Listening Underwater

by Lisa Walker

Within the earth's environments of air and water we have two radically different media for the propagation of sound. Entering the underwater environment we find ourselves in a three-dimensional space where the need to breathe becomes regulated and the buoyancy of water acts against the pull of gravity. The creatures that live in the water have responded to these pressures, developing an array of perceptual and physiological adaptations. This brings us into a world that both mirrors our understanding of sound and challenges us to investigate new definitions and relationships.

I was introduced to this underwater world in 1996 when I was invited to join a research team in southeast Alaska studying the acoustic ecology of the Humpback Whale. It was thought that with my background as a classically trained musician, I might be able to identify subtle patterns in the acoustic activity of the whales that were not readably evident to the scientist.

Classified as Cetaceans—or marine mammals—Humpbacks are warm-blooded, give birth to live young ones, use lungs to breathe air, retain similar sensory organs to ours—eyes, ears, nose (blowhole)—and are thought to be descendants of land mammals similar to present day cows.

Humpbacks have two main types of vocalizations, the first of which is the Winter Song—a resonating chorus of deep groans, staccato bursts and high whistles that fills the waters of the Humpbacks' tropical breeding grounds with constant sound. Sung exclusively by the males, the Winter Song is thought to either attract females by the qualities of a particular singer's sound or to warn off competing males. Each year small changes are introduced in the song's 25-minute composition, which are then incorporated into the following year's refrain.

When the humpback's winter vocalizations were first discovered by researchers, Drs. Katy and Roger Payne, they noted a strong semblance between the phrases, rhythms and patterns within the underwater vocalizations and those found in poetry. While many theories abound about the song's purpose, scientists such as Jim Darling are investigating how the execution of the song's components, such as rhythmic accuracy, control over pitch, or the capacity to memorize patterns of great length, may act as a type of 'sonic antlers'—displaying information about the singer's fitness, or desirability, as a mate.

Figure 1 (see page 36) is a sonogram of a small portion of the winter song, recorded in Hawaii in 1999. It shows the rhythmic and patterned nature of the song with the two vertical bars being the 'beats' or low frequency groans and the two horizontal bands the higher frequency 'hoots'.

The second type of vocalization is less well known and is classified as a "call" rather than a "song". The Feeding Call is characteristically short, swooping up and down in elegant phrases with trumpet-like timbre. Lasting anywhere from one to three minutes, these calls are a rare event and are heard only in the feeding grounds of southeast Alaska when the Humpbacks engage in a behaviour known as lunge feeding: it consists of a group of Humpbacks acting in cooperation to encircle a group of herring in an underwater bubble net. The whales then blast the prey with sound before lunging upwards through the herring ball to the surface, mouths wide open to swallow as much prey as possible.

Photos: Lisa Walker

Feeding calls are always variations on a theme. Octaves change and parts rearrange, yet particular elements lend them a consistency—or as scientists would call it—a signature or voiceprint. Certain whales have been creatively named for the quality of their calls: *Screamer* for his acoustic aerobatics, *Melancholy* for her mournful pleas and *Trumpeter* for his trumpet-like honks.

While the initial reasons for the recordings were scientific, I soon became intrigued by another course of exploration. I found that through careful examination of the calls, subtle qualities began to emerge in the vocalizations—qualities such as overtones, cadences and rhythmic cycles that lent themselves more to terms of music and composition than pure scientific vocabulary.

My goal then became twofold: to learn more about Humpback's system of acoustics from a purely observational point of view, listening and analyzing the sounds much like a scientist would do while at the same time playing with the inherent rhythms and phrases within the sounds to create building blocks of musical compositions.

Explorations

While the tasks of composition and analysis seemed at first divergent methods of exploration, the questions they raised in contrast to one another lead me further down the road of exploration into the purpose and fit of these vocalizations with the underwater environment.

In the brief 50 or so years that cetacean acoustic research has been conducted an amazing variety of vocal behaviour has been revealed. Scientific discoveries in the fields of behavioural ecology, bioacoustics and cognitive ethology are furthering the understanding of how specific information encoded in acoustic communication plays a role in maintaining social cohesion, coordinating group foraging techniques and selection of potential mates. For someone like myself these discoveries are a wealth of inspiration, giving me the chance to inquire about the internal world of the whales, how they structure their societies and form relationships.

More importantly, scientific methodology has provided me with a means to design experiments, test hypotheses and overcome the limitations and ingrained interpretations my own biases bring to the research. During the process of analysis I was always aware of the fact that by no means was I the 'objective' observer—that between the passage of sound from the whale through the water, through my equipment to my ears, I was an inextricable part of the listening relationship

By placing my own perceptual organization in context of evolution and environment, I began to see the extent to which we are defined by our relationship to sound: how language is considered to be the pinnacle of our acoustic achievement as a species and is often the criterion against which other animals' intelligence or acoustic ability is measured; how our complex social behaviour and rise to the top of the food chain is wrapped up in our relationship to sound; and how an alternative evolutionary pathway and an alternate relationship to sound has given rise to the cetaceans at the top of the underwater food chain.

As my definition of acoustic ecology began to deepen, so did the extent of my exploration. Cetacean vocalizations are not exclusively for communicative purposes and in many instances act as an 'eye' in aid of navigation and orientation. Toothed whales, such as Orca (Killer Whale), dolphins and belugas emit a high-frequency click known as echolocation which brings back precise information of distance, texture, composition of the underwater world and provides the whales with a "view" of their surroundings. The more I inquired as to how my ear acted in conjunction with my other senses the more I began to understand how alternate sensory organizations could render sight and sound as interchangeable rather than separate means of gathering information.

I also became curious as to the inherent qualities of water and how different depths and distances affected the transmission of sound. I began experimenting with an underwater speaker system deployed in various locations to measure how different conditions and underwater geographies affected sound, whether attenuating certain frequencies or causing others to rapidly dissipate and disappear.

With this additional knowledge in hand, my musical explorations began to take on value as an analytical tool, revealing qualities of vocal behaviour that were not evident through the more traditional means of scientific analysis, and allowing for further discovery of a world that reflected a non-linguistic understanding of sound.

Comparative Ecologies

While my research techniques run from scientific to experimental and have covered many areas pertinent to cetacean acoustics, a common thread has re-occurred throughout all aspects of my explorations: each vocalization found in this environment has evolved to serve a purpose and has done so by developing its own inherent properties and patterns. The cetacean ear listening to these vocalizations is designed to receive these sounds and interpret the contained information. It is attentive to these tasks.

In gathering information from our external environment, the human ear is designed to do much the same. However in our current state of evolution, we seem to be relying less on the ear and more on the eye to monitor our surroundings. While this shift

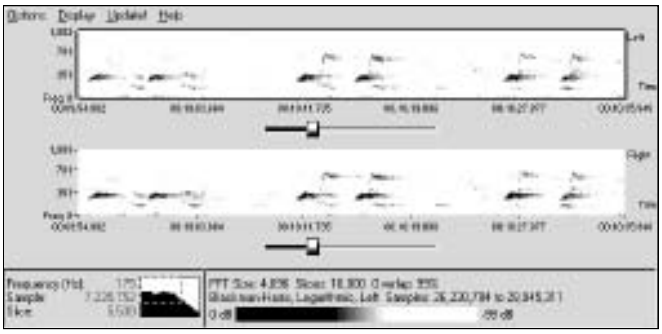

Figure 1: A sonogram of a small portion of the winter song.

could be seen as a consequence of natural adaptation, whereby over the centuries we have outgrown our need to hear, I believe it is more likely a response to the pressures of our immediate environment, to levels and frequency of sound not present in our evolutionary development. Within this perspective, increasing reliance on the visual sense can be seen as an appropriate and even beneficial response to unfavourable auditory conditions.

While our particular sensory organization permits us to adapt or even thrive in our acoustically aberrant world, we are making it increasingly impossible for other species to compete for acoustic space. This is all the more apparent in the liquid environment of the ocean where we too have learnt to use sound to collect information about the underwater environment. The development of long-distance monitoring devices (Sonobouys), assessing evidence of global warming (ATOC) and protecting and defending territory (Low Frequency Active Sonar), all use high-decibel sound propagation to collect information from the ocean's surroundings and threaten the natural acoustics of this environment.

Underwater nuclear explosions, mining explorations, shore based and non-acoustic human activity also create inhospitable underwater acoustic environments. Poisons flushed down the household drain, ramifications of forestry practices, fish farms and other industrial activity degrade the underwater environment, deplete it of its natural resources and have reduced the cetacean population and the ocean's acoustic vibrancy to a small fraction of its historical level. To lose such a system of acoustic beauty and complexity as we find in the underwater environment would be a tragedy and we are in great jeopardy of doing exactly that.

Further understanding of cetacean acoustic behaviour and ecology is needed to make the case for the damage these infringements cause on cetacean populations. We need to establish that the ability to listen to their environment is critical to their survival, that their survival depends upon our conscious monitoring of their environment and our careful attention to sonic detail. By combining our sum knowledge of sound and ecology, whether from the perspective of scientists or composer, sound designer, philosopher, artist, activist or engineer, we can further the understanding of this liquid environment, draw attention to the needs of the ocean's inhabitants and help preserve the ocean as an acoustically viable environment.

Lisa Walker's interest in nature, sound and technology, combined with her classical violin background, has given her a unique blend of skills with which to explore nature's acoustic nuances. Born in Vancouver, Canada and trained at the Vancouver Academy of Music, her musical influences include a wide range of styles and traditions to which she adds a small dose of scientific perspective. Her album, Grooved Whale, is based on her explorations of humpback vocalizations and took home 2001 NAV awards Ambient Album of the year. She currently is involved in a research project studying the vocal learning behavior of belugas and is working on her third album. www.groovedwhale.com