Sound of Rivers: Stone Drum
Translating limnology into multimedia

Charles Nichols
School of Performing Arts,
Institute for Creativity, Arts, and Technology
Virginia Tech, USA
csnii@vt.edu
http://www.charlesnichols.com

Mark Lorang
Flathead Lake Biological Station,
University of Montana, USA
mark.lorang@flbs.umt.edu
http://flbs.umt.edu

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With the intention of translating the research of limnologist Mark Lorang into art, computer music composer and electric violinist Charles Nichols collaborated with video artist and animator Amber Bushnell, choreographer Nicole Bradley Browning, poet Mark Gibbons, dancer Allison Herther, and narrator Stephen Kalm, on a multimedia piece for computer-processed audio, sonified data, electric violin, computer-processed video, animation, narrated poetry, and dance, performed live and later reworked into a piece for fixed media.

Starting with a float down the Middle Fork Flathead River, on the border of Glacier National Park in Montana, where data and audio were recorded, musician Charles Nichols joined a collaboration with limnologist Mark Lorang, to translate into multimedia art scientific research into how stoneflies navigate flood plains by the sound of rivers.

Nichols assembled a team of artists, including animator Amber Bushnell, choreographer Nicole Bradley Browning, and poet Mark Gibbons, who created a live multimedia piece, that Nichols and Bushnell performed with dancer Allison Herther and narrator Stephen Kalm. Later, Nichols and Bushnell assembled material from the live performance into a piece for fixed media (Nichols et al. 2014).

Musical textures were composed by mapping environmental data to settings of bandpass filters processing above water and underwater recordings, and using river and wind data to drive bowed string physical model synthesis parameters. Recordings of read poetry were computer-processed to complement the live narration, with a chorus of text-painting accompaniment, and melodies were composed for electric violin, that combined rhythms and motivic fragments by musicians mentioned in the text. Both the bowed string physical model and live electric violin were processed with layers of phaser effects and delays, that evoked a watery environment.

Limnology

The flow of water in a gravel-bed river creates unique sounds from low frequency moans and groans associated with breaking waves in rapids and the pumping of water in boils during floods to the babbling of riffles. When flows reach levels high enough to move the cobbles, gravel and sand that compose the channels and banks of the river also begin to change shape and form. New channels are created; banks are eroded with that bank sediment being deposited further downstream in the form of new gravel bars. This geomorphic process of cut-and-fill results in the creation of new or reshaping of old aquatic habitats in the form of riffles, runs and pools that compose the channel. Seeds and self-propagating pieces of wood from riparian vegetation also deposit on the newly formed gravel and sand bars resulting in colonization of these new sub aerial habitats of the river and its flood plain with an array of plant cover. The growth of riparian vegetation creates new wetlands, grassy meadows and forests that in turn support a wide diversity of organism from insects to birds and mammals like beavers, elk and bear. The abandoned channels create new ponds, backwaters and springbrooks which support the growth of a wide variety of aquatic insects that then provide food for juvenile fish; hence these habitats become the nursery grounds for fish. Perhaps most importantly portions of surface water from the river flows into the ground below and next to the river while in other areas water in the ground flows back to the river. Biological and chemical processes that occur beneath the surface of the river and flood plain during this exchange of ground-and-surface water cleanse the water, cool it and support a wide variety of aquatic insects that live most of their life in this subterranean environment. Hence a river is much more than just the channel where we fish or simply sit to enjoy the soothing sounds but rather a river is a complex 3D array of interconnected habitats above and below ground that all change in time. In a healthy river this mosaic of habitat is constantly changing as a function of flow levels from floods to base flow that move sediment composing the bed to major changes that reshape the entire flood plain. These processes are pivotal to maintaining a "shifting" mosaic of habitat (sensu Stanford et al. 2005) because the flow of water coupled with the movement and transport of gravel as bedload in rivers and streams are primary drivers of ecosystem structure and function in fluvial systems.

A natural product of bed material transport is the sound that is generated by particles banging and rubbing into each other as well as the scrubbing action of sand (Lorang and Tonolla 2014). This sound can range from an intermittent plinking caused by sporadic collisions of individual particles colliding to a load roar produced when the whole bed is moving. These various levels of sediment transport intensity and associated bed scour during floods can become a catastrophic disturbance for benthic communities (plants and animals that live on the bed), drastically reducing their abundance. The movement of gravel in rivers and streams is also an important regulator of aquatic ecosystem metabolism linked directly to watershed hydrology, and hence, climate change (Cronin et al. 2007). In this regard rivers can be thought of as organisms that need to breathe whereby floods cleanse the lungs or bed sediments allowing new plants (algae) to grow that are grazed upon by aquatic insects which then feed the carnivores in the system.

River bed sediments are colonized from two directions: (i) from surface organisms (e.g. insects) which penetrate downward into the sediments and need to return to the surface to complete their life cycles, and (ii) from groundwater organisms (e.g. crustaceans) who colonize near-surface bed sediments by migrating upwards from deeper groundwater attracted to near-surface habitats because of the higher food availability (Brunke & Gonser 1997, Ward et al. 1998). The production of sound by the river may provide the cue that these organisms use to migrate through the subterranean environment of the river (Tonolla et al 2011, Lorang and Tonolla 2014). Sediment dwelling invertebrates (stonefly larvae) do seek such refugia during flood events, and some migrate laterally over many kilometers to the river through the subterranean environment of the floodplain to emerge as adults and mate thereby completing their life-cycle (Stanford & Ward 1988). Almost nothing is known about the cues these organisms perceive to induce such behavior. The underwater sound produced by the river provides a river soundscape that such organisms can use as a cue to guide these types of life cycle behavior patterns (Tonolla et al 2011, Lorang and Tonolla 2014).

Figure 1. Scientists Chris Gotschalk, Diego Tonolla, and Mark Lorang calibrate an Acoustic Doppler Profiler, before a series of floats, down the Middle Fork Flathead River. Photo by Charles Nichols.

Music

To translate this limnological research into how animals, specifically stoneflies, navigate the floodplains throughout their life-cycle by the sound of rivers, three kinds of music were composed, to accompany narrated poetry, danced choreography, processed video, and animation.

Appearing first in the piece, to illuminate the onomatopoeia of river sounds and movements in the narrated poetry, source recordings of the poet reciting his text were processed, creating an echoing chorus of text-painting accompaniment. Using the Sinusoidal Partial Editing Analysis and Resynthesis (SPEAR) software programmed by Michael Klingbeil (Klingbeil 2009), recordings of words were stripped of their harmonic partials, stretched in time, and shifted in pitch, so that similar soundfiles could be differentiated, when spatialized in parallel around the audience. These processed soundfiles were then granularized, using the Grani instrument programmed by Fernando Lopez-Lezcano, for the Common Lisp Music programming language written by William Schottstaedt, in the Grace application developed by Rick Taube. The result was a chorus of insectoid voices, mirroring the stonefly subject of the poem.

To set the piece in the floodplain, three harmonic background textures, based on spectral analysis of environmental sound at the field station, entered progressively in the second section. The data, recorded every second in 1/3 octave bands between 12.5 Hz and 20 kHz, were mapped to bandpass filterbanks processing three audio recordings taken above water. This mapping of environmental analysis data to audio bandpass filterbanks was first interactively workshopped in Max software, and later programmed in Csound, to generate soundfiles for the piece. To heighten musical interest, the period between amplitude data samples was compressed to a tenth of a second and linearly faded between points, the 1/3 octave bands were uniformly swept in frequency to create glissandi between pitches, and envelopes were applied to the filtered soundfiles.

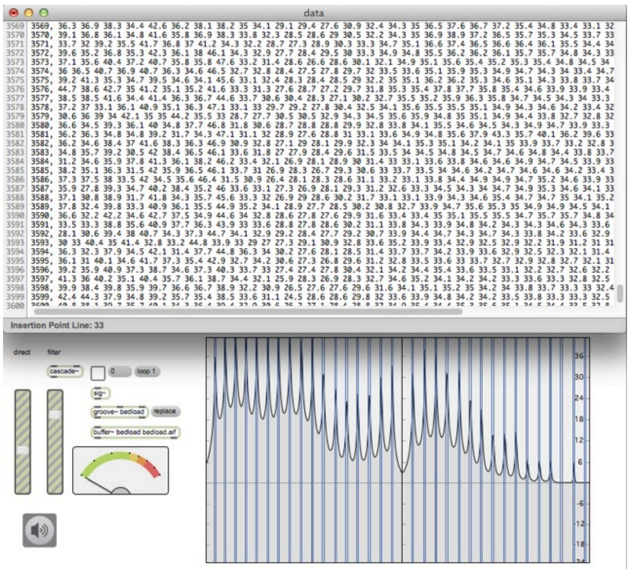

Figure 2. Sonification of environmental data: periodic spectral analysis of ambient noise on the river drives an undulating bandpass filterbank, processing an underwater recording.

Further into the second section, over the harmonic wash produced by the filtered above-water recordings, a bowed-string physical model played a simple melody, driven by sampled data of river velocity and depth, and wind velocity from the North and East, mapped to bow speed, pitch, bow pressure and position synthesis parameters. The synthesized bowed string was processed, in GuitarRig effects software, with five phasers set to different rates, between 0.01 to 0.05 Hz, for overlapping slow sweeps across the spectrum, three reverse delays, two transposed to an octave down and an octave up, and a large room reverb. The resulting effects placed the synthesized bowed string in a watery sonic environment.

In the third section, the live electric violin played phrases based on rhythmic motives and melodic fragments from Jazz standards and Pop tunes of artists mentioned in the poem. First, the violin played the opening riff from Duke Ellington's "Take the A Train", stretched out in slow pizzicato. Next, the violin explored the pitch collection of Dave Brubeck's "Koto Song", in bowed descending lines, that were echoed by the falling motive of Frankie Valli's "Silence Is Golden", further elaborated upon with piercing false harmonics. All of these melodic fragments were played through the same effects that processed the synthesized bowed string, with an additional quadraphonic delay, pinging throughout the hall, spreading the electric violin around the audience.

After each texture was presented separately in the first three sections, they were incrementally combined in the second half of the piece. In a brighter version of the bandpass filterbank texture, three underwater audio recordings of gravel bedload traveling down the river, recorded from the raft, were processed with two separate data-driven filterbanks. In this case, the filterbank parameters were manipulated with data recorded with hydrophones every 5 seconds in octave and 1/3 octave bands, during floats down the Middle Fork Flathead River. Like before, the period between amplitude samples was compressed, this time to .4, .6, and 1 second, and faded between points. Envelopes again were applied to pitch and amplitude, but this time also shaped the bandwidth of the filterbanks.

While the six harmonic background textures built into a full watery soundscape, two bowed-string physical models, driven by river velocity and depth, and wind velocity from two directions, synthesized overlapping melodies with staggered entrances. Again, these synthesized bowed-strings were processed with layers of phaser and delay effects. Over the filtered background and bowed-string lines, pairs of processed recorded text reflected the spoken poem, echoing the narrator in parallel trajectories around the audience.

Finally, in response to the narrator mentioning Lionel Hampton and Charles Mingus, the electric violin entered with dotted-rhythm riffs from "Flying Home" and "Moanin'", adding one and two octave doublings below in the effects, mimicking the Jazz bass. As the poem wound down, and the other parts faded, the electric violin slowed the rhythm, changing again to false harmonics, while the computer effects thinned.

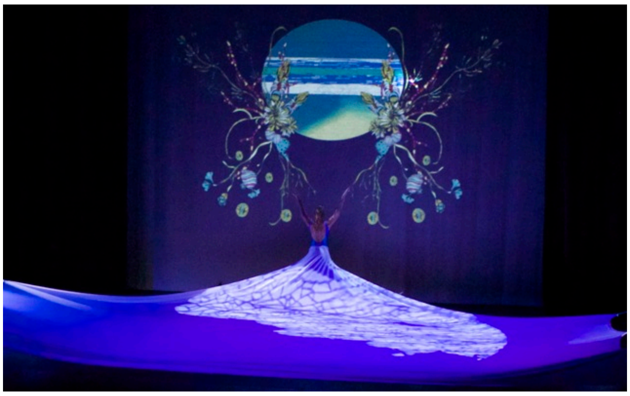

Figure 3. A panel of processed live video, manipulated by the amplitude of the music, projected behind dancer Allison Herther. Photo by Amelia Hufsmith.

The processed recorded text, data-driven bandpass-filtered soundfiles, and bowed-string synthesis were played from audio workstation software, with the electric violin performing through an input track processed with plugins. While the output of the multitracking software was spatialized through the surround-sound system around the audience, it also manipulated parameters of the video software, processing a live feed of the dancer projected on the back of the stage. As the amplitude of the computer-music fluctuated, it agitated striations and shading inside a panel of processed live video, surrounded by animations of river plants and animals.

Conclusion

Sound of Rivers: Stone Drum was performed live, during a week of shows at the College of Visual and Performing Arts at the University of Montana, on the Dance in Concert series. A wide shot of the live performance can be viewed at https://www.youtube.com/watch?v=3IEqF6kKyUo, and a stereo video of the quadraphonic fixed media piece can be seen at https://www.youtube.com/watch?v=9Rtm6EA29Bw.

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References

Brunke, M. / Gonser, T. (1997). The ecological significance of exchange processes between rivers and groundwater. Freshwater Biology, 37: 1–33.

Cronin C., / McCutchan Jr., J. H. / Pitlick, J. / Lewis Jr., W. M. (2007). Use of Shields stress to reconstruct and forecast changes in river metabolism. Freshwater Biology, 52: 1587–1601.

Lorang, M.S. / Tonolla, D. (2014). Combining active and passive hydroacoustic techniques during flood events for rapid spatial mapping of bedload transport patterns in gravel-bed rivers. Frontiers in real time ecohydrology, Fundamental and Applied Limnology, 184/3: 231–246.

Klingbeil, M. (2009). Spectral Analysis, Editing, and Resynthesis: Methods and Applications. Columbia University.

Nichols, C. / Lorang, M. / Gibbons, M. / Browning, N. B. / Bushnell, A (2014). Sound of Rivers: Stone Drum: a Multimedia Collaboration, with Sonified Data, Computer-Processed Narration, and Electric Violin. Proceedings of the International Computer Music Conference, 420-424.

Stanford, J. A. / Ward, J. V. (1988). The hyporheic habitat of river ecosystems. Nature, 335: 64–66.

Stanford, J. S. / Lorang, M. S. / Hauer, F. R. (2005). The shifting habitat mosaic of river ecosystems. Verhandlungen des Internationalen Verein Limnologie, 29:123–136.

Tonolla, D. / Lorang, M. S., / Heutschi, K. / Gotschalk, C. C. / Tockner, K. (2011). Characterization of spatial heterogeneity in underwater soundscapes at the river segment scale. Limnology and Oceanography, 56:2319–2333.

Ward, J. V. / Bretschko, G. / Brunke, M. / Danielopol, D. / Gibert, J. / Gonser, T. / Hildrew, A. G. (1998). The boundaries of river systems: the metazoan perspective. Freshwater Biology, 40: 531–569.

Figure 4. Electric violinist Charles Nichols, dancer Allison Herther, and video artist Amber Bushnell rehearse *Sound of Rivers: Stone Drum*. Photo by Amelia Hufsmith.