Development of a Shallow Water Ambient Noise Database

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***Abstract*— The number of underwater activities and experiments in tropical waters has been growing; people are increasingly becoming interested in the development of underwater applications that rely on acoustic communications. Ambient noise is a limiting factor in the performance of underwater acoustic detection and communication systems at shallow water. Knowledge of ambient noise characteristics at a location will be helpful for ambient noise imaging systems like ROMANIS, built at Acoustic Research Laboratory.**

The Singapore straits and surrounding waters contain some of the busiest shipping channels in the world. Monitoring of ambient noise is of crucial interest to acousticians and oceanographers due to the high level of shipping and snapping shrimp noise in the region. Since there was no such systematic ambient noise database existing to support oceanographers and acousticians, the Acoustic Research Laboratory (ARL) at the Tropical Marine Science Institute (TMSI) has embarked on developing a shallow water ambient noise database. This Graphical User Interface (GUI) -based database will benefit and enhance the research and development of marine acoustic systems.

This paper describes the collection of ambient noise data and the structured compilation of this information into a useful database. The data collected covers a frequency range of 11 – 8300 Hz. The data is indexed and stored in a database and presented to the user via a GUI. The GUI uses an approach similar to typical Geographical Information System (GIS) databases. The user is able to select different layers of information on a map. The user may search for ambient noise data based on various parameters such as location of data collections or classification of the environment. The GUI is also integrated with Matlab®, popular mathematical analysis software, to display the time series, power spectral density and 1/3rd octave spectrogram of the ambient noise data.

The database GUI, some example data and a summary of the collected ambient noise data will be presented. The high levels of noise due to shipping and snapping shrimp are all readily apparent in the data; with typical intensity levels considerably exceeding classic reported values. Shipping noise is reported to dominate the frequency range below 1 kHz. Snapping shrimp noise is found in all warm and shallow waters. The ambient noise data collected from near a fish farm area shows that the snapping shrimp noise is dominant above 2kHz.

***Index Terms*—Acoustic, Ambient Noise, Database, Graphic User Interface.**

I. INTRODUCTION

A. Background

The performance of marine instruments in terms of the capability of underwater acoustic detection or communication is affected by ambient noise. Unfamiliarity with the shallow water acoustic environment has often been an issue for most marine engineers while designing such instruments. Furthermore, the type of marine environment has a significant impact on the underwater sound characteristics. Hence, a user-friendly ambient noise database will be useful for the research and development of marine acoustic systems.

B. Objective

The objective of the development of Shallow Water Ambient Noise Database is to support oceanographers and acousticians by providing easy access to knowledge of shallow water ambient noise in local waters. Data collection from different ambient noise environments over different frequency bands was conducted in order to build a set of representative shallow water ambient noise profiles. A systematic way of updating ambient noise data into the ambient noise database has been made available. The database is updated on an annual basis. The resulting database is available on CD-ROM.

II. METHOD

A. Database

Shallow Water Ambient Noise Database was developed using Visual Basic application (VBA) programming language. It was designed to be user-friendly; it provides a graphic user interface (GUI) as shown in Fig. 1 & 2. The presentation of the GUI is similar to certain Geographical Information Systems (GIS). The GUI presents a hyperlinked map, which provides easy access to the ambient noise information at the specified geographical coordinates.

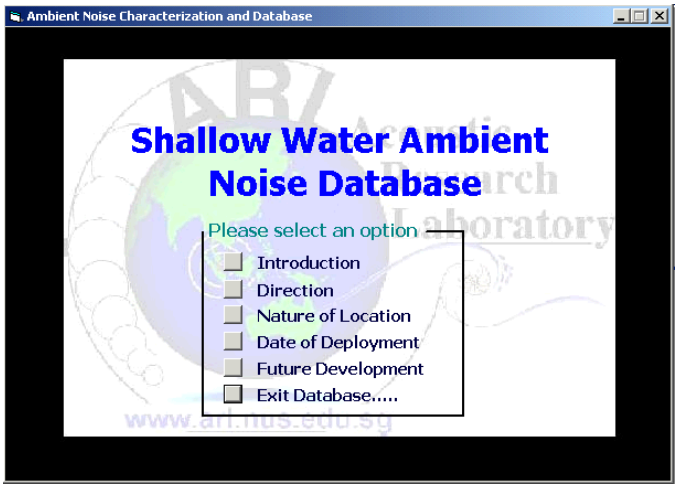

Fig. 1 The front page of Shallow Water Ambient Noise Database

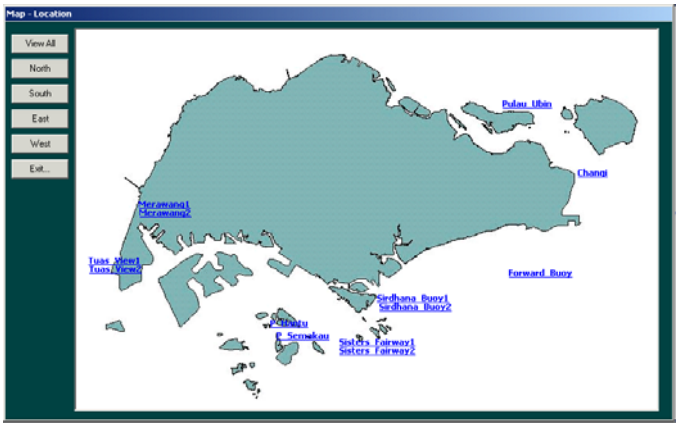

Fig. 2 The main GUI of Shallow Water Ambient Noise Database

A Microsoft Access database has been created for organizing the data in the Shallow Water Ambient Noise database. Currently, there are two types of data stored in the Microsoft Access database's tables. The first table contains the spatial data, a collection of coordinate pairs which represent the data collection points on the map. The second type of the data stored in the database is attribute data. Attribute data describes meta-information related to every ambient noise data collection at each location. The meta-information includes the date and the time of the collection, comments from author related to the collection as well as an address that provide the directory location of each ambient noise data sets in CD-ROM.

Fig. 3 explains the data flow of the ambient noise data through the Shallow Water Ambient Noise Database. A Pop-up Ambient Noise Data Acquisition (PANDA) system [1] developed by the ARL, was used for the ambient noise data collection. After the collection and retrieval of the recorded data from PANDA, the dataset was processed by a Matlab® program. This program reads the data piece by piece and calculates the ambient noise level (as power spectral density) as well as its probability distribution function. Once the results were checked, representative ambient noise data were selected and integrated into the database. During the integrating process, the user allocated a directory location for the data and updated the spatial information and attribute meta-data information in the Microsoft Access database.

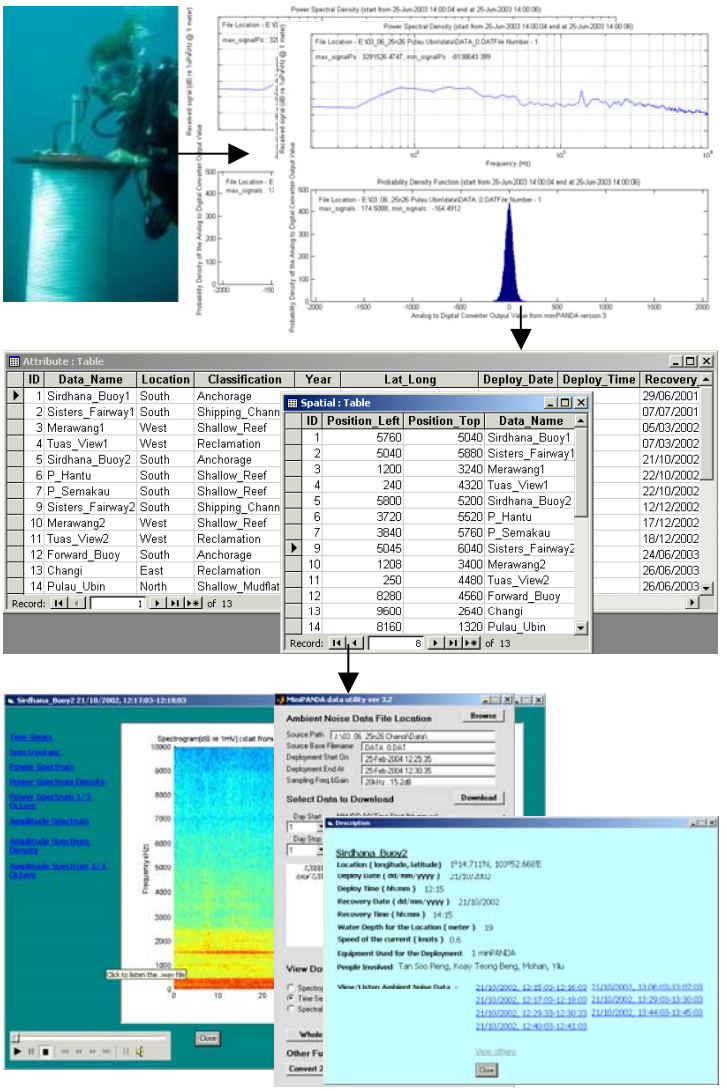

Fig. 3 Data flow of ambient noise data through the database

B. Functional Description

One of the main design features of the database is that users are able to access the collected representative data by different keys. The keys include broad regions such as North/South/East/West, nature of location and date of deployment. Fig. 4 shows a table of keys available. Users can specify the area of interest, such as shipping channel, coral reef or reclamation site, and retrieve the entire representative ambient noise data of interest accordingly. With this feature, users are able to compare and analyze the differences between each representative data and the relationship to their data collection points.

In addition, different presentation formats are provided in the database. These include time series, spectrogram, power spectrum, power spectrum density, power spectrum 1/3 octave, amplitude spectrum, amplitude spectrum density and amplitude spectrum 1/3 octave (see Fig. 5). Once the dataset has been chosen and shown in the selected presentation format, users can choose to listen to the recorded data by clicking the 'play' button on database GUI. The respective ambient noise wav file, residing in the data file directory, will be played through the speaker.

Only a small portion of the ambient noise data was selected as representative ambient noise data for each location in database. An alternative access method is provided to allow access to additional collected data on a separate CD. The database GUI allows the user to access this data via a clickable icon on the GUI. (see Fig. 6). During the access to this data, users have to insert the data CD into the CD-ROM in order to enable the data download process. The user specifies the length of the data of interest before the downloading process. Once the data has been loaded, it can be analyzed using the same spectral analysis tools as the representative data.

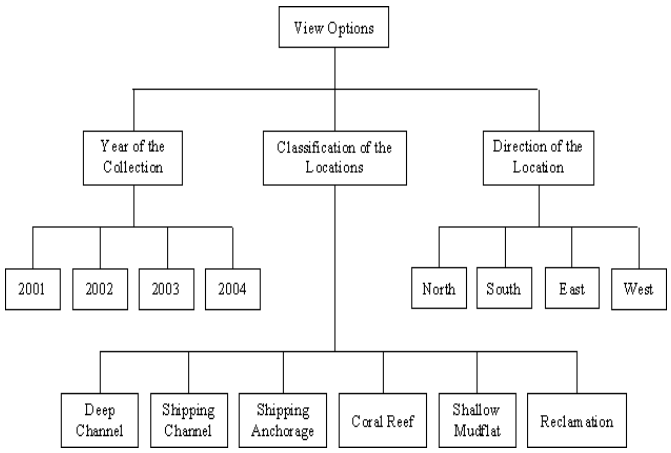

Fig. 4 Selection of the View Options

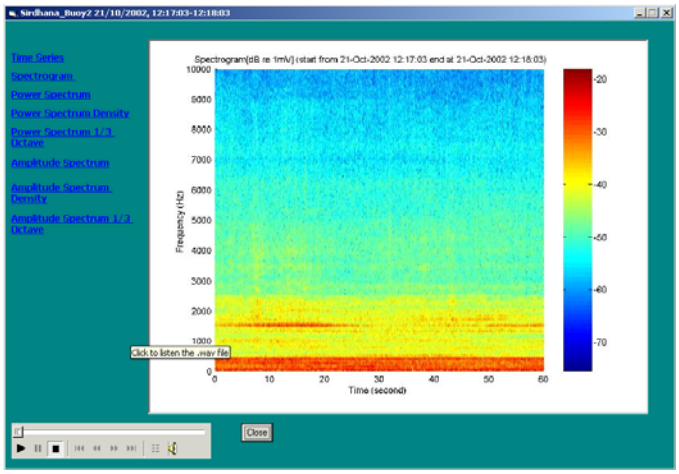

Fig. 5 Ambient Noise Data Presentation Format - Spectrogram

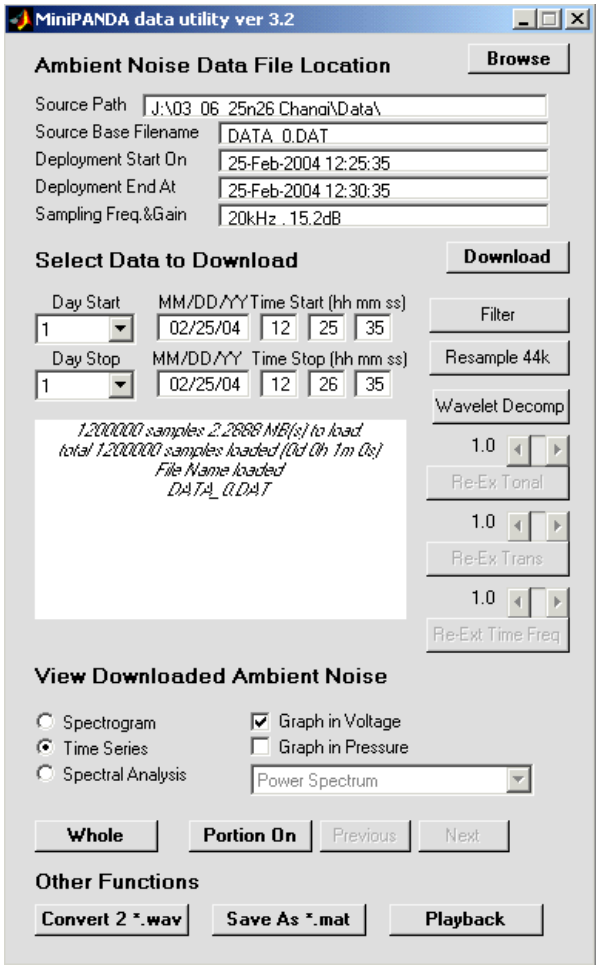

Fig. 6 Access to additional ambient noise data

III. RESULTS

This paper presents some power spectral density curves taken from 4 different locations, selected to be characteristic of the major type of ambient acoustic environments in local waters. The data are shown as solid lines, whereas the dashed lines are the snapping shrimp and shipping curves reported by others from various locations. In addition, some of these 'classic reported' curves have been shifted to a higher or lower dB value (shown as heavier dashed lines). The purpose of superimposing our data with these 'classic' curves is to compare these curves with the low and high frequency trends of ambient noise in local waters. The results are as shown in figures 7-10 and the table below.

Fig. No.	Characteristic of the location:	Summary Results
7	A coral reef site, shallow water, close to an anchorage area.	**Observation on frequencies above 1kHz:** It matches the snapping shrimp curve from San Diego [2] very well. The snapping shrimp click can be clearly heard from the recorded ambient noise. **Observation on frequencies below 1kHz:** A shifted 'Medium Shipping' curve [2] was shown in the figure. The comparison shown that the data has a slightly higher shipping noise compare to the original 'Medium Shipping' curve. Besides, there are some tonal found at the transition band between shipping and snapping shrimp noise.
8	A ferry terminal and airport are nearby, shallow water, moderate shipping traffic.	**Observation on frequencies above 1kHz:** Again, the result show the respective power spectral density curve was fitted with the snapping shrimp curve from San Diego [2] reasonably well at frequency above 1kHz. However, there is some energy noticed around 500 – 900 Hz, which may be cause by different species. On the other hand, the data was compare with the snapping shrimp curve reported by Cato and Bell [3] as well. It is observed that the data goes well with the 'shifted snapping shrimp noise' curve. It has lower power value than the 'reported' curve. **Observation on frequencies below 1kHz:** It is clearly seen that the data collected from this shipping fairway has a higher power than the 'heavy shipping' curve [2]. At the same time, it is found that a large power of tonal at frequency 400Hz, which was believed, that come from the boats noise at nearby ferry terminal.
9	Located in between an anchorage area and one of the busy shipping channels, about 40m water depth.	**Observation on frequencies above 1kHz:** It is believed that snapping shrimps are populated at this shipping area as well, as the curve is consistent with that snapping shrimp curve from San Diego [2]. Besides, we also noticed the data has a different power spectral density curve with the curve reported by Potter, Lim and Chitre [4]. **Observation on frequencies below 1kHz:** This shipping channel data has a higher power spectral density value than the 'heavy shipping' curve [2]. Besides, there is a large region of power found in between 200 - 2000 Hz which was strongly believe contribute by the vessels anchor at the location.
10	A site nearby a fish farming, shallow water, depth less than 10m.	**Observation on frequencies above 1kHz:** The pattern of frequency above 1kHz is founded consistent with the snapping shrimp curve reported by Cato and Bell [3]. However, it has a power that is lower than the snapping shrimp collected from San Diego [2]. It might due to the different species or the distance to the snapping shrimp from the measurement location. **Observation on frequencies below 1kHz:** This location is considered as a light shipping area as it's power is lesser than a typical 'low shipping' curve [2]. An 'unknown' sweep signal is found at 50 – 80 Hz. It might produce by low frequency active sonar or biologic sound.

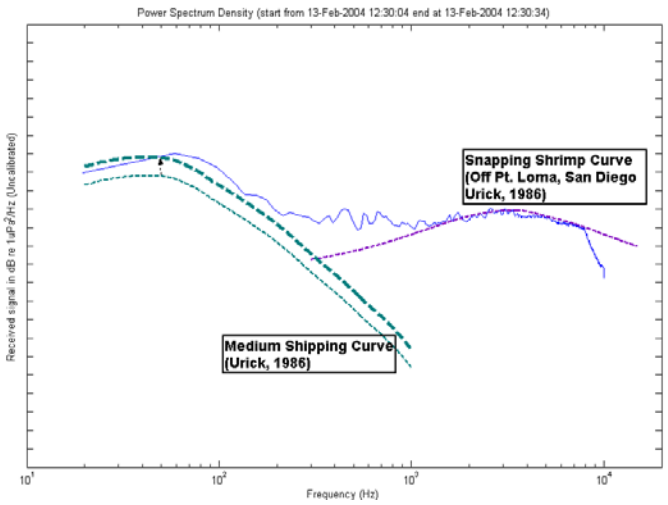

Fig. 7 Power Spectral Density curves for 'Coral Reef' site

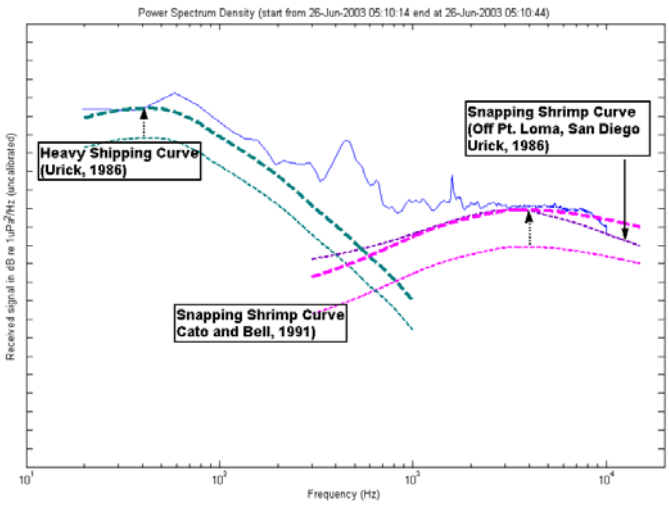

Fig. 8 Power Spectral Density curves for 'Shipping Channel' site

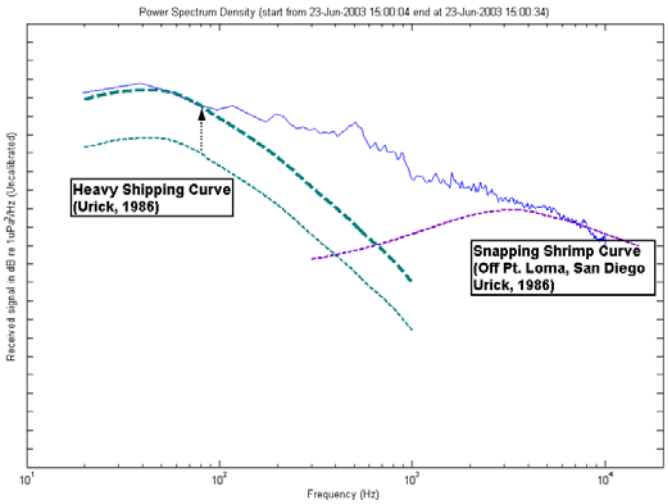

Fig. 9 Power Spectral Density curves for 'Shipping Anchorage & Channel' site

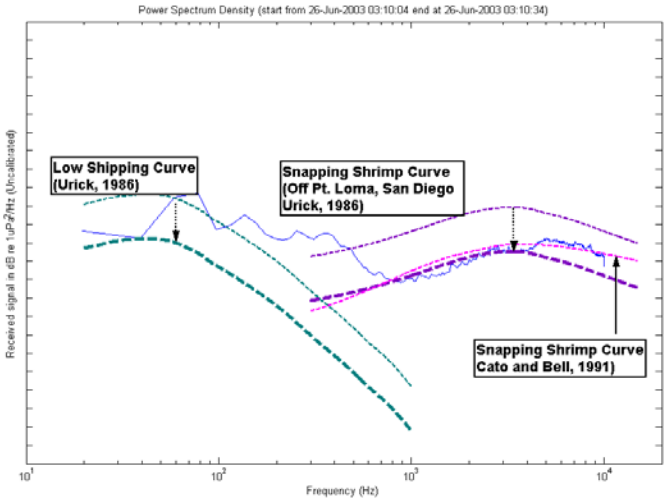

Fig. 10 Power Spectral Density curves for 'Shallow Mudflat' site

IV. CONCLUSION

A user-friendly shallow water ambient noise database was developed; several GUIs were designed for the ease of access the database. Data flow of the ambient noise data and the functionality of the database have been described.

A brief summary of the data collected is presented in terms of the power spectral density curves. The observed data is compared with the 'classic' curves reported by others. The data collected shows that different ambient noise environments are found in the various shallow water environments.

The shallow water ambient noise database provides complete ambient noise knowledge of local water environments.

ACKNOWLEDGMENT

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