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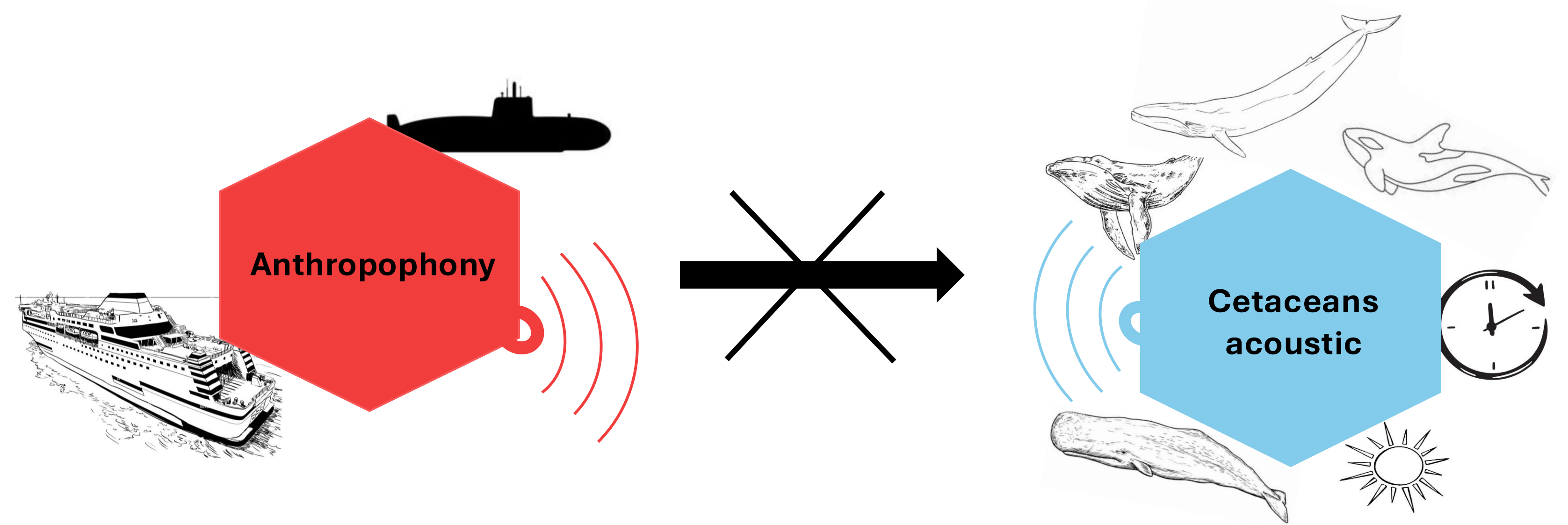
Circadian rhythms of cetaceans from Arctic and Mediterranean seas with controlled anthropophony

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OBJECTIVES

- ◆ Assess diel and solar acoustic patterns of cetaceans
- ◆ Identify anthropophony pressure
- ◆ Compare soundscape between different locations
- ◆ Define circadian rhythms in low ambient noise



METHODS

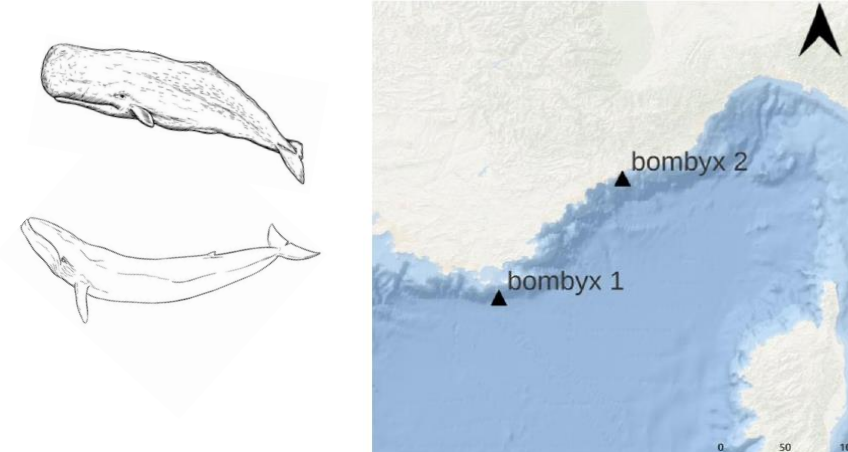
Field recordings

Bombyx 1 Port-cros 2015-2018

Stereo antenna at 25 m depth
Intermittent recordings at 50 kHz

Bombyx 2 Monaco 2022-2024

5 hydrophones array at 25 m depth
Intermittent recordings at 256 kHz

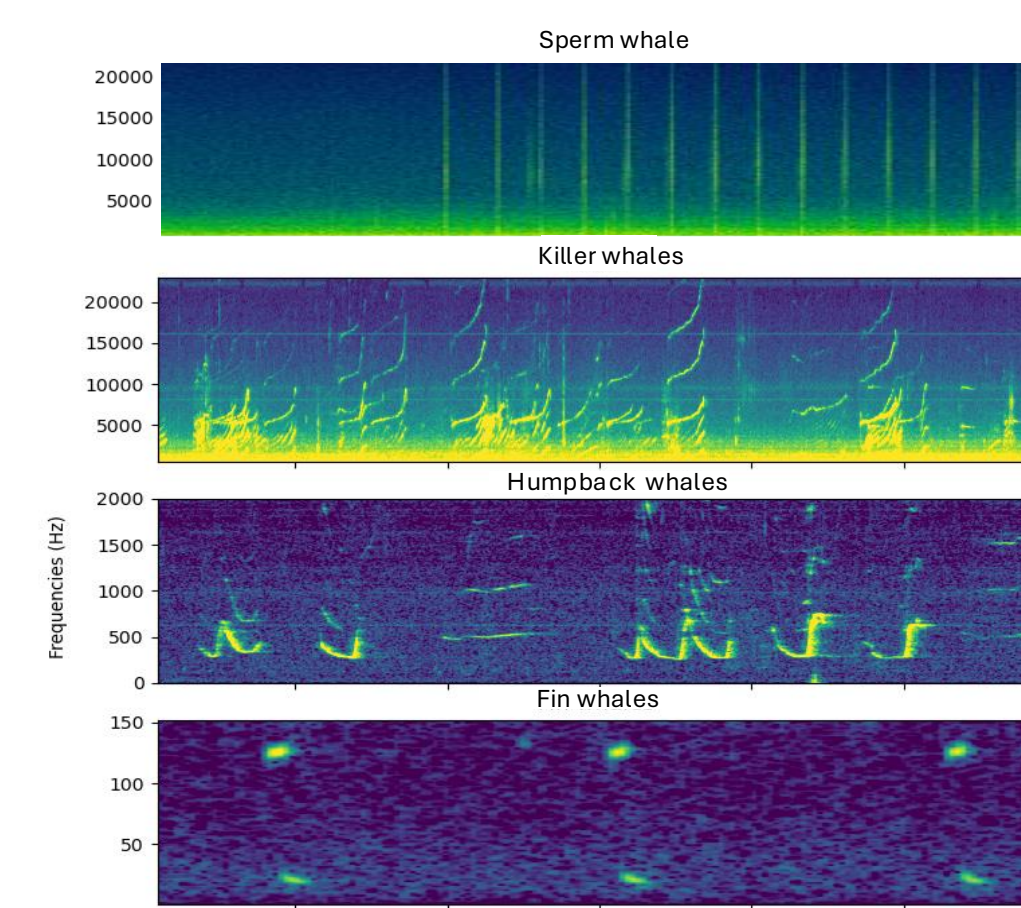


Kvaenangen fjord

Stereo antenna on the seabed
Continuous recording at 192 kHz
November 2022 – January 2023

Fig. 1: Location of acoustic antennas (Mediterranean Sea on the left, Seglviik, Norway on the right).

Automatic detectors



CNN on spectrogram in Mediterranean [1, 2]

Yolo v5 in Norway [3]

Fig. 2: spectrogram of vocalizations of the four studied species.

Recording selection

Power spectral density (PSD) for soundscape analysis: power of a signal for different frequencies, normalization with hydrophones parameters

Selection of recordings with less than the median ambient noise for each area:
238.5 hours in Mediterranean Sea
118 hours in Norway

RESULTS

Cetaceans rhythms in Mediterranean Sea

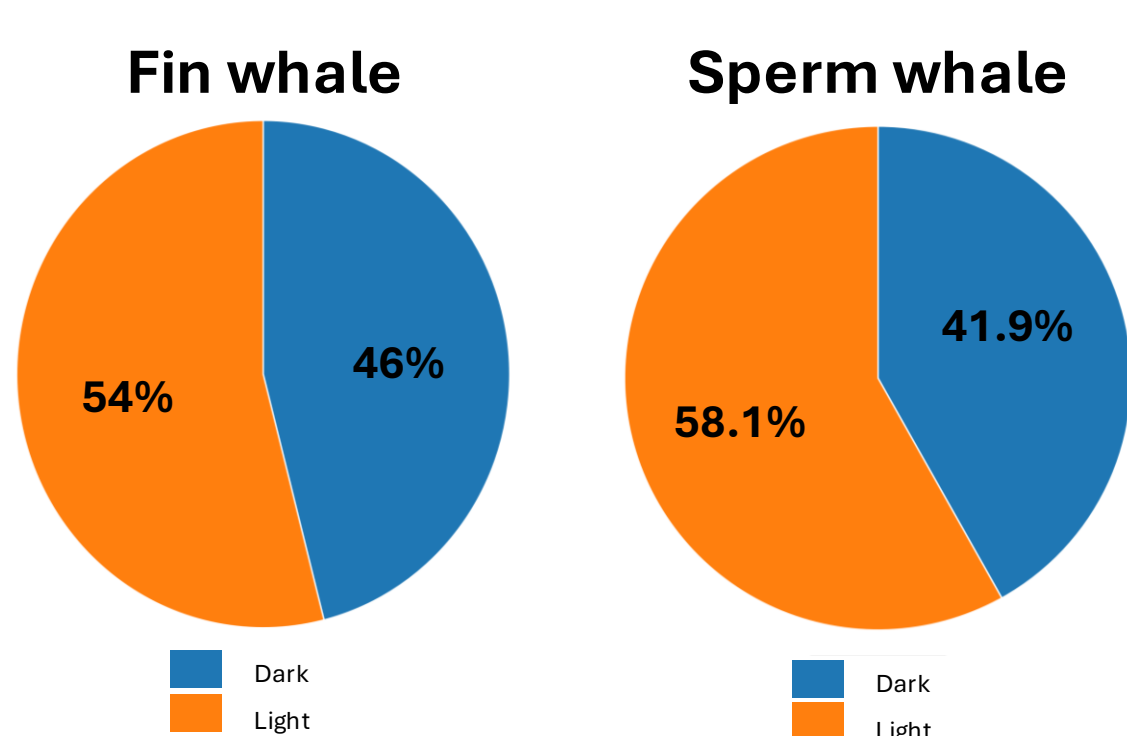


Fig. 3: The percentage of positive recordings according to the solar period (dark or light).

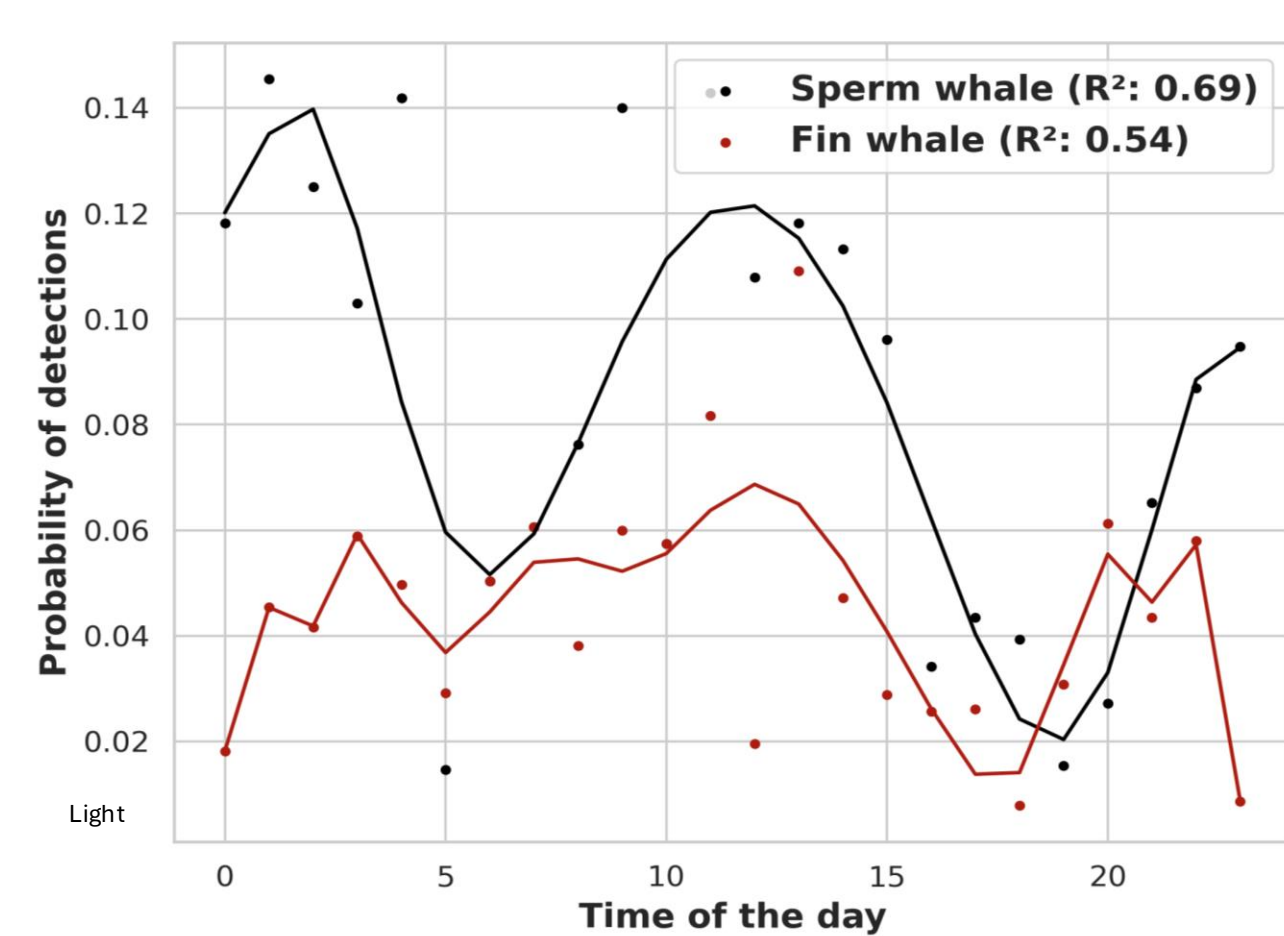


Fig. 4: Polynomial function (degree=10 for sperm whale, 14 for fin whale) of mean probability of detection throughout the day.

Maximum detection probability of **sperm whale** around 12a.m and 12p.m
Similar detection probability for **fin whale** along the day

Daily pattern of anthropophony

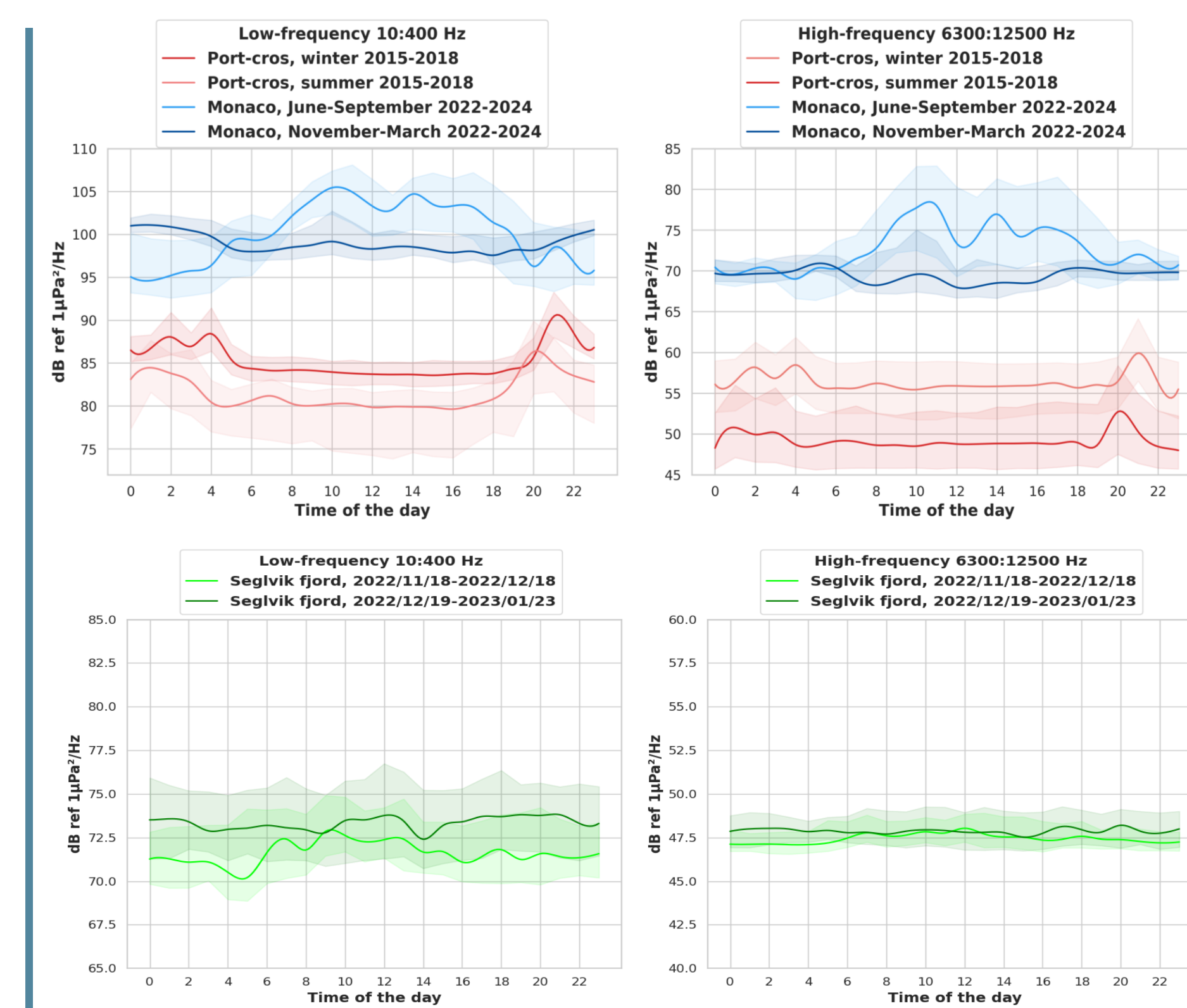


Fig. 7: Evolution of median ambient noise in low (10-400 Hz) and high frequencies (6500-12500 Hz) throughout the day in the three study sites.

Distinct pattern of ambient noise between two sites of Mediterranean Sea :

- ◆ Potential high **tourism pressure** in **Monaco** highlighted by the difference in ambient noise between summer and winter
- ◆ Noise peaks in **Port-cros** induced by **ferry routes** from Toulon/Marseille to Corsica
- ◆ **Relatively stable** daily ambient noise in **Arctic fjord**

Cetaceans rhythms in Seglviik, Norway

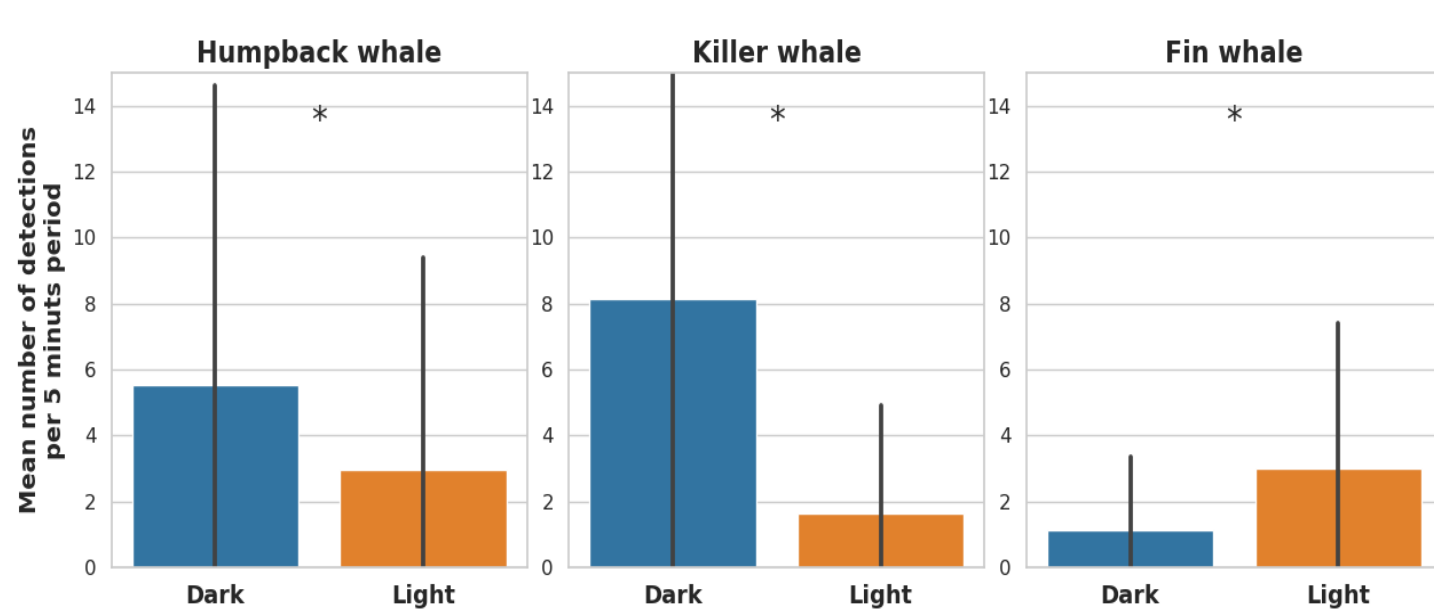


Fig. 5: Acoustic activity according to solar period (excluded polar night period). * = p-value < 0.05 for Kruskal-Wallis test.

Solar period and time of the day significantly influenced **humpback** and **killer whale** acoustic activity

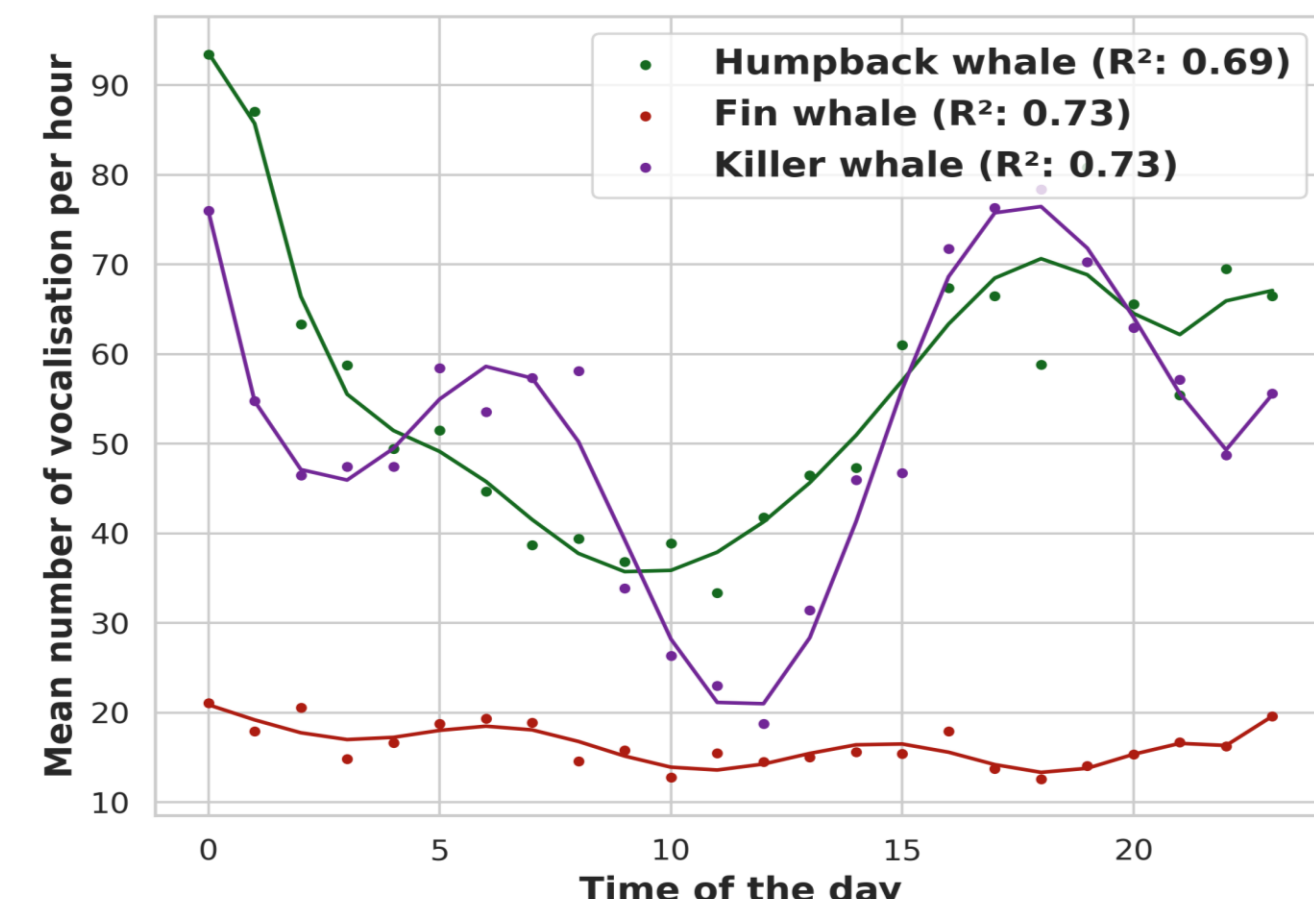


Fig. 6: Polynomial function (degree=10) of mean number of vocalization per hour for the three species.

The **three species** exhibited different acoustic activity on a daily basis

DISCUSSION & PERSPECTIVES

- ◆ A clear daily acoustic pattern was observed for cetaceans in Mediterranean Sea and Norway : does it reflect actual activity or movement within the detection range ?
- ◆ The high anthropophony pressure suspected will be confirmed using AIS data.
- ◆ Further research are needed to investigate long term effects of anthropophony on cetaceans acoustic behavior. To mitigate detection biases caused by high ambient noise, simulations will be conducted.