic signal (Lehnhoff et al., 2022), characterize the features of whistles (Lehnhoff et al., in review.a) and identify signature whistles in the whistling repertoire of these animals (Lehnhoff et al., in review.b). However, it should be noted that the dataset made available here is slightly different than the one used in our previous analyses (due to the exclusion of audio recordings containing DOLPHINFREE signals).

From these works, the technical quality of the dataset is supported by manual and automatic detections of dolphins signals in audio recordings. A standard Teager-Kaiser click detector coupled with a data projection to exclude false positive detections (Lehnhoff et al., 2022) was used to confirm the presence of echolocation clicks in most files. A semi-automatic detector of whistles was also applied to extract contour coordinates of whistles (Lehnhoff et al., in review.a) with a manual validation of the detections. In total, we confirm the presence of about 68,000 echolocation clicks, 4,600 whistles and 350 pulsed sounds in the provided audio data recorded with the icListen hydrophone (Lehnhoff et al., 2022, in review.a).

The distribution of dolphin signals across the recordings is quite heterogenous. Figure 5 showcases the different signals that can be found in the audio files made available. In addition, we show the magnitude spectrum of a sample of echolocation clicks recorded by the icListen hydrophone at 512 kHz, revealing the broadband nature of these clicks (see Fig 6).
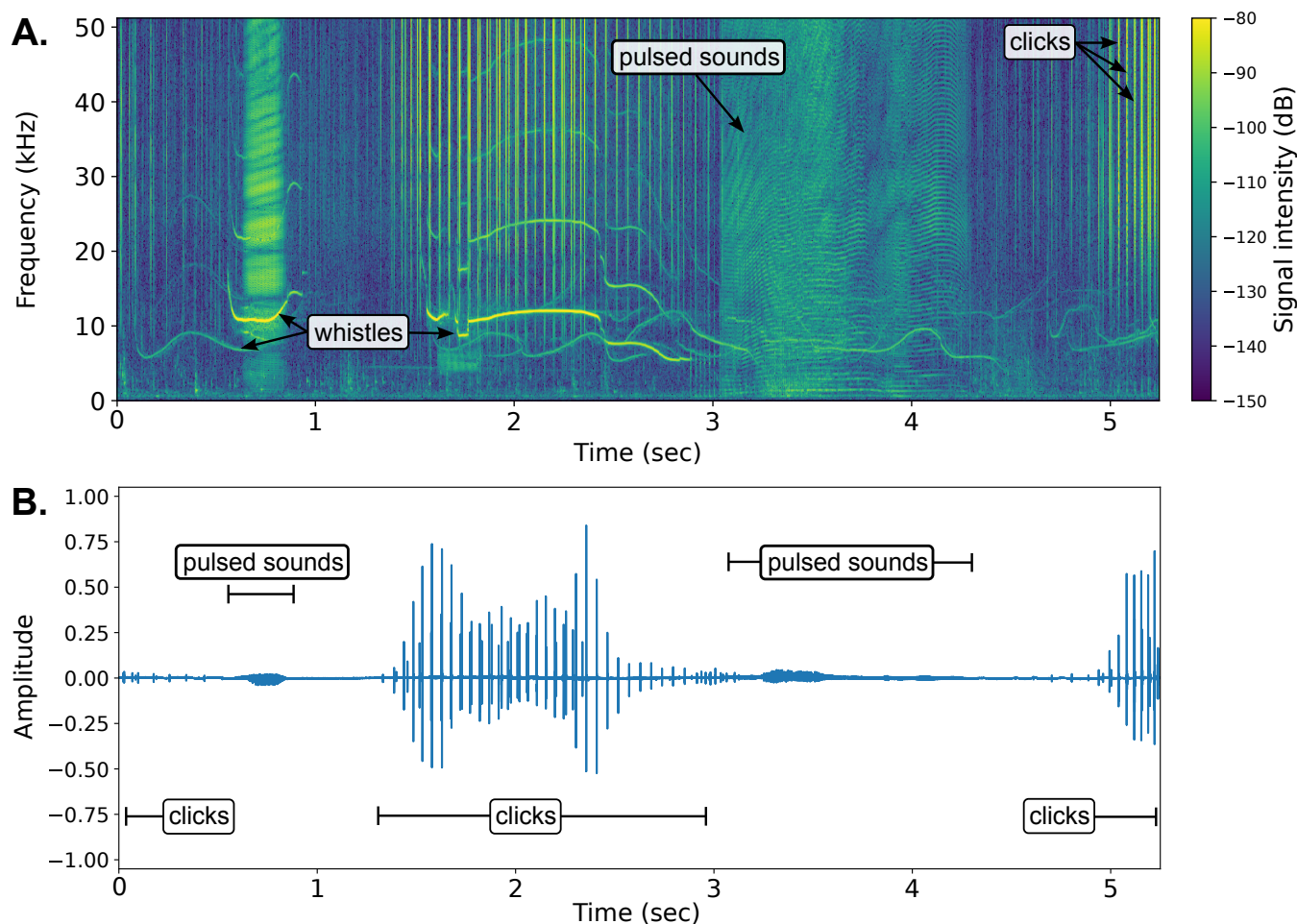
Figure 5. Spectrogram (**A**) and waveform (**B**) extracted from audio recording "SCW1807_20200713_064400.wav".

(A) Arrows point to representative signals. B Segments show the timespan of click-like sounds. The annotations indicate only some of the signals emitted by short-beaked common dolphins that are visible on the spectrogram.
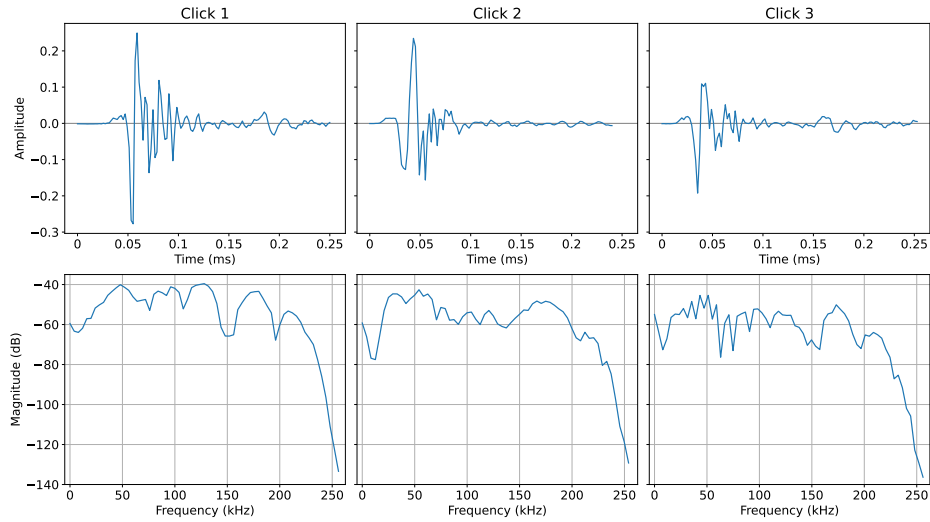
Figure 6. Waveforms and magnitude spectrums of 3 echolocation clicks selected randomly in audio file "SCW1807_20200713_064400.wav".

4.1 2D localisation

TETRA's recordings (4 channels, see Figure 7) can be used to determine the time difference of arrival (TDoA) of echolocation clicks to the hydrophones of the antenna, also enabling the estimation of the angle of arrival (AoA) of those clicks. A validation
225   sequence, to evaluate the errors made in the estimation of the AoAs, was conducted. DOLPHINFREE signals were emitted from the boat and recorded by the TETRA antenna at different angles around it.
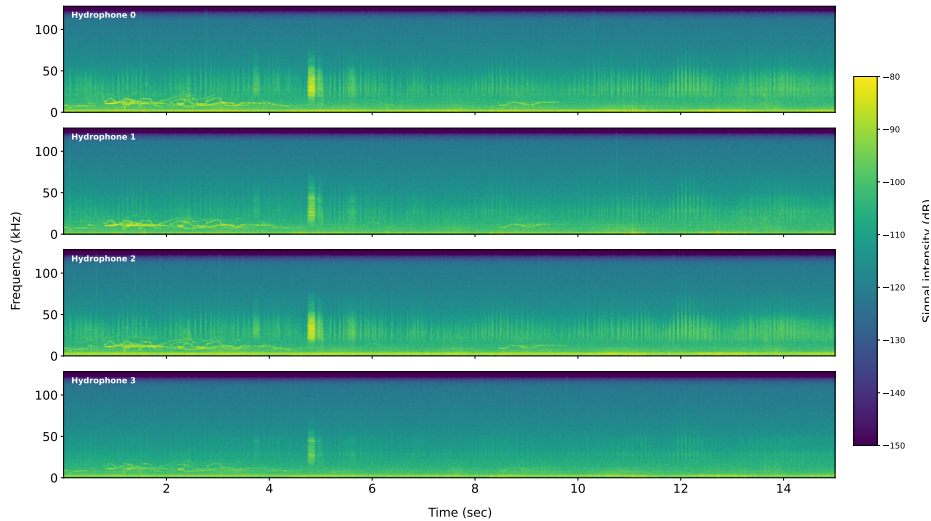
Figure 7. Spectrogram extracted from audio recording "20210709_135634UTC+2_V12.wav" collected with the TETRA antenna. Hydrophone 0 is a CR3, other hydrophones are SQ26.

The position of the antenna relative to the observation boat was determined by two GPS devices: one located on the observation boat and the other attached to the TETRA antenna buoy. Then, using the audio recordings, the DOLPHINFREE signals were used to estimate AoAs from TDoAs. A comparison of the values estimated by these two methods is shown in Fig. 8. It highlights that there are only a few deviations in the estimation of AoAs using TETRA, compared to GPS measurements (on average 0.15 radians (8.6°) for the azimuths and 0.08 radians (4.4°) for the elevation angles). However, since calibrations were made by recording the DOLPHINFREE signal, the corresponding audio recordings are not publicly available.
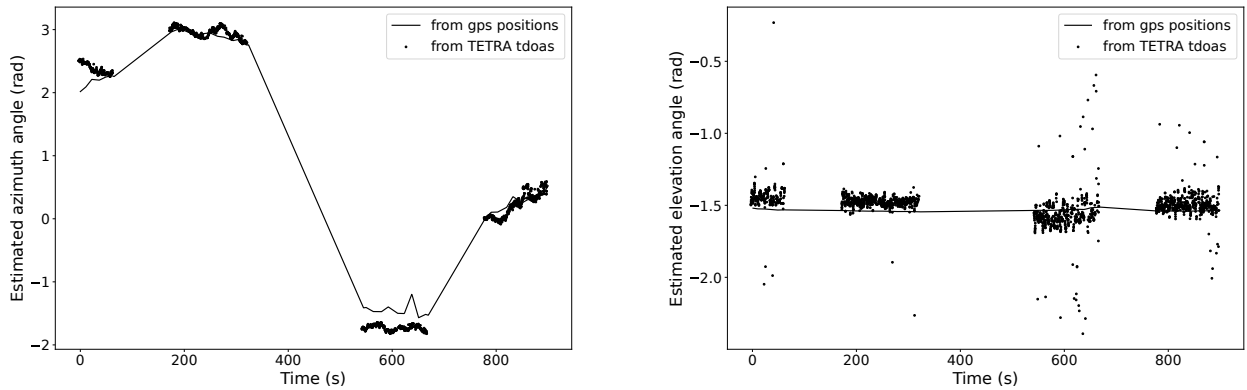
Figure 8. Angular comparison of azimuths (left) and elevation (right) between GPS references and TETRA estimates during a calibration experiment. *The emitter's elevation is interpolated from the immersion depth of the TETRA antenna.*

4.2 Whistle contours

Whistle contours were determined using DYOC (Lehnhoff et al., in review.a), a deep learning tool made for whistle contour annotation and developed using parts of this dataset. Then, contours were manually cleaned using PyAVA, a custom-made annotation tool in Python. An example of the results is shown in Fig. 9.

In total, 4,637 annotated whistle contours were verified and are provided as .json files (dictionaries) with the audio recordings. In each file, different keys correspond to different whistle contours, with points represented as lists of time-frequency coordinates. This dataset provides ground truths that could be used to study short-beaked common dolphin whistle repertoire, and to train and/or test performances of models for the extraction of whistle contours.
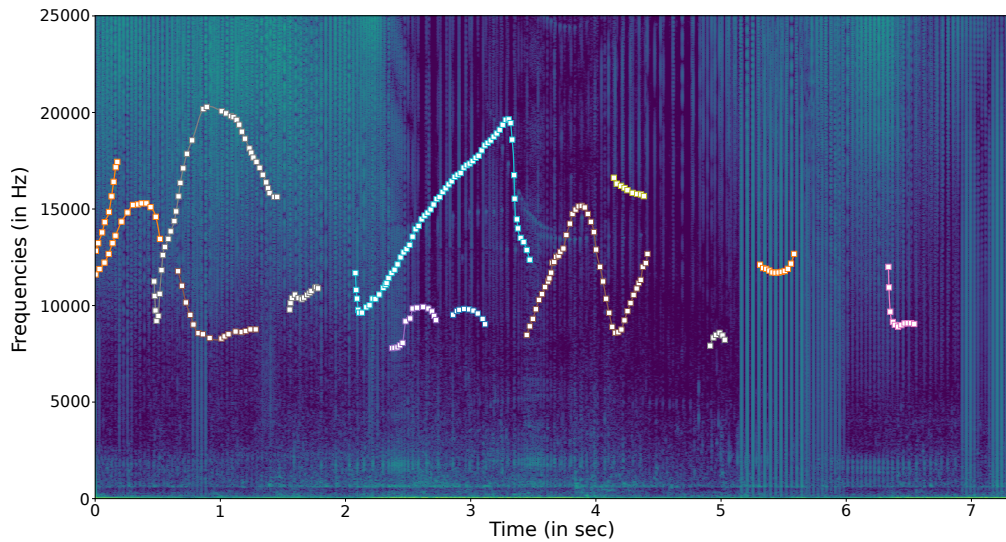
Figure 9. Screenshot showing whistle contour annotations of audio file "SCW1807_20200712_090400.wav".

5 Conclusions

Overall, this open-access dataset is the first to provide high-quality recordings of free-ranging short-beaked common dolphins (*Delphinus delphis*) ~~in various~~ across multiple observed behavioural states. ~~The size of this dataset is substantial, with~~ It comprises over 400 minutes of acoustic ~~recordings of~~ data collected from wild animals at sea, ~~containing about~~ including approximately 68,000 echolocation clicks, 4,600 whistles, and 350 pulsed sounds. The combination of recordings made from a single hydrophone and a tetrahedral array of hydrophones, along with detailed behavioural ~~observations and manual whistle annotations , enables diverse research applications including~~ annotations and manually validated whistles, offers a rich resource for acoustic repertoire analysis, behavioural ~~studies~~ research, and sound source localisation. ~~Future work could leverage this data to better understand the relationship between dolphin vocalizations~~

This dataset represents a significant step forward in documenting and understanding the etho-acoustics and ecology of a widely distributed but understudied species. By providing both contextual behavioural data and high-resolution acoustic recordings, the dataset can support a wide range of future research, including investigations into the links between vocalisations and specific behaviours, ~~improve automated whistle detection~~ development of automated detection and classification tools, and comparative studies across species and habitats. Ultimately, this dataset has the potential to enhance passive acoustic monitoring techniques, and ~~advance our knowledge of dolphin communication systemsin general~~deepen our understanding of cetacean communication systems.

Code and data availability. Data described in this manuscript can be accessed at zenodo.org/records/14637675 under data DOI: 10.5281/zenodo.14637674 (Lehnhoff, 2025). Reuse of this dataset is facilitated by several scripts available at gitlab.lis-lab.fr/dolphinfree-experiments.

Appendix A: Observation table

260 Visual observations were written down by observers on board using the following table document (Fig. A1).

Date :   Observation plateform :   Observers :

TIME	GROUP	SEQUENCE	PINGER		NET	GENERAL BEHAVIOUR					INT.	SPECIFIC BEHAVIOUR					DIST.	NUM.	SPACE	DIR.	SPEED	DIVE TIME	BOATS	NOTES
HH:MM	# ID	# seq	pinger 1: pre- (off) 2: on 3 : post-	type	Orientat-ion	Yes (1) No (0)	Travel. %	Forag. %	Soc. %	Mill. %	Attrac. %	Response intensity to pinger 0, 1, 2	Simult. surfacing %	Active surfacing %	Blows %	Dive %	Others (Jump, Lobtail, Spyhopping) %	Observers to dolphin group (m)	Number of dolphins in group	Group spacing: Compact. Scattered	Direction of the group: Variable Continuous	Slow (<10 kt) Fast (>10 kt)	Std. <2 min Variable Long >2 min	Number of boats present in a 1 NM radius	**Additional observations** (including sudden change in direction, speed and/or dive time, etc.). Start/End time of pinger transmission; hydrophone launch.

Figure A1. Document used to record visual observations during surveys.

Appendix B: Technical details

B1 Fishing nets

During the DOLPHINFREE surveys, 4 nets were utilised to mimic the setting of fishing net underwater by professional fishermen. They were all set from the surface and weighted with lead weights. These nets are described in Table B1.

Name	Net type	Material	Mesh size	Net Size (H x W)
trammel	monkfish trammel net	nylon	220 mm	2 x 4 m
white_trawl	trawl netting	reinforced nylon	12 mm	2 x 4 m
green_trawl	trawl netting	polyethylene	40 mm	2 x 4 m
large_net	entangling net	nylon	136 mm	3 x 20 m

Table B1. Description of the fishing nets used during the DOLPHINFREE surveys.

265 B2 icListen HF Hydrophone

The icListen HF Hydrophone is produced by ©Ocean Sonics. Its specifications are available on their website (link). In the following figures, we report the hydrophone specifications provided by the manufacturer.
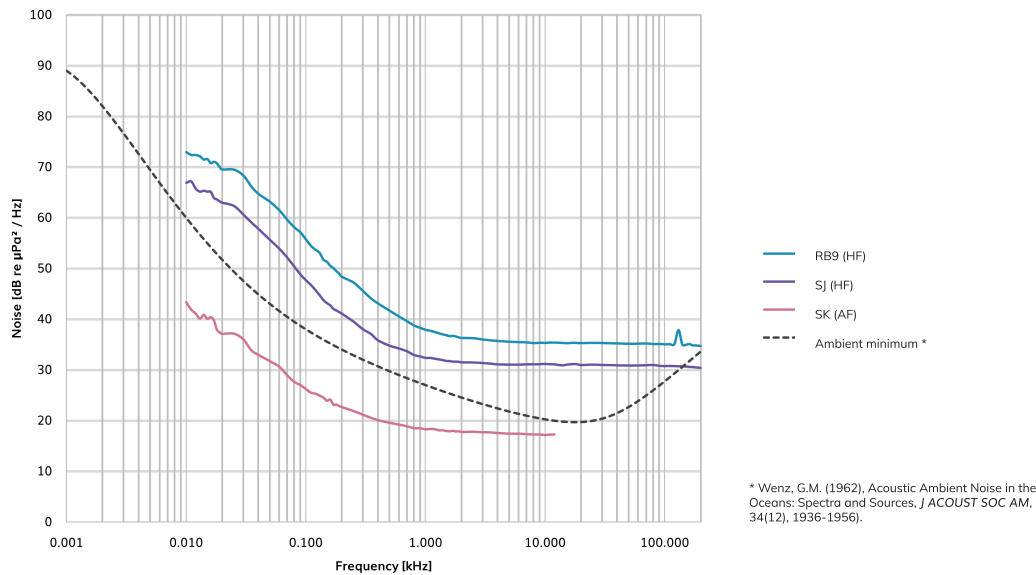
Figure B1. Noise spectrum levels of different iclisten HF hydrophones, provided by ©Ocean Sonics.
The model SJ (purple) was the one used in this study.

	SJ	RB	SK	Units
SIGNAL PERFORMANCE				
Low Frequency Cutoff	10	10	10	Hz
±3 dB Bandwidth	200	200	12.8	kHz
Usable Bandwidth	200	200	12.8	kHz
Maximum Data Sample Rate	512	512	32	ksps
Minimum Data Sample Rate	1	1	1	ksps
Resolution	24	24	24	bits
Minimum Self Noise	32	36	17	dB re µPa²/Hz
Peak Input Level (µPa)	180	184	168	dB re µPa
Peak Input Level (Volts)	6	6	6	dBV
Voltage Sensitivity	-173	-177	-162	dB re V/µPa

Figure B2. Signal performance table of different iclisten HF hydrophones, provided by ©Ocean Sonics.

The model SJ (purple) was the one used in this study.

B3   CR3 hydrophone

The CR3 hydrophone is produced by Cetacean Research™. Its specifications are available on their website (link). In the
270   following figures and tables, we report the hydrophone specifications provided by the manufacturer.
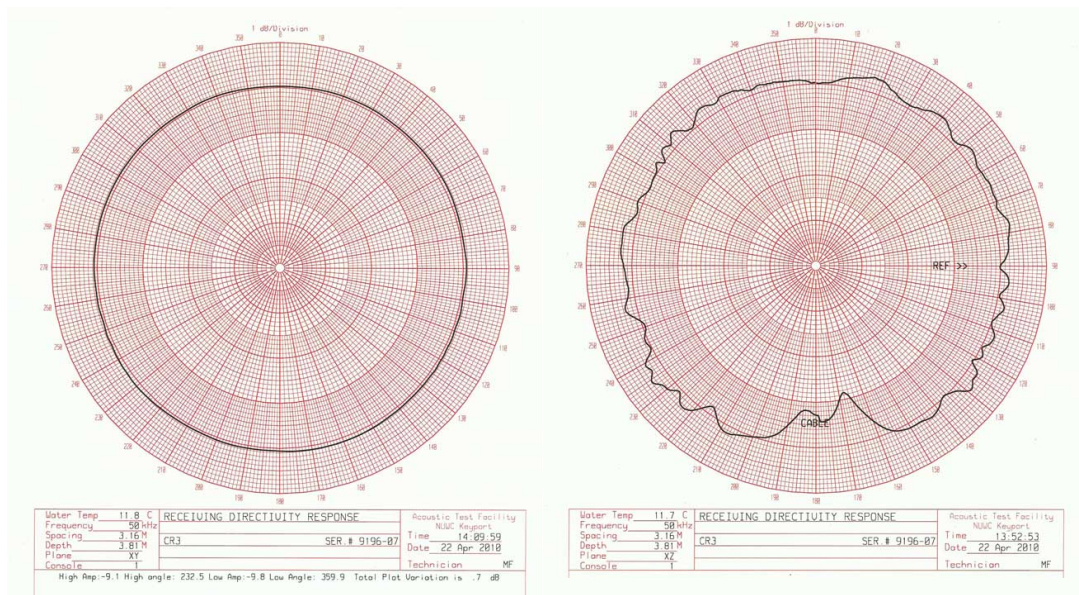
Figure B3. Horizontal (left) and vertical (right) beam pattern of the CR3 hydrophone, provided by Cetacean Research™.
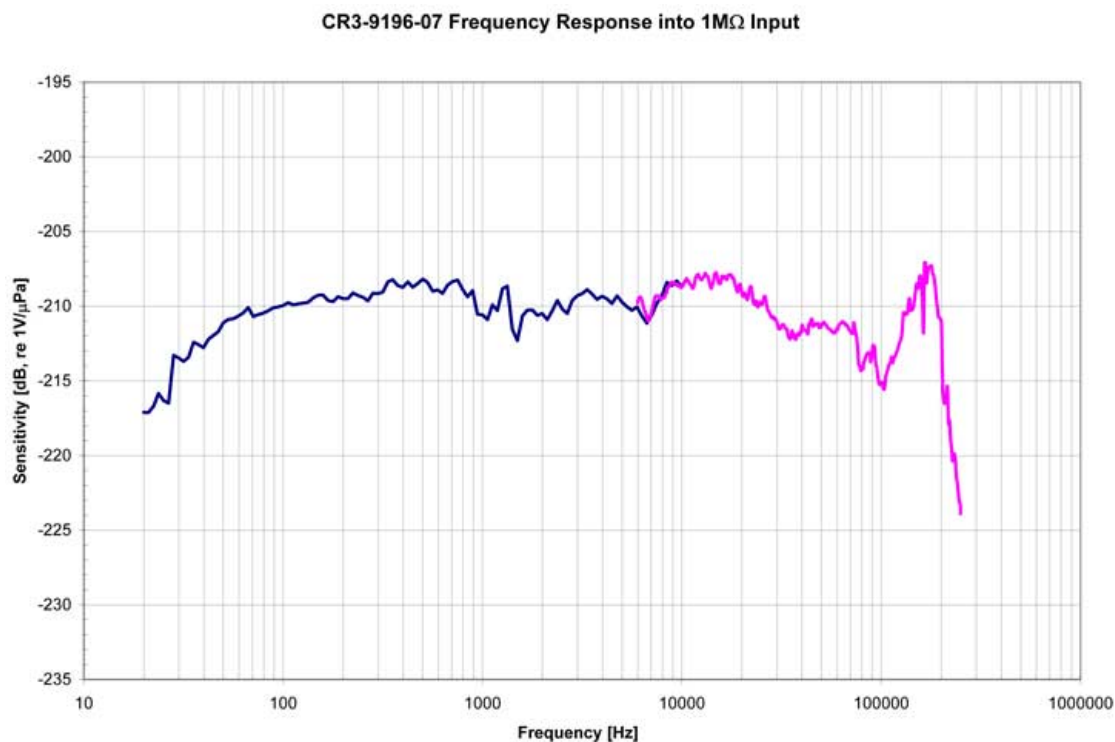
Figure B4. Frequency response of the CR3 hydrophone, provided by Cetacean Research™.

Parameter	value
Linear Frequency Range ($\pm$3dB)	0.0004 to 180 kHz
Usable Frequency Range (+3/-12dB)	0.0001 to 240 kHz
Transducer Sensitivity	-207 dB re 1V/μPa
SPL Equiv. Self Noise at 1kHz	54 dB re 1μPa/$\sqrt{}$Hz
Maximum Operating Depth	980 m
Operating Temperature Range	-40 to 90 °C
Capacitance	6.7 nF
Dimensions	50 mm L x 18 mm dia

Table B2. CR3 hydrophone specifications, provided by Cetacean Research™.

B4 SQ26 Hydrophone

The SQ26 hydrophone is produced by Cetacean Research™. Its specifications are available on their website (link). In the following figures and tables, we report the hydrophone specifications provided by the manufacturer.
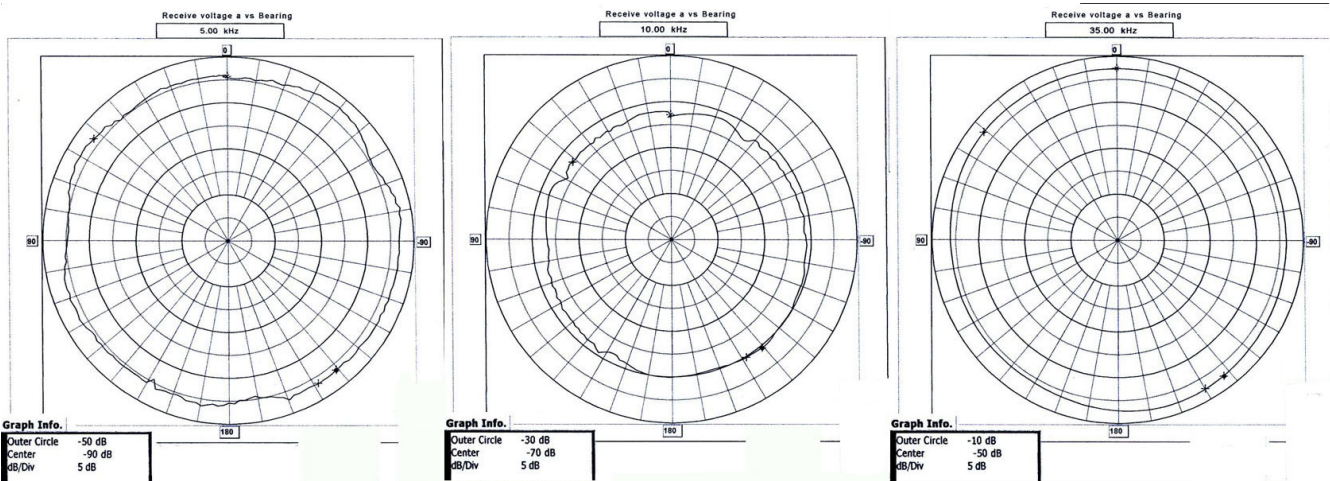
Figure B5. Horizontal beam pattern at 5 kHz (left), 10 kHz (centre), and 35 kHz (left) of the SQ26 hydrophone, provided by Cetacean Research™.
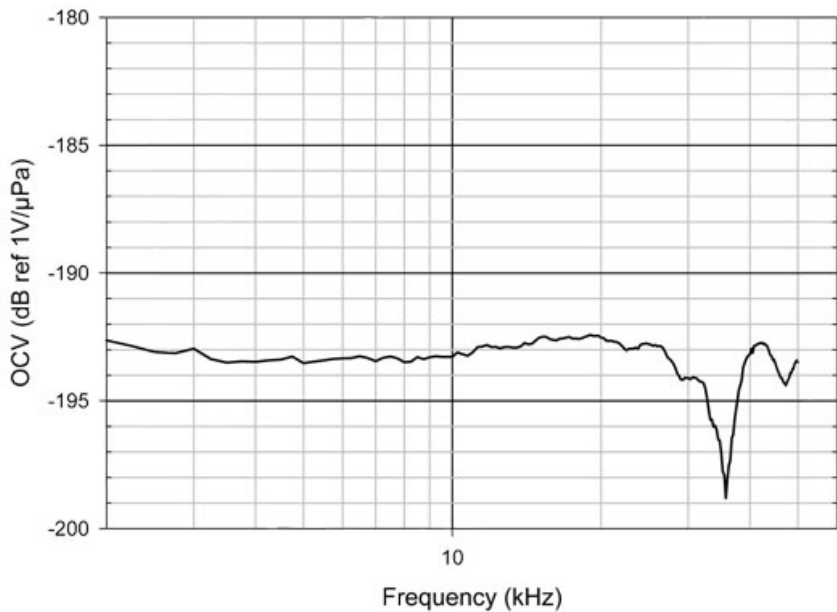
Figure B6. Frequency response of the SQ26 hydrophone, provided by Cetacean Research™.

Parameter	value
Linear Frequency Range ($\pm$1dB)	0.001 to 28 kHz
Usable Frequency Range (+3/-12dB)	0.001 to $>$ 50 kHz
Transducer Sensitivity	-193.5 dB re 1V/μPa
SPL Equiv. Self Noise at 1kHz	54 dB re 1μPa/$\sqrt{}$Hz
Maximum Operating Depth	down to 2,000 m
Operating Temperature Range	-30 to 60 °C
Capacitance	1.4 nF
Dimensions	25.4 mm L x 25.4 mm dia

Table B3. SQ26 hydrophone specifications, provided by Cetacean Research™.

Author contributions. Conceptualisation: B.M., H.G. and L.L.; methodology: B.M., H.G., L.L., Y.L.G., E.M. and O.V.C.; TETRA design: H.G.; Code, formal analysis: L.L., H.G. and B.M.; validation, supervision: B.M. and H.G.; data curation: B.M. and L.L; writing—original draft preparation: L.L.; figures: L.L. and O.V.C.; data acquisition, writing—review and editing: all authors; project administration: B.M.; project funding acquisition: B.M. and H.G. All authors reviewed the manuscript.

Competing interests. The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, nor in the decision to publish the results. The decision to publish only a part of the collected data was prompted by the presence of signals protected by intellectual property.

Disclaimer. The DOLPHINFREE project has been approved by agreement 0-12520-2021/PREMAR_ATLANT/AEM/NP from the French Maritime Prefecture of the Atlantic "to conduct a survey for monitoring groups of common dolphins by means of scientific instruments off the south Finistère coast, following Décret n°2017-956 of the scientific marine research". The DOLPHINFREE project obtained a favourable opinion from the Ethical Committee for Animal Experimentation of Languedoc Roussillon (CEEA-LR) for request #26568.

Acknowledgements. We thank Paul Best, Sophie Boyer and Eleonore Meheust for their assistance in collecting some of the data made available with this paper. We thank Michael Paul for improving the English of the paper.

References

Agafonov, A. V., Melnikova, P. K., Panova, E. M., Logominova, I. V., and Litvin, V. A.: Whistles in the Vocal Repertoire of Bottlenose Dolphins (Tursiops truncatus Montagu, 1821) and Common Dolphins (Delphinus delphis Linnaeus, 1758), Oceanology, 64, 421–434, https://doi.org/10.1134/S0001437024700097, 2024.

Ansmann, I. C., Goold, J. C., Evans, P. G., Simmonds, M., and Keith, S. G.: Variation in the whistle characteristics of short-beaked common dolphins, *Delphinus delphis* , at two locations around the British Isles, Journal of the Marine Biological Association of the United Kingdom, 87, 19–26, https://doi.org/10.1017/S0025315407054963, 2007.

Au, W. W. and Hastings, M. C.: Emission of Social Sounds by Marine Animals, pp. 401–499, Springer US, ISBN 978-0-387-78364-2 978-0-387-78365-9, https://doi.org/10.1007/978-0-387-78365-9_10, 2008.

Au, W. W. L.: The Sonar of Dolphins, Springer New York, New York, NY, ISBN 978-1-4612-4356-4, https://doi.org/10.1007/978-1-4612-4356-4, 1993.

Barchasz, V., Gies, V., Marzetti, S., and Glotin, H.: JASON High Blue ultra high velocity recording : a big data Carabian biodiversity survey, in: e-Forum Acusticum 2020, pp. 3217–3224, Lyon, France, https://doi.org/10.48465/fa.2020.0875, 2020.

Baumgartner, M. F. and Mussoline, S. E.: A generalized baleen whale call detection and classification system, The Journal of the Acoustical Society of America, 129, 2889–2902, https://doi.org/10.1121/1.3562166, 2011.

Berg Soto, A., Cagnazzi, D., Everingham, Y., Parra, G., Noad, M., and Marsh, H.: Acoustic alarms elicit only subtle responses in the behaviour of tropical coastal dolphins in Queensland, Australia, Endangered Species Research, 20, 271–282, https://doi.org/10.3354/esr00495, 2013.

Branstetter, B. K., Moore, P. W., Finneran, J. J., Tormey, M. N., and Aihara, H.: Directional properties of bottlenose dolphin (*Tursiops truncatus*) clicks, burst-pulse, and whistle sounds, The Journal of the Acoustical Society of America, 131, 1613–1621, https://doi.org/10.1121/1.3676694, 2012.

Caldwell, M. C. and Caldwell, D. K.: Individualized Whistle Contours in Bottle-nosed Dolphins (Tursiops truncatus), Nature, 207, 434–435, https://doi.org/10.1038/207434a0, 1965.

Caldwell, M. C. and Caldwell, D. K.: Vocalization of Naive Captive Dolphins in Small Groups, Science, 159, 1121–1123, https://doi.org/10.1126/science.159.3819.1121, 1968.

Conant, P. C., Li, P., Liu, X., Klinck, H., Fleishman, E., Gillespie, D., Nosal, E.-M., and Roch, M. A.: *Silbido profundo* : An open source package for the use of deep learning to detect odontocete whistles, The Journal of the Acoustical Society of America, 152, 3800–3808, https://doi.org/10.1121/10.0016631, 2022.

Cones, S., Dent, M., Walkes, S., Bocconcelli, A., DeWind, C., Arjasbi, K., Rose, K., Silva, T., and Sayigh, L.: Probable signature whistle production in Atlantic white-sided (*Lagenorhynchus acutus*) and short-beaked common (*Delphinus delphis*) dolphins near Cape Cod, Massachusetts, Marine Mammal Science, 39, 338–344, https://doi.org/10.1111/mms.12976, 2023.

Di Nardo, F., De Marco, R., Alessandro, L., and Scaradozzi, D.: A WAV file dataset of bottlenose dolphin whistles, clicks, and pulse sounds during trawling interactions, Scientific Data, 10, https://doi.org/https://doi.org/10.1038/s41597-023-02547-8, 2023.

Fearey, J., Elwen, S. H., James, B. S., and Gridley, T.: Identification of potential signature whistles from free-ranging common dolphins (Delphinus delphis) in South Africa, Animal Cognition, 22, 777–789, https://doi.org/10.1007/s10071-019-01274-1, 2019.

Filby, N. E., Bossley, M., and Stockin, K. A.: Behaviour of free-ranging short-beaked common dolphins (Delphinus delphis) in Gulf St Vincent, South Australia, Australian Journal of Zoology, 61, 291, https://doi.org/10.1071/ZO12033, 2013.

Glotin, H., Girardet, J., Prévot, J.-M., Sarano, F., Sarano, V., Giraudet, P., Gies, V., d'Alvise, N. P., Ferrari, M., Poupard, M., Dunning, K., Patenotre, G., Chavin, S., Priou, P., Guiderdoni, J., Tanneau, R., Camus, L., and Chami, M.: Seconde exploration bioacoustique en fjord arctique: mise en évidence de chorus inédits de quatre superprédateurs & étude de leurs interactions, Tech. rep., University of toulon, CIAN ; Laboratoire d'informatique et des Systèmes - LIS (UMR 7020), https://mnhn.hal.science/mnhn-04785408, 2024.

Halkias, X. C. and Ellis, D. P.: Call detection and extraction using Bayesian inference, Applied Acoustics, 67, 1164–1174, https://doi.org/10.1016/j.apacoust.2006.05.006, 2006.

Halkias, X. C., Paris, S., and Glotin, H.: Classification of mysticete sounds using machine learning techniques, The Journal of the Acoustical Society of America, 134, 3496–3505, https://doi.org/10.1121/1.4821203, 2013.

Henderson, E. E., Hildebrand, J. A., Smith, M. H., and Falcone, E. A.: The behavioral context of common dolphin (Delphinus sp.) vocalizations, Marine Mammal Science, 28, 439–460, https://doi.org/https://doi.org/10.1111/j.1748-7692.2011.00498.x, 2012.

Herman, L. M. and Tavolga, W. N.: Cetacean Behavior: Mechanisms and Functions., chap. The communication systems of cetaceans., pp. 149–209, NY: Wiley & Sons, Inc., 1980.

Jones, B., Zapetis, M., Samuelson, M. M., and Ridgway, S.: Sounds produced by bottlenose dolphins (*Tursiops*): a review of the defining characteristics and acoustic criteria of the dolphin vocal repertoire, Bioacoustics, 29, 399–440, https://doi.org/10.1080/09524622.2019.1613265, 2020.

Lammers, M. O. and Au, W. W. L.: DIRECTIONALITY IN THE WHISTLES OF HAWAIIAN SPINNER DOLPHINS (*STENELLA LONGIROSTRIS*): A SIGNAL FEATURE TO CUE DIRECTION OF MOVEMENT?, Marine Mammal Science, 19, 249–264, https://doi.org/10.1111/j.1748-7692.2003.tb01107.x, 2003.

Lammers, M. O., Schotten, M., and Au, W. W. L.: The spatial context of free-ranging Hawaiian spinner dolphins (*Stenella longirostris*) producing acoustic signals, The Journal of the Acoustical Society of America, 119, 1244–1250, https://doi.org/10.1121/1.2151804, 2006.

Lehnhoff, L.: PyAVA : Python interface for the Annotation of Vocalisations in Audio recordings, https://gitlab.lis-lab.fr/loic.lehnhoff/PyAVA, 2022.

Lehnhoff, L.: A dataset of acoustic recordings of wild free-ranging short-beaked common dolphins, https://doi.org/10.5281/ZENODO.14637674, 2025.

Lehnhoff, L., Glotin, H., Bernard, S., Dabin, W., Le Gall, Y., Menut, E., Meheust, E., Peltier, H., Pochat, A., Pochat, K., Rimaud, T., Sourget, Q., Spitz, J., Van Canneyt, O., and Mérigot, B.: Behavioural Responses of Common Dolphins Delphinus delphis to a Bio-Inspired Acoustic Device for Limiting Fishery By-Catch, Sustainability, 14, 13 186, https://doi.org/10.3390/su142013186, 2022.

Lehnhoff, L., Glotin, H., Le Gall, Y., Menut, E., Meheust, E., Peltier, H., Pochat, A., Pochat, K., Spitz, J., Van Canneyt, O., and Mérigot, B.: Characterisation of whistles using artificial intelligence: responses of short-beaked common dolphins *Delphinus delphis* to a bio-inspired acoustic mitigation device, Scientific Reports, https://doi.org/10.21203/rs.3.rs-5234650/v1, in review.a.

Lehnhoff, L., Glotin, H., Le Gall, Y., Menut, E., Peltier, H., Spitz, J., and Mérigot, B.: Signature whistles of free-ranging \textit{Delphinus delphis} and responses to a bio-inspired acoustic beacon for by-catch mitigation, Philosophical Transactions of the Royal Society B: Biological Sciences, in review.b.

Li, P., Liu, X., Klinck, H., Gruden, P., and Roch, M. A.: Using deep learning to track time × frequency whistle contours of toothed whales without human-annotated training data, The Journal of the Acoustical Society of America, 154, 502–517, https://doi.org/10.1121/10.0020274, 2023.

Martin, M. J., Elwen, S. H., Kassanjee, R., and Gridley, T.: To buzz or burst-pulse? The functional role of Heaviside's dolphin, Cephalorhynchus heavisidii, rapidly pulsed signals, Animal Behaviour, 150, 273–284, https://doi.org/10.1016/j.anbehav.2019.01.007, 2019.

Murray, S. O., Mercado, E., and Roitblat, H. L.: Characterizing the graded structure of false killer whale (Pseudorca crassidens) vocalizations, The Journal of the Acoustical Society of America, 104, 1679–1688, https://doi.org/10.1121/1.424380, 1998.

Norris, K. S., Prescott, J. H., Asa-Dorian, P. V., and Perkins, P.: An experimental demonstration of echolocation behaviour in the porpoise, *Tursiops truncatus* (Montagu), The Biological Bulletin, 120, 163–176, https://doi.org/10.2307/1539374, 1961.

Overstrom, N. A.: Association between burst-pulse sounds and aggressive behavior in captive Atlantic bottlenosed dolphins (Tursiops truncatus), Zoo Biology, 2, 93–103, https://doi.org/10.1002/zoo.1430020203, 1983.

Pagliani, B., Amorim, T. O. S., Castro, F. R. D., and and, A. A.: Intraspecific variation in short-beaked common dolphin's whistle repertoire, Bioacoustics, 31, 1–16, https://doi.org/10.1080/09524622.2020.1858449, 2022.

Peltier, H., Authier, M., Dabin, W., Dars, C., Demaret, F., Doremus, G., Canneyt, O. V., Laran, S., Mendez-Fernandez, P., Spitz, J., Daniel, P., and Ridoux, V.: Can modelling the drift of bycaught dolphin stranded carcasses help identify involved fisheries? An exploratory study, Global Ecology and Conservation, 21, e00 843, https://doi.org/10.1016/j.gecco.2019.e00843, 2020.

Poupard, M., Ferrari, M., Schluter, J., Marxer, R., Giraudet, P., Barchasz, V., Gies, V., Pavan, G., and Glotin, H.: Real-time Passive Acoustic 3D Tracking of Deep Diving Cetacean by Small Non-uniform Mobile Surface Antenna, in: ICASSP 2019 - 2019 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP), pp. 8251–8255, IEEE, Brighton, United Kingdom, ISBN 978-1-4799-8131-1, https://doi.org/10.1109/ICASSP.2019.8683883, 2019.

Ridgway, S., Samuelson, D., Van Alstyne, K., and Price, D.: On doing two things at once: dolphin brain and nose coordinate sonar clicks, buzzes, and emotional squeals with social sounds during fish capture, Journal of Experimental Biology, pp. 3987–3995, https://doi.org/10.1242/jeb.130559, 2015.

Roch, M. A., Scott Brandes, T., Patel, B., Barkley, Y., Baumann-Pickering, S., and Soldevilla, M. S.: Automated extraction of odontocete whistle contours, The Journal of the Acoustical Society of America, 130, 2212–2223, https://doi.org/10.1121/1.3624821, 2011.

Sayigh, L. S.: Sayigh, Laela Suad. Development and functions of signature whistles of free-ranging bottlenose dolphins, Tursiops truncatus., phdthesis, Massachusetts Institute of Technology, https://dspace.mit.edu/bitstream/handle/1721.1/12900/27832240-MIT.pdf?sequence=2, 1992.

Shane, S. H.: Behavior and Ecology of the Bottlenose Dolphin at Sanibel Island, Florida, in: The Bottlenose Dolphin, pp. 245–265, Elsevier, ISBN 978-0-12-440280-5, https://doi.org/10.1016/B978-0-12-440280-5.50016-0, 1990.

Stockin, K., Lusseau, D., Binedell, V., Wiseman, N., and Orams, M.: Tourism affects the behavioural budget of the common dolphin Delphinus sp. in the Hauraki Gulf, New Zealand, Marine Ecology Progress Series, 355, 287–295, https://doi.org/10.3354/meps07386, 2008.

Tyack, P.: Population biology, social behavior and communication in whales and dolphins, Trends in Ecology & Evolution, 1, 144–150, https://doi.org/10.1016/0169-5347(86)90042-X, 1986.

Van Canneyt, O., Larnaud, P., Le Gall, Y., and Morizur, Y.: Effets des dispositifs de dissuasion acoustiques sur le comportement du dauphin commun, Delphinus delphis, Rapport CRMM de mission, contrat IFREMER 2005 2 22734206, Observatoire Pelagis, 2006.

Wisniewska, D. M., Johnson, M., Nachtigall, P. E., and Madsen, P. T.: Buzzing during biosonar-based interception of prey in the delphinids *Tursiops truncatus* and *Pseudorca crassidens*, Journal of Experimental Biology, pp. 4279–4282, https://doi.org/10.1242/jeb.113415, 2014.