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A pilot study in the Dutch Oosterschelde

Author(s): Jip Vrooman, Benoît Bergès

Wageningen University & Research report C016/22

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Contents

Summary

The aim of this pilot project is to investigate whether and how harbour porpoise clicks can help us to identify the presence of calves. This would be a first step to developing detection methods applicable to hydrophone data that can identify behaviours and/or calf presence. A method was developed and experimented to record calf clicks, by actively searching for calves on the Oosterschelde and recording their clicks while close. Five field trips were conducted over the summer of 2021.

Finding harbour porpoises was done with the help of Rugvin Foundation and was successful, but finding calves proved a bit harder. Moreover, calves always occur in close vicinity of their mother, so isolated recordings of calves were not made. However, differences in vocalisation characteristics were found in conjunction with sightings with and without calf, but this aspect needs to be validated with more replication. More data is thus necessary for further conclusions.

The Oosterschelde proved a suitable and accessible research area, with a very high chance of harbour porpoise sightings. This is an ideal area for developing, finetuning and replicating scientific methods.

A second goal of the project was to conduct outreach activities, bringing our research and the harbour porpoise a bit closer to the Dutch public. Two short movies were developed about the project, which were well received. Moreover there was an item about the research on the popular radio program 'Vroege Vogels'.

1 Introduction and research question

Underwater microphones (hydrophones) are regularly used to monitor cetaceans. The local Dutch cetacean species, the harbour porpoise (*Phocoena phocoena*), produces very specific high frequency clicks to navigate, hunt and communicate. Stationary hydrophones (passive acoustic monitoring) can be used to provide information on when porpoises are in the area and on how their clicking changes over time (Carlén et al., 2018; Verfuß et al., 2007). This has been especially useful when determining the impact of human activities that can be harmful, such as the noise that is emitted when wind farms are built (Scheidat et al., 2011; Wingfield et al., 2017). Within the Netherlands, large-scale use of passive acoustic monitoring of harbour porpoises has taken place (Brinkkemper et al., 2021; Geelhoed et al., 2018; Scheidat et al., 2011). This data is collected primarily within projects related to the construction and operation of wind farms but not exclusively.

For effective conservation, it is necessary to investigate disruption to specific animal behaviour and to animals in vulnerable life stages, such as calves. However, the implementation of conservation policies is constrained by the ability to analyse passive acoustic data and identify specific behaviour and animal groups. In that context, advances in detection methods are essential.

Harbour porpoise emit Narrow Band High Frequency (NBHF) clicks. Generally, different behaviours can be associated with a different modulation in intervals between clicks (Miller, 2008; Sørensen et al., 2018). For example, when animals approach their prey the click rate changes in a specific way, ending with a "feeding buzz", a phase that exemplifies a distinct sequence of very low intervals between clicks. WMR recently was able to improve the automatic classification of this behaviour (Bergès et al., 2019). This allows us to better assess the impact on populations when they are disrupted, and consequently improves our options for mitigating the threats posed by human activities.

Click characteristics depend on the size of the animal and it is demonstrated that clicks will differ between adults and calves (García, 2016; Li et al., 2007, 2008; Melcón et al., 2015). This would allow the use of stationary hydrophones to identify areas where calves occur regularly as well as monitor any changes in their habitat use. So far it has not been possible to apply this to the data available in Dutch waters.

The aim of this pilot project is to investigate whether and how harbour porpoise clicks can help us to identify the presence of calves. This would be a first step to developing detection methods applicable to hydrophone data that can identify calf presence. The research question is: can we identify the presence of calves based on click patterns and click characteristics? To answer this question we collaborated with Rugvin Foundation[1] to find harbour porpoise calves on the Oosterschelde, and developed a method to collect their click data. A second goal of the project was to conduct outreach activities, bringing our research and the harbour porpoise a bit closer to the Dutch public.

[1] A non-governmental organisation that focuses on the research and monitoring of cetaceans in the North Sea and the Oosterschelde, and on the provision of educational activities. https://rugvin.nl/

2 Materials and Methods

2.1 Data collection

In total five fieldwork trips were organised on the Oosterschelde during the spring and summer months of 2021, in collaboration with Rugvin Foundation. These trips were aimed at finding mother-calf pairs, and, whilst close, recording their clicks with a hydrophone deployed from the boat. Since this was a pilot study, the method developed along the way, generating a final sampling protocol and data sheet in the end.

2.1.1 Location

The Oosterschelde is a semi-closed sea-arm in the south of the Netherlands, covering roughly 350 km^2 and with a depth between 5.60 & 48.80 m (Figure 2-1). Since 1986 it's connection to the North Sea is closed off by the 'Oosterscheldekering', the biggest and most famous of the Dutch Deltaworks. The barrier consists of 42 sluices and can be fully closed in case of high water threat, which happens once a year on average. In the Oosterschelde area there is a resident population of around 50-60 harbour porpoise, as confirmed by PhotoID (Rugvin Foundation, 2020). It is unknown to what extent these animals (are able to) pass the barrier and whether exchange with the North Sea population occurs.

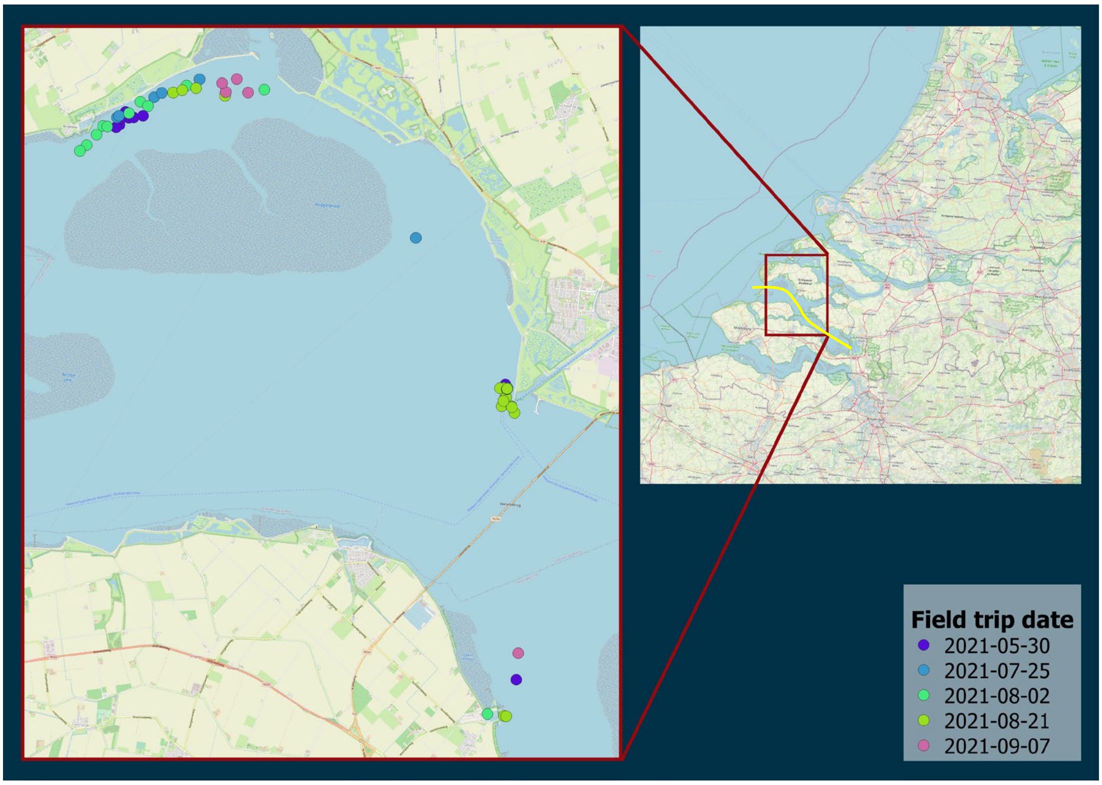

Figure 2-1: Harbour porpoise sighting locations. Yellow line in right pane indicates the Oosterschelde Area.

The fieldwork trips for this study were conducted using one or both of two rigid inflatable boats (RIB), the Scheurrak (owned by WMR) and Zeevarken II (owned by Rugvin Foundation). On board would be a driver and one or more observers. The boats would start in the harbour of Kats, and would then drive to one or several known harbour porpoise hotspots, based on the experience of Rugvin Foundation. These hotspots lay mainly 1) in front of the Kats haven, 2) in front of the pier from Zierikzee and 3) in front of Burghsluis (Figure 2-1). Figure 2-1 depicts the locations in which harbour porpoises were spotted.

2.1.2 Hydrophone

The towed hydrophone was custom made for us by Jonathan Gordon (Marine Ecological Research Ltd, UK). It consisted of a High Frequency Magrec HP03 unit, comprising a spherical ceramic and HP02 preamp, connected by a 50m cable. The sampling rate of the data acquisition was 500 kHz. For further specifics, see Annex 1.

2.1.3 Hydrophone deployment

Once one or more harbour porpoise were in sight, the monitoring was conducted through the following steps (for full protocol including pictures see Annex 2):

1. Boat engine was turned off or stationary
2. The hydrophone was lowered into the water to a depth of about 5 m and secured to the boat
3. A new *GPS waypoint* was marked on the GPS
4. A continuous recording through a Avisoft Soundgate 116H and Avisoft software (Avisoft Bioacoustics e.K, 2021) was started
5. Data entry sheet was filled in, noting various variables such as waypoint, Avisoft recording number, time, weather, number of adult and calf harbour porpoises in sight and their behaviour. For final data entry sheet see Annex 3.
6. A new record was entered to the data sheet every 10 minutes or with every new harbour porpoise (group). A new Avisoft recording was started every 10 minutes to prevent unnecessary large datafiles.
7. If preferable, a small handheld hydrophone that directly transformed the clicks to audible frequencies was lowered into the water to listen 'live'.
8. When the animals were out of sight again (or because of another reason), recording was stopped and the hydrophone was hauled to the boat again.

These steps were repeated for every sighting.

2.2 Data analysis

The data analysis was conducted in four steps:

1. The PAMguard software[2] was used to run a systematic click detection workflow. The workflow is presented in Figure 2-2 and is a classical click detection workflow. The associated click detection parameters are given in Table 2-1 and Table 2-2. The output of this processing resulted in the extraction of click time series and selected metrics.
2. The individual click time series from the PAMguard processing were read and processed individually in MATLAB to compute custom metrics. Both metrics and time series were extracted with time stamps for further analysis. A listing and description of these metrics are given in Table 2-3.
3. Clicks were attributed to one of two categories: 'adults only' or 'adults possibly accompanied by a calf'. Clicks were associated with one of the categories if within 5 minutes of a reported sighting. If sightings of both categories (with or without calves) occurred within the same interval as the clicks, clicks were attributed to both groups.
4. A statistical analysis was conducted using R statistical packages to investigate click characteristics and potential differentiation between calf and adult clicks.

[2] https://www.pamguard.org/

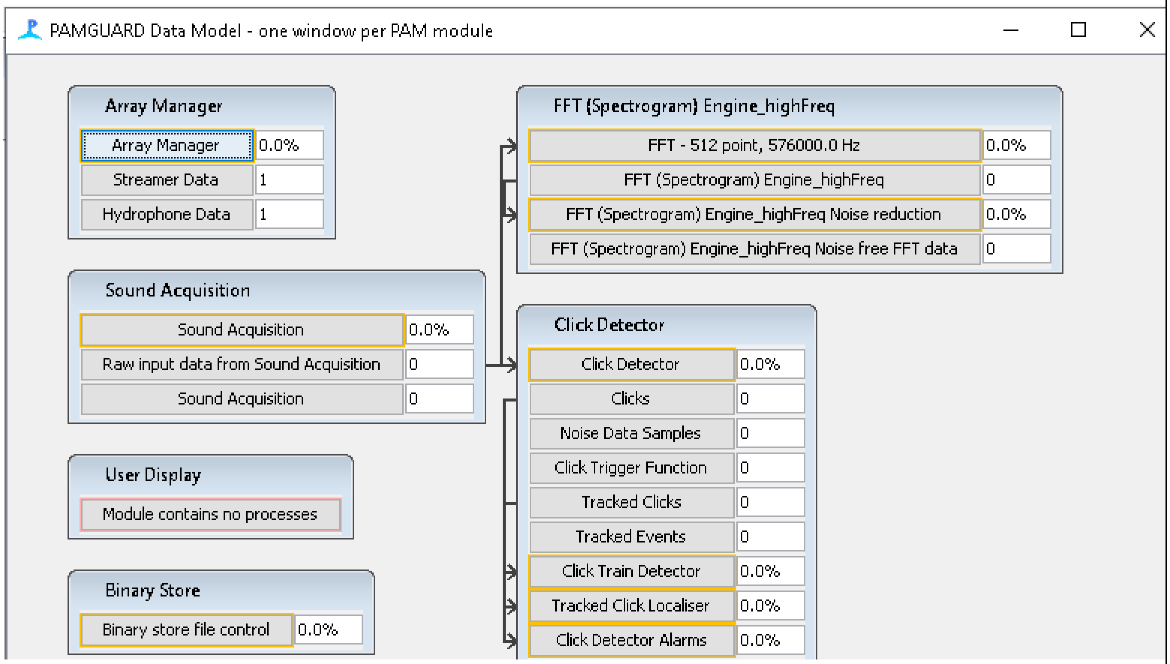

Figure 2-2: PAMguard workflow used for the detection of clicks in the acoustic records.

Table 2-1: Click detection parameters.

Click detection							
Trigger				Click length			
Threshold	Long filter	Long filter 2	Short filter	Min click separation	Max click length	Pre sample	Post sample
15 dB	0.00001	0.00001	0.1	512	256	40	0

Table 2-2: Click classification parameters.

Click classification				
Pre filtering	Click length			Zero crossing
	smoothing	Length range	Threshold	Number of zero crossings
bandpass 80-200 kHz	5	0.1 to 0.9	20 dB	5 to 5000

Table 2-3: List of computed click metrics.

Metric	Description
Duration (95% cumulative energy)	Duration is defined by interval comprising the 95% cumulative energy
Centre frequency	Centroid frequency
Peak frequency	Frequency of maximum energy
Peak SPL	Maximum soup pressure level
Rms SPL	Rms sound pressure level
Occupied bandwidth	Frequency range of 99% occupied bandwidth[3]
Occupied bandwidth upper bound	Upper frequency of 99% occupied bandwidth[3]
Occupied bandwidth lower bound	Lower frequency of 99% occupied bandwidth[3]
Occupied bandwidth power	Power within 99% occupied bandwidth[1]
10dB bandwidth	Frequency range of 10 dB bandwidth

[3] The occupied bandwidth is the difference in frequency between the points where the integrated power crosses 0.5% and 99.5% of the total power in the spectrum.

10dB bandwidth upper bound	Upper frequency of 10 dB bandwidth
10dB bandwidth lower bound	Lower frequency of 10 dB bandwidth
10dB bandwidth power	Power within 10 dB bandwidth
3dB bandwidth	Frequency range of 3 dB bandwidth
3dB bandwidth upper bound	Upper frequency of 3 dB bandwidth
3dB bandwidth lower bound	Lower frequency of 3 dB bandwidth
3dB bandwidth power	Power within 3 dB bandwidth

3 Results

3.1 Harbour porpoise in the Oosterschelde

Data was collected on the following days: 2021/05/30, 2021/07/25, 2021/08/02, 2021/08/21 and 2021/09/07. The data collection included hydrophone recordings and associated sightings (see Annex 4).

The time series of click occurrence and adult/calves sightings are shown in Figure 3-1. Whilst recordings late in the season (2021/09/07) yielded low click detections, the other recordings (2021/05/30 to 2021/08/21) showed consistency in click presence through each recording period in the day (8AM-2PM). In terms of sightings, the largest number of observations occurred in August (2021/08/02 and 2021/08/21). In total, through all the days of operation, 116 harbour porpoise sightings were recorded (mind that this includes multiple sightings of the same animal(s)), of which 11 potentially were calves (idem). Due to their shy and elusive nature and their brief surfacing, effective sighting is challenging. Judging size at large distances can also be difficult. Consequently, there are uncertainties surrounding the sightings of calves. Moreover, calves almost exclusively occur within close range of their mother. It was therefore impossible to record isolated calf clicks. Clicks were therefore attributed to one of two categories: 'adults only' or 'adults possibly accompanied by a calf'.

From each recording, individual clicks were extracted and the associated characteristics calculated (Table 2-3). The time series of click characteristics for each day or recording are given in Annex 5. The association with one of the categories mentioned above was based on matching times (within 5 minutes). If sightings of both categories (with or without calves) occurred within the same interval as the clicks, clicks were attributed to both categories. The click metrics were then used to investigate potential differences between sightings with and without calves. Figure 3-2 shows the following click characteristics disaggregated by day of observation and associated with only adult or adult and calf sightings: centre frequency, 10 dB bandwidth, occupied bandwidth and click duration. Of interest is that the centre frequency, 10 dB bandwidth and occupied bandwidth (Figure 3-2(a), (b) and (d)) are higher for the category including calves on 2021/08/02. This is translated in an average spectra (Figure 3-3) that exemplifies a larger frequency spread for the sightings including calves. These results should be put in perspective to the results from studies such as (García, 2016, Figure 3-3) or in Bergès et al. (2019).

The frequency of the clicks is generally higher for the porpoises in the Oosterschelde (150-160 kHz) than for those observed on the Dutch coast (Bergès et al., 2019) or in captivity in Denmark (120-150 kHz Figure 3-4(a), (García, 2016)). For the adult category, the 10 dB bandwidth observed in the Oosterschelde is in line with other studies. In contrast, the level of click 10 dB bandwidth as observed by (García, 2016) was higher than those observed here (Figure 3-2(b) and Figure 3-4(b)). This was especially true for calves in their early life stage. The differences between data sets could be related to the life stages of the calves, the difference in areas (i.e. specifics of harbour porpoises residing in the Oosterschelde) but also to behaviours specific to captivity (for the results from García (2016), Figure 3-4).

It is important to note that the categorizing into one of the animal categories is done using a simple rule; clicks are associated to a specific category (with or without calf) if within 5 minutes of a sighting. In addition, uncertainties in calf sightings should be considered. The implication is two-fold: the categorizing was not validated and the association with acoustic records can lack accuracy; observations of both categories (with or without calf) can lead to clicks being associated to both categories. Moreover, a caveat to the categorizing of the data presented here is that it is usual for calves to swim in pair with an adult, leading to the likeliness co-occurrence of adult and calf clicking activity. However, enough replication could reveal potential patterns and characteristics associated with calf presence.

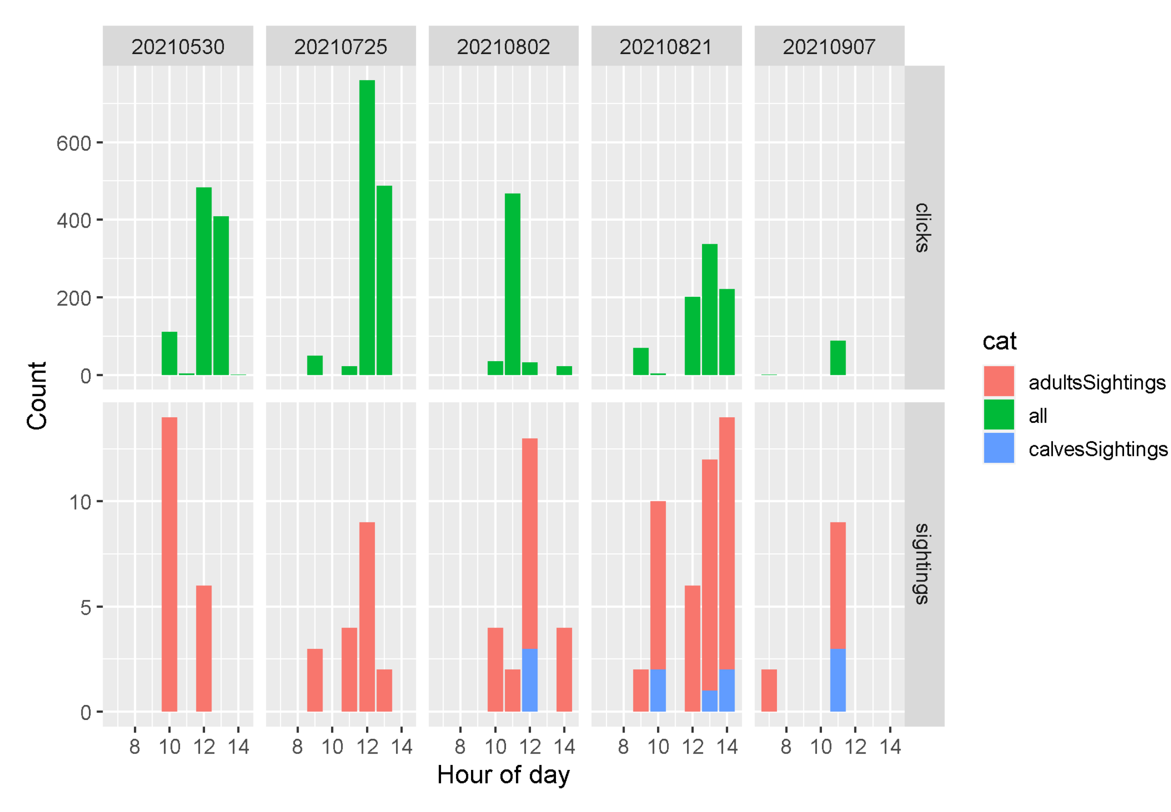

Figure 3-1: Time series of detected clicks and adult/calves sightings per hour.

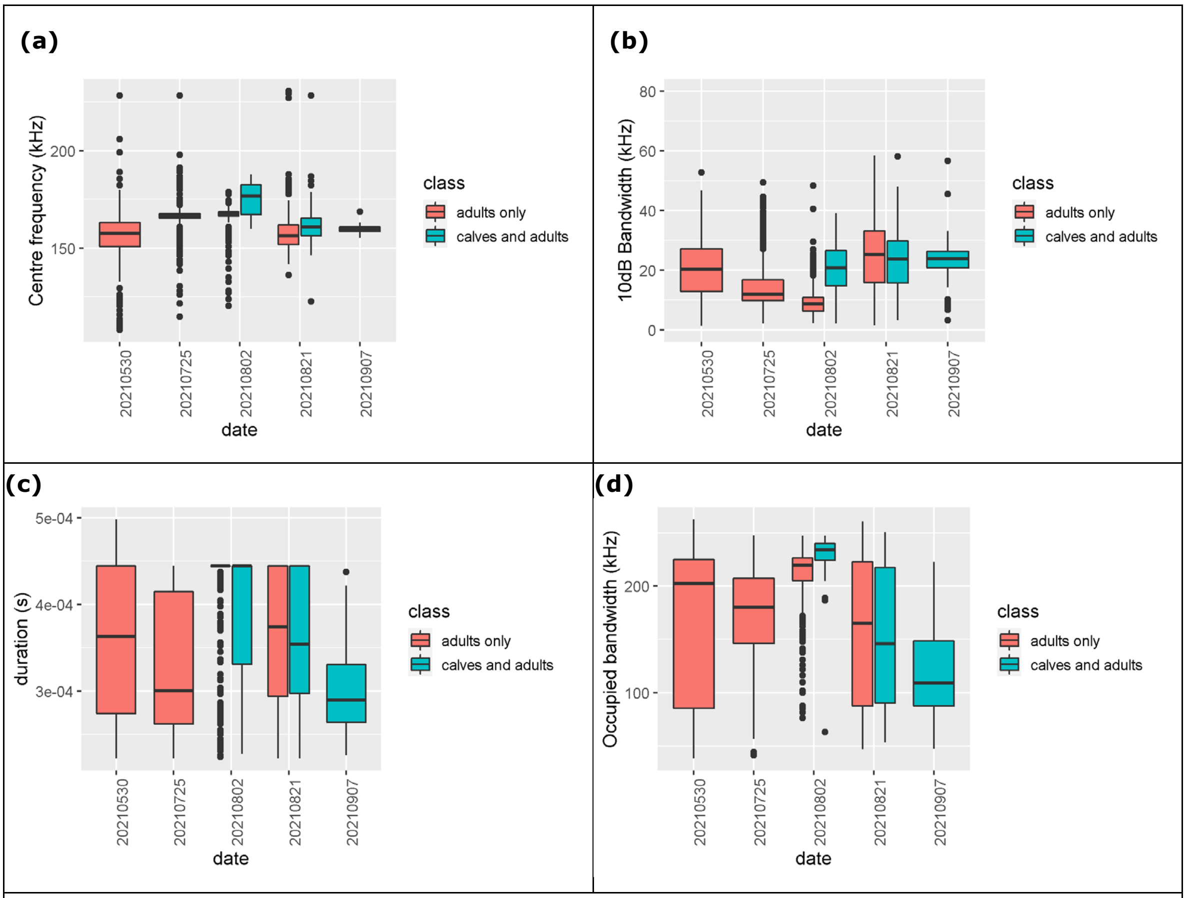

Figure 3-2: Click statistics for each recording day per animal category (adults only or calves and adults). (a) Centre frequency; (b) 10 dB bandwidth; (c) click duration; (d) click occupied bandwidth.

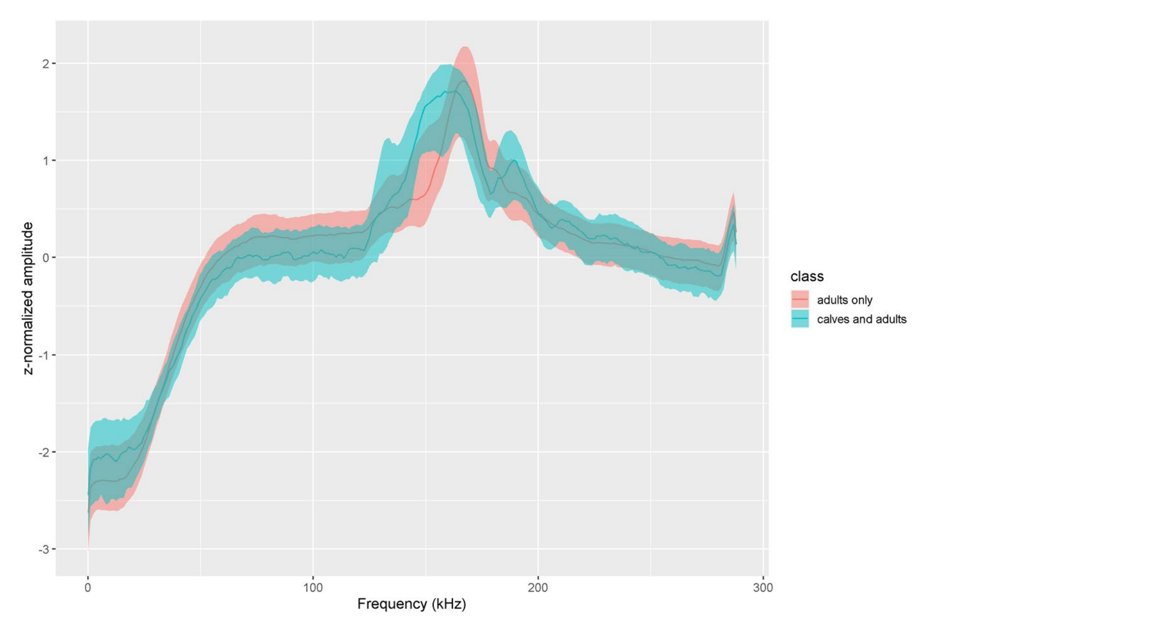

Figure 3-3: Acoustic spectra of clicks from adults only and adults potentially with calf.

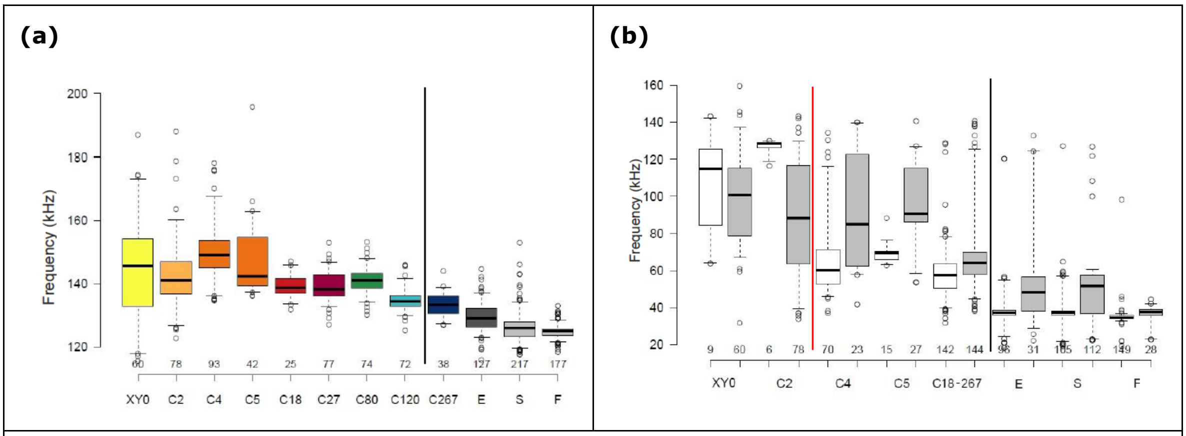

Figure 3-4: Click statistics at different aged calves and adults - Extracted from (García, 2016). (a) centroid frequency; (b) 10 dB bandwidth. Labels: calves X,Y or C and their age in days; adults E,S,F.

3.2 Outreach

Two short clips were developed and shared through the WUR website, and on LinkedIn. The first video focusses on the fieldwork, and the second on the data analyses. Both videos can be found here:

https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksinstituten/marine-research/show-marine/Akoestisch-onderzoek-naar-bruinvissen-op-de-Oosterschelde.htm

Additionally there was an item about the project in the Dutch radio program “Vroege Vogels” on NPO Radio 1. The item can be found here:

https://www.wur.nl/nl/Onderzoek-Resultaten/Onderzoeksinstituten/marine-research/show-marine/Jip-Vrooman-en-Hans-Verdaat-bij-Vroege-Vogels-over-het-geluid-en-gedrag-van-bruinvissen.htm

4 Conclusions and recommendations

In this pilot project we proposed and experimented with a method to investigate calf click characteristics in at-sea conditions. We developed a protocol to collect data, and did a first rough analysis of the collected data.

4.1 Approach & material

At-sea data collection can be tedious, and depends on weather conditions. Monitoring harbour porpoises poses extra difficulty, due to the shy and elusive nature of the animal. The collaboration with Rugvin Foundation proved very successful. They have a lot of local knowledge about harbour porpoises in the area, and finding them was relatively easy. Additionally the use of their boat worked well.

The hydrophone was easy to handle and proved adequate for recording harbour porpoise clicks. The fact that it was mobile allowed for targeted recording; once animals were close, the hydrophone was lowered into the water, while at the same time the animals could be counted, observed and group composition determined. However, it proved difficult to find and/or distinguish calves. Harbour porpoises surface only briefly, and judging its size at large distances is difficult. Moreover, not many mother-calf pairs were found.

The Oosterschelde is an ideal area for harbour porpoise field work. It offers harbour porpoises in the wild, but it’s a manageable area and the weather conditions are generally slightly better than at the North Sea. Moreover there is a population of harbour porpoises with known hotspots, yielding very high chances of sightings. This is an ideal area for developing, finetuning and replicating scientific methods.

4.2 Results

More replication is needed for statistical significance of the results. The method we suggest has a weakness in the fact that we try to link observations with acoustic records, but it does not mean recordings associated with calf sightings exclusively exemplify calf clicking activity. Calves usually occur in the close vicinity of their mother. As a result we can only consider our results in a statistical sense, as opposed to more deterministic with clear calf sightings and an acoustic link. This is an associated difficulty of operating in at-sea conditions. In that context, there was very little data to be used, especially if we also consider the fact that the very differentiable click form probably only occurs for very young calves (García, 2016). The analysis done does not allow for further conclusions; differences in vocalisation characteristics were found in conjunction with sightings with and without calf, but this aspect needs to be validated with more replication.

4.3 Outreach

The two short videos were well received, as was the Vroege Vogels item. The radio channel on which Vroege Vogels is broadcasted reaches approximately 2.2 million people per week[4].

[4] https://www.ster.nl/media/ubxlnqwv/radio-zendersheet-2020-npo-radio-1.pdf

5 Quality Assurance

Wageningen Marine Research utilises an ISO 9001:2015 certified quality management system. This certificate is valid until 15 December 2021. The organisation has been certified since 27 February 2001. The certification was issued by DNV GL.

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Justification

Report C016/22
Project Number: 4316100241

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: Bart Noort
Onderzoeker

Signature:

Date: 31 maart 2022

Approved: Jakob Asjes
Manager Integratie

Signature:

Date: 31 maart 2022

Annex 1. Hydrophone specifics

High Frequency Passive Acoustic Monitoring System for Wageningen Marine Research

Hydrophone

The hydrophone used is a High Frequency Magrec HP03 unit, comprising a potted spherical ceramic combined with a HP02 pre-amplifier providing 29dB of gain and a gentle low cut filter (-3dB @ 2kHz), connected by a 50m cable.

The hydrophone is mounted in an oil-filled polyurethane tube.

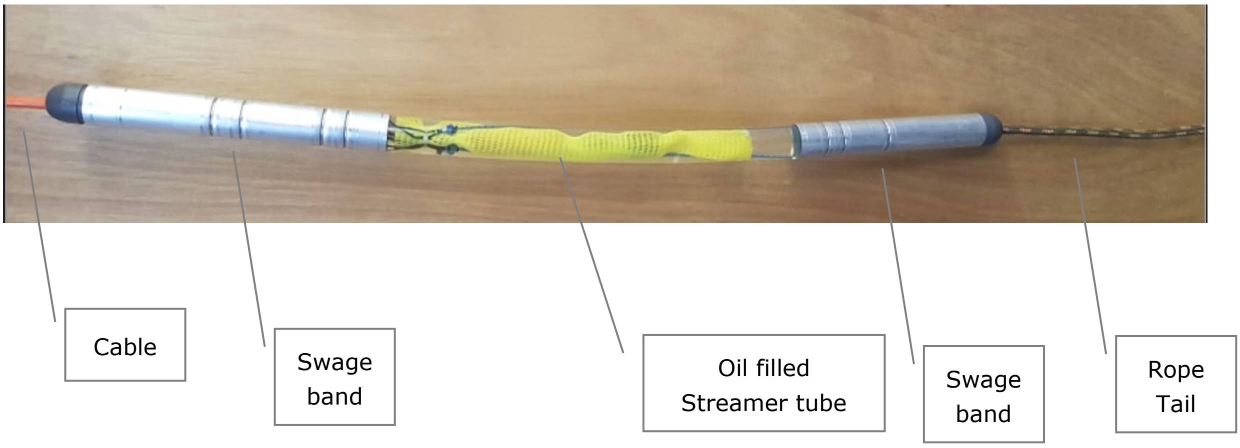


Figure A1-1 Hydrophone mounted in oil-filled streamer section (photo by Jonathan Gordon)

The Topside Box

In its default configuration the topside box consists of a waterproof Pelicase, and is equipped with a small DC computer (Intel NUC), a screen and a Sail DAQ card.

However, WMR found the DC computer and screen in combination with the DC filtering equipment caused severe disturbance in the audio recordings during testing. Furthermore WMR did not own a Sail DAQ card.

WMR decided to power the pre-amplifier from three 18650 Li-ion rechargeable batteries providing the required 12 volt, and mounted a little power switch in the casing to power off or shut down the pre-amplifier.

WMR furthermore removed both the screen and the DC computer and used a laptop with its internal battery during the fieldwork.

The configuration used by WMR was a bit unpractical, since it needed two different power sources and the lid of the pelicase could not be closed during work. But it performed well without generating disturbance in the audio recordings.

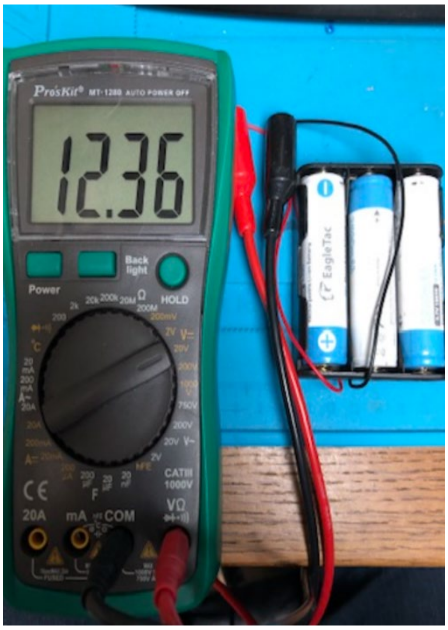


Figure A1-8 pre-amplifier powered using 18650 batteries

Hydrophone Connection

The hydrophone is connected to a 5 pin waterproof socket on the box. This provides 12v DC power for the hydrophone preamp, receives positive and negative balanced signals from the HP03 through a lead which terminates in a 5 pin Din plug to connect to the Avisoft digitiser and the outer screen of the cable. Table A1-1 shows the pin assignments for this connector.

Table A1-1. Hydrophone Connector Pins

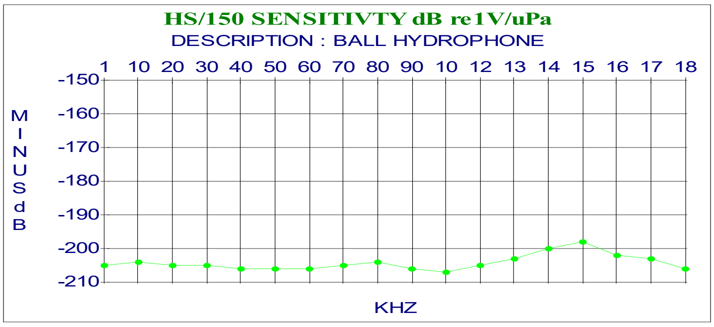
Hydrophone Pin		5 Pin Din pins
1	0V	1
2	+12	
3	Signal +ve	2
4	Signal -ve	3
5	Outer screen	

Earthing

The box provided an earthing through a earthing tube which could be dropped in the water when electrical noise appeared, however electrical noise was not noted and the earthing was unused.

Appendix

The hydrophone ceramic in the HP03 has the same specifications as that used in a HS150 and has similar acoustic characteristics.



Specification:

Resonant Frequency	150 kHz
Source Level At 150 kHz	145 dB re 1uPa/V at 1m
Impedance	300 Ohms
Capacitance (Nominal)	2800pF (at 1 kHz)
Sensitivity (Nominal)	-204 dB re 1V/uPa
(+/- 1 dB) Range	1 Hz to 80 kHz
(+/- 2 dB) Range	1 Hz to 160 kHz

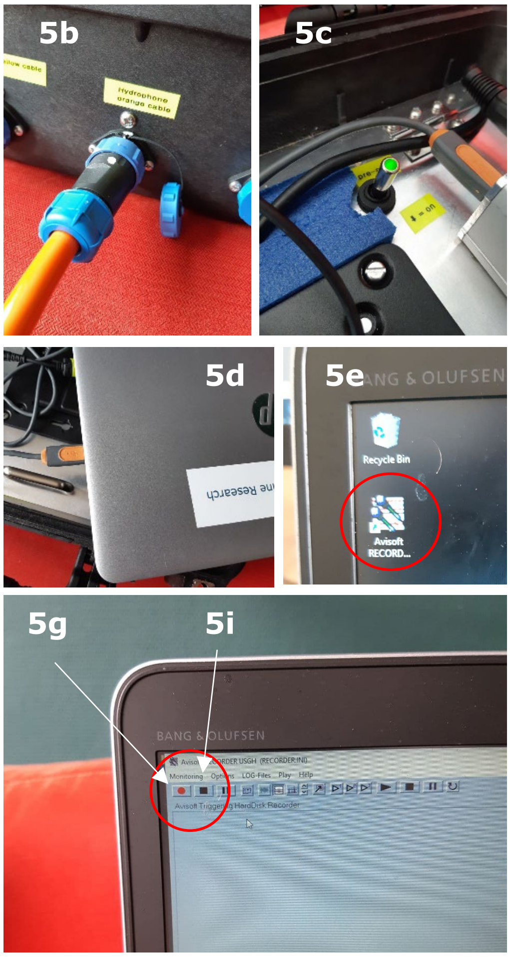
Annex 2: Hydrophone deployment protocol

Preparation:

1. Make sure batteries (GPS, computers, hand-held hydrophone, amplifier box) are full
2. Make sure you have all equipment (see equipment list below)
3. Make a new folder on the field laptop under C:\DATA\Oosterschelde\[fill in date of fieldtrip] (or any other location for you project).

In the harbour:

4. Load all equipment onto the boat
5. Set up equipment according to the following steps;
    a. Turn on laptop
    b. Connect hydrophone to amplifier box
    c. Switch on pre-amplifier in box and check the light
    d. Connect USB cable to USB port in laptop
    e. Open Avisoft recording program
    f. Change saving configuration by pressing “Options” --> “Configuration” and edit “Base Directory” to the new file created under 2.
    g. Press record
    h. Tap on hydrophone to test
    i. Stop record
6. Close laptop lid
7. Turn on GPS by pressing button on the side
8. Sail out to chosen (hot)spot



Out in the field:

9. Once a harbour porpoise is in sight, drop the hydrophone into the water, lower it to about 5 m. Watch out with the motor/propellor at the back! Preferably stop engine to reduce abiotic sounds.
10. Secure it to the boat
11. Make a new *GPS waypoint* on the GPS by pressing "Mark"
12. Start the *recording* by pressing the record button on de computer
13. Fill in *data entry sheet*
14. Fill in one line per HP group in the area.
15. Throughout the deployment conduct a scan every 10 minutes to record HP groups, and start a new recording every 10 minutes by pressing stop and record on the computer.
16. If preferred, lower the handheld hydrophone into the water to listen (can also be done before hydrophone is in water)
17. When the animals are out of sight again (or because of another reason), stop the recording, by pressing stop button on computer
18. Before moving to a next spot, remove hydrophones from water, while drying it with a towel
19. Store everything safely
20. Repeat step 3 – 7 at next hotspot/sighting.

Back in the harbour:

21. Turn off computer
22. Turn off amplifyer
23. Disconnect everything that was connected under 5.
24. Make sure all equipment is off the boat again
25. Rinse hydrophone and other sea-going equipment well with fresh water and let dry

Processing (computer):

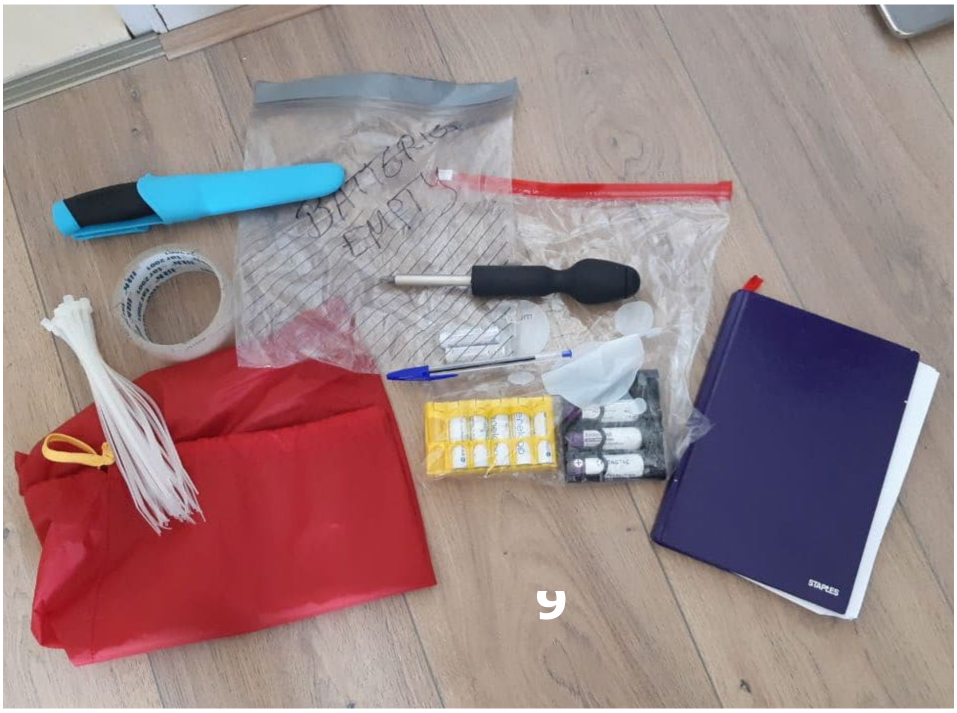
26. Extract GPS waypoints .gpx file from the GPS.
27. Convert to csv (e.g. in QGIS)
28. Match information from *GPS waypoints* (time, GPS location) with data from *data entry sheet* and enter in *Excel file* (template)
29. Extract audio files from field laptop
30. Save following items in new folder with date in this folder, see here for example:
    a. Audio recordings
    b. Excel datafile
    c. GPS files (.csv, .gpx)
    d. Optional: photo's, map, ...

Equipment list

1. Hydrophone
2. Amplifier box
3. Laptops
4. Extra batteries for amplifier power, GPS, hand-held hydrophone
5. Data entry sheets [link]
6. Handheld hydrophone(s)
7. Strap band/rope to strap hydrophone cable to boat
8. GPS
9. Towel
10. Bag with extra batteries, notebook, tape, scissor, other useful stuff
11. Water and lunch


C-click
5


ThinkPad
GARMIN
GPSmap 62st
GARMIN
FIND
PAGE
MARK
MENU
QUIT
ENTER


9
STAPLES

Annex 3: Data sheet template

Date: / /202 Observers: Vessel:

Time	GPS WP #	Avisoft Rec #	Engine on / off	Cable length (m)	# HP total	# HP calves	Behaviour[1]	Dist. (m)	Sea state (Bft)[2]	Cloud cover[3]	Swell height (m)	Glare strength (0 to 3)	Glare %	Comments (e.g. begin deployment, end deployment, rain, technical issues)
:														
:														
:														
:														
:														
:														
:														
:														
:														

For each deployment record BEGIN and END. Fill in one line per HP group in the area. Throughout the deployment conduct a scan every 10 minutes to record HP groups, and start a new recording

[1]**Behaviour:**
T = travelling (directional swimming) R = resting
M = milling (unidirectional swimming) O = other (put in comment)

[2]**Sea state**:
0 = sea like a mirror, 1 = small ripples, 2 = small wavelets 3 = crests break
4 = numerous white caps 5 = moderate waves, some spray, 6 = larger waves, more spray

[3]**Cloud cover:**
0/8 = no clouds in 1/8th up to
8/8 = complete cover

Annex 4: Collected sighting data (basic[5])

dataSet	year	month	day	timeUTM	lat	lon	tapeNo	obsAdult	obsCalves	comments	tapeName
20210530	2021	5	30	8:17:33 AM	51.63422	3.886926		0	0	Buoy Rugvin Foundation	
20210530	2021	5	30	8:34:31 AM	51.63346	3.886831		0	0	Buoy Rugvin Foundation	
20210530	2021	5	30	10:00:24 AM	51.67726	3.769051	7	3	0		Oosterschelde_210530095949_0000007.wav
20210530	2021	5	30	10:13:00 AM	51.67784	3.773197	8	3	0		Oosterschelde_210530101255_0000008.wav
20210530	2021	5	30	10:22:33 AM	51.67739	3.770444	9	3	0		Oosterschelde_210530102229_0000009.wav
20210530	2021	5	30	10:32:13 AM	51.67587	3.766502	10	1	0		Oosterschelde_210530103133_0000010.wav
20210530	2021	5	30	10:34:55 AM	51.67532	3.765563	11	2	0		Oosterschelde_210530103447_0000011.wav
20210530	2021	5	30	10:45:13 AM	51.67707	3.766703	12	1	0		Oosterschelde_210530104450_0000012.wav
20210530	2021	5	30	10:55:58 AM	51.67827	3.767933	13	1	0		Oosterschelde_210530105552_0000013.wav
20210530	2021	5	30	12:03:41 PM	51.63344	3.887539	14	2	0	Buoy Rugvin Foundation	Oosterschelde_210530115854_0000014.wav
20210530	2021	5	30	12:26:52 PM	51.63344	3.887539	15	2	0	Buoy Rugvin Foundation	Oosterschelde_210530122652_0000015.wav
20210530	2021	5	30	12:56:50 PM	51.63344	3.887539	16	2	0	Buoy Rugvin Foundation	Oosterschelde_210530125650_0000016.wav
20210530	2021	5	30	2:06:54 PM	51.5803	3.897439	17	0	0		Oosterschelde_210530140659_0000017.wav
20210725	2021	7	25	9:17:04 AM	52.28236	4.587216					
20210725	2021	7	25	9:25:51 AM	51.63363	3.887593	14	1	0		Oosterschelde_210725092427_0000014.wav
20210725	2021	7	25	9:27:31 AM			15	1	0		Oosterschelde_210725092731_0000015.wav
20210725	2021	7	25	9:33:19 AM	51.63321	3.887984	15	1	0		
20210725	2021	7	25	9:35:22 AM	51.633	3.888106	15				
20210725	2021	7	25	11:41:26 AM	51.67747	3.766097	17	2	0		Oosterschelde_210725113957_0000017.wav
20210725	2021	7	25	11:53:28 AM	51.68141	3.775996	18	2	0		Oosterschelde_210725115517_0000018.wav
20210725	2021	7	25	11:56:17 AM	51.68161	3.776683	18				

[5] The data collection sheet was improved along the course of the project. This table provides data over all days and thus consists of the most basic items.

20210725	2021	7	25	12:01:51 PM	51.68234	3.778181	19	2	0		Oosterschelde_210725120401_0000019.wav
20210725	2021	7	25	12:01:55 PM	51.68239	3.778236	19				
20210725	2021	7	25	12:11:27 PM	51.68542	3.788978	19				
20210725	2021	7	25	12:14:53 PM	51.68556	3.796009	19				
20210725	2021	7	25	12:16:36 PM	51.68488	3.799522	19				
20210725	2021	7	25	12:38:37 PM	51.65972	3.856852	20	2	0		Oosterschelde_210725125058_0000020.wav
20210725	2021	7	25	12:39:22 PM	51.65745	3.859122	20	1	0		
20210725	2021	7	25	12:44:33 PM	51.64202	3.873723	20	1	0		
20210725	2021	7	25	12:47:54 PM	51.63393	3.884942	20	1	0		
20210725	2021	7	25	12:48:03 PM	51.63377	3.885091	20	1	0		
20210725	2021	7	25	12:54:02 PM	51.62971	3.890273	20	1	0		
20210725	2021	7	25	1:02:45 PM	51.62908	3.89051	20	1	0		
20210725	2021	7	25	1:04:09 PM	51.62898	3.890668	20	1	0		
20210802	2021	8	2	10:36:07 AM	51.67366	3.75997	24	2	0		Oosterschelde_210802103555_0000024.wav
20210802	2021	8	2	10:57:41 AM	51.67535	3.76164	25	2	0		Oosterschelde_210802105755_0000025.wav
20210802	2021	8	2	11:21:15 AM	51.68039	3.772032	26	2	0		Oosterschelde_210802112115_0000026.wav
20210802	2021	8	2	12:20:36 PM	51.67809	3.768982	27	2	0	Calf	Oosterschelde_210802122036_0000027.wav
20210802	2021	8	2	12:26:01 PM	51.67531	3.762933	28	2	1		Oosterschelde_210802122547_0000028.wav
20210802	2021	8	2	12:31:20 PM	51.67159	3.757264	29	3	1	Definitely clicks in this recording	Oosterschelde_210802123113_0000029.wav
20210802	2021	8	2	12:37:27 PM	51.67043	3.755456	30	3	1		Oosterschelde_210802123713_0000030.wav
20210802	2021	8	2	2:10:55 PM	51.67972	3.774438	32	1	0		Oosterschelde_210802141044_0000032.wav
20210802	2021	8	2	2:23:21 PM	51.68406	3.785322	33	2	0		Oosterschelde_210802142312_0000033.wav
20210802	2021	8	2	2:38:20 PM	51.68454	3.808365	34	1	0		Oosterschelde_210802143801_0000034.wav
20210821	2021	8	21	9:00:55 AM	51.63189	3.887171	2	1	0	Start deployment	Oosterschelde_210821083502_0000001.wav
20210821	2021	8	21	9:04:00 AM						End deployment	
20210821	2021	8	21	9:07:03 AM	51.6336	3.886499	3	1	0	Start deployment- definitely clicks	Oosterschelde_210821090043_0000002.wav
20210821	2021	8	21	9:13:00 AM						End deployment	
20210821	2021	8	21	10:15:05 AM	51.68258	3.781523	4	3	1	Start deployment	Oosterschelde_210821090711_0000003.wav
20210821	2021	8	21	10:24:25 AM	51.68317	3.784118	5	3	1	New recording	Oosterschelde_210821101441_0000004.wav

20210821	2021	8	21	10:36:37 AM	51.68374	3.788157	6			New recording	Oosterschelde_210821102357_0000005.wav
20210821	2021	8	21	10:38:00 AM						End deployment	
20210821	2021	8	21	10:55:17 AM	51.68282	3.796923	7	2	0	Start deployment	Oosterschelde_210821103607_0000006.wav
20210821	2021	8	21	10:56:00 AM						End deployment	
20210821	2021	8	21	12:25:27 PM	51.63347	3.88545	8	1	0	Start deployment	Oosterschelde_210821105500_0000007.wav
20210821	2021	8	21	12:34:13 PM	51.63187	3.887439	9	2	0	New recording?	Oosterschelde_210821122504_0000008.wav
20210821	2021	8	21	12:37:00 PM						Stop recording	
20210821	2021	8	21	12:46:47 PM	51.63339	3.887505	10	1	0	Start deployment - clicks?	Oosterschelde_210821123404_0000009.wav
20210821	2021	8	21	12:57:09 PM	51.63344	3.887505	11	2	0	New recording	Oosterschelde_210821124617_0000010.wav
20210821	2021	8	21	1:06:26 PM	51.63342	3.887444	12	1	0	New recording	Oosterschelde_210821125658_0000011.wav
20210821	2021	8	21	1:19:12 PM	51.63343	3.887458	13	0	0	New recording	Oosterschelde_210821130606_0000012.wav
20210821	2021	8	21	1:28:22 PM	51.63348	3.887538	14			New recording	Oosterschelde_210821131847_0000013.wav
20210821	2021	8	21	1:34:30 PM	51.63349	3.887526	15	2	0	New recording	Oosterschelde_210821132818_0000014.wav
20210821	2021	8	21	1:44:00 PM						End deployment - move	
20210821	2021	8	21	1:50:46 PM	51.6302	3.88638	16	1	0	Start deployment	Oosterschelde_210821133408_0000015.wav
20210821	2021	8	21	1:52:18 PM				3	0		Oosterschelde_210821135018_0000016.wav
20210821	2021	8	21	1:53:00 PM						End deployment	
20210821	2021	8	21	1:58:15 PM	51.6292	3.890332	17	4	1	Start deployment	Oosterschelde_210821135747_0000017.wav
20210821	2021	8	21	1:59:00 PM						End deployment	
20210821	2021	8	21	2:02:10 PM	51.63032	3.889253	18	3	1	Start deployment	Oosterschelde_210821140144_0000018.wav
20210821	2021	8	21	2:06:00 PM						End deployment	
20210821	2021	8	21	2:08:59 PM	51.63018	3.889399	19	3	1	Start deployment - Definitely clicks	Oosterschelde_210821140836_0000019.wav
20210821	2021	8	21	2:18:29 PM	51.63119	3.886761	20	4		New recording	Oosterschelde_210821141802_0000020.wav
20210821	2021	8	21	2:19:00 PM						End deployment	
20210821	2021	8	21	2:42:15 PM	51.57351	3.89467	21	1		Start deployment	Oosterschelde_210821144154_0000021.wav
20210821	2021	8	21	2:43:00 PM						End deployment	
20210821	2021	8	21	2:44:46 PM	51.57345	3.89534	22	1		Start deployment	Oosterschelde_210821144426_0000022.wav
20210821	2021	8	21	2:48:00 PM	51.58519	3.897349				End deployment	
20210907	2021	9	7	7:36:15 AM	51.58519	3.897349	24	2	0	Start deployment	Oosterschelde_210907073540_0000024.wav

20210907	2021	9	7	7:39:00 AM						End deployment	
20210907	2021	9	7	11:17:34 AM	51.68374	3.803645	25	2	1	Start deployment, Vroege Vogels aanwezig	Oosterschelde_210907111654_0000025.wav
20210907	2021	9	7	11:19:00 AM						End deployment - move closer	
20210907	2021	9	7	11:24:25 AM	51.68349	3.797042	26	2	1	Start deployment, definitely clicks, Vroege Vogels aanwezig	Oosterschelde_210907112341_0000026.wav
20210907	2021	9	7	11:35:00 AM						End deployment - move	
20210907	2021	9	7	11:48:29 AM	51.68506	3.795737	27	2	1	Start deplyment, Vroege Vogels aanwezig	Oosterschelde_210907114756_0000027.wav
20210907	2021	9	7	12:01:46 PM	51.68605	3.799965	28	0	0	new recording	Oosterschelde_210907120101_0000028.wav
20210907	2021	9	7	12:05:00 PM						End deployment	

Annex 5: Daily acoustic results of monitoring in the Oosterschelde

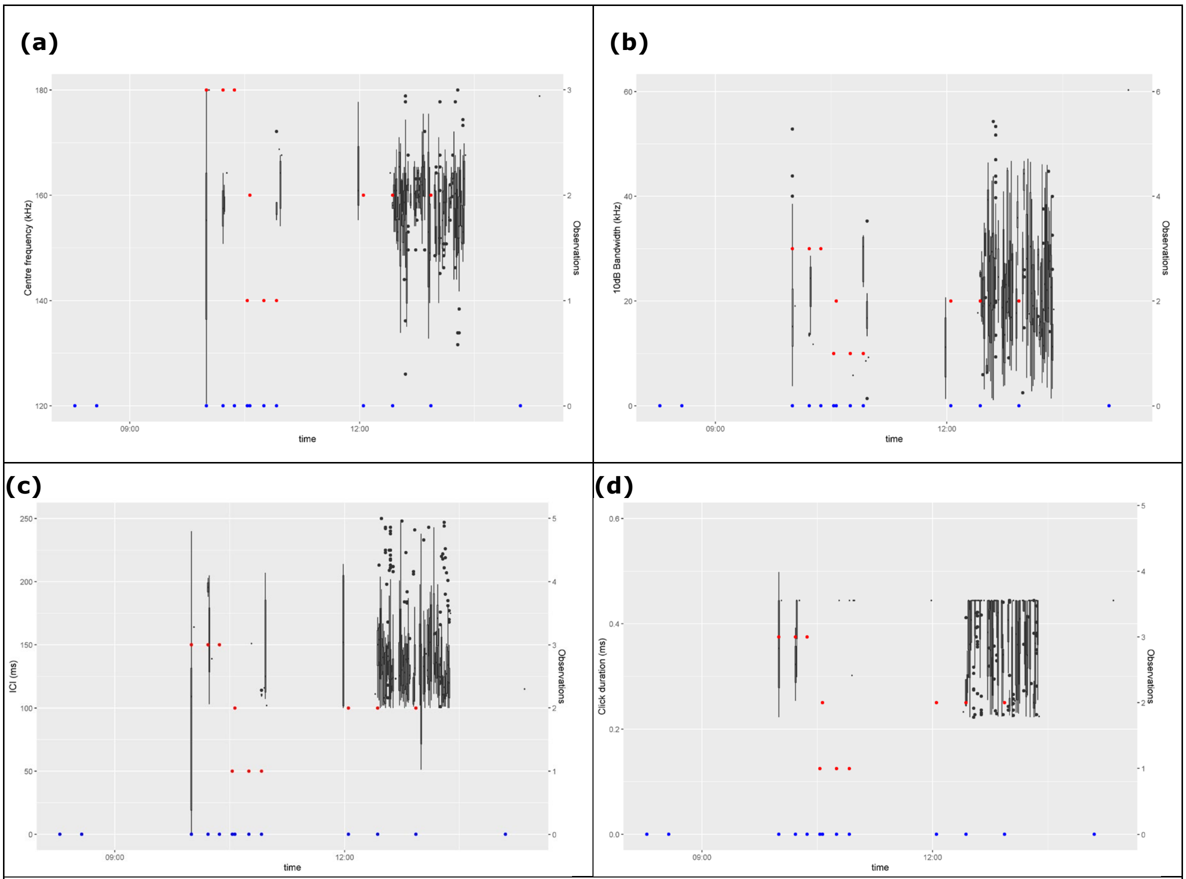


Figure A5.1: 1 minute click statistics of Oosterschelde data from 2021/05/30. (a) click centre frequency. (b) 10 dB click bandwidth; (c) inter-click intervals, (d) click duration. Associated sightings are shown as circle markers on the right y scale. Red markers are the porpoise sighting counts. Blue markers are the porpoise calf sighting counts.

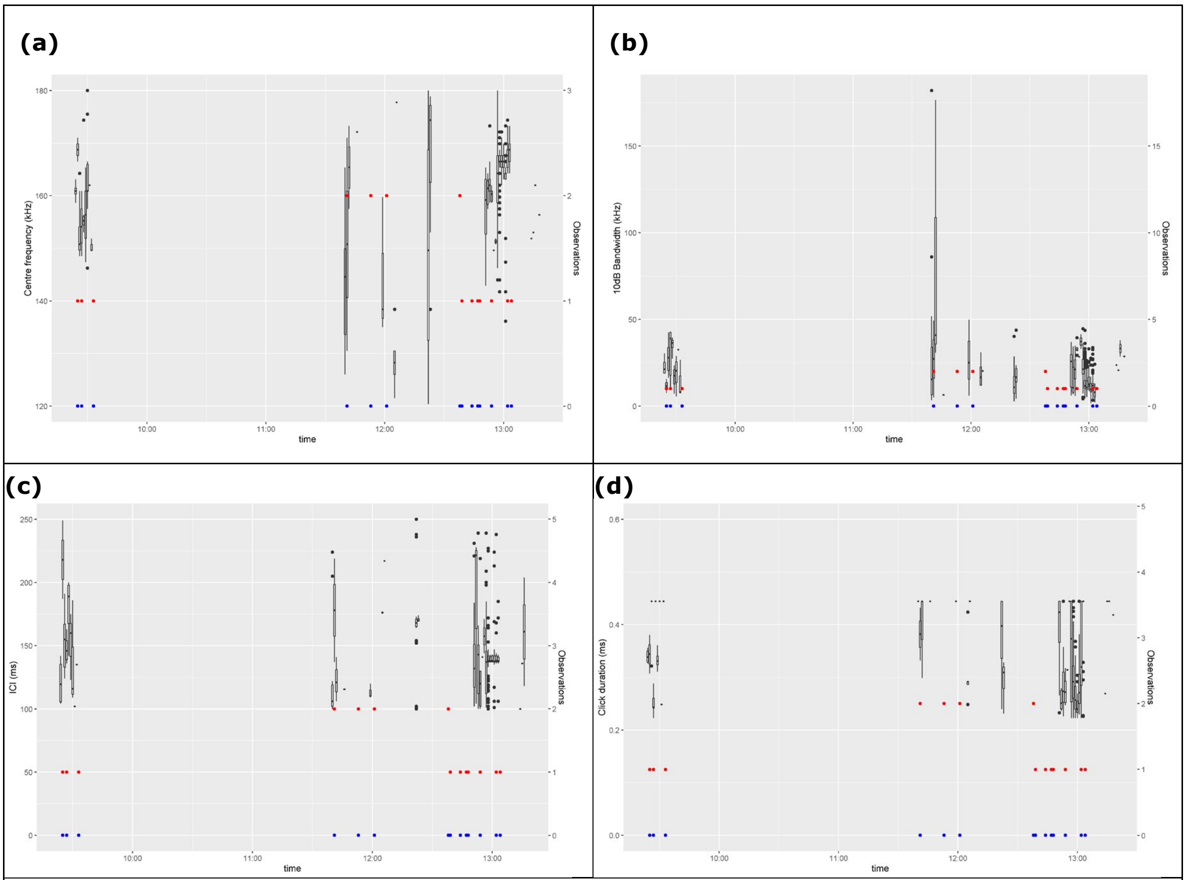


Figure A5.2: 1 minute click statistics of Oosterschelde data from 2021/07/25. (a) click centre frequency. (b) 10 dB click bandwidth; (c) inter-click intervals, (d) click duration. Associated sighting are shown as circle markers on the right y scale. Red markers are the porpoise sighting counts. Blue markers are the porpoise calf sighting counts.

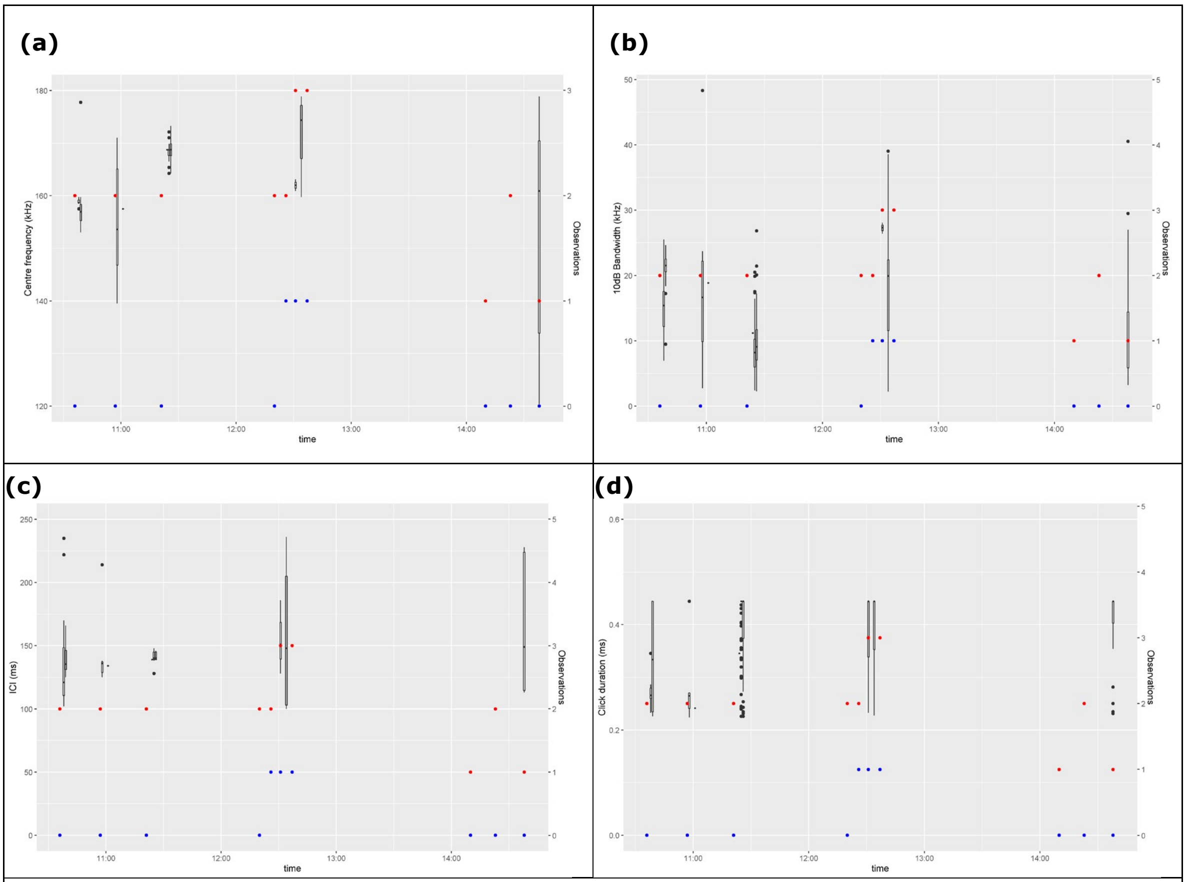


Figure A5.3: 1 minute click statistics of Oosterschelde data from 2021/08/02. (a) click centre frequency. (b) 10 dB click bandwidth; (c) inter-click intervals, (d) click duration. Associated sighting are shown as circle markers on the right y scale. Red markers are the porpoise sighting counts. Blue markers are the porpoise calf sighting counts.

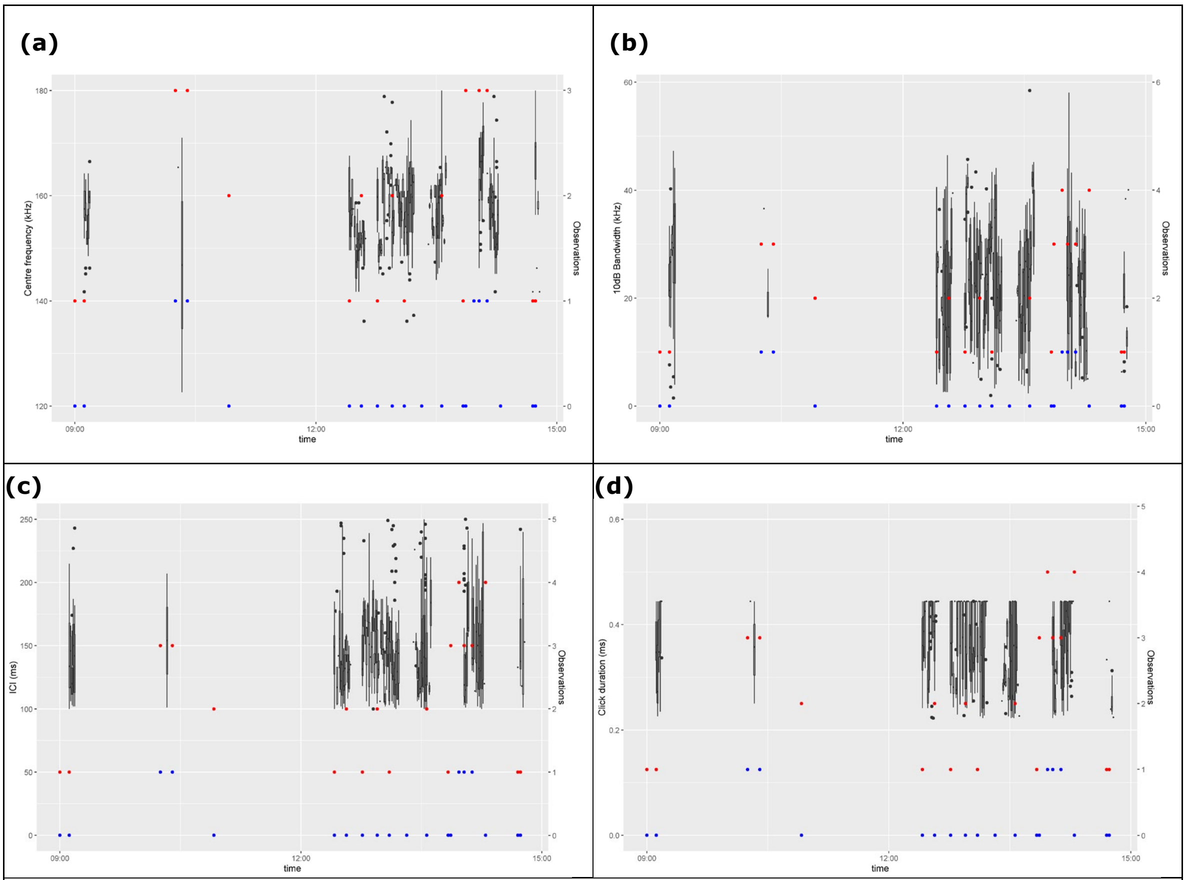


Figure A5.4: 1 minute click statistics of Oosterschelde data from 2021/08/21. (a) click centre frequency. (b) 10 dB click bandwidth; (c) inter-click intervals, (d) click duration. Associated sighting are shown as circle markers on the right y scale. Red markers are the porpoise sighting counts. Blue markers are the porpoise calf sighting counts.

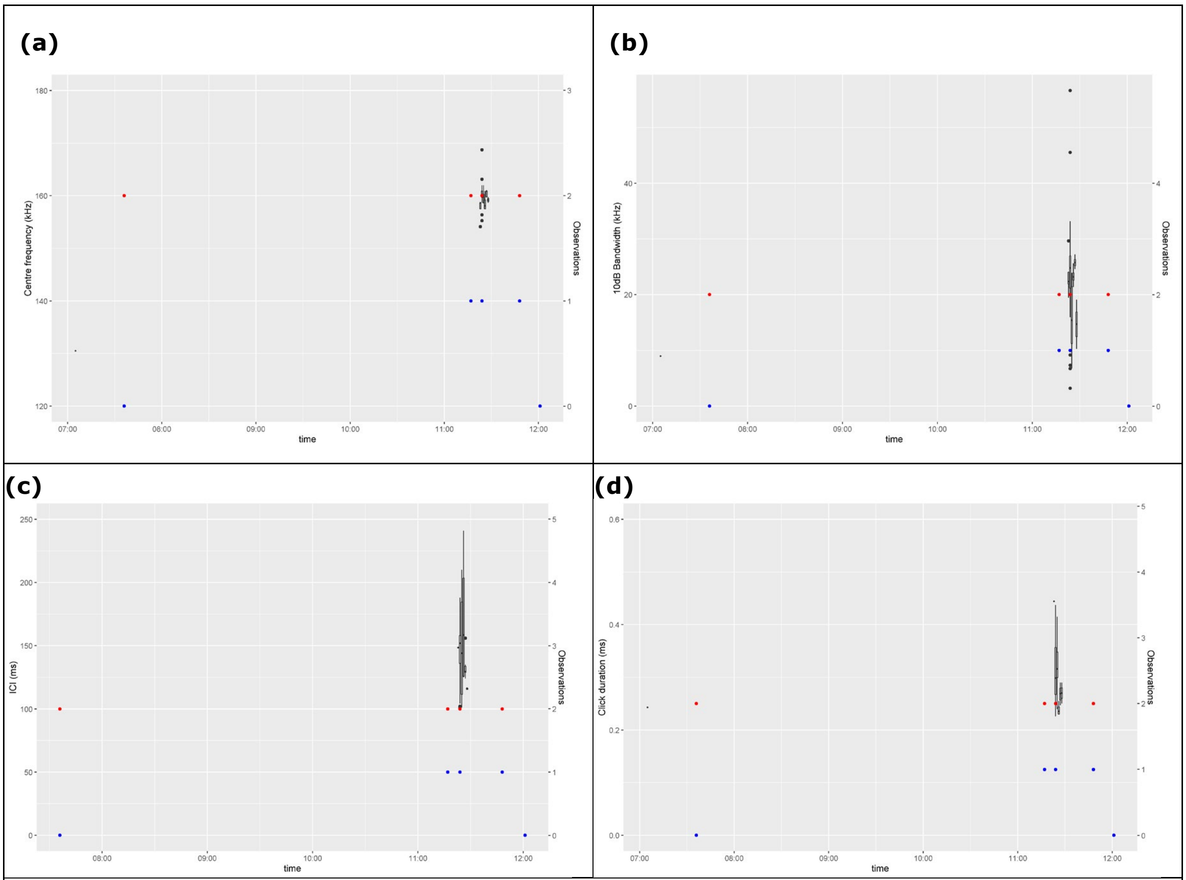


Figure A5.5: 1 minute click statistics of Oosterschelde data from 2021/09/07. (a) click centre frequency. (b) 10 dB click bandwidth; (c) inter-click intervals, (d) click duration. Associated sighting are shown as circle markers on the right y scale. Red markers are the porpoise sighting counts. Blue markers are the porpoise calf sighting counts.

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With knowledge, independent scientific research and advice, **Wageningen Marine Research** substantially contributes to more sustainable and more careful management, use and protection of natural riches in marine, coastal and freshwater areas.

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