2016 SURVEY ACOUSTIC REPORT

EDMAKTUB ASSOCIATION

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CONTENT

INTRODUCTION

EDMAKTUB ASSOCIATION

Founded in 2000, Edmaktub is a non-profit organization that aims to improve scientific knowledge, conservation and raise awareness on marine mammals and the marine environment. Edmaktub operates from a dedicated boat-based platform in the South of Catalonia, mainly in the Balearic Sea, with focus on the Garraf coast. The association conducts various scientific projects involving cetacean photo-identification using camera and drone, behavior and acoustic studies and collects data on oceanographical parameters. Edmaktub has developed and runs the Fin whale project since 2013, which emphasizes on understanding the seasonal presence of fin whales along the Garraf coast during spring.

CETACEAN POPULATIONS ON THE GARRAF COAST

Located in the northwestern Mediterranean, the study area belongs to a temperate region characterized by a narrow continental shelf indented by submarine canyons. A southwestern flow of the Catalan Current runs along the continental slope. The biological production in the zone is mainly associated with the inputs of nutrients provided by waters of continental origin from the rivers of the region (Estrada, 1996; Cruzado et al., 2002), with autumn–winter mixing processes (Salat, 1996), and presence of the Catalan permanent density front (Alcaraz et al. 2007). Additionally, submarine canyons have been reported as hotspots for Mediterranean cetaceans, especially beaked whales and sperm whales (Wurtz 2010).

21 cetacean species have been recorded in Mediterranean Sea. Ten species are represented by populations regularly present in the Mediterranean Sea (Pace et al. 2015). Among them, 8 species inhabit the study area: common bottlenose dolphin, short-beaked common dolphin, striped dolphin, Risso's dolphin, long-finned pilot whale, Cuvier's beaked whale, sperm whale and fin whale (Appendix I). Many of these species exhibit distinct subpopulations in the Mediterranean Sea with evidence of genetical differentiation from the Atlantic populations: bottlenose dolphin (Natoli et al. 2005), striped dolphin (Garcia-martinez et al. 1999), Risso's dolphin (Gaspari et al. 2007), Cuvier's beaked whale (Dalebout et al. 2005), fin whale (Bérubé et al. 1998) and sperm whale (Drouot et al. 2004). The IUCN Red List provides conservation status for cetaceans in the Mediterranean Sea, with one species classed as endangered, four as vulnerable, and three as data deficient, which reflects the vulnerability and the lack of scientific knowledge for these populations. Few studies are available (Forcada et al. 2004 Rendell and Canadas, 2005, Gomez de Sagura et al. 2006).

PASSIVE ACOUSTIC MONITORING APPLICATIONS

Passive acoustic monitoring (or PAM) has been widely applied to obtain information on the distribution, density and abundance of numerous cetacean species (Zimmer 2011). Technical equipment and methodology has developed rapidly over recent decades, and PAM is considered as a cost effective method for cetacean monitoring. It allows data collection on species presence when visual data collection would not be possible (nighttime or poor weather conditions, cetacean elusive behavior at the surface). Combined visual and line transect surveys have been successfully applied to several cetaceans, increasing the detection rate of cetacean (Rankin et al. 2007). PAM is a tool for estimating population density or abundance (Marques et al. 2013), determining range and seasonality (Mellinger, 2007) and can allow identification of species in absence of visual confirmation using automated detection and classification algorithms (Oswald et al. 2003, 2007; Roch et al 2007, Gillespie et al. 2013). This method can also provide important details about the acoustic environments of cetaceans, especially regarding effects of human activities e.g. ship traffic, offshore exploration, military and civilian sonar… (Zimmer, 2011).

Edmaktub contributes to passive acoustic data collection on fin whales via the deployment of an autonomous buoy and by collecting acoustic data on other cetacean species using onboard equipment (a handheld hydrophone and a two element towed array), in collaboration with the Laboratori d'Aplicacions Bioacustiques (LAB).

The present report presents the acoustic research conducted in the 2016 field season of the Edmaktub project.

MATERIALS & METHODS

Acoustics recordings were made along the Garraf coast between March and June 2016. Both fixed and non-fixed recording equipment were used.

Detailed technical specifications for the different recording equipment are in Appendices II-V.

LAB AUTONOMOUS BUOY

The autonomous acoustic buoy, owned by the LAB, was deployed from the 7th march 2016 and will be recovered at the end of July. The location of the deployment is 41°08'06.4"N 1°47'22.6"E and is indicated on the fig 5. The buoy recording system is on a duty cycle 1/2 in daylight and 1/4 at nighttime, to cope with energy requirements. Buoy recordings are made using a hydrophone sampling at 24 kHz with a frequency response of 1 Hz to 80 kHz. The hydrophone is attached to the buoy through a 15m cable. The buoy itself is moored to the seafloor (around 100 m depth) with a mechanical cable and anchors.

Objectives

- To detect fin whale signals and to analyse the signals' acoustic characteristics (On Individual/Subpopulation/Population level and in comparison with data from other locations in the Mediterranean, Atlantic and elsewhere)
- To develop an automatic fin whale detector that is reliable to assess the fin whale presence in the area
- To assist the Fin whale Project in determining the temporal limits of fin whale presence in the area (in combination with visual detections for signal ground truth)
- To assist the Project in understanding the local distribution patterns and the conditions that favour fin whale presence
- To aid the Fin whale Project in legal initiatives as to declare the area as MPA

Methods - recordings

Developing an automated detection and classification algorithm for fin whale signals and assessing the temporal (annual, seasonal, daily) trends

Calculating ambient noise levels in several relevant 3rd octave frequency bands and calculating noise level trends over time. Assessing if there is any relation with the presence of fin whales

Acoustic analysis

Acoustic analysis is conducted through daily inspection of spectrograms and noise data sent through 3G/Satellite, using LIDO software (http://www.listentothedeep.com). Whenever the circumstances allow, raw data is downloaded from the buoy using WiFi and/or an Ethernet connection. (Software: Filezilla) and manual analysis of raw acoustic data is carried out by means of Adobe Audition CS6 and LiDO software. In parallel, an automatic detector is developed using MatLAB R2009a software, and tested in MatLAB and LiDO.

ON-BOARD RECORDINGS

A handheld hydrophone Aquarian Audio H2a XLR with solid state recorder (Marantz PMD661 or Zoom H4n) was deployed opportunistically from the vessel on 17 occasions, with the engine off, at speeds below 3knots and below sea state 3. The hydrophone has a frequency response of 10 Hz to 100 kHz and was sampled at 48 or 96 kHz with the recorder. Concurrent visual sightings of cetaceans were recorded.

A towed array was deployed on 3 days. The array is equipped with two Teledyne Bentos AQ-2000 hydrophones, with 1Hz to 10 kHz frequency response, sampling at 24 kHz. The array is towed behind the vessel with a with 100m cable.

On-board recordings were manually inspected using Adobe Audition CS6 and each occurrence and type of cetacean vocalization was noted.

RESULTS

FIN WHALE - *Balaenoptera physalus*

- Signals recorded on autonomous buoy - *Preliminary results*

From the start of the deployment, there has been a lot of mechanical noise in the lower frequency region below 150 Hz, which is the region of interest (Fig. 1). Several attempts have been made to address this problem, which was not resolved until the beginning of May. 'Clean' data (i.e. data with high signal to noise ratio) are very often presented with low frequency, high-energy sounds of unknown origin that can mask the signals of interest. Examples of different types of unknown signals can be seen in Fig. 2 and 3.

Manual analysis of a very limited amount of data from 2016 has not yet shown the presence of clear fin whale signals.

The preliminary detector, which is based on a very limited number of most probable true positive signals of data from 2015 (ground truth not available), is now being tested on limited data from 2016. For now, the detector gets often triggered by the low frequency tonal signals present in the 2016 data. To address this, we are in the process of developing different detectors that would be able to distinguish between the similar signals. Fig. 4 depicts an example of a 70 Hz downsweep signal that is probably produced by a fin whale, and the results of the preliminary detector in this segment.

Work in process:

Gathering of all raw data. The buoy will be retrieved in July, which is when all data from 2016 will be downloaded for analysis

Testing and developing the preliminary 'Fin whale 70Hz tonal detector' on a limited amount of acoustic data from the buoy, data from the Laboratory of Applied Bioacoustics, and other recordings.

Testing of a preliminary 'Fish 10-40 Hz detector'

A short tonal detector specific for the low-frequency tonal signals (40-100 Hz) that are most probably produced by one or several fish species is being developed.

Analysing time-location (GPS) data

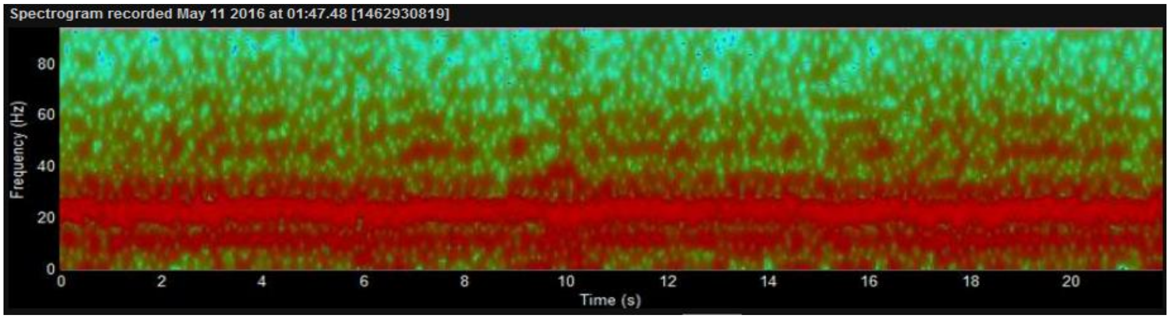

Fig. 1. Spectrogram example of the low frequency noise around 20Hz

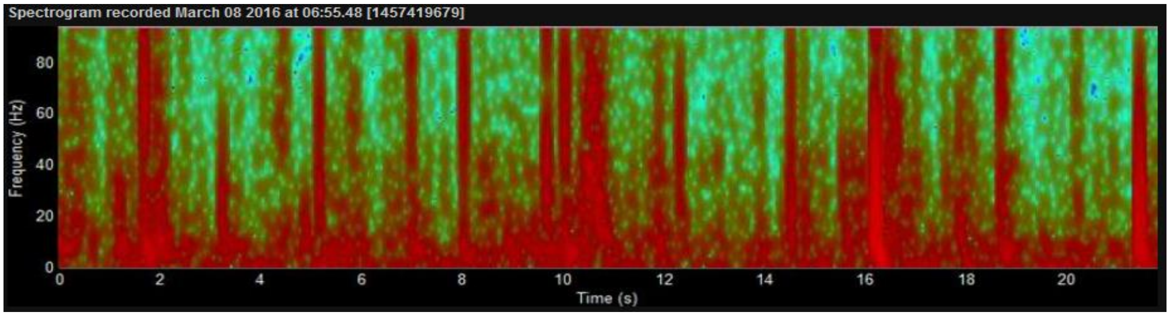

Fig. 2. Spectrogram example of the broadband mechanical noise caused by the configuration of the mooring and hydrophone

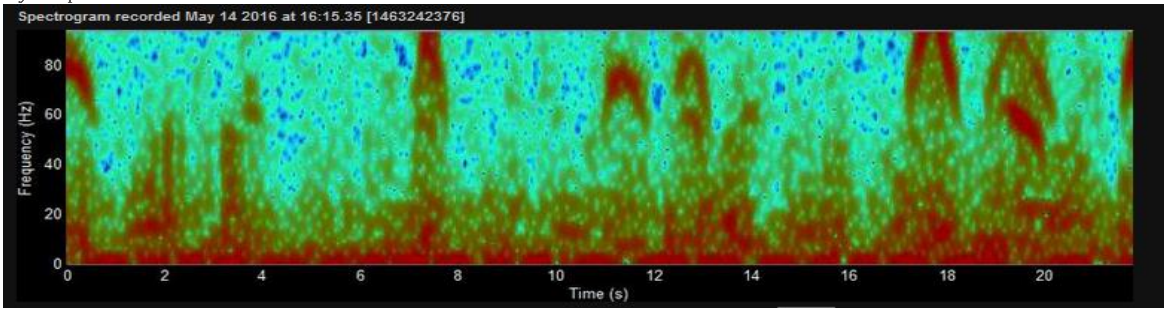

Fig. 3 Spectrogram example of relatively 'clean' data with the presence of low frequency tonal signals (fish?)

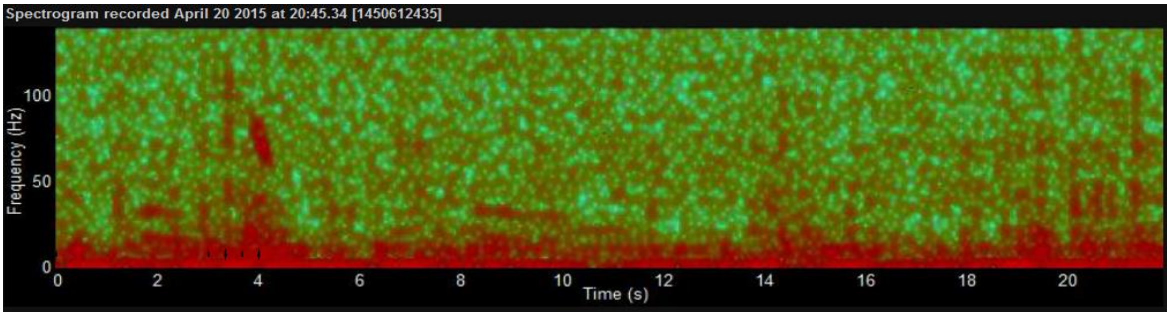

Fig. 4. Spectrogram example of a 70 Hz downsweep signal at about second 4, with the concurrent triggering of the preliminary detector (black dots just above time line). (Note: data from 2015)

- Onboard recordings

Approximately 13 hours of recordings on 17 days were conducted, including 6 hours in the vicinity of whales (<1500 m). Recordings included solitary animals and groups of 2 to 3 individuals. Individuals in groups were either separated by one or two body lengths (sometimes displaying synchronized surface movements), or more dispersed showing no obvious signs of one animal being aware of the presence of the other. Most of the time, concurrent behavioral observations seem to indicate prevalent foraging or feeding behavior.

No 70 Hz downsweeps corresponding to the signals captured on the autonomous buoy have been detected and no attempts were made to detect potential lower frequency fin whale signals in the 40 Hz and the 20 Hz bandwidths. The low frequency bandwidth up to 60 Hz was regularly masked by noise generated by the water flow on the hydrophone, preventing reliable visual detection of the signals on the spectrograms. This noise is induced by the speed of the boat while on sail, and swell and wind conditions.

Equipement	Specie	No. of recording days	Total lenght of recording	No. of files with concurrent visual detections	No. of files with acoustic detection
Handheld hydrophone	Fin whale	17	06:09:27	26	0
	Bottlenose dolphin	3	02:06:39	19	11
	Risso's dolphin	1	00:14:40	2	1
	Long-finned pilot whale	1	00:20:39	2	1
	Striped dolphin	1	00:23:55	1	1
	Sperm whale	1	na	0	1
	Dolphin spp.	1	na	0	1
	Total	**17**	**12:56:21**	**50**	**16**
Towed array	Risso's dolphin	1	00:46:14	6	6
	Dolphin spp.	1	02:13:15	0	11
	Sperm whale	2	na	0	5
	Total	**3**	**06:00:55**	**6**	**22**

Table 1. Summary of on-board recordings

Five other cetacean species have been opportunistically recorded on-board, with the handheld hydrophone and the towed array. Table 1 resumes the acoustic detection during the 2016 survey season and raw data appears in Appendices VI and VII. Overall, 20 days of recordings including 17 with hydrophone and 3 with towed array. Fig. 5 displays the location of the recordings for both recording systems.

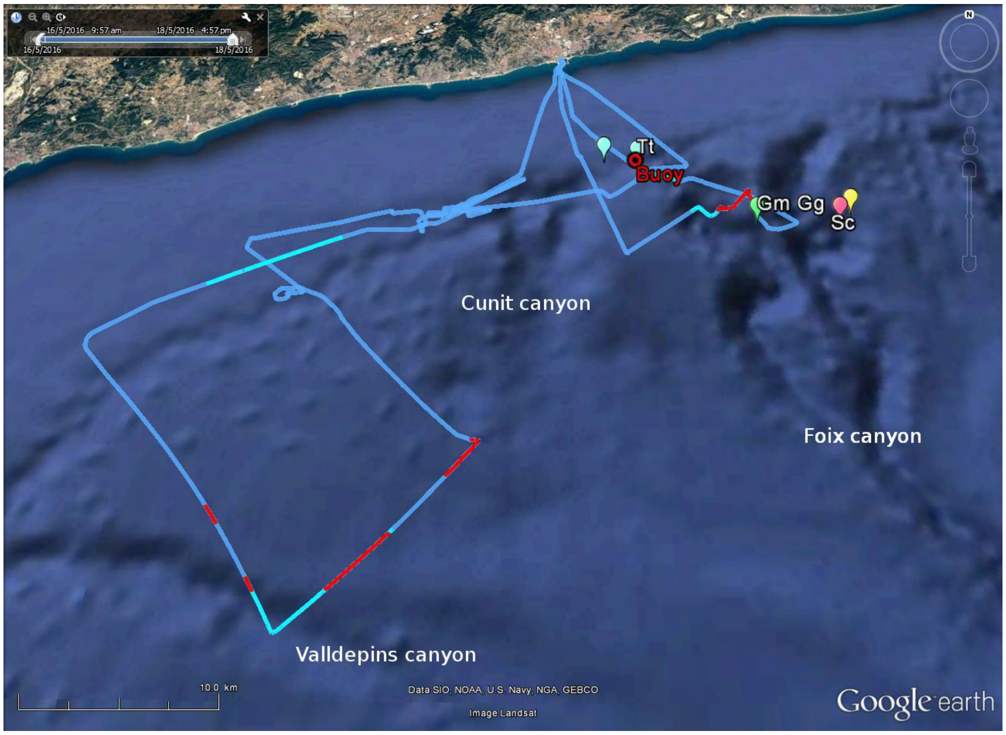

Figure 5. Towed array and handheld hydrophone recording map
Off acoustic effort (dark blue), on acoustic effort (light blue), detection (red) with towed array.
Pins shows location of the buoy and recordings of different species with handheld hydrophone (Tt *Tursiops truncatus*, Gg *Grampus griseus*, Gm *Globicephala melas*, Sc, *Stenella coeruleoalba*).

SPERM WHALE - *Physeter macrocephalus*

Sperm whale clicks were detected on two occasions without visual detection of the presence of the animals. The GPS location of the first recording indicates a vessel position above the Foix canyon, while on the second occasion, recordings were made further offshore, between Valldepins and Cunit canyons. Both locations correspond to depths around 1000 m. The spectrograms showed clicks with inter click interval (ICI) duration of approximately 500 ms, characteristic of this species (Fig. 6).

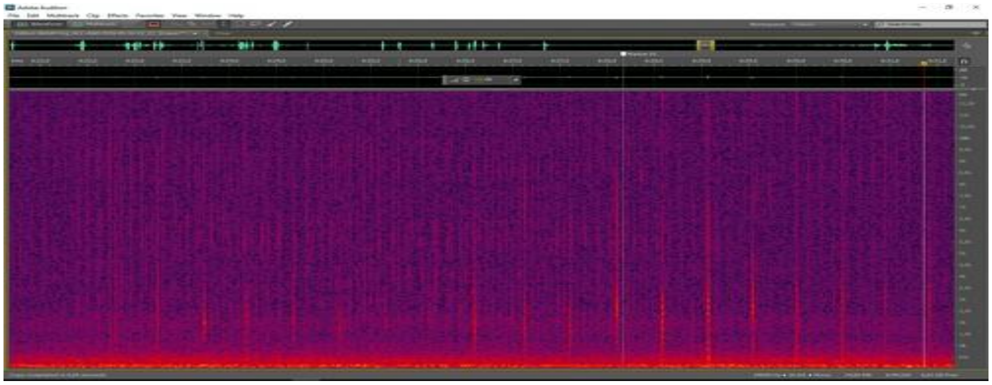

Fig 6. Spectrogram screenshot showing sperm whale clicks recorded on the 16 May 2016
(Spectrogram settings: Hann window, FFT 512, 0-12 kHz, time window 10s)

LONG-FINNED PILOT WHALE - *Globicephala melas*

On one occasion, a group of 6 pilot whales was recorded using the handheld hydrophone. The recordings were made between the two heads of the Foix canyon. The analysis of the recording showed clicks, buzzes and pulsed calls (Fig. 7 and 8). A pulsed call shows a low frequency and a high frequency component.

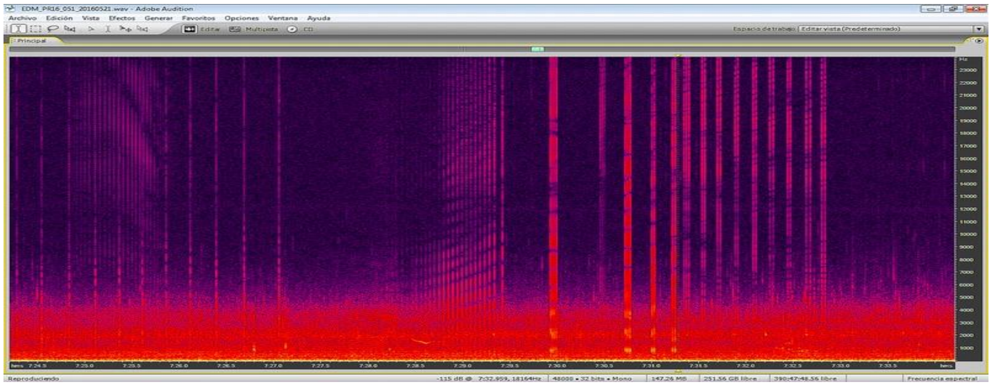

Fig 7. Spectrogram screenshot showing long-finned pilot whale clicks recorded on the 21 May 2016
(Spectrogram settings: Hann window, FFT 512, 0-24 kHz, time window 10 s)

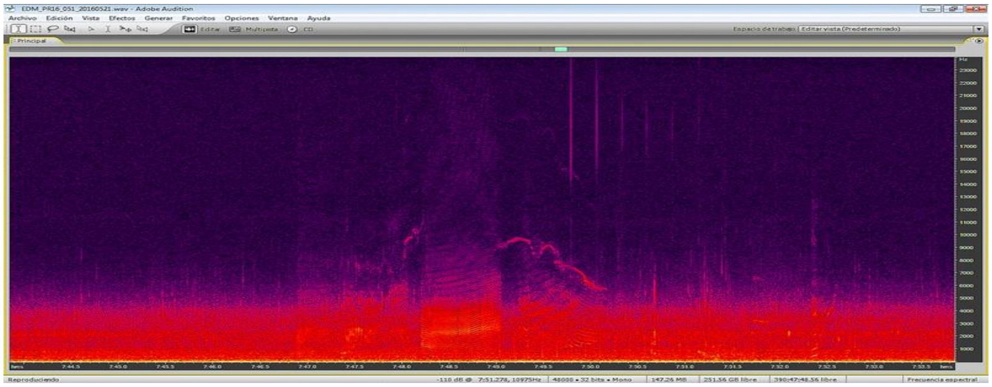

Fig 8. Spectrogram screenshot showing long-finned pilot whale buzz and pulsed call recorded on the 21 May 2016 (Spectrogram settings: Hann window, FFT 512, 0-24 kHz, time window 10 s)

RISSO'S DOLPHIN - *Grampus griseus*

Risso's dolphin were recorded on two occasions, using the towed array and the handheld hydrophone. Both recordings are located on top of the Foix canyon. Handheld hydrophone and towed array both display clicks with difference in frequency bandwidth. Clicks on the handheld hydrophone are characteristics of the species regarding the minimum frequency around 20 kHz and the presence of spectral peaks and notches (Fig. 9). Clicks recorded on the towed array do not show those characteristics and displays very low frequency components and no spectral peaks (Fig. 10). This can be caused by aliasing, an artifact that results when the signal reconstructed from samples is different from the original signal. Aliasing occurs when frequency components of the original signal are above the folding frequency for the considered sampling rate. Here, the sampling rate of the towed array is 24 kHz, corresponding to a folding frequency of 12 kHz. The clicks of Risso's dolphin have mean maximum frequency around 100 kHz, so aliasing is likely to occur.

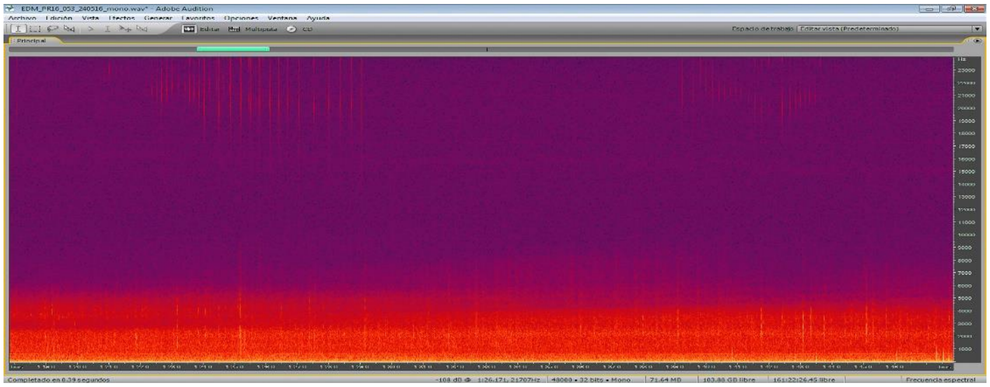

Fig 9. Spectrogram screenshot showing Risso's dolphin clicks recorded on the 24 May 2016 (Equipment : handheld hydrophone, Spectrogram settings: Hann window, FFT 512, 0-24 kHz, time window 30 s)

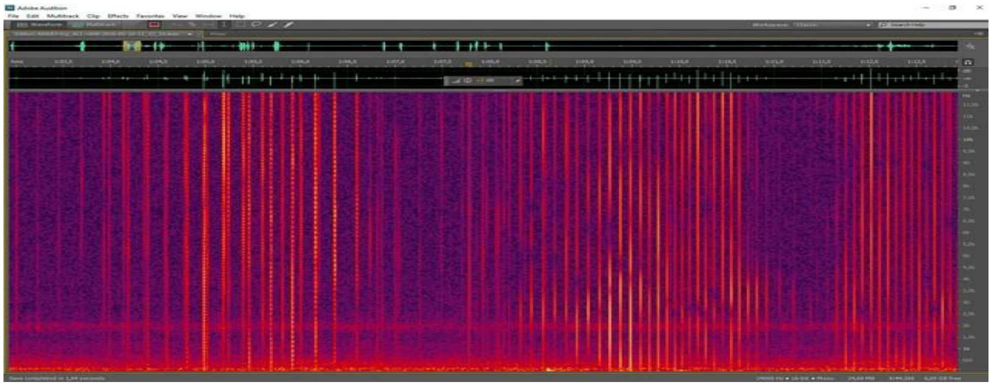

Fig 10. Spectrogram screenshot showing probable Risso's dolphin clicks recorded on the 16 May 2016 (Equipement : Towed array, Spectrogram settings: Hann window, FFT 512, 0-12 kHz, time window 10 s)

BOTTLENOSE DOLPHIN - *Tursiops truncatus*

On three occasions, the handheld hydrophone was deployed in the presence of Bottlenose dolphins. On 3 May and 30 May 2016, in the same area above the continental shelf, at depth between 85-107 m, vocalizations were recorded. Analysis revealed presence of clicks, buzzes and whistles including REWTs. REWTs (Repeatedly emitted whistles types) were detected on 5 files (Fig. 11 and 12). REWT refers to whistles types that are produced at least twice in a time period of 0.25 s to 10 s. (Kriesell et al. 2014).

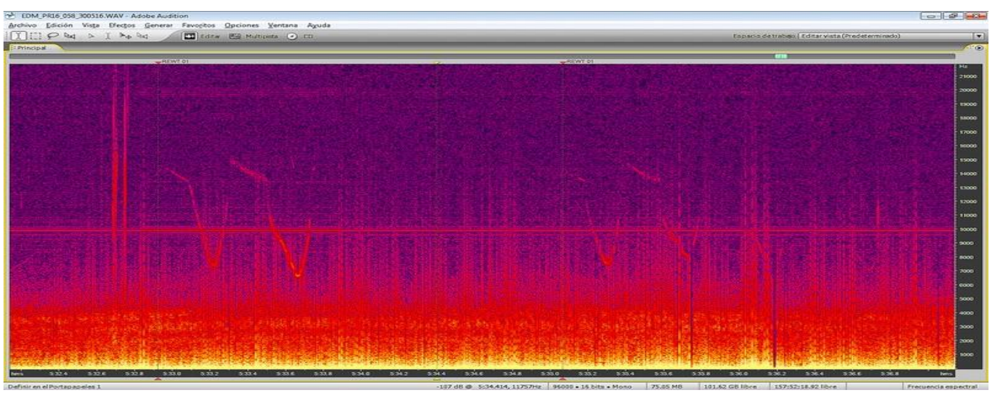

Fig 11. Spectrogram screenshot of bottlenose dolphin's REWT, recorded on the 30 May 2016 (Spectrogram settings: Hann window, FFT 512, 0-24 kHz, time window 5 s)

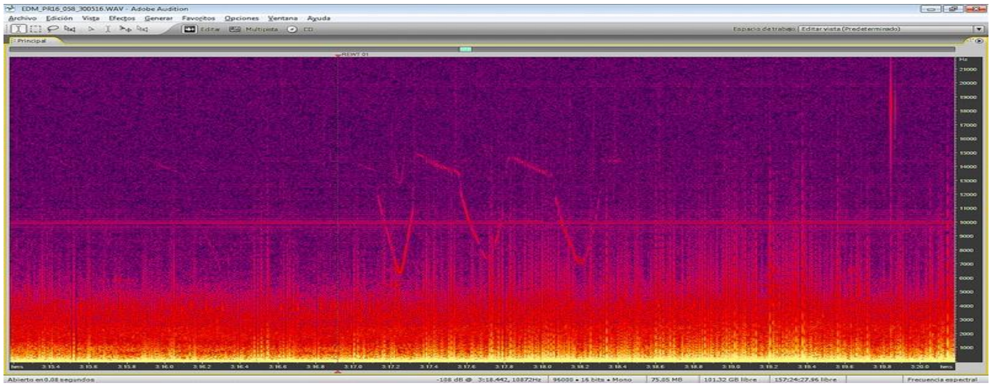

Fig 12. Spectrogram screenshot of a bottlenose dolphin's whistle, showing the same REWT separated by 2 minutes. (Spectrogram settings: Hann window, FFT 512, 0-24 kHz, time window 5 s)

DISCUSSION

FIN WHALES

From the preliminary 2015 and 2016 results on the buoy recordings, very few 70 Hz signals were detected and no signals were manually detected in the 6 hours of recordings from the handheld hydrophone deployed in the presence of whales. Nevertheless, 2015 and 2016 buoy recordings are still to be analysed with the latest version of the automated detector. In addition, on-board recordings were opportunistic and the mean length of a recording session was short, below 30 min. Thus, these results need to be interpreted with caution.

Despite those limitations, these data suggests that fin whales in the Garraf coast tend to be vocally quieter than previously reported by literature. Nevertheless, most studies have focused on the 20 Hz signal emitted in patterned song, (Watkins et al. 1987, Edds Walton, 1997, Clark et al. 2002, Sirovic et al. 2009, Siacca et al. 2015) and the 70 Hz downsweeps signal from fin whale seems much less studied. For example, in the Balearic Sea, Castellote (2012) refers to those signals using autonomous recorders, but his analysis focused on the most prevalent signal, the 20 Hz note and no information on single 70 Hz downsweeps call rate were available from this dataset. In the Northern Atlantic Ocean, matching signals in the same frequency bandwidth were reported. Occurrences of those signals were rare (4%) compared to the others types of signals, including the 20 Hz call (Boisseau et al. 2008). In an earlier study, Watkins (1981) refers to similar higher frequency downsweeps between 40-100 Hz. This study emphasizes on the relationship between behavioral state and the use of vocal repertoire. His findings shown that the higher vocalizations were most often heard during group activity. The study also refers to the presence of more than one animal when these vocalizations were recorded, but points out that the animals were silent most of the time. Interestingly, Watkins (1981) also reported an apparent increase in the calling rate at nighttime. Delarue (2008) studied the vocal repertoire of fin whales in the Gulf of Saint Laurent (Quebec) and found 8 distinct types of calls, among them D-Calls, which frequency parameters and shape match our 70 Hz signals. As noted by Watkins, this type of signal appears to be related to specific behavioral context of socialization between whales in surface active groups (Delarue, pers. comm.). In addition, other studies from acoustic recording tags on fin whales concluded that calling animals were more likely to be travelling than milling, in groups rather than solitary, and shown great variability between tagged individuals, some whales remaining silent during several hours (Stimpert et al. 2015).

From the data collected on-board it seems that the overall number of fin whales per encounter are between 1-2, and behavioral foraging or feeding states were prevalent. Both group size and behavioral state could then explain the overall very few numbers or the absence of 70 Hz calls recorded in this study.

OTHERS CETACEANS

Five species of cetaceans have been recorded during opportunistic encounters while on transect survey for the Fin whale project. Although these recordings are few and of short duration, their analysis revealed some interesting features.

Sperm whale clicks detected on the towed array and the handheld hydrophone show typical characteristic of ICI (Inter Click Interval) duration of 500 ms (Weilgart & Whitehead, 1988). Acoustic detection was reported on both occasions in the absence of visual detection. Sperm whales dive to great depths using repetitive, distinct vocalizations for echolocation and communication but spend little time at the surface, reducing the likelihood of visual sighting. Combined visual and acoustic surveys increase the detection rate (Van Parijs et al., 2009). Once acoustic localization is achieved and animals are encountered, individuals can be identified using photo identification techniques.

Recordings of Bottlenose dolphins display interesting vocalization features called REWTs. REWTs refer to whistle types that are produced at least twice in a time period of 0.25 s to 10 s. (Kriesell et al. 2014) and can be indicative of the presence of signature whistles in the recordings (Janik et al. 2013). A signature whistle type is an individually distinctive whistle type within a dolphin's repertoire that broadcasts the identity of the caller (Janik and Sayigh, 2013). The small amount of data gathered here on these whistles did not allow the identification of signature whistles. Literature reports that *Tursiops truncatus* can emit 50% of the whistles as signature whistles (Cook et al. 2004), thus granting the possibility of readily identifying individuals when extending the recording time.

Pilot whales were recorded on one occasion during 20 minutes. Spectrogram analysis shows presence of whistles, clicks, buzzes and pulsed calls. Long-finned pilot whales produce complex pulsed calls that can involve biphonation and combinations of pulsed and tonal elements, and separate high frequency tonal components (Caldwell & Caldwell, 1969; Nemiroff and Whitehead, 2009). Sayigh et al. (2013) showed that those calls can be stereotyped and suggested that these may be indicative of group identity.

CONCLUSION

Edmaktub documents Fin whale presence along the Garraf coast since three years. The use of an autonomous buoy through a collaboration with the LAB and the use of on-board recordings can bring new insight into this presence, and the habitat use of these whales in this area. Passive acoustics can generate large amounts of data and work is still in progress to improve automatic detection and to extract useful information from the data collected. On-board opportunistic recordings did not show the fin whales signals of interest, which could be attributed to behavioral states or group size and would require further investigations. The use of a handheld hydrophone and a towed array aboard the Edmaktub vessel permitted to record five additional cetacean species. Although there are only few opportunistic recordings for each of these species, this work highlights the contribution that PAM can bring into Edmaktub research, with more extensive use or dedicated surveys.

Although eight cetacean species occur in Catalan and Balearic seas, few studies have examined cetacean distribution, abundance estimates or habitat use in this area. However, those populations are listed as endangered, vulnerable, or data deficient and face many threats in Mediterranean Sea, including interactions with fisheries, noise and chemical pollution, maritime traffic. The study area along the Garraf coast is of special interest and represents a unique opportunity to gather scientific data on Mediterranean cetacean populations, including oceanic species that are usually difficult to study. Passive acoustic monitoring is a useful non-invasive method for assessing cetacean abundance and trends, defining habitat use and monitoring population characteristics. Acoustic data gathered during Edmaktub campaigns can improve general knowledge about cetacean populations and contribute establishing baselines for the future assessment of cetacean population in the Catalan-Balearic sea.

GOING FURTHER

FIN WHALE

- To extend on-board recordings to assess use of vocal signals during different behavioral states, different group size, and different times of the day (nighttime, dusk, dawn) .
- To record detailed behavioral data concurrently to acoustic recordings, in order to relate calling signals and calling rate to behavioral states.
- To obtain autonomous buoy data with reasonable background noise levels that allows automated detections to be performed over the 4-month fin whale presence in the area.
- To develop a classifier: due to similarity with probable fish sounds in frequency bandwidth, shape of signal, there is necessity to develop a classifier that can accurately discriminate between these two types of signals.
- To develop an acoustic tagging project to obtain integrated visual, acoustic, dive and feeding behavior of fin whales.

OTHER CETACEAN SPECIES

The use of handheld hydrophones onboard is simple, with the advantage of fast deployment. Systematic use of these devices will provide extra information on other cetacean species along the Garraf coast.

- To collect acoustic data at daytime combined with visual sighting to obtain labelled data for development of an automated classifier
- To collect acoustic data at nighttime to gain more information of cetacean presence in conditions were visual is not an option and examine diel variations in the acoustic behavior.
- To identify species using vocalizations characteristics:
  - Sperm whales, beaked whales, Risso's clicks can be used to discriminate between these species
  - Delphinids whistles can be used to identify species through automated detection and classification algorithms.
- To identify sub population or groups using vocalizations characteristics. Bottlenose dolphins signature whistles and pilot whales stereotyped pulsed calls can be used for individual or group identification.
- To conduct study on acoustic repertoire combined with behavior and estimate call rates that are compulsory for abundance estimation.
- To conduct study on habitat use employing echolocation characteristics as indicators of foraging effort.

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APPENDICES

APPENDIX I : CETACEAN SPECIES ALONG THE GARRAF COAST AND CONSERVATION STATUS

COMMON NAME	SCIENTIFIC NAME	IUCN RED LIST GLOBAL STATUS	IUCN RED LIST MEDITERRANEAN STATUS	CATALOGO ESPANOL DE ESPECIES
Common bottlenose dolphin	*Tursiops truncatus*	Least concern	Vulnerable	Vulnerable
Striped dolphin	*Stenella coeruleoalba*	Least concern	Vulnerable	Special interest
Short-beaked common dolphin	*Delphinus delphis*	Least concern	Vulnerable	Vulnerable
Risso's dolphin	*Grampus griseus*	Least concern	Data deficient	Special interest
Long-finned pilot whale	*Globicephala melas*	Data deficient	Data deficient	Vulnerable
Cuvier's beaked whale	*Ziphius cavirostris*	Least concern	Data deficient	Special interest
Sperm whale	*Physeter macrocephalus*	Vulnerable	Endangered	Vulnerable
Fin whale	*Balaenoptera physalus*	Endangered	Vulnerable	Vulnerable

List and conservation status of cetacean species represented by population regularly present in the Mediterranean Sea.

APPENDIX II : LAB AUTONOMOUS BUOY - TECHNICAL SPECIFICATIONS

Customized Buoy Mobilis DB 500

Mooring with anchors, chain and rope

Solar power: 3 solar panels with12V/32Wp @ 92Wh/d with dimensions 440 x 460 x 2 mm, 2kg, inox support, 1 regulator, 1 solar battery with max 12V/80Ah, IP66 weatherproof box with loading capacity of about 460x400x230mm

1 analogue hydrophone: 1 Hz to 80 kHz, sensitivity: -180 dB re 1V/µPa

A/D converter, 16-bit, sampling 200 kS/s

System to process the signal in real time (embedded computer)

Transmission system for sending data via WiFi/3G/Satellite

GPS and AIS reception

Sampling frequency 24 kHz

On the left:

LAB team members, Alba Solsona Berga, Michel André, Mike van der Schaar, Steffen de Vreese, Ludwig Houégnigan and Edmaktub president Eduard Degollada during buoy deployment.

On the right:

Details of the buoy showing hydrophone cable (top) and weatherproof case containing acquisition system (bottom).

APPENDIX III : HANDHELD HYDROPHONE AND RECORDERS - TECHNICAL SPECIFICATIONS

Aquarian Audio H2a-XLR	Marantz PM661 Solid State Recorder	Zoom H4n Solid State Recorder
		
Sensitivity: -180dB re: 1V/mPa (+/- 4dB 20Hz-4.5KHz) Useful range: <10 Hz to >100KHz Polar Response: Omnidirectional (horizontal) Operating depth: <80 meters Power: 0.6 mA (typical)	Digital recording at 44.1/48/96 kHz sample rate at 16 or 24-bit quantization Uses stable, reliable SD or SDHC memory cards WAV (Broadcast WAV File) or MP3 recording format Two XLR inputs, mic/line switchable with +48V phantom power S/PDIF digital input, plus a spare 1/8" stereo line in RCA stereo line level outputs USB 2.0 port for easy file transfer ¼-inch headphone jack with volume control	Records 24-bit/96 kHz digital audio, bitrates up to 320kbps Two combination XLR & 1/4-inch input jacks with phantom power Mini-Jack Mic Input with plug-in power WAV (Broadcast WAV File) or MP3 recording format USB 2.0 file transfer

APPENDIX IV : TOWED ARRAY - TECHNICAL SPECIFICATIONS

Box

The box is equipped with a pre amplifier, has connection to ADC converter and a connection to the hydrophone cable

ADC converter USB-1608G

16-bit high-speed USB devices

Acquisition rates ranging from 250 kS/s to 500 kS/s

16 single-ended (SE) or 8 differential (DIFF) analog inputs

Up to 2 analog outputs

8 digital I/O

Two 32-bit counter input channels

One timer output channel

Teledyne Benthos AQ-4 hydrophones

Sensitivity (dBv re 1µPa @ 20C) : -201

Frequency response (+/- 1.5 dB): 1Hz to 15 kHz

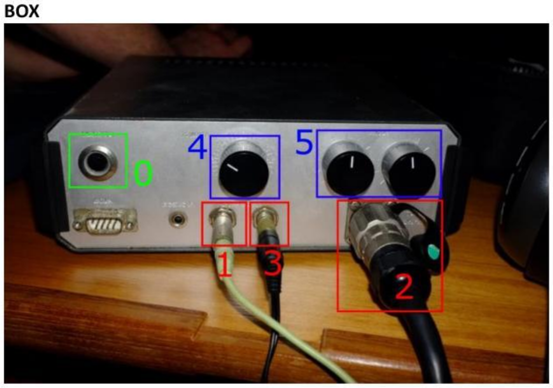
Depth (m): 3300

APPENDIX V : TOWED ARRAY USER NOTES

LIDO/EDMAKTUB Towed Array Recording System – USER NOTES

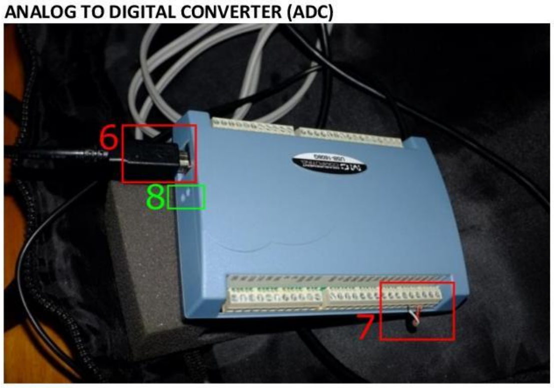
1- Presentation: Box, ADC, Netbook and Array

BOX



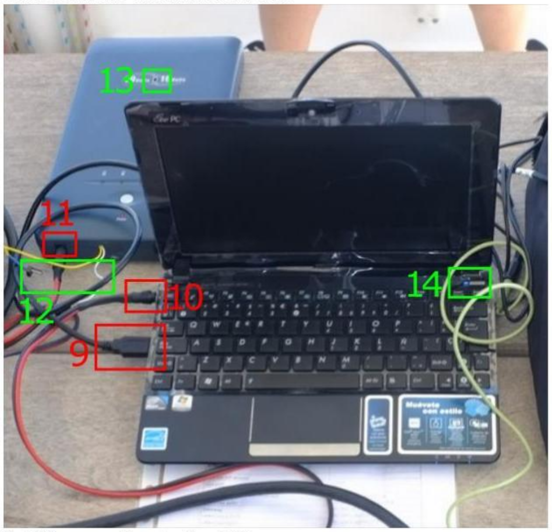
0- Switch on button
1- Connection to the ADC
2- Connection to hydrophone array via dedicated cable
3- Connection to headphones
4- Headphones gain (Volume button – very sensitive)
5- Hydrophones gain (Sensor button – 2 channels, one for each hydrophone in the array)

ANALOG TO DIGITAL CONVERTER (ADC)



6- USB connection to the Notebook
7- Connection to the box
8- Green light (lower one blinking when recording)

NETBOOK AND EXTERNAL BATTERY



9- USB connection to the ADC
10- Power connection to the external battery
11- Power connection to the Notebook
12- Switch on/off system of the external battery (on by unplugging the 2 wires /off by plugging them)
13- Switch button 19V-16V to allow battery charging
14- Switch on button

ARRAY

15- Connection to the array cable connected to the box
16- Connection to the array

2- Steps to connect the system

1 - Box

Plug the internal battery of the box (do not forget to unplug the battery when recording is done at the end of the day)
Plug in the connection to ADC converter (green and black cable) (1)
Plug in the array connection cable (2)
Plug in the headphones (3)

2 - ADC converter

Plug in the USB connection to Netbook (6)
The connection to the box is wired and cannot be removed (7)
Connect to grounding point if electrical noise (batteries of the boat are charging) – Ask Eduard to do it

3 - Netbook

Plug in the external battery (10-11)
Plug in the USB connection to ADC (9)

4 - Array

Plug in the array connection cable from box to array (15-16)

SYSTEM CONNECTED

3 - Recording

Box
Switch on the box (0)

Netbook
Switch on the netbook :) – press top right button
Allow some time for the Netbook to start, wait until the desktop appears.
(No password require, otherwise, NURC password: akula971)
Open Firefox (It automatically opens to the LIDO webpage)

To start (and stop) recording:
Click on “Configuration”

To start recording
Press “Start acquisition”
The green light should be blinking on the AD/C box (8)
To stop recording
Press “Stop acquisition”
The green light on the AD/C should stop blinking (8). If not, unplug and replug the USB cable from the AD/C connection from the computer side.

To see the (practically) real-time spectrogram:
On the LIDO webpage, click on “Status page”
Wait for half a minute to see the data appearing on the spectrogram (delay)
If spectrogram appears red, the gain is too high, turn the hydrophone gain button to the left (5)
If spectrogram appears blue, the gain is too low, turn the hydrophone gain button to the right (5)
If you want to change the volume or change the gain on both channels at the same time, turn the headphones gain button.
Check on the spectrogram the change in gain are OK.

To listen (almost) real-time
On the LIDO webpage, click on “Listen on site”. There are two channels available, the first one (ch 00) is high pass filtered to avoid hearing engine noise, the second channel (ch 01) has the full bandwidth.
Other (better) option to listen:
Plug headphones directly to the box (4), sound is real-time and in stereo, allowing (a skilled operator) to hear if an animal is in front or behind the array.

Recording storage and transfer (on Netbook – temporary solution until the Toshiba is prepared)
Either click on the shortcut “Array” on the desktop or go to:
Home folder/file system/mnt/datasets/array, to see all the run
As the memory space is limited on the Netbook, transfer the run from the day to a USB key (usually formatting in FAT32 or EXFAT).

To charge the external battery of the netbook
Disconnect the two external wires of the battery (white and red), the battery should be on (red light on). Then switch small button on top of the battery from 19 to 16. This will allow the battery to be charge (the red light should be off).

Any questions, inquiries or complains:
Contact Mike, hardly ever happy to help :) - mike.vanderschaar@upc.edu

FE for LAB/Edmaktub – Last updated on 26/05/2016

APPENDIX VI : ON BOARD RECORDINGS – HANDHELD HYDROPHONE

Date	File lenght (hh:mm:ss)	Start time UTC (hh:mm:ss)	Fin whale visual detection (Y/N)	fin whales 70Hz signal (Y/N)	Other cetacean specie visual	No. animals	Click Whislte Buzz Other	Behavior	Estimated distance to animals (m)	Depth (m)
2016-03-30	01:03:12	07:06:05	Y	N	N	2	C W	Not evaluated	15	97
2016-03-30	01:03:15	08:09:20	Y	N	N	2				
2016-03-30	00:09:38	09:12:38	Y	N	N	2				
2016-03-30	00:45:57	09:23:34	Y	N	N	2				
2016-04-07	00:00:41	12:05:53	Y	N	N	2		unidentified	1000	79,1
2016-04-07	00:00:53	12:06:54	Y	N	N	2				
2016-04-07	00:02:41	12:22:42	Y	N	N	2				
2016-04-07	00:01:31	12:53:10	Y	na	N	2	na			
2016-04-07	00:19:50	14:40:20	N	N	N					
2016-04-10	00:09:35	10:47:49	Y	na	N	2	na	Not evaluated	300	na
2016-04-10	00:07:24	10:58:26	Y	N	N	2				
2016-04-10	00:25:23	12:25:00	Y	N	N	2			600 to 1500	
2016-04-16	00:01:04	10:02:02	Y	na	N	1	na	Unidentified	926	120,4
2016-04-16	00:00:41	12:41:47	Y	na	N	2	na	travelling	1852	117,1
2016-04-16	00:02:30	12:45:39	Y	N	N	2				
2016-04-16	00:05:40	13:16:15	Y	N	N	2				
2016-04-16	00:20:33	13:59:14	N	na	N		na			
2016-04-17	00:15:03	10:00:13	Y	N	N	3		Unidentified	1852	73,2
2016-04-17	00:05:58	10:16:08	Y	N	N	3		Unidentified	1852	na
2016-04-17	00:02:50	11:00:00	Y	N	N	2				
2016-04-17	00:07:52	11:42:20	Y	N	N	2				
2016-04-18	00:07:53	09:39:58	Y	N	T. truncatus	15		other	400	85
2016-04-18	00:28:13	12:49:38	Y	N	N	2		not evaluated	400	na
2016-04-18	00:15:17	13:18:40	N	N	T. truncatus	10		not evaluated	5	105
2016-04-19	00:21:38	14:22:08	Y	N	N	1		not evaluated	400	na
2016-04-19	00:34:19	14:44:47	N	N	N					
2016-04-25	00:01:57	14:45:32	Y	N	N	2		Unidentified	2798	na
2016-04-25	00:08:03	14:48:03	Y	N	N	2		foraging	150	na
2016-04-26	00:15:02	12:41:09	N	N	N			socializing	200	na
2016-04-29	00:07:09	14:22:30	N	N	N			travelling	250	na
2016-04-29	00:34:39	14:58:25	N	N	N					
2016-04-29	00:16:23	15:34:32	N	N	N					
2016-05-03	00:03:07	12:38:48	N	N	T. truncatus	6	W	socializing	700	na
2016-05-03	00:03:01	12:42:00	N	N	T. truncatus	6				
2016-05-03	00:03:34	12:45:03	N	N	T. truncatus	6				
2016-05-03	00:01:50	12:49:42	N	N	T. truncatus	6				
2016-05-03	00:17:14	12:52:17	N	N	T. truncatus	6	W			
2016-05-04	00:30:54	08:57:15	N	N	N			unidentified		100
2016-05-04	00:23:55	13:10:53	N	N	S.	50	C? W?	travelling	50 to 300	na
2016-05-04	00:04:11	13:34:52	Y	N	N	1	C?		100 to 200	
2016-05-11	00:25:42	12:39:00	Y	N	N	1		not evaluated	200	na
2016-05-21	00:13:24	12:05:00	N	N	G. melas	8	C W B O	unidentified	80	na
2016-05-21	00:07:14	12:18:25	N	N	G. melas	8				
2016-05-24	00:06:31	13:21:34	N	N	G. griseus	4	C		20 to 100	na
2016-05-24	00:08:09	13:28:11	N	N	G. griseus	4				
2016-05-28	00:03:03	13:19:24	N	N	N					
2016-05-28	00:06:51	13:23:23	N	N	N					
2016-05-28	00:35:18	13:30:44	N	N	N					
2016-05-30	00:06:50	11:51:07	N	N	T. truncatus	10	C W	foraging	50 to 100	107,6
2016-05-30	00:04:56	11:58:00	N	N	T. truncatus	10			50 to 300	
2016-05-30	00:04:23	12:02:59	N	N	T. truncatus	10	C W		50 to 200	
2016-05-30	00:05:25	12:07:26	N	N	T. truncatus	10	C W		100 to 400	
2016-05-30	00:05:01	12:12:54	N	N	T. truncatus	10	C W		150 to 300	
2016-05-30	00:04:02	12:17:58	N	N	T. truncatus	10	C		out of sight	
2016-05-30	00:07:35	12:22:02	N	N	T. truncatus	10	C W B		200 to 400	
2016-05-30	00:06:25	12:29:39	N	N	T. truncatus	10	W B		20 to 100	
2016-05-30	00:09:34	12:36:09	N	N	T. truncatus	10	W		200 to 500	
2016-05-30	00:03:31	12:45:44	N	N	T. truncatus	10	C W B		20 to 100	
2016-05-30	00:09:53	12:49:17	N	N	T. truncatus	10			400 to 600	
2016-05-30	00:07:09	12:59:11	N	N	T. truncatus	10			out of sight	

APPENDIX VII : ON BOARD RECORDINGS –TOWED HYDROPHONE

Date	Time UTC (hh:mm:ss)	File lenght (hh:mm:ss)	Vocalization (Click, Buzz, Whistle)	Species	Number of animals	Visual confirmation (Y/N)
2016-05-16	10:12:42	00:08:44				
2016-05-16	10:21:26	00:06:11		shrimp?		
2016-05-16	10:28:37	00:08:44		shrimp?		
2016-05-16	10:37:21	00:08:44				
2016-05-16	10:46:05	00:08:44				
2016-05-16	10:54:50	00:08:44				
2016-05-16	11:03:34	00:08:44				
2016-05-16	11:12:18	00:08:44	C	Pm(?) + Gg	3 Gg	Y (Gg)
2016-05-16	11:21:03	00:08:44	C, B	Gg	3 Gg	Y (Gg)
2016-05-16	11:29:47	00:08:44	C, B	Pm(?) + Gg	3 Gg	Y (Gg)
2016-05-16	11:38:31	00:08:44	C	Gg	3 Gg	Y (Gg)
2016-05-16	11:47:15	00:08:44	C	Pm(?) + Gg	3 Gg	Y (Gg)
2016-05-16	11:56:00	00:02:33	C	Pm(?) + Gg	3 Gg	Y (Gg)
2016-05-16	12:04:35	00:01:27				
2016-05-16	13:58:28	00:08:44				
2016-05-16	14:07:12	00:08:44		shrimp?		
2016-05-16	14:15:16	00:06:55		shrimp?		
2016-05-17	19:38:48	00:08:44				
2016-05-17	20:33:23	00:08:44				
2016-05-17	20:42:07	00:08:44				
2016-05-17	20:50:52	00:06:11				
2016-05-18	00:18:26	00:08:44	C, B	dolphin spp		N
2016-05-18	00:27:41	00:01:49	C	dolphin spp		N
2016-05-18	00:59:08	00:08:44	C, B	dolphin spp		N
2016-05-18	01:07:52	00:08:44				
2016-05-18	01:16:36	00:08:44				
2016-05-18	01:25:21	00:08:44				
2016-05-18	01:34:05	00:08:44				
2016-05-18	01:42:49	00:08:44				
2016-05-18	01:51:33	00:08:44				
2016-05-18	02:00:18	00:08:44				
2016-05-18	02:09:02	00:08:44	C, B	dolphin spp		N
2016-05-18	02:17:46	00:08:44	C	dolphin spp		N
2016-05-18	02:26:31	00:04:44	C	dolphin spp		N
2016-05-18	02:35:52	00:08:44	C, B	dolphin spp		N
2016-05-18	02:44:37	00:08:44	C, B	dolphin spp		N
2016-05-18	02:53:21	00:08:44	C, B	dolphin spp		N
2016-05-18	03:02:05	00:02:33				
2016-05-18	03:54:58	00:08:44	C	dolphin spp		N
2016-05-18	04:03:43	00:08:44	C, B	dolphin spp	>1	N
2016-05-18	04:12:27	00:08:44	C	dolphin spp		N
2016-05-18	04:21:11	00:08:44	C	dolphin spp		N
2016-05-18	04:29:55	00:08:44	C, creak	Pm + dolphin spp	2	N
2016-05-18	04:38:40	00:08:44	C	dolphin spp		N
2016-05-18	04:47:24	00:08:44	C W	dolphin spp		N
2016-05-18	04:56:08	00:04:22	C	dolphin spp		N

Pm : Physter macrocephalus
Gg : Grampus girseus