Research Note

Identification of the Noise hotspots for Marine mammals in the Indian Ocean Region.

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Abstract

Anthropogenic underwater noise is a form of pollution considered as a major threat for the conservation of marine wildlife, the impact of noise on marine mammals is a source of concern given that they heavily depend on acoustic signals to fulfil their vital functions. Their "acoustic habitat" appears nowadays altered by anthropogenic noise having both direct and indirect effects on individuals and populations. Finally, based on IUCN Red-list assessments, several marine mammals species are experiencing a decreasing population trend, e.g. short-beaked common dolphin, the sperm whale.

Identifying areas of high anthropogenic pressure on the marine environment is a key element for an effective environmental management. I undertake a work aiming at identifying noise hotspots and areas of potential conflicts with vulnerable marine mammals habitat in Indian Ocean Region. The global aim of this project is to gather baseline knowledge on noise-producing shipping activities.

Areas accumulating noise-producing activities (*noise hotspots*) are pointed out, with a focus on zones overlapping with important marine mammals habitat. Results revealed several noise hotspots overlapping important marine mammals habitat.

Background

1. Impulsive noise vs continuous low-frequency noise

Marine environment experience two different noise: **Impulsive noise and Continuous low-frequency noise**. **Impulsive** noise are relatively short duration "on/off" pulses, impulsive sounds from human-made sources occur widely in the marine environment ; these are produces intentionally(e.g. sonar , seismic survey) or occur as a by-product of an activity(e.g. pile driving) and are the some of the most powerful sounds produced under water. On the other hand**, Low frequency noise**, considered as the frequency range from about 10Hz to 200Hz, causes extreme distress to a number of people who are sensitive to its effects. Noise from shipping is primarily produced by cavitation with most of energy in the low frequencies, i.e. less than 1 kHz (Wenz, 1962; Leaper and Renilson, 2012). As low frequency sound can travel over long distances (Tasker *et al.*, 2010; Van der Graaf *et al.*, 2012; Dekeling *et al.*, 2013), shipping noise contributes to raise background noise levels.

2. <u>Effects of low-frequency noise on marine mammals</u>

Marine mammals, especially cetaceans, are highly vocal and dependent on sound for almost all aspects of their lives, e.g. food-finding, reproduction, communication, detection of predators/hazards, and navigation. They are thus likely sensitive to anthropogenic noise. Sound has a large potential area of impact, sometimes covering millions of square kilometres of ocean with levels high enough to cause possible disturbance in marine mammals. There can be great variation in the reaction of marine mammals to noise, depending on such factors as species, individual, age, sex, prior experience with noise, and behavioural state. Species with similar hearing capabilities can respond differently to the same noise. Observed effects of noise on marine mammals include: changes in vocalizations, respiration, swim speed, diving, and foraging behaviour; displacement, avoidance, shifts in migration path, stress, hearing damage, and standings[1].

3. <u>Propagation of low frequency noise in ocean</u>

Sound in the ocean travels in curved or refracted paths and will arrive at a hydrophone from various vertical angles, depending on the depth of the source and the hydrophone and on the separation range.

The main concern of the propagation of low-frequency noise is the Transmission loss, the KRAKEN model[2] provides accurate approximation for computations of transmission loss at low frequencies, and is computationally highly efficient. To calculate the acoustic transmission loss (TL) between each ship location and a given set of receiver positions, the KRAKEN model is fed with source and receiver geometry, a discrete set of source frequencies, and environmental parameters. The received acoustic field is calculated by combining the TL with a given source spectrum.

Domain: Acoustic habitat degradation

Different noise sources in oceans have their unique frequency characteristics and also the marine species they have their hearing ranges in different bands; so whenever there is matching between the source sound and the receiver sound, we find there is an interference and that was a **<u>Acoustic habitat degradation is all about</u>**. Acoustic habitat degradation[*] is a major fallout of the rising maritime activities without comprehensive regulatory framework. The increasing maritime comprehensive regulatory framework. The increasing maritime activities are also accompanied by higher noise level in the ocean. The frequent stranding of marine mammals along the Indian coast is a manifestation of the catastrophic Acoustic habitat degradation. Recent incident's (Blue whale stranding off the Alibag coast, 2015 ; Bryde whale stranding off the Mumbai coast in 2016) of stranding that is manifestation of the severe Acoustic habitat degradation. Such stranding is attributed to the navigation failure due to high ambient noise leading to disorientation.

Main text :

1. <u>Vulnerable marine mammals(IOR):</u>

There are many marine mammals in Indian ocean region whose condition as stated by IUCN[*] is vulnerable or endangered. some of them is going to be distinct because of the anthropogenic noise, I am focusing on the marine mammals whose hearing range is less then 1KHz, low frequency noise produce by the commercial shipping. There are many mammals listed in Red-list of IUCN some of them found in IOR are – from Balaenopteridae family; Blue whale (Balaenoptera musculus),hearing range less than 100 Hz; Fin whale (Balaenoptera physalus), hear low-frequency sounds in the range of 10–200 Hz Sperm whale (Physeter macrocephalus), hearing sensitivity is between 0.9 KHz to 30 KHZ; Bryde's whale (Balaenoptera edeni), belongs to the same group as blue whale; Indo-Pacific bottlenose dolphin, are generally assumed to have a functional hearing range of 100 Hz to 150 kHz, above which sensitivity falls off at 495 dB per octave.

2. <u>Marine Environment(important for mammals).</u>

One of the characteristics of **low frequency sound** is that it **can travel** relatively long distances without much attenuation (reduction in level). For each observation we need definite information of each species like depth (animal habitat), Sound in the ocean travels in curved or refracted paths and will arrive at a hydrophone from various vertical angles, depending on the **depth** of the source and the hydrophone and on the separation range. As a result, for finding the Ship source spectra at a certain depth using different models precise depth of animals habitat is very useful.

Density maps of marine mammals; An transect survey effort and the use of advanced spatial modelling techniques generated interpolated density maps. These includes Blue whale[3], fin whale[4], sperm whale[5], bryde whale[6], indo-pacific bottlenose dolphin[7]. Density surface models were used in study, to be consistent with a previous spatially explicit ship strike risk assessment [8] and biodiversity assessment [9], but the response variable could be any continuous variable that can be plotted as a surface.

Marine mammals audibility; We took the published audiogram data for blue whale from the literature[*], and for the other mammals, literature[10].We extrapolated all audiograms down to 10 Hz by extending the slope over the three lowest-frequency measurements.

3. Spatio-temporal mapping(way of implementation)

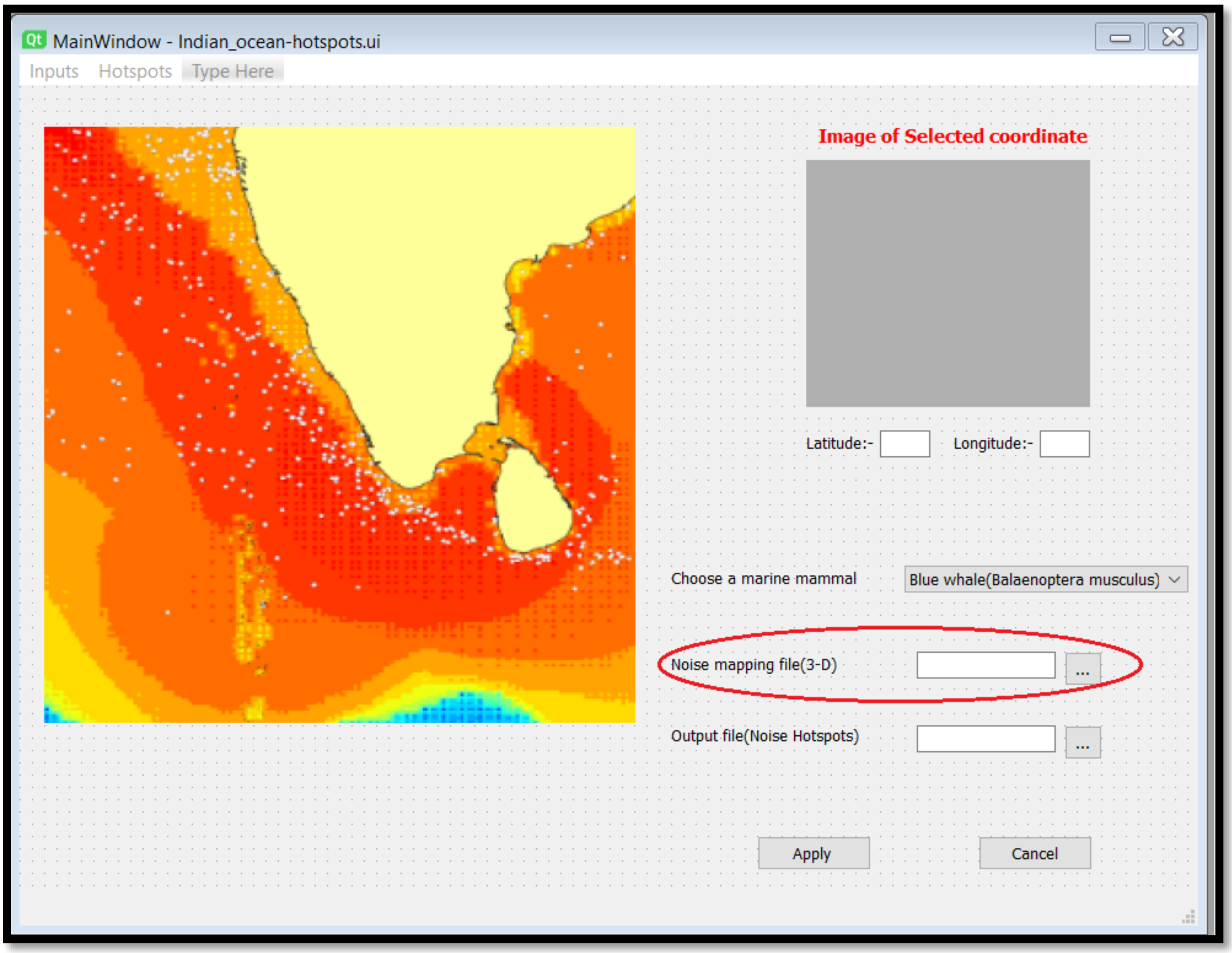
The work attempts to study and map variations in the ambient noise levels corresponding to the fluctuations in the surface parameters and shipping traffic. The site specific behaviour of the tropical IOR is demonstrated using surface data available from moored buoy at three distinct locations of IOR. Shipping traffic density based on AIS data is used to map highest shipping noise levels in IOR. Further, Received levels of ship noise were computed on a 5 km x 5 km grid over a 100 km radius from each source cell (i.e. each cell with ship logs). To propagate ship noise through the marine environment, a geometric spreading model was applied decreasing the noise level by 20 log10(range/m) until the range equalled the maximum water depth along the specific source-cell to receiver cell transect, and by 10 log10(range/m) thereafter. for computing the ship spectrum received at each cell. In source cells, the level plotted is the sum of all contributions from neighbouring cells plus the contribution from ships within this cell propagated over 2 km. Up to this point, the methods have been described in more detail elsewhere[11]

The ship spectrum received at each receiver cell was filtered by the animal audiogram.

4. Noise and noise-mammals interaction hotspots.

The audibility maps were limited to the area that had previously been surveyed for marine mammals [*]. The audibility maps were scaled to range from 0 to 1 by subtracting the minimum received energy over all cells from the entire map, and by dividing the audibility map by the maximum received energy. This was done for each species. The density maps were normalized to 0–1 the same way. The normalized noise audibility map and the normalized density map were multiplied for each species. In areas where the audible energy was high (i.e. close to 1) and where animal density was high (i.e. close to 1) the product was high, indicating a ‘‘hotspot. Risk indices computed this way are not comparable among species (as the map for each species was normalized to 0– 1), but can be used to rank habitat for each species.

Graphical user interface(GUI):



Challenges :

1. Data collection: Indian ocean Region

Indian ocean region covers 20 lakh square kilometre, but only less than 20 % of the ocean have been studied. There is a lot to discover, data for the many marine mammals is not appropriate, there habitat, threats in the IOR, etc . Waters in every ocean is different like tropical waters of Indian ocean has way different properties than other oceans. We can't rely on the different ocean's research. India needs to build unconventional data collection tools and methods.

2. Finding the audible acoustic energy

The audible acoustic energy is the audibility of the shipping on marine mammal. While dividing the chosen sites into small cells and fetching the ship source spectra.

The ship spectrum received at each receiver cell was filtered by the animal audiogram. The audible energy in each receiver cell of the map was integrated over all ship positions within 100 km radius, over all vessel classes, over frequency and over time. The result was a map representing audible acoustic energy from shipping. Animals with the least hearing sensitivity below 20 kHz (Steller sea lions and dolphins) are expected to perceive the least amount of acoustic energy. Animals with better hearing sensitivity at low-to-mid frequencies (50–300 Hz) experience the most ship noise (baleen whales and true (phocid) seals).

3. Lack of Precise data noise mapping at each pixel :

Many sound sources are simply missing from this estimate of cumulative ship noise energy. The most important of these missing sources in our noise maps is small boat traffic. Small boats do not log AIS positions, and can exist in large numbers in certain area for recreational fishing, boating or whale watching [66,67]. Repeated disturbance from small boats can disrupt feeding in killer whales [22] and alter the behaviour of humpback whales [68].

4.Vulnerability assessment

This is a function of the acoustic signature of the platform modified by the underwater channel fluctuation benchmarked against the ambient noise at the receiver location. The real-time channel fluctuations and the ambient noise values at the receiver have been used to derive the vulnerability assessment. For the application of the project I need to plot, The average vulnerability range as presented in the form of a heat map with nautical miles (nm) scale represented according to the colour scale

Results :

The number of noise-producing human activities was computed on a spatial grid (grid size = 40 x 40 km). As stated , only activities using low-frequency noise sources were addressed in this analysis. Values vary from 0 to 1 (all activities using low-frequency noise sources considered in this study were recorded). Areas showing highest values (1 types of activity) are located in the

Finally, we superimposed this last map to the layer of important cetacean habitats as identified and recognised by Parties. This result yields important information of areas where potential conflicts between human activities and cetacean conservation might occur, in the framework of noise pollution.

A demonstrator system for real-time noise monitoring has been built up in an important conservation area where noise due to anthropogenic sources has been recognised to be a threat for marine mammal. The project having the potential to become a helpful tool for implementing conservation, management and mitigation policies.

Conclusion:
It is hoped that the efforts could serve three important purposes:

(a) As a current best estimate of co-occurrence of marine mammals and chronic ocean noise levels in Indian ocean region, regions for conservation, management and mitigation,

(b) As a framework for making predictions about the consequences likely to result from increased noise levels as various parts of the coast are subject to industrial development applications, or conversely as places where ship-quieting technologies may be most useful,

(c) As a simple M-weighting method that could be used anywhere that a variety of marine mammal species may be at risk from chronic anthropogenic noise.

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