



Universiteit
Leiden
The Netherlands

Scorescapes : on sound, environment and sonic consciousness

Harris, Y.

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5. Whale: An Investigation of Underwater Sound

5.1 Fishing for Sound

Submerging into a sea of sound, it surrounds, immerses my hearing and my being. Underwater I am out of my element, in a medium in which I cannot survive without technical aids and only for limited periods of time. What does it mean to relate to such an environment through sound?

If I dream about underwater sound, and what it means to me, I have an atmosphere of density yet floating, blue light yet darkness, great distance and reverberation yet closeness. I am fluctuating in a sea of sound, full of background noise. I try to identify by listening, I listen to myself suspended, floating in liquid. The sound is like the liquid. And I can pull sounds out, fish for them.

Santiago, the Cuban fisherman in Hemingway's *The Old Man and the Sea* (1952), knows his surface environment, the boat and weather. He knows the underwater environment beneath his boat by the signs he reads from the surface - birds, currents, weed, shoals of fish, the other fishing boats. As the story develops he extends his senses underwater by literally feeling the behaviour of the giant marlin, through the touch of his fishing lines on his hands, his fingertips, and later, his back as it tows him through the sea for three days and nights.

I can catch my sounds from the surface, I can know something of what is down there, through my technology I can listen and by learning sounds and signs from the surface I can understand another medium. I breathe air, I can only visit underwater, I cannot inhabit it. Or can I? How can I begin to understand what it is like, its complexity, and how my activity effects it, if I cannot spend time there? The first time I lower a hydrophone beneath the surface, a probe into water, what do I hear? What other information do I need to collect to understand the underwater environment? I have to listen, and use sound to understand.

5.2 Underwater Sound

Underwater sound intensifies the relationship between human dependency on technological mediation and biological life. Our relationship with the underwater environment is fundamentally defined by how alien it is, an uninhabitable medium, which we can access

through active imagination and immersion. In the underwater environment our physiological human limitations are challenged and our only knowledge of these environments and their sounds must be mediated by technological extensions. The implications for sound research and roles of the composer are considerably more radical and expansive than those of land-based soundscapes where we can have direct access and experience. Exploring this area requires investigating the history, science, technologies and myths of underwater sound.

Except for sailor's tales of sounding deep-sea monsters, the underwater environment generally has been considered a silent place. Our notion of sound and the sea is always related to our technological means to hear it, initially through the slight amplifying qualities of the submerged part of the hull of a boat, more recently through hydrophones. The strange assumption that the sea is silent comes from the limitations of human hearing, combined with an anthropocentric attitude, exacerbated by the alien nature of the underwater medium. The vastness, complexity and fractional knowledge we have of ocean ecologies suggests that we need to change this attitude to find sustainable solutions. The relationship between biological sound and anthropogenic technological sound is not just a theoretical distinction. It is central to our understanding and hearing underwater, and so is built into the history of human relationships with underwater environments.

In the years following World War II, developments in sonar and submarine warfare catalyzed research into underwater sound and a highly specialized form of listening, an enormously expensive and technologically challenging area of development (Payne and McVay, 1971; Stocker, 2002; Helmreich, 2007). During the Cold War human listeners were stationed to monitor the potential sounds of enemy submarines and human activity, trained to effectively shut their ears to other sounds. Reports of strange sounds possibly linked to passing whales and dolphins were reported as they were hard to ignore. Frank Watlington, who worked for the US government listening for Russian submarines, collected recordings of what he believed were humpback whales, from hydrophones deep in the North Atlantic off the coast of Bermuda between 1953 and 1964. These recordings were most probably used by one of the first whale sound researchers, William Schevill, in the 1960s. But it was not until the structure of Watlington's recordings were analysed and interpreted as 'songs' in the seminal paper (Payne and McVay, 1971) and recordings (1970) by Payne and McVay, entitled "Songs of Humpback Whales", that underwater soundworlds entered the public consciousness. The public release of these humpback whale 'songs' almost immediately influenced both mainstream popular music and experimental music, and helped fuel the 1970s and 80s environmental movement (Rothenberg, 2008; 15).

Discourses pertaining to underwater sound have emerged at a complex intersection of scientific research, art and music, military and industrial development, and environmental activism. These discourses are a surprisingly recent phenomenon. In the scientific research and international policy fields, the First International Conference on the Effects of Noise on Aquatic Life, took place in 2007 hosting 250 scientists, regulators and industry representatives to discuss and mitigate the problems generated by the increasing sound levels in the oceans. The second conference has only just taken place in August 2010 after a century of dramatic increase in anthropogenic sound in underwater environments (Aquatic Noise 2010). In June 2010, a scientific article by Dutch scientist Hans Slabbekoorn from Leiden University made international headlines because it drew connections between rising underwater sound levels and declining fish-stocks, with the implication of continuing financial losses for industrial fishing (Slabbekoorn, 2010). Supported by International Marine Mammal Project of the Earth Island Institute, the recent award winning documentary film *The Cove* by Ric O'Barry (Oceanic Preservation Society, 2010) shows current attempts by activists to stop dolphin slaughter by Japanese fishermen and reveals how these fishermen use sound to drive the dolphins to the shore. These examples demonstrate both how new and how urgent this area of research is, and the overwhelming necessity for sustainable approaches to human impact on underwater ecologies. It appears that sound has never been so crucial and played such a dominant role in environmental issues as in underwater environments.

Further research into underwater sound continues to develop in tandem with the technological means to collect, listen and analyze complex and previously unheard sound. Ironically, the rise in anthropogenic noise in the oceans - from shipping, naval experiments and industrial oil and mining projects - has developed hand-in-hand with the ability to listen for and monitor the biological sounds of the sea. However, financial, political and industrial interests in keeping these technological developments secret, hindered civilian knowledge about this enormously complex world of sound. For example, the U.S. Navy SOSUS (Sound Surveillance System), which was the first underwater listening array of hydrophones initially deployed in 1954-5, was only made publicly available after 1992.

In addition to being able to hear, locate and track individual whales by way of their vocalizations, for the first time scientists also heard the density of anthropogenic sounds that cluttered the marine soundscape (Stocker, 2002: 24).

This unbalanced relationship between the access to high-end technological development and the ability to listen and learn about underwater sound has been sustained by the incompatible agendas of industry, science and environmentalists. The necessity of a more

cohesive, open and collaborative approach is beginning to be addressed by groups such as ESONET (European Seas Observatory Network) which “aims to promote the implementation and the management of a network of long-term multidisciplinary ocean observatories in deep waters around Europe”(ESONET, 2010). The data from these deep ocean observatories is being made available to bio-acoustic scientists and other interested groups. The project LIDO (Listening to the Deep Ocean Environment), uses the ESONET network for live internet streaming of underwater sound and data from these ocean stations in the Mediterranean and North Atlantic. The aim is to give the wider scientific community live access to sound sources and analytical tools to assess levels of anthropogenic and biological sound over long-term periods (LIDO, 2010).

These projects recognise the expansiveness and multidisciplinary nature of ideas provoked by the contemplation and study of underwater sound. Likewise, in his paper ‘An Anthropologist Underwater: Immersive Soundscapes, Submarine Cyborgs, and Transductive Ethnography’, anthropologist Stefan Helmreich draws on a wide range of trans-disciplinary notions discussed in new media theory, sound theory, anthropology, systems theory and cybernetics, and the history of technology (Helmreich, 2007). In studying the scientists use of sound in a specialized three-person submarine named Alvin, used for mapping deep sea-floor surfaces, he questions the relationship of immersion to the sonorous qualities of underwater life, and the possibilities of human inhabitation of and interaction with aqueous environments through technological and sonic aids. The implications of the study and experience of underwater sound are raised by Helmreich’s questions:

As we drop down to the ocean floor, amidst a wash of submarine sounds, some questions surface: How did the domain that Jacques Cousteau (with Dumas, 1953) once named “the silent world” become so sonorous? How did the underwater realm, this zone to which humans cannot have extended, unmediated access (without drowning, that is), become imaginable and accessible as a space of sound? What kinds of technical work have been necessary to bring this field into audibility for human ears? And what have been the cultural effects – for people in submarines, for example – of such work? Learning the answers requires dipping into some submarine history, tuning into the technical specifics of underwater listening, considering cybernetic networks of communication and control, and querying the multiple modes through which people imagine immersion: as a descent into liquid, as an absorption of mind and body in some activity or interest (such as music), and – in a meaning of relevance

for anthropologists – as the all-encompassing entry of a person into an unfamiliar cultural milieu. (Helmreich, 2007: 623)

The study of underwater sound demands such a trans-disciplinary research approach where scientists, artists and environmentalists work across their disciplinary boundaries. This may indeed mean facing up to the uncomfortable and challenging difficulties of entering into “an unfamiliar cultural milieu”. This Scorescapes research project is an attempt to gather together some of the most significant contributions to underwater sound research across different disciplines from science to musical composition, with the aim of finding new approaches to contribute to a more sustainable relationship to the environment through sound.

5.3 Understanding Biological Ecosystems Through Underwater Sound

The assumption that underwater is silent has been turned on its head in the last decades as scientists begin to understand just how crucial sound is to aquatic life, in a largely dark environment where it is used to detect motion, currents and prey, and to communicate. It continues to be an extremely difficult area to study, as the sound source can often be undetectable. Moreover, little is known about how sounds are produced or used and what they might mean. In *The Soundscape* Schafer devotes only two pages to “the sounds of water creatures”. He writes, “many fish have no sound producing mechanisms and no developed organs to hear sounds” citing the few exceptions to this as if characters from an alien world, making sounds by “grinding or snapping their teeth ... expelling gas or by vibrating the gas bladder ... gulping air bubbles and expelling them forcibly through their anus.” (Schafer, 1977: 37). It is striking how limited knowledge on underwater sound was at that time, even by specialists in environmental sound like Schafer. Interestingly, Schafer mentions the humpback whale song, although he does not include a specific reference to the scientific source despite reproducing the recognisable analysis and visualisation by Payne and McVay (Schafer, 1977: 38). The lack of reference to scientific journal publications in Schafer’s writing suggests a different relationship between the arts, sciences and music research in the 1970s than in 2010, where scientific research was not as easily accessible to non-specialists.

Although research has developed dramatically since Schafer was writing, underwater sound is an endlessly extensive area about which we still know relatively little. In 2002, the International Marine Mammal Project of the Earth Island Institute commissioned a comprehensive report on the state of known knowledge of biological underwater sound by

bio-acoustician Michael Stocker. This was republished by *The Soundscape Journal of Acoustic Ecology* with the full title “Ocean Bio-Acoustics and Noise Pollution: Fish, Mollusks and other Sea Animals’ Use of Sound, and the Impact of Anthropogenic Noise in the Marine Acoustic Environment” (Stocker, 2002). The report examines research since 1950, giving an extremely informative overview of the issues of underwater sound, including the characteristics of sound propagation in water, different species’ use, production and sensing capabilities of sound, and the quality and effect of human made sounds in the ocean. However, even with this knowledge Stocker states, “while considerable efforts are being made to understand the auditory perception of sea animals, our understanding is miniscule compared to the vast diversity of sea animals and their adaptations to sound” (Stocker, 2002: 18).

Following are some of the key points raised by Stocker that demonstrate the breadth of the topic and the alien nature of the environment to humans. Because of the density of water, sound travels five times faster in water than in air. Because light levels are very low, sound is the primary sensory faculty for biological life. Many species of fish, crustaceans and mollusks can sense both wave motion and particle motion at such sensitive levels as to detect currents, tides and approaching prey. Sound can travel vast distances underwater, reflected through layers of the ocean, a feature used by whales for communication and perhaps by other species for navigation. Cetaceans and other marine mammals use highly developed echolocation to navigate and hunt, and some species like the snapping shrimp stun their prey by sound. Abiotic sounds (natural – sea, storm), biotic sounds (animal), and anthropogenic sounds (motors, seismic explosions, sonar testing) form the three most basic categories of bioacoustics. Underwater sound is in no way bound by human sense perception, extending well into larger and smaller scales, frequencies, time-frames, spatial dispersion and volumes.

Given the field’s infancy, it is not yet known how the proliferation of anthropogenic sound may affect long term development of marine organisms and the larger ecology. Underwater bio-acoustic scientist Michel André clearly identifies the problem and suggests that research on cetaceans offers a particularly fruitful line of inquiry into the sustainability of marine ecosystems.

Ocean noise has always existed, both in natural and biological forms. Without any doubt, due to its recent and uncontrolled character, the massive introduction of artificial sound sources at a large scale has become a threat to it’s balance, *more importantly than any other pollution found in the marine environment*. Cetaceans, as top predators of the food chain, have evolved for millions of years on their acoustic

perception of the environment and can be considered as bio-indicators of the acoustic balance in the oceans. Understanding how marine mammals perceive their environment and unraveling their communication methods means investigating for the conservation of the marine ecosystems and the development of sustainable human activities in the sea (André, 2010, *my italics*).

These ideas on sound in the ocean suggest that its impact is potentially of greater threat to marine ecologies than toxic waste, oil spills and other forms of pollution.

5.4 Sonic Evidence and the Composer

Every underwater sound raises questions. Sound is, in turn, listened to in order to find answers. In the case of the whale and other cetaceans, sound is the primary way into researching the animals' lives, behaviours, communications, intelligence and interactions within ocean ecologies. The sound contains clues and can be used to prove or disprove hypotheses. In this sense sound is a witness, or 'evidence' to be unravelled within its larger context of underwater environments and ecologies. These are sounds that are entirely embedded in their context, a context in which humans are alien and have difficulty accessing and assessing. In order to make sense of sound in this environment researchers must piece together its function from highly mediated sonic evidence, by correlating the qualities of the sounds themselves with behavioural patterns and contextual knowledge of their environment.

The role of sound within this context is far from what is generally considered as the role of sound within musical practice. However, to incorporate such ideas into one's musical practice may lead to fruitful lines of inquiry. Understanding scientific approaches to underwater sound can offer composers alternative perspectives on the role of music in human terms. It may be possible to go beyond the techniques and common presentation strategies of artistic field recording to include and further develop concepts and techniques specific to underwater sound. And by developing a deeper understanding of scientific techniques, composers will be able to contribute more effectively to research into underwater sound.

5.5 The Whale as a Stage

Research on underwater sound is intimately bound up with the story of the whale. These underwater mammals are known to use sound in a very sophisticated manner. Humans have only recently been able to hear whale sounds and still have very limited understanding of them. The whale's popular appeal, our "natural human empathy for these intelligent, air-breathing creatures", contributes to increased financial support for research, often to the detriment of urgent research into other species (Stocker, 2002:16). Nonetheless the power of this animal in human imagination, the whale's function as "a touchstone for our common knowledge" (Stocker, 2002:18), leads us to further understanding of underwater environments and underwater sound. Interest in the whale goes far further than scientific research endeavours to find out about the specifics of the animal, its sounds, its context and social behaviours. The mythic resonance of the whale often overshadows its qualities as an animal species in its own right.

The whale is an imaginative springboard, a stage on which myths of environmental destruction have been played out. It has catalysed environmental movements and even suggested possibilities of interspecies communication (Lilly, 1962; Bateson, 1972). The whale seems to re-emerge at moments of intense environmental awareness, for example Herman Melville's *Moby Dick* (1851) coincides with Thoreau's *Walden* (1854). The release of *Songs of the Humpback Whale*, the first publicly available recordings of 'whale songs' in 1970, coincides with the founding of Greenpeace in 1971, the growing environmental movement of that era, as well as with the concurrent development of the soundscape studies by the Acoustic Ecology movement. Similarly, a number of recently published books on the whale, including David Rothenberg's *Thousand Mile Song* (2008) and Philip Hoare's *Leviathan, or The Whale* (2008), coincide with current debates about climate change, sustainability and the environment. The figure of the whale again provides a stage on which these debates and questions can be dramatised.

Cetaceans are underwater mammals that breath air. This connection between air and water, between whales and humans, is part of our imaginative fascination with cetaceans, almost like a mirror of ourselves, acting as a bridge between these media. The difficulty of studying these sea animals, as emphasised by Melville in *Moby Dick*, is that we can only have such limited contact with them. It is still barely understood not only why the whales make the variety of sounds that they do, but in many cases how they make them. One of the many extraordinary questions is that some whales make sounds of such intensity that it should theoretically deafen them. Cephalopods - octopus, squid, cuttle-fish, the Kraken or Giant

Squid (the 'Bloop'?) - are even more obscure to humans and yet equally mythical. However, largely due to the bias towards investigations on cetaceans, most scientific research on these animals has focused on their function as food for whales. Recent research however suggests that the cephalopods are enormously sensitive to sound and experience what is scientifically termed 'acoustic trauma' - permanent physical damage to the hearing organ - at very low decibel levels (André, 2011). This would suggest that exposure to repetitive, loud anthropogenic sound is, or will, have drastic consequences for populations of cephalopods that cannot move away from the sound source as cetaceans can. The impact of such an imbalance on the underwater ecology is potentially catastrophic.

Human interaction with the whale crosses art, science and activism. The status of whales as pop icons ironically makes cetaceans a difficult topic to research, largely because of dismissive preconceptions that associate them with a redundant romantic notion of environment, one that favours the 'charismatic' animals, or the star of the film *Flipper* (1963). A plethora of whale projects founded this on romanticism and often incorrect scientific information do a disservice to this important area of study. Alongside artistic approaches, run scientific research endeavours into communication through sound in underwater environments. But even these researches seem to generate myths of their own, for example the films made around the character of dolphin researcher John Lilly and his scientific experiments in interspecies communication (Lilly, 1962). Calling on Bateson's notion of double description, he added, "The richest knowledge of the tree includes both myth and botany" (Mary Catherine Bateson on her father Gregory Bateson) (Bateson and Bateson, 1987). The various interpretations of the figure of the whale - in science, as song and music, as spatial composition, and as encompassing long distance and interspecies communication - gain richness by the interaction between the whale as a stage for myth and as a subject of scientific research.

Scientists calling on the help of music to analyse whale sounds is rare and controversial but also illuminating. They raise critical questions about 'music in nature', 'beauty', and the function of music as a communicative or even evolutionary force. Dunn's opinion that, "Music is one of the most profound means we have for growing the capacity to perceive the world through sound" (Miller, 2007: 14) highlights the tensions between our definitions and understandings of the role of music and its relationship to sound in the environment.

The following discussion addresses three seminal works on whale sounds - two by scientific teams and one by a composer - that have not previously been considered in relation to each other. Particular attention is paid to their different approaches to sonic context. I compare

Payne and McVay's analysis of humpback whale sounds as 'songs', with marine scientists André and Kamminga's work on decoding the click trains of a sperm whale pod using rhythmic analysis, and composer Alvin Lucier's interpretation of sending sounds over extremely long distances in *Quasimodo the Great Lover*. The first deals with notions of song and melodic pattern structure revealed through visualisation techniques, the second about rhythmic ideas of spaces between clicks as percussive sound in environment, and the third about processes of transmission through sonic environments emphasizing context.

5.6 Humpback Whale Songs

The seminal paper 'Songs of Humpback Whales' with accompanying recordings by Payne and McVay, remains one of the most clear and accessible reports on whale sound and is worth examining in more detail. The research is significant for a number of reasons: firstly, they were the first publicly available recordings of whale sound; secondly, they use a primitive visualisation technique to discover and analyse the sound patterns; and thirdly, the authors use simple musical analysis to describe these sounds in terms of songs, themes, phrases and units. As previously mentioned, they describe a series of recordings of humpback whales over a number of years from the coast of Bermuda. They report "It is from these studies of the herd sojourning these waters that we have become aware of the humpbacks' most extraordinary feature – they emit a series of surprisingly beautiful sounds, a phenomenon that has not been reported previously in more than a passing way." (Payne and McVay, 1971: 585).

Drawing on aesthetic musical notions, these "surprisingly beautiful sounds" are described as "the humpbacks' sonic repertoire". Payne and McVay justify their use of the term 'song' by referring to a report by Broughton (1963) on classification of animal sounds where he defines song as "a series of notes, generally of more than one type, uttered in succession and so related as to form a recognisable sequence or pattern in time." (Payne and McVay, 1971: 590). Rothenberg in *Thousand Mile Song* opines "too many whale scientists consider beauty to be too subjective to trust that term to describe the sounds they spend years studying ... it's a shame they forget that nature offers up beautiful music as well" (Rothenberg, 2008: 133-5). But how helpful or misleading is this discussion of whale sound in relation to human music? To judge an idea of musical beauty in natural sounds, when ideas of beauty are contentious even in human music encourages an interpretation of whale song as some kind of animal form of music making, overruling important questions about communication. Such

an attitude suggests a largely anthropogenic approach towards the topic, a circular logic that reflects back on our own notion of what music is.

Extraordinary differences in the relative hearing capabilities between whale and human result in an inevitable compromise in the analysis of these sounds, as with most animal sounds, a fact that emphasizes the importance of making the inaudible audible or visual (Harris, 2010). The association of whale sound with human music forms the basis of Payne and McVay's analysis, even though the whales emit frequencies beyond our hearing range and outside of our temporal perceptions with durations either too long or too short. Recognition of this fact is noted in the paper's subtitle "Humpbacks emit sound in long, predictable patterns ranging over frequencies audible to humans", and later reference to analysis of the 'unit' as "the shortest sound that is continuous to our ears when heard in 'real time'", as different from the 'subunit' that must be "listened to at slower speeds, or analyzed by machine". Further, "An interesting sound that is sometimes superimposed on the grunts may represent the audible component of a train of ultrasonic pulses, but this possibility must await recordings on equipment sensitive to ultrasound" (Payne and McVay, 1971: 594). On first listening to these humpback whale sounds one has "the impression of an almost endless variety of sounds" because the temporal length is beyond what we can easily hold in our minds (Payne and McVay, 1971: 594).

As a result of this limit to human sonic abilities, another approach had to be taken. It is significant that Payne and McVay's discovery of song structure came from the visualisation by the spectrographic analysis of the recordings. The "exceedingly tedious process" involved extracting 9.6-second segments of tape-recorded sound and analyzing them on a spectrograph, to graphically represent the frequency, amplitude and time in a visual image. These printed segments were carefully matched, glued together and reduced in size to make them manageable to see altogether as an overview. These spectrograms were then traced onto new sheets of paper by hand, to clarify the whale sounds from the background ocean noise and echoes. This level of interpretation of the images of the sounds removed the parameter of amplitude, leaving diagrams representing frequency (pitch) over time (Payne and McVay, 1971: 592). This choice of what information to remove from the spectrograms resulted in an interpretation of the whale song that conforms to the basic parameters of Western musical notation. To depict something sonic in a visual form that is conventional for music, and then "discover" music in it, appears to be a tautology.

Payne and McVay's spectrogram notations of whale recordings seem to implicitly suggest a reading mode like a graphic musical score, where the repeating patterns become visible,

analysable and comparable to other notations. The first form of graphic analysis presented is the entire song in both spectrogram and graphic tracing. From this they deduced a hierarchical scheme of temporal structure summarised as follows: “subunit < unit < phrase < theme < song < song session”, the first of which is too small to be detectable by the naked ear, the last of which can continue for hours (Payne and McVay, 1971: 591). The structure is clear, recognisable and repeatable, but there is distinct variation in the detail rather than the overall. They discovered that the sequence of themes stays consistently in the same irreversible order. The place of most variation occurs in the phrases that make up the distinct themes.

The second form of graphic analysis examines these slight variations in phrases. By layering phrases vertically above one another as they appear in temporal sequence, we see how these phrases “systematically change, or ‘evolve’, with each successive repetition during the theme” (Payne and McVay, 1971: 593). Subsequent research has shown how humpbacks evolve new songs over seasons, years and large distances, although it is not known why these transformations happen. The visual presentation is suited to reveal the qualities of the phrase evolution, which in one theme is almost like stretching; in another, more like addition. It not only shows the sounds made, but also the variations in the spaces between sounds. In one of their example themes the phrases seem to repeat with great regularity, suggesting what composers would term a recognisable rhythm. However, ‘Theme 2’ does not ideally fit into this analysis as it consists of one long phrase. “It may consist of a great variety of sounds, but all, or most, of them are ascending frequency sweeps or brief (less than one second) high-frequency squeaks or chirps” (Payne and McVay, 1971: 593). This is a strange phrase/theme because there can be so much variation in the detail of spacings between sounds or units. The “interunit spacing” is only mentioned in passing and is not given consideration as a potentially important aspect of the sounds, the assumption being that the sound alone contains the information, the ‘on’ rather than the ‘off’.

The inclusion in the paper of both the spectrograms and the graphical tracing side-by-side enables the reader to compare the two levels of visual interpretation. Moreover, by noting what is excluded in this process of translation from one graphic form to another, reveals that the environmental contextual information within the sound recordings is diminished. Of the elements visible in the spectrograms but excluded in the tracings, the most prominent are the contextual and spatial characteristics of the underwater sound environment that are clearly audible when listening to the recordings. In the recording *Songs of the Humpback Whale* (1970) which includes a voice-over describing the chief characteristics of their

discoveries, the echoes in particular are mentioned, “the water is very deep and the sounds are echoing off the under-surfaces of waves and from the submarine canyons and ridges on the island’s slope” (Payne and McVay, 1970). These echoes are visible in the spectrograms, as shapes with a shadow that repeats three times in very close succession, but are excluded in the tracings as they are distracting to the visual clarity required to recognise the patterns in structure. Another example of excluding the environmental context in which the whale sounds are made, includes dynamite blasts occurring in pairs every ten minutes. The authors’ conclusion from extended listening is that “the blasts do not have any detectable effect on the whale’s rendition of its song” (Payne and McVay, 1971: 586). The sounds emitted by the whale are prioritised over what is actually recorded and how the sound behaves and transforms in interaction with the space and other sonic events in it. This approach applies an idea of communication that requires removing noise – unwanted interference - from information. The more we accept the relativity of sound and theorise the relation between sender and receiver in terms of spatial context rather than direct communication, as will be seen in both André and Kamminga’s work on sperm whales and Alvin Lucier’s *Quasimodo*, the less we can afford to continue to exclude the role of the underwater sound context within these recordings.

I discussed this notion of the spacing between sounds as carrying information with André in relation to his research into the possible communicative function of sperm whale clicks. Substantiating my above critique of Payne and McVay’s important work from the 1970s, André’s hunch of the relative importance of non-sounding to sounding in sperm whales became the basis for his RIME hypothesis described below.

5.7 Sperm Whale RIMEs

In their paper on echolocation in sperm whales, André and Cees Kamminga report research into the rhythmic function of clicks used for echolocation, and suggest their simultaneous potential for communication and identification (André and Kamminga, 2000). This research is significant in its implications for whale communication, as well as for methodology. The authors combine scientific techniques of analysing the time intervals between clicks to reveal dominant rhythmic patterns, with the listening observations of a Senegalese drum master, expert in identifying dense polyrhythmic patterns. By conducting these rhythmical analyses on the apparent cacophony of sperm whale clicks, they drew on musical concepts of rhythm,

which became what they call RIME (Rhythmic Identity MEasurement), to unearth potential uses of these sounds for communication.

Payne and McVay distinguish different kinds of sounds produced by the Mysticete or baleen whales such as the humpback or fin whale, and those made by the Odontocetes or toothed whales which includes the sperm whale, killer whale, dolphins and porpoises. Unlike the varied 'song' of humpback whales (*Megaptera novaeangliae*), sperm whales (*Physeter macrocephalus*) emit 'trains' of clicks. Regularly spaced click trains were thought to be used for echolocation, and the observation of moments of irregularly spaced clicks, named 'codas' (note another musical term), were considered for communication. In contrast, André and Kamminga argue that "the exclusive function of echolocation attributed to the series of usual clicks might be too restrictive" (André and Kamminga, 2000: 164).

They suggest that the clicks may play an important role in helping large groups of sperm whales communicate over distances of several kilometres. "The social character and the cohesive behaviour of the sperm whale suggests a continuous exchange of information which cannot be based on visual cues, given the great distances over which the whales are separated while looking for food and the virtual absence of light at foraging depths." (André and Kamminga, 2000: 164) The scientists noticed that during foraging they emit these click trains (not the 'codas') and that the whales never parted further than six miles, perhaps to stay within acoustic range of their pod. Is it possible to deduct from their sounds if and how they communicate through them? Much like the first listening of the humpback songs, the clicks from a pod of sperm whales appear to be a cacophony with no discernible order. If they contain some communicative information (more than echolocation functions), how could we recognise this? André and Kamminga hypothesise that "the temporal aspects of these signals are crucial to information transfer, since pulse timing is less subject to environmental distortion than wave form" (André and Kamminga, 2000; 164). By considering the contextual aspects of group behaviour in relation to the clicks and the way sound travels in the underwater environment, they start to investigate possible rhythmic patterns unrecognisable to humans. I note that this stands in contrast to Payne and McVay's exclusion of context in their interpretation of humpback whale sounds.

The most radical and controversial aspect of André and Kamminga's research lies in its hybrid, interdisciplinary methodology that combines both high-end analysis techniques accepted by the scientific community, and direct auditory observations by a human listener expert in polyrhythmic music. André connected the rhythmic expertise and social cohesion of West African drumming with the possible connection to sperm whale clicks. He played a

sample of the whale recordings to the Senegalese drum-master Arona N'Daye Rose, who was “spontaneously able to separate and identify the individual whales in the sample recording through their strong individual rhythmic structure.” N'Daye Rose deduced from first listening the number of whales in the group and detected a dominant rhythm around which the others were organised “belonging to what he called the leader of the group, in reference to the organisation of the rhythmic structure of an African tribe” (André and Kamminga, 2000: 164). André remarked “We knew there were four whales because we took notes during the recording, but all we heard was a confusion of clicks. I asked Arona how he could tell there were four different animals. He said, ‘I don’t know how, but I know.’” (Rothenberg, 2008: 181)

Although the musician could identify these social details communicated through rhythms, the scientists needed to have that observation corroborated by scientific analysis. N'Daye Rose’s analysis was “spontaneous” but it took the research team months to prove. André and Kamminga detail these levels of analysis which identify the “pulse repetition frequency (PRF)” and the “inter-click interval (ICI)” as parameters for calculation, from which they pull apart, or parse, the click trains of individual whales revealing their distinct acoustic signature. From this they determine the idea of RIME, which they suggest is a learned behaviour, much like the West-African drumming traditions, shown by each member of the group. Crucially, it “identifies each individual by the rhythm of its acoustic signals – a time parameter – and not through the shape of the signal wave forms” (André and Kamminga, 2000: 166). Again in contrast to Payne and McVay’s 1970s ‘songs’, this RIME project shows how much information can be gleaned from the spaces between the sounds, and the contextual information of behaviour and medium, rather than only considering the content of the emitted sound itself. It also demonstrates the value of music’s knowledge to scientific research on sound.

Every new research step seems to reinforce a sense of the previously unimagined complexity of the underwater environment revealed through its sound. Payne and McVay opened up a world of sound and questions of structure, behaviour and meaning in humpback whale songs, creating a basis for future researchers to build upon. André and Kamminga, by suggesting that the sperm whale clicks actually have a double function, that of echolocating and communicating at the same time using the same sound, allowing the whale “to distinguish its own echoes against the background of other whale click trains” (André and Kamminga, 2000: 166). This insight opens up unimagined complexity and sophistication in the whales

connection between sound and its environment, an approach that is applicable to research on other marine species.

5.8 Alvin Lucier's *Quasimodo the Great Lover*

These scientific examples of humpback whale songs and sperm whale RIMes open up ideas and questions around visualisation techniques and musical scores, long distance sounds, and possible relationships between science and art. Many musicians were inspired by early scientific recordings of humpback whale sounds. Composer Alan Hovhaness' *And God Created Great Whales* (1970), scored for symphony orchestra and tape, juxtaposed recordings of humpback whales with acoustic instruments. Composer George Crumb incorporates whale sound in less direct manner in *Vox Balaenae (Voice of the Whale)* (1971) which explores extended techniques of piano, flute and cello to imitate the kinds of vocalisations produced by the whale. More recently, the work of musicians and composers, including David Rothenberg and Dunn, reference André's scientific research. Alvin Lucier's *Quasimodo the Great Lover* (1970) was inspired by the humpback whale's ability to send sounds over very long distances. Lucier attended a lecture by Payne at the University of California Santa Barbara in 1969, prior to the publication and record release. In an interview with Douglas Simon he describes his impressions, which resonate with the discussion above of Payne and McVay's work, and give an example of the kind of influence these recordings had on composers of the time.

While I was there, Roger S. Payne came to give a lecture-demonstration and play his recent recordings of whale music. I, like everyone else, found it very beautiful. What struck me more than the sounds, however, was the ability of whales within a species to communicate with one another over tremendously long distances, across ocean basins in some instances. They do this by echoing their sounds within a specific temperature layer in the sea so that the sound doesn't get absorbed into the bottom of the ocean or dissipated out through the surface. I was very impressed by that. So instead of imitating the sounds of the whales, or using Payne's recordings, I imitated the feature that struck me strongest, their amazing long-distance sound-sending ability. (Lucier, 1995: 112)

Lucier transforms this "long-distance sound-sending ability" into a work that can be set up to travel through almost any medium, linking different acoustic spaces by relays of microphone-amplifier-loudspeaker, accumulating the subtle differences of a sound that is passed through

them. *Quasimodo the Great Lover* is the last in a series of works “which explored the acoustic characteristics of natural and architectural spaces” (Lucier, 1995: 428). The other three works included *Chambers* (1968) for resonant objects as portable environments, *Vespers* (1968) exploring spaces using echolocation devices inspired by bats, and *I am Sitting In A Room* (1970) based on a spoken text that is re-recorded and played back within the same space over and over again. *I am Sitting In A Room* and *Quasimodo the Great Lover* are both systems that explore how the accumulation of sound in loops can bring out the inherent sonic qualities of acoustic spaces. In a kind of mirror of each other, the first explores the resonant properties of a single space as activated and transformed by a voice, playback and recording loop, the second by using a repetitive process to string spaces together into an elongated form of transmission. One system is a closed loop feeding back on itself, the other moves in a forward direction.

To send a sound over any distance requires a signal, a medium and a receiver. This system, multiplied over on itself, is a way to send the sound further than the limits of the medium allow, like a chain or relay, but in the process it collects discrepancies. *Quasimodo* was inspired by the ability of the humpback whale to make sound that is heard hundreds of miles away from its source, using the temperature layer in the oceans that allows the least diffraction of the sound wave, and the most suitable frequency and amplitude levels to derive the greatest effect from the medium. Thinking beyond the medium of water, however, Lucier extends the possibilities for using different media dedicating the score of *Quasimodo* “for any person who wishes to send sounds over long distances through air, water, ice, metal, stone, or any other sound-carrying medium, using the sounds to capture and carry to listeners far away the acoustic characteristics of the environments through which they travel” (Lucier, 1995: 318)

Interestingly, and quite typically for Lucier, the text score was written after the first performances, allowing him freedom to suggest possibilities that he would like to try out in the future. What was learnt in his performances concretises into a score that can be practical yet open to variation: “I’ve often dreamed of doing it in steel, or in rock, or in earth, or underwater ... I’m composing it after the fact of those performances we did, but before the fact of many other versions I want to do” (Lucier, 1995: 108). This piece is not initially conceived as a score, but rather it emerges in score form through the practice of making one or more versions of the piece. The score in this case is a part of the larger system of development, performance and transmission of the idea, but does not precede, or command the system in a hierarchical manner. As such it provides a fascinating hint towards

a scorescape that blends environment, sound, and technology in a mutually dependent system.

The system of *Quasimodo* consists of a chain of microphones and loudspeakers that passes from the first space where the sound begins, through adjacent spaces to the final performance space. In each space the loudspeaker and microphone are placed as far as possible from each other to get the maximum distance. Playing the sound activates the acoustics of the particular space, which is re-recorded by the microphone. This accumulated sound is passed to the next space by means of an audio cable where it is reproduced on the next loudspeaker. The adjacent space is likely to have totally different acoustics properties. In this way the sound of one space becomes the input for the following resonating sound space. This relay system can continue over any distance and through any number of spaces, collecting a sound that is transformed by each acoustic space it travels through. The end result, at the final location of the chain, is an accumulative sound based on transfer over distance by means of alternating transduction of sound from electronic signal to sound waves transmitted through a medium such as air.

This “system” (as Lucier calls it) of sound transmission, transduction and acoustics, is dependent on the specific sound input at the beginning of the chain. Lucier builds directly on Payne and McVay’s analysis of the humpback whale song, using it not as a sound source in itself, but rather as a model for potential sounds, sound transmission and evolving structures. Sounds are not limited to vocal or instrumental ranges, timbres, envelopes and durations but can be modified by electronic, mechanical or any other means at the input stage only. Beyond the input source and mediating equipment, which could be of a limited variation in quality, only the acoustic qualities of the environments will distinctively change the sound. In doing so Lucier emphasises one ‘voice’ as the source of the sound, echoing a whale’s ability to communicate and send its voice over vast distances.

The text score of *Quasimodo* is described by Lucier as “a guidebook of sounds suitable for acoustic testing, with suggested procedures for putting them together” (Lucier, 1995: 112). The form of the score is in three noticeable sections, first describing all the possibilities for how and where to set-up the piece, then how to consider the kinds of sounds and developments to use as input material at the beginning of the chain, and finally opening up further possibilities for variations and future instantiations. Far beyond the technical specifics, the score lists diverse kinds of spaces, environments and contexts for this to explore, “prairies, glaciers, or ocean basins ... rock formations within faults, detached railroad cars

on sidings, the rooms, foyers, and corridors of houses, schools, or municipal buildings ... libraries, laboratories, cafeterias, offices ...” (Lucier, 1995: 318).

The score outlines the kind of sounds to make and the structural progression of these sounds in the system. Both these elements have direct resonance with the whale sounds. The sound source is described abstractly, “compose a repertory of simple sound events such as ... upward and downward sweeps ... accelerating or decelerating pulse trains, upward sweeps followed by tones of short duration ...” (Lucier, 1995: 320). The score is more specific about the possible structures of these sounds, “Design formal structures with sets of successions of sound events in which each event within a set is subject to gradual, repetitive, and cumulative variation with respect to pitch, timbre, amplitude, envelope, or any other aspect of sound and time in order to amplify in time the relationship between the original sound event, its change, and the environment through which it travels” (Lucier, 1995: 320). Two aspects are prominent. Firstly, the way the sound events in *Quasimodo* evolve through variation is reminiscent of the way in which Payne and McVay described how whale songs “systematically change, or ‘evolve’ with each successive repetition of the theme” (Payne and McVay, 1971: 593). Secondly, the consistently irreversible order of themes in whale songs, is reflected by “taking care not to reverse the direction of a variation between two adjacent sets” (Lucier, 1995: 320). Perhaps most importantly however, unlike Payne and McVay’s analysis of Humpback whale song, but more like André and Kamminga’s analysis of Sperm whale click trains, the transformation of the sounds in *Quasimodo* is tied to their presence and transformation in the environments they travel through. This aspect of the sounds interaction within environment makes the piece focused on sonic qualities that move beyond the details of the sounds themselves, making clear that sound is never independent from the environment in which it occurs.

5.9 Physically Experiencing Sonic Processes

Lucier’s translation of whale sound into sonic processes occurring in an air environment gives access to understanding underwater sound in an embodied manner. In order to test my ideas through practical experience rather than only theoretical speculations, I initiated a performance of *Quasimodo* at the Atlantic Center for the Arts in Florida (2009) where Lucier was Master Artist, put together by his Associate Artists including myself. We linked the spaces of the Center, through the tropical forest environment. Each interior and exterior space differed in scale and acoustic characteristics, as well as levels of humidity and

temperature. I was impressed by the quality of sound accumulation as one physically experiences it moving from one space into another. It made me conscious of how I sense the changing qualities of space as I walk across a threshold from one space into another.

My experience of this piece led to the insight that the sound enhances the other senses. I could see, feel and smell the differences between a room, a corridor, and an exterior space. By accentuating the acoustic properties of the spaces my attention to their specific characteristics and their differences was heightened. At the same time the directional long-distance sending of the sound through these proximate spaces enhanced an idea of continuity and forward motion, of passing thresholds, of accumulation, resonance and a relational consideration of the sounds. As I travelled through this long and varied distance, my body and senses activated by the piece, I could sound out the spaces and experience what happens between them.

There is something captivating about this piece that is hard to describe without actually experiencing it – a quality often associated with Lucier's music. The sound seems to be a strange acoustic shadow of travel through these spaces, like an experience of the architecture but absorbed and removed from the spaces into a kind of live memory as one hears these sounds. There is a tension that the person playing, sending the initial signal, is unable to hear the transformations of the final sound being heard by the audience. The performer is physically removed and isolated, and yet still very present.

Although this piece relies on physical spaces, the transduction into electronic media that is required between microphone and subsequent loudspeaker, it could be extended beyond the bounds of a cable. It could, for example, be thought of as being sent over a computer network, connecting a chain of very distant locations. Sound artists Laura Cameron and Matt Rogalsky organised such an Internet version of *Quasimodo* in 2009 (Cameron and Rogalsky, 2009). This version raises the question of how physical one's real experience of space is and how is this changed by wireless or networked transmission. Does *Quasimodo* need to be linked together by chains of cable and acoustic environments? The nature of the piece would seem to change because it is no longer about physically proximate spaces chained together over distance but distributed nodes chained together by a system already in place.

Technically, it is now easy to send sound over global distances. But this stands in contrast to the embodied experience of linked accumulations across neighbouring spaces, the directness of experiences of built and environmental spaces through their acoustic properties in situ. Long distance and wireless transmission of the electronic stages require spaces that are physically distant but virtually linked together. This is based on a different understanding of

spaces and their juxtapositions that has been absorbed by long distance proximity over network infrastructure. I argue that the accumulation of the acoustics of distant spaces has a different effect on our bodily experience of space than those linked together in physically adjacent spaces within a locale. In such an interpretation of *Quasimodo* one can only experience *representations* of distant spaces rather than the spaces themselves.

Lucier's work draws the participant into the process of transmission over long distances through environment, as paralleled by the whale underwater but directly experienced in our own environment. This participation demands an imaginative leap away from musical metaphors such as song or rhythm, situating the participant inside a sonic environment that is being activated in a way unusual for us as humans to experience. In this way Lucier requires the listener to participate, to become involved on a conceptual level through listening and experiencing on a physiological level. My own works such as *The Pink Noise of Pleasure Yachts in Turquoise Sea* (2010), *Fishing for Sound* (2010) and *Swim* (2010-11) build on this approach to involvement, not so much by direct physical interaction, as by a level of commitment to listening using a first person perspective and multi-sensory video and sound, to draw one in to sound worlds that are unfamiliar. This kind of approach can, I believe, move us closer to redefining the role of composers and sonic ecologists as activators of a sustainable attitude towards the sonic environment, one that is less passive than the genre of field recording and more immersed and committed to the environment.

5.10 Long Distance Sounds

The question arises as to how does the physicality of experiencing these proximate or virtually connected sound spaces in *Quasimodo* relate to the experience of underwater sound. How does the idea of sending sounds over long distances relate to both the particularity of different media such as air, water, earth or metal, and contemporary experiences of long distance communication over the internet? And how does the figure of the whale, sending these communications across oceans, relate to the human imaginings of long distant communication via telematic networks and other forms of remote transmission and reception? And what implications might this have for musical composition and the sonic ecologist?

Unlike sound conveyed by global electronic networks, the whale actually inhabits and moves through the medium it uses to send the sound, without transduction of any sort. Writer Steven Connor suggests that, "the development of radio... would be identified with the air

through which it was for the most part transmitted, rather than through the sea or earth” (Connor, 2008: 161). But even our use of air to send wireless radio transmissions requires some form of transduction to broadcast and receive the radio signals. In the case of the whale, communication is more direct, “whales actually pass through these extended physical spaces with their own bodies, emitting and receiving sounds that ‘echo off the under-surfaces of waves and from ... submarine canyons and ridges’ to use the words of Payne and McVay from 1970” (Shanken and Harris, 2010). Thoughts about the “presentness” of sound for the whale, the being in the medium, prompt one to dream, “what might it be like to experience a form of direct communication over hundreds if not thousands of miles and/or across time? To intimately know one’s position in space on three axes and the relationship of that position to the contours of a vast environment and to the locations of others? Is this perhaps something that humans already do?” (Shanken and Harris, 2010).

This line of thought consciously reflects imaginative ideals of long distance communication and connection. Connor opens his article on atmospherics by saying “wireless signalling unleashed a dream of absolute communication and universal contact. Contemporary communications – or the material imagination which makes sense of them – still have as their ideal horizon a universe of absolute transparency and traversibility” (Connor, 2008: 159). Historical explorations into telepathy, globally distributed consciousness, synchronicity, and their relationship to technological development, particularly electricity are revealed, for example, by media theorist Siegfried Zielinski’s media archaeological approach in *Deep Time of the Media* (Zielinski, 2006). Early telematic works include telephone and radio networks such as *Public Supply* (1966) and *Radio Net* (1977) by artist Max Neuhaus, and the use of a satellite telecast in *Hole in Space* (1980) by media artists Kit Galloway and Sherrie Rabinowitz who linked large public screens in New York and Los Angeles to make what they called a public communication sculpture. These ideas continue to develop in the work of media artist Roy Ascott and composer Pauline Oliveros. Attempts to achieve altered, extended states of consciousness, through shamanic practices, sonic meditation and dream practices, are combined with technological developments and tools for communications and improvisations over global distances. The theoretically dense and visionary work of Ascott presents the ideal of distributed consciousness as a “telematic embrace” in his essay of 1990 (Ascott, 2003: 232-46), while Oliveros’ “telematic music” which she began in 1991 (Oliveros, 2009) is expanding through her international network of “Deep Listeners” connected via social media sites. Both Oliveros’ Deep Listening Institute and Ascott’s Planetary Collegium PhD network for media arts researchers show how artistic practice has led to the development of global educational programs that utilise distributed, connected learning by

combining both virtual networks and local nodes to enable hybrid forms of communication and community.

Quasimodo seems to foreshadow these practices of long distance connectivity and communication. But the realities behind the ideals of perfect communication are, as Connor points out, rife with interference, delays and noise (Connor, 2008). Are there similar interferences underwater, where the whale's communication channel is, after all, not exclusive to its signals?

The whale's use of the "specific temperature layer in the sea" that so inspired Lucier, is scientifically described in Stocker's report on underwater sound (reproduce diagram here, Stocker, 2002: 27). Because the speed of sound depends on the density of the medium, sound travels faster in water than in air. The density of water in the ocean depends on temperature, pressure and salinity, which change according to depth. "As the ocean gets deeper, the pressure rises increasing the density, and thus the velocity" of sound. According to these parameters the ocean is generally divided into four distinct layers, each defined by the changing environmental factors of temperature, seasons, weather systems and ocean currents. The surface layer, and the two lower layers referred to as the seasonal and main thermocline, vary according to these environmental factors. Below this, beginning at a depth of anywhere up to 4,000 feet, there is a thermal boundary in the ocean, "this abrupt thermal and density boundary acts as a sound reflective surface underwater" (Stocker, 2002: 27). This lowest, or deep isothermal layer, is the most dense and the least affected by turbulence, with a steady temperature of about 4 degrees C, and so can carry sounds at highest speeds and furthest distances with least interference. It is likely that whales use this channel for their long-distance communication, but also probably for navigation during migration, by listening to distant sound sources made by waves and currents around ocean geographies. "In this 'sound channel', whales have been heard at distances exceeding 1500 miles, and anthropogenic noise has been transmitted over 11,000 miles in the Heard Island Feasibility Test (HIFT)" (Stocker, 2002: 27).

Of course, practical tests to research possible sending and receiving of sounds over long distances using this ocean sound channel have been executed, with varying success and almost always contributing to high levels of anthropogenic sounds in the oceans. The HIFT experiment from 1991 proved the efficiency of sending and receiving sounds across oceans by transmitting extremely loud sounds within this channel. With this knowledge the ATOC (Acoustic Thermography of Ocean Climates) program began in 1996. It hoped to gain reliable confirmation of global warming by monitoring temperature changes in the deep

ocean isotherm based on changes in the speed of sound. Stocker notes that it was “the first pervasive deep-water sound channel transmission, filling an acoustical niche previously only occupied by deep sounding whales and other deep-water creatures” (Stocker, 2002: 25). The tests were scheduled to last ten years with periodic twenty-minute sound transmissions every few hours. Ironically, the concern with pressing environmental issues of global warming ended up causing other serious environmental consequences by contributing to very high levels of anthropogenic sound in the oceans, creating interference in the whales’ sound channel!

These issues of very long distant ocean sounds have been placed in a more detailed context by Kahn in his paper entitled ‘Long Sounds’ (Kahn, 2010).

The reflex is to imagine a long sound as a held note, a drone, an ‘eternal music’, or something murmuring away on a geological or cosmological time-scale. Yet there are also long sounds that have travelled a great distance or, more importantly, have acquired their specific character from all that occupies the in-between, the channel, the medium of space. They are sounds that are long on time and long on space. (Kahn, 2010: 52)

Kahn’s examples of long sounds include volcanic eruptions, electrical disturbances listened to on telegraph wires, bombs and earthquakes, the ionosphere and ocean. They span the media of air, metal, earth and water, reminiscent of Lucier’s wishes for future performances of *Quasimodo* “in steel, or in rock, or in earth, or underwater” (Lucier, 1995: 108). Kahn compares Lucier’s piece *Sferics* (1981) which uses antennas to hear sounds of electromagnetic bursts coming from lightning storms in the ionosphere, a technique accessible to both scientists and amateur ‘space’ listeners. These sounds are generated within a sound channel, the ‘earth-ionosphere waveguide’, reminiscent of the deep ocean channel. In a recent installation of *Sferics* in Den Haag (Lucier, 2010), one could hear the fragile small sounds of these enormous spatial events in the ionosphere. As Kahn wrote, “It is not merely a remarkable shift in magnitude, from global and larger-than-global expanses to little blips, but more the embodiment and foreshortening of such an expanse in a little blip” (Kahn, 2010: 58). We experience a similar sense of awe at these long distant sounds whether in the ocean or the air, and they feed our parallel fascination with developing long distance communication.

5.11 (Inter-Species) Communication, Evolution, Music

We must strip ourselves, as far as possible, of our preconceptions about the relative place of *Homo Sapiens* in the scheme of nature. If we are to seek communication with other species we must first grant the possibility that some other species may have a potential (or even realised) intellectual development comparable to our own. We cannot continue to insist that man is at the top of the evolutionary scale and that no further evolution is possible. This vain assumption may be preventing valuable kinds of research. (Lilly, 1962: 21)

While one of the dreams provoked by whales is long-distance communication and connectivity, another lies in possibilities of inter-species communication, of understanding and communicating with an alien other through language, sound or music. Lilly began early work with dolphins in the 1950s. Initial research, which saw a series of dolphin casualties caused by lack of knowledge of their breathing system and intolerance of anaesthetics, included electrical brain stimulation experiments on restrained dolphins kept for long periods of time in a glass tank in a laboratory. These experiments led Lilly to startling discoveries into the potential intelligence of these large-brained mammals, which seemed to corroborate his intuition. In 1958 he began to put forward the idea that “perhaps dolphins are much more intelligent than we give them credit for ... we are severely handicapped in our efforts to measure the intelligence of individuals of other species than our own” (Lilly, 1962: 83). In the same year he began the development of his own, independently funded, Communication Research Centre in the Virgin Islands to test the possibilities of communication between different species of similar brain size, specifically between the *Tursiops truncatus* bottle-nosed dolphin and humans. This period of his work is described in his book *Man and Dolphin* published in 1961. Of the fundamental and provocative research questions underlying this study is, he explains:

One of the last remaining thrones upon which man places himself is being shaken if not toppled by modern scientific research. Man thinks of himself as the most intelligent species on earth and as proof of this points to the accomplishments of his hands, his aspirations, his traditions, and his social organisations. In other words, man is said to be the most intelligent species because of what he does with his huge brain. May there not be other paths for large brains to take, especially if they live immersed in some other element than air? ... In the case of the Cetacea, which are without benefit of hands or outside constructions of any sort, they may have taken the path of

legends and verbal traditions rather than that of written records. Have they or haven't they? That's the essence of this research (Lilly, 1961: 95).

The success of this inter-species communication research depended on teaching the dolphins human language and understanding their range of sound producing abilities. Lilly noted the dolphins ability to recognise the limited hearing range of humans and restricting their frequency range so as not to produce ultrasonic frequencies humans cannot hear. Although he optimistically says "Luckily for us, a good deal of their natural communication is within our hearing, though in its upper range" (Lilly, 1961: 146), he notes that the meaningful patterns of their speech may be in the ultrasonic range and not overlap ours at all. He describes games of whistling between dolphin and human and use of mimicry, with some examples of specific phrases repeated by the dolphin. Lilly recognised that recordings of the dolphin's sounds had to be slowed down in order to make them intelligible in the "Donald Duckish" voice he called the "dolphinsese" accent (Lilly, 1961: 144-53). He also accepted difficulties that the dolphin's loudest and most varied sound production occurs in water, and humans in air.

The air-water boundary is a very real and difficult interface for either us or the Cetacea to cross so that we may meet one another halfway. If they are to meet us in air we must furnish them with 'flesh-conduction' earphones so that they can hear us in air. If we are to meet them in water we must be furnished with some means of talking underwater (Lilly, 1961: 96).

The closest he seemed to get to this idea was a working method whereby

I placed in the tank an underwater loudspeaker connected to an air microphone so that he [dolphin Elvar] could hear our voices no matter what we were saying in the laboratory and get used to the sounds produced by humans. We also had in the tank a hydrophone connected to an air loudspeaker so that we could hear all of his sounds (Lilly, 1961: 144).

Finally, he gives a description of the "voices of the dolphin" in which he lists the kinds of sounds they naturally make, such as "clicks, creakings, whistles, squawks, quacks, and blats" (Lilly, 1961: 151), and the kinds of sounds they produce that appear to imitate human sounds, such as laughter, whistles, 'impolite noises' and even human words.

This work on interspecies communication with dolphins was taken up in 1966 by Bateson. He first published the essay "Problems in Cetacean and other Mammalian Communication"

while working with Lilly at his dolphin research centre (Bateson, 1972: 364 – 78). Perhaps in a way of deferring criticism about his interest in Lilly's controversial work, he clearly states his angle on the topic: "The point is not either to discover that dolphins have a complex language or to teach them English, but to close gaps in our theoretical knowledge of *communication* by studying a system that, whether rudimentary or complex, is almost certainly of an unfamiliar kind" (Bateson, 1972: 365).

The central problem of understanding cetacean communication lies in the difficulty of approaching communication that may have completely different goals and importance. Bateson draws on behaviours of terrestrial, non-linguistic mammals, such as the wolf and the domestic cat, to describe the predominance of communications of relationship (love, hate, dependency etc). In such communications there is no need for a language of data such as humans have developed; humans have hands and manipulate objects and language, according to Bateson, is built out of this ability and necessity. The communication of relationship in humans is, according to Bateson, less explicit in language but can be found in gesture, termed proto-linguistic communication, common to all mammals. As they do not use objects, cetaceans, Bateson proposes, are almost solely communicating issues of relationship. However, unlike land-based mammals they have very little in the way of visible gestures as facial expression, body hair and limbs are all smoothed in underwater life where vision is strained. It is not only almost impossible for us to guess at their proto-linguistic meanings, but dolphins themselves must have developed alternative ways of communicating – most probably through their complex sounds. He goes on:

I personally do not believe that the dolphins have anything that a human linguist would call a 'language'. I do not think any animal without hands would be stupid enough to arrive at so outlandish a mode of communication. To use syntax and category system appropriate for the discussion of things that can be handled, while really discussing the patterns and contingencies of relationship, is fantastical (Bateson, 1972: 372).

But what then is the meaning and function of their enormously complex acoustic soundings? Is it necessary for communicating about relationship? Does it form a different kind of language altogether? Or is it closer to what humans call music? Going further, Bateson distinguishes between what he calls analogue and digital in communication. Human language could be considered mostly a digital communication system, where signs may express but do not contain magnitude in themselves, "the word 'big' is no bigger than the word 'little'" (Bateson, 1972: 373). But the analogic system of proto-linguistic gesture or behaviour expresses magnitude directly in matters of degree, a muscle can be more or less tensed, a

smile more or less intense. The analogic system of gesture is more intelligible across cultures, and recognisable in terrestrial mammals, than is the digital system of human languages. And yet, Bateson claims, on listening to the dolphins sounds, he cannot comprehend much analogic communication that he would recognise in the cat or wolf. Perhaps dolphin communication through sound is another digital system, but one more concerned with questions of relationship than human language? “This system is something we terrestrial mammals cannot imagine and for which we have no empathy” (Bateson, 1972: 374). How can we then study and potentially understand this communication “which might, more probably, resemble music” (Bateson, 1972: 374)? And if it does resemble music, then we are still left with the question of what music communicates.

What then is music in relation to these ideas of inter-species communication? In a recent interview published in the *Soundscape Journal for Acoustic Ecology*, Dunn proposes that “it’s a way of keeping alive a modality of communication that we share with other forms of life” (Miller, 2007: 16). As inspiration and support for this theory that underlies his work, Dunn cites Bateson on dolphin communication described above, reiterating the cybernetician’s point that it has very little to do with human language “the only thing he could relate it to, in terms of human experience, was music” (Miller, 2007: 16). His second example of music as paralleling non-linguistic forms of communication shared with other species, is the previously described work of André and Kamminga, collaborating with West African drum master N’Daye Rose, to investigate the polyrhythmic communications of sperm whales (André and Kamminga, 2000). As we have seen, in this example the opinions of an expert musician opened up possibilities for the scientific team to explore otherwise indecipherable meshes of clicking sounds from a group of sperm whales. Echoing Lilly and Bateson, Dunn says, “Much more is being communicated by the complexity of this [non-linguistic] modality of communication than we have usually dared to imagine and that is something that musicians can relate to and talk about” (Miller, 2007: 16).

The possibility of inter-species communication with cetaceans, particularly through the possible closeness of their sound to human music, has recently been revisited by Rothenberg who explores clarinet improvisation with whales of different species. In his book *Thousand Mile Song* (2008) Rothenberg maps a history of whale song and scientific explorations into the world of underwater sound in relation specifically to cetaceans. In his own musical improvisation with whales he relies on fundamental notions of musicality that are specific to humans. In doing so, his approach to exploring the relationship of music to the sounds of another species must be questioned.

The *Leonardo Music Journal* published a paper by Rothenberg specifically about his improvisations with humpback whales, entitled “Whale Music: Anatomy of an Interspecies Duet” (Rothenberg, 2008: 47-53). Using an underwater loudspeaker to broadcast his clarinet improvisations beneath the sea, he attempted to “try interspecies jamming with humpback whales”. He claims that “this chain of technology enables the clarinetist to talk to the whale or, more accurately, use music to cross species lines. Why do I think this is even worth trying? Because music can communicate across cultures in a way language cannot” (Rothenberg, 2008: 47-53). Although he appears to echo the reasoning of Lilly, Bateson and Dunn, Rothenberg’s motivations, methods, results and conclusions are entirely different. He goes on to say, “I would essentially be interrupting a reverie whose purpose we do not know. In the musical moment I did not care about the purpose, but instead wished to understand the result” (Rothenberg, 2008: 49). But of what value is the result if founded on ‘not caring’ about the foundations? Rothenberg’s paper is full of assumptions that amount to an imposition of human music on whales.

Why does Rothenberg assume that a whale will respond in duet form? There is no evidence that whales ‘sing with’ or respond to each other over short time-spans, despite the fact that their song evolves. They must listen to each other but it is not thought that they enter any communicative back-and-forth of sounds or call and response within their songs.

Rothenberg mentions that another whale singing at a distance of one kilometer, is likely to be more important to the near whale than clarinet sounds. When he writes, “we really seemed to be listening to each other” (Rothenberg, 2008: 49) he refers to a musical notion of ‘listening’ in improvised music, where the result of some level of communication between the players is particularly poignant and tangible. He implies that there is a possibility that the whale recognises this musical idea of ‘coming together’ in improvisation, an assumption based on a specific genre of human musical techniques. Indeed, would free jazz improvisation even be recognised or understood as ‘jammable’ with by non-Western musicians, let alone another species?

As discovered by Payne and McVay, and referred to by Rothenberg, the structure of whale song lasts up to thirty minutes and a session may last many hours. The four minute excerpt that, according to Rothenberg, demonstrates some hint towards inter-species communication or ‘jamming’, does not equate with the different temporal song structures of whales and humans. Building on Payne and McVay’s use of spectrogram visualisation, Rothenberg illustrates the moments of greatest confluence, but without the larger structure it is hard to tell if the whale is changing its song in response to the clarinet or repeating its

themes and variations to which the clarinet is responding. To substantiate Rothenberg's claim an overview of the structure of the larger whale song, combined with an analysis of it in relation to the whales time-frame is necessary.

Further questions dispute Rothenberg's approach and conclusions. Why would the whale respond to (clarinet) interference occurring within a small band of its frequency range and at relatively low amplitude levels in comparison with its own sound? Why assume this is experiment and not harassment? The whale is approached by the boat, not the other way around. The clarinetist humorously mentions that "the aiding and abetting of musicians who try to harass whales by playing amplified underwater clarinets to them is against the U.S. Marine Mammal Protection Act of 1972" but he does little to argue why his own work is other than harassment. His conclusion suggests a strange arrogance, when the "highest compliment an interspecies musician could receive" would be to influence the evolution of the humpback songs. He hopes that what he has learnt from whales will be mutually influential.

5.12 Underwater Sound in Scorescapes

This research into underwater sounds and cetaceans has been influential to my work in numerous ways. *Pink Noise*, *Fishing for Sound*, *An Image of the Sound of a Dolphin Echolocating in Scorescapes Spectrograms*, *Ponce Inlet*, *Swim* and *S.W.A.M.P. 1, 2 & 3*, all revolve around what I have learnt through this research. I experimented with making hydrophone recordings in a number of situations, and exploring the interpretation in sound compositions, spectrogram images, audio-visual installations, audio-visual performances and group improvisations. Learning about the sonic characteristics of underwater helped me in creating works that embraced the particularities of this unusual environment. For example, the audio-visual installation, *The Pink Noise of Pleasure Yachts in Turquoise Sea* (2010), and performance, *Fishing for Sound* (2010), exemplify my artistic approach to absorbing the complex topic of underwater sound into a perceptually immersive (rather than didactic) experience, while emphasizing the importance of making the inaudible audible.

In *Pink Noise* I experimented with hydrophones to question our access to and influence on the underwater environment. Recorded in a national marine reserve in Spain, the work reveals the unearthly anthropogenic sounds of pleasure yachts set against an idyllic moving image of the surface of the environmentally protected seascape. Conceptually more complex, *Fishing for Sound* presents a plethora of spatial connections between phenomena

underwater, in the mind, and from outer-space. The performance weaves sounds from scientific analysis of marine environments, sounds used in psychological treatment for post-traumatic stress disorder, and sonified data from satellites orbiting the Earth. All share in a mass of background noise, sounding in the contexts of environment, memory and information. Listening in these spaces is like fishing for sounds. These works will be discussed in greater detail in the chapter seven, to emphasise their relationship to the breadth of concerns of my practice.

Through the process of making *Pink Noise* and *Fishing for Sound*, I recognised the central importance of considering the *context* in which sounds occur rather than exclusively the qualities of a sound in itself. For example, *Pink Noise* and *Fishing for Sound* present a wide spectrum of sounds recorded underwater with barely any post-production editing or isolating of individual sounds. The effect is a very dense sonic texture reminiscent of how one may actually hear it in the field. This is in contrast to many field recordings recorded and edited for artistic purposes which typically proceed by splitting up the soundscape into isolated sonic events. That standard editing approach, combined with playback in a location different from the recording, effectively isolates the sound from any suggestion of its original context, an issue discussed in detail in the following chapter. Yet in working with environmental sound an understanding of its contextual nature, in terms of spatial acoustics and interaction with other sonic ecologies, is crucial, as exemplified by the works of André and Lucier discussed in this chapter. This insight also builds on LaBelle's notion of the 'relational' quality of sound (LaBelle, 2009), where sounds can only be understood in relation to the broad environment in which they occur.

Through works such as *Pink Noise* and *Fishing for Sound* I offer alternative answers to the question as to what extent such notions of a relational, contextual and embodied approach towards sound in the environment, can extend into physically inaccessible environments such as underwater. By researching the salient characteristics of underwater sound and considering the use of sound as 'sonic evidence', my analysis of whale sounds hopes to reveal contrasting and complementary ways of interpreting and understanding underwater sound through the overlap of practices of music and science. Rather than attempting to directly interact with whales, I propose developing a heightened sensitivity to an embodied experience of sound in specific environmental contexts. This perspective offers a more productive approach towards understanding the immersive experience of underwater sound. The works discussed in this chapter lead away from a certain anthropomorphising of whales, understanding them in terms of human song and musical structures, towards an

immersion in the sonic process, medium and context the whales inhabit. This immersion in sound may lead to more embodied approaches to understanding and exploring underwater sound both in the arts and sciences.

It is clear that the scientists are influenced by music, and composers by science, but what can be learnt from the comparison beyond this rather superficial observation? By placing these works next to each other, and developing my own artistic works as part of the research process, they resonate together and offer new perspectives on our methods and relationships to the underwater environment through sound. The overlapping interest of scientists using musical metaphors for interpreting data, and composers exploring scientific and acoustic properties, raise important implications for composers, sound artists and sonic ecologists working today.