

Characterisation of the underwater noise caused by marine traffic in the Bay of Gibraltar

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Introduction

The introduction of sound from human activities is a pollutant known as Underwater noise. Low-frequency continuous noise (10-1000 Hz), mainly from ships (e.g. propeller cavitation, hull, engine), has increased since the nineteenth century (1). International regulations continue to be developed (e.g. MSFD), focusing on stipulating guidelines for its measurement and monitoring (2).

The Bay of Gibraltar is a relevant marine area, with a high diversity of species and high maritime traffic (3). Elevated continuous underwater noise will likely impact all the marine fauna and ecosystems in this area. There is a data deficiency in underwater noise in key biodiverse maritime areas; as such, this study is the first baseline characterisation of underwater noise within the Bay of Gibraltar.

Methods

A critical and synthesised literature review was developed to identify the best methodology, acoustic data analysis, impacts on marine fauna knowledge gaps and mitigation strategies.

An RTSys EA-SDA-14 hydrophone was deployed, in Rosia Bay, through a bottom-moored method. Data from commercial and recreational vessels were acquired (observation & AIS).

The collection of continuous underwater noise was focused on mainly three different time frames (morning, midday and evening) for a weekday and a day of the weekend.

Extraction of fifteen minutes of high & low noise peaks data files was carried out using Audacity software.

Acoustical analysis in RStudio, using PAMGuide to obtain noise metrics such as Power Spectral Density (PSD) [power/intensity of the signal (Hz)], Third-octave level band (TOL) [power/intensity in logarithmic scale] and Sound Pressure Level (SPL) [sound amplitude within time period & frequency (dB)].

Multivariate analysis (e.g. nMDS, ANOSIM) was conducted for the SPL values in broadband and for the MSFD 1/3-octave band frequencies (63Hz, 125Hz) with an additional frequency of 2,000Hz.

Main findings

Noise measurements of the Bay of Gibraltar were reported as Sound Pressure level (SPL) in Broadband and Third-octave frequency levels (TOL). Noise levels ranged from frequencies around 20 to 500 Hz and above 1,000 Hz up to 10,000 Hz (See Figure A), with several possible biological sources (e.g. snapping shrimps, fishes, sea urchins & other invertebrates) occupying similar frequencies. In the latter higher frequencies, recreational vessels could be discerned. (See Figure A, A2).

Broadband SPL was, therefore, analysed to include several frequency bands used by recreational & commercial vessels.

- Broadband SPL ranges of the Weekday: 113 to 138 dB re 1µPa.
- Broadband SPL ranges of the Day of the Weekend: 115 to 140 dB re 1µPa.
- Average of all means of both days: 123.25 dB re 1µPa.

As for the TOL SPL range for the MSFD bands 63Hz(1), 125Hz(2), and 2,000Hz(3) reported for a:

- Weekday:
(1) 95 to 125 dB re 1µPa (2) 97 to 120 dB re 1µPa (3) 95 to 118 dB re 1µPa
- Weekend:
(1) 98 to 125 dB re 1µPa (2) 100 to 125 dB re 1µPa (3) 100 to 120 dB re 1µPa

In the Figures section, examples of a TOL (Fig A & B) and an SPL (Fig C) analysis can be observed.

- The noise levels on the weekday were mostly produced by commercial vessels (n=34) [Oil/Chemical Tankers, Cargo, Bulk carriers, ferries, Law enforcement RHIB...] than recreational vessels (n=10) [fishing boats, jet skis, sailboats, yachts...].
- Over the weekend, an almost equal number of recreational (n=44) and commercial (n=41) vessels were observed. The increase in recreational fishing boats was attributed to the opening of the 2021 Atlantic Bluefin Tuna season.
- Significant differences were observed when comparing different time frames of both days, with *higher commercial activity in the mornings and recreational vessel activity in the evenings* [ANOSIM (p<0.01)]. The temporal differences observed reflect human activity patterns (recreational) (Mustonen et al., 2019) and that *Gibraltar is the largest (low-cost) bunkering port in the Mediterranean Sea* (commercial) (Gibraltar Port Authority, 2021).

Implications

The Bay of Gibraltar has important populations of marine fauna (e.g. dolphins-resident, tuna-migratory). With studies detailing several negative impacts of underwater noise (e.g. hearing loss, vessel strikes risk), a detailed analysis of these effects needs to be further elaborated.

The most effective mitigation and management strategies considered here are: 1) Define allowable harm noise limits, 2) Develop temporal restrictions through marine spatial planning regarding the presence of sensitive and protected species with implications for the reduction of emissions & fuel consumption savings.

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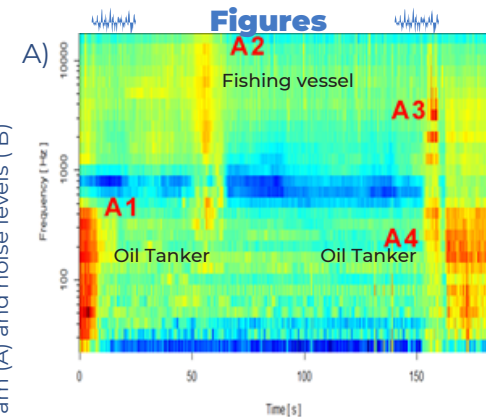


Fig A - TOL: High intensity around 20 to 500Hz from Oil Tanker (A1, A4). Above 1,000 Hz, high intensity represented noise from a passing fishing boat (A2) & commercial (A3).

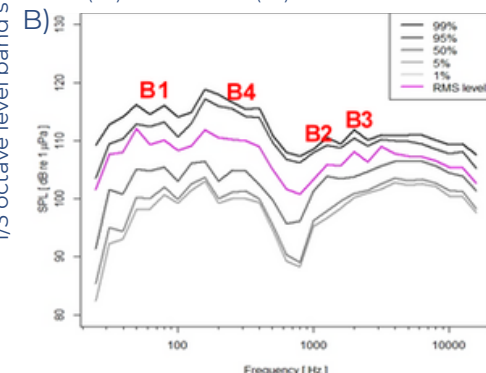


Fig B- TOL: Noise levels of ~100 dB re 1µPa (B2) for a fishing boat passing near the hydrophone [B2]. Noise levels around 110 dB re 1µPa for high intensity in frequencies above 1,000 Hz (B1, B3, B4)

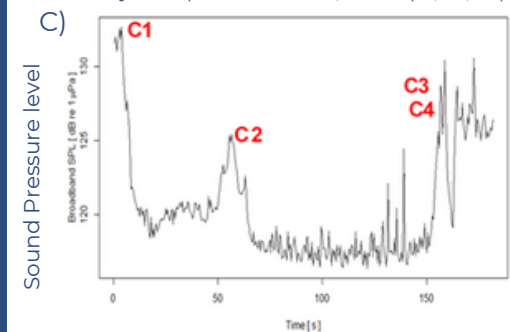


Fig C - SPL: Levels range from 120 to 135 dB re 1µPa:

- Fishing boat noise levels registered around 125 dB re 1µPa (C2).
- For the Oil Tanker, noise levels are around 110 dB re 1µPa (C3, C4) & above 130 dB re 1µPa (C1).
- The mean RMS noise levels of this analysis are ~122.6 dB re 1µPa.

References

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