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FISH BIODIVERSITY ASSESSING USING BIOACOUSTICS AND VIDEO DATA FROM A MARINE SHALLOW WATER OBSERVATORY

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ABSTRACT

Underwater observatories produce long time series of different data types providing valuable information for studying the ecosystem and its temporal variations. Here, the results of the fish biodiversity assessment obtained through the Capo Granitola (Sicily Channel, Mediterranean Sea) observatory are discussed. Video (138 h) and acoustic (274 h) recordings were analyzed to obtain the number of species, number of specimens, number of acoustic types, Shannon Index, and Acoustic Complexity Index. The number of species detected and identified with videos is much higher (11) than with acoustics (<5). The two techniques have limits and advantages that here are discussed. Our results highlight that the use of both video and bioacoustics methods can fill the gaps of knowledge helping to obtain an integrated assessment of the fish community.

Keywords: *Marine observatory, Acoustic Index Complexity, fish biodiversity, bioacoustics, underwater video analysis*

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1. INTRODUCTION

Marine cabled stations collect large amounts of data continuously, over very long-time intervals, posing the problem of how to analyze them quickly and effectively (Lopez-Vazquez et al., 2020). Manual data analysis can take quite a long time and the use of many operators and energies, consequently it is of great interest to refine the automatic analysis techniques. The analysis of the acoustic recordings can be performed with algorithms capable of estimating the noise levels on different frequency bands but they are not accurate in distinguishing the different sources, be they anthropic, biological or geophysical. For images, variations in brightness, limited visibility, and other factors make the identification of the species often problematic (Aguzzi et al, 2020; Štifanić et al., 2020; Ben Tamou et al., 2021). Moreover, the availability of different sensors data highlights the necessity of integrated studies to improve our knowledges of complex systems such as marine ones. It is therefore a very promising and complex research field, which has great potential and could in the future contribute to making marine monitoring by means of acoustic and video data standardized and more efficient. This study has as its main objective the comparison of fish biodiversity assessments obtained using Acoustic Complex Index and Biodiversity Shannon Index applied respectively on acoustic and video recordings of the Mediterranean shallow water cabled marine observatory sited in the Sicilian Channel.

2. MATERIAL AND METHODS

The cabled marine station of the CNR-IAS of Capo Granitola is located about 350 meters from the coast of Capo Granitola (Sicilian Channel; Lat 37°34.09'N, Lon 12° 39.33'E), on a sandy bottom at a depth of about 9 meters (Figure 1). The station is equipped with a digital hydrophone (HF icListen, Oceansonics, Canada. Sensitivity: -170 dBV re µPa), two ip cameras (SNC-CH110, Sony), and a CTD probe (concert3, RBR Ltd, Canada). The hydrophone records continuously with a sampling rate of 32 kHz with a resolution of 24 bits, the audio files are saved in real-time in .wav format in the land station laboratory.

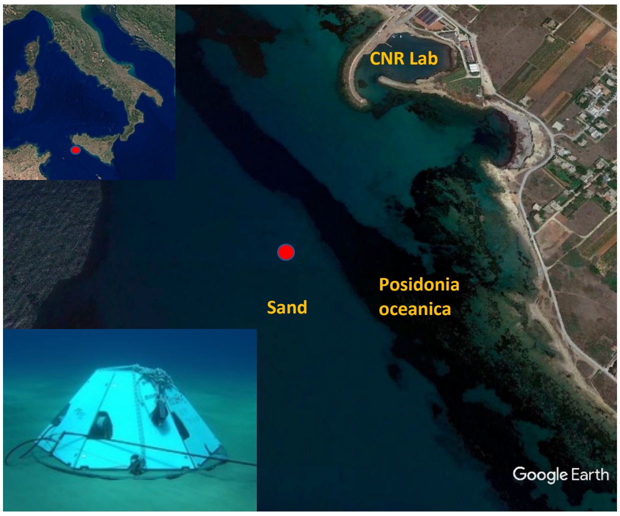

Figure 1. Marine cabled station (red point) and its location in the Sicilian Channel shallow water.

The video files, in .mp4 format, were viewed with the QuickTime Player software. Each video, lasting 60 ± 1 minute, was grouped into time intervals of ten minutes each, to facilitate subsequent comparison with the recordings acquired by the hydrophone. For each time interval examined, the taxa of fish were identified, and for each taxon, the total number of individuals present was counted. For the recognition of the animals, the manual "Guide to the Identification of marine fish of Europe and the Mediterranean" (Louisy, 2006) was used as a reference. Where visibility was good and the animals were close to the camera, identification took place at the species level, otherwise it stopped at the genus level. The camera's field of view includes the sandy bottom in front of the monitoring station and the portion of water above it. Consequently, the observations have mainly focused on benthic or close-to-the-bottom animals, and, only occasionally, on species that usually swim further from the bottom. The data collected during the video analysis were reported in Excel spreadsheets.

The acoustic files, in .wav format, have been visually divided into 10 minutes time intervals in order to facilitate subsequent comparison with the videos. A visual analysis of the spectrograms allowed the detection of any sound emissions from fish. The search was centered in the frequency band between 1 Hz and 3 kHz, i.e. the interval within which most of the sound emissions of fish are located (Carriço et al., 2019), displaying time windows of ten seconds at a time. To recognize the sounds emitted by fish, the sounds detected were compared with bioacoustic studies focusing on Mediterranean species were taken as reference (Picciulin et al., 2002; Bertucci et al., 2015; Ceraulo et al., 2018; Desiderà et al., 2019; La Manna et al., 2021). For each recording analyzed, the presence or absence of sounds emitted by fish was reported on Excel spreadsheets, together with the number of sounds emitted and the duration of consecutive emissions.
To try to identify the animals responsible for the emissions of these sounds, a manual cross search was carried out between audio files and video files. To simplify the search, video frames with an abundance of animals were chosen and compared with the corresponding time intervals recorded by the hydrophone. This was repeated both before and after identifying the fish sounds on the spectrograms.

Acoustic complexity index and biodiversity index
Thanks to the analysis of the videos, the Shannon index have been calculated with the number of fish species and their abundance in order to quantify the biodiversity observed around the marine station from a visual point of view. To compare it with the diversity that can be observed through the audio recordings, we calculated the acoustic complexity index (ACI) adjusted to fish sounds. The ACI is based on the assumption of a strict relationship between the complexity of animal assemblages in communities and the spectral and temporal complexity of a soundscape in an acoustic community. This means that the more species present and individuals present, the higher the value of the ACI, representing the acoustic information of these individuals (Farina et al. 2016).

3. RESULTS

Video analysis of August 2021 (11 days, 138 hours) allowed us to detect 11 fish species and 3961 specimens. The most abundant genres were *Diplodus*, *Percoidea*, *Lithognathus*, and *Seriola*. Acoustic recordings (13 days, 274 hours) contain about 5 categories of fish sounds in 77% of files and mostly during the night. Identification of species that produce these sounds is not certain, and *Scorpaena* sp. could be one of this already present in the video recordings. Spectrograms analysis shows both pulsed and frequency modulated sounds with different pattern.

The comparison among ACI and Shannon/Eveness index did not show any correlation except for 812 Hz frequency band in which a weak linear relation is present ($p<0.05$, r-squared =0.04).

Figure 2. A frame from video recordings with a *Diplodus sargus* specimen.

4. DISCUSSION

Acoustic and video analyses have revealed a different temporal pattern and specific advantage and disadvantages. Acoustics can operate continuously without weather/light limitations but with a limited capability to detect the only soniferous species. Otherwise, video shows a higher capability to detect species around the camera but with a limit of light/visibility and a reduced volume of sampling area. The application of two different biodiversity analysis, the one based on the acoustic algorithm ACI and the other on classic biodiversity index, provide complementary results that can be applied jointly on long series of data of different type to better explore ecosystems.

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