Research Note

Mapping Snapping Shrimp in the IOR: Impact on Sonar

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ABSTRACT

OCEAN AMBIENT NOISE IS USUALLY CONSIDERED AS AN INTERFERING BACKGROUND FOR UNDERWATER ACOUSTIC SYSTEMS. THESE SOUNDS HAVE A SERIOUS EFFECT ON SONAR. FROM LOW FREQUENCY BAND (10HZ-500HZ) TO MID-FREQUENCY RANGE (500HZ-25KHZ), MARINE ANIMALS SIGNIFICANTLY INCREASES OCEAN AMBIENT NOISE. RESULTS REVEAL THAT BIOLOGICAL NOISE FROM MARINE INVERTEBRATES LIKE SNAPPING SHRIMPS DROPS DETECTION RANGE FROM 35 KM TO 2-11 KM BY INCREASE IN 20-25 DB OF NOISE. THESE LONG PROPAGATING SOUND OF MARINE ANIMALS INFLUENCES PASSIVE SONAR DETECTION. HENCE, IT DETERIORATES THE SONAR'S EFFICIENCY BY 80%.

1. BRIEF BACKGROUND

The World War 2 warfare of American and Japanese submarine, along the Australian coastline, was the first time light was shed upon something unusual noise activity in the ocean. Since World War 2, extensive investigations have been going in the underwater domain. Due to submarine warfare and harbor defense, technology in the maritime field has increased significantly.[1]

Exceeding noise in the ocean has been in concern to mariners. Many invertebrates like crabs and shrimps and mammals like whales and dolphins are said to be the source of the highest noise in the ocean. The most widespread among the high frequency marine animal is snapping shrimp (2 kHz-200 kHz). Snapping shrimps, shallow water creatures, are considered to be one of the loudest underwater animals. They produce crackling noise with release of intense amount of energy in the form of light and sound. The sound intensity is enough to kill small fishes and animals alike.[2]

The Indian Ocean Region, which is surrounded by many archipelagos and major landmasses, is the strategic location for many of the countries. IOR, lying between 35 N to 40 S, acts as the major hub for crustaceans. The ambient noise in the coastal region is more complex than ambient noise in the deep ocean due to the breaking waves and the marine life as well as the shipping operations. Since IOR has tropical waters, with very few developed countries lying around its boundaries, it has not been importance as compared to polar or temperate waters.[3][4]

Sonar (sound navigation ranging) is the technique which is used to navigate as well as communicate with other vessels underwater. They are used to detect marine animals as well as other objects. But due to various losses in sound propagation like traffic noise, wind noise and biological noise, sonar's performance is reduced much.[10]

2. IMPACT ON PASSIVE SONAR

Sonar has been the heart of the vessels which helps vessels to navigate its path. Marine animals have a significant impact on the sonar's performance. Due to co-existing ambient noise of wind and ships along the coastal region where shrimps resides generally, the detection performance is more effected by shrimps rather than the mammals. The main focus of the paper is to determine the sonar's efficiency under influence of snapping shrimp's noise.

Shrimps produce pistol noise with its bigger claw with a cavitation bubble of low pressure and high temperature. They produce such noise in order to prey or to mate.[5] The sound level is of about 218 dB. The other noises present are that of wind, rain and other vessels. In the IOR, as per data the ambient noise level ranges between 75dB with lowest to 110dB highest. The shrimps generally reside in seabed of depth about 55-75 m. The cavitation bubble bursts unveiling huge amount of sound energy of high frequency.[6] IOR serves as the most suitable growth place for shrimps' habitation because of moderate temperature and littoral tropical waters.

Due to overlapping frequency band of sonar and shrimp, it is quite difficult to operate in low and shallow water which is the breeding place for shrimps. Due to various factors such as salinity, temperature and seasonal variations, their activities as well as habitation are affected. Many studies and researches indicate that increase in biological noise in ocean decreases the detection range of sonar drastically. Recent studies indicate the detection range decreases from 19NM to 0.9-6NM. This significant drop adds to the drawback in performance of sonar systems.

Transmission loss increases and deteriorates the strength of the sound of wave signal due to various other noises. Further, correlation between detection range and transmission loss is to be analyzed in order to determine sonar's efficiency. The data needed for the analysis is based on the IOR and its surroundings. The correlation between various parameters like frequency, depth and transmission loss will help us to analyze further about sonar's efficiency.[7]

3. CHALLENGES

The major challenge is to deal with a large band of operating frequency of shrimps and its interference with sonar. Due to natural phenomenon like global warming and climate change, their habitations are much affected which leads to variation in different parameters. Traffic and climate change also affects shrimps' habitation. Global warming has led to severe consequences which include the migration of many marine animals towards polar region. Thus, this causes uneven distribution of density of shrimps from place to place and time to time.[8]

Shrimp snaps are impulsive phenomenon occurring apparently at random. The minuscule duration of each snap allows these events to be modeled as a point process in time. Point processes are used to model many naturally occurring phenomena including neuron firings, seismic events, radioactive decay, lightning discharges and shot noise in semiconductors. These snaps may be strong enough to even destroy delicate parts of semiconductor.[11]

Tropical water in the IOR supplements to the transmission loss of sonar. The speed of sound also varies with depth. With increase in depth, speed of propagation of sound decreases significantly. Thus, it has impact on sonar's performance. Rains also produce high ambient noise. They add up to transmission loss, thus , reducing sonar's capability.[9]

It is important to realize that sound transmission in the ocean is three-dimensional and that transmission loss versus horizontal range alone is not sufficient information for most operational situations. Areas of no sonar coverage occur at various intervals of range because of refraction, reflection, and interference between waves travelling via different paths. This is also a major issue.

4. OPPORTUNITIES AND RESEARCH DIRECTIONS

Shrimps, being loudest among the marine invertebrates, have been not given much importance as compared to humpback whales and bottlenose dolphins. More studies are carried out on marine mammals whose frequencies are most frequently impeding with sonar's frequency.

Measures can be taken in order to develop some technique by which we can reduce the loss and can have better SNR ratio. Experiments are being carried out by various universities at Australia and America for fine study of shrimps in order to provide more effective and modified device to deal with the noise. More analysis can be done of how these sound effects the communication between two vessels at different positions and how can that be minimized.

Since India is located at a strategic position in the IOR, India has a major role in order to study various aspects of noises at the coastal region which in turn will help us to fine tune the parameters accordingly to the situation. IOR is surrounded by more than 35 countries with nations like China and India, effective technologies can be used to record the parameters to have more refined study of these creatures.

By getting well known locations of shrimps by soundscape mapping in the seabed, they can act as acoustic screens for submarines and other vessels. Since submarines, aircraft carriers and other navy ships are part of national securities, performance provided by the sonar in these vessels needs to be quite good. Poor efficiency and bad accuracy might lead to false results and miscommunication. Thus, more research must be done in order to make more effective and powerful underwater telemetry systems.

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