“MUSIC FROM THE OCEAN”: A MULTIMEDIA CROSS-DISCIPLINE CD

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ABSTRACT

“Music from the Ocean” is a multimedia CD that explores the sonification of ocean wave data for oceanography, science pedagogy, and music and sound synthesis. Turning this data into sound provides new ways of experiencing and comprehending the phenomena involved; the processes come alive and are more comprehensible, memorable and exciting than graphs of the data. This CD contains over 55 minutes of sound examples as well as an interactive Flash presentation and research paper explaining the methods in more detail. An accompanying 16-page booklet features graphics and information about the data, phenomena, and music. The CD appeals to a wide variety of consumers, from oceanographers, science teachers, experimental computer music enthusiasts, and music therapists.

1. INTRODUCTION

A previous paper details the author’s methods used to sonify ocean buoy data [1]. The data used is collected by the Coastal Data Information Program (CDIP), at Scripps Institution of Oceanography (SIO), at the University of California, San Diego (UCSD). For 25 years this program has measured, disseminated, and archived coastal environment data for use by coastal engineers, planners, and managers as well as scientists, mariners, the military, and surfers. CDIP operates approximately twenty buoys which record ocean conditions including wave height, period, and direction, air and sea temperature, wind velocity and direction, and barometric pressure [3]. Such multidimensionality and the data’s cyclic wave nature is inviting for sonification and computer music composition.

The basic sonification mapping is quite direct. The spectrum of the original wave data is shifted and transformed into an audible signal. Thus frequencies in the sound domain are proportional to frequencies in the ocean waves. Amplitudes are determined by energies present in the corresponding frequencies. Each component can be spatialized according to the direction from which it is originating.

Low frequencies are long period swells which create large breakers that come in long regular intervals. High frequencies are short period waves, which create choppy water. Several times in the sonifications there are clear frequency sweeps from low to high. These signify passing energy that originated in a faraway storm. At other times there are quick downward frequency sweeps. These events were mysterious, even to oceanographers, until they were correlated to local afternoon winds.

The author has professionally produced a CD demonstrating the sonification method, and composing with the ocean [2]. There

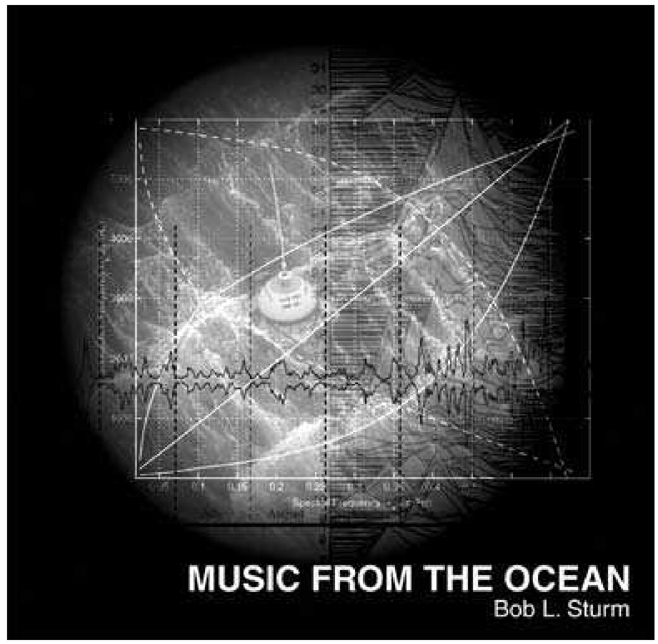

Figure 1: “Music from the Ocean” *cover*

are thirty-four tracks of sound and music that demonstrate the mapping, a phenomena, and composing with the ocean. The CD also contains an interactive Flash application that combines the sonifications with graphs of the data, as well as the publication [1]. The accompanying 16-page booklet contains more text, graphs, and explanations of the data and sonifications.

1.1. Introduction to Physical Oceanography

The ocean is a vast body which has unprecedented complexity, the movements of which are the subject of study for physical oceanography. CDIP buoys only measure waves and not currents, which actually transport water. Waves are the undulations of the ocean surface, which are normally produced by winds that grip and push even millimeter ripples. Waves can also be produced by earthquakes, volcanic eruptions, and massive underwater mudslides.

Waves are classified into two categories. “Sea waves” are locally generated which are irregular or choppy, and peak in the same area as the “fetch”—the area over which the wind and ocean interact. When the waves leave the area of the fetch they are classified as "swell waves." The velocities of ocean waves are proportional to their periods, so the longer periods outrun their shorter counterparts. Thus the previously localized energy becomes a "wave train" and moves often thousands of miles to finally break and release the energy on some distant shore. An excellent introduction to these concepts can be found in [4].

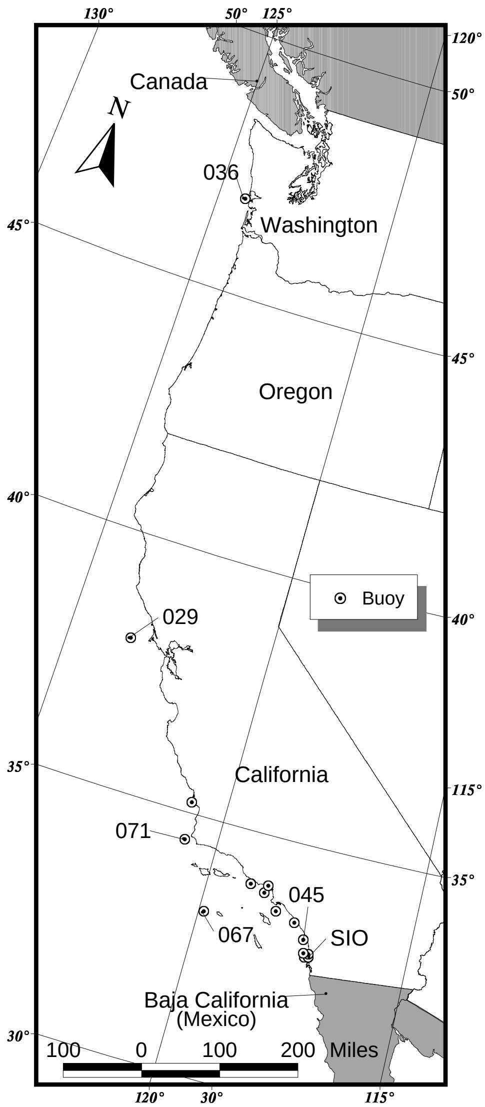

Figure 2: *Locations of current West Coast CDIP buoys.*

2. THE BUOYS AND DATA

The buoy seen in the middle of *figure 1* is a 0.9 meter diameter steel sphere that weighs approximately 180 kg, and is tethered to the ocean bottom with a mooring line and 450 kg of ballast chain. This particular buoy measures temperature and accelerations in the three dimensions. Wave height is determined by vertical acceleration; wave direction comes from the accelerations measured in the XY-plane. Typically CDIP buoys are in regions 500 meters deep, but are used closer to shore in as shallow as 20-meter depths. *Figure 2* shows the locations of all currently operational West coast buoys operated by CDIP.

The buoy transmits its measurements via radio to an onshore field station. Every thirty minutes CDIP queries the field station, downloads and processes the data, and then disseminates it to the National Weather Service and makes it freely available on the CDIP home page (http://cdip.ucsd.edu).

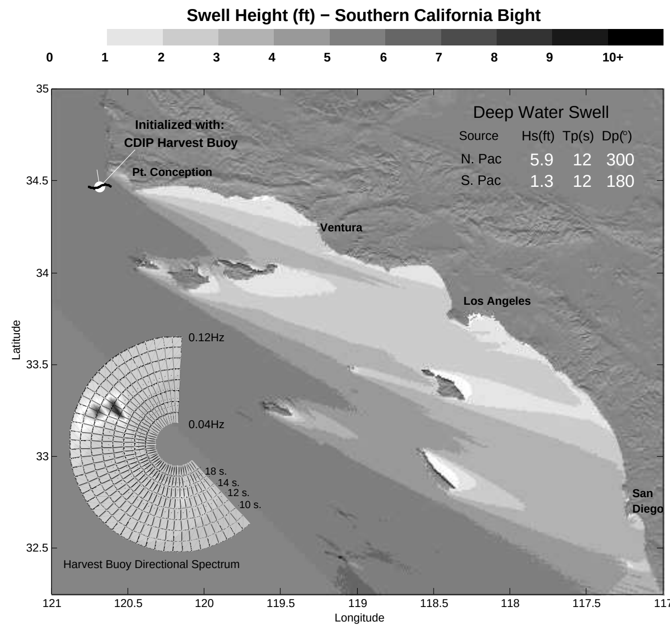

Figure 3: *Predicted Southern California wave conditions.*

Using this data forecasts of up to 72 hours are available. *Figure 3* shows a 'snapshot' of current wave conditions along the Southern California coast, based on the measurements from the Harvest Buoy (071). This image shows the islands casting "shadows" in the ocean, blocking energy coming from the Northwest.

For a given month a buoy can make approximately 1,500 measurements; for an entire year, an average of 17,000 measurements are reported. This makes a humongous collection of data. The total size of the current CDIP database is over 50 gigabytes and spans twenty-six years—all of which is freely and publicly accessible through their website. It increases each day by approximately 15 – 20 megabytes (Mb), or about 1 Mb of data for each operating buoy.

3. THE SONIFICATION

The acoustic conversion of the data is simple and direct. The spectral composition of the sound is the shifted spectrum of the wave-driven motions measured by the buoy. The energies within the spectral components are the amplitudes of the spectral components in the sonification. The spatialization of a spectral component is determined by the direction from which that component is observed originating. In its most basic presentation, the ocean waves are being scaled to audibility.

The most important parameters for the sonification are adequate spectral shifts, and the time compression of the data. Certain

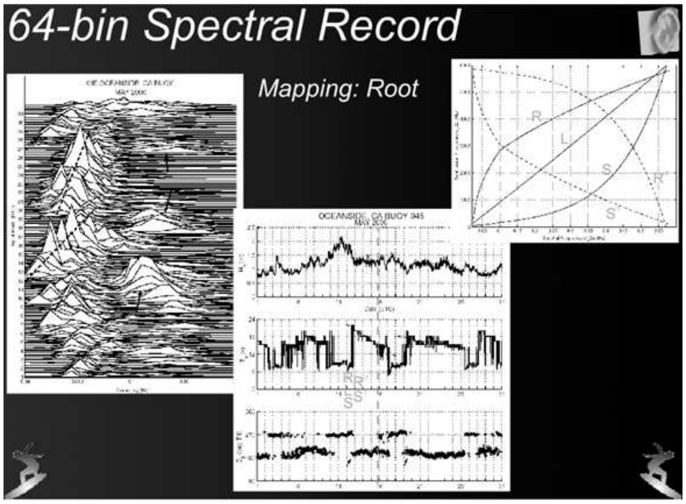

Figure 4: Screengrab of the Flash application.

portions of the spectra can be emphasized more than others, which can make swell more or less perceptible than sea. Compression of the time-series data can turn a year's worth of data into a sonification lasting seconds to hours.

4. MAKING THE CD

The music and sound on the CD were created using MATLAB 6.0 on a Sun Blade 1000 running Solaris 7. Ten gigabytes of sound were computed over a period of one month and from this just over 600 MB were chosen. The CD tracks are arranged in three sections: sonification parameters, ocean phenomena, and composition.

The first section demonstrates several sonifications of the same datasets, showing how different spectral mappings and time compressions change the perceived information of the sonification. In the time compression examples an entire year of data is compressed into 10, 3, and 1 minute durations.

The phenomena section gives aural examples of swell, sea, wave-trains, and sea surface temperature change. A general characteristic of the sonifications are long upward sweeps and short regular downward sweeps. Those latter effects were mysterious until they were correlated with the normal afternoon winds near the sonified buoy. These effects are not apparent in visual representations of the data, and only came to be "discovered" after making the sonifications.

The third section of the CD demonstrates the use of the sonifications for compositional purposes. There are at least three ways of composing music using this data. The first is to keep the data as an intact representation of the ocean activity and find a time-period that is compositionally interesting. A second method focuses on altering the spectral mapping throughout a dataset for one or more buoys. This keeps the shape of the phenomena intact but uses composer specified pitches. A dataset can also be read in any order, removing any scientific meaning of course, but creating interesting possibilities.

The CD also includes an interactive Flash application of the methods and data to allow for a more complete understanding of the technique. The user is able to hear the data and watch a visual representation as the sound plays. *Figure 4* shows one such display where the user chooses a sonification mapping and watches a red progress bar sweep over graphs of the data as the sonification plays.

5. CONCLUSION

"Music from the Ocean" is appealing to more than one market. It has applicability in oceanography, demonstrating a new technique for data analysis. It has value for pedagogy as well, providing interesting lessons for physical oceanography that are entertaining and memorable. The CD is also musically interesting for computer music, science and art topics, and as relaxation music. One co-worker suggested that if he knew the data sounded like that his job would be more interesting and dramatic. Other auditors have remarked how calming it is. A second grade teacher has used it in lessons about the ocean. Many customers either relax or sleep to the CD, which isn't such a good thing for a serious composer. To appreciate and be intrigued by the music one doesn't need to follow the science.

The ocean buoy spectral data of CDIP lends itself well to sonification by its being not only cyclic and dynamic, but a measurement of waves. Since the CDIP database is very large it provides a rich collection of data for auditory display experimenting and algorithmic composition. Further work should be done to enable real-time interaction with this data, image, and sound. It could then become a tool for data exploration.

It is rare to find a CD that is not out of place with books on physical oceanography, Diana Deutsch's aural illusions and paradoxes, experimental computer music, and new age music. "Music from the Ocean" is an attempt at creating a CD that successfully crosses all these disciplines and remains an interesting application of sonification.

6. REFERENCES

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