GETTING MUSIC OUT OF THE WAVES

by

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List of Figures & Sounds

Sound examples supplied this version - Acrobat 6 or higher required.

1 Surface Wave Spectra versus Music Spectra

Plots of the dynamics of wave trains at a coast or lake and plots of the dynamics of a piece of music at a first glance look alike, Figure 1. Of course, the frequencies differ by orders of magnitude. While the surface waves from ocean waters are in the range of 0.002 KHz to 0.015 KHz, the music ranges between 0,03 kHz and 9 KHz, e.g. a drumloop as shown in Figure 2.

The famous sound of ocean waves approaching shallow and steep coasts is the result of the transformation of dynamic wave energy into pressure variation and vibrations, resulting in sounds in the air and vibrations in the ground. Additional sounds - some feel it more as noise - result from the release of the air compressed under the breaking wave offshore and nearshore during run-up or due to shoaling effects.

The question was, what might be behind the dull and chaotic sounds of wind-driven sea waves? Is there some kind of musical behaviour in the background? To obtain some answer, an interface had to be found for the comparison of the lower wave frequencies with the audible musical frequencies.

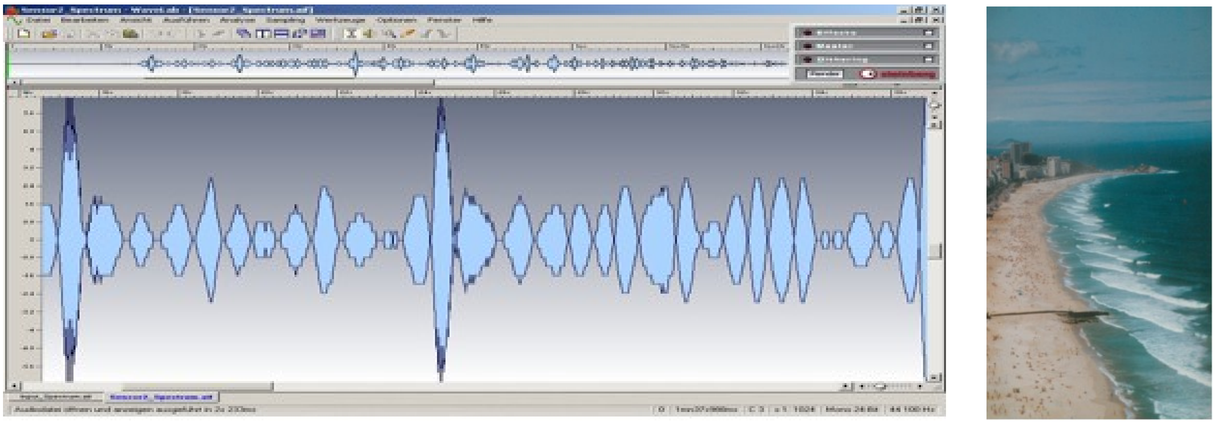

Figure 1: Dynamics of Waves - Wave Train at a Coast

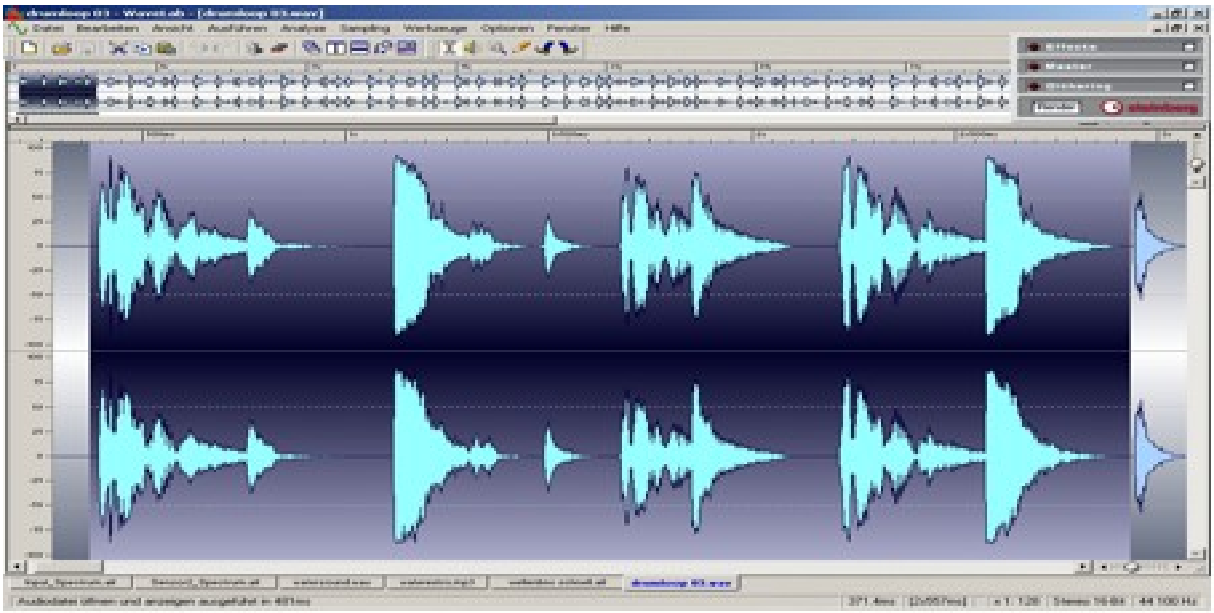

Figure 2: Dynamics of Waves - Music Piece (Drumloop)

2 Analogy Between Sea Waves and Music

Figure 3: Resistance Type of Wave Gauge

A simple way of recording the regular and irregular motion of a wavy water surface is the use of wave gauges as applied in the hydraulic laboratory or on the foreshore of coasts, Figure 3.

Analyzing gauge records of natural wave as shown in Figure 4 in terms of musical relevance was done by using various methods of transformation.

The transformation of the gauge records into the audible range via linear multiplication produced only white noise.

Another way of analysis was to feed a wave maker of a wave channel with data of wave gauges recorded in the field and listening to the resulting rhythm of the waves in terms of musical relevance, which did not lead to results either.

Looking from the opposite end data of converted musical wave forms were fed into the wave maker to see what kind of water waves would result.

In order to convert the musical waveforms a program was developed, which transforms standard audio files, e.g. wave files in 16 Bit, 44.1 kHz resolution, into data that could be read by the wave machine.

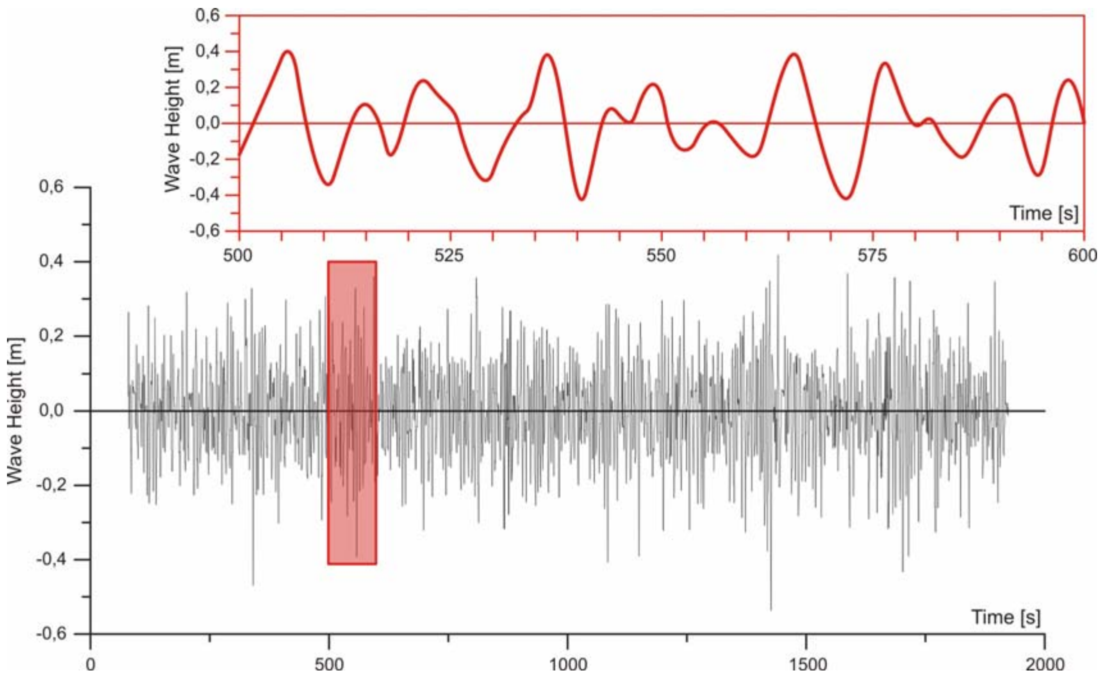

Figure 4: Record of Wave Trains at Sea

A simple drumloop as depicted in Figure 2 consisting of bass drum, snare and hihat served as an example. Using cross-correlation, the program compares the wave structure of each instrument with the wave structure of the entire wave file to find the positions at which each instrument beats, resulting in starting points of the bass drum, the snare etc..

At the starting point of the instruments sound, the program generates a sinus impulse with different amplitudes, high for the bass drum, middle for the snare and low for the hihat. This serves as a good approximation for the reproduction of the envelope of the former dynamic curve of the wave file. Such simplification was necessary due to the inertia of the wave machine and channel water which prevented better approximation. Improvement of this approximation could be subject to further research in a wave channel equipped for compensation of reflections which could not be applied during these experiments. The process is illustrated in Figure 5. However, the resulting sound, produced by the water waves and the recorded gauge records showed some interesting musical results which served as a basis for further musical treatment, e.g. composition a “Wave Suite”.

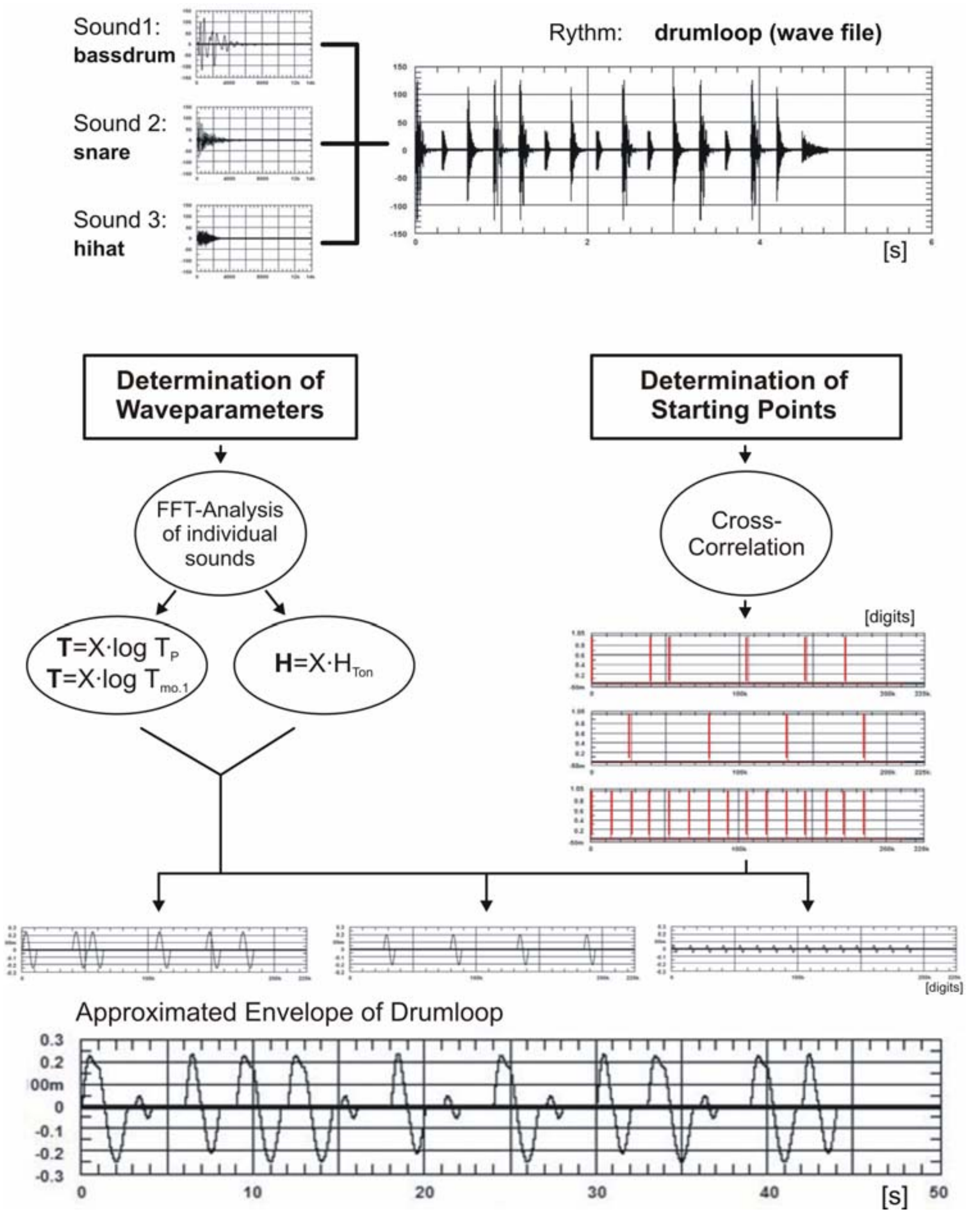

Figure 5: Process of Approximation of the Dynamic Curve of a Drumloop

3 Experimental Verification

A different way of surface wave motions recording with an immediate correlation to musical sounds is an open tube above the water surface that dips into the passing waves. Depending on the impact, i. e. the uprising wave velocity, the air within the tube is compressed and vibrates, comparable to a big organ pipe. Selecting tubes of different diameter, length and material and recording the resulting sound with a microphone gave some interesting sound features. These can be used as an "Acoustic Wave Gauge" or - combined with a trigger and a synthesizer – as a basis for further musical treatments.

Figure 6: “Wave Tube” Installation in a Laboratory Wave Channel with Large Tube "blue" contra E♭ (38,89 Hz), Medium Tube "red" B♭ (58,26 Hz), Small Tube "yellow" E♭ (77,78 Hz)

Three different plastic tubes were installed, Figure 6. Length, diameter and material were found in pre-tests with regular waves, selected according to their resulting sound defined by pitch, volume and sonority as taken from the installed microphones. The distance of the tubes to the water surface and the optimum angle of the tubes depends on the wave parameters length, amplitude and were determined in tests. Result for the selected regular waves was an optimum distance of 15 cm with an angle of 65° at a wave height of 35 cm. Here, the tubes produced good and most profound sounds, which can be heard in the sound example 1 supplied on our server. Pressure impulses of the tubes can also be used as a trigger for other sound samples. The varying wave height itself as obtained from the resistance gauge can serve as an additional source of modulation for an analogue synthesizer.

click here to play

Sound example 1:
sound of a “wave tube”

Connecting the two poles of a resistance type of a wave gauge with the synthesizer the outgoing voltage variations can play melodies or vary the timbre, modulating the cutoff frequency of a filter or other voltage controlled effect processors, Figure 9.

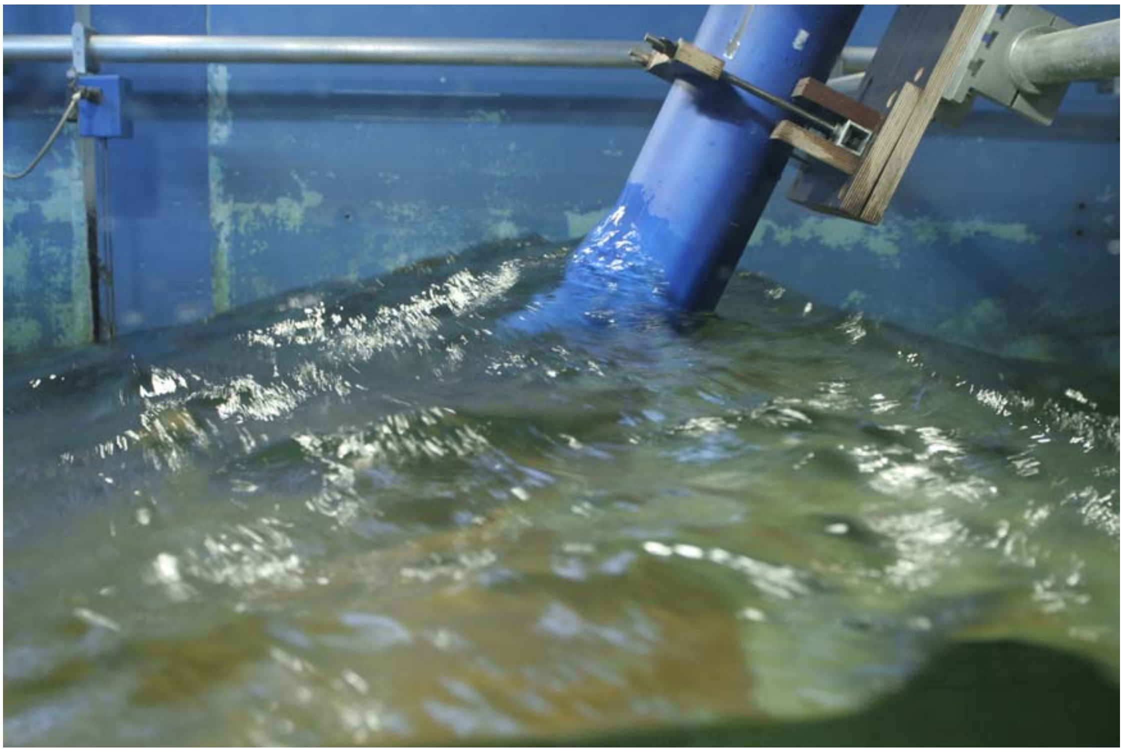

Figure 7: Impact of Uprising Wave on Orifice of "Wave Tube" Resulting in a Single Sound Recorded with a Microphone

Figure 8: Orifice of "Wave Tube" Immersed by Passing Wave

Figure 9: Synthesizer Setup: Analogue Synthesizer Connected to Wave Machine, "Wave Tube" Microphones and Wave Gauges

4 Musical „Verification“

A combination of the bass sound of the “Wave Tubes” with sounds from the analogue synthesizer and the rhythm of the waves let the wave channel “make music” and compose its own “wavechannel groove”, supplied as sound example 2 on our server.

click here to play

Sound example 2:
getting music out of the waves in a wave channel

Combining sounds “played” by the wave channel with other musical instruments result in a unique new sound, which was integrated in a “Wave Suite”, two parts of which are also given as example. Sound example 3, the “Wave Suite part 1”, is a piece for wave channel, piano and solo violin.

click here to play

Sound example 3:
piece for wave channel, piano and solo violin

Sound example 4, “Wave Suite part 2”, is an orchestral development using the sound of the wave channel, the sound of the wave tubes, the modulation of the analogue synthesizer with its effects section plus an entire orchestra. The recorded sounds of the wave-tubes where fed into a sampler and serve as a bass, while the control voltages produced by the wave channel were recorded into a sequencer for proper reproduction and then played back into the analogue synthesizer. Finally, additional instruments where recorded live and programmed to finalize it as music.

click here to play

Sound example 4:
piece for wave channel and orchestra

5 Literature

ANWANDER, F.
Synthesizer, Verlag: PPV Medien GmbH; Auflage: 4., Aufl., 2006

DEAN, R.G.; DALRYMPLE, R. A.
Water Wave Mechanics for Engineers and Scientists, World Scientific Publishing, 1991

DICKREITER, M.
Handbuch der Tonstudiotechnik 1/2, Verlag: Saur; Auflage: 6., vollst. neubearb. Aufl., 1997

HOLTHUIJSEN, L. H.
Waves in Oceanic and Coastal Waters, Cambridge University Pr., 2007

ROEDERER, J.-G.
The Physics and Psychophysics of Music. An Introduction, Springer, B.; Auflage: 3., ed., 1998

VEIT, I.
Flüssigkeitsschall: Hydroakustik in Rohrleitungen und offenen Gewässern, Vogel-Verlag, 1979