Measurements of Snapping Shrimp Colonies Using a Wideband Mobile Passive Sonar

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Abstract: A wide band passive sonar has been developed to study ambient noise levels in coastal regions. During the past two years a large number of measurements have been made with this system in shallow water off Boca Raton, Florida. The results have demonstrated that the noise from snapping shrimp dominates in this area during low sea states. Localization of the colonies has been possible by moving the sonar to different locations over the period of a few hours. Typically the shrimp are clustered close to man made structures at or near the shoreline, with additional smaller colonies on nearby coral reefs. To speed up the data collection the system has been mounted to an Autonomous Underwater Vehicle and on board intelligence is being developed to optimize the survey locations in real time. Results from a demonstration experiment will be presented.

INTRODUCTION

This paper presents the results obtained during an experiment conducted off the coast of Boca Raton, Florida, where a novel technique was used to measure the noise and spatial distribution from colonies of snapping shrimp. Snapping shrimp noise is widely reported in the literature (1,2), as an ambient noise source found in tropical waters. Their spectra are broadband in nature and individual snaps can produce very large sound pressure levels. The correlation between pulses from one colony of shrimp make up the content of the source spectrum. On the other hand, different colonies can be considered as uncorrelated noise sources, since the snaps from different colonies occur at random. Recent studies on the noise from snapping shrimp (3,4) study the spatial and diurnal variations of the process, the statistical parameters and the actual mechanism used by the biologics to produce such noise. It was noticed early on by Widener (2), during measurements in the Key Biscayne, that the noise from snapping shrimp was strongest in bays and harbors. The distribution of these sources along the coastline is still unknown and this study proposes to measure the spatial distribution of these colonies in the near shore region.

THE AMBIENT NOISE SONAR AND THE DEERFIELD PIER EXPERIMENT

The measurements were made using the Ambient Noise Sonar (ANS) developed to measure the ambient noise global directivity (5). This array consists of six receivers placed in a sparse volume array of maximum dimension 2m. The noise directivity is imaged using a multiplicative processing of the broadband cross-correlations measured between the receivers from 0 to 20 kHz. The electronics and power source which can run for up to 32 hrs, are integrated into a payload for the AUV Ocean Voyager II which makes it easy to deploy and to suitably sample the near shore regions at various locations in a minimum amount of time. The first set of measurements were made at a site located ~.75 miles south east of Boca Raton inlet in South Florida. The water depth at the measurement location is 10 m and the bottom is mostly sandy with a coral reef located just offshore of the measurement location. Other important features include Deerfield fishing pier, which is located approximately one mile to the south west of the measurement site. This area is of interest because it offers a wide variety of ambient noise sources. The inlet to the NW is relatively busy at times with small boat traffic. Small boat noise’s signatures dominate at the site when a boat is within visual range. In the absence of boats and at low sea states, noise spectra and time signatures clearly identify the primary source of ambient noise to be biological in nature. The horizontal directivity of ambient noise was measured in the band 3-13 kHz and averaged over 1/2 hr, ~800m North of the pier. The results indicate the presence of a source in the direction of the pier SSW. By moving the system south of the structure the peak appears NNW. It was possible to triangulate this source of biological noise clustered around the Deerfield fishing pier, which corroborate Widener's measurements.

THE SIMULATED AUV EXPERIMENT

As a result of the Deerfield fishing pier experiment it was proposed to search for similar clusters of biological sources along the coast, simulating a typical AUV mission. The system was deployed at five different sites.
within a 1x1.5 km area over a 5 hours time span in order to search for shrimp colonies (fig.1). The measurement area is located 2 miles north of the Inlet, chosen because it is remote from heavy boat traffic.

The system was deployed at site 1 where the first source was detected (see fig. 2 a)). Using this information site 2 was chosen to triangulate the source, and it was localized around a man made groin at the waters edge (fig. 1). After identifying the source the system was moved further up the coast in search of additional sources. Site 3 showed a broad lobe of lower correlation between 90° to 180°(fig.2c)), indicating the presence of a nearby source distribution located on a natural coral reef at 75 m range from site 3, ~ 100 long running north south at 10 m depth. Additional measurements were made at site 4 but the reef could not be triangulated because of noise pollution from boats. The system was moved between the two clustered sources and the horizontal directivity showed two peaks at -140° and 25°, identifying the two sources (fig.2e)).

CONCLUSION

Theoretical studies of ambient noise often assume that the ambient noise is generated by breaking waves which are uniformly distributed on the ocean surface and as such generate an isotropic noise field in azimuthal angle. However, if the noise field is anisotropic sonar performance can be improved in quiet look directions. One of the objectives of this study was to evaluate whether the noise field in shallow water was isotropic or nearly isotropic. The results shown above indicate that the noise field in low sea states is generated by biological noise sources (snapping shrimp) and not by breaking waves, and that these sources are clustered around very specific features. This has important implications on how shallow water ambient noise is modeled theoretically and on how to optimize sonar performance. This research showed that the sources can be considered as creating interfering fields at an array rather than incoherent noise.

ACKNOWLEDGEMENTS

This work is supported by the Office of Naval Research

REFERENCES