Project ID : 2927

Monitoring and Conservation Strategies of Dugong in Northern Mozambique

FINAL REPORT

Location:
Pemba, Mozambique

Project Period
15/05/16 – 31/06/2017

Institutions Involved
Parque National das Quirimbas
Istituto Oikos Onlus

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Project Partners & Collaborators

Istituto Oikos – logistic and operational support

Eco Moçambique – support in the implementation of awaraness rasining activities

PNQ - logistic and operational support

Lúrio University – dissemination of project activities

Centro Interdisciplinare di Bioacustica e Ricerche Ambientali of University of Pavia

AEST – set up of electronics of bioacoustics devices

COLMAR – realization of waterproof container

Alessandra Gagliardi, Insubria University – technical support on field activities

Gianni Pavan – design of underwater recorders, technical support, field work and data analysis

Section 1

Summary

The intervention was carried out in Quirimbas National Park, Northern Mozambique with the overall objective of promoting conservation actions in favor of dugong and biodiversity in the area.
The project had 2 specific objectives: i) to collect baseline and scientific evidence and information of the presence and distribution of dugong in QNP northern Mozambique; and ii) to reduce the disturbance on marine species by stakeholders communities.
Data were collected using automatic underwater sound device system. The project involved park staff and fishermen communities in order to build local capacities and spread awareness about the importance of conservation and management of natural resources. The project counted on the support of an international NGO working in the Park and a research group expert in bioacoustics monitoring.
Key results of the projects were: 1) Analysis of 201 days of recording in 7 sites which show no proven evidence of dugong presence in the monitored area; 2) 600 people more aware of the role of marine mammals species in biodiversity conservation; 3) 5 park staff trained in biodiversity monitoring techniques.
Unfortunately, during the third monitoring session, 2 recorders were found stolen.

Introduction

Many dugong populations worldwide are decreasing and severely fragmented. Effective protection measures are needed for this species (Vulnerable following the global IUCN Red List, East African populations were assessed as Endangered by Marsh et al. 2011). Dugongs play an important role in seagrass-ecosystems, influencing the amount as well as the species of seagrass. The reduction of dugongs from this ecosystem may alter species composition (seagrasses are nurseries for many fish and invertebrates).
The project was set up to fill the gap of information about the presence of dugong in QNP and promote proper and sustainable conservation measures among local communities and park manager.
The project was implemented in the Quirimbas National Park, a key conservation site in Mozambique protected by law since 2002 having as main objective to conserve the diversity, abundance and ecological integrity and all physical and biological resources in the park area, so that they may be enjoyed and used productively by present and future generations (*PNQ Plano de Manejo 2012 – 2021*). The Archipelago of Quirimbas, where the Quirimbas National Park is located, hosts a high diversity of corals (160 species of which 5 listed on the IUCN red list), mollusks (140 species) and fish, important nesting ground for sea turtles, is home to migratory whales, dolphins and many bird species. In terms of marine vegetation, it hosts 6 species of mangroves trees, 10 seagrass species and 259 seaweed species.

The following partners were involved in the project
Istituto Oikos - a non-profit organization that operates to safeguard biodiversity and promotes a responsible management of natural resources and the widespread adoption of more-sustainable lifestyles as tools for social and economic development and for fighting poverty. It works in Cabo Delgado Province since 2013. It supported the project providing logistic support in the area.
Quirimbas National Park – Main institutional partner of the project. It was involved in all the project stages. Technical staff of the park was involved in the implementation of field activities and was beneficiaries of the training actions.
Centro Interdisciplinare di Bioacustica e Ricerche Ambientali of University of Pavia – the reference person, Mr Gianni Pavan, helped the team handling the construction of the acoustic devices and providing technical support to the 3 team members in all stages of the research. He also came to Mozambique for supervising the first monitoring session and to provide specific training to park staff.

Eco Moçambique – local NGO which supported the project team in the implementation of community awareness and education outreach activities.

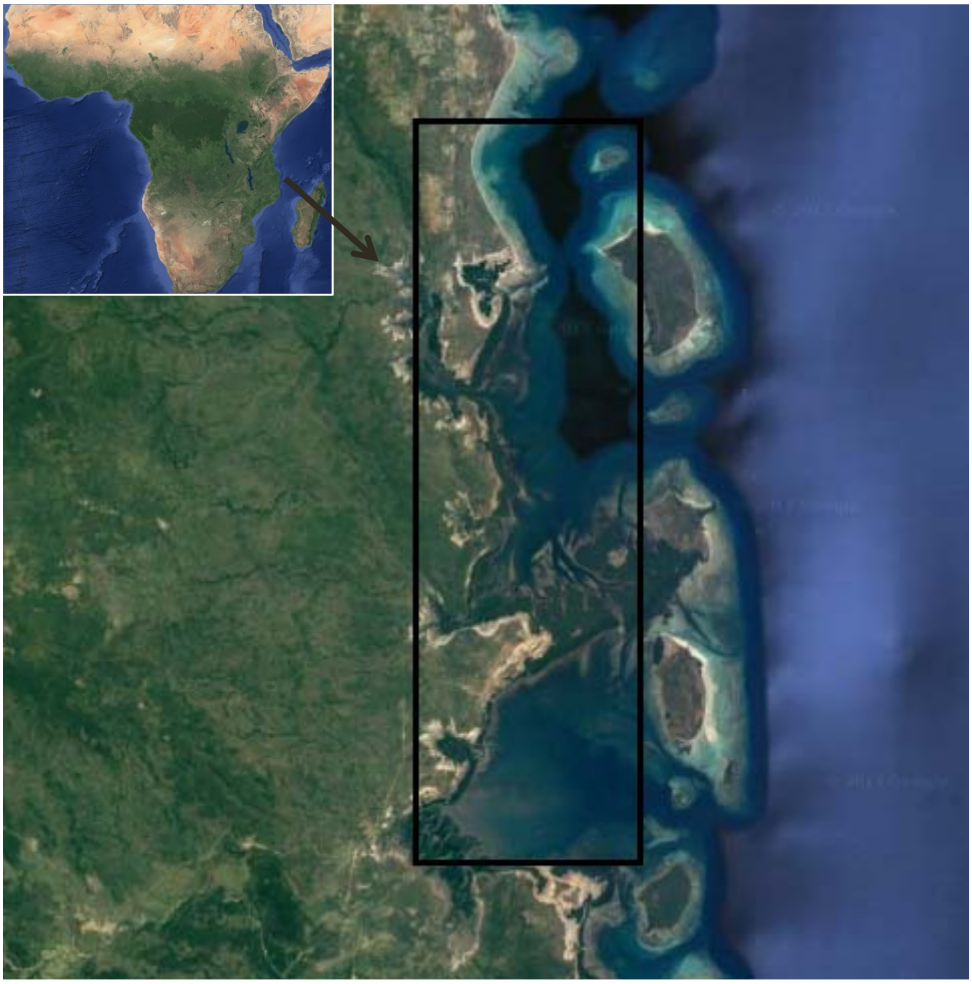


Fig. 1 Coastal area of QNP where the project took place – Northern Mozambique

Project members

Gelica Eugenio Inteca, born in Moçambique in 18.11.1989

Relevant qualifications

- 2014- 2016. Master degree in Natural Resources Management for Tropical Rural Development Areas, University of Florence, Italy
- 2009 – 2013. Bachelor in biology sciences, Lurio University, Mozambique

Experience

- 2015: Collaboration in Preliminary survey about sea mammals for Protection of coastal and marine habitats of the Quirimbas National Park for food security and economic development (PHARO) project;
- September 2014: Collaboration in training activities with Conservation Society (WCS), IUCN Global Marine and Polar program, on how to take pictures and genetics of whales (Cetacean Research Pilot Study) to develop a cetacean research and monitoring project at Vamizi Island;
- 2013: Research and assistant lecture of LURIO University Mozambique;
- 2012: Monitoring assistant of sea turtles in conservation canter of Vamizi Island in Mozambique

Current occupation and employer

Lecture and researcher at Lurio University

Main roles in the project

- Responsible for the implementation of all the field work
- Liason with all project partners and donor
- Reporting
- Communication of project activities through Lurio University network

Anna Giovannini, born in Italy in 1985

Relevant qualifications

- 2004 – 2008. Degree in biology, University of Milano Statale, Italy
- 2008 – 2009. Master in Land use and water management in Developing Countries, University of Milano Bicocca, Italy

Experience

- 10/2004 – 03/2017: Post graduate researcher involved in the implementation of biodiversity monitoring activities in the Quirimbas National Park (Mozambique) and Lampi Marine National Park (Myanmar);
- 03/2012 – 03/2013: Support Associate under the framework of the UN-REDD Programme in Sri Lanka;

Current occupation and employer

- Program manager for Istituto Oikos

Main roles in the project

- Support in the implementation of field work
- Liason with Istituto Oikos staff and Pavia University
- Data analysis
- Reporting

Lúcia Justo Alberto , born in Mozambique in 10.12.1987

Relevant qualifications

- 2007 – 2011: Master Degree in Biology University Eduardo Mondlane
- Training course attended: 02/2015 Vulnerability mapping related to Climate change Trainer: USAID 09/2014 Introduction to GIS in the framework of Projecto de Adaptaçao as Mudanças Climatica do Ministerio para Coordenaçao da Accao Ambiental (Moçambique); 01/2009-03/2009 Training in

eproduçao, gametogenese e histotecnologia de Animais Aquaticos e Marinhos Trainer/location: Universidade Rural e Federal de Amazonia (Brasil)

Experience

- 02/2013–06/2015: Univerity professor of Marine Ecology and Ecology (Docente das Cadeiras de EcologiaMarinha e EcologiaGeral) Universidade Lúrio (Unilúrio), Faculdade de Ciências Naturais (Pólo de Cabo Delgado) Bairro Eduardo Mondlane, Pemba (Moçambique)
- August 2014: Consultant for marine mammals surveys in the QNP Istituto Oikos
- 05/2012–03/2013: Docente das Cadeiras de Ecologia Marinha e Ecologia Geralna Universidade Católica de Moçambique Universidade Católica de Moçambique (UCM), Delegação de Pemba Bairro Cimento, Avenida 25 de Seteembro.

Current occupation and employer

Direcçao Províncial de Terra Ambiente e Desenvolvimento Rural

Main roles in the project

- Support in the implementation of field work
- Liason with Lurio University

Section 2:

Aim and objectives

The project had the overall goal to "increase conservation actions on threatened species, in favour of dugongs and marine biodiversity" and the purpose to "contribute to fill the gap on baseline knowledge of the presence and distribution of dugong in the Quirimbas National Park".
Three keys objectives were identified at project proposal stage: 1) To gain scientific evidence on the presence of dugong in QNP for future conservation actions; 2) To increase local stakeholders knowledge and awareness on marine natural resources value, protection and sustainable use; 3) To reinforce technical capacities of QNP staff on monitoring and managing marine natural resources.

Following the training and capacity building activities in Canada the project team re-defined the project goals as follow:
Overall goal - To promote conservation in favour of dugong and biodiversity in QNP northern Mozambique.
Project purposes:

1) Have a baseline and scientific evidence and information of the presence and distribution of dugong in QNP northern Mozambique;
2) Reduce the disturbance on marine species by stakeholders communities.

The changes were done based on a more appropriate project planning around the scope of objectivies to make it smart and effective.

Changes to original project plan

Objective 1: Despite the effort the project team did not succeed in contacting the Bazaruto team working on dugong; anyway contacts have been established with other research groups working in India and Madagascar.
Objective 2: During the post training work the project team decided to slightly change the approach of the education activities addressed to the local population of Quirimbas National Park marine area, in order to implement a more comprehensive and effective strategy. Instead of conducting awareness and dissemination meeting with fishermen representatives, the project conducted theatre representation addressed to the whole community. Six theatre presentations have been realized. In addition to this activity the project organized a seminary at the local Lúrio University addressed to professors and students to spread the work done and the importance of conservation actions in Quirimbas National Park.
Problems: During the third monitoring session, two recording devices have been stolen. We reported the bad news to the park administrator, but devices were not found so far.

Methodology

Objective 1
Environmental monitoring through bioacoustics devices
<u>Set up of the devices</u>
The underwater recording devices have been designed and built to satisfy the requirements of the project: limited budget, long duration, 16 kHz bandwidth. The recorders are based on a commercial digital recorder modified to get powered by 8 D size standard batteries (1.5V 18Ah each). The recorder is placed in an underwater housing (max 100 depth) with a standard hydrophone powered by the recorder. The recorders can be programmed to perform different types of recordings (see appendix 4.3 for instructions).

Calibration of the equipment

For setting parameters see annex 02 instructions

Selection of location

The selection of the locations of the instruments deployment was done, based on the following criteria: on the basis of the available information about Dugong biology and ecology, an evaluation of the areas of the Park that actually maintain the characteristics of potentiality for the species (presence of sea grass beds, adequate depth of the sea, presence of sea currents) was done. Based on this information, a map of the most suitable areas was developed. Interview with local fishermen and Park staff allowed to gather information about the past area of presence and the most recent sightings of the species. The final site selection was done taking into account also a low human disturbance level and an easy accessibility of the area, even during the raining season.

Location of devices deployment during the three monitoring session: first session (orange dots); second session (blue dots) and third session (yellow dots).

Installation of devices

In order to reduce the probability of equipment loss, devices were anchored to a 50x50x20 concrete base, using iron wire and locks. Each device was marked with a specific color tape to simplify the recognition and data storage. In order to select a suitable detailed place for the deployment of devices (presence of seagrass, flat surface of the bottom and absence of obstacles), some pictures of the sea bottom were taken using an underwater camera. After the selection of the precise location the device was deployed and a GPS waypoint was taken for an easy further recovery.

Data analysis

Once the recorders were recovered, MP3 files were copied to a portable 2.5" hard disk, then converted from the original MP3 format (44.1kHz stereo, lowest compression at 320Kbps) to wav files (mono, 16 bit, 32 kHz sampling) for easier data analysis. Preliminary analysis was based on the generation of a compact spectrogram for each recorded file (7h and 27m of duration) and then listening and high resolution spectrogram production on interesting cuts found on the compact spectrograms. A final analysis phase was based on listening and real-time visualization with a semi-random scheme, 10 minutes of analysis/listening every hour plus random samples.

The software used are:

- Sox, freeware, for file conversion (MP3>WAV)
- SeaPro, produced by University of Pavia, for real-time listening and spectrogram generation
- Adobe Audition, for fast browsing and listening

Number of files recorded in each session			
Recorder unit	blue	black	red
Session 0 (TEST)	48 wav 96kHz = 74h		
Session 1: July 15th	95 = 29 days	96 = 29 days	95 = 29 days
Session 2 : Dec 09th	100 = 30 days	99 = 30 days	99 = 30 days
Session 3: Febr 7th	stolen	104 = 32 days	Stolen

Objective 2

Rural theatre

The activity was planned and implemented based on the experience of the NGOs locally working on community awareness raising. Rural theatre is a tool to promote dialogue, debate and reflection among the public. The objective of the activity was to provide a comprehensive knowledge of relationship between marine species and ecosystems conservation and to involve the public in the identification of possible solutions.

Essential elements of rural theatre:

- Participation: the public interact directly with the actors and can actively participate to the show;
- Interactivity: use of music, dance and visual supports;
- Cultural suitability: it is based on typical elements of local culture;
- Variation of narration: mix of comic and drama

Recommendations:

- Identify one single and clear message;

- Use ad hoc music, create a specific refrain which will be easy to be memorized by the public

To implement the performance a local theatre company was hired.

Outputs and Results

Objective 1 - 1. Have a baseline and scientific evidence and information of the presence and distribution of dugong in QNP northern Mozambique

Result 1: To evaluate the current presence of dugong and their suitable habitat in QNP

Near 210 days of recordings distributed in 7 sites allowed the collection of a huge library of sounds. The acquisition of acoustic data did non evidence sounds similar to the few shown and described in literature and thus there are no options to link any recorded sound to the presence of dugongs. However many different sounds have been recorded, some of which high-pitched, that could potentially be linked to some other biological source than fishes or dolphins. The underwater acoustic soundscape is really rich, composed by different types of sounds and further research is required to link those sounds to emitting species.

Objective 2 - 2. Reduce the disturbance on marine species by stakeholders communities

Result 2: Stakeholders communities aware about the role of dugong in biodiversity

Awareness was realized through theatre performances. Shows were conducted with the involvement of the local youth theatre association "Culamuca". The script was approved by the Direcção Provincial do Meio Ambiente. To reach the majority of the community the shows were mainly performed in the local language (Kimwani), with some parts in Portuguese.

Quantifiable research outputs

- 1 theatre script produced
- 6 theatre performances realized: Mussemuco, the 1st of October at the Mussemuco school; Quirimba island, the 2nd of October at the Sede and Cumilamba schools; Matemo island, the 3rd of October at the Palussança school; Quirambo, the 16th of October at the Quirambo school; Arimba, the 17th at the Arimba school; Ibo island, the 18th od October at the Cumuamba school.
- 600 people reached by the events (about 100 per event)
- poster produced and distributed among local communities




Result 3: To improve technical capacity in monitoring of dugong for QNP staff

Participation and capacity building of Quirimbas National Park staff was ensured throughout all field operations starting from identification of survey areas, equipment set up, dislocation, surveillance and recovery. A specific training sessions addressed to the Park Marine Areas staff was organized in August 2016 by the project supervisor Mr Gianni Pavan.

Quantifiable research outputs

- Four park staff received a basic training
- One park staff participated to the field trip to install and recover devices




Communication & Application of results

The following means were used to communicate projects activities and results:

- Istituto Oikos Facebook page
- Seminar at Lurio University: a short presentation was done at the beginning of the project to present the intervention. Following the field work and data analysis a seminary was organized with students and teachers to present project results. Main focus was given to the importance to preserve and conserve the Quirimbas marine ecosystems.

Furthermore, the team, with the support of its project supervisor, is planning to produce a scientific paper on the sound landscape of the park listing all the acoustic events recorded.

Monitoring and Evaluation

Capacity building: by involving park staff in project activities it was possible to evaluate, session after session, the acquirement of technical skills on equipment use and data collection. By the third session park staff was independent in installing devices, taking GPS position (waypoints) and recovery the equipment.
Local awareness: awareness increment is a difficult indicator to be measured, the idea of the project team was to count on patrolling report issued by park rangers but the lack of funds and systematic patrolling activities made it impossible to count on comparable data.

Achievements and Impacts

Achievement/ Impact	Contribution to the project's objectives and overall goal
Local communities more aware of the importance of marine mammals and environmental protection	Locally people awareness and education is the first step to achieve long lasting results in terms of natural resources conservation and biodiversity protection.
Park staff more skilled in environmental monitoring activities	One person in particular (Head of Patrolling Sector of the Marine Block of the Park) became independent in the field operations needed for the installation and recovery of the equipment. The development of locally based skills will help in improving environmental conservation and monitoring operations by the QNP.
Increased awareness at local level (QNP, local administration, local NGO, students, people) on the presence of marine mammals species	The project allowed to increase the level of attention at local level on the conservation of marine mammals species stressing the importance to increase patrolling and other protection measures.
Set up of a survey methodology	The project tested a long term methodology that could be applied in other sites and in other researches.

Capacity Development and Leadership capabilities

Technical skills: the participation to the project allowed the team to develop specific skills in the field of bioacoustics, learning how to utilize scientific monitoring devices and to interpret the obtained data. Thanks to the project the team learnt how to apply a scientific approach to a field research.
Institutional skills: thanks to the project, team members developed stronger skills and experience in terms of relationship with local authorities (Park and community leaders) and capacity to ensure the proper participation of the communities, project beneficiaries and stakeholders to the project activities, in order to achieve the targeted results.
Managerial skills: the project was an opportunity to learn how to plan activities and budget over a consistent period of time, which turn into strong managerial skills development. In this framework specific skills developed were: preparation of technical and financial reports, management of financial resources, coordination of local partners in the field.
The participation of one of our team member in a training in Canada allowed the team member to learn, explore and exchange ideas with other researches, allowed to improve skills on project planning process for conservation purposes.

Section 3:

Conclusion

The research activity allowed to collect considerable data on underwater biological sounds in Quirimbas National Park water. For some of these sounds it was possible to determine the source (i.e. whales and dolphins) combining existing sounds bibliography and observations. For other sounds it was not possible to determine the origin due to the lack of the above mentioned conditions (sound bibliography and observations). Further analysis need to be performed to specifically categorize these sounds. With the current information it is not possible to exclude the presence of dugong in the QNP water.
Data collected show anyhow an underwater context rich and scientifically interesting. Information collected will be useful starting points for the realization of additional studies.

Problems encountered and lessons learnt

All the activities went as planned. Awareness raising activities were very much appreciated either by local communities and local authorities. People showed a high degree of participation during all the performance, the head of park patrolling team also participated as an actor during the performance for further pushing the importance of law enforcement and respect of rules. Local authorities highly appreciated the work done and requested for more awareness events.

Training and capacity building to park staff was generally positive concerning practical operations of equipment set up and use. It was not possible to perform a proper training on data analysis due to the complexity of the analysis compared to the technical and scientific preparation of the park staff working in the marine area.
The security of bioacoustics devices in the field was a challenge. To ensure the maximum security of the team: i) included park staff patrolling team during all the field operation and asked for their support in patrolling the area, ii) informed community leaders of the activities on going, iii) set up a security system (locks and iron wire) to protect the equipment. Despite the efforts during the third monitoring sessions 2 devices were stolen. Movements in the project area and selection of proper sites was not always easy due to weather conditions (rain and strong wind).
Despite the efforts the team did not succeed in collecting reference sounds on dugong (team working in Bazaruto on dugong never replied to our requests; the authors of the few publications on dugong acoustic detection did not replied to our request to provide their original recordings)

Project methodologies and conservation tools used
Underwater acoustic recorders are expensive but valuable tools to detect the presence of vocalizing species underwater. To reduce the cost of the equipment, the instruments have been designed and built on the purpose, with the primary goal to provide long duration recording on a bandwidth tailored for the target species. The results are highly satisfactory as the recorders allowed the capture on a wide variety of underwater sounds, most of them of unknown but of presumably biological origin that are worth of further studies. Some biological sound detections, potentially linked to the presence of dugongs can't be confirmed because 1) there are not enough reference recordings to confirm a match and 2) there are no visual detections to possibly explain those sounds.

Important lessons and recommendations
Considering the elusive behavior of the species it is important to improve the collection of information from local population; on the instrumentation side, considering the transparency of the waters, it will be important to add a time lapse underwater camera to take a picture every few minutes for the whole period of acoustic monitoring to hopefully catch some useful image in case animals dive around.

In the future

Two out of the four bioacoustics devices will remain on site to be used for future monitoring activities. According to the experience gained it would be important to conduct additional monitoring sessions not only focused on dugong but marine mammals in general and to invest to associate to the recorders, video camera in order to support the sounds with images.
During May 2017, at the end of the 3 planned monitoring sessions in Mozambique, one of the devices was temporary sent in Myanmar, to Lampi Marine National Park, where Istituto Oikos (partner of the current CLP project) is leading some monitoring surveys to deepen the knowledge on the marine wildlife of the Park. In Lampi Marine National Park the dugong evidence has been confirmed in recent years (dugong feeding trails) and the main objective of this collaboration is to collect comparative samples of dugong vocalization. The device worked for 22 days and collected data will be analyzed in the coming months when they will be transferred to Italy.
The team will work with the institutions involved in the project (PNQ, Istituto Oikos, Eco Moçambique, Lurio University) to raise additional funds to continue investing in research and awareness activities.
Project methodology and results collected will be disseminated in order to be useful for future studies and work in the area and worldwide.

Financial Report

Itemized expenses	Total CLP Requested (USD)*	Total CLP Spent (USD)	% Difference	Details & Justification (Justification must be provided if figure in column D is +/- 25%)
PHASE I - PROJECT PREPARATION				
Communications (telephone/internet/postage)				
Field guide books, maps, journal articles and other printed materials				
Insurance	120,00	169,71	141%	the cost of insurance was higher than expected due to the fact that Mr Pavan has 2 children
Visas and permits	60,00	157,65	263%	Visa cost was higher that expected, in addition to the cost of the visa we had to pay the currier service to send the passport to Rome (Italy) and sent it back to Mr Pavan house.
Team training				
Reconnaissance				
Other (Phase 1)				
EQUIPMENT				
Scientific/field equipment and supplies	8.150,00	8.366,19	103%	
Photographic equipment				
Camping equipment				
Boat/engine/truck (including car hire)	440,00	395,16	90%	
Other (Equipment)				
PHASE II - IMPLEMENTATION				
Accommodation for team members and local guides	570,00	562,22	99%	
Food for team members and local guides	920,00	810,44	88%	
Travel and local transportation (including fuel)	2.000,00	1.839,99	92%	
Customs and/or port duties				
Workshops				
Outreach/Education activities and materials (brochures, posters, video, t-shirts, etc.)	240,00	204,44	85%	
PHASE III - POST-PROJECT EXPENSES				
Administration				
Report production and results dissemination				
Other (Phase 3)				
Total	**12.500,00**	**12.505,80**		

Section 4:

Appendices

4.1 CLP M&E measures

Output	Number	Additional Information
Number of CLP Partner Staff involved in mentoring the Project	-	
Number of species assessments contributed to (E.g. IUCN assessments)	1	Dugong dugon
Number of site assessments contributed to (E.g. IBA assessments)	-	
Number of NGOs established	-	
Amount of extra funding leveraged ($)		Contribution of Istituto Oikos to the project activities
Number of species discovered/rediscovered	-	
Number of sites designated as important for biodiversity (e.g. IBA/Ramsar designation)	-	
Number of species/sites legally protected for biodiversity	-	
Number of stakeholders actively engaged in species/site conservation management	-	
Number of species/site management plans/strategies developed	-	
Number of stakeholders reached	600	
Examples of stakeholder behaviour change brought about by the project.	-	
Examples of policy change brought about by the project	-	
Number of jobs created	-	
Number of academic papers published	-	The project team will considerate to publish a paper on underwater biological sounds recorded
Number of conferences where project results have been presented	-	

Appendix 4.1 CLP M&E measures

4.2 DATA ANALYSIS REPORT

Bibliographic analysis

Dugong bioacoustics

The first publication on sounds produced by dugongs was by ***Neir et al, 1975*** and it involved airborne recordings of a captive dugong in India. The animal produced different bouts of chirp-squeaks that lasted for 1-8s. The frequency range was from 3 to 8 kHz and lasted 0.1-0.3 s. It is hypothesised that the animals produce sounds for alarm or emotional distress or another form of communication. According to another study, dugongs produce principally 3 types of sounds. The first, chirp sounds, is the most abundant and is a FM sound whose frequency range goes from 3 to 18 kHz lasting ca. 60 ms. The second, trills last as long as 2.2 s and have a 3-18 kHz bandwidth. The third, called barks, are broadband signals of 500 to 2200 Hz lasting 30-120 ms with up to 5 harmonics. The estimated source level here was estimated 134-138 dB (re 1 µPa). It is hypothesised that chirps are used for ranging function due to their FM nature. Trills and Barks are instead used for affiliative and aggressive behaviour, respectively.

TABLE 1. *Analysis of sound of Sirenians.*

Species	Frequency (kHz)	Duration (Sec.)	Interval of each squeak	No. of squeaks/ burst
Florida manatee* (*Trichechus manatus latirostris*)	2.5 to 5.0	.15 to .5	—	—
Amazon manatee** (*Trichechus inunguis*)	6.0 to 8.0	.15 to .22	—	—
Dugong (*Dugong dugon*)	3.0 to 8.0	.1 to .3	.1 to .5	5 to 20

* After Schevill and Watkins (1965)
** After Evans and Herald (1970)

From Nair et al, 1975.

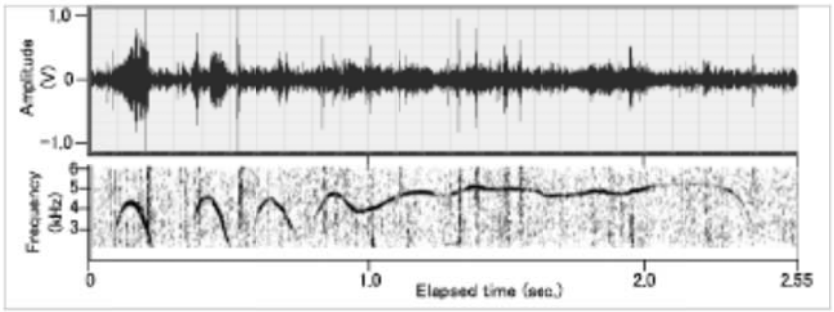
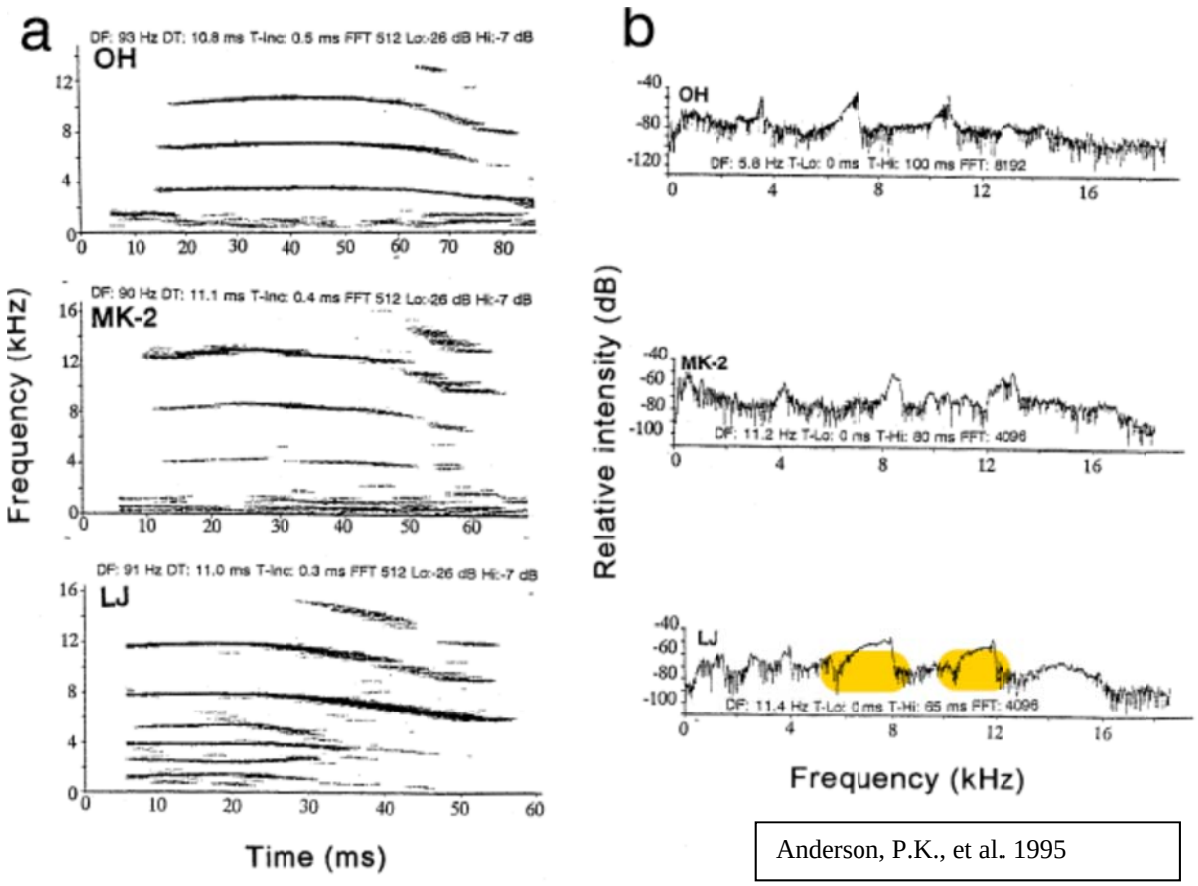


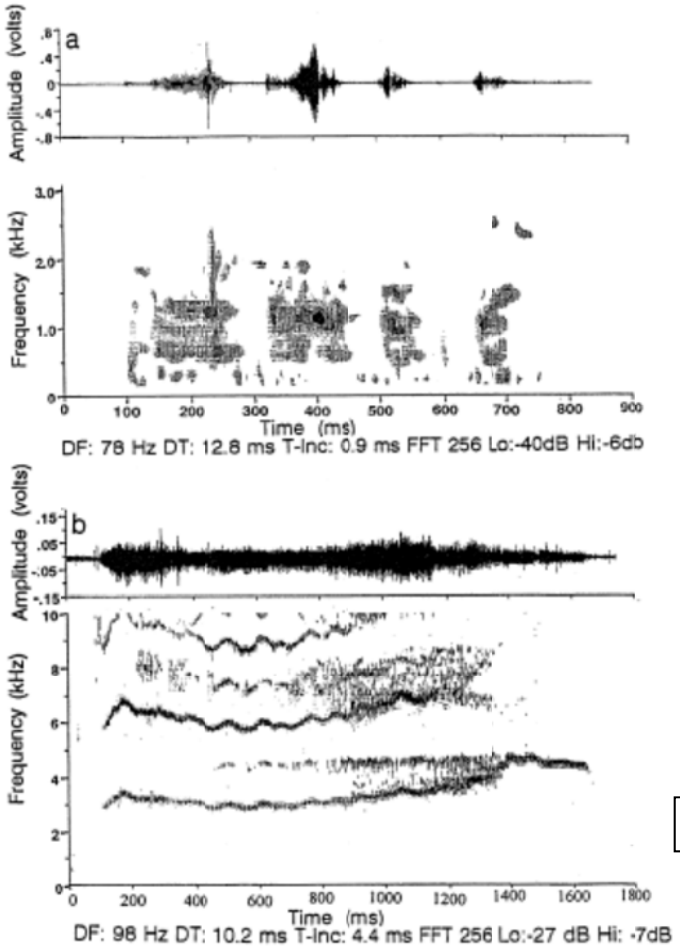
Fig. 1. A sonogram (bottom inset) and a waveform (upper inset) of typical dugong calls, including three chirp calls and a trill call, recorded in the study area. Chirp calls were the most frequent vocalization in the study area.

Ichigawa et al,



Anderson, P.K., et al. 1995

FIG. 2.—Spectrograms illustrating (a) chirp-squeaks produced by three individual dugongs, with patterns of frequency modulation and number and distribution of harmonics over the duration of the signal, and (b) power spectra of the same sounds showing characteristic patterns of amplitude (intensity) modulation plotted against frequency for the same sounds. See text for explanations of abbreviations.



Anderson, P.K., et al.

FIG. 3.—Wave forms and spectrograms of (a) four barks and (b) a single trill. See text for explanations of abbreviations.

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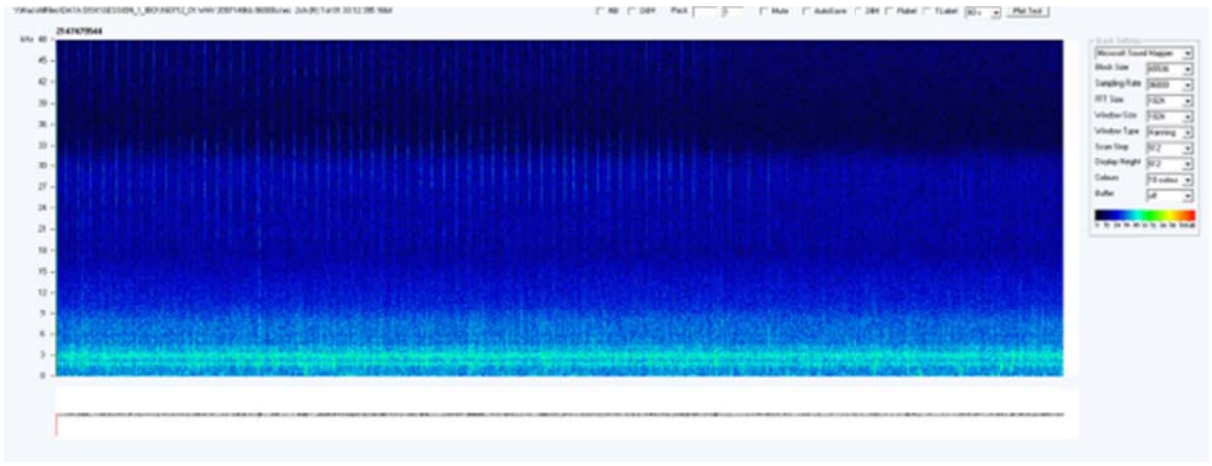
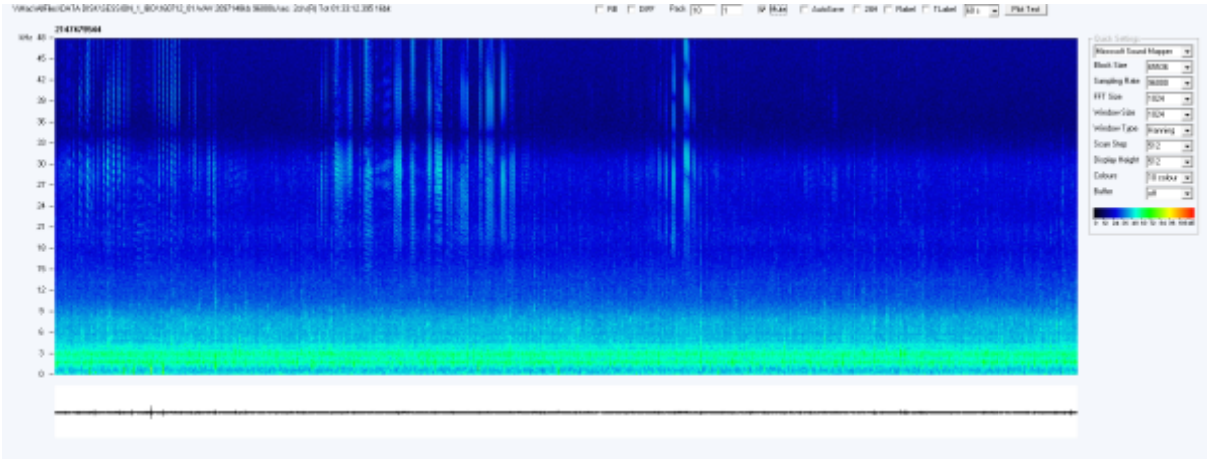
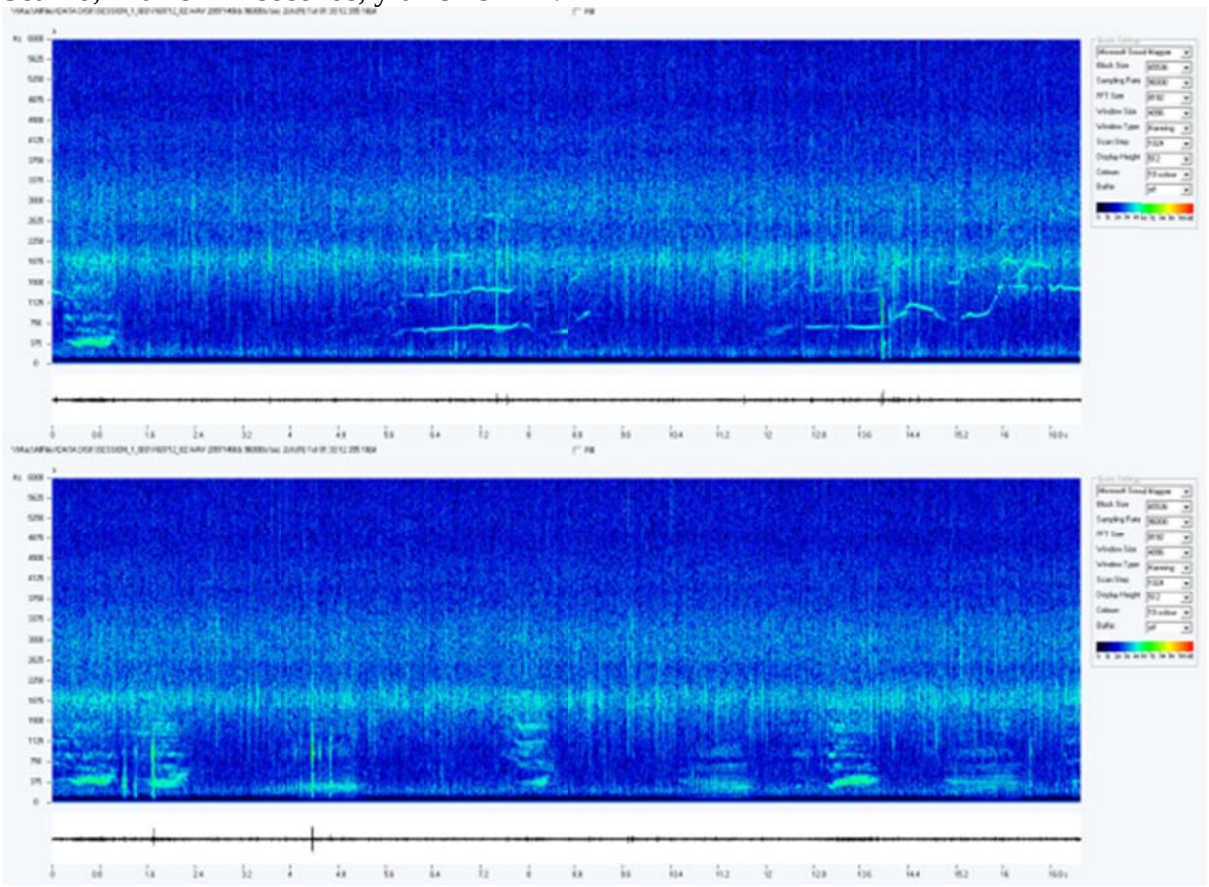
Recording sites in Session 1. The test of the recorders has been made in R3 in wideband recording mode, then the recorders have been set for standard long term deployment with 16 kHz bandwidth.



Wideband recording at 96 kHz. The spectrogram 0-48 shows echolocation pulses emitted by dolphins (12 to 48 kHz) and low frequency tonal sounds (< 3 kHz) emitted by humpback whales. Software SeaPro.



Packed spectrogram (172 seconds) to show echolocation series emitted by dolphins. Software SeaPro, x–axis 172 seconds, y-axis 48 kHz.



Spectrogram in the 0-6 kHz band to show modulated tonal sounds emitted by humpback whales. Software SeaPro.

Data analysis of standard recording sessions.

The standard recording sessions have been made with recorders set to record in MP3 format with a bandwidth of 16 kHz (sampling rate 44.1 kHz) with compression at 320kbp (highest quality) to allow continuous recording in files lasting 7 hours and 27 minutes to cover about 30 days (continuous recording).

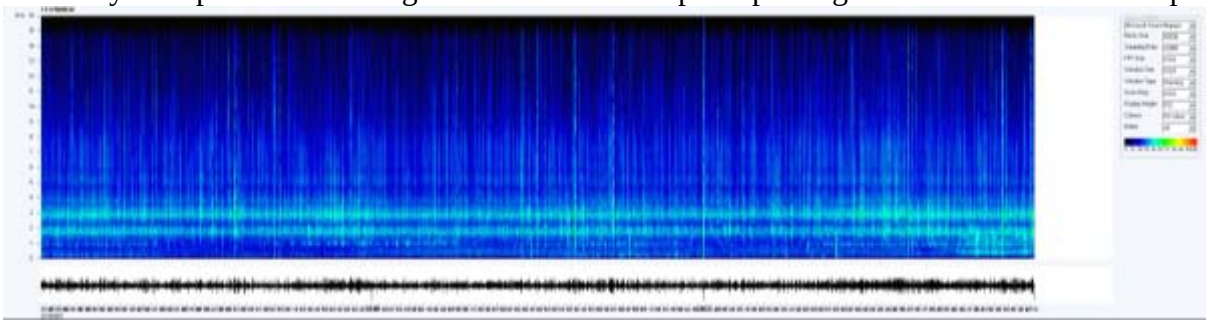
Once the recorders were recovered, MP3 files were copied to portable 2.5” hard disks, one for each session, then converted from the original MP3 format to wav files (mono, 16 bit, 32 kHz sampling) for easier data analysis. Preliminary analysis was based on the generation of a compact spectrograms for each recorded file (7h and 27m of duration) and then listening and high resolution spectrogram production on interesting cuts found on the compact spectrograms.

This phase
A final analysis phase was based on listening and real-time visualization with a semi-random scheme, 10 minutes of analysis/listening every hour plus random samples.
Then an automatic search for tonal sounds in the band 3 to 6 kHz, 200ms to 2s duration, has been performed on the whole set of files for each recording site.
The software used are:

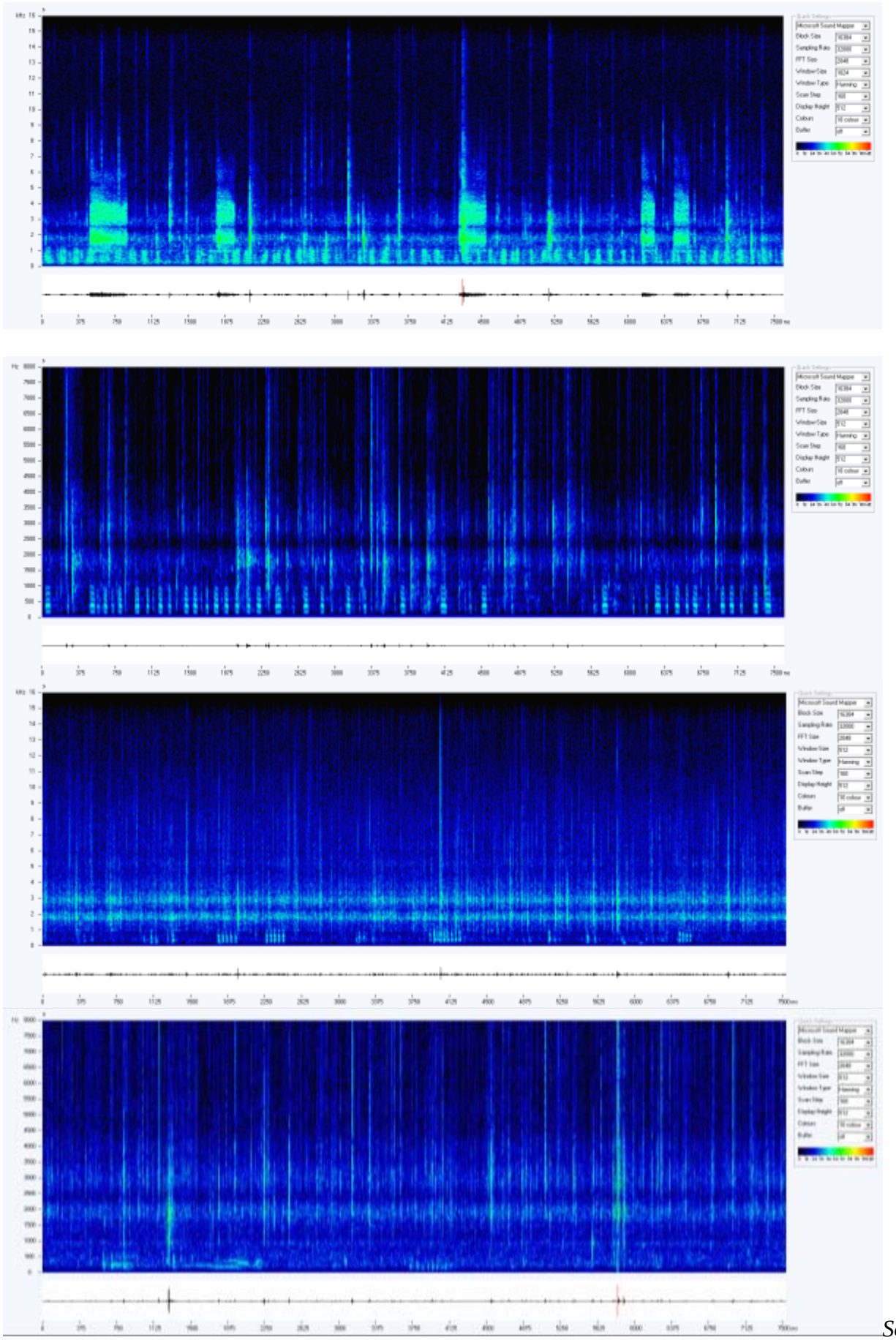
- Sox, freeware, for file conversion (MP3>WAV)
- SeaPro, produced by University of Pavia, for packed spectrogram generation, for real-time listening and high resolution spectrogram generation
- Adobe Audition, for fast browsing, listening, and samples extraction
- Kaleidoscope (WildlifeAcoustics) for automated search of tonal sounds

Number of files recorded in each session			
Recorder unit	blue	black	red
Session 0 (TEST)	48 wav 96kHz = 74h		
Session 1: July 15th	95 = 29 days	96 = 29 days	95 = 29 days
Session 2 : Dec 09th	100 = 30 days	99 = 30 days	99 = 30 days
Session 3	stolen	104 = 32 days	Stolen

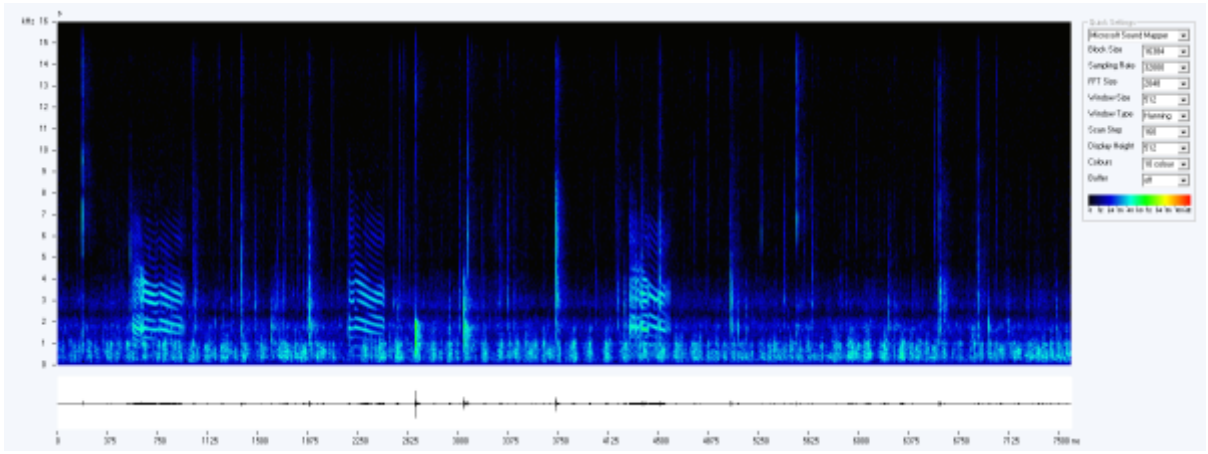
Manual sampling and listening
Because of the almost continuous presence of wideband noises and sounds, it was not possible to focus the attention and automatically detect only sections with sounds. Most of the search has been driven by the operator searching for cues on the compact spectrograms and on random samples.



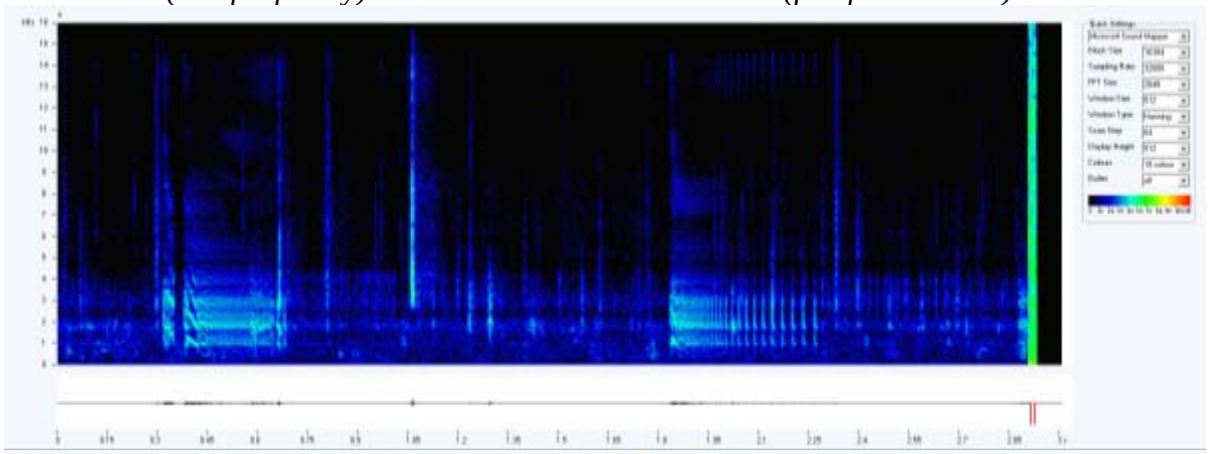
Example of packed spectrogram.
The main sound categories found can be linked to the following sources:
Boat
Fish
Humpback whales
Dolphins
Unidentified probable biological sources
Other unidentified sounds (contacts, water noise, vegetation rubbing on the hydrophone)

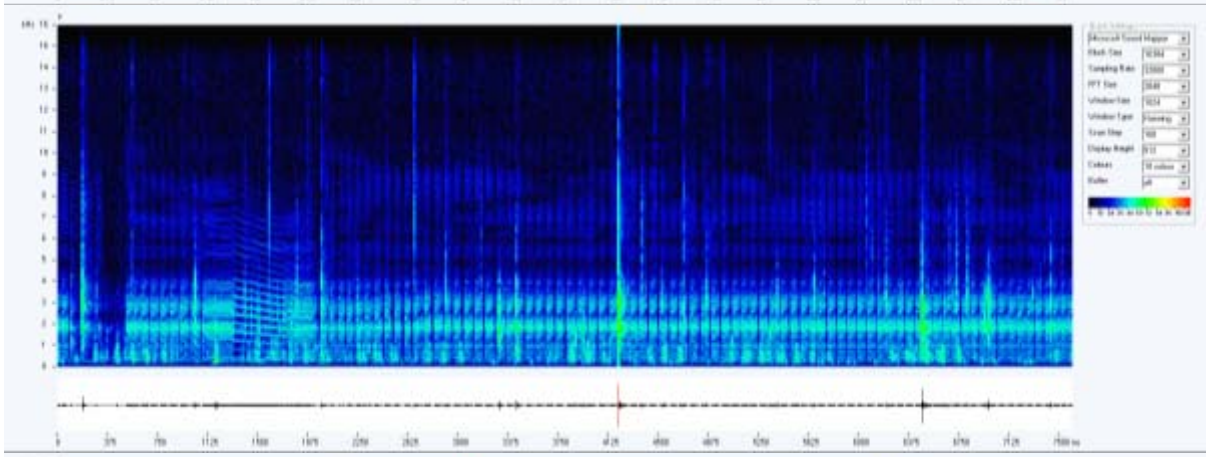


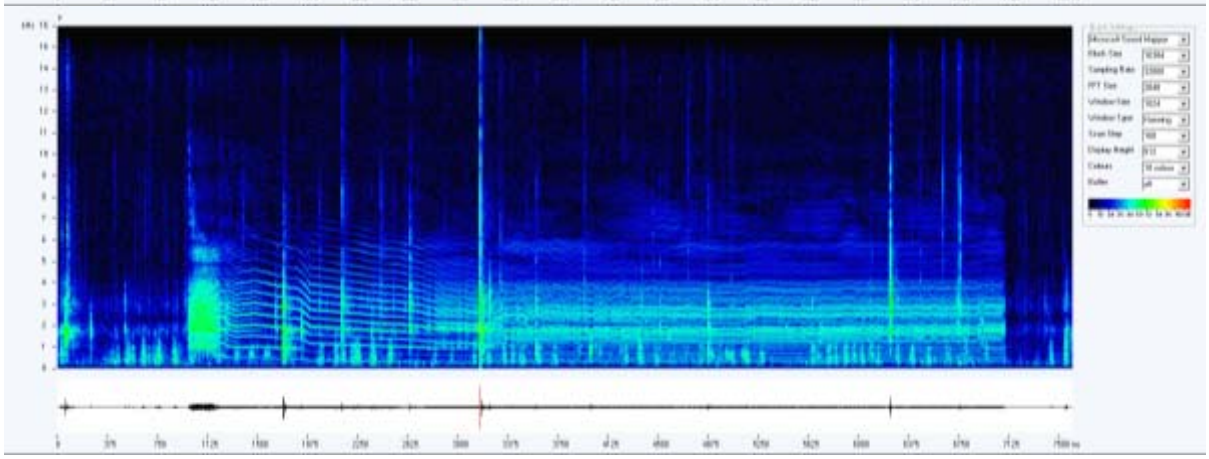
Some categories of low frequency sounds probably produced by fish species

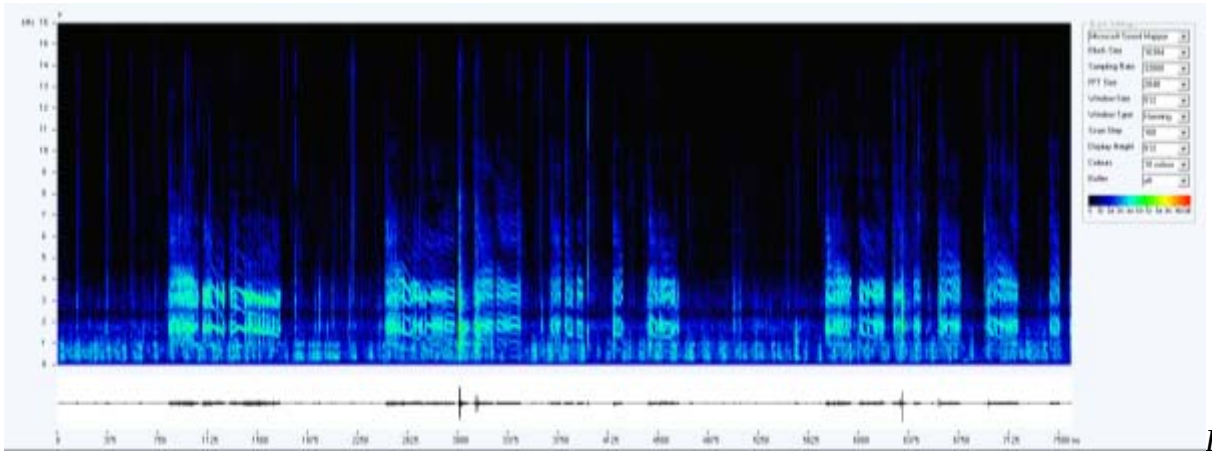


Fish sounds (low frequency) and unknown harmonic sounds (fast pulse bursts).

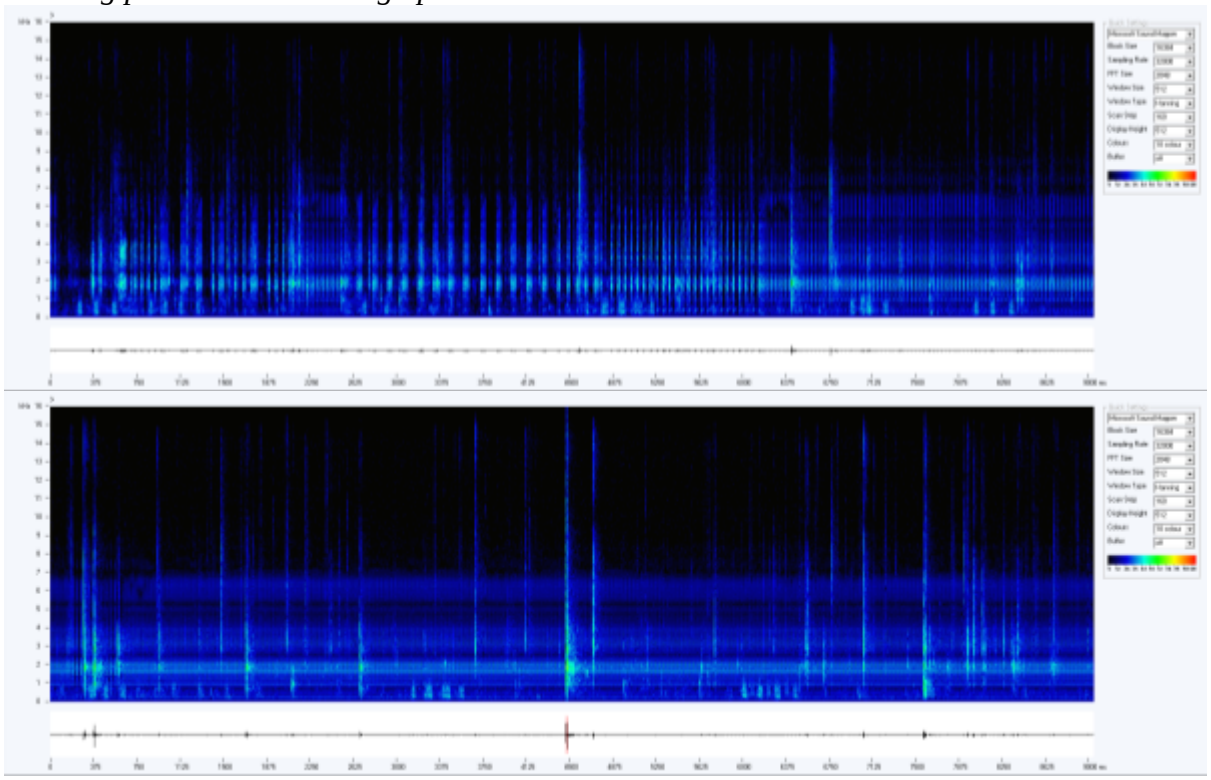


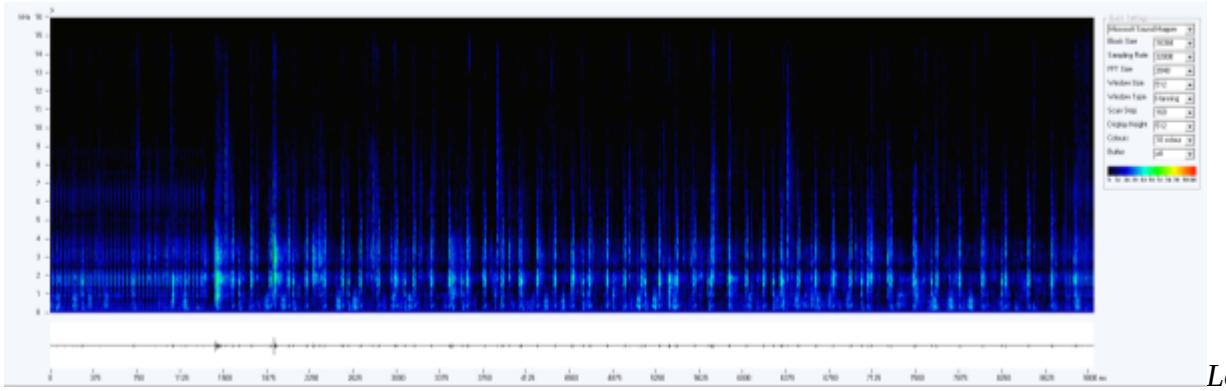






Fast and long pulse bursts showing up as harmonic sounds





Long series of pulses at both constant and variable rates

Automatic search

For the automatic search it was not possible to build a model, or search template, because the information in literature is vague and samples of real sounds are not available. Based on the info in literature we searched for tonal sounds in the frequency range 3000 to 6000 Hz with duration in the

range 200 ms to 2 seconds. The search produced a huge amount of detections, some of which related with dolphin sounds or humpback whale sounds, but no sounds matching or similar to the literature descriptions.

Conclusion and possible advances of the research

The acquisition of acoustic data for a long period of time in multiple sites did non evidence sounds similar to the few shown and described in literature and thus there are no options to link any recorded sound to the presence of dugongs. However many different sounds have been recorded, some of which high-pitched, that could potentially be linked to some other biological source than fishes or dolphins. The underwater acoustic soundscape is really rich, composed by different types of sounds and further research is required to link those sounds to emitting species. A further research step should be based on the combined use of an underwater videocamera with sound recording; this appears possible in many of the sites because of the clear waters and low depth. A 360° video camera could be employed to have a vision of the animals around the hydrophone and allow to link the recorded sounds, when loud, at least to the presence of some species at close distance around. The audio/video equipment should be set for continuous recording, or based on a sampling schedule, because the continuous presence of noise and sounds makes impossible to set a “on event” recording system.

4.3 Underwater Recorders Setting Instructions

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Underwater Autonomous Recorders for Mozambico DUGONG Acoustic Monitoring Project
Version 1.0, Gianni Pavan, July 2016

Description and applicative notes

Four Underwater Autonomous Recorders have been designed and assembled by CIBRA to support the research and conservation plans on dugongs in Mozambico.
Recorders are based on a cylindrical underwater housing with a removable cap that hosts a hydrophone; inside, a recorder with an external battery package and a customized memory card. These recorders allow continuous recording, 24/24h. A scheduled mode will be available in a next version.

Dimensions: (with hydrophone) (without hydrophone)
Housing: internal size 8cm x 40cm, made by COLMAR on CIBRA specifications
Depth rating: 200m
Hydrophone: Aquarian Audio H2C (Plug In Power)
Recorder: SONY PCM-M10 (modified)
Memory: microSD 128GB with customized formatting
Powering: 3Vdc with up to 8 size D alkaline cells (suggested Duracell Industrial 1.5V 18Ah)
Powering options: 2 (8 days), 4 (16 days), 6 (24 days) or 8 batteries (>32 days)
Buoyancy: TBD, varies with battery load (positive with two batteries)
Recording options:
PCM 22kHz, 16bit to provide 11kHz frequency range for near 400 hours recording (16.5 days)
PCM 48kHz, 16bit to provide 24kHz frequency range for near 184 hours recording (7.6 days)
PCM 96kHz, 16bit to provide 48kHz frequency range for near 92 hours recording (3.8 days)
MP3-320K 44.1kHz to provide 15kHz frequency range for 39 days recording with 8 batteries
Low Pass Filter: optional 200 Hz (to check)
Channels: 1 hydrophone is recorded on two channels with different level

Other recording options to be set on the recorder are available. Memory and battery requirements vary accordingly.

RECORDERS ARE MARKED WITH COLOURS (BLU, RED, BLACK, WHITE-no mark)

OPEN THE TUBE AND PREPARE FOR RECORDING SESSION

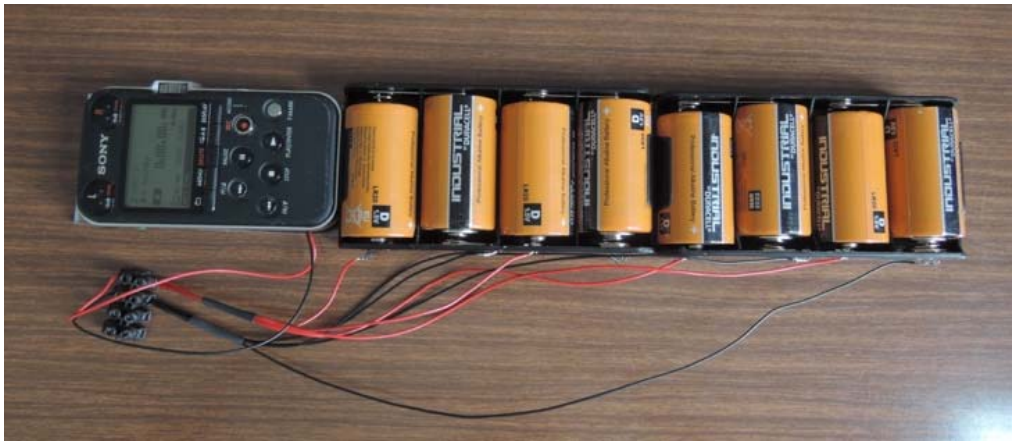
Always keep the hydrophone protected with its protective foam/cup
Unscrew the cap screws, put them in a safe container

WARNING: in case a screw turns without moving out there are two options:
1 – when trying to extract the cup force more where there is the blocked screw
2 - use a grinding wheel to remove the head of the screw, remove the cap, leave the body of the screw in place or try to extract it without damaging the container

Open up the cap
Gently insert a smooth knife below the cap in different positions around the tube and gently force the cup up 1-2 mm, then try to extract the cap by hand
WARNING: Take care of the black o-rings. Don't damage them with the knife !!!
Extract the plate with the electronics, disconnect the mini-jack of the hydrophone
Extract the silica-gel envelopes and heat them to dry
Extract the foam and if required dry it

INSERT THE BATTERIES

Insert alkaline batteries size D. The flat end of the batteries is the negative pole, always to be inserted to be in contact with the spring (black wire)



8 batteries allow >30 days recording in compressed mode (MP3-320k), e.g. for dugongs

For shorter recording sessions insert less batteries: 4 for 15 days, 2 for up to 8 days.

If the recorder is set for dolphins (PCM 96kHz 16bit, 3.5 days recording duration, or PCM 48kHz 16bit, 7 days recording), insert only 2 batteries in the slots closer to the recorder.

Prepare the recorder SONY PCM-M10

(memory card should be already inserted) NEVER FORMAT THE CARD

switch ON the recorder (push down the sliding switch on the right side)

be sure that the recorder performs the complete memory check, first on the internal memory (quick), and then a longer test on the memory card

Check/Set the date and time :
Menu > Detail Menu > Clock

Delete the memory:
Menu > Delete > Delete All ….. Execute …..

Set the card memory for recording:
Menu > Memory > Memory Card

Set the low frequency filter:
Menu > LCF > ON

Set the recording mode:
Menu > REC MODE > set recording mode according to the following rules:

For dugongs (long recording mode):
MP3 44.1kHz 320k (16 kHz range, >30 days recording on 128 GB memory, requires 8 batteries)

For dolphins (wide frequency range mode):
LPCM 96kHz/16bit (48 kHz range, 3.5 days recording on 128 GB memory, requires 2 batteries)
For dolphins or generic audio (normal range mode):
LPCM 48kHz/16bit (24 kHz range, 7 days recording on 128 GB memory, requires 2 batteries)

For low frequency sounds (e.g. fishes)
LPCM 22 kHz/16 bit wav (11 kHz range, 15 days recording on 128 GB memory, requires 4 batteries)

Set the recording level:
REC LEVEL knob on the right side: set on 5

There are three switches to check/set on the back of the recorder. By looking frontally:

On the right side of the recorder set the switch	MIC SENSITIVITY to LOW
On the right side of the recorder set the switch	REC LEVEL to MANUAL
On the left side of the recorder set the switch	DCPISPEEDCONTROL to OFF

Clean the mini-jack plug of the hydrophone with a cloth
Insert the mini-jack in the socket of the microphone (RED ring).
A message should appear on the display: PLUG IN POWER ON. In case the message does not appear do Menu > Plug In Power > ON

Press the REC button, the RED led will light ON and the YELLOW led will FLASH

Check the level bars on the display, touch the hydrophone and verify the bars (or at least one bar) are moving

Then press PLAY to definitively start the recorder, then only the RED led should be ON

be sure the numbers on the display are advancing

On the right side of the recorder move the ON/OFF slider in the top direction to HOLD it in recording mode. A key will briefly appear on the display to confirm the recorder is locked.

Be sure the recorder is running (only RED light ON and numbers on the display are advancing)

Insert the bag(s) with silica-gel to absorb humidity (the humidity of the air condenses when the recorder is put into water that is colder than air)

Cover the batteries and the recorder with the foam strip and gently insert in the tube

Put a thin line of grease (Vaseline) around the black o-rings

Gently push the hydrophone cable inside

Put the cap on the tube taking care of the alignment of screw holes (insert one or two screws to be sure, in case is necessary gently rotate the cap without extracting it), THEN gently insert the cap until the first o-ring

Check that the black o-rings are properly positioned and greased

Press firmly on the whole cap to insert it fully, then insert and tighten the screws (start with two opposite screws and then go on with the others) DON'T FORCE: it is enough when you feel the resistance of the key with just one finger

DEPLOYEMENT

Keep the protective foam/cup on the hydrophone all the time
Manage the tube carefully, avoid to hit the hydrophone
Remove the hydrophone protection foam/cup just before putting the recorder into water

RECOVERY FROM WATER

Put the foam/cup protection on the hydrophone
Before opening wash with fresh water

DATA DOWNLOAD AFTER A RECORDING SESSION

Open the tube (see OPEN THE TUBE)
Disconnect the hydrophone mini-jack
Extract the recorder plate
Move down the switch on the right side to unlock the recorder.
If batteries are fully discharged extract them
Insert two batteries in the slots close to the recorder to allow the data download

Connect the PC to the recorder with a mini-USB cable.

You'll see two devices: select the memory card and the folder /PRIVATE/SONY/HIFI/FOLDER01 (also check if there is something in /FOLDER02)

On the external disk connected to the PC create a dedicated folder named with the COLOUR of the recorder (BLACK, RED, BLU, WHITE) and its LOCATION and deployment DATE.

Example: X:/SESSION_BLU_IBOPOINT3_20160715

Copy the data (files .wav for dolphins, files .MP3 for dugongs) in the proper folder

This requires about 6-7 hours to transfer 128GB of data over USB2
Be sure the data is completely copied in the external PC disk (double check !!!!)

NEVER FORMAT THE CARD nor DELETE FILES by the PC

TO ERASE the card for the next recording session, with the memory card in the recorder:
Menu > Delete > Delete All ….. Execute (or do it when you set for the next recording session)

A much FASTER OPTION (about 60-80 minutes but only with USB 3 card reader connected to a USB 3 PC) requires to extract the microSD memory card from the recorder:

Extract the microSD card (open the little door on the left side of the recorder)
Insert the microSD in the card reader connected to the PC
Copy the data as described before
Re-insert the microSD in the Recorder (with contacts facing up), then switch on the recorder and verify that both checks are performed correctly (one quick on the internal memory, one longer on the memory card). In case you see only one check, extract and insert again.

Don't touch the microSD card contacts with dirty fingers (salt or grease); in case, clean your hands and clean the contacts with a clean cloth

NEVER FORMAT THE CARD nor DELETE FILES by the PC
ALWAYS DELETE ALL WITH THE RECORDER MENU – NEVER FORMAT !!!!!

RECORDER STORAGE

Be sure the the tube is clean and not wet inside
Put the protective foam/cup on the hydrophone
Put the recorder and the foam line in the tube WITHOUT batteries
Put a silica gel bag
Clean the hydrophone mini jack if a clean cloth
Insert the hydrophone cable in the tube, WITHOUT connecting to the recorder
Put the cap on the top of the tube WITHOUT pressing it in
Seal the cap/tube together with a large adhesive tape around the tube and the cap
Be sure to keep the screws in a safe place (eventually just inside the tube)
Store the tube in a safe place

PREPARE THE RECORDER FOR SHIPMENT

Follow the instructions OPEN THE TUBE, then

Be sure the the tube is clean and not wet inside
Unscrew the hydrophone by using the proper key
Put the hydrophone in his protective foam
Clean the recorder and the other components with a clean cloth
Place the foam with the hydrophone and its cable on a battery holder
Insert the recorder plate in the tube (along with the hydrophone)
Insert a foam strip on the recorder to keep it in place during transportation
Put the 6 screws in a plastic bag and put it in the tube
Close the cap by pushing gently until the first o-ring, the push firmly on both sides of the cap
Put an adhesive tape on the hole in the cap

DATA HANDLING

Copy the data of all recorders from the external PC disk to one of the portable disk and ship to CIBRA/UNIPV

DATA PRE-PROCESSING

For each recorder folder:

Rename files using BRU (Batch Rename Utility) to add to the filenames the creation date and time

After renaming, files can be viewed with Audition or Audacity

Then, by using Adobe Audition in batch mode:

WAV files, merge 2 channels into 1 channel, thus producing

MP3 files, merge 2 channels and convert to 1 channel wav at 44.1kHz

MP3 files, downsample to 32kHz, merge 2 channels into 1 channel wav at 332 kHz

SeaPro-SABIOD can be used to analyze WAV files (can't read MP3) and produce "compressed" spectrograms day by day. (at present SeaPro can't work on single channel files)

Brief introduction to DEPLOYMENT AND ANCHORAGE OPTIONS

Shallow waters

To be managed by usual divers, the recorders must be placed at a suitable depth. Here some typical cases:

1 – recorder tube fixed horizontally on a basement (e.g. 100kg of concrete) on the seafloor
2 – recorder tube fixed on a cable anchored to a basement and pulled up by a subsurface floater
3 – recorder tube fixed on a cable of an anchored surface buoy

In case 1 the basement must be placed on a divers' reachable seafloor. In case 2 the basement can be deployed at any depth, a cable is anchored at the basement and pulled up by a floater that stays below the sea surface, e.g. 10m deep; the recorder can then be attached (in vertical position) to the cable just below the floater, in a position where it is easy for a diver to attach and then recovery it. In case 3 any surface buoy can be used, independently of the depth of the basement, and the recorder tube is attached at the most suitable depth for the diver, e.g. 10 to 15 meters deep. It is important that the cable is a rope, not a chain that could be noisy.

Pros and cons of different solutions:

1: good for shallow waters, easy to deploy and recover, not visible from the surface, possibly damaged or moved by fishing gears, the basement can be used for several deployments, for clean operation it is possible to recover the basement too.

2: good for more deep waters, easy to deploy and recover, not visible from the surface, possibly damaged or moved by fishing gears, the cable can be used for several deployments, for clean operation it is possible to recover the basement too.

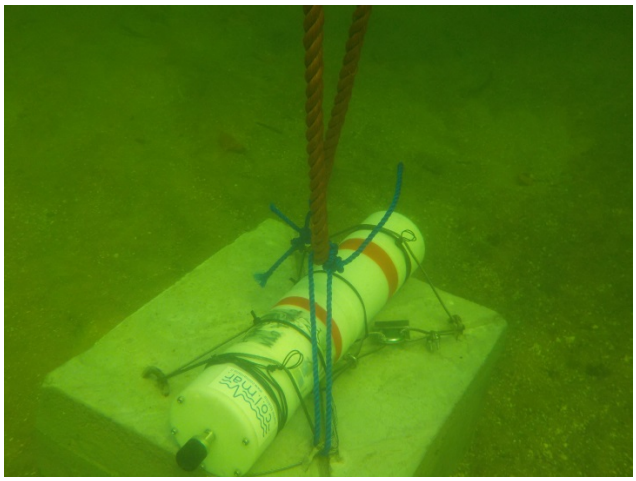
3: easy solution wherever surface buoys are already in place, e.g. to mark the boundaries of a protected area, easy to find for recovery operations and for repeated deployments, maybe noisy in high sea state, more exposed to theft or intentional damage.

Deep waters

Depending on the depth, cases 2 and 3 can be an option.
A further, but more expensive and complicate option is similar to 2 but with an additional decice (acoustic release) in between the basement-cable and the recorder-floater assembly. Provided the housing of the recorder is suitable for the depth, the assembly basement-acousticrelease-recorder-floater assembly can be deployed by a ship on any depth. To recover the equipment, an acoustic generator is used to send a sound-coded command from the surface to the acoustic release. When the acoustic release receives the command, it disconnects itself from the basement or from the basement-cable and the assembly acousticrelease-recorder-floater comes up to the surface.

4.4 Project pictures


CONSERVATION
LEADERSHIP
PROGRAMME



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