Designação do Projeto|	AWARENESS - Estudo das vocalizações da baleia comum para uma avaliação robusta da densidade populacional por métodos acústicos passivos
Código do Projeto|	LISBOA-01-0145-FEDER-030514
Objetivo Principal|	Reforçar a investigação, o desenvolvimento tecnológico e a inovação
Região de Intervenção|	Lisboa
Entidade Beneficiária|	FCiências.ID – Associação para a Investigação e Desenvolvimento de Ciências
Data de Aprovação|	13-03-2018
Data de Início|	01-10-2018
Data de Conclusão|	23-05-2021
Custo Total Elegível|	239.939,66€
Apoio Financeiro da União Europeia|	FEDER – 52.099,36€
Apoio Financeiro Público Nacional/ Regional|	OE – 187.840,30€

Objetivos

The main goal of the project is to support robust density estimation of fin whales from passive acoustic monitoring (PAM), by providing acoustic
parameters to be incorporated into density estimation models, and by developing methods to locate fin whale sounds from either single or multiple
sensors. We will integrate data collected from PAM, land-based visual observations, animal-borne acoustic tags and biological sampling to generate
an archive of fin whale vocalizations with extensive metadata. This dataset will then be used to estimate sex- and context-specific vocalization
rates, to investigate temporal patterns in vocal activity and to identify new calls suitable for monitoring purposes. Existing recordings spanning 8
years and a large geographic area will be used to determine consistency in acoustic properties and in usage of different calls. This project will
contribute to improve efficiency of passive acoustics to monitor whale populations and assist in risk mitigation efforts.

Atividades

1 - Land-based visual and acoustic observations
2 - Deployment of animal-borne acoustic recording tags
3 - Estimation of context-specific vocalization rates
4 - Analysis of existing recordings
5 - Development of methods for estimation range and source location using OBS and EAR data
6 - Estimation of sound levels
7 – Integration
8 - Management and outreach

Resultados Esperados / Atingidos

« Resultados Esperados / Atingidos »

AWARENESS aimed to describe fin whale vocal behaviour, develop methods to calculate their acoustic detectability and estimate their absolute density from passive acoustics. Specific objectives were to: identify new calls and assess their feasibility for monitoring; investigate the effect of sex, behaviour, time and season on call rates; investigate the relationship between call density and whale numbers; develop and test methods for ranging and locating calls; compare methods and sensor configurations for assessing whale density. To address these objectives, AWARENESS integrated passive acoustics, land-based visual observations, animal tagging and biological sampling.

Task 1

Visual observations were done simultaneously with acoustic recordings following a pre-defined protocol to gather data for tasks 3-7. The 1st sampling period was in 2019 with 4 EARs (March-June) and 5 OBSs (March-September). EARs recorded 110 days (1980h) and OBSs 165d (3960h). Visual observations were done on 36d (168h) and fin whales were seen once. In the 2nd period (September 2019-June 2020) 2 EARs recorded 279d (3348h). Observations were done on 72d (324h) but no fin whales were sighted. Given the low number of fin whale detections, we did a 3rd sampling period (April 2021-March 2022) with 311d (1866h) of EAR recordings.

EAR and OBS data were processed to correct time drift and seismometer orientation. Fin whale calls were identified by inspecting spectrograms (EAR) and with automated detectors (OBS). Calls were annotated, their acoustic properties characterised, and information was integrated in excel with the number and behaviour of whales. To increase sample size, we added data from 2017-2018. The final database includes call rates/hour for 20Hz and 40Hz calls for 2017-2022 calculated from 1186 (EARs) and 165 (OBSs) recording days, and 237 sightings of fin whales.

Task 3

Using the positions of vocalizing whales (T5) for the EAR data matching the positions of visually identified fin whales (T1), we calculated individual calling rates. Whales produced 102.7 calls/hour for 20Hz and 5.1 calls/h for 40Hz notes. Hourly call rates of 20Hz and 40Hz calls were used to examine diel and seasonal patterns and investigate the relationship with number of whales sighted per hour, day, month and year. 20Hz and 40Hz call rates were significantly higher during the day than at night. 20Hz call rates were higher in autumn and winter and null in summer; 40Hz calls peaked in spring but call rates were much lower than those of 20Hz calls. Call rates correlated with nº of whales seen per month (40Hz) and year (20Hz, 40Hz) but not per day (Romagosa et al. 2022a). We studied the relationship of 40Hz call with prey availability to investigate their environmental context, and found a positive association with prey biomass, demonstrating a food-associated function of this call (Romagosa et al. 2021a).

Task 4

We combined data from the project with existing recordings (Cadiz, Gorringe, Azores) to describe seasonal and annual patterns of different call types and assess their potential for monitoring. All milestones and expected results were fulfilled. 20Hz notes and double pulses (20Hz+130Hz) are more common in autumn and winter, while 40Hz calls are produced at lower rates and mainly in spring-early summer (M4.2; Romagosa et al. 2020a, 2021a). Call seasonality was consistent over years and areas. Diel patterns of all call types indicate that whales vocalize more often during the day than at night (Romagosa et al. 2020a).

Intensity of 20Hz notes was 3dB higher than of 40Hz notes, and their detection range was 3-4 times higher (Romagosa et al. 2021a), indicating 20Hz are more suitable for monitoring. Yet, the fact they are rarely produced in spring and summer means that year-round monitoring requires using also 40Hz notes. We compared stability in temporal structure and spectral properties of 20Hz notes and double pulses using 20 years of data from central and Northeast Atlantic. Inter-note intervals (INIs) of 20Hz notes changed both gradually and rapidly, and frequency of the 130Hz pulse has decreased from 2007 to present. Temporal changes in INIs affect the estimation of calling rates and need to be accounted for to avoid bias in acoustic density estimation (Romagosa et al. 2022a).

Task 5

Data from T1 were used to develop and test methods for ranging and location of fin whales. Using OBS data we tested 3 location methods: Single Station (SSM), Triangulation (TM) and Multipath Methods (MM). SSM can only be applied for ranges smaller than the critical range defined by ocean bottom properties, typically the order of sensor depth (~800m). 40 SSM locations were compared with locations by TM but quality was poor due to noisy conditions. MM was tested with synthetic data computed with AWARENESS parameters using PlaneRay code. Given the sensor depth, it was not possible to distinguish between multipath arrivals and interference patterns from the Lloyd's mirror effect (LME). Under these circumstances MM cannot be applied. TM was applied to a long sequence of calls recorded by 3 OBS. The irregular track was smoothed by a modification of a Bayesian state-space model that computes the probability of locating a call given constraints on whale speed (Pereira & Matias 2021b). Localization of whale calls from EARs was based on Time-of-Arrival-Differences, which then served to estimate whale speed. Localisation accuracy was tested by localising low frequency sounds by an underwater speaker. Results were used to derive detection ranges for OBS and EARs (Pereira et al. 2022b) and a methodology to estimate depth of calling whales using LME (Pereira et al. 2020b).

Task 6

A procedure and R code were developed to compute sound level (SL) of 20Hz calls from OBS hydrophone and vertical seismometer channel. Sound speed profile for acoustic propagation modelling was derived from climatological databases and nearby CTD profiles. A calibration experiment was done for EAR SL using a calibrated hydrophone, a calibrated sound source and ship noise recorded simultaneously by OBS. SLs of OBS and EARs were compared in Pereira et al. 2020b, 2021a, 2022a.

Task 7

The scarcity of simultaneous fin whale recordings and visual observations (T1) and lack of data on individual vocal behaviour (T2), made it impossible to fulfil most activities planned. However, AWARENESS provided valuable results and lessons on the use of PAM for population density estimation. These were the focus of an International Workshop organized in March 2022 (M7.1) with colleagues from Univ St. Andrews: Workshop on Passive Acoustic Monitoring Density Estimation: raising AWARENESS of latest developments and discussing practical challenges, 7 March 2022. Organizers: D. Harris, T. Marques, L. Thomas, L.M. Matias, A. Pereira, M. Romagosa, M.A. Silva. In: 9th International Workshop on Detection, Classification, Localization, and Density Estimation of Marine Mammals using Passive Acoustics, Oahu Hawaiʻi, 7-11 March 2022. https://www.soest.hawaii.edu/ore/dclde/tutorials-workshops/