EVALUATING THE IMPACT OF VESSEL NOISE ON MARINE PROTECTED AREA FISH SPECIES: A dB_{ht} (*species*) APPROACH AS A MANAGEMENT TOOL

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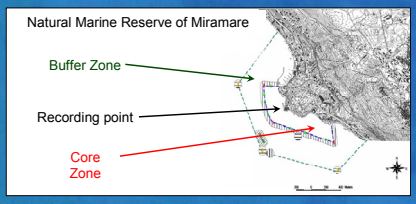
Introduction

Increasing anthropogenic noise pollution requires evaluating its potential effects on fishes and defining mitigation measures. Managers often request a single, simple index representing the impact of noise. A dB scale for fish species analogous to the dB(A) scale for humans was suggested (Nedwell et al. 2004a).

This study aims to consider the dB_{ht} (*species*) approach (see methods for details) as a management tool for assessing the effects of anthropogenic noise on two target fish species, *Chromis chromis* (Pomacentridae) and *Sciaena umbra* (Sciaenidae).

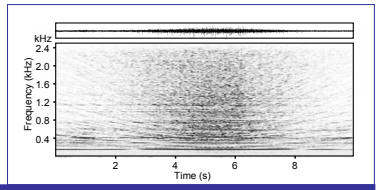
Methods



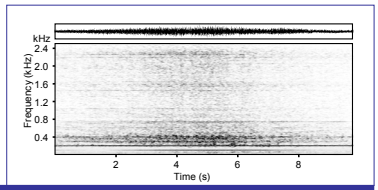
The WWF-Natural Marine Reserve of Miramare is a small 'urban' marine protected area located about 8 km from the city of Trieste (North Adriatic Sea, Italy). Many fish species populate the Reserve, some of which, such as *C. chromis* and *S. umbra*, rely on acoustic communication during reproductive activities.

The noise generated by five types of boats was recorded as well as samples of sea ambient noise using a Reson TC4032 hydrophone and a Pioneer DC-88 DAT-recorder. Boat noise levels were from 2 dB to 47 dB above the sea ambient noise ($L_{Leq,\ 1min}$ = 105.6 dB re 1 µPa).

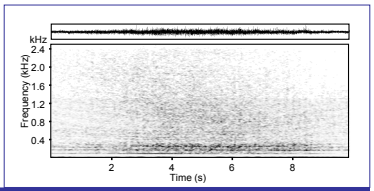
Figures show boats (left) and oscillograms and sonograms of their noise (right).



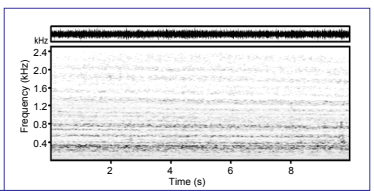
➢ 7-meter inflatable boat with 130 HP in-outboard engine (20 knots speed) recorded at a distance of 10 meters ($L_{Leq,\ 1min}$ = 130.4 dB re 1 µPa).



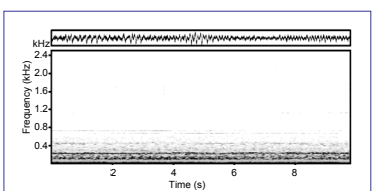
➢ 5-meter fibreglass boat with 40 HP outboard engine (15 knots speed) recorded at a distance of 10 meters ($L_{Leq,\ 1min}$ = 129.6 dB re 1 µPa).



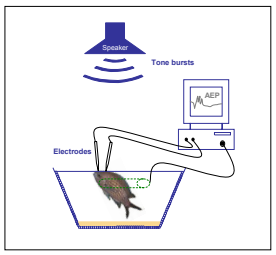
➢ 8.5-meter cabin cruiser with 163 HP inboard diesel engine (6 knots speed) recorded at a distance of 10 meters ($L_{Leq,\ 1min}$ = 131.8 dB re 1 µPa).



➢ 26-meter tourist ferry with inboard diesel engine (6 knots speed) recorded at a distance of 10 meters ($L_{Leq,\ 1min}$ = 152.2 dB dB re 1 µPa).

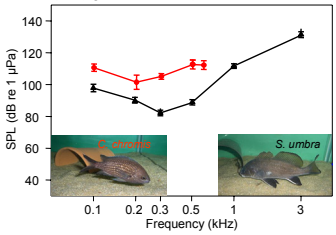


➢ 340-meter cruise ship with diesel engine (5 knots speed) recorded at a distance of 6 nautical miles ($L_{Leq,\ 1min}$ = 108.1 dB dB re 1 µPa).



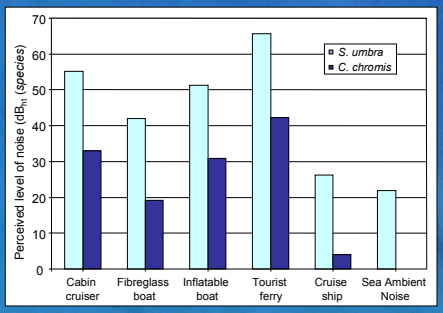
On the right, the fish audiograms of the two target species (in red *C. chromis*, in black *S. umbra*) measured by the AEP-technique.

Auditory sensitivity to tone bursts of various frequencies was determined under quiet laboratory conditions utilizing the non-invasive auditory evoked potential (AEP) recording technique (figure on the left).



The boat noises were processed through a filter that mimics the hearing ability of the species based on the above audiograms. A set of coefficients was used to consider how hearing sensitivity varies with frequency (Nedwell et al. 2004b).
The **dB_{ht}** (*species*) metrics are **a measure of how much a noise is above a species' auditory threshold.** The subscript 'ht' (hearing threshold) relates to the fact that the sound is expressed in decibels, which are referenced to the hearing threshold of the species.

Results



The analysis of the recorded soundtracks yielded, for each track, a single number expressed as the maximum sound pressure level, with "FAST" time constant, weighted with the frequency response of each species; these values reached at maximum 65 dB_{ht} (*S. umbra*) and 42 dB_{ht} (*C. chromis*).

The estimated dB_{ht} level for *S. umbra* is close to the 70 dB_{ht} limit at which a mild behavioural reaction (e.g. subtle change in swimming direction) would be expected to occur (Nedwell et al. 2004a)

Discussion

The benefit of a dB_{ht} (*species*) approach is that it enables reducing all the studied data into a single number that incorporates the ability of a species to perceive the sound. Indeed, our data show how the same boat noises generate different measured levels in the target species, whereby the dB_{ht} of *S. umbra* proved to be higher than that of *C. chromis*. Nevertheless, all the calculated dB_{ht} levels are still below the limit of behavioural reactions. Preliminary behavioural observations at sea seem to confirm the last statement.

The dB_{ht} (*species*) hypothesis assumes that the degree of behavioural effects induced by noise depends on the dB_{ht} (*species*) level. Some evidences are collected right now in order to confirm this (Nedwell et al. 2004b, 2005), but further tests of the dB_{ht} metric are needed, especially in open water.

A laboratory study indicates that noise emanating from the same cabin cruiser recorded at a distance of 10 m potentially worsens sound detection in both species (*C. chromis* and *S. umbra*; Codarin et al. 2007). Potential impacts other than short-term behavioural effects should therefore be considered when evaluating the effect of noise on fish populations.

Conclusions

- ✓ The dB_{ht} metric might help managers to define simple limits of noise exposure when implementing mitigations measures.
- ✓ The dB_{ht} metric approach suggests that the most hearing-sensitive species should be taken into account as a model for mitigations measures in marine protected areas.
- ✓ Further short- and long-term behavioural studies in open waters are needed to evaluate the validity of this approach.

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