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Impact of maritime security policies on the marine ecosystem

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ABSTRACT
The maritime piracy issue drew significant global attention post-2012. The response from the major nations, even those geographically distant from the Indian Ocean Region (IOR), has been highly pro-active. Two important changes that are relevant to this paper are the increased deployment of multi-national naval forces for anti-piracy operations and also re-routing of the shipping lanes closer to the shores. The acoustic impact of these actions was completely ignored but their impact on the marine ecosystem needs to be reviewed. A rare stranding of a blue whale in June 2015 and a Bryde's whale in January 2016, off the west coast of India, are a possible manifestation of the degraded acoustic habitat due to high levels of low-frequency ambient noise in the region. The paper presents an investigative analysis of the two reported events and their correlation with acoustic habitat degradation which may be attributable to increased shipping in the region.

KEYWORDS
ambient noise; marine ecosystem; maritime security policy; noisonomics; Indian Ocean Region (IOR)

Introduction

The Indian Ocean Region (IOR) and the South China Sea are emerging as the central theaters of 21st century geopolitics.[1] The socioeconomic volatility and the political instability of the nations in the IOR and the high-stakes energy flow from the Gulf countries to major economies in South East Asia have made the IOR a global hotspot for geostrategic interaction and confrontation.[2] To add to that, the heightened economic activities combined with the political and socioeconomic vulnerability gave rise to maritime piracy, principally originating from the failed state of Somalia in the late 20th century.[3] The end of the first decade of the 21st century saw an increase in the piracy, but what was worrying was the resource mobilisation, extended reach, the level of violence and ransom amounts being demanded by the pirates.[4] The early years of the decade commencing 2010 saw a significant response from all the major navies of the world, and warships have been deployed for anti-piracy initiatives. Combined Maritime Forces: a collaboration of 26 countries and three task forces – CTF-150 with Maritime Security and Counterterrorism, CTF-151 with Counter-piracy and CTF-152 with Persian Gulf Security Cooperation – were created. Among these, CTF-151, was formed in January 2009 to focus solely on the counter-piracy mission in the IOR.[5]

The west coast of India saw significant maritime activities due to the proactive initiative from the multilateral coalitions engaged in anti-piracy.[6] High-Risk Areas (HRAs) were declared, and shipping companies were advised to avoid the HRAs as part of their Best

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Management Practices or BMPs.[7] Figure 1 shows the initial marking of the HRAs based on incidents of piracy attacks on merchant vessels. The declaration of HRAs ensured the shifting of the shipping lane closer to the Indian coast.

The low-frequency ambient noise (< 300 Hz) is reported to have been rising at an alarming rate of 3 dB per decade since the industrial era (1950s), primarily driven by shipping noise.[8] The shipping noise spectral characteristics have been found to directly overlap with the vocalisation of the largest of the cetaceans, the baleen whales (Mysticetes).[9] The elevated low-frequency noise levels near shipping lanes and busy ports have been known to acoustically mask these cetaceans and potentially interfere with their biologically critical functions.[10]

A 42-foot-long blue whale was washed ashore on June 24, 2015, off the coast of Alibaugh, near Mumbai.[11] The closest species to the blue whale to be possibly identified in this region is the North Indian blue whale, typically found off Sri Lanka.[12] The vocalisation signal characteristics of this species reported in the literature are up to 160 Hz.[13] The stranding of blue whales in this part of the world is extremely rare, and a few months before the stranding, on March 28, 2015, a team of marine researchers reported the sighting of a mother–calf pair, 2.7 km from the shore at a depth of 16 m, apparently after a century. The last blue whale sighting recorded in the region was in 1914, which was a dead carcass that washed ashore.[14] More recently, in January 2016, a 50-foot Bryde whale was washed ashore off the Mumbai coast.[15] The Bryde whale is reported to have vocalisation in the spectral band between 50–150Hz.[16] Anthropogenic noise is a documented threat to the survival of these species as it significantly masks their communication,

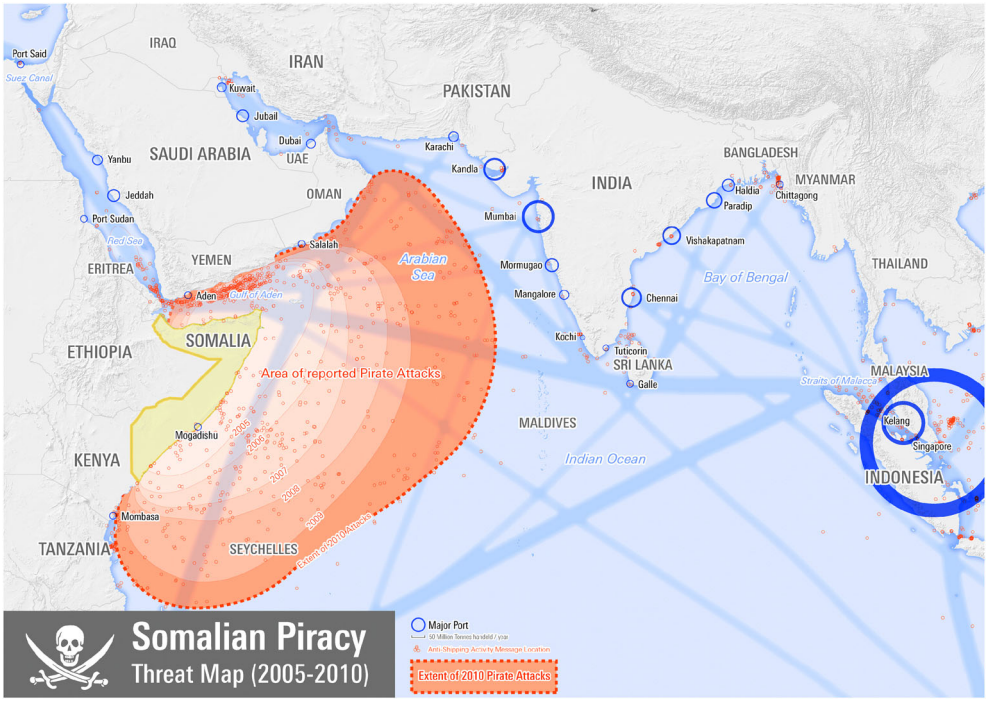

Fig. 1. Map of Areas Under Threat by Somali Pirates (2005–2010).[17]

leading to severe disorientation.[18] The rare sighting followed by the strandings of a blue and Bryde whale on this coast, infested with increasing low-frequency ambient noise, is an indicator of severe acoustic habitat degradation for these endangered cetaceans. Although information on the hearing characteristics of such large animals (which cannot be taken into captivity) is not available, vocalisation characteristics do indicate approximate hearing capabilities, and the close overlap of the increasing ambient noise could indicate masking of these animals, causing navigational failure and subsequent stranding.[19]

This paper attempts to analyse the impact of marine security policies on the acoustic habitat of marine species, with a case study of the recent stranding of the blue whale and the Bryde whale. The real data have been compared with similar shallow-water recordings that are available in the literature.[20]

Maritime policy issues

There are two aspects that become critical when we discuss pollution related issues – the definition of "pollutant" and the boundary of the influence of the pollutant. In the case of ocean noise pollution, the definition of pollutant itself is a complicated subject as the traditional pollutants such as oil or sewage are substances that have a physical structure and occupy space. However, here in the case of ocean noise, it is in the form of energy that is yet to be recognised as a pollutant. The transborder nature of ocean noise pollution further complicates the physical jurisdiction aspect of any regulatory framework.[21]

The earliest reference to ocean noise as a pollutant was in a 1993 report by the Worldwatch Institute, which listed 10 types of marine pollution, their causes and their effects.[22] Noise, the tenth pollutant in the list, fits the description in the United Nations Convention on the Law of the Sea (UNCLOS, 1982) of marine pollution, which states that "it can be a substance or energy released into the marine environment, and which may result in deleterious effects on marine life".[23] UNCLOS has been signed by 138 countries, but it has yet to take the shape of a formal regulation, even today. Low-frequency (< 100 Hz) acoustic signals, in particular, can travel through entire ocean basins and, thus, the noise that originates in one country travels into neighbouring jurisdictions, affecting marine populations across political and legal boundaries, necessitating regulations to be addressed at a global level. Ocean noise, thus, needs to be legally treated as a "transboundary pollutant".[24]

The International Maritime Organization (IMO) addresses pollution from vessels through its key instrument termed the protocol of 1978 (MARPOL), which aims to "achieve the complete elimination of international pollution of the marine environment by oil and other harmful substances and the minimization of accidental discharge of such substances".[25] The use of the word "substance" and the exclusion of the term "energy" appears to exclude the application to noise *per se*. The six annexes that define pollutants (oil, noxious liquid substances, harmful packaged substances, sewage, garbage and air pollution) fail to mention noise. The "Agenda 21" (referring to the 21st century) of the United Nations (UN)'s plan of action, recommended that the IMO adopt further regulatory measures to prevent degradation of the marine environment. Consequent to that, the IMO came up with the concept of Particularly Sensitive Sea Areas (PSSAs). It is within the context of PSSAs that the IMO can be considered to have recognised

noise as a hazard to the marine environment. The establishment of the PSSAs represents a spatial, ecosystem-based approach to pollution prevention as opposed to earlier approaches that focused on individual activities. In April 2008, the IMO recognised the harmful effects of commercial shipping noise and invited member states to participate in a dialogue to determine mitigation.[26]

There are multiple regional agreements that address the issue of noise in their region. However, these fail to comprehensively address the concern at a global level. As can be seen, there seems to be no shortage of international agreements, and more so in the case of Europe with good and ambitious intentions to protect the marine ecosystem, where there has been an obvious recognition of noise as a stressor to the marine habitat. Despite years of deliberations, there seems a distinct lack of agreement on the methods of protection. These agreements and guidelines have been subject to the seriousness of the individual countries, and compliance has been a causality more often than not. The myriad of activities involved, the complexity of their noise-generating mechanisms and the uncertainty of their impact on the marine habitat are probably attributable to the lack of explicit guidelines.

The regulations and enforcements vary from country to country and even within certain big countries from state to state, or regional jurisdictions which regulate noise differently. The United States probably has the most progressive regulatory framework and monitoring mechanism with instruments like the Endangered Species Act (ESA), National Marine Sanctuaries Act (NMSA) and the Marine Mammal Protection Act (MMPA). The MMPA, administrated by the National Marne Fisheries Service (NMFS), is regarded as the most effective act based on the precautionary principle.[27] Some European nations like the United Kingdom (UK)[28] and Germany[29] along with others like New Zealand[30] and Australia[31] are considered to be sensitive to the marine environment and have invested significantly in legislation of the marine environment, and more specifically of ocean noise. Migratory marine animals do not understand political boundaries, and there is a serious chance of accumulation of impact across such exposures.

Acoustic habitat degradation

Sound signals are known to propagate well in the marine environment, and are probably the only signals that are conducted efficiently undersea.[32] Thus, it is imperative that even the creatures under the sea use sound to perceive the environment around them. Marine species are known to depend on sound for most of their biologically critical functions such as foraging, navigation, communications, echolocation, predator avoidance, etc.[33] Thus, the increasing noise in the oceans due to heightened maritime activities potentially can have an adverse impact on the marine ecosystem.[34]

The potential impact of anthropogenic noise on the marine animals and marine ecosystems include varied dimensions. It could be a physical injury or physiological dysfunction such as temporary or permanent loss of hearing sensitivity. Further, it may manifest as behavioural modification, including changes in foraging or habitat-use patterns, separation of mother–calf pairs, etc. Masking is another impact, which means the inability to discern biologically significant sound as a result of increased background noise, also

referred as a poor signal-to-noise ratio (SNR).[35] The direct impact or secondary consequences on individual animals may vary from negligible to fatal.

Commercial shipping is the single ubiquitous source of low-frequency background noise in the ocean. Large merchant vessel operations are well dispersed over large geographical areas. Thus, these sounds constitute the background ambient noise, making the sounds of individual platforms often spatially and temporally indistinguishable from distant vessel traffic. However, the shipping traffic is also not uniformly distributed, and the major commercial shipping lanes follow well-defined routes to ensure minimum distance and safety standards. Vessels found outside the shipping lanes are fishing boats, military platforms, scientific ships and recreational crafts. Vessel traffic has shown steady growth since the pre-industrialisation period, both in the number of ships and in the tonnage of goods transported.

There is significant evidence to attribute the stranding of dolphins and whales to human causes. In most of cases, acoustic trauma has been observed as a possible cause of death and is either sonar related or triggered by seismic activities.[36] Such stranding has also been termed the tip of the iceberg as many scientists believe that apart from the animals that have been stranded, many more would have died and sunk at sea, and thus may not have been reported for analysis.

The species involved and the activity responsible have a connection in terms of spectral characteristics. The source frequency, whenever it overlaps the hearing range of the animal, can cause disorientation, failure of navigation and possible stranding. Shipping noise is typically very low frequency (< 300 Hz with a peak around 100 Hz) coinciding with the frequency used by large creatures like the baleen whales, whose sound perception has been inferred from their vocalisation pattern. The slow increase of radiated noise in

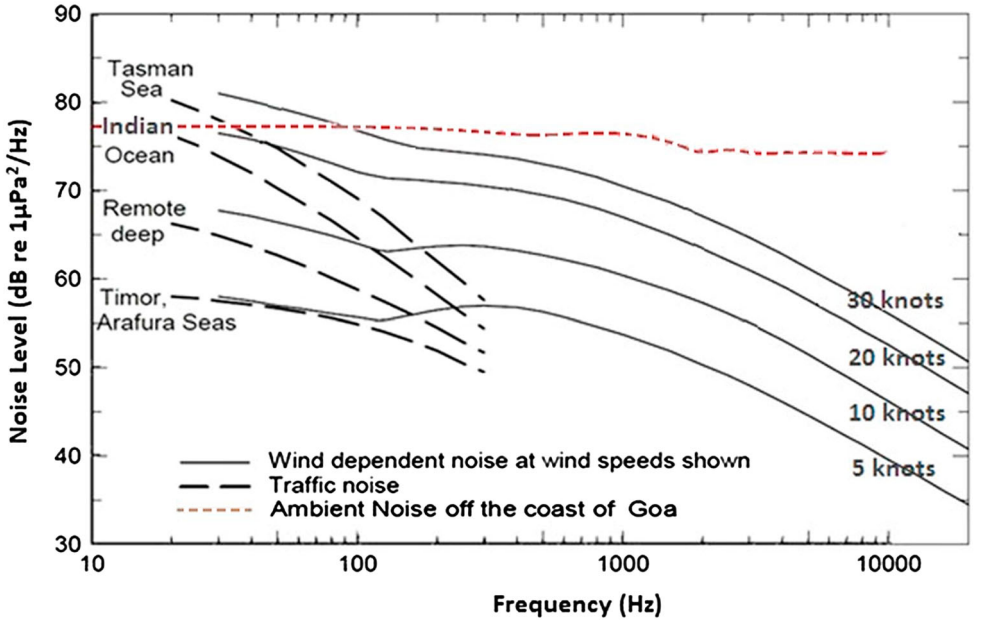

Fig. 2. Ambient Noise Comparison Across Different Sea and Indian Ocean Recordings over a Decade.[37]

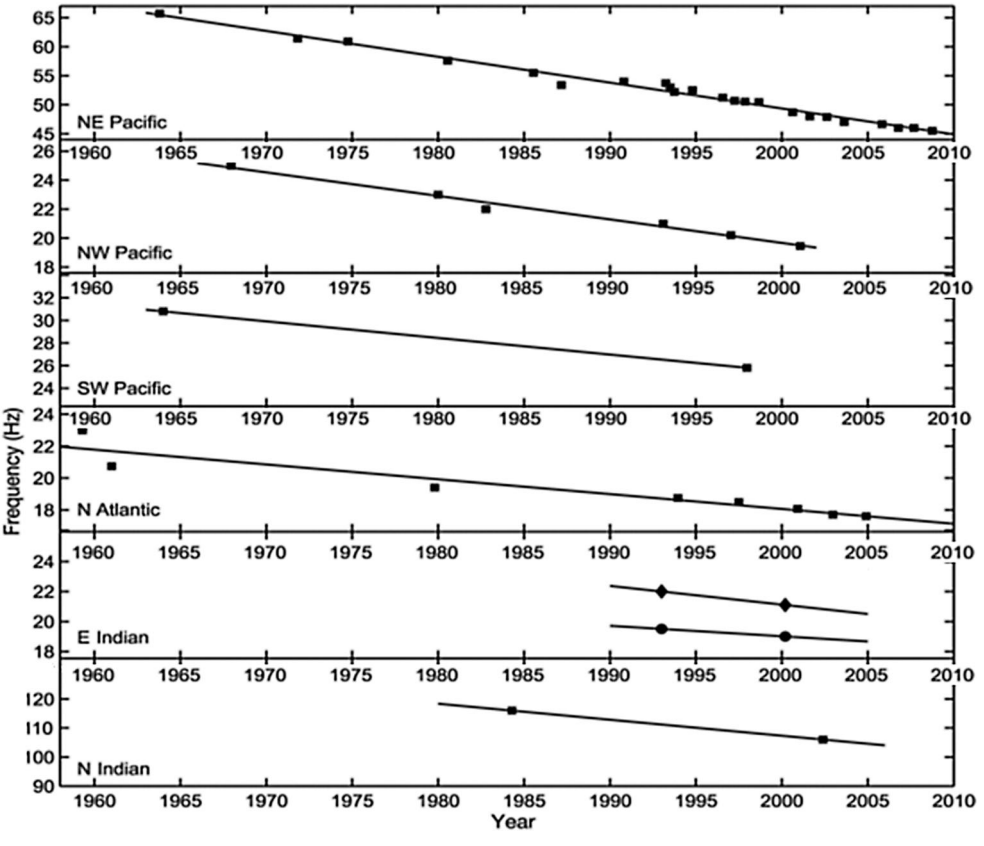

Fig. 3. The Trend of Frequency Shift for Different Subspecies of *Banaenoptera musculus* (Blue Whales) over Time.[38]

the ocean had typically not triggered such stranding in the past, unlike the stranding due to sonar transmissions and seismic activities. The high level of ambient noise due to the high volume of shipping traffic in the region, and also the compounding impact of anti-piracy efforts, could have resulted in the rare stranding of such big mammals. Figure 2 shows ambient noise recordings across many seas and also the Indian Ocean.[39] It compares data recorded in 2010 (in red) with records of ambient noise from a decade earlier. We see an obvious rise in the overall ambient noise spectrum in the low frequencies, attributable to the increasing shipping traffic in the region.

Figure 3 presents the shift in frequency of vocalisation of blue whale subspecies.[40] The bottommost line, representing the North Indian subspecies, is relevant to this discussion as it represents the whale found stranded in June 2015 off the Mumbai coast. It is important to note that the tonal frequency of blue whale songs worldwide has declined due to increased human intervention in their habitat. The radiated noise spectral band peak of 100 Hz coincides with their vocalisation and, thus, could possibly trigger strandings. Figure 4 presents the "long moan" and "tonal sequence" of the Bryde whale.[41] Here again, we see an overlap with the peak of the radiated noise spectrum.

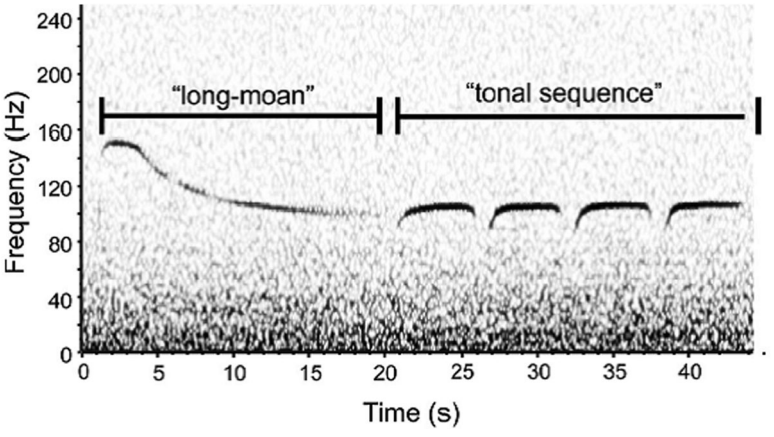

Fig. 4. Spectogram of "Long Moan" and the Trailing "Tonal Sequence" of Bryde Whale Vocalisation.[42]

Conclusion

The volatile Indian Ocean Region is seeing increasing policy initiatives. The growing strategic relevance of the region is also bringing more attention globally to ensure law and order in the region. Multinational forces and even global powers beyond the region are participating in matters internal to the IOR. It may be important to draw the attention of the global community to the increasing noise pollution aspect of the marine environment. This paper attempts to bring three clear messages:

(a) Increased shipping has a direct impact on the well-being of large marine mammals. Acoustic habitat degradation is no longer only a hypothetical conservation concern, and there are increasing incidents of marine mammal stranding directly attributable to human intervention with nature.
(b) The earlier stranding events were due to sonar transmissions and seismic activities that are transient in nature, and their cause and effect can be easily established. However, the possible stranding of large marine mammals like the blue whales and Bryde whales attributed to shipping noise is a grave concern as shipping noise reflects a permanent degradation of the acoustic habitat.
(c) The absence of regulatory provisions for noise in the oceans is a serious matter; however, the more important aspect is the lack of awareness among policy experts on the serious impact of growing ambient noise. The anti-piracy efforts possibly causing the rare stranding of such large marine mammals need to investigated.

We need to have a comprehensive view of underwater domain awareness, that addresses the security concerns arising out of piracy and maritime terrorism, the socio-economic aspect of generating jobs for the growing global population and also the noise concerns arising out of human intervention with the marine environment. Sustainable growth is possible only with equal concern for the marine ecosystem.

Notes on contributor

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Notes

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