

A PASSIVE SONAR FOR UUV SURVEILLANCE TASKS

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LONG TERM GOALS

To develop a passive, autonomous, mobile system to investigate all types of noise in the ocean, both man-made and naturally occurring. The information will be used to improve the understanding of the noise field and the environmental factors which affect the propagation of underwater sound in coastal regions.

OBJECTIVES

The objective of this project is to develop an ambient noise sonar system mounted to an autonomous underwater vehicle to carry out noise surveys. The vehicle will be able to relocate to several measurement locations during a mission. In the future it will be able to optimize the survey locations in real time using on board intelligence.

APPROACH

To achieve the goals and objectives outlined above an Ambient Noise Sonar (ANS) system has been developed which can be mounted to the payload section of the Ocean Explorer OEx II autonomous underwater vehicle (also developed at Florida Atlantic University under a separate project). The sonar is designed to minimize the electro-mechanical complexity of the system at the same time as providing a high resolution volume array. A novel broadband signal processing procedure has been utilized to achieve this goal. To verify the array performance and understand the environment in which the array will be deployed an extensive series of measurements have been carried out in shallow water off Boca Raton. The measurements showed interesting features of the ambient noise field and identified that noise sources were very localized. This led to the development of a noise mapping procedure which is described in detail below.

WORK COMPLETED

The Ambient Noise Sonar system, which was designed in the previous year, has now been mounted to the OEx II payload section as illustrated in the two photographs below. In the first photo the array is retracted so as to cause minimal interference with the operating characteristics of the vehicle. In this configuration the vehicle will be deployed from its mothership and transit to its measurement locations where it will land on the ocean floor. Having landed, all the vehicle systems and propulsors will be turned off to conserve power and the array will be deployed in the configuration shown in the second

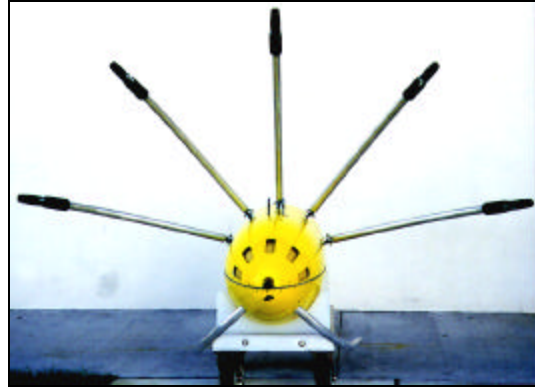
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photograph. After a suitable measurement period, chosen by the vehicle's own intelligence, the array will be retracted and the vehicle will take off and move to a new measurement location. It is planned to carry out a demonstration of the vehicle operation before the end of 1997.

Photo 1: ANS Array Retracted



Photo 2: ANS Array Deployed



The array consists of six ITC low noise 6050C transducers which are connected to amplifiers, A/D converters and anti-aliasing filters, and signal processing hardware in a canister mounted in the payload. The operational frequency of the array is 1-25 kHz, which corresponds to the frequency range where the ambient noise is dominated by naturally occurring sound sources. The lower limiting frequency can be easily lowered if required since the signal processing software is written in a high level language which can be adapted during an experiment if different tasks are required. The data is stored on a 2 GB hard drive and images are processed in the vehicle. The data and the results can be down loaded onto an external laptop via an ethernet link when the array is recovered onto the mothership. This allows for data review within minutes of recovering the vehicle.

In order to verify the performance of the array, check the signal processing hardware and the engineering of the canister in which the electronics are mounted, a large number of experiments have been carried out during the last year. The ANS system, mounted to a static structure, has been deployed in shallow water up to two miles off the coast of Boca Raton. All the deployments were successful and the system performed to specification on each occasion. The results and conclusions from these experiments are described below.

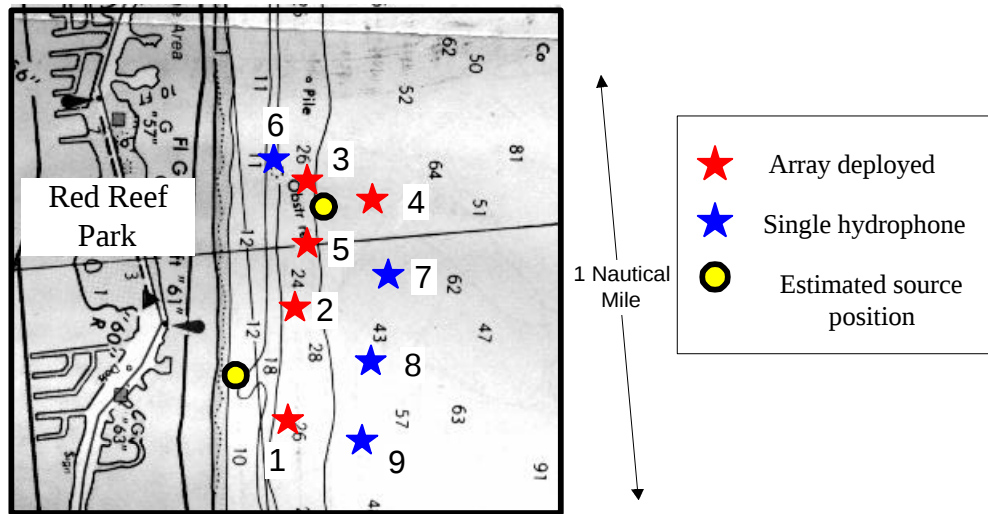
RESULTS

An experiment was conducted to mimic the intelligent behavior of an AUV carrying out a noise survey. Previous results had shown that the ambient noise in the region off Boca Raton was dominated by the signatures from snapping shrimp. The shrimp were clustered close to man-made structures and appeared as a point source on most occasions. It was decided therefore to carry out a survey using the ANS system which sought to identify the location of the shrimp colonies by triangulating from at least two measurement locations,

and use the results to project the noise field to the complete area of interest using a high frequency sound propagation model. This experiment was carried out twice during the summer of 1997 and the results of the second experiment are presented below.

The area of the experiment is shown in figure 1 and the array was deployed in sequence at locations 1 through 5. Single hydrophone measurements were taken sequentially at sites 6 through 9.

Figure 1: Map of the Experimental Sites Off Red Reef Park, Boca Raton FL.

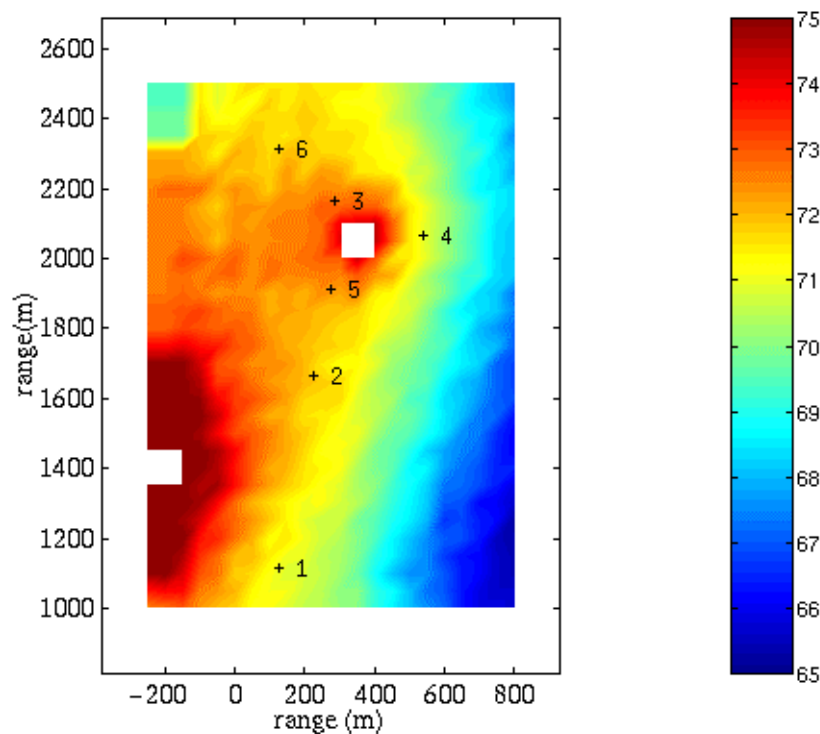


The ambient noise was measured for 20 minutes during each array deployment. A real time decision was made on the next array location on the basis of the data collected up to that point. The objective was to locate the colonies of snapping shrimp and to estimate their average source level. Measurements at sites 1 and 2 clearly indicated a noisy shrimp colony located by the southernmost yellow mark on the map, which corresponds to a man-made groin which is close to the shore line. The measurements at site 3 indicated a distributed source to the south east. Moving the array to site 4 gave inconclusive results which were associated with a widely distributed source. It was therefore decided to move the array back towards the known source to the south, and from the measurement at location 5, two source locations were clearly identified. Triangulating with the results from site 3 indicated a source close to sites 3 and 4 as shown. It was concluded that the measurement locations at sites 3 and 4 were not in the far field of the sources so they did not appear as isolated clusters. There were several areas of patch reef close to the northern source location, which would provide suitable habitats for the snapping shrimp.

Based on the results of these measurements a noise map was generated by calculating the acoustic propagation from two point sources located at the measured source locations. The source levels were determined from the least square error for the measurement points 1-5 and the predicted field was checked against the single hydrophone measurement at

site 6 (unfortunately the single hydrophone measurements at sites 7-9 were corrupted by local boat traffic during the period of measurement). The predicted noise map for the area on the basis of these measurements is shown in figure 2. The predictions were carried out using a ray tracing algorithm and utilized the measured sound velocity profile and the known bathymetry and bottom properties. The white squares indicate the location of the sources and the blue areas indicate lower noise levels in deeper water. In general the noise levels are higher in the along shore direction because of propagation effects. The sources are usually close to the shore and the sound energy is dispersed in the deeper water offshore as indicated in the predictions shown in figure 2.

Figure 2: Predicted Noise Map



IMPACT/APPLICATIONS

The system developed in this project will be of on going value for autonomous underwater surveillance and survey tasks. To date the ANS system has only been used to study biological noise sources in the ocean but we also have excellent sonar images of boat traffic and scuba divers. During the next year it is planned to use the sonar to study acoustic propagation based on the analysis of acoustic modem signal which have frequency content in the operational range of the sonar.

TRANSITIONS

Signatures of snapping shrimp were measured and forwarded to NRL (Marsall Orr)

RELATED PROJECTS

Development of the OEx AUV vehicles at Florida Atlantic University (Dr. S. Smith).

REFERENCES

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- 2) "Array processing methods for imaging ambient noise sources." Marc P. Olivieri and Stewart A. L. Glegg. presented at the 132nd meeting of the Acoust. Soc. of Am., Honolulu, December 1996.