Analyzing Belgian marine soundscapes using unknown sound events

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Soundscape studies haven been proven to be a reliable tool to provide information about marine ecosystems in a non-invasive and continuous way. The most common way of doing such analysis is to detect known sound events and analyze their spatio-temporal patterns of occurrence. This can provide insight on animal presence, migration patterns, seasonal changes, ecological composition, and the interaction with human activities. These sounds can be from biological sources (biophony), from physical sources (geophony) and from human activities (anthropophony).

To be able to detect these sound events, prior knowledge on the sound sources present in the environment is needed. This is not yet the case in the North Sea in terms of biological sources, meaning that the link between marine fauna and their sound production is very limited. One of the reasons is due to the high turbidity present in the Belgian Part of the North Sea (BPNS), which reduces visibility and therefore limits the possibility of ground-truthing sound sources with their producers. The other method to determine sound produced by the fauna is doing tank experiments and recordings, but these are expensive and labor-intensive tasks.

In this study we propose to analyze Belgian underwater soundscapes with a novel approach based on detecting, clustering and analyzing unknown sound events. The method is applied to the data from the LifeWatch Broadband Acoustic Network (Parcerisas *et al.*, 2021), which comprises recordings from 6 different locations in the BPNS. First, a deep learning object detection algorithm from computer vision - Yolov8, (Jocher *et al.*, 2023) - is re-trained on a representative subset of the data to detect any acoustic event in the recording. As input to the model, the recordings are converted into spectrograms, which are a visual representation of the spectrum of frequencies of a signal as it varies with time. For this method, we define an acoustic event as anything which is acoustically and visually salient from the background, in the raw audio and the spectrogram, respectively. Next, the detected sound events are clustered in different classes in an unsupervised way. The obtained clusters represent the different sound classes present in the BPNS. These unidentified sound classes are then manually studied, providing insights into their source – if possible -, acoustic characteristics, and potential ecological significance. The soundscape of each location can then be described using these clusters to unravel daily patterns, seasonal variance and differences between stations.

The implications of this study have practical applications in environmental monitoring and marine conservation efforts. The knowledge of Belgian underwater soundscapes contributes to increasing the understanding of the region's marine acoustic biodiversity, enabling more informed conservation strategies. Furthermore, the ability to monitor marine soundscapes regardless of whether the sound sources are known or not allows for early detection of environmental changes, such as shifts in species composition or habitat disturbances**.**

References

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