

# Wildlife Sound Recording: Dealing with the Distance and On-Axis Issues

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**Wildlife Sound Recording: Dealing With The Distance And On-Axis Issues**  
**Ljudinspelning av vilda djur: att handskas med avstånds- och riktningsproblem**

By

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## ABSTRACT

In natural history filmmaking recording fauna vocalisation often produces difficult challenges especially when recording sound from a distance. The camera in many cases is able to solve these problems due to lens changes, but the microphone cannot do this, which creates major problems when combining sound and picture. This thesis using a multi disciplinary approach, looks at these problems in particular the 'Distance' and 'On-Axis' issues and attempts to solve them using both a theoretical and practical approach. The thesis consists of two parts, part one the theoretical section discusses the idiosyncrasies of natural history sound recording giving examples where the problems of actual situations have been resolved. Part two is an applied method or practical experimentation using technology designed to test certain theories in effectively dealing with the 'Distance' and 'On-Axis' issues. The practical experimentation takes place at various locations using avian subjects to demonstrate the problems and solutions when recording wildlife vocalisation. As a result of the tests, a remote-controlled microphone operating system was developed and tested in the field to ascertain its capabilities. Although still a prototype it has the potential through further development, to be a useful technological instrument for recording wildlife sound.

## INTRODUCTION

Sound is an important aspect in audio visual communication especially in natural history filmmaking and it starts at the very beginning with the first recording – and it is this recording the central peg, on which all other connected sounds pivot in their process to final presentation. But how do we arrive at this juncture, there are many factors to consider for example:

- Environmental, the sound stage and subject/s disposition
- Technical awareness, the recording approach
- Content destination, scientific, educational, broadcast, other media

These initial problems are but a few the sound recordist is confronted with and perhaps the most difficult problem to solve, is that there is very little control over a given situation - if any at all. In many cases the camera is able to suppress these problems via the use of lens changes, but sound cannot do this because as David Attenborough in his lecture to the Royal Society<sup>¶</sup> tells us. There is no microphone that can record at distance; and distance is the biggest problem we have in wildlife filmmaking moreover, each recording environment poses different problems. To solve these problems, the sound recordist must consider the following and find a balance appropriate for each scenario.

- Subject availability may be seasonal
- They may be nocturnal, diurnal, camouflaged, microscopic, aerial or fleet of foot
- Their location may be impenetrable jungle or deep within the ocean
- Their behavioural activities and disposition is/are often timorous and unapproachable
- They are often situated at a distance

This thesis using a multi disciplinary approach, will look at some of the problems attributed to natural history sound recording by using alternative methods. Meaning that there are no ideal solutions to solving a particular situation, because each will contain its own idiosyncrasies and the methodology used for one scenario may not work for another. Therefore, we have to find alternatives to compensate and two issues that present the biggest challenges are, 'Distance' and 'On-Axis'.

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¶ Sir David Attenborough. (2004). Michael Faraday Lecture: Perception, Deception and Reality. Royal Society (Accessed 28/01/2004) <http://www.royalsoc.ac.uk/page.asp?id=2404> and/or <http://www.royalsoc.ac.uk/portals/attenborough/msh.htm> (Accessed 01/12/2005 and 03/03/2011). See CD-ROM Audio disc for aural version of the lecture.

The thesis will consist of two parts, part one a theoretical section will discuss natural history sound recording and the phenomena that affects it, because there are factors to consider when recording good bioacoustic data. They include: Distance, direction, reverberation, phase, phase shift, frequency, amplitude, masking and harmonic content.

Also included in this section are brief discussions on a few post production issues. Although these are supplementary to the main research question, they demonstrate to their relevance prior to production for example,

- Sound and picture combination, an important element. because, the sound must match what is seen. Often referred to as 'likeness' (Wide shot) subject/s sound/s will contain more ambience. (Mid to close-up) subject/s sound/s will have more prominence and less ambience
- Fidelity, meaning has the subject/s sound been recorded in natural surroundings or from other environments such as animal parks and/or zoological establishments

Because the latter will contain sound stage acoustic properties that differ from natural surroundings for example, reverberation, refraction and timbre will play an important role, which could render the end product as a poor acoustic imitation. Also in this section we look briefly at fiction film sound design practices and compare them to those of the wildlife film, because although both are tied by the laws of dramaturgy, they differ in many ways.

Part two is an applied method or practical experimentation, designed to test certain theories relating to the problems identified by Attenborough, which include:

- Environmental issues and sound stage acoustics
- Subject disposition and the approach
- The 'Distance' and 'On-axis' issues
- Technical awareness and practical know-how

And because these factors are important, there are several considerations when planning the construction of an optimal recording device/s, of which two were built, tested and evaluated during the

recording of wildlife vocalisation. - The first instrument is/was a parabola and the reason for choosing this for the first test as opposed to other recording set ups for example, play back and microphone plants (Microphones placed in trees or bushes) is because of the following attributes:

- The sound stage consists of both open plain and dense forest and the problems associated with these two locations will be (a) wind noise and (b) reverberation and phase shift respectively
- Subject/s disposition is/are extremely timorous and approachability is restricted to 400 metres they constantly move from one location to another therefore, equipment mobility is a concern

The second instrument to be constructed and tested is a radio controlled (R/C) recording device. R/C is not a new concept nor is the microphone, but by combining these two elements, we have a new approach to recording wildlife sound.

The reason for constructing this R/C device for the second test is because it negates the need for play back instrumentation and/or the placement of static microphones because:

- It can be situated practically anywhere
- Is small and unobtrusive to fauna
- Can be operated from afar solving the 'distance' and 'on-axis' issues

This thesis is constructed in the following way - nine chapters, which are:

- 1. A Background to the wildlife film. In this section, there are three topics; The development of natural history filmmaking, The different methods of story telling used in wildlife filmmaking, Wildlife sound – natural or artificial and a section summary.
- 2. The importance of sound when combined with the picture. This chapter contains the following subjects; Sound in the wildlife film, Diegetic sound, Non-Diegetic sound, Music, Narration, Subdued narration, Stereophonic sound, Fidelity and a section summary.
- 3. The factors influencing wildlife vocalisation recording. The contents of this chapter are; Distance, Frequency, Direction, Phase, Amplitude, Masking, Harmonic content, Understanding the sound stage, Subject disposition and a section summary.

- 4. The approaches to recording wildlife vocalisation. This chapter discusses the various approaches to recording wildlife sound and the technologies that exist including, parabolic reflectors and a section summary.
- 5. Parabolic reflector construction. A chapter which looks at Parabola advantages and disadvantages and a section summary.
- 6. Introduction to the field studies. In this chapter, we look at the location where the applied section or field experiments took place and includes, Recording equipment used in the studies, Subject information in brief, Recording experiment synopsis, Location or sound stage and Subject behavioural patterns.
- 7. Field studies. Contained herein are the Location or sound stage and a Diary of field experiments from the period 11/09/05 to 25/09/05 and a section summary.
- 8. A possible solution in solving the 'distance' and 'on axis' issues. This chapter contains the following topics; Transmitters and servos, Powering the unit, Transmission and reception, Operating systems and other recording devices, Stepper motors and servomechanisms, Differences between stepper motors and servomechanisms, Radio controlled recording device, R/C experimentation - recording session 23. Location 4, R/C experimentation – recording session 24. Location 7, Sub section summary, R/C recording device advantages and disadvantages - pros, R/C recording device advantages and disadvantages- cons.
- 9. This chapter contains the final discussion or summary of this thesis.

NOTE: to the reader.

Throughout this thesis, the terminology 'Natural History Film', 'Wildlife Film', 'Natural History Sound Recording' and 'Wildlife Sound Recording' is used. To avoid confusion a brief explanation of their meaning is given. The term natural history film came into being during the 1940s via the British Broadcasting Corporation's (BBC) natural history unit, (NHU) hence the title. The wildlife film is an American alternative<sup>¶</sup> for the natural history film, but they are one in the same. This consensus also applies to natural history sound recording or wildlife sound recording.

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<sup>¶</sup> *The Living Desert* written and directed by James Alger is often considered as one of the first full-length cinematic nature films. The film was produced by the Walt Disney Company and was released in 1953.

## 1. A BACKGROUND INTO THE WILDLIFE FILM

This work focusses its attention on the problems that occur when recording fauna vocalisation. The work will investigate these issues and will offer solutions, to solve the inevitable problems (listed below) from both a theoretical and practical point of view. And in support a CD-ROM containing a selection of wildlife sounds is in accompaniment.

- An understanding of the sound stage, because the properties of each location will have great bearing on how, the sound is perceived and understood
- Research into animal behaviour, as this tells us the subject/s disposition and accessibility
- The 'Distance' and 'On-axis' factors, how to solve these in order to record optimum sound
- Technical awareness, because this allows for correct selection of instrumentation in order to record good bioacoustic data

In this chapter we look at an overall view of the development of natural history filmmaking and the different methods of story telling. Because, audio visual filmic presentations regardless of their genre are governed by the laws of dramaturgy and as their paths often intertwine, they leave an influence on those that follow. The topics debated are:

- The development of natural history filmmaking
- The different methods of story telling used in wildlife filmmaking
- Wildlife sound – natural or artificial

The natural history film is the portrayal of events that occur in the natural world and there are various styles these include, science, education, environment and conservation and the Hollywood approach. The following works can be considered as examples of these:

- Scientific – Kingsley Noble's *The Social Behaviour of the Laughing Gull* (1940)
- Educational - *The Undersea World of Jacques Yves Cousteau* (1966)
- Environment and conservation – David Attenborough's *Life on Earth* (1979)
- The Hollywood approach - Brady Barr's *Reptile Wild* (2003)

These different styles of wildlife production copy and adapt filming techniques from each other in their approach to portraying subject/s. And each will undoubtedly encounter a host of problems on location especially when recording sound.

To give a broader picture consider the BBC film *Kingdom of the Ice Bear*. (1985) In one particular scene we see a polar bear *Ursus maritimus* exit her lair and begin to walk around. This scene was an important part of the story, because the narration tells us that '*After a long winter in cramped conditions, the mother leaves her den to exercise*'. The distance between the camera and the bear was approximately 400 metres and a long lens was used to capture the activity, but the sound of the action was not recorded.

The contributing factors to this phenomenon were partly due to (a) the atmospheric conditions of the sound stage – wind and (b) recording sound was not a requirement. But Attenborough in his lecture to the Royal Society, stated that this mute scene needed sound to accompany it and as none had been recorded, it was decided to mimic the bear's footsteps using an effect produced in foley. When Attenborough admitted this fact to the members of the audience, there were many questions pertaining to the reality of natural history films, as they were/are reputed to be factual presentations of the natural world.

### **1.1 The development of natural history filmmaking**

The very early films portraying events of the natural world were considered as the foundation/s on which other forms of filmmaking would evolve for example. Robert F. Scott's *Animal Life in the Antarctic* (1913) and John Ernest and George M. Williamson's *How Life Begins* and *Thirty Leagues Under the Sea*. (1916)

According to Sihvonon the initial purpose of the camera “was developed as a tool for scientific observations.”<sup>1</sup> Those who attempted to follow this directive were American zoologist Gladwyn Kingsley Noble and Walter J. Breckenridge; and as the popularity of wildlife films increased, filmmakers seized the opportunity to reap the benefits. One such filmmaker was Martin E. Johnson with his film *Congorilla* (1932) “the first ever film with sound authentically recorded in Africa”<sup>2</sup> which was subsequently followed by *Baboona*. (1935)

Other filmmakers who presented the inhabitants of the natural world were, Heinz Sielmann a renowned wildlife photographer, biologist, zoologist and filmmaker. Jacques-Yves Cousteau explorer, conservationist and filmmaker who studied the sea and its inhabitants. David Attenborough (Later Sir) broadcaster, naturalist and zoologist. These filmmakers saw the benefits of natural history filmmaking, from a scientific, educational and environmental conservational aspect, delivering their filmic presentations of flora and fauna to audiences worldwide.

Kingsley Noble's experimental research although varied was devoted to the study of courtship behaviour in vertebrates, including fish, reptiles, birds and finally mammals. Noble believed that analysis of the physiological and neurological mechanisms governing behaviour, relied heavily on detailed observations of subjects in their natural environment, thus film became an indispensable tool for his research.

In his film, *The Social Behaviour of the Laughing Gull*, (1940) Noble considers the ramifications concerning the colouration difference in male, female and juvenile plumage and according to him, the resulting difference in plumage colouration has a social significance. The film follows the rituals of courtship, mating, nest building and the rearing of young. Noble's approach to scientific observation using film was the benchmark for other researchers, naturalists and filmmakers to follow.

Walter Breckenridge a director of the Bell Museum of Natural History at the University of Minnesota, recognized the benefits of film as an educational tool. His early films on fauna behaviour for those who were interested in natural history, were shown during the museum's Sunday afternoon programs. Later, Breckenridge produced films to accompany the lectures he gave on his excursions throughout America. Like Noble, Breckenridge's films were primarily scientific, giving an insight into the natural world presenting messages about natural history, conservation and wildlife biology. His later films both silent include *Island Treasure* (1957) and *Migration Mysteries*. (1960)

Heinz Sielmann produced a number of natural history films. His first, *Zimmerleute des Waldes* (Woodpecker) (1938) was a success when presented to audiences in the United Kingdom; and arguably, was one of the reasons that sparked a creative interest in British natural history film production. Sielmann's other natural history films include: *Lords of the Forest* (1958) known in the USA under the title *Masters of the Congo Jungle*. *Galapagos: Dream Island in the Pacific*, (1962) *The Mystery of Animal Behaviour* (1969) and *Vanishing Wilderness*. (1974) From 1965 to 1991 Sielmann produced a

series of films called *Expeditionen ins Tierreich: Expeditions into the Animal Kingdom* - these became one of the most popular animal series portrayed on German television.

Jacques-Yves Cousteau will probably be best remembered for his approach to the natural world via a personal perspective, narrating the story of what he saw and how he related the facts from an explorer's perspective; using his own unique charismatic charm. His basic premise was to reveal, record and portray but not to pass judgement, although the latter became more apparent in his later films. *The Cousteau Amazon Series*, (1982-1984) *Cousteau's Rediscovery of the World I* (1985-1991) and *Rediscovery of the World II*. (1992-1994)

Jacques Cousteau did much to bring life in the oceans to public awareness, his films including *The Silent World* (1956) and *The Golden Fish* (1959) although made for the cinema, attracted vast audiences. Cousteau later made films for television including the series, *The World of Jacques Cousteau* first broadcast in 1966 re-titled *The Undersea World of Jacques Yves Cousteau* and re-televised for a further eight years.

David Attenborough preferred a more scientific approach, imparting information on various species of flora and fauna with relevant explanations; allowing the spectator to receive a more educative in depth view of how the natural world functioned. His distinctive style, has had profound influence on generations of ecologically aware audiences, and his representations that often include a sensitive use of computer-generated simulations, have produced. As Cubitt contends a, "spectacular intellectual montage driven by the desire to communicate scientific theories, as well as a sense of awe in the face of natural complexity and diversity."<sup>3</sup>

Attenborough's films directed solely for television include, the BBC's long-running series *The World About Us*, (1967-1986) that resulted in the creation of the BBC's Natural History Unit. The *Life on Earth* (1979) series and its sequel *The Living Planet*. (1984) These films with their Darwinistic approach, a perspective that emphasises the role of natural selection, portrayed the planet's evolutionary progress, and were the stepping-stones on which other films of this genre evolved. Although other naturalists including the intrepid biologist Dr. David Bellamy with his flamboyant 'hands on' approach were making their mark, Attenborough is probably the most notable, because it was he together with the BBC who pushed natural history filmmaking to the fore.

It can be said the above mentioned filmmakers, depicted their subject/s from a scientific, educational, environment and conservational perspective; though their individual styles were many and varied. These presentations thrilled the spectator/s, because the majority had never seen such creatures in the 'flesh' - although they were portrayed through a celluloid medium. However, this observational footage considered adequate to satisfy the demands of the museums and other scientific institutions, did little to persuade the movie moguls in supporting this genre.

Although naturalists were adamant that any visual representations remain scientific, the need for financial input was a major problem that affected much of natural history filmmaking sector. Thus came the dilemma - on one hand realism, meaning reality that has been manipulated by intervention - and financial assistance. On the other, scientific reality and isolation. And if a filmmaker chose the former, then he/she was bound by the dictates of those who held the purse strings namely Hollywood. Because "Hollywood had decisively defined the terms in which the medium would be used, seen and understood and no one who partook of this technology could evade its influence."<sup>4</sup> But, control was not only confined to Hollywood, in Europe especially the UK other factions including commercial broadcast and corporate institutions were exercising their power.

The natural world is a world of serenity and quietude where its inhabitants conduct their lives at a pace convenient to their particular needs. But, this stillness and silence have no place in the minds of the financial controllers, not because they are incapable of conveying these qualities, but because they are as Bousè points out "incompatible with the social and economic functions of film and television."<sup>5</sup> Film and television are about movement, action, dynamism whereas the natural world rarely functions in this way.

Moreover, "film and television have little tolerance for what is normal and usual in life, thriving instead on what is rare and unusual."<sup>6</sup> The spectacular chases, confrontations and bloody kills portrayed on film and television, occur with "remarkable regularity and predictability; yet are surprisingly rare occurrences in reality."<sup>7</sup> Film and television has become astutely adept in portraying the natural world through realism; "That is at giving convincing impressions of reality."<sup>8</sup> Where stories of the natural world are as Sihvonen suggests "Controlled by the dictates of production and consumption."<sup>9</sup> And according to Nichols. "This concept or practice has no fixed boundaries"<sup>10</sup>

Therefore, filmmakers were willing to compromise their scientific documentation in order to gain funding and still be able to find a balance between science and popular interests. Moreover, as Mitman points out “film could also accommodate the conventions of realism so central to the traditional representational practices of the museum diorama, and to the study of nature in the wild.”<sup>11</sup> As a result, films were typically created to educate the general public although they contained an eye for the dramatic.

To summarise this discussion, it can be said that these early filmmakers depicted the natural world from different directives. Subjects were portrayed from a reality observational viewpoint and also through educational entertainment that incorporated a sense of drama.

## **1.2 The different methods of story telling used in wildlife filmmaking**

Story-telling is the conveying of events in words, images and sounds, often by improvisation or embellishment. Stories or narratives have been used as a means of entertainment, education, cultural and preservation and according to Shedlock. “Story-telling is almost the oldest art in the world - the first conscious form of literary communication.”<sup>12</sup>

Stories can be short and simple or long and complicated, but they all contain the essential elements; the plot, characters and narrative point of view. A story is a 'whole' made up of the action, characters, scenes and sequences, episodes, locations and events; it is as Field points out, “A paradigm of dramatic structure.”<sup>13</sup> All stories have a beginning, a middle and a resolution, not necessary in this order, a story can start anywhere providing it reaches a form of conclusion.

Writing stories in text form has its complications, but turning the text into images and sounds is even more so, because there are many other factors to consider. For example, how the camera is manipulated in order to get the best out of the character's performance, because for every action there is a reaction; and this perspective has to be covered from different angles. Otherwise there will be a lack of continuity, and if this happens the spectator can become confused. And least we forget this directive also applies to sound recording.

Story telling can be relatively straight forward or extremely complicated because much depends on the meaning and message. Rabiger points out that “Film exists to create a sophisticated

consciousness in an audience”<sup>14</sup> therefore, to achieve this factor, the story must have a directive with balanced rhythm, pace and flow. Stories have a beginning, middle and resolution, but how these factors are arranged depend on the narrative, meaning and message, which is. “A set of collectively generated conventions, that enable us to tell each other stories through the orchestration of images, actions, sounds and words in time.”<sup>15</sup>

Rosenthal tells us that “No matter what the film, and no matter who is supporting it, it is essential that the boundaries of the topic and the purpose of the film be clarified from the start.”<sup>16</sup> This is critical, because it states what the film is about, what it is attempting to say and to whom. It also makes the filmmaker adhere to the directive as the film progresses from both an aural and visual point of view. Nonetheless, there are times during the editing process where the story is changed, a practice used by test audiences in the Hollywood sector.

According to Kawin, “There is more to telling a story than having it acted out in front of the camera”<sup>17</sup> and arguably, presenting natural history from an observational concept is not only educative, but has high entertainment values; and would be considered as scientifically and politically correct. And contemporary wildlife films must strive to find a balance between untampered authenticity and drama.

But, there will be those who disagree, their premise is for more realism as Blake argues. “Today’s audience want a story with an uncertain end, with something at stake.”<sup>18</sup> Which brings us to the last example, that being the Hollywood approach to natural history filmmaking. And if this ideology becomes a benchmark, then how do we accomplish this without interfering in what is a natural phenomenon if we are to remain as observers?

Therefore, in many respects, the wildlife film has now changed; metamorphosing as an entity depicting the natural world from a 'new' perspective; one of realism as opposed to reality. And the difference is that reality, can be defined as the quality or state of being actual or true; events having occurred through a natural process. Realism can be defined as reality that has been manipulated by idealistic intervention and to use Grierson's directive; the penalty of realism is that it is about reality and has to bother for ever not about being spectacular - but about being right.

Attempts in trying to portray the Hollywood approach came with such presenters as Mark O'Shea with his *O'Shea's Big Adventure* (2001), the late Steve Irwin *The Crocodile Hunter: Collision*

*Course* (2002), and Brady Barr, National Geographic Channel's *Reptile Wild* television series. (2003) Although these presentations attracted a certain following, they were subject to criticism because many of the animals were subjected to trauma. Moreover, the presenters put themselves at risk - Steve Irwin sustained an injury from one of his subjects, which resulted in his demise in September 2006. Alastair Fothergill executive producer of the BBC's *Planet Earth* series branded the late Irwin a showman, more interested in his own stardom than the animal kingdom.

But much debate regarding the presentation of natural history exists, some maintain that flora and fauna should be depicted from an observational perspective, which can be considered as puristic or traditionalist; a way of revealing the reality and totality of real things and events. Whilst others contend the natural history film needs the assistance of realism - the influence of drama in order to maintain entertainment value.

Moreover, it can be argued that reality and realism are connected, but are they? Reality is a state of being real, a portrayal of an entity or state of affairs. Realism is something that is plausible, but not necessarily a true representation. It is the filmmaker's responsibility to present the whole story rather than make the subject/s into a character/s via the exaggeration of its behaviour.

Adhering to the practice of reality, meaning that which occurs naturally as opposed to human incitement, goading or provocation as Allen points out. "Keeps strictly and often excessively to established or traditional usage."<sup>19</sup> And the problems with this approach, is that it can confine the filmmaker within certain parameters.

But as Kawin explains the challenge "To capture something real and to present it in a way that it will allow it to look real"<sup>20</sup> meaning that, which occurs naturally becomes much more difficult. In addition, the filmmaker has to ensure that this approach as Messaris argues does not, "Present a spectator with a world which is absolutely discontinuous with the real world."<sup>21</sup> But how can we capture something real and present it in a way that it will look real? Kawin explains that, "One will arrive at different ways of letting the real declare itself."<sup>22</sup>

To explain this further, consider *The Blue Planet* (2001) series episode *The Open Ocean* part two. The following scenes are above and below the surface of the ocean. We see a pod of Common dolphin *Delphinus delphis* chasing a bait ball of fish. On the surface, a flock of Cory's Shearwaters

*Calonectris diomedea* waits for the dolphins to drive the fish towards the surface. When the bait ball is in range the birds dive from great heights into the water to join the dolphin's banquet. As the dolphins swim away, Yellowfin Tuna *Thunnus albacares* move in to take their place and the feeding frenzy continues. It is only when the tuna move off, that the remains of the bait ball can dive deeper to escape the marauding birds.

When we look at this scene, we note that cameras are placed at strategic points above and below the surface to capture the 'real' produced by the participants. For example below the surface, the camera looks up from below the bait ball to give dimension and perspective revealing its immense size; and to portray the hungry predators, dolphin and Shearwater's tearing into it. On the surface, the camera slightly elevated above the water captures images of the birds plummeting into the sea to attack their prey. It can be agreed that this dramatic portrayal needs no intervention, but it lacks the support of natural sound.

But, there are many instances where wildlife behavioural patterns are considered mundane; lacking the power to captivate. For example, a gaggle of Barnacle geese grazing peacefully is a natural phenomenon, but from a realism viewpoint this causes problems because the action is minimal although there is an abundance of natural sound. Thus, some form of intervention or incentive is needed to produce a responsive action.

Hiemenz, believes that "wildlife filmmakers commonly use captive or tame animals to play the part of wild animals, and may stitch together footage of several animals and portray them as the same one."<sup>23</sup> Creating as Bousè suggests, "composite characters and events."<sup>24</sup> There is evidence to support Hiemenz's argument for example, in the film *Baja-The Other California* (2005)<sup>¶</sup> a scene depicts the drama between two lizards one predator and one prey.

At the beginning of the scene, we see the prey (Dark green in colour) scampering across the sand with the predator (Tan/light brown in colour) in hot pursuit. At the end of the chase, the victim is caught but the captor's colorisation is green and white and is not the lizard seen in the previous shots. One may argue that the predator (Baja California Collared Lizard) has the ability to adopt pigment change and in this respect the scene would have creditability. However, according to the San Diego museum of natural

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¶*Baja California* was/is a co-production between Austrian television (ORF), Devillier Donegan Enterprises (DDE) West German television (WDR) and North German television (NDR).

history, the Baja California Collared Lizard *Crotaphytus vestigium* does not possess the ability to change colour. Therefore, it would appear from the evidence that the lizards used in this scene were used purely for the purposes of realism.

### 1.3 Wildlife sound – natural or artificial

Returning to his Royal Society lecture, Attenborough stated that:

“Natural history filmmakers inevitably and perfectly properly transform, and certainly change in many ways the reality of what we try to show, we have no alternative if we are to make it into a film that is visible on television.”<sup>25</sup>

For example, a woodland scene showing the four seasons, which has to be condensed into an 8 second shot. We know that what we see has been constructed via the use of computer generated images (CGI) and we accept this, because of the scene's complexity. But, what happens when sounds are deliberately added in place of natural sound that can be recorded or not recorded as the case may be. To argue this issue further, consider the following examples. The BBC film *Kingdom of the Ice Bear* (1985) mentioned in the beginning of this chapter and the BBC series *Wildlife on One* circa 1980.

BBC film *Kingdom of the Ice Bear* (1985) – the problem was centred around the polar bear who was seen exercising her limbs around the confines of her den and to recapitulate, the camera was held to a distance of 400 metres. Evidence of this is due to the images' contrast and definition, that projected a 'hazy' appearance. We also note the location's elements (Wind) in action, which from a sound point of view would have been audible.

In addition, the pads of a polar bear's feet as Stirling and Guravich point out “are covered with small papillae, which increase friction between the foot and the ice.”<sup>26</sup> Maintaining grip and stability when the animal runs and making its movements virtually silent. Therefore, the bear's actions could not have been recorded. Nonetheless, Attenborough argued that the scene needed sound, but the question is why resort to a Foley effect (Custard powder in a silk stocking) when there is natural sound – wind?

In the BBC series *Wildlife on One* circa 1980 the trials and tribulations of the Secretary bird *Sagittarius serpentarius*<sup>¶</sup> are portrayed. The story tells us that this native of the African savannah includes in its diet - a variety of reptiles, which are dispatched by the bird stamping its feet on the skull of its potential meal. However, to capture such an event could cause problems due to a number of factors including (a) height of the grass, 30-40 centimetres (b) the subject's timorous disposition; and (c) the possibilities of the bird encountering its reptilian meal at the right juncture.

To solve the problem a small team (That included the author) was sent to a bird of prey centre in the UK where a secretary bird had been reared as a family pet. This bird had been trained to use its natural hunting instincts via the inducement of rubber snakes. The bird's feet action was recorded on sound synchronised with film and in close-up on a surface made to resemble the African savannah. The end product contained the following sequences; Africa - bird walks through grass and encounters a snake, cut to the UK - bird kills snake with feet, cut back to Africa - bird consumes snake and continues walking. However, prior to broadcast the natural sound of the bird's feet was substituted for an effect (Description unknown) created in Foley and why this transpired remains unclear.

These two examples of sounds engineered in Foley demonstrate how such effects are widely used as opposed to natural sound. But what of the alternatives? - With *Kingdom of the Ice Bear* we know that no natural sound was recorded and Attenborough's argument for incorporating the Foley effect was to keep the scene alive. He maintains that without it, the scene may have lost its impact therefore, it can be argued that the issue here is one of cosmetics.

With *Wildlife on One* there is no clear reason why the synchronised recorded sound was not used. Because both the author and cameraman had taken steps to reproduce a setting on which the action took place from visual references of the subject's natural habitat. It is possible that either the director, producer and or sound editor wanted a more dynamic sound to enhance the dramatic, which again is a cosmetic issue. The issue of natural sound versus artificial will be further debated in the next chapter 'The Importance of Sound' as it relevant to the questions regarding alternative methods.

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¶The Secretary Bird is only found in Africa south of the Sahara desert. Its preferred habitat is open grass plains, steppes and savannah. The staple diet of the Secretary Bird is a combination of small ground mammals and large insects, some young birds, lizards, snakes and occasionally larger creatures up to the size of a young hare. Its equipment for killing differs from all other birds of prey in that it kills by stamping with its long, powerful legs, engaging the short rear talon with the base of the skull of its prey with extreme force and absolute accuracy. <http://www.hawk-conservancy.org/priors/secretary.shtml>

## 1.4 Section summary

In this chapter we have discussed how the natural history film came into being using different styles and techniques. The different methods of story telling used in wildlife filmmaking and the inclusion of realism or drama into the visual. In addition, we have witnessed how natural sound can be discarded in favour of an artificial effect.

## 2. THE IMPORTANCE OF SOUND WHEN COMBINED WITH PICTURE

This dissertation's main research question is solving the problems that occur in wildlife sound recording with emphasis on 'Distance' and 'On-axis' (Direct sound) and the relevant factors applicable are; sound stage acoustics, subject disposition, the approach and instrumentation.

A wildlife film's visual divulges information and the sound delivers emotion. But there are many factors to consider before arriving at this juncture, because the sound track will have a compilation of different sounds. Thus, the sound recordist has to consider not only the visual content and principle sounds required, but additional sounds that are needed as accompaniment. Therefore, to present a broader picture the following topics are discussed, because they are all related to a wildlife film's sound track.

- Sound in the wildlife film
- Diegetic and non-Diegetic sound
- Music
- Narration and subdued narration
- Stereophonic sound
- Fidelity

### 2.1 Sound in the Wildlife film

When sound had been established in wildlife filmmaking, its use brought fundamental changes to story telling. Indeed, the synchronisation of sound and picture (Optical sound printed to celluloid) has enabled filmmakers to demonstrate a greater economy than was possible in the silent era. Now came a

greater freedom and with it, the ability to portray the subject/s from different points of view. According to Reisz and Millar, “The character of a place or a person can be conveyed more directly, because it comes to the spectator in terms nearly akin to those of everyday life.”<sup>27</sup> And sound could not only strengthen the actuality of events, but also sharpen its impressiveness, allowing the filmmaker to demonstrate dramatic emphasis as he/she wishes.

However, the interrelation of sound and picture and the relative amount of attention each is afforded is not easy to calculate, because every presentation is different. And “making a quantitative estimate between the amount of visual and aural appeal can serve no useful purpose.”<sup>28</sup> Because each story regardless of any similarity will be projected through the eyes of the individual filmmaker.

It was mentioned in the introduction that fiction film sound design practises and those of wildlife would be discussed as both are connected by the laws of dramaturgy. Therefore, consider the following examples that are used in fiction and wildlife films to create dramatic tension. The British psychological horror film *The Haunting* (1963) directed by Robert Wise and National Geographic's *Last Feast of the Crocodiles*. (1996)

In *The Haunting*, the story is centred around the conflict between a team of paranormal investigators and the house in which they spend several nights.<sup>¶</sup> In one particular scene everyone has retired for the night and the house is silent, but the silence is short lived as banging and footsteps are heard. (Non diegetic sounds whose source is not visible on screen) Two frightened women (Theo and Eleanor) are seen together huddled on a bed. We see their terrified expressions as they watch the door, with banging and footsteps growing louder and stopping outside; the door's handle begins to turn, then suddenly all is quiet. The initial silence in this scene establishes intimacy and vulnerability and as the sounds and footsteps are introduced the tension begins to mount bringing the drama to its height then relaxing back into silence.

In the *Last Feast of the Crocodiles*, the story focusses its attention on a shrinking waterhole home to crocodiles and the animals that risk all to drink. In one scene a monkey with offspring ventures near the water's edge, but backs away as a crocodile approaches. The monkey tries again but the response is the same, as the crocodile submerges the monkey makes a third attempt, and the crocodile

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¶Actors are: Julie Harris - Eleanor, Richard Johnson - Dr. Markway, Russ Tamblyn - Luke, Clair Bloom - Theo, Valentine Dyall and Rosalie Crutchley - Mr. and Mrs. Dudley, and Lois Maxwell - Mrs. Markway.

lunges ensnaring the offspring in its jaws. The monkey tries to wrench the offspring free, but loses the battle and watches the crocodile devour it. Again intimacy and vulnerability are established through silence rising to a height via a cacophony projected by other animals, (Diegetic or on-screen sound) then relaxing back into silence. These two examples have demonstrated how tension and mood are used to heighten the drama, by the use of simplistic methods to produce intimacy and vulnerability.

However, stories of the natural world are becoming more spectacular, which is a problem, because with the visual content more graphically involved, sound has to keep pace and the difficulties are in applying sound that is not only appropriate, but is in context with the visual. But this sound and picture combination its rhythm, pace and flow have a problem, as the visual must relax after high energy action sequences to allow the audience to recover, so must the sound.

Yewdall agrees, “One must bring the sound track down; the levels should be lowered and relaxed”<sup>29</sup> this is important, because by coming down, the sound track is allowed to rise again. If it is constantly active and loud, “the sound track has nowhere to go - when it must go up for the action moments.”<sup>30</sup> Sound track creation and compilation is about, “conceptualising, designing and executing dialogue, music and sound effects into one continuous fluid audio event.”<sup>31</sup> Its function is to enhance and/or compliment and reinforce rather than disrupt and/or confuse.

An example of this is found in the following films one fiction the other wildlife; a British television series *Jack The Ripper* (1988) and *Crocs of Katuma*. (2010)



1. Graphic depicting Bucks Row in the Mary Anne Nichols scene, 1988 Television series *Jack the Ripper*.

In the *Jack the Ripper* scene, the assailant is about to attack Mary Anne Nichols one of his five canonical victims. Nichols intoxicated has just left a public house and is attempting to make her way home, she has to pass through this area in order to reach her lodgings. Her starting position in this scene is at the number 1. Number 2. is where she drops her purse and goes on her knees to retrieve it and in so doing makes a noise. A window at the number 3. opens and a voice calls out '*what's going on down there*'; Nichols cursing staggers to her feet and proceeds down the row towards the number 4. where the assailant is lying in wait. At this point, the film cuts to another scene (Action at a Police station) thus the tension is reduced allowing the sound track levels to go down, But then rises again as the film cuts back to location number 4. where we see Nichols' corpse.

In *Crocks of the Katuma* (2010) a lioness approaches a river looking for a meal her target is a young hippo located near the water's edge. Other animals sensing her presence move away as stalks her prey. As the lioness makes her strike, the mother hippo sees the danger and rushes to the rescue; thus a confrontation begins. The film cuts at this point showing other animals fleeing in all directions, which allows the sound track levels to go down, then rises as the film then cuts back to a mortally wounded retreating lioness. These two examples have shown how sound track levels are able to rise and fall in enhancing and complimenting the scene; and although they are not pertaining to the main research question, they are a useful observation of one of the many elements that are part of a film's sound track.

The majority of wildlife films will have a sound track containing narration, music, effects and location sound that supports the visual presentation; and there are examples where sound comes into its own and takes a more dominant role. For example, the Emperor penguin scene in *Life in the Freezer* (1993) episode 5. *The Big Freeze*.

Here we see hundreds of ice encrusted birds huddled together being buffeted by fierce winds, the visual gives an impression of extreme cold and desolation; the dramatic tension is further increased by the supporting sound; howling wind. It is true to say that similar choices are made in fiction films where sound design is often more emphasized in fantasy, space or underwater. This is to increase immersion and to offer an understanding of what cannot be experienced at first hand.

Another example where natural sound takes a dominant role can be found in the BBC's *Life of Mammals* (2002), episode 8 *Life in the Trees* where the behaviour of nocturnal animals are depicted on a stage chorused by a large variety of fauna. Other examples where sound plays the dominant role can be

heard by referring to the CD-ROM tracks 01 Amazon Night 1 and 02 Amazon Night 2. The Amazon tracks give a good indication of how nocturnal creatures rarely seen, fill the night with their intense vocalisation dominating all other action.

Some locations due to their landscape configuration are able to produce a natural aural phenomenon. For example, craters, canyons and dense woodland have their own distinctive sound qualities where, the sound is either absorbed or reflected by various mediums creating for example reverberation and phase shift. Other locations such as grasslands, marshes and open spaces are considerably flat, rendering a dull appearance when heard. This is due to the lack of mediums from which the sound can propagate, because of absorption. Therefore, ways must be found to enhance these qualities and these can be achieved via the use of diegetic and non diegetic sound, music, narration. Because quite often authentic sound recordings are unable to recreate the experience of being there or convey their drama.

To summarise this section, we have seen how sound design is used in both fiction and wildlife films to create drama by using both diegetic and non-diegetic sound; and to allow the tension to rise and fall by raising and lowering the sound track levels. How sound is able to present itself in a 'leading role' by offering an understanding of what cannot be experienced at first hand. Different environments where sound has different appearances, due to the existing mediums and because these authentic sounds fail to convey the experience of being there, other sounds are often needed to assist in conveying drama.

## 2.2 Diegetic sound

(On-screen sound) - is sound, whose source is visible on the screen or that, which is implied to be present by the action of the film. Elements within this field include natural phenomena such as wind, water and/or vegetation movement and subject/s vocalization/s. Nonetheless, there is a tendency to over dramatise this phenomenon for example, in *Prehistoric Park* (2004) dinosaur vocalisations can be heard but, these renditions although realistic in their appearance do not coincide with scientific theory.<sup>¶</sup>

According to Holtz, science has shown that vocalisation “is produced via cavities, air sacs and chambers inside the head throat and in some cases the nose or snout.”<sup>32</sup> Therefore, in prehistoric times

¶Norell, M.A. & Makovicky, P.J. 1999. Important features of the dromaeosaurid skeleton II: information from newly collected specimens of *Velociraptor mongoliensis*. *American Museum Novitates* 3282: 1-45. - Barsbold, R. & Osmólska, H. 1999. The skull of *Velociraptor* (Theropoda) from the Late Cretaceous of Mongolia. *Acta Palaeontologica Polonica* 44 (2).

sound resonance was certainly a possibility however, Holtz maintains that. “There is no way to estimate the vocalisation behaviour from a fossilised skull”<sup>33</sup> therefore, vocal construction of creatures from the future as in *The Future is Really Wild Series* (2004) that creates a contradiction. Because from our position as privileged observers, how are we able to hypothesize what is yet to evolve - if we are tied to this present time frame. In truth we cannot, but then again, if there are no audible animal vocalisations, films of this nature could lose their power to captivate.

Other elements within the diegetic include Foley, electronic sound, 'spot' effects and atmospheric, and combined these elements give rise to the sound track's realistic creation where the images come to life; and as Monaco inform us. “In a utilitarian sense, sound shows its value by creating a ground base of continuity to support the images.”<sup>34</sup>

### **2.3 Non-Diegetic sound**

(Commentary sound) - is sound whose source is neither visible on screen nor has been implied to be present in the action. Elements within this field include, sound effects added for the dramatic effect for example, the howl of a timber wolf. Such an effect could be used in a scene where a moose has just given birth and the calf fails to respond to her encouragement to rise. Such sounds do enhance the dramatic but, if they are used excessively, some form of visual representation is needed to justify the usage otherwise, the film becomes confusing.

### **2.4 Music**

Is a vital element in wildlife filmmaking, according to Reisz and Millar its purpose is to “Establish and strengthen the prevailing mood of the piece, and to keep the track live while the commentator is not speaking.”<sup>35</sup> But this is not the total sum of its functionality, Bienvenido points out that. “Music often plays a very important role on the emotional side of the discourse”<sup>36</sup> due to its flexibility and power of persuasion. Wingstedt tells us that music can be categorised into various classes Emotive, Informative, Descriptive, Guiding, Temporal and Rhetorical.

The emotive - where music is used in film to include such functions as describing the emotions of a character, but the character does not have to be human. For example, apes can be and are often considered as characters in their behaviour as demonstrated in the film *Jane Goodall's Wild*

*Chimpanzees*. (2002) Therefore, the emotive can be associated to the behaviour patterns of a mother gorilla grieving over the death of her young.

Wingstedt contends that “The functions of the informative class achieve meaning by communicating information on a cognitive level rather than on an emotional level.”<sup>37</sup> Which would include the clarification of various situations, cultural setting or establishing recognition. For example, Penguins returning to their mates after long periods of time on food gathering excursions.

“The descriptive class is related to the informative class in certain aspects, but differs in that the music is actively describing something rather more than passively establishing associations and communicating information.”<sup>38</sup> This class is different from the emotive class, because it attempts to express, describes and or illustrate the physical world.

In the guiding class musical functions can be described to show or indicate the way, to direct, or influence the behaviour or development directing the spectator's attention to a particular aspect within a scene for example. In *Crocs of the Katuma* (2010) a confrontation between a crocodile and hippopotamus is taking place, presenting an opportunity for a monitor lizard to dart in and egg-raid the crocodiles nest. The lizard action is edited into the crocodile hippo footage to indicate that other actions are in motion.

The temporal deals with time-based dimension of music. According to Wingstedt the two categories are, to define structure and form and to provide continuity albeit long or short term. Although irrelevant to natural history films, the rhetorical class “Functions also come into play when image and music are contrasting, making visible not only the semiotic codes of the music but also the effect of the narrative on how we perceive the meaning of the music.”<sup>39</sup>

However, music can become a dominant factor over powering both the visual, natural sound and narration and therefore, should be used with care for example, *The Blue Planet* series episode *The Deep* (2004) a 90-minute film contains 80 minutes of music, which could be thought of as excessive. But, *The Deep* is a natural history film of oceanic activity, and there is very little natural sound thus, other forms of aural composition are used.

We have the narrators voice who imparts educative and entertaining information, describing the events, which is evenly distributed throughout the film, but alone it is insufficient. We are able to add sound effects in order to make the action more dynamic but, these cannot be over indulged in and, they should reflect the reality of what we see. Therefore, the main ingredient for films depicting marine life is predominantly music. *The Deep's* music score composed by George Fenton was/is to explain, emphasize, enrich and develop emotion within the visual (Because we are now in a world seldom seen) and in so doing, displays all the aspects of Wingstedt's music categorization; Emotive, Informative, Descriptive, Guiding and Temporal.

The following extract from *The Deep's* narration gives an indication of how the music was composed to coincide with the visual presentation.

“At a depth of one thousand meters a new discoveries were made a ‘Hairy Angler’ fish half a meter across, the first time this creature had been seen.

Two thousand meters, a new kind of coral thirty meters high, two hundred meters long with three centimetre tentacles found off the coast of Norway and completely independent of light from the sun. Two thousand five hundred meters an eight meter living fossil, the six-gilled shark unchanged for one hundred and fifty million years seldom seen from submersibles and of which very little is known about its behaviour. Four thousand meters, echinoderms (spiny sea urchins and brittle stars) crinoids (sea lilies), four thousand five hundred meters tube worms *Lamellibrachia luymesii*, and its bacterial symbionts living on sulphide produced by anaerobic oxidation of oil and gas.”<sup>40</sup>

Nevertheless, there are instances where excessive music becomes problematic, because as Reisz and Millar point out the; “Sudden variations in the volume of the sound track are rather disconcerting to the audience.”<sup>41</sup> This is most noticeable when music and narration are used together and one of the reasons for this phenomenon is because; speech and music contain similar harmonics, and our ability to distinguish between them is not always possible. Thus, both music and voice often appear in conflict. But, much depends on their individual properties and how they are/were originally balanced within the sound track.

## 2.5 Narration

Is the process of explaining and/or enhancing the visual via speech, it can reduce certain problems for example, add information to cover a sequence of events that were not captured on camera; but as Rabiger points out. “It becomes one more element to shape and control.”<sup>42</sup> In addition, finding the correct voice for the film is quite difficult, because will the narrator have the qualities to enhance the visual. Arguably, “the search is for one that, by words and quality, can act as a surrogate for one’s own attitude towards the subject.”<sup>43</sup> Meaning (a) that it is limited to factual information, (b) it is emotionally non-manipulative, (c) it avoids judgement unless first established by the visual and (d) it allows the audience to affirm its own conclusions.

Some may contend that narration is important, especially when discussing the behaviour of flora and fauna. Whilst others may infer that narration interferes with the film's visual language. However, much depends on the story, its meaning, message and what reaction the filmmaker is attempting to generate among the audience. We can approach this topic using three modes commonly used in wildlife films; scientific, subdued narration and dramatic narration.

The scientific approach - can be seen as an advantage insomuch that idiosyncrasies peculiar to flora and fauna are explained in an educative, but entertaining way. For example, consider the exotic habits of the Satin Bowerbird *Ptilonorhynchus violaceus* depicted in the BBC series, *The Life of Birds* (1998) episode six *Signals and Songs*. The program’s presenter (Attenborough) sits adjacent to the birds’ display site and explains on camera the reasons for this strange behaviour, and how this particular bird is able to detect any alteration to its decorative arrangement. “This bird instinctively knows if its jewel display has been tampered with. If I place this empty snail shell among the display the bird will detect its presence and remove it.”<sup>44</sup> The visual confirmed Attenborough’s statement thus, it can be agreed that this informative style of narration is beneficial, because it explains certain behaviour that if not there - would leave the spectator in some confusion.

## 2.6 Subdued narration

This form of story telling can be considered perspicuous, because it is used sparingly allowing the visual to explain the action only coming to the fore to support, enhance or explain a particular action; it is also able to cover missed events. For example, in *Crocks of the Katuma* (2010) we witness a

confrontation between a lioness and a Hippo, this action is self explanatory, and does not require further explanation. But, in the following scene, we see a mortally wounded lioness; her lower jaw dismembered; there is no visual evidence of events that led to this. Thus, we can only assume it is/was connected to the confrontation in some way or another. Nonetheless, the scene requires some form of clarification in order to explain how the lioness was injured in addition, there has to be a connection to bridge the two scenes. The following narration taken from the film explains this. “One lion will never eat again, the cubs mother may have crossed an angry hippo – her hunting days are over, she can't even take a drink; its just a matter of time.”<sup>45</sup> We now have an indication as to how the lioness was injured and how the two scenes are connected because of the narration.

Wildlife films that incorporate narration in its lucid form are usually designated for European audiences, not because of their approach to reality, but because of the way reality is approached in content intended for presentations in this market. Nonetheless, these same films if intended for distribution on Asian and American networks are subject to major transformations. Because according to Bousé, “the lives of wild animals, like the stillness of open spaces, may simply be unsuited to film and television presentation.”<sup>46</sup> Not because of any technological incompatibility, rather in the way they are constructed in their portrayal of wildlife. The natural world often has far less to do with science or real out door experience, but more on as Bousé contends, “media economics, established production practices, viewers expectations and the ways each of these influence others.”<sup>47</sup>

Thus, a wildlife film will be radically altered to fit into the requirements, where most of the inactive footage is replaced by action sequences in addition, the script will be changed to accommodate the new sequences. The gentle but friendly narrator is usually replaced by an actor/actress who deliberately emphasises the dramatic, often repeating the same information as Bernard points out. “To remind viewers that they are seeing something for the very first time, or that it is extremely dangerous or that no one knows what's around the next corner.”<sup>48</sup>

A good example of this dramatic narration can be found in *Predator Battleground*. (2009)<sup>¶</sup> In this film lions, jackals, wild dogs and hyenas use a dry river bed to hunt for prey, which is plentiful given that it is the dry season, extremely hot and water is scarce. Yet we see constant battles between the predators whom are attempting to purloin each others kills; and although a spectacle of visual merit, in

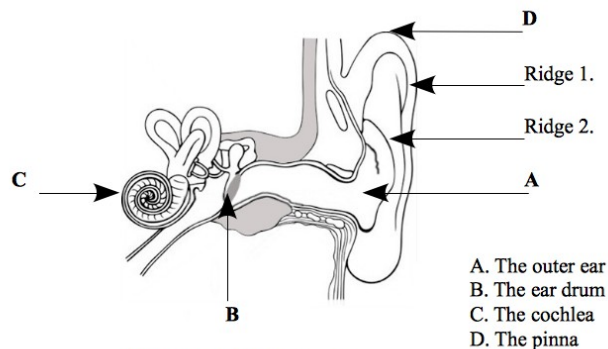
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¶*Predator Battleground* 2009. 50 mins. Director Nathan Pilcher, Narrator Dominic Frisby, Script Writer Percy Hugget. Aquavision TV Productions.144 Western Service Road, Woodmead, Gauteng, 2191 South Africa.

reality would not be the case. Because with the given conditions and ample food resources, these predators would normally refrain from confrontation. Nevertheless, the actions scenes are considerable and are continuously portrayed with very little respite, which is an imbalance between the film's rhythm, pace and flow. Moreover, the dramatic narration is constant often repeating the same information, with over zealous emphasis on the dangers of being a predator. This film was constructed for the American networks in particular; The National Geographic Channel.

## 2.7 Stereophony

Before we delve into the arguments concerning stereophonic sound, it might be prudent to discuss briefly the human hearing and auditory system. Huber and Runstein tell us that, “A sound source produces sound waves by alternately compressing and rarefying the air between it and the listener.”<sup>49</sup> These compressions create differences in pressure that are both above and below normal atmospheric pressure, allowing the ear's auditory components to respond to them. When sound pressure waves arrive at the outer ear or pinna, (which has two ridges) they are collected and directed into the auditory canal.



2. Graphic of the human ear.

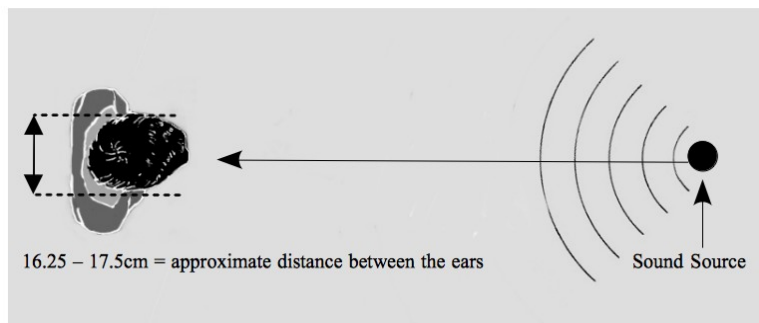
Sound waves traveling through the auditory canal will arrive at the tympanic membrane, (eardrum) and this wave information travels across the air-filled middle ear cavity via a series of delicate bones called malleus, (hammer) incus (anvil) and stapes. (stirrup) These ossicles act as “both an amplifier (by amplifying the vibrations given them by the ear drum many times) and as a limiting protection device (reducing the level of loud transient sounds).”<sup>50</sup> In addition, they act as both a lever

and a teletype, which converts low pressure eardrum sound vibrations into high pressure sound vibrations. High pressure is necessary because, the inner ear beyond the oval window contains liquid as opposed to air. But sound is not amplified uniformly across the ossicular chain, the stapedius reflex of the middle ear muscles helps protect the inner ear from damage. However, the middle ear still contains the sound information in wave form, which is converted to nerve impulses in the cochlea.

The ear an extremely sensitive device has to cope with an immense variety of sounds; sounds that have, are or will be subjected to many changes including amplitude, frequency, temperature, phase, harmonics, timbre and acoustic environment. A more detailed discussion on these topics is explained in the next chapter – The factors influencing wildlife sound recording.

Our perception of direction when discerning sound sources is referred to as binaural localization, a process of using both ears in detecting the origin of the source within an acoustic space. However, there are factors that govern this perception. (a) “Inter-aural intensity differences, (b) inter-aural arrival-time differences”<sup>51</sup> and (c) the spectral colourisation of the pinna.

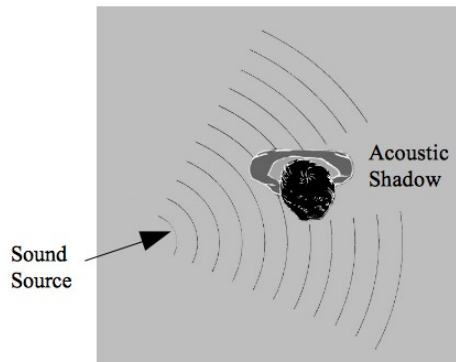
In the following illustration the listener is facing the sound source where the head is aligned in order to receive direct sound to both ears at the same amplitude.



3. Diagram – Listener directly facing the sound source.

However, if the head is turned so that one ear is further away from the sound source, then this will create a phenomenon called an acoustic shadow. In the following illustration, the sound source is to the right of the listener therefore, sound arriving from this location, will reach the right ear first at a

higher intensity level, because the right ear is closer to the sound source as opposed to the left ear. The left ear is further away from the sound source and is masked by the head and this causes inter-aural intensity difference because; from the head's position direct sounds to the left ear are reduced. This reduced area known as the acoustic shadow, permits only those frequencies that have been reflected from the surrounding surfaces.



4. Graphic of an acoustic Shadow.

Therefore, as the intensity of sound at the left ear is reduced, it is natural to assume that the sound's direction is from the right. However, it is interesting to note that this phenomenon has relatively little effect with frequencies at the lower end of the scale, because the wavelengths are larger. This is because "A different method of localization known as inter-aural arrive-time difference is employed at lower frequencies."<sup>52</sup> The illustration also indicates that the acoustic path to the left ear is longer as opposed to the right thus, the sound wave's pressure will reach the left ear later.

The factor responsible for this phenomenon is the human head - due to its ear/brain combination that determines the frequency at, which our sense of direction diminishes caused by the distance separating the ears. (Approximately 16.25 to 17.5cm) According to Aldred this "Is exactly half of the wavelengths of frequencies in the region of 800Hz to 1kHz."<sup>53</sup> Therefore, sound with frequencies approximately lower than 1kHz would have little difference in the time factor, (Although we hear it at a different amplitude) as their wavelength would be larger than 17.5cm. Frequencies approximately above the 1kHz range become more noticeable, because of their audibility, and this gives us a better sense of direction as to the location of the sound source.

It can be agreed that detecting a sound source from the back or front is disorientating, hence the reason for turning the head to align the ears to locate it. “By turning the head until each ear appears to be receiving the same intensity”<sup>54</sup> our sense of direction is formulated. However, the localisation of sound relies on the processing of implicit acoustic cues - and as Hofman, Van Riswick and Van Opstal maintain, “the brain must learn to calibrate these cues”<sup>55</sup> thus, a phenomenon called a Head-Related Transfer Function (HRTF) assists the listener in this respect.

HRTF sometimes known as the anatomical transfer function (ATF) is a response that characterises how the ear receives sound from a point in space - and although as humans we have but two ears, we are able to locate sound from a three dimension perspective. This being distance, direction, above and below, left and right and front and rear; this is made possible because as Starch points out “the brain, inner ear and the external ears (pinna) work together to make inferences about location.”<sup>56</sup> He (Starch) also maintains that we are able to, “estimate the location of a source by taking cues derived from one ear (monaural cues) and by comparing cues received at both ears. (Difference cues or binaural cues)”<sup>57</sup> The monaural cues derive from an interaction between human anatomy and the sound source, where the original sound source is modified prior to entering the ear canal for processing via the auditory system. These modifications include the shape of the listener's outer ear, shape of the head and body, and the acoustical characteristics of the space from which the sound emanates.

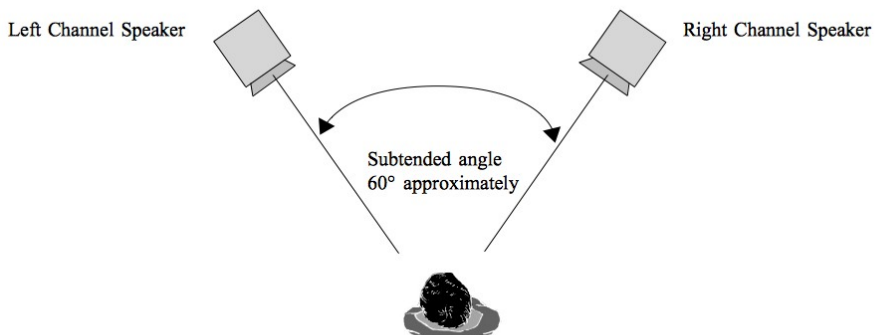
The external ear or pinna as Lonsbury-Martin, Martin and Hannley point out serves two functions. (1) “It aids in sound localisation, especially front-to-back and high-to-low distinctions”<sup>58</sup> And (2) together with the external ear canal, “it increases acoustic pressure at the tympanic membrane.”<sup>59</sup> The pinna has two ridges which reflect incident sound into the ear and these as Huber and Runstein inform us, “introduce time delays between the direct sound (Which reaches the entrance to the ear canal) and the sound reflected from the ridges. (Which vary according to the source location)”<sup>60</sup>

Nonetheless, Huber and Runstein contend that, “beyond about 130° from the front axis there can be no ridge reflections because they are blocked by the pinna.”<sup>61</sup> Therefore, sounds that are unreflected having a delay of approximately “0 to 80 microseconds”<sup>62</sup> will appear to emanate from behind. In addition, the pinna's inner ridge “will produce delays of between 100 and 330 microseconds, corresponding to a source located within the vertical plane.”<sup>63</sup> These delayed reflections radiating from the outer and inner ridges will combine with sound that is direct and in so doing, produce “the characteristic frequency response colourisations that are due to constructive and destructive interference

at differing frequencies.”<sup>64</sup>

The pinna's structures form direction selective filters and depending on the sound input direction within the median plane, different filter resonances become active. These resonances implant direction-specific patterns into the frequency responses of the ears, which can be evaluated by the auditory system. Thus, the brain is able to decipher the colourisations from each ear and provide information to indicate a sound sources position; and this applies to more than one sound source.

The basic principle of stereophony (Commonly known as stereo) is the reproduction of sound using two independent audio channels, through a symmetrical configuration of loudspeakers, which are generally positioned to form an equilateral triangle with the listener. (Illustrated below) The aim is to create an illusion of directionality and audible perspective.



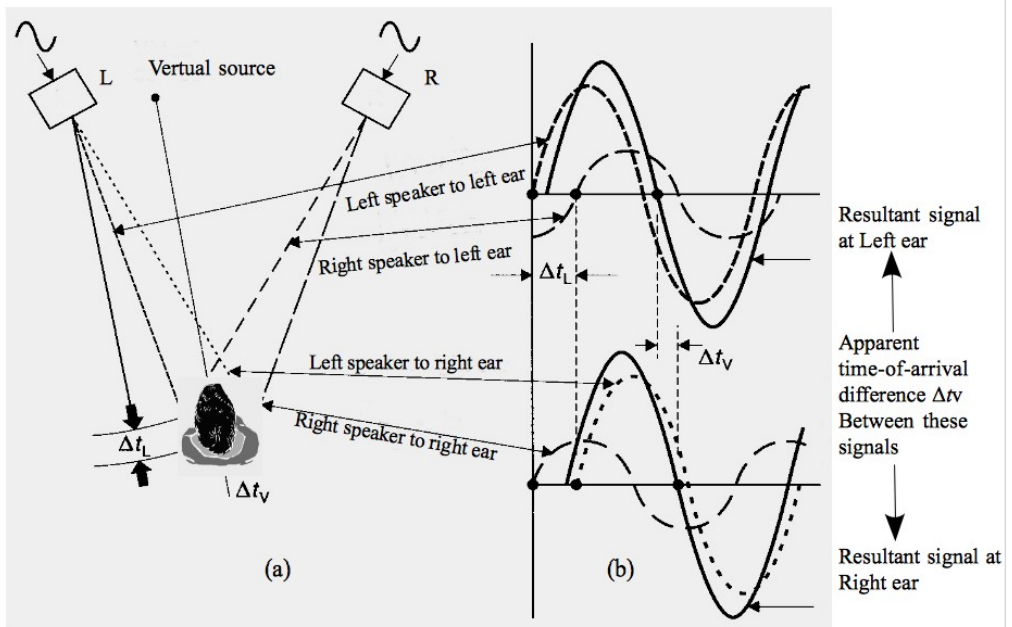
5. Configuration use for stereo listening.

Stereo sound is perceived by the keen sense of direction in our hearing and to illustrate this meaning, consider this entity from a photographic viewpoint. If we study a photographic picture, both eyes perceive images that are identical, but are devoid of perspective or depth. A pair of identical photographs side by side produced by a camera having two lenses equally spaced apart in accordance with human eyes, (Approximately 63 millimetres) would in fact give a third dimension or perspective. However, this would only occur if the right eye concentrated on the right picture and the left eye on the left picture.

When these two pictures are merged together, the images contained within the pictures would be interpreted by the brain as having a third dimension and this principle can be applied to our perception

of stereo sound. In addition, the principles of stereo are founded on the fact that we are able to hear with both ears and interpret the same sound wave, although we hear it at a slightly different amplitude and time. This time difference allows us to determine the direction of the sound source, but this can vary according to the frequency received. As previously discussed, the listener is able to determine to some degree from where the sound source emanates and as Watkinson maintains. “An understanding of the mechanisms of direction sensing is important for the successful implementation of spatial illusions such as stereophonic sound.”<sup>65</sup>

As mentioned above, stereo works by creating sound time arrival differences at the listener's ears. The following diagram (a), illustrates that the difference in time arrival, is achieved by the production of the same wave form at each loud speaker simultaneously; but having a difference in the relative level, as opposed to phase. Thus, each ear will pick up the sound from both speakers and in so doing, calculate the waveforms.



6. Time arrival differences.

A stereo illusion can only work properly if both speakers are producing in-phase signals; and should phase reversal occur, “the stereo will be ill-defined and give a spatial effect without images.”<sup>66</sup>

Another factor to consider is that anti phase connection resulting in base cancellation can occur, when both speakers are in each other's field when low frequencies abound. However, the sound source's position between the two speakers can be controlled by adjustments to the level from each one, and according to Watkinson. "It is possible to 'steer' a monophonic signal from a single microphone into a particular position in a stereo image using a form of differential gain control."<sup>67</sup> For example, a device called a panoramic potentiometer (Pan-pot) is able to produce outputs of equal gain when centralised, and by either moving the control to the left or right, "One output will increase and the other will reduce, moving or panning the stereo image to one side."<sup>68</sup>

The diagram (a) also reveals the sound arriving at the ear, that is on the same side as the speaker is in advance of the same, which is heard by the opposite ear. However, when the amplitude from the left speaker is greater than that of the right. (diagram b) "The sum of the signals received at the left ear is a waveform, which has arrived earlier than the sum of the waveforms received at the right ear."<sup>69</sup> Therefore, the difference in time arrival is perceived as the sound source being due to left of centre.

The coupling of stereo sound and the moving image is now common place, indeed many broadcast companies use this format in their various productions. But, it is not without its problems especially in domestic use – the home; where the majority of films and television programmes are viewed. To explain this perception, consider the following reasoning.

With mono, the key is that the signal contains no level and arrival time/phase information that would replicate or simulate directional cues because, the signals are mixed together and routed through a single audio channel. Mono systems can incorporate multiple and widely separated loudspeakers, still be full-bandwidth with full-fidelity - and are able to reinforce both voice and music effectively. Arguably, the big advantage of mono is that everyone hears the very same signal, and, in properly designed systems, all listeners would hear the system at essentially the same sound level. This makes well-designed mono systems very well suited for speech reinforcement, as they can provide excellent speech intelligibility. However, it can be argued that the downside of mono is because it has very little depth, due to the fact that the signals emanate through one channel thus, comb filtering problems can occur.

Comb filtering can be defined as a frequency response, that is caused by combining a sound with its delayed duplicate. This frequency response depicts a series of peaks and troughs caused by phase interference. For example, when two loud speakers are emitting the same signal at different distances

from the listener, a comb filtering effect will occur. And in a enclosed environment, the listener will hear a mixture of both direct and reflected sound - and because the reflected sound takes a longer path, it constitutes a delayed version of the direct sound therefore, a comb filter is created where the two signals combine at the listener.

To reduce the effects of comb filtering, acoustically absorptive materials are situated at the reflection points responsible for the interfering waves. However, such materials must be of a size and appropriate substance in order to address the frequencies of each specific problem. For example, the Acoustics Science Corporation contend that, “sound panels, sound planks, and fractional tube traps are often used to control comb filter reflections, with the appropriate device chosen based upon the frequency of the problem.”<sup>70</sup>

Stereo sound is considered to have more depth because it is being put through two channels, allowing the listener to appreciate it's dimension giving the spectator the impression that the sounds are radiating from different places thus, placing him/her in the forefront of the action. However, for the spectator in his/her domestic environment, stereo requires optimal directivity pattern sometimes referred to as the “sweet spot”.<sup>71</sup> Meaning the area between the two loudspeakers, where the level differences and arrival time differences are small enough that the stereo image and localization are both maintained. In addition, the entire listening area must have equal coverage of both the left and right channels, at essentially equal levels.

This optimal directivity pattern or sweet spot is limited to a fairly small area between the two loudspeakers and when a listener is outside that area, the image collapses and only one or the other channel is heard. And in a larger venues, a church or theatre auditorium, the optimal directivity pattern or sweet spot might only include one third the audience, leaving two thirds of the audience wondering why they only hear half the program. Moreover, a stereo playback system must have the correct absolute phase response input to output for both channels. Meaning that a signal with a positive pressure waveform at the input to the system, must have the same positive pressure waveform at the output of the system. Thus a clap of thunder when recorded, produces a positive pressure waveform at the microphone and should produce a positive pressure waveform in the listening room.

Stereo sound in the wildlife film like most other audio visual presentations is also common place; and although it can be agreed that stereo adds another dimension to a sound track, there are

arguments for and against its use. For example, Portman contends that “All sound is monophonic”<sup>72</sup> and stereo is merely the reproduction of mono sound; produced using two or more independent audio channels through asymmetrical configuration of loudspeakers. Its purpose is to create the impression of sound heard from various directions, as in natural hearing. It is often contrasted with mono, where audio is in the form of one channel, often centred in the sound field that is analogous to a visual field. Belton claims that stereo is, “unable to displace mono as the dominant, stereo could only retain its place as a variant and as a variant it could only continue to attempt to exploit its spectacular characteristics.”<sup>73</sup>

However, there are those who will disagree with this perception, because to their way of thinking mono recordings are unattractive, because they contain natural ambience. For example, Margoschis argues that “Most people listening to mono recordings which include a background ambience think they are ugly!”<sup>74</sup> Moreover he (Margoschis) claims that “Mono recordings need ideal circumstances, and as everybody knows such circumstances are rare nowadays.”<sup>75</sup> In addition, Margoschis states that “By far, - I claim - the most common 'solution' to the mono-problem, is that the recordist doesn't record! Most of the times when wind or traffic noise is present, the traditional mono recordist leaves his equipment at home; It won't be good anyway”<sup>76</sup>

Margoschis' statements bring into question 3 immediate points, (1) background ambience, (2) the sound stage properties and (3) the choice of microphone and its relation to the sound source. These three factors although only a part of any recording venture are extremely important to comprehend.

(1) Background ambience will always be part of any recording no matter what the location coastal, jungle, desert, arctic, suburban or urban and these locations will have their distinct peculiarities. Because they are part of the natural phenomenon that is applicable to each location nonetheless, Margoschis believes that. “Making stereo recordings means a truly significant simplification of this problem. Even if a stereo effect is poor, even really poor, even really distorted! - there will be a difference between the background and the soloist.”<sup>77</sup>

But, surely, if the 'soloist'/subject's sound is distorted, then it is unclean, tainted. Moreover, the background sound will also be affected resulting in low quality sound and low quality sound is not usually accepted for broadcast purposes. (This will be explained at the end of the discussion) Far better to use different methods of approach when attempting to record the subject. A more detailed explanation on this topic is discussed in the next chapter; The factors influencing wildlife vocalisation recording.

As to Margoschis' statement that mono recordings need ideal conditions, we have to ask what are these ideal conditions? In truth ideal conditions do not exist, there will always be an entity in one form or another to hinder a recording. Brockett concurs, he states that "Excessive ambient noise is one of the toughest issues to work with because often, the excess ambient sound is beyond your control."<sup>78</sup> Skeoch confirms this viewpoint he maintains that "Recording nature is not as easy as it seems! It is an art, not a science, and most often it is the skill and ear of the nature recordist that captures the most evocative recordings."<sup>79</sup>

Other problems to mar location recording are the elements - wind and/or rain; in most cases the microphone can be protected from these, but in other cases these elements need to be heard because they show the reality of what is happening for example. In the CD-Rom disc track 03 Amazon morning we hear the sound of avian calls, but we also hear the sound of rain drops as they fall on the leaves. And as the visual depicts the Amazon during the rainy season, this sound not only supports the visual presentation, it is appropriate to what we see.

(2) The characteristics of the sound stage will have an affect when recording a particular subject, because they are idiosyncratic to their design - meaning what is contained within or without. For example, a forest will have an abundance of vegetation – trees, and these known as mediums will affect the sound source due to their absorption and/or reflective properties. In many respects the same phenomenon can apply to a canyon or gorge due to the surrounding walls; and a coastal sound stage if open, will be affected by the sound of sea wash and wind noise. Therefore, the biggest problem here in reducing these properties, is the relative distance and position of the microphone to the sound source. This subject is given further discussion in the next chapter; The factors influencing wildlife vocalisation recording.

(3) The choice of microphone is an important factor that must be considered, because of its capabilities. In broadcast sound recording, perhaps the most common microphone used for field work is the RF condenser microphone often referred to as the 'shotgun' for example, the Sennheiser MKH 416-P48U3. This short gun interference tube microphone has good directivity and excellent off-axis rejection of sound arriving from the sides and rear. Its other features include; high consonant articulation and feedback rejection, increased directivity due to interference tube principle, very low inherent self-noise and high sensitivity; it is also transformer less and has a fully floating balanced output.

Other microphones containing attributes similar to the MKH 416 and quite popular include: the Sennheiser ME66/K6, MKH70, Neumann KMR 82 and Schoeps CMIT5U and as technology improves newer models are becoming available for example.

The KEM 970 cardioid plane microphone from Microtec Gefell, (Neumann company) a multi-capsule microphone system with unique directional characteristics independent of frequency. It has the characteristic of a cardioid microphone along the horizontal axis, whilst resembling shotgun capability on the vertical with a narrow acceptance angle of about 30°. This directional pattern is well suited to situations where the source to be recorded is widely spread, or moving across the horizontal plane and where sound arriving from other directions needs to be attenuated. The KEM 970 although excellent for a wide range of applications (Radio/television production and large conference venues) is not really a field microphone, because its seven pin Tuchel screw-in connector is incompatible with most field recording equipment. (3-pin XLR connections and circuitry) In addition, it requires a mains supply although a digital version does exist and its price tag of €5,573 + VAT is a major deterrent.

The Schoeps Super CMIT 2U a new category of shotgun microphone using two transducers with a two channel output. (Super CMIT signal in channel 1 and direct, single-transducer CMIT signal in channel 2) This relatively new shotgun is said to increase directivity and suppress diffused sound giving high quality transparent sound. However, this microphone is digital and requires an AES 42 PCI audio system<sup>¶</sup> and at the time of writing, this format is/was only available on more expensive sound recorder/mixer models<sup>¶</sup> - analogue recorders and/or mixers will not function with the CMIT 2U.

Nonetheless, many broadcast companies especially in the UK and main land Europe favour the analogue 'shotgun' due to its high capabilities; and its recorded sound is easily digitized. But, in order to receive optimum performance from a 'shotgun', it should be positioned as close to the sound source as possible, because this will reduce reverberated sound and enhance the amplitude. A more detailed explanation on microphone positioning is given in the next chapter; The factors influencing wildlife vocalisation recording.

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¶ TRACE AES42-4 a PCI audio system with 4 digital microphone inputs in AES42 format with 24 bit and up to 192 kHz. [http://www.marian.de/en/products/trace\\_aes42](http://www.marian.de/en/products/trace_aes42)

¶ Sound Devices 788T portable eight input twelve-track recorder. <http://www.sounddevices.com/products/788t/>

When recording wildlife sounds especially for broadcast, there is a procedure that is adhered to and that is; to attempt to record the cleanest optimum sound available allowing for the conditions that prevail. The BBC for example, require that all wildlife sound be recorded in mono, because this reflects the normal spectral balance of the natural world; meaning sound that has been recorded in its 'raw' state without modification or enhancement. Raw sound can be modified and/or enhanced in accordance with how the sound editor perceives it to be, namely the end product – that which the spectator hears. Sound which has been altered during the initial recording, can often create complications. For example, where a sound recordist has altered the intake level by continuously adjusting the potentiometer commonly know as 'riding the pot'.

Many sound editors prefer uncomplicated recordings (The cleanest sound possible) which, allows them the option to create a sound track to their own design. Therefore, in many cases mono recordings are preferred because, the complications often found when using stereo are reduced. However, if additional sound is required, (And most broadcast sound recordists provide this option to assist the sound editor) then separate recordings of the location in mono and/or stereo are taken. This procedure affords the editor the option of deciding if a particular scene warrants judicial enhancement.

Nevertheless, adding stereo sound to the wildlife film may add dimension and depth giving the spectator a different perspective, an expanse of a natural environment. It can present movement and relative distances between objects in effective ways particularly when the camera changes its point of view. In contrast, authentic mono sound is a natural phenomenon and although has to bother with extraneous ambient sounds has always served as the realistic form of sound production.

Portman, Watkinson and Belton *et al.*, agree with this contention, “most available recordings of the natural world are garnished with the niceties of stereo and in many cases the goal is novelty rather than realism.”<sup>80</sup> But stereo has more depth and dimension, which monaural sound is unable to do. These are the alternatives that the filmmaker and or sound designer must decide when compiling a wildlife film's sound track. No doubt there are many issues pending for both mono and stereo sound practitioners, who will continue to debate their arguments in support of their beliefs.

## 2.8 Fidelity

Fidelity is the degree of accuracy with which sound is recorded or reproduced and it also means loyalty or commitment, meaning applying sound that was recorded from the locations presented in the film. Using sound from other sources as opposed to where the film was originally shot, can cause problems, because every location is different in portraying acoustic characteristics for example, natural ambience. When incorporating sounds from other venues, their properties often differ, although they may have similar sound stage acoustics; hence the need for alteration and/or enhancement via engineering. Nonetheless, this is a practice commonly used in natural history filmmaking and numerous reasons abound. For example, to aid the mute cut-away image, to replace distorted sound and to make the track or scene more interesting for the spectator.

If we begin with the concept that the word 'sound' as Huber and Runstein tell us is only a given name for the “brain's interpretation of a certain type of physical stimulus arriving at the ears.”<sup>81</sup> We are able to comprehend this phenomenon in three ways; (a) the nature of the stimulus (b) the characteristics of the ear as the transducer and (c) the psychoacoustics of hearing; which deals with how the brain interprets the stimulus.

As we are aware, sound requires a medium in which to propagate such as air molecules, but in this medium sound will change according to the temperature and as Aldred tells us. “This is borne out in practice by the tuning of wind instruments in an orchestra, which tend to become sharp with a temperature rise and go flat with a temperature fall.”<sup>82</sup> But sound is not only effected by the temperature, it is effected by mediums that absorb and reflect it, which in turn effects the harmonics of sound. “It is the very presence of harmonics which determines the sound quality.”<sup>83</sup>

For example, in a canyon, sound will be reflected off its stone walls giving a reverberated sound; whereas sound recorded in an open field would have a flat sound because there are no mediums (Trees, buildings) to reflect it. Another important factor is the actual sound source – fauna. Species of fauna are either diurnal or nocturnal for example, birds will be active during the day and insects will be active at night. Therefore, as sound is affected by temperature (Also referred to as refraction) and the reflective mediums, there will be a remarkable difference in the harmonics of a particular sound source in a certain location during a 24-hour period. To demonstrate this argument listen to the following tracks on the CD-ROM audio disc.

01 Amazon Night 1 - 0.46 Sec - 02 Amazon Night 2 - 0.46 Sec

03 Amazon Morning 0.62 Sec - 04 Distant Howler Monkey 1.02 Sec

Using sound from other sources as opposed to where the visual was recorded does have its consequences, because (a) the listener can become confused when the sound harmonics do not reflect the reality of what is seen. And (b) Sound *mise en scene* tends to make the presentation lose its credibility if the accompanying sound or effect is not in keeping with what is seen. To explain further, consider the two following examples. *Search and Rescue* circa (1980s) and *Polar Bear Diary*. (2004)

In Harlech Television's *Search and Rescue* this series depicts humans being rescued by animals. In one particular episode, an African elephant is used to push over a tree. For technical reasons the tree had been sawn off elsewhere, but was replanted with roots attached in a pre-excavated hole; the area was subsequently landscaped to give the impression of reality.

The purpose of the exercise was to portray the elephant's strength thus, a camera was positioned to capture the roots being ripped out as the tree was pushed over. However, according to Glasier "the tree came over but the roots remained obstinately in the ground."<sup>84</sup> The tree was reassembled and replanted with a crane holding it in position, with earth loosely packed around its base. Visually the second attempt was successful, but for the sound there were noticeable problems.

To explain further, in reality, a tree contains a large proportion of earth around its base due to its root system; when pushed over much of this earth will remain attached and this causes a 'ripping' sound as the earth breaks up. Moreover, as the tree falls roots will break creating a variety of 'snapping' sounds. In this case as the roots pulled through the loose earth, the critical sounds were missing. To solve the problem, the original sound was mixed with similar sounds from other sources; but were obvious in their mismatch because (a) they were not in synchronisation with the visual and (b) and their infidelity was apparent.

In National Geographic's *Polar Bear Diary* (2004), evidence indicates that the film's sound track is/was a montage of aural renditions, taken from locations other than where the visual presentation was filmed. Factors supporting this consensus include; (a) the lack of synchronisation between sound and picture, (b) sounds crucial to the picture were absent including, the vocalization of two bears in

confrontation over a carcass. (c) The harmonics and clarity, did not coincide with atmospheric conditions normally found in this arctic environment thus, it can be argued that adhering to fidelity was not a consideration. This argument is corroborated via the films credits, which state that the sound track was compiled by sound designer Dan Gibson.

The problem with incorporating sounds from other venues, is that their harmonic properties differ from those they are intermixed with thus, the need for alteration/enhancement via engineering is required. But the end product is often poor because, it lacks acoustic detail and as Traux explains; “These can change a listener’s habits or modes of listening particularly through frequent exposure.”<sup>85</sup> Because the spectator can become familiar with these sounds and through time; accept them as authentic renditions of reality. Moreover, as Schafer contends they “Tend to pollute their natural counterparts; they change the audience’s perception of what is real and what is not.”<sup>86</sup> Whereas natural sounds as Brady infers, “Are unique in reflecting the physical world’s complexities.”<sup>87</sup>

To pursue this argument, three examples are given, which can be found on the CD-ROM audio disc. Track 06 Indian elephant in the jungle, track 07 the lions roar and track 08 the Red fronted Conure.

Track 06 Indian elephant in the jungle is a compilation of sounds taken from various subjects, (CD-ROM audio disc tracks 09, 10 and 11) and mixed together to give a representation of the natural world. But, it contains idiosyncrasies that deny this for example, (a) the sound was recorded in a zoo and evidence to substantiate this claim stems from its ambience. The timbre is too deep due to the surfaces from which the sound is/was reflected, (Concrete flooring and walls) - this is clarified by the resonance of a bird’s squawk who was kept in similar conditions. (b) The track is sterile and devoid of natural ambience as would be normally found in the wild. The individual vocalisations have been mixed together instead of being layered; lacking the impression of depth.

To explain, a sound image contains a background, middle ground and foreground and this gives the impression of depth, because we are able to differentiate between these three sections and the sounds contained within. To give a further understanding of this, refer to the CD-ROM track 02 Amazon Night 2 - 0.43 Sec.

In this recording we hear vocalisations of primates and bird species that are distant, and this can be deemed as the background sound because the sound image gives the indication of a wide perspective.

We also hear more prominent sounds that of insects, which can be construed as near and this would represent the middle ground. The foreground in this instance is represented by raindrops falling on leaves, which are pronounced. Therefore, it can be agreed that this particular recording contains the perspective of depth as opposed to track 06 Indian elephant in the jungle, which does not - and the clue to this, is in the ambience of the Amazon night track. And (c), track 06 Indian elephant in the jungle contains human voices that are out of context and this corroborates the argument.

Track 07 the lion's roar was recorded in captivity and evidence to support this claim is due to the resonance of the sound reverberating off the enclosure's walls. Under natural conditions this sound would have produced a flatter timbre, due to the lack of mediums from which the sound can radiate. Another point to this argument is that the lion's vocalisation is unnatural, it was probably induced via provocation during feeding time - evidence to suggest this stems from the vocalisation's repetitiveness.

Track 08 Red fronted Conure was recorded in a room and information to support this argument derives from the sound's 'dead' appearance. The cause of such a 'dead' appearance is due to surrounding objects having high absorption properties such as, carpets, curtains and soft chairs. Had this Conure's vocalisation been recorded under natural conditions, the ambience would reveal other sounds including wind and/or foliage movement. Moreover, there would be more depth in the sound, giving the impression of space.

## **2.9 Section summary**

This discussion has delved into the fiction film to show how sound is used to enhance the drama. It can be complicated as in the banquet scene in Oliver Stone's *Alexander*, (2004) or simplified as in Roberts Wise's *The Haunting* (1963) and the Mary Anne Nichols scene in Jack the Ripper. It allows the sound designer and/or filmmaker the option to formulate his/her own perception, of what they conceive to be the most dramatic for the spectator. The discussion has touched on diegetic and non-diegetic sound, to show how these can be used to their full advantage in visual support. On music to reveal how through its compilation and persuasiveness can further the drama through emotive, informative, descriptive, guiding and temporal ways. On narration to show the different approaches used to develop the story. The properties of stereo, how it is perceived, its function and the different opinions on its relation to the wildlife film. On fidelity; sound taken from other venues and the problems that can occur when mismatched. Also included throughout this discussion were the following CD-ROM sound tracks;

01	Amazon Night 1.	0.46
02	Amazon Night 2.	0.46
03	Amazon Morning	1.04
04	Distant Howler Monkey	1.02
05	Natural wind	0.47
06	Indian Elephant in the jungle	0.53
07	Lion's roar	1.22
08	Red fronted Conure (Parrot)	0.53
09	Monkeys (Species unknown)	0.25
10	Macaw and other birds	0.53
11	Indian Elephant	0.34

These tracks are important and relevant because, not only do they demonstrate and explain within their own right, they support the argument. And finally, the point of this discussion is to show that each section is an important factor in sound recording, and from a wildlife directive; how they are appropriate, utilised and displayed to their full advantage.

### 3. THE FACTORS INFLUENCING WILDLIFE VOCALISATION RECORDING

In this chapter, we consider the factors that influence natural history sound recording and the associated problems, because they are related to the main research question, which is solving the 'Distance' and 'On-axis' issues. The topics discussed are:

- Understanding the sound stage - Distance and Direction – Amplitude – Phase – Frequency
- Harmonic content - Inharmonicity - Masking - Subject disposition - Section summary

In early wildlife sound recording, the general consensus was to mimic camera perspective via the camera's point of view therefore, as Holman points out “a wide master shot contained greater reverberation than its associated close-ups.”<sup>88</sup> This caused problems because when the particular scene was edited together, a noticeable change in reverberation was apparent. “The microphone perspective was loosened for the master and tightened for the close up.”<sup>89</sup> Thus, attention was drawn to the sound

track due to unnatural changes in editing that are not duplicated in natural circumstances.

In copying the camera perspective, positioning a microphone over a camera would seem logical, indeed many cameras incorporate this function in their design. For close up news reportage this may be acceptable but, in wildlife filmmaking it does not work, because a fixed microphone cannot match the lens changes. But as Ginsburg points out “there is a tendency for filmmakers to rely too heavily on their camera mounted shotgun mics rather than separately mounted boom mics.”<sup>90</sup> Ginsburg makes an important point, because this methodology captures many sounds within the area that are not necessary of interest. This causes major editing problems in addition, camera mounted microphones are susceptible to handling noise for example, the sound of the motor as the camera's zoom control is used.

An example of the problems using camera mounted microphones is found in *Grey Seals: Life on the Edge*. (2006)<sup>¶</sup> In one particular scene the camera positioned on the cliff edge looks down on two grey seals, resting in the surf in a small cove. The shot is wide and in this instance, the camera’s on-board microphone captures the ambient sound reflecting the visual perspective. But, when the camera zooms into a close shot, the on-board microphone is recording the same sound perspective as in the previous shot thus, continuity between sound and picture is broken. Evidence to support this argument is found in the film's footage.

- (a) The camera's position on a coastal cliff edge is prone to atmospheric conditions for example, wind; and this sound is noticeable
- (b) The close shot depicts wave (Surf) action, this should have been reflected in the sound, but it was absent
- (c) The change in timbre and clarity of the recording would have been more apparent due to the sound being reflected off the cliff walls
- (d) If the camera’s position had been closer to the seals, (Arguably ground level) the wind noise may have dissipated or at least been reduced, due to surrounding cliff’s shielding properties
- (e) The on-board microphone has delivered one perspective throughout the film; a wide point of view

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¶*Grey Seals-Life on the Edge*. 46 mins. Jacquie Cozens. Flat 3, 7 Sydenham Ave, London SE26 6UL. UK.

Attenborough has pointed out that, “distance is the biggest problem we have, because there is no microphone that can record from afar.”<sup>91</sup> Recording a 'single' sound from a distance causes problems, because the recording will be tainted with other sounds that corrupt, and in many cases, the recording is often discarded.

The distance between the subject/s and the microphone is a critical factor because it affects direct sound, and if the intake volume is increased to compensate, then all sound elements within the microphone's receptive response are enlarged. The only way to eliminate unwanted elements as Holman tells is by, “Decreasing the distance between a microphone and a sound source, this decreases reverberation and increases direct sound.”<sup>92</sup> And in a sound/picture combination, this is a crucial factor because the sound properties must match what is seen.

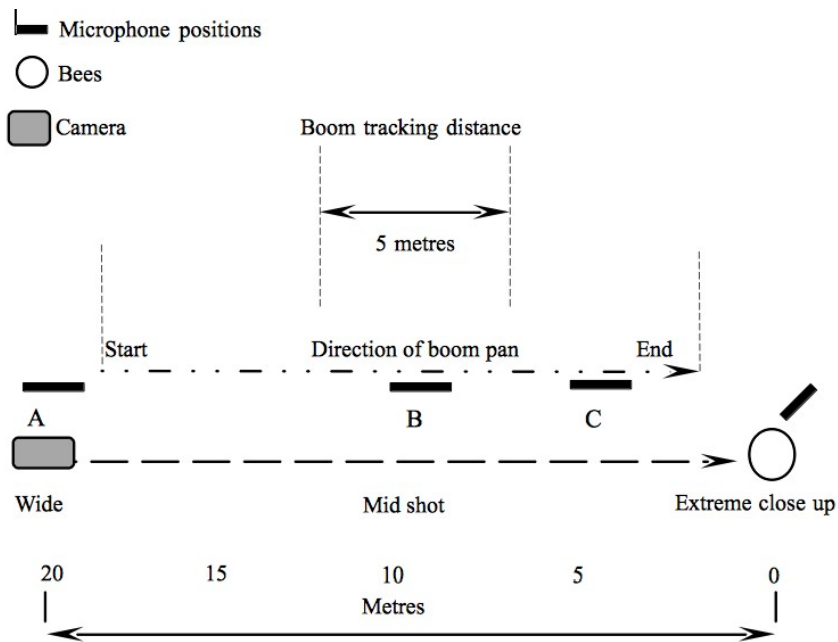
However, instances occur where different visual perspectives incorporate a variety of sounds including the principle one. For example, if an 'on camera' presenter were describing a particular species of flora in a rain forest, not only would his/her voice be audible, but other sounds that are associated with the location. When these sounds are combined, determining the differences between individual sounds is possible due to “The human perceptual capability that resolves the various elements into separate auditory objects.”<sup>93</sup> Meaning that although we can hear many sounds at the same time, one sound can be distinguished from another.

Sub section summary - This section has explained the problems that will occur when using camera mounted microphones and the given example *Grey Seals: Life on the Edge* is evidence of this. As Ginsburg contends, in order to record optimum sound, boom mounted microphones have a distinct advantage over those mounted on cameras, because they can be moved closer to the sound source.

### **3.1 Understanding the sound stage**

In 1992 the author was the production sound recordist for a Peruvian Television production on killer bees. In an opening scene, the composition called for a wide shot zooming into an extreme close up on bee activity at the hive. The camera's position was held to a distance of 20 meters due to the subjects aggressive behaviour therefore, to match the camera perspective the following methodology was used.

- Three wild track recordings were taken prior to the scene being filmed, the first from the camera's position (A) a second from mid-distance, (B) and the third from the same position with the boom extended towards the hive (C).
- To record bee activity a hidden microphone was planted approximately 30 centimetres from the hive<sup>¶</sup> and for the synchronized shot, the boom was stationed at point (B); the following diagram illustrates the set up.



7. Diagram of a recording plan for killer bees.

In looking at this example, we note that the scene contains a variety of shots; wide, mid and close-up although they were in one continuous movement and all will have different sound perspectives, that are affected by the sound stage acoustics. Distance, amplitude, phase, frequency, masking and harmonic content due to the mediums that abound.

<sup>¶</sup>This was achieved by dousing the nest with smoke to placate the bees prior to filming.

This sound stage had an abundance of vegetation and this would reflect any sounds causing phase shift. (This will be discussed shortly) Hence the reason for the planted microphone, positioned close to the hive to eliminate this and in so doing, capture uncontaminated bee sound. Knowing that the camera's movement would incorporate a wide into a close up using zoom, two approaches were used. The first was by recording 3 separate tracks using a wide, mid and close up perspective; these were for optional back up purposes and to capture the location's ambience. The boom tracking movement was performed, because not only were sound and picture in synchronisation, there was the probability that other activity may be caught on camera for example, a bird flying by. The technological equipment needed for this venture was a recorder and two short shot gun microphones.

It can be construed that in this example the sound recording approach was excessive and not necessary, but in hindsight if one has ample material then it can only benefit the editing process. Alternatively, insufficient material can only lead to unwanted problems. Some may contend that this example is relatively uncomplicated because access to their environment was straightforward. But what approach can be formulated for subject/s whose environment/s are difficult to access for example, birds high in the canopy of a densely forested terrain. The problem here is twofold, (a) closer proximity to reduce unwanted elements, (b) differentiating the subject/s call or song from its rivals; and isolating it from calls of other birds within the same vicinity. This problem will be discussed later in this study.

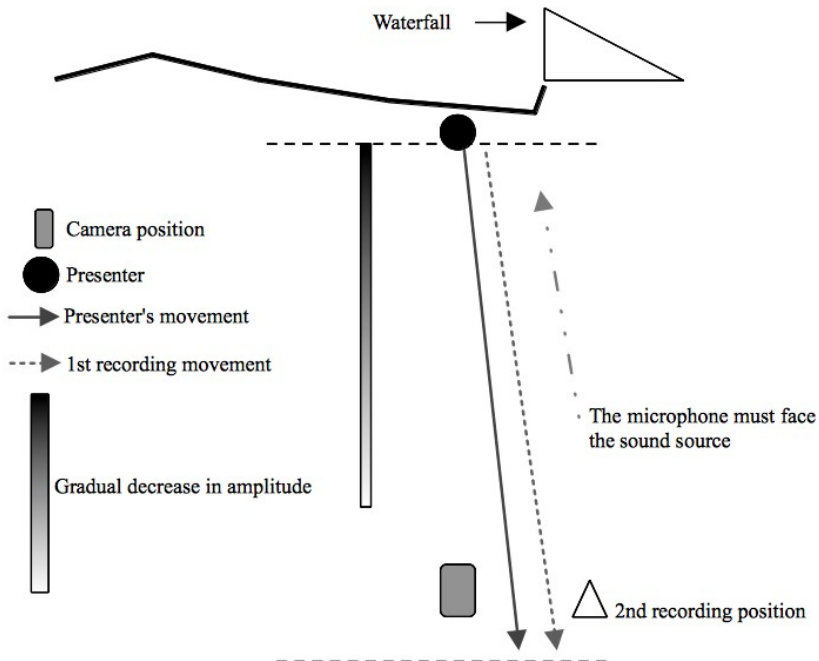
All sound stages are unique, in that their acoustic properties will produce a variety of ambiances, which will be affected by phase, frequency, amplitude, masking and harmonics. Moreover, the very nature of the location can produce sound of such an intensity as to cause problems especially when the presenter is 'on camera'.

For example, in the BBC's *The Living Planet* (1984) Episode 1 'Sweet Fresh Water', Attenborough is narrating the river Amazon's journey from its source to the sea. He is depicted in a wide shot watching the river cascading over a waterfall, he turns and walks towards camera eventually exiting frame right. As he turns from his position by the waterfall he explains that - '*although this waterfall is the last obstacle for the river; it still has a long way to go before reaching the sea*'.

In this instance, phase, frequency, amplitude, masking and harmonics are very much apparent and the problem is that any dialogue will be affected by these entities. As the shot is wide, using a boomed microphone to record dialogue is not a recommendation because. (a) The waterfall's amplitude

would mask his voice, and (b) to record the dialogue, the microphone would have to be that close it would be in shot. Arguably one could use a radio mic, but there is an added problem in using this method, because as Attenborough turns away from the waterfall the change in amplitude will be noticeable so microphone control is an important consideration.

The following approach is how the author would have solved the problem. Two recordings can be taken (a) one from the presenter's position, at the waterfall, retreating back towards his exit point. This gradual decrease in amplitude should give a natural aural perspective matching the action and can be used as the guide track. (b) The second is for Attenborough's footsteps as he approaches camera. The radio mic's intake volume is turned down whilst he is looking at the waterfall; then turned up when he turns away. And when these are mixed together, a balanced recording should be achieved. The following diagram illustrates the working method.



8. Diagram showing a working method in reducing amplitude.

In this next example the problems are with phase shift, reflections, distance and direction and these will affect any sound/s emanating from this location. In looking at the scene, we can ascertain that vegetation to the right of the track is not quite as dense as on the left as confirmed by the amount of light penetration. Therefore, from a sound recording perspective we are able to divide the scene into three parts; left, centre and right. (Solid white lines) With our recording positions located along the broken white dimension lines, (In accordance with ground level) we are able to comprehend the difference in ambience within these three sections.



9. Graphic illustrating ambience in a pine forest.

The left section is heavily wooded and sound from this area would be subjected to much reflection therefore, phase shift becomes a problem. Moreover, ascertaining a particular sound source's location, becomes more difficult because, although we can hear it we cannot see it; and sounds emanating from above will be affected by comb filtering; a delayed version of a signal to itself, that causes constructive and destructive interference. In addition, sound at ground level would be greatly reduced, due to a build up of decayed vegetation, which absorbs sound. Moreover, as sound is affected by temperature, this would be noticeable because of the lack of air circulation caused by the dense vegetation; and the deeper we venture into the forest, the more apparent it becomes. The ambience radiating from the left section, would only change when the recording device is elevated to a higher position closer to the tree line; or moved towards the centre section.

The centre section is an area open to the elements as confirmed by the track way and although the same problems would be in situ, there would be a noticeable difference. Furthermore, the ambience should sound brighter due to air flow and the problem with sound absorption would be reduced, because there is little decayed vegetation. In addition, the ability to locate a sound source's direction improves, but determining the distance does not because our field of vision is still restricted.

In the right hand area the forest becomes less dense and although the problems with reflection and phase shift, would not dissipate entirely, they would be greatly reduced. Our line of sight has now improved thus, determining a sound source's direction becomes much easier as does our ability to assess the distance. The ambience in this section becomes much brighter due to air flow, which allows other sounds to be heard.

The final example in this discussion concerns itself with intake volume control and distance. A common methodology in recording wildlife vocalisation, is the propensity to increase the recorder's intake volume. But in doing so we are allowing all other sounds within the immediate vicinity, to infiltrate the recording and the result is that the principle sound/s becomes less useful.

As previously mentioned, the most logical solution would be to move closer to the sound source as this would reduce unwanted sounds. But if we adopt this approach the chances are that the subject/s will abscond. Some have argued that by changing the microphone this will reduce the problem; and in many respects this option does work for example. A general purpose field recording microphone such as the RF electret condenser shotgun, (Sennheiser MKH 416) has a wide field of reception, suited for many recording situations. A long shot gun (Sennheiser MKH 816) has a narrower field of reception and is extremely capable at distance.

The problem here is in deciding which alternative to use, whether one wishes to opt for a wider perspective forgoing direct sound; or for direct sound at the expense of a wider directive. Ideally, it would be better to record both perspectives, because this directive will allow for more freedom during editing. Alternatively, one may wait to see what the visual perspective will be and then decide the approach. The following illustration is a good example of this.



10. Graphic displaying a Gannet colony

The illustration portrays a Gannet colony *Morus bassanus* and as we can see there are birds in close proximity, in a wide point of view and in flight therefore, sound would be radiating from all these perspectives. Does the sound recordist opt for a generalised sound, a tighter viewpoint of the birds in the foreground; or distant sound - the birds in flight; much would depend on the visual preceding this scene and what will succeed it. Therefore, it would be prudent to take a recording of the three perspectives.

Sub section summary - The killer bee and 'waterfall' examples have demonstrated that by using a methodical approach to sound recording, all aspects of visual representation are covered. An issue that a sound recordist must consider when deciding which alternative is the better solution. This section has also given a brief insight into understanding the sound stage and its associated entities, which are important factors to consider when recording good wildlife vocalisation. The sound stage topic will be covered more extensively during the chapter concerning the practical field experiments.

We now turn to the following important topics; distance and direction this being the main research question in this thesis. This particular issue cannot be covered in depth in this section, because it reappears in further discussions throughout this study to explain other associated problems. Therefore, it is discussed in general terms. Other topics are: amplitude, phase, frequency, masking, harmonic content and subject disposition. These are well known problems frequently encountered and included are common solutions. Many of the topics listed here have been covered extensively by other authors and little can be gained in giving long explanations therefore, they have been condensed but still keeping the relevant information.

### 3.2 Distance and Direction

Determining a sound's distance and direction via ear/brain combination is referred to as Huber and Runstein point out “A sense of the acoustic space in which a sound occurs.”<sup>94</sup> This theory can be accepted when applied to an enclosed space such as an auditorium or concert hall, because the sound within is confined. Arguably the same directive is applicable to sound from an outdoor music concert, but sound from such a concert is usually propagated from one focal point; that being the same as the musician/artist. Thus, determining the location of the sound source is simplified, because not only can we hear it we can also see it.

But in the natural world there are many cases where we are unable to see the subject/s although we can hear them for example, dusk in the Amazon jungle. Birds return to roost rendering an aural cacophony, enhanced by primate calls and the commencement of insect vocalisation. This creates an acoustic space where sound radiates in all directions at the same time. In an environment such as this, it is possible to locate the direction of some individual sounds, by turning the head and align the ears to ascertain their location with the possibility of seeing it or them. But there are instances where we can hear but not see and to explain this phenomenon more clearly consider the following example.

In 1992, attempts were made to record the vocalisations of the Black Howler Monkey. *Alouatta villosa*<sup>¶</sup> At base camp these primate calls were pronounced due to atmospheric conditions, and properties of the surrounding mediums from which they were reflected. Determining the primate's direction was assessed by using a long shotgun microphone, (Sennheiser MKH 816) but calculating the distance was difficult. Although advancement towards the sound source (2 kilometres) showed improvement in

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¶The Howler monkey has the loudest vocalisation of any land dwelling animal (110dB-130dB).

amplitude with its direction remaining the same, determining the primates location was not possible. Estimates concluded that these primates were more than treble this distance. (6 - 7 kilometres approximately) Reference to this example can be heard via the CD-ROM audio disc track 04. (Distant Howler Monkey)

Distance and direction are important factors in wildlife sound recording in order to achieve the best sound possible allowing for the conditions that prevail therefore, let us consider this scenario.

In a tree approximately 40 metres away sits a bird whom is in full song and at this distance the song is audible and the subject is visible. The question is - does the recordist record the song from this distance, (40 metres) or move closer to the bird. If he/she records the bird's song from a 40 metre distance, then all other sounds within the vicinity or location will be recorded as well. And because these sounds are potentially equal in loudness, they are also audible. The recordist has two potential options to record optimum sound; (a) he/she moves closer or (b) selects different technical equipment.

(a) By moving closer other sounds may be apparent, but the bird's song has an increase in amplitude, which will be more prominent.

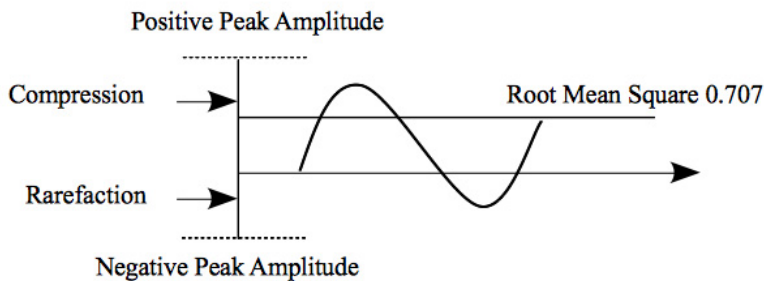
(b) selecting a particular microphone could be the solution, but it would have to be able to reject other signals from the sides and rear. These are the alternatives which a recordist has to decide.

An example of these alternatives is the author's sound recording of a Herring Gull *Larus argentatus* nest site. (CD-ROM disc - track 12 Herring gulls) The options were to move closer to the subject/s or select a different microphone technique, the preferred choice was to move closer to the subject/s. In this recording (Taken from a distance 15ft or 4.5 meters) we are able to determine that although the recording contains atmospheric ambience, the gull sounds are prominent and distinctive.

Sub section summary - To sum up this discussion, we know that a particular sound source when recorded from afar will have additional sounds that are noticeable, and from this we are able to recognise the appearance of distance and direction. But if the recording device is moved closer to the sound source, it becomes prominent and distinctive over other ambient sounds, and this gives the appearance of nearness. Thus we are able to assess the distance factor to some degree. These examples are 'food for thought' for the sound recordist in deciding, which alternative is more advantageous to the situation.

### 3.3 Amplitude

Defines the strength of a particular sound wave or as Aldred contends, “The maximum displacement of any particle matter”<sup>95</sup> and this according to Alkin, “Is a measure of the extent of the wave”<sup>96</sup> meaning the distance found above and below the centre line of a waveform such as in a pure sine wave as shown in the following illustration.



11. Graph of a pure sine waveform showing amplitude values.

The positive and negative maxims of a wave are generally called its peak amplitude value, and when combined the difference between both positive and negative peaks are referred to the peak-to-peak value. The development of the root-mean-square (RMS) value was to obtain a meaningful average between the two values, in order for human ears to perceive the signal level. But before proceeding with the RMS discussion it is important to explain what average means.

The meaning of average when dealing with waveforms, is the same as its common meaning. Thus, by sampling a graph of a waveform be it voltage, current, power versus time - at equally spaced times; then proceed to add up their values and divide by the number of samples, we would in effect have the average value of that voltage, current, power, or whatever the waveform represents. And the smaller the time intervals between samples, the more accurate the average will be. Therefore, the mathematical operation of integration is to define what a particular value would be, if we could condense the time interval close to zero - and this is needed for calculating the exact average value of certain waveforms.

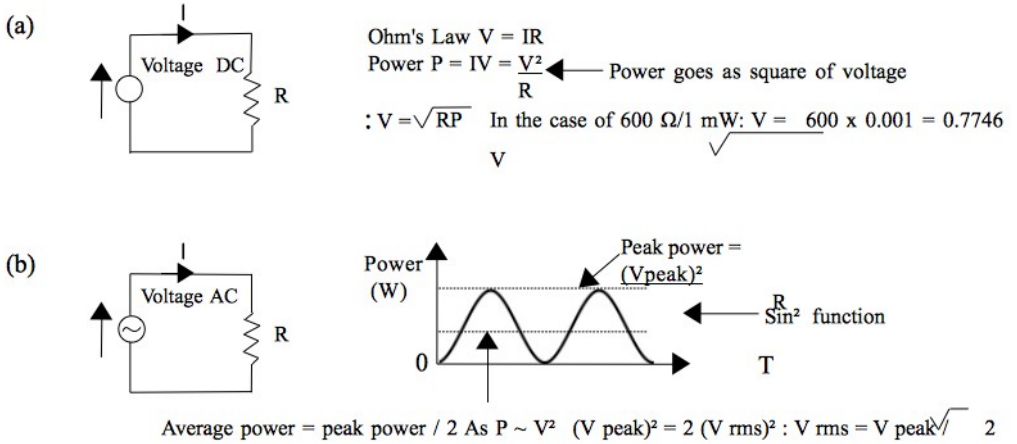
Lewallen informs us that, “RMS is a mathematical function, like average, that reduces a complex function to a single value. And, like average, it has a precise definition.”<sup>97</sup> This definition is revealed by its name, which is the square **R**oot of the **M**ean of the **S**quare of the function - and as **M**ean is the same as average; we calculate the RMS value of a function or waveform by “first squaring it, then taking the average of the squared function or waveform, then taking the square root of the average.”<sup>98</sup> And according to Huber and Runstein, “For a sine wave the RMS value is arrived at by squaring the amplitude of the wave at each point on the waveform and is equal to 0.707 times the peak amplitude level.”<sup>99</sup>

The RMS according to Ohm’s law<sup>¶</sup> is the power dissolute in a resistance and is relative to the square of an applied voltage. At this point, it might be prudent to give a brief explanation on the difference between Direct Current (DC) and Alternating Current (AC). According to Kuphaldt “DC is voltage or current that maintains constant polarity or direction, respectively”<sup>100</sup> as in for example a battery. Whereas, AC is “voltage or current that changes polarity or direction back and forth respectively.”<sup>101</sup> An example of this, is a rotating magnetic field around a set of stationary wire coils with a revolving shaft, as in an AC generator also known as an alternator.

As we are aware, DC is continuous so there are no inherent problems in measuring its power outlet, but AC fluctuates and measuring its power via this format is harder. Therefore, a unit of voltage was devised and according to Watkinson, “Since power is proportional to the square of the applied voltage, the same power would be dissipated by a DC voltage whose value was equal to the mean square root of the mean square of the AC voltage.”<sup>102</sup> Therefore, as the square of both positive and negative will inevitably be positive, it can be accepted that the RMS value will always be positive. The following illustration shows the root mean square in Ohm's law.

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¶ Ohm’s law: Georg Simon Ohm a German physicist who studied the measurement of electrical resistance.



12. Diagram indicating the root mean square in Ohm's Law.

If amplitude is the strength of the sound wave, then according to Aldred, “The greater the sound wave the louder will be the resultant sound.”<sup>103</sup> Therefore, we can agree that amplitude is an important statistic in sound recording, because if its strength is maintained, the level remains consistent; although much depends on a given situation. In addition, consideration should be applied to how the sound will be heard in conjunction with its visual counterpart. For example, in an extreme close up of a bird calling, the call would be pronounced, in a mid shot it would dissipate and in a wide shot the call's strength would reduce even further. Thus, the relationship between increase and decrease in distance from the source, and increase or decrease in amplitude is a crucial factor.

Sub section summary – This section has explained why amplitude is an important factor in sound recording not from just a theoretical perspective, but also from a practical one. Volume intake increase is not necessary the solution for recording optimum sound, because all other sounds within the vicinity will be increased. The principle sound is the most important factor to consider.

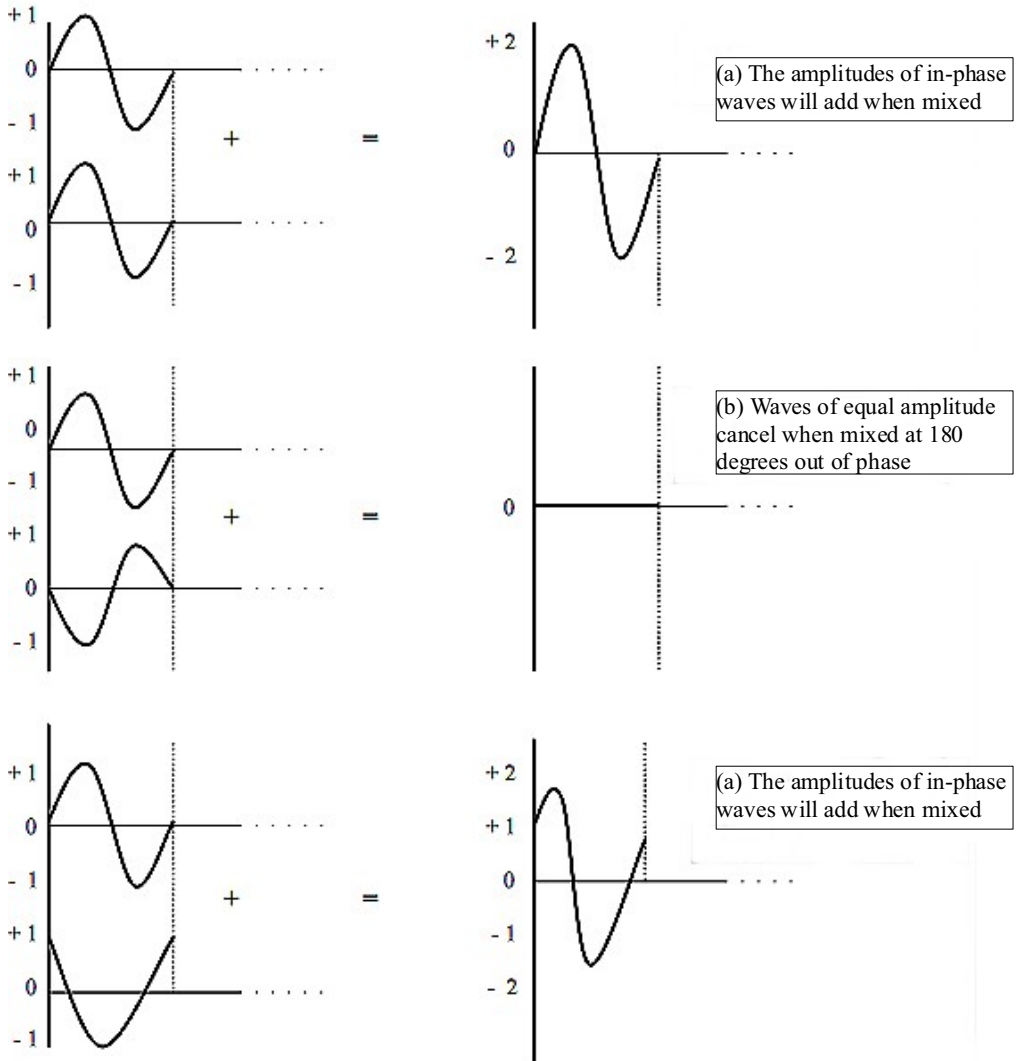
### 3.4 Phase

Phase an important factor because it contains attributes (Phase shift) that have an affect on sound recording and will be discussed shortly. Phase is “The term used to describe the actual point reached by a sound wave in its cycle of movement.”<sup>104</sup> It is measured in circular terms meaning that 360 degrees corresponds to one completed cycle of movement. Where a sound wave is able to commence its cycle at any given point on a waveform - providing it passes over a circle’s 360-degree axis. Phase is not usually referred to its positive and negative peaks in a waveform, but more in conjunction as Holman tells us with. “The point at which the waveform goes through zero heading in a positive direction.”<sup>105</sup>

A waveform may consist of two generated sound sources containing identical peak amplitudes and frequency and can be either classed as in-phase, (Correlated) or out-of-phase (Uncorrelated) for example. If two waves containing the same frequency were depicted as correlated, (0.0 phase difference) then by adding peak amplitude and shape, they would culminate in a waveform of the same frequency, phase and shape.

Alternatively, if the two waves were uncorrelated (180 degree phase difference) then they will cancel each other, resulting in a horizontal line through zero amplitude. Should one of these waves be slightly out of phase meaning not completely  $2n - 1 \times 180$  degrees, Huber and Runstein contend that “It would interfere constructively where the amplitudes of the two waves have the same sign. (That is both positive or both negative)”<sup>106</sup>

The effect of this would cause greater amplitude because the waves have been combined, but uncombined the amplitude would be unaltered. Moreover, these uncorrelated waves would create a destructive interference where the signs of these two waves are opposite, and this would result in a decrease in amplitude. To illustrate this meaning concerning the topic of in-phase and out-of-phase, consider the following diagrams.



13. Diagram of waves in and out of phase

Another issue concerning phase, is phase shift, which is very appropriate in wildlife sound recording. “Phase shift is a term that describes the amount of lead or lag in one wave with respect to another.”<sup>107</sup> The cause of this is a result from a time delay in one wave’s transmission for example. A 500Hz sound wave will complete its cycle every 0.002 seconds but, if we commence with two in-phase waves and delay one by 0.001 seconds (Which is half the period of the wave), “the delayed wave will lag the other by one half a cycle, or 180°.”<sup>108</sup> Calculating the amount of degrees in a phase shift is achieved by the following equation.

$$\emptyset = \Delta t \times f \times 360^\circ$$

where  $\emptyset$  represents the phase shift in degrees  
 $\Delta t$  is the time delay in seconds  
 $f$  equals the frequency in Hz.

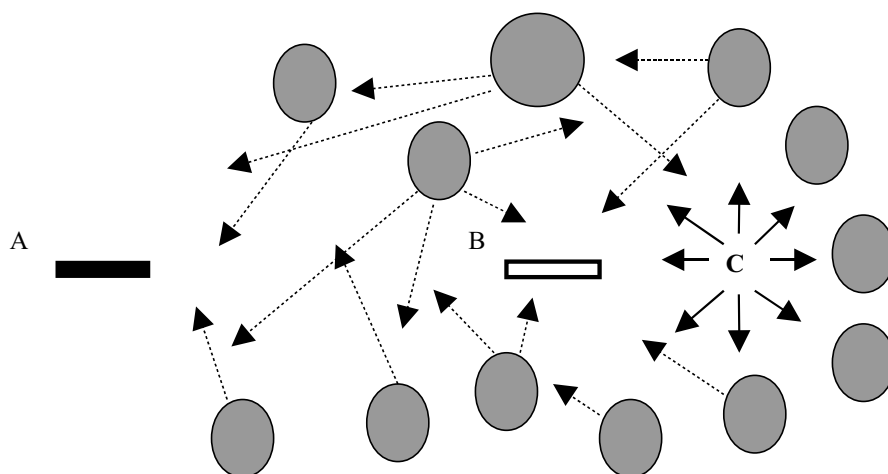
Thus, the amount of phase shift that can occur resulting from a fixed time delay in direct relation to the involved frequency varies considerably for example.

- 250Hz, 90°; 500Hz, 180°; 1000Hz, 360°; 1500Hz, 540°; 360° which equals 180° 2000Hz will equal 720° minus (2 x 360° which equals 0° and so on.

From this we are able to determine that for every one thousand Hz, which is a whole number and a multiple of 360°, (1000Hz 360°) the wave will appear as in-phase in connection to the original. Alternatively, if the number is part of the full cycle as in 90° or 180°, then the wave will be presented as out-of-phase. Therefore, it is possible to determine that when sound waves travel in different paths culminating at the same end point with the energy from one wave delayed, a frequency-dependent phase difference is formulated.

However, if the wave’s energy is added together, peaks and troughs in frequency response will be created, as a result some frequencies will either be enlarged by constructive interference - while others will ultimately be reduced by destructive interference. The main problem with out-of-phase is distance “Distance is the most common source of this time delay”<sup>109</sup> and in natural history sound recording, if awareness of the acoustic environment is not taken into consideration then the problem of phase shift can occur.

For example, microphones placed in certain locations will not only pick up the direct sound, but also delayed sound reflected from surrounding items such as trees, sea cliffs or buildings. The following diagram shows a hypothetical location where phase shift would present a problem.

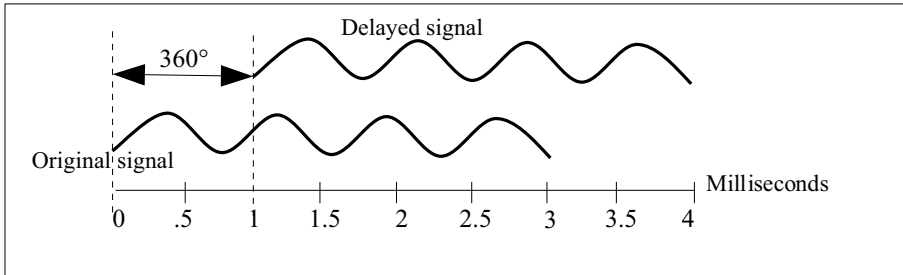


14. Diagram indicating the problem of phase shift.

In this diagram **A** represents the recording device at distance, **B** is the recording device in close proximity to the sound source **C** and is the preferred microphone position. The ovals portray objects such as trees that reflect direct sound. The broken arrows represent reflected sound, whereas the solid arrows depict the path of direct sound.

As this illustration indicates, the recording device at position **A** is susceptible to both direct and reflected sound. And because reflected sound takes a longer path, it constitutes a delayed version of the direct sound thus, comb filtering becomes apparent. (The problems with comb filtering were discussed in the previous chapter the importance of sound when combined with picture, sub heading - stereophonic sound) Moreover, reflected sound reverberates and if repeated many times, it will appear as an echo and this phenomenon often occurs in locations where mediums abound such as forests, canyons and ravines.

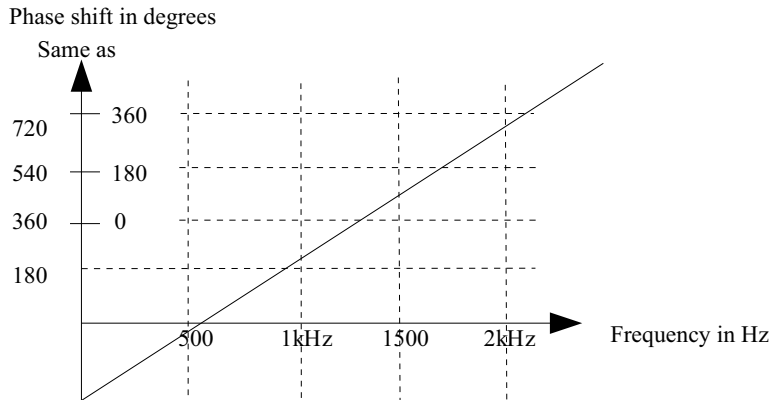
In addition, the delayed sound can cause an increase in amplitude. To explain further if we use for example, a 1kHz frequency depicted in sine wave form and set the delay time to one-thousandth of a second, the sound and its delayed iteration would have the following relationship.



15. Diagram of a 1kHz sine wave with its delayed iteration.

When these two signals are summed or mixed together, the result is a 1kHz sine wave, which is 6 decibels (dB) louder than the original, because as Moulton explains, “the phase shift is exactly  $360^\circ$ , which is functionally equivalent to a  $0^\circ$  phase shift.”<sup>110</sup> And because the original signal and its delayed counterpart overlay exactly, “their amplitudes when added together result in a doubling of overall amplitude at each point in the waveform resulting in an overall increase in amplitude of 6 dB.”<sup>111</sup> And this results in a signal which is louder than the original; this is referred to as constructive interference.

Furthermore, if we were to use a 1millisecond (ms) delay with a signal of 2kHz, we would receive the same constructive interference, because the phase shift is now at  $720^\circ$ , which is also equivalent to  $0^\circ$ . But, if we were to delay a sine wave signal of for example, 500 Hertz by 1ms, phase shift will be only  $180^\circ$  and thus would create a phase shift cancellation of  $180^\circ$ . In addition, signals of 1500Hz, 2500Hz, 3500Hz or any other frequency that is a multiple of 1000Hz above 500Hz, will also cause complete cancellation. Moreover, the amount of “phase shift varies for a given delay time as a function of frequency,”<sup>112</sup> meaning lower frequencies have less phase shift, whilst higher frequencies have more thus, each frequency will contain a unique amount of phase shift as shown in the following diagram; where “the diagonal line represents the increasing phase shift as a function of frequency. Note that we can think of  $540^\circ$  as being effectively the same as  $180^\circ$ .”<sup>113</sup>



16. The phase shift for any frequency with a delay of 1 millisecond.

To summarise, whole number multiples of the frequency whose period is the same as the delay time 1kHz and in this example we are describing, 2kHz, 3kHz, 4kHz and so on, will have delayed iterations that will be in phase with the original. But a frequency whose period is twice as long as the delay time in this case 500 Hz “will have a delayed iteration that will be out of phase with the original.”<sup>114</sup> Therefore, all frequencies that are above that frequency by the amount of the original frequency, will also be out of phase with their original signals. In short this means that a broad-band frequency response containing a mixed result of a signal and its delayed counterpart may be extremely uneven. “Resulting in boosts of 6dB, which are interspersed with total cancellations at frequencies across the spectrum that are related to the period of the delay time.”<sup>115</sup>

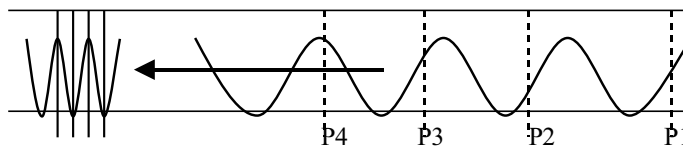
If we recall illustration 14 (Diagram indicating the problem of phase shift) we see that at **A** the recording device is prone to receiving phase shift. But if the recording device is moved to point **B** then phase shift is minimized nevertheless, there are many instances where obtaining close proximity to the sound source is not always practical due to the nature of the location, and the disposition of the subject/s. Therefore, epistemological knowledge and applied methodological approach; meaning understanding the sound stage and subject behaviour, and, awareness of one's equipment limitations is crucial in knowing how to solve the problem.

When identifying sound sources, human ability is rather poor compared with other fauna and height can be a confusing factor for example. The chatter of primates in trees causes the listener to search extensively in order to associate the aural with the visual, because the sound has/is reflected to

the ground through a longer path. This longer path contains certain frequencies corresponding to a phase shift of 180-degrees, which cause cancellation at the ear, and as Watkinson points out “The result is a frequency response consisting of evenly spaced nulls<sup>¶</sup> which are defined as comb filtering.”<sup>116</sup> Which in brief is a delayed version of a signal to itself, that causes constructive and destructive interference.

In addition, a moving object such as a bird travelling across the sky is prone to geometric changes, because the null’s frequencies emanate to a point where they reach an overhead position. But, much depends on the type of bird. For example, Eurasian cranes *Grus grus* in flight<sup>¶</sup> calling to one another. The calls radiating from these birds are of high frequency and are heard from a distance. And at a distance, the fundamental frequency of the call (At the ear/microphone) appears lower than it is emanating from the bird's syrinx, (An avian vocal organ) as they pass overhead, then culminating in high frequency as they fly away This frequency shift is called the Doppler effect.<sup>¶</sup>

The diagram below shows how sound waves are compressed as they approach the listener and the intervals between diminishing waves, which translates into an increase in frequency or pitch. As the cranes pass by, the sound waves are stretched relative to the observer causing the frequency of the calls to decrease. An example of this is found on the CD-ROM audio disc track 13. (Cranes flying overhead)



17. Diagram of the Doppler effect. (Crane sound waves)

Sub section summary – phase is a critical issue in sound recording as this discussion has demonstrated, because if the microphone's position is not properly calculated, then the following issues will occur. Reflected and or delayed sounds, boosts in amplitude and comb filtering and these are the problems we have to eliminate when sound recording. In addition, selecting the appropriate technical equipment is also a factor that requires consideration.

¶Nulls are reflections that reach the listener soon after the direct sound causes a phenomenon known as comb filtering. The appearance of a single reflection in a frequency response looks similar to the teeth in a hair comb and comb filtering is due to a single 2 ms reflection.

¶The sound field experiments involving the Eurasian crane at Söderfjärden is the main focus of this study.

¶Doppler effect: Originally discovered by the Austrian mathematician and physicist, Christian Doppler (1803-53), results from a shift in the frequency of the sound waves.

### 3.5 Frequency

Frequency and wavelength are both related to the speed of sound inasmuch that as the wavelength becomes shorter, its frequency gets higher; alternatively as the wavelength gets longer the frequency becomes lower. Thus frequency is equal to the speed of sound divided by the wavelength where, ( $f$ ) denotes the frequency in Hz (cycles per second) ( $c$ ) is the speed of sound in matter or medium and ( $\lambda$ ) is the wavelength.

$$f = \frac{c}{\lambda}$$

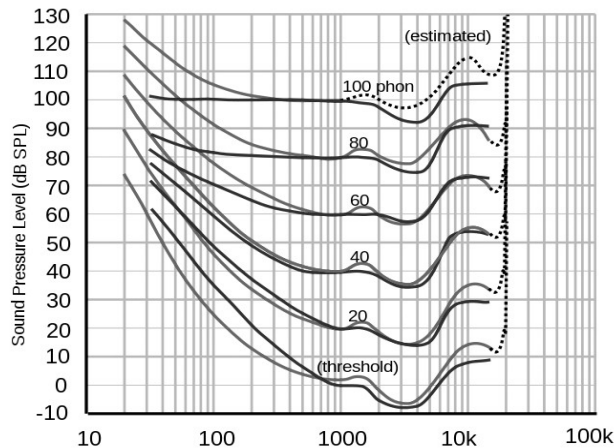
Many inhabitants of the natural world communicate in frequencies beyond the human hearing range (20-20,000 Hz) and also outside standard recording equipment capabilities. Above 20,000 Hz we enter the realms of ultrasound, and are unable to detect high frequency sounds for example, “the sounds made by the Lesser Horseshoe Bat. *Rhinolophus hipposideros* (55 to 60 kHz)”<sup>117</sup> Below the 20 Hz threshold, infrasound; “it is almost impossible to witness African elephant *Loxodonta africana* vocalisation. (10 to 16 hertz)”<sup>118</sup> Unless specialised recording equipment is used.

However, according to Aldred, “The lowest frequency which can be appreciated as a definite tone is roughly 16 Hz.”<sup>119</sup> This definite tone associated with the lowest note on a pipe organ as Holman contends, “Is considered audible sound not infrasonics.”<sup>120</sup> However, Aldred informs us that, “The frequency range to which the ear is sensitive depends largely on the individual.”<sup>121</sup>

It is believed that young people are able to detect frequencies that border on the thresholds of infrasound and ultra sound, but as the ageing process develops, appreciation of both the upper and lower frequencies become harder to detect. The graph below (Fletcher/Munson curves)<sup>¶</sup> shows a hearing threshold in both young and older humans. Contours of equal loudness indicate that the ear’s frequency response is highly level dependent.

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¶Harvey Fletcher (1884-1981): Distinguished scientist, engineer and investigator of the nature of speech and hearing noted for his contributions in acoustics.



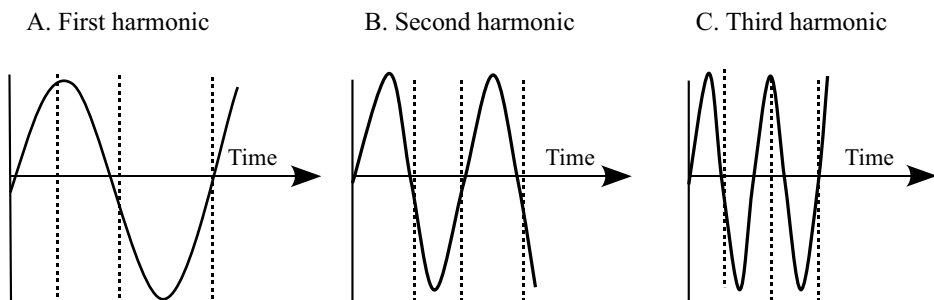
18. Diagram of Equal-loudness contours (grey) from (ISO 226:2003 revision) Fletcher-Munson curves shown (black) for comparison.

Another issue with frequency is that direct sound allows for determination of the sound source's location and conveys its true timbre, "The amount of absorption that occurs when sound is reflected from a surface is not equal at all frequencies."<sup>122</sup> Meaning that the timbre is affected by the different surfaces it has encountered for example. A sound's timbre reflected from stone or brick will contain vast differences as opposed to reflections from wood or fibreboard. To explain this further, a comprehensive chart depicting - Absorption coefficients of common building materials and finishes is found in the appendix section.

Sub section summary – Frequency plays an important part in sound recording especially when dealing with fauna whom communicate in the ultrasound and infrasound range. And to appreciate these sounds specialised equipment is needed not only to record them, but also hear them. Moreover, a sound's frequency can be affected by the mediums it comes into contact with for example, absorption and reverberation, affecting its true timbre, which is an important factor to consider. Because a sound's appearance can change quite considerably after being in contact with a particular medium. For example, a heavily furnished room will absorb sound whereas an empty room will reflect sound.

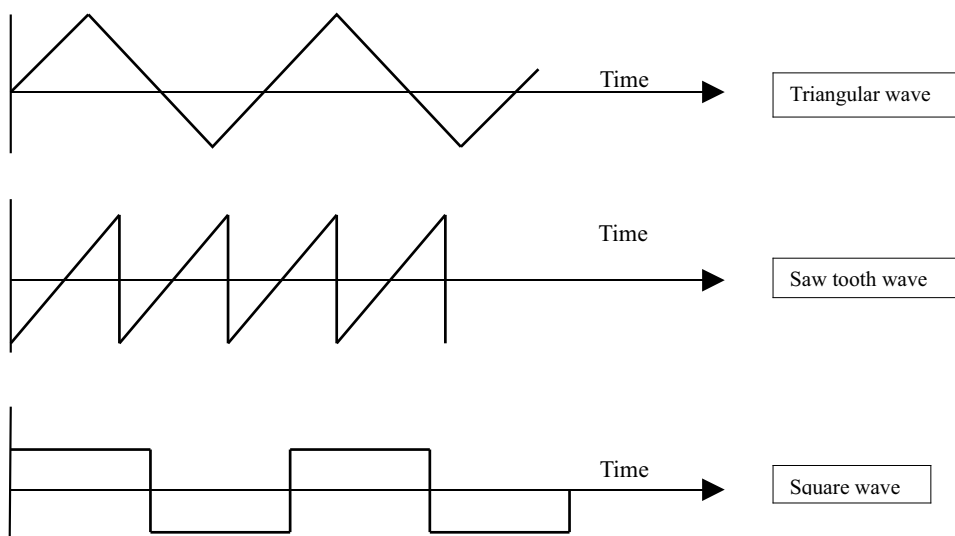
### 3.6 Harmonic content

The various frequencies and sound waves produced by musical instruments can be differentiated due to the frequency, and its accompanying note called the fundamental. Frequencies that are not fundamental are referred as partial, and frequencies that range above the partial, are referred to as upper partial or overtones. Sound in music is determined by the presence of harmonics and these are complete multiples of the fundamental frequency. Thus the first fundamental would be the first harmonic, the second harmonic would be twice the fundamental, the third harmonic three times the fundamental and so on up to the sixth harmonic with all subsequent harmonics reducing in intensity. The following illustration shows how this would appear in a waveform.

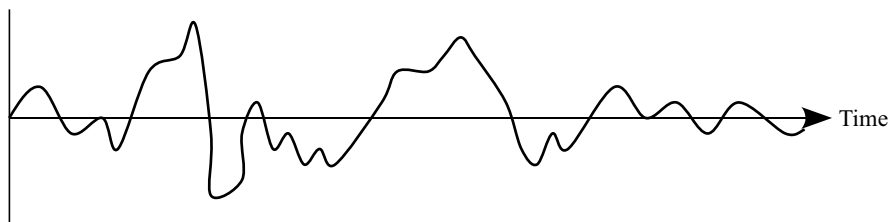


19. Diagram illustrating harmonic wave form over time.

When the ear encounters musical sound it deciphers it with a frequency ratio of 2:1, we perceive these frequencies in the form of scale or octave for example. Concert A, has a frequency of 440Hz - the next octave above would be 880Hz and above that 1760Hz. But, human hearing does not respond to all frequencies although, much depends on the individual and his/her age. According to Huber and Runstein, “Musical waveforms can be divided into two categories simple and complex.”<sup>123</sup> In the simple category waveforms can be represented as triangular, saw tooth and square as shown in the following diagrams. And these waveforms are said to be simple because, they are repetitive and continuous with one wave’s cycle very much like the other in appearance.



Alternatively, complex waves are said to be non-repetitive and not necessarily symmetrical in relation to the zero line, and “Since complex waves often do not repeat it is difficult to divide them into cycles or categorize them as to frequency simply by looking at the wave-shape.”<sup>124</sup> As shown below.



20. Diagram illustrating different waveforms.

Sub section summary – Almost all signals contain energy at harmonic frequencies including that of the fundamental and if all the energy in a signal is contained at the fundamental then the signal becomes a sine wave. But, if the signal is not a sine wave then some energy will be contained in the harmonics. In addition, some waveforms contain large amounts of energy at harmonic frequencies and the examples given are an indication of this. Harmonics although important, are not usually a concern for the field sound recordist as opposed to distance and direction, amplitude, phase shift, frequency and masking as these are issues that occur quite often when on location.

### 3.7 Inharmonicity

Inharmonicity or In-harmonics as it is referred to is the degree to which the frequencies of overtones, called partial tones or harmonics depart from whole multiples of the fundamental frequency. And pitch according to Oxenham, “is one of the primary auditory sensations and plays a defining role in music, speech, and auditory scene analysis.”<sup>125</sup> And many animals are sensitive to pitch for example, Primates, chinchillas, cats and marmosets and nearly all avian species.

When communicating with other conspecifics and also between different species, birds will make a variety of sounds and these are produced when needed and all sounds have some specific meaning. The majority of sounds are produced by the syrinx, (Avian vocal organ) and in many species this syrinx is bipartite, allowing the bird to produce two notes simultaneously. According to Selin Et al. “bird sounds can be tonal or inharmonic, which is one way to divide the bird species into groups.”<sup>126</sup>

Inharmonic sounds are often ephemeral with frequency contents very near to each other in avian vocalisation in both calls and songs. Calls are relatively shorter than and more simpler than songs and both the male and female produce them. In addition, many birds have from five to fifteen various distinct calls that include, flight, alarm, excitement and some species have several different calls for the same function. In addition, “in many species there is high individual and regional variability in phrases and song patterns.”<sup>127</sup> Such differences are an indication as to a particular kind of avian activity that is useful information to the sound recordist for example. The nest building antics of the *Ploceidae*, (Weaver bird) where these passerines will remain in one location allowing for the recording of optimum sound.

Sub section summary – With many types of fauna pitch plays an important role in the auditory sensations and inharmonic sounds especially with birds are part of their communication process. Some avian species and indeed insects are able to use inharmonic sounds and frequencies, which human hearing does not respond to nevertheless, they are there. Therefore, specialised technical equipment may be needed to record such sounds.

### 3.8 Masking

In sound terms masking although not limited to sources in close frequency is defined as covering or shielding, if incoming sound waves have similar frequencies this occurrence is most noticeable, especially when recording the vocalisations of amphibians. Is this then a question of volume, in short the answer is no – according to Aldred, “Masking is not merely a question of volume, for when the masking tone differs in frequency from the masked tone the problem is not so severe.”<sup>128</sup> However, a tone that is loud and pure can easily mask one of a higher frequency for example.

Frogs in their courtship produce a vast array of high and low frequencies that are relatively close to one another. And a listener with normal hearing meaning no impediment, would be able to hear a single frog vocalising. In addition he/she may be able to differentiate between a small number of frogs but, as their numbers increase, so do the vocalisations. Therefore, it becomes harder to calculate the amount of vocalisations even though some frogs may be silent and this is because, of (a) the similarity in frequency, which masks individual calls and (b) frogs will often call in unison.

The problem in this case is if the camera is focussed in close-up on one particular frog, the sounds of the other frogs would seem strange or out of context to the spectator, because the frogs cannot be seen. But, if the single frog was visually seen to call and the call was audible, then hearing all the other calls would make sense and this should/would be supported by a wide shot of the area; in which the other frogs are visible.

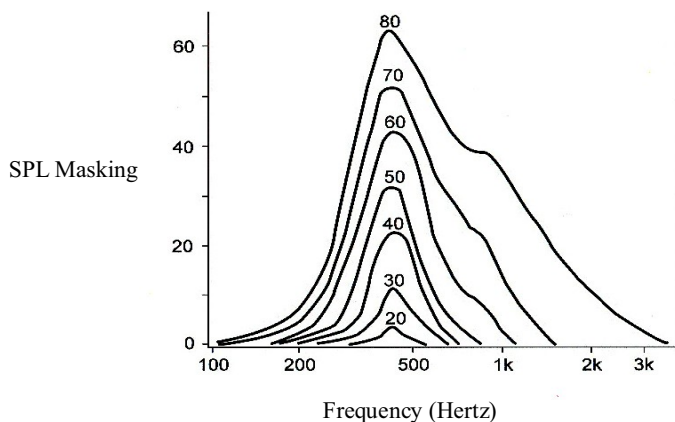
This problem also occurs with insect vocalisation, in particular the 13 and 17 year periodical cicadas *Cicada magicicada* of eastern North America. These insects spend most of their lives underground and emerge after long juvenile periods, in huge numbers. Cooley and Marshall tell us, “they form much denser aggregations than those achieved by most other cicadas.”<sup>129</sup>

And once congregated to their preferred locations, males produce specific courtship calling songs and “form choruses that are sexually attractive to females.”<sup>130</sup> This results in a conflicting mixture of sounds; where it is extremely difficult to assess an individual sound due to the high density of their numbers. And because of this, it would be difficult to depict a single cicada in close up. “Periodical cicadas achieve astounding population densities, of tens to hundreds of thousands per acre.”<sup>131</sup> To appreciate insect vocalization on mass affected by masking refer to the CD-ROM disc tracks;

01	Amazon Night 1.	0.46
02	Amazon Night 2.	0.46

The degree of masking depends on the properties of the masking tone in relation to other tones in close proximity, as harmonic distortion produces frequencies that are widely displaced. The following illustration shows a simple graph of frequency masking - indicating a narrow band of sound located near 400Hz masking nearby sound frequencies.

According to Holman “The effect grows to cover greater frequency range especially towards the higher frequencies.”<sup>132</sup> And as the level increases, “the curves are numbered with the sound pressure level of the masking noise and show the level versus frequency which is masked.”<sup>133</sup> In other words as Egan and Hake inform us, “Any frequency components lying below the curves are masked when a band of noise at 400 Hz and the stated sound pressure level (SPL) is present.”<sup>134</sup>



21. Graphic depicting sound pressure level in masking.

Sub section summary – This issue has shown that masking can be problematic when recording certain fauna – insects and amphibians. Because, individual sounds are not that easy to differentiate from others especially when recording sound to match the visual. Therefore, it is preferable to record an individual whom is calling to support the scene if possible as this retains continuity with sound and picture.

### 3.9 Subject disposition

In understanding the subject/s disposition or behaviour, a recordist/researcher must embark on good research to ascertain the behavioural patterns of a particular species, regardless of whether they are solitary or living in groups. The main reason for this, is to build up a pattern of knowledge about their territory, feeding rituals, mating and rearing of young. In addition, the fact of knowing whether they are stationary meaning residing in a particular location, or whether they are migratory is an important factor. There is another issue to be taken into consideration and that is whether the proposed subject/s are rare, illusive or relatively common; here are a few examples.

Rare: - The Hispaniolan solenodon.<sup>¶</sup> *Solenodon paradoxus* (Also known as the Haitian Agouta) According to Rebecca Morelle a BBC science reporter, “Little is known about the creature, which is found in the Caribbean.”<sup>135</sup> It was unknown to science until 1833 when first described by German naturalist Johann Friedrich von Brandt. These mammals primarily nocturnal remain in their burrows, trees, hollowed out logs or in caves during daylight hours. Their diet contains a wide variety of animals including, worms, snails and small reptiles; they may also feed on roots and fruits.

To record the sounds made by this creature further research would be needed to ascertain its burrow/lair and its movements. Once this has been achieved, a form of approach can be devised in selecting the technical equipment and in setting up a recording configuration. Without this knowledge, the sound recordist has little or no opportunity to record the animal's sounds.

The African Golden cat. *Profelis aurata*<sup>¶</sup> Dr. Gary Aronsen tells us that, “It is spread across equatorial Africa, but it is cryptic and we presume solitary”<sup>136</sup> and due to its extremely reclusive habits, little is known about the behaviour. These cats are normally crepuscular (Active during twilight) or nocturnal, but have been observed hunting during the day - depending on the availability of local prey. Their diet includes rodents, birds, small monkeys and small antelope and according to Sunquist, “these cats have also been known to take domestic poultry and livestock.”<sup>137</sup>

Morelle and Aronsen state that these animals are mainly under threat from deforestation, hunting and introduced species and are extremely difficult locate and observations are few and far between.

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¶Hispaniolan solenodon resembles an overgrown shrew able to inject passing prey with a venom-loaded bite.

¶African golden cat sighted in the Kibale National Park, Uganda is melanistic, meaning that its colour varies over its lifetime.

Therefore, any attempt to capture these creatures from a aural and/or visual directive will be extremely problematic, partly due to their crepuscular and/or nocturnal activities, and partly due to their reclusiveness. This is why research is most important, because it allows the recordist/researcher to devise a working hypothesis.

Illusive: - Yellow-tailed Woolly Monkey. *Oreonax flavicauda* This primate a native of South America, resides in the cloud forests of the Peruvian Andes at elevations of 1,500 - 2,700 metres. (4,900–8,900 ft) Buckingham and Shanee estimated “its potential forested habitat to be at least 11,240 km<sup>2</sup>.”<sup>138</sup> But, this has been greatly reduced due to constant deforestation thus, it could be construed that the monkeys would be easier to locate. However, locating these primates remains extremely difficult because of the following factors. (a) The elevation, (b) this particular habitat is characterized by steep gorges and ravines that are difficult to access. And (c) these primates are extremely timorous and dislike human intrusion.

The Kagu or Cagou *Rhynochetos jubatus*, is a long-legged, crested, bluish-grey flightless bird endemic to the dense mountain forests of New Caledonia. It is exclusively carnivorous, feeding on a variety of animals including worms, snails, lizards and various types of beetles. The kagu population has seen a dramatic decline due to hunting for its prized crest feathers used in hat making during the 19<sup>th</sup> century. The species was also trapped extensively for museums and zoo exhibits in addition, Ekstrom *et al.* point out that. “Rats have a big impact on nestlings, accounting for 55% of losses.”<sup>139</sup> The current population of wild Kagu is about 250-1000 birds, and is the focus of a long conservation effort.

The discussion so far has concentrated on fauna that are either rare and illusive, and difficult to access, but what about locations as in for example, open spaces where the subject/s are accessible. You will recall that this issue was discussed earlier in this chapter with the killer bee film. The problem here is that for some particular reason, many species of fauna do not feel at ease when humans are present. They usually flee to avoid confrontation, but if offspring are in situ then warnings are given and if the desired response is not forthcoming; an attack is the norm.

Relatively common: - It appears (According to scientists and filmmakers) that with many species of fauna, motorised vehicles do not present a problem even though they can be extremely noisy. We see wildlife filmmakers driving their vehicles close to lion prides, hyena packs and among herds of wildebeest and zebra without creating panic.

Indeed, the same can be said of the huge flocks of Eurasian cranes that gather on the grain fields at Söderfjärden in Western Finland. These birds extremely timorous in nature, are not perturbed by the heavy agriculture machinery trundling its way through the fields gathering harvest. But what happens when we leave the confines of the vehicle, with predators it can be considered unwise for obvious reasons, but, in the case of the cranes it is unadvisable. The reason for this is that, a human approaching these birds less than 400 metres causes them to take flight. And as a result attempting to record their vocalisation becomes problematic; further discussion on the eurasian crane and the recording of their vocalisation is covered in the field experiments.

Sub section summary - To conclude this section, it can be agreed that this brief discussion, has given some indication of the problems associated with inhabitants of the natural world. All fauna have their distinct peculiarities, and this is what makes them unique and interesting. The key in finding a way to document their activities and/or vocalisations is research, as this will assist the recordist and/or researcher in understanding the problems that will undoubtedly be encountered whilst on location.

### **3.10 Section summary**

To summarise this section, it can be agreed that the issues discussed in this chapter, are extremely relevant in the approach to wildlife sound recording, because they give rise to the idiosyncrasies that can be found on a particular location; regardless of what is contained within. As individuals or even a collective body, they cannot solve the problems encountered in recording wildlife vocalisation. But, appreciation of their principle characteristics, will afford the recordist a greater understanding in finding a solution to the problems he/she is likely to encounter.

#### 4. THE APPROACHES TO RECORDING WILDLIFE VOCALISATION

In natural history sound recording there are many recording situations, which create problems and least we forget the biggest problem is the 'Distance' and 'On-axis' factor. However, as wildlife filmmaking covers fauna in both aquatic and terrestrial species, these too produce problems that are difficult to overcome. This chapter will look at some of these issues.

In an aquatic environment, it is important that the sound recordist be conscious of the technical requirements needed to record some essence of the aquatic ambience, using incorrect instrumentation can only lead to disappointment. For example, Griswold in his paper to [phonography.org](http://phonography.org) a group of sound recordists dedicated to the art of sound recording suggests that. “You can experiment with underwater recording by waterproofing a microphone, one way to waterproof a mic is to seal it inside a deflated balloon.”<sup>140</sup>

But according to Maurer, “Merely covering a normal microphone with waterproof material (A balloon, for example) proves altogether ridiculous, and amplifying the signal to even the highest extremes will not reveal much of anything.”<sup>141</sup> Nisbet confirms this hypothesis, he explains that, “Under the sea an Omni-directional microphone is likely to pick up a great deal of noise from sea-wash, ships or passing aircraft.”<sup>142</sup>

In a marine environment, hydrophones are the appropriate equipment, but even these can cause problems; as Charif explains “a major problem was over sensitivity.”<sup>143</sup> The equipment used recorded not only cetacean vocalization, but also sound from various other mechanical devices including ship’s engines. In addition, marine subjects rarely remain static and recording their vocalisations is often haphazard. For example, Orcas *Orcinus orca* and pilot whales *Globicephala melas* can swim over 48 kilometres an hour with increased bursts in order to catch prey therefore, it would be extremely difficult to keep pace with them. This example is comparable to predatory felines (Lions) of the African plains.

If these cetaceans were to relax their pace and a sound recordist resorted to towing hydrophones behind a boats to record their calls, this would cause problems. Because as marine biologists Watkins and Daher state. “We used 200 metres of cable to place the hydrophones away from boat noise, but other problems such as sea wash and cable hum occurred and even experiments in vessel speed variations fail to eradicate the problem.”<sup>144</sup>

What then is the solution, some researchers have opted to use sail as opposed to mechanical power, British marine biologist Oliver Boisseau spent seven arduous months at sea, on a research sailing vessel in search of the Beaked whale (Family *Ziphiidae*), in order to record their vocalisations, Boisseau explains the problems he encountered using this methodology in his film, *Tracking their silent voices*.<sup>¶</sup> (2009) He contends that sail reliant on wind was detrimental to his research because of inconsistent manoeuvrability. As an alternative method in recording marine vocalisations, some scientists and recordists have resorted to using captive animals; a tactic employed by Szymanski and his research team “Where the subjects Killer Whales *Orcinus orca* were trained to remain stationary.”<sup>145</sup>

But the problems in recording wildlife vocalisations are not solely confined to a marine environment, they are applicable to land-based fauna and as Burbidge contends. “Special techniques have to be employed to record wild animals.”<sup>146</sup> For example, Payne, Langbauer and Thomas's solution to recording infrasound was in selecting the correct equipment, whether analogue or digital. They explain, “The discovery in 1984 that elephants produced infrasonic calls was made with an analog system including a Nagra IV SJ reel-to-reel recorder and a Bruel & Kjaer (B&K) 4133 microphone.”<sup>147</sup>

To make these vocalisations audible, the tape speed was increased and “If you speed up a recording containing infrasonic elephant calls 3 times, you will easily be able to hear them.”<sup>148</sup> Although this technique can still be used, a more appropriate method is to use a Real Time Analyser for low-frequency sound and vibration,<sup>¶</sup> where the signals are converted to an audible frequency. Alternatively, recording infrasound with a digital approach can be accomplished by using such technology as Autonomous Recording Unit, (ARU) developed by engineers in the Cornell University Bioacoustics Research Program.

This unit consists of a small microphone mounted on a signal conditioning board, that connects to a more generalized filter amplification board. The output from the filter amplification board, then feeds into a circuit that converts the analog signal into a digital one, and then stores the data to a laptop computer hard drive. This type of unit can be used for both terrestrial and marine infrasound.

When recording ultrasound complications can occur, because some animals including rats, mice, squirrels, insects and some amphibian species have frequencies that range across the ultrasonic

¶ *Tracking their silent voices*. 44 mins. Stefan Geir. Ton und film, Production Company. Preysingstrasse 10, 81667, Munich, Germany.

¶ The Rion NA-18 used to evaluate sounds that are not audible to most humans, frequency range of 1-1000 Hz.

spectrum. For example consider this small selection taken from Semafor's European Bat Frequency chart<sup>¶</sup> - as we can see, the frequency range is quite extensive. Moreover, as Schmieder explains the Buzz calls of the Clear-winged Woolly bat *Kerivoula pellucida* found in Brunei, Indonesia and Malaysia, “had mean bandwidths of 170 kHz and attained maximum starting frequencies of 250 kHz which makes them the most broadband and most highly pitched tonal animal vocalisation known to date.”<sup>149</sup>

Bat species	Scientific name	Hunting frequency	Social frequency
Free-Tailed	<i>Tadarida teniotis</i>	20kHz	20-45kHz
Daubenton's	<i>Myotis daubentonii</i>	50kHz	35-85kHz
Greater Horseshoe	<i>Rhinolophus ferrumequinum</i>	82kHz	70-120kHz
Lesser Horseshoe	<i>Rhinolophus hipposideros</i>	110kHz	100-120kHz
Bechstein's	<i>Myotis bechsteini</i>	112-40(50)kHz	34-100kHz

## 22. Semafor European Bat Frequency chart

Bats emit three types of echolocation call - frequency modulation (FM), constant frequency (CF) (Sometimes referred to as amplitude modulation) and composite calls with both FM and CF components. And although there exists a wide variety of manufactured and even 'home-built' bat echolocation recording devices, (Often called bat detectors) not all are capable of recording the ultrasonic spectrum range, due to the absorption of ultrasound in air. According to Ahlén and Baagøe “At mid range frequencies around 50 kHz, the maximum range is only about 25 to 30 metres in average atmospheric conditions when bats fly”<sup>150</sup> which will decrease with increasing frequency. Bat calls having components approximately 20 kHz or lower can be detected at 2 or 3 times the usual range. But “only the lower frequency components will be detected at a distance.”<sup>151</sup> Thus, the usable range of bat detectors decreases with humidity and in misty conditions can be reduced significantly.

There are many devices available for recording bat echolocation including, Zero Crossing Analysis (ZCA), High Frequency Recording (HFR), Digital Signal Processing (DSP) and Time Domain Signal Coding (TDSC). But the most common 'real-time' audio bat detectors in use are; the heterodyne, frequency division, and time expansion and these bat detectors are able to combine two or all three types of this function. A short explanation on these three methods is given below.

¶<http://www.semafor.co.uk/bat-detector.html#Nottop>

Heterodyne – (Also referred to as direct conversion bat detectors) this type of detector is probably the most common, because it simply moves all the ultrasound frequencies downwards by a fixed amount so we can hear them. The heterodyne function is often built into the other types of detector including devices that are self-built.

A heterodyne is a beat frequency, which can be heard for example, when two close musical notes are sounded together. It combines the bat call with a constant internal frequency so that sum and difference frequencies are generated. For example, a bat call at 45 kHz with an internal frequency of 43 kHz will produce output frequencies of 2 kHz and 88 kHz. But as the 88 kHz frequency is inaudible, it is filtered out and the 2 kHz frequency is transmitted to either a pair of headphones, or some other listening device with the internal frequency depicted on a visual display.

Heterodyne detectors vary considerably in their capabilities, better quality models such as the super-heterodyne detector are more flexible. With the super heterodyne version, the bat signal is mixed with a high frequency oscillator, constituting around 450 kHz to 600 kHz. This frequency difference is then amplified, then filtered via an intermediate frequency (IF) amplifier before being converted back to audible frequencies. “This design, which is based on standard radio design, gives improved frequency discrimination and avoids problems with interference from the local oscillator.”<sup>152</sup> In more recent Digital Signal Processor (DSP) based detectors, heterodyne conversion can be achieved completely digitally.

The advantages of a heterodyne bat detector is that it works in real time - exaggerating bat call frequency changes and is able to recognise the doppler shift in CF calls of bats at various speeds during flight. It is relatively uncomplicated and inexpensive and in some models such as the CDB 101 R3 from Ciel Electronique, stereo listening and recording is possible, which can assist in tracking bats in poor visibility. However, the heterodyne bat detector does have its drawbacks for example, it can only convert a narrow band of frequencies, typically 5 kHz, and therefore, has to be constantly re-tuned - easily missing species out of its current tuned range. This tuning issue can be solved by using a scanning circuit or bat scanner, which enables the detector to scan the spectrum automatically and stop scanning when a bat call is heard.

Frequency division (FD) - “Bat detectors synthesise a sound which is a fraction of the bat call frequencies, typically 1/10.”<sup>153</sup> This is achieved by converting the call into a square wave, this is then divided via an electronic counter by a factor of 10 to provide another square wave. However, square

waves can sound harsh; they may contain harmonics that can cause problems during analysis and therefore, are filtered out where possible. More recent 'all-digital' detectors are able to synthesise a sine wave as opposed to a square wave and an example of such a detector is the Griffin - from Batbox Limited. Nonetheless, some FD detector units do output this constant level signal - where both ambient sound and bat calls are at the same intensity level causing problems with listening and analysis. More sophisticated FD detectors such as the Duet also from Batbox, measure the incoming volume level, which limits the noise threshold and uses it to restore the output level variations.

The FD detector also works in 'real-time' regardless of whether it has a heterodyne function or not, allowing bat calls to be heard in their entirety over their whole range as opposed to a limited frequency range. Generally, high quality FD detectors do not need constant re-tuning, but some lower-cost dual type FD heterodyne models may require some adjustment. A major problem considered by some is that with 'real-time' listening, the bat's speed of call is rapid; often too fast for a particular species to be recognised. Moreover, unlike the heterodyne detector, the frequency of CF calls are not exaggerated and therefore, are less noticeable in FD detectors.

Another minus point with FD detectors are calls at the higher end of the spectrum for example, the Lesser Horseshoe bat has a call around 110 kHz, which can be recorded. But, synthesising the call means that only one bat call can be reproduced at a time, thus confusion by other simultaneous calls may be apparent. This is not a major problem, because the call can be analysed at a later juncture.

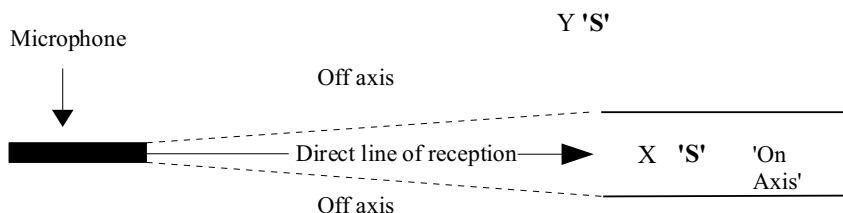
Time expansion (TE) detectors – are 'real-time' devices that can be monitored during a recording session. They operate by digitising bat calls at a high sampling rate by using an analog-to-digital converter, that stores the digitised signal to its on-board memory. But, there is one slight drawback with this process because, a delay will be apparent while the high speed sample is extracted - slowed down and replayed. Regardless of whether or not TE detectors incorporate either the heterodyne or FD function or both, slowed down calls will be heard as an elongated call at audible frequencies. In addition, fast FM calls will be heard as a descending note as opposed to a click. Therefore, it is possible to differentiate FM calls that sound like clicks on the heterodyne and Frequency division detectors. And once the recording has been downloaded to a computer, the original calls are analysed as if they were still at the original non-expanded rate.

As with FD devices, TE detectors are able to output their information directly to an audio recorder. Later TE models include an internal memory function such as a compact flash card, where the entire waveform is recorded preserving its full range, as opposed to 1/10 of the waveform as in an FD detector. And because both frequency and amplitude information are preserved in the recorded call, more data is available for species analysis. TE detectors are normally used for professional and research work, as they allow a complete analysis of the bat's calls at a later time. Such 'high-end' devices are the Pettersson D500X and the SM2BAT+ Passive Ultrasonic Bat Recorder, which are designed to be left in the field for several days.

#### 4.1 Alternative solutions

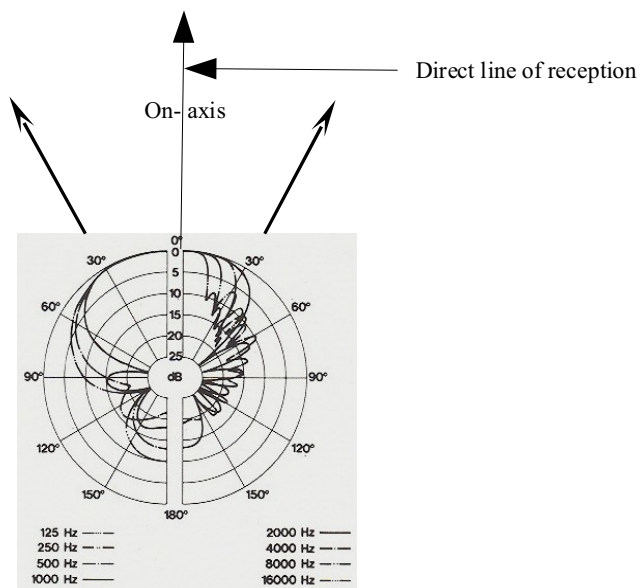
One technique proposed by Bartlett is that “For recording animals, some recordists hide the microphone in shrubbery near the animals and run long cables back to the recorder so they won't inhibit the animals.”<sup>154</sup> This approach is intended to capture a specific sound or sounds made in the proximity but, in adopting this strategy two immediate questions spring to mind.

(a) If a recordist enters a subject/s area, there is the distinct possibility that it/they will abscond to avoid human confrontation. Moreover, should the subject/s return to the locale, there is no guarantee that it/they will position themselves in direct alignment with the microphone's 'on-axis'. Therefore, it is most likely that the subject will be 'off-axis' and any sound may/will appear distant or weak and this is a problem, because there is no microphone control. This problem is part of the main research question pertaining to this study. As discussed earlier, we need to record sound that is direct, sound that is in line with the microphones receptive capabilities, referred to as 'on-axis' and sound that is outside of this area is referred to as 'off-axis'. (Illustrated below)



23. Diagram of sound source in relation to the microphone's line of axis.

Axis according to Allen “is a straight line with respect to which a body or figure is symmetrical.”<sup>155</sup> Axis can also be defined as one of the reference lines of a coordinate system and if these two definitions are combined, 'on-axis' could describe the primary direction from the microphone. And as Aldred tells us, “This permits an uninterrupted passage to 'on-axis' sounds, and proportionate delay networks to sounds approaching off-axis, which cause their partial cancellation especially at high frequencies.”<sup>156</sup>



24. Diagram illustrating Sennheiser 816 P48 U3 microphone polar chart and on-axis.

The above diagram showing the Sennheiser 816 polar chart, is found in its data specification, indicating its directional characteristics. It also depicts the 'on-axis' direction showing the response of the microphone at other directions in relation to the 'on-axis' response. (The other directions are referred to the 'off-axis' response) This Polar Chart is a 1-dimensional graph, depicting a 3-dimensional phenomena or one 'slice' of the pick up pattern. It also represents the level a microphone will pick up at the same distance in a 360° sphere.

For most microphones, 'on-axis' is a line in the same direction as its long dimension. We are using a 'shotgun' microphone, (Sennheiser 816 P48 U3) because of its good directivity and 'off-axis' rejection of sound from the sides and rear (Discussed in the chapter the importance of sound) and will be at its most sensitive when 'on-axis'. Meaning the sound source is best received when in direct line.

Prior to recording we noted that our sound source 'S' (Figure 22) was located at position X, hence our microphone was placed accordingly with the subject 'on-axis'. Therefore, in principle, the sound source would be direct and relatively strong, dominating other ambient sounds. But, our intrusion into the area caused the subject to flee, it did however return, but positioned itself at location Y, which is 'off-axis' often referred to as 'off-mic'. And the result of this means, that our sound source becomes less pronounced and tainted with other ambient sounds that will probably dominate it.

Moreover, now that our target sound is 'off-axis', there will be a notable change in how it is perceived, this is due to the difference in colourisation, which Halmrast points out “is defined as changes in Timbre.”<sup>157</sup> And timbre depends on the relative strengths of the components of different frequencies, which are determined by resonance and these affect the clarity of the recording. (Discussed in the factors influencing wildlife vocalisation recording) Therefore, the microphone's position in relation to the sound source, is a crucial factor and this applies not only to the horizontal plane, but also to the vertical, because if subject/s are not 'on-axis', (Direct line of reception) then problems will occur.

(b) A microphone should be as close to the subject/s as possible, because of the problems with phase shift- reflected sound. And because reflected sound takes a longer path, it constitutes a delayed version of the direct sound thus, comb filtering becomes apparent. (Discussed in the chapter -The importance of sound when combined with picture, sub heading - stereophonic sound)

Furthermore, delayed sound can cause an increase in amplitude as much as 6 db, which results in a signal that is louder than the original, which is referred to as constructive interference. Therefore, the technique that Bartlett suggests although logical can be deemed somewhat problematic, because of the 'on-axis' factor.

In Budney and Grotke's *Techniques for audio recording vocalizations of tropical birds* 1997, they see methodology and applied techniques as an important factor in this respect. They maintain that “The researcher who records in the tropics faces not only unprecedented opportunities but also unique challenges.”<sup>158</sup> Because a large proportion of bird species remain hidden by dense impenetrable vegetation - or are located high in the forest canopy. To solve this problem, the use of playback (A recording of a song or call) to induce a response from a particular subject/s is a practice, often used. And “in many cases playback is the only practical method for observing a species.”<sup>159</sup> Moreover, “an elusive bird hidden in thick foliage will often move into the open to investigate playbacks.”<sup>160</sup>

A good example where this technique proves its value, can be found in BBC's *The Life of Birds* (1998) episode 6 'Signals and songs'. In this episode, Attenborough plays a recording of the Tieke or Saddleback bird *Philesturnus carunculatus* and views the reaction made by its 'live' counterpart. This approach was successful given that this particular bird who is singular, has its own territory, was extremely aggressive in defending it with abundant warning calls.

But to use playback successfully, one must be aware of the subject/s behavioural patterns that are appropriately naturalistic in addition, the playback device output level, must be in accordance with those of the subject/s. Another factor to consider is that the subject/s "May use different vocalisations or alter the temporal pattern of their song in response to playback."<sup>161</sup> And quite often "Birds will respond to signals of varying fidelity including distorted signals."<sup>162</sup> And as Dhondt and Lambrechts point out, "If an investigation involves a quantitative and qualitative study of a species' response to playback, then it is essential to know the frequency response of each component in the playback system."<sup>163</sup> And this of course would include the system used to record the original source recording.

To end this section, Hopp, Owren and Evans point out that, "For a modern integrated approach to research in comparative bioacoustics, researchers need access to a wealth of technical and methodological information."<sup>164</sup> This is a crucial factor in recording wildlife sound in addition, Budney and Grotke maintain that it is essential to understand. "Good recording technique combined advance preparation, the ability to recognize and create recording opportunities and the knowledge of how to operate recording equipment properly."<sup>165</sup> This also involves an understanding of animal behaviour and using it to one's advantage, and this will hopefully "Yield superior acoustic data for analysis, experimentation, and publication."<sup>166</sup>

## 4.2 Parabolic Reflectors

Another approach to recording wildlife vocalisation, especially over distance is the parabolic reflector/mirror; this apparatus is not a 'new' device for recording fauna vocalisation, it has been in existence since the 1930s. Probably bought to the fore by scientist Clarence R. Carpenter, whom in 1937 used such for making the first sound-recordings of wild gibbons, at Doi Dao - north of Chiangmai; Thailand. But with all parabolic design and construction problems will occur and these involve vibration, microphone capabilities, the field of reception and frequency response; because the parabola's effectiveness is determined by the diameter of the reflector, in relation to the wavelength of the sound.

However, by today's technological standards, it is argued that parabolic reflector development has not kept pace with the needs of field sound recording. It is said that the component technology utilized, is somewhat dated resulting in less than ideal self-noise and overall frequency response characteristics. Nonetheless, some modern reflectors have overcome most problems and are capable of recording good bioacoustic data. But some of these devices sold as complete units are inflexible in adapting various microphones and thus, are not considered suitable for every recording occasion.

For example, Cornell University's view of Dan Gibson's 18-inch (Approximately 45 cm) plastic parabola is that it is outdated; "Component technology utilized is somewhat dated resulting in less than ideal self-noise and overall frequency response characteristics."<sup>167</sup> In contrast Mineroff Electronics offer an 18-inch (Approximately 45 cm) epoxy coated aluminium reflector SME-PR-1000. But, this low budget unit is inadequate for broadcasting and scientific research, because the components used are prone to problems that impair clarity. Alternatively, Sweden's Telinga offer a 22 inch (Approximately 55 cm) parabola complete with high quality microphones. However, this unit the Pro Universal MKH series (With directionality starting at about 680 Hz) is considered expensive retailing at around €1,634<sup>1</sup>.

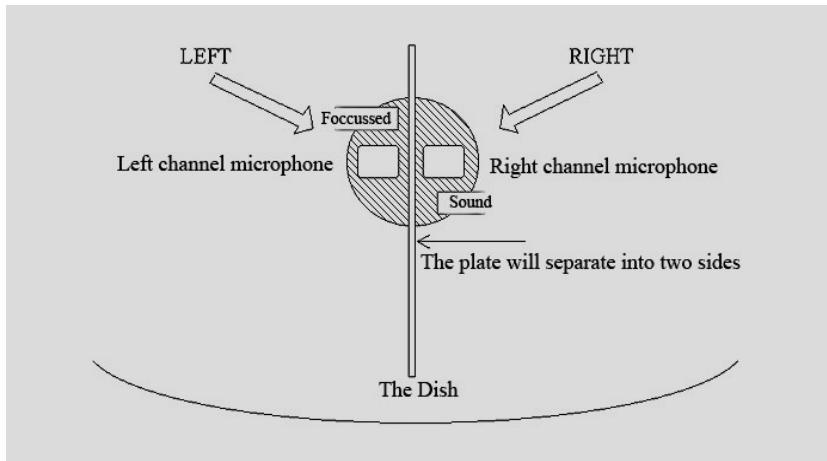
The parabolic reflector is a useful tool, but it does have its limitations and size is an important factor. Kettle and Vielliard in their *Documentation standards for wildlife sound recordings: Bioacoustics* 3:235-238 state that. "For a parabola to become effective at frequencies as low as 100 Hz, its diameter must be larger than 3 meters. Common diameters are 45 cm, 60 cm and 90 cm, with directionality starting respectively at about 750, 550 and 375 Hz."<sup>168</sup> Therefore, according to Kettle and Vielliard's calculations, recording frequencies as low as 16 Hz (Infrasound elephant vocalization), the parabola would need to be in excess of 7 meters in diameter. A parabola of this dimension is impractical due to many factors including, transportation, size, vibration, and wind and as Alkin points out. "Even a small parabolic dish can be extremely cumbersome, especially when used out of doors in a high wind."<sup>169</sup>

Another important factor with parabolic construction, is finding suitable microphones that can be used; and many makes and models are available to suit different recording requirements. In broadcast natural history filmmaking, parabolic devices normally use mono microphones, as this produces a recording that is similar to that of the source; taking into account the acoustic surroundings. But, some believe that stereo improves a sounds quality and thus, have tried to incorporate this feature in a parabola set up.

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<sup>1</sup>This price was correct at the time of writing in 2009, but maybe subject to change.

In a theoretical paper published by the Journal of Audio Engineering Society, *The Parabolic Reflector as an Acoustical Amplifier* 1985, Sten Wahlström concludes that. “It is even possible to adopt a reflector for stereophonic recordings by a simple method. A shield separates the front into two sides and will thus create a stereo background when the sound is picked up by the two separate microphones. The sound source in the centre of the sound picture will be equally amplified by the reflector to the microphones.”<sup>170</sup>



25. Wahlström. Diagram of a stereo parabola.

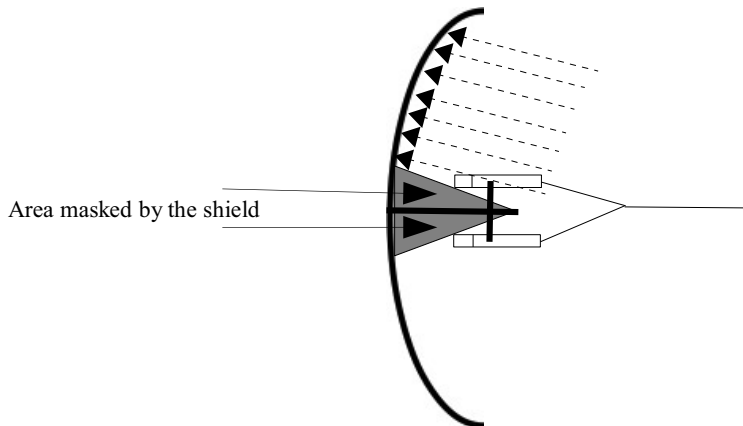
It can be argued that what Wahlström is trying to achieve in his design is Optimum Stereophonic Signal recording, (OSS) sometimes referred to as baffled stereo<sup>1</sup> which is a configuration of the Jecklin disc developed by Swiss sound engineer Jürg Jecklin. The Jecklin disc according to Josephson Engineering, is that this “idea of a new microphone arrangement is the result of the dissatisfaction about the sound of usual music recordings.”<sup>171</sup> It is basically a 10 mm thick circular central plate, that is covered on both sides with thick foam, which is intended to suppress high frequencies. Two microphones preferably small diaphragm omni condensers are positioned, one on each side of the disc, with their capsules 165 mm apart, which is calculated to give the correct delay time difference between the two channels.

<sup>1</sup>Baffled stereo is a generic term for a number of different stereo techniques which use an acoustic baffle in between a pair of matched microphones to enhance the channel separation of the stereo signals.

<http://www.recording-microphones.co.uk/Jecklin-Disk.shtml>

The perception of how the disc works is that as the frequency increases, the two microphones become more and more separated. It is believed that below 200 Hz the two microphones record the same, but frequencies above this are attenuated by the acoustic muffling of the disc. And this results in a frequency response difference of the two channels, depending on the sound's angle and impact. Furthermore, there is also a sound diffraction around the rim of the disc, which is dependent on frequency and angle. And if we try to incorporate the Jecklin principle into a parabola there will be problems for example.

(a) Sound waves radiate in all directions in much the same way as ripples on a pond do when a stone is thrown into it; and if a barrier is placed in the path of the ripples, their energy will be detracted, reflected or absorbed. And this same perception can be applied to sound waves, incorporating a barrier into a parabola would produce the same effect and would also negate its natural properties. For example, impairing the focal point of wave reflection and reducing the effect of its curvature for incoming sound waves. Moreover, according to Ward “the dividing baffle itself masks out some of the desired sound.”<sup>172</sup>



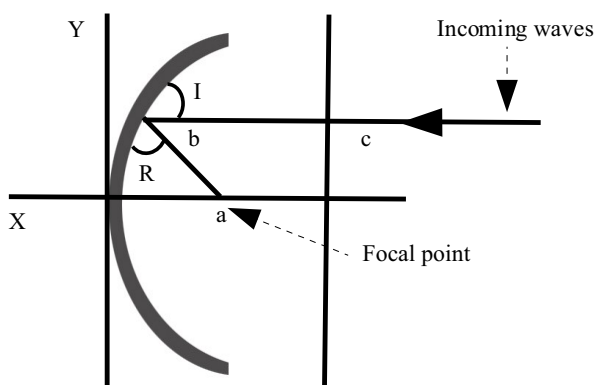
26. Masking of the reflector surface reduces the gain provided by the reflector.

(b) If we work on the Jecklin principle (Mounted microphones on a 10mm plate 165mm apart) they will be away from the focal point and “the result is that each microphone can only receive sound from half the reflector surface”<sup>173</sup> therefore, the gain is halved and recording levels have to be increased.

(c) In the natural world, there are many kinds of sounds all having different frequencies, which are a reflection of the natural world's spectral balance. And a reproduction of this natural context often

has a very wide range. Therefore, our function as sound recordists is to record these sounds as they are; in their raw state without any modification or enhancement. The sound can be modified and/or enhanced at a later time in accordance with how the sound editor perceives it to be, namely the end product – that which the spectator hears.

Before we continue with this discussion, it might be appropriate to comprehend how a parabolic mirror functions as this will assist in understanding the various viewpoints.



27. The principle of a parabola. Parallel incoming waves all converge at a focal point.

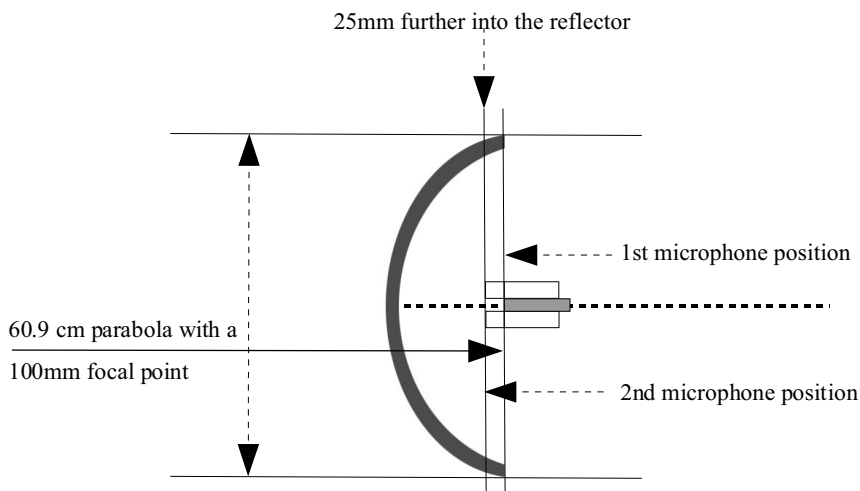
A “parabolic reflector is constructed to the formula  $y^2 = 4ax$ , 'x' and 'y' being the two axes and 'a' the focal point.”<sup>174</sup> It will have the “property that whatever the angle 'ba' makes to the axis 'x', 'cb + ba' is a constant.”<sup>175</sup> Therefore, sound waves travelling in plane wave form after reflection, will arrive at the focal point precisely and will be in phase.

As mentioned, inserting a barrier into a parabola and using two microphones as in Wahlström's design will be problematic. Nonetheless, some practitioners have made experiments on this system with mixed results for example. Sound recordist Roger Boughton realised that partitioning the disc with microphones spaced apart did not work. His directive was to dispense with the partition altogether and use two omni-directional microphones, with the centres of the heads 25mm apart on either side of the focal point (100mm) of a 60.9cm reflector. The result was a very confused 'stereo' image.

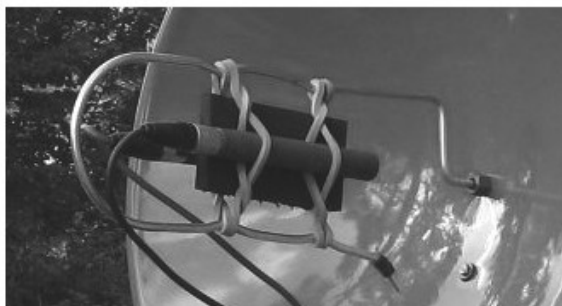
According to Robjohns, “When you use this method of creating a fake stereo signal from a mono source, the apparent width is determined entirely by the amount of Side signal relative to the amount of Mid signal.”<sup>176</sup> For example, if there is a lack of 'side' the result will be mono, but plenty of 'side' will give a wide perceived stereo image. But “Too much side signal means a hole in the middle and quiet mono.”<sup>177</sup> therefore, attempting to create an acceptable balance between the two signals can be difficult, because much depends on how the end result is to be perceived. In addition, changing signal delay time also affects our perception of width and size. For example, “Larger delays (30-70 ms) create more hall-like effects, while shorter delays (5-30 ms) are more subtle and less ‘roomy’.”<sup>178</sup> However, some contend that this middle/side M/S stereo approach is unconvincing; the end result is an assortment of frequencies spread thinly across the sound stage. Because, “There is no discrete spatial positioning, and no coherent imaging”<sup>179</sup> and therefore, will not sound as true stereo does.

The main disadvantage of using spaced microphone techniques as opposed to coincident systems, is mono compatibility, because each microphone will capture the sound from a given source at different times. Moreover, Robjohns points out that “If the outputs from all of the microphones are mixed together (to produce a single mono signal), the sound will become coloured”<sup>180</sup> because of comb filtering. This phenomenon is discussed in the chapter the importance of sound when combined with the picture. In severe cases, comb filtering can alter the sound to such an extent, that the sound gives a 'tunnel' appearance as if it is emanating from the end of a long tube. Alternatively, if the signals from spaced microphones are not combined into a single mono recording, but remain separate, then “the comb-filtering problem becomes totally irrelevant.”<sup>181</sup>

Analysing his findings, Boughton realised that the position of the microphones, although aligned in the correct direction left and right, were not parallel. “They each converged to points some distance in front of the reflector, and then spread out again, in other words each became laterally inverted.”<sup>182</sup> Boughton after further experimentation, repositioned his microphones 25mm closer to the reflector, with their centres still 25mm apart. (Illustration 27) The result was that, “two diverging beams were obtained, giving a total horizontal spread of 25 degrees with 6 degrees of overlap in the centre.”<sup>183</sup>



28. Plan view of Boughton's perspective.



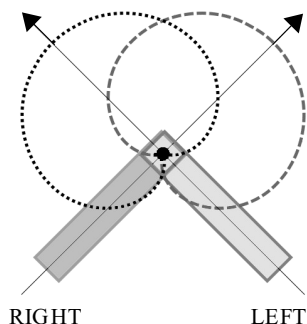
29. Close up view of Boughton's design.

From Boughton's point of view the results were encouraging, but further tests in microphone placement are/were needed to determine the optimum position, especially with parabolic mirrors containing different focal lengths. He (Boughton) suggests that a good starting point for experimentation, is to position the microphones at 75% of the focal length. Moreover, with the barrier removed, weight and bulk factor give this system an advantage, but as Ward contends "the main advantage is that of GAIN; each microphone uses the whole reflector surface, so the gain is doubled."<sup>184</sup>

We can accept the consensus that 'stereo' in whatever guise, can be achieved by using two omnidirectional microphones in a parabolic reflector; that is providing problems with microphone positioning

at the focal point are resolved. But, 'single-bodied' stereo microphones have been in existence for decades for example, the Neumann SM 2<sup>1</sup>, introduced in 1957 considered the world's first stereo microphone. More recent models are available including the Audio-Technica BP4029 and Sennheiser MKE 44P. Therefore, would it not be more convenient - even simpler to use one of these as opposed to two separate microphones?

When recording stereo the formats normally used are: an X/Y format, an A/B set-up containing two figure-of-eight microphones set at a 45-degree angle, an M/S (Mid/side) system, or a single microphone set up that incorporates one of the afore mentioned systems as shown in the following images.

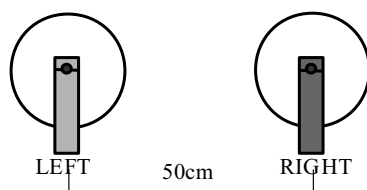


30. Graphic of X and Y stereo.

X-Y technique: (Intensity stereophony) – The illustration shows two directional microphones typically placed at 90° to each other and a stereo effect is achieved through differences in sound pressure level between two microphones; due to the lack of differences in time-of-arrival and phase ambiguities. For some practitioners, the sonic image produced by this configuration is a realistic, almost holographic soundstage. But opponents contend that the sonic characteristic of X/Y recordings has less sense of space and depth when compared to recordings using an A-B format. Because of the lack of differences in time-of-arrival/phase ambiguities.

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¶ The SM 2 microphone is essentially a pair of KM 56 microphones in a single body, arranged so that their directional patterns could be controlled remotely.



31. Graphic of A and B stereo.

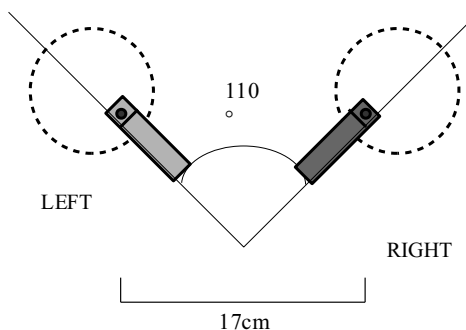
The A and B method (Time of arrival stereophony) uses two parallel omnidirectional microphones spaced apart, which allow for the capture of time-of-arrival stereo information. However, as a stereo recording's acoustic character is really a matter of personal preference, it is impossible to dictate general rules for stereo microphone spacing using this approach. And since the stereo width of a recording is frequency-dependent, the deeper the tonal qualities required, the wider the microphone spacing should be.

A general guideline for microphone spacing is a  $\frac{1}{4}$  of the wavelength of the deepest tone, providing we take into account the human ear's reduced ability to localize frequencies below 150Hz. This then leads to an optimal microphone spacing of between 40 and 60cm however, spacings of 17 to 20cm are detectable by the human ear, because this distance is equivalent to the distance between the two ears.

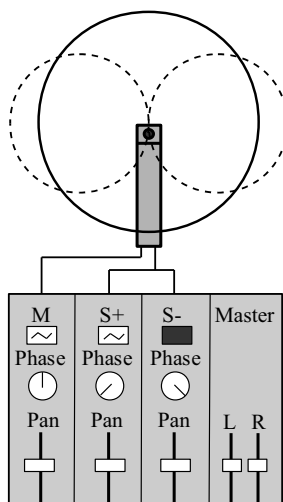
The ideal distance from the microphone pair to the sound-source not only depends on the type and size of the sound-source, but on the surroundings in which the recording is to be made, and on how the image is to be perceived. But it should be noted that if the distance between the two microphones is increased, it effectively decreases the pickup angle and at a distance of 70cm it is approximately equivalent to the pickup angle of the near-coincident ORTF<sup>¶</sup> setup illustrated below.

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¶ The ORTF stereo microphone system is a microphone technique used to record stereo sound. It was devised around 1960 at the Office de Radiodiffusion Télévision Française at Radio France. ORTF combines both the volume difference provided as sound arrives on-and off-axis at two cardioid microphones spread to a 110° angle, as well as the timing difference as sound arrives at the two microphones spaced 17 cm apart.



32. Graphic of an ORTF stereo.



33. Graphic of M and S stereo.

The M/S (Middle side-signal) is a coincident technique employing a bidirectional microphone (Having diaphragms with discrete outputs) that face sideways and a cardioid at an angle of  $90^\circ$  facing the sound source. According to Robjohns, “The ‘M’ microphone will be chosen to give the appropriate polar pattern for the mono listener and the ‘S’ microphone must be of a figure-of-eight polar response.”<sup>185</sup> One microphone is super imposed over the other so that “The diaphragm of the ‘S’ microphone is as close as possible to that of the ‘M’ microphone.”<sup>186</sup> If the ‘S’ microphone is positioned in front, the result is sounds that are difficult to locate therefore, it must be placed slightly behind the

‘M’ microphone where the sound is more stable.

The left and right channels are produced through a simple matrix:  $\text{Left} = \text{Mid} + \text{Side}$ ,  $\text{Right} = \text{Mid} - \text{Side}$  (The polarity-reversed side-signal). This M/S configuration produces a good monophonic compatibility and considerable postproduction flexibility for example. Eargle tells us that, “the ‘S’ component can be reduced to produce a narrowing of the resultant array.”<sup>187</sup> And can also “be increased to produce a wider resultant array”<sup>188</sup> and this makes it especially useful for film-based projects.

If a stereo signal is to be reproduced in mono its signal out-of-phase parts will cancel, which can cause unwanted reduction or even loss of some parts of the signal – and this can be an important factor when deciding which technique to use.

(1) In using the X-Y technique, the microphones should be exactly in the same place, which is not always possible. If they are separated either left or right this may result in the loss of high frequencies when played back in mono therefore, they are often separated vertically. But the negative with this configuration, is that there may be problems with sound from above or below the height of the microphones. For example, if we recall the Gannet colony (Illustration 26) we have sound radiating from the air as well as from the ground.

(2) As the A-B technique use phase differences to give the stereo image, they are the least compatible with mono. Moreover, defining the correct microphone spacing is extremely difficult, because increasing the distance between them, effectively decreases the pickup angle.

(3) The M/S technique is especially ideal for mono compatibility, because summing Left+Right will give a Mid signal return, which allows for more flexibility and control.

The equipment for these techniques also varies considerably, from bulky and cumbersome to small and convenient. X and Y microphone capsules can be incorporated into one unit. Whereas, A-B techniques normally use two separate microphones, often mounted on a bar to define the separation. M/S setups are able to give a variable soundstage width and are often used in field recording.

### 4.3 Section summary

To summarise this section, many approaches to wildlife sound recording have in their fashion met with various results. Thus it can be agreed that, recordists and researchers require a wealth of technical knowledge of equipment and how to use it. In addition, an understanding of animal behaviour and using it to one's advantage, is equally important; and together will hopefully allow for the recording of good bioacoustic data.

If we remember some situations are/were still creating difficulties for example. The problems encountered by marine biologist Boisseau with his Beaked whale vocalisations, in *Tracking their silent voices*. (2009) We can appreciate Boisseau's approach of only using sail-power, because he was trying to eliminate the problems experienced by Charif *et al.* (Engine noise, sea-wash and cable hum - discussed in the chapter the approaches to recording wildlife) However, being solely reliant on sail-power, can result in inconsistent manoeuvrability; meaning unable to keep pace with the subjects.

Other examples causing complications, are the attempts to record certain avian species that reside high in a forest canopy, as Budney and Grotke have pointed out in their *Techniques for audio recording vocalizations of tropical birds* (1997). They suggest that playback in many cases is the only way to induce a subject to respond. But quite often the use of playback can agitate the subject into producing different behavioural patterns - as demonstrated in the Tieke example in the BBC's *The Life of Birds* (1998) episode 6 'Signals and songs'. Here we see Attenborough using playback in close proximity with the subject - the latter whom is giving a frantic display of aggression. (Discussed in the chapter the approaches to recording wildlife)

Moreover, as we delve deeper into the realm of the natural world in our attempt to visually capture an elusive species of fauna, situations will arise creating complications when trying to record their vocalisation. Because as Attenborough *et al.* have pointed out, the flexibility of sound technology has not kept pace with its visual counterpart; meaning that it is extremely difficult and in many cases impossible to match a camera's lens changes. Therefore, the sound recordist needs extensive of knowledge on the following factors, (a) understanding the idiosyncrasies of the sound stage. (b) A good appreciation of fauna behaviour and (c) technical knowledge. Because, this information will give an indication in determining a possible method of approach to a particular recording situation.

## 5. INTRODUCTION TO THE FIELD STUDIES

In the previous chapters we discussed the problems associated with recording wildlife sound and examples were given on how to overcome a particular situation using different a

- The Killer Bee film (1992)
- The Living Planet Episode 1 'Sweet Fresh Water' (1984)

But our immediate concern and main research question in this thesis is the 'Distance' and 'On-axis' issues – how to get close to the subject/s and record their vocalisation without disturbing them.

The next section in this chapter will detail the experimental conditions and constraints starting with the sound stage, subject disposition and technical approach.

The results of this experimentation will show a mixture of both positive and negative, but through examination and analysis a way to record good bioacoustic data will be found. At this juncture it should be noted that the experiments conducted in this exercise are not a mandate, they are in their entirety an example of one way to approach a given situation. It should also be noted that the experiments have nothing to do with microphone and/or subject/s vocalisation acoustics, they are as described; an approach to recording wildlife sound. The results of the field studies/practical experiments will be shown in the following manner:

(a) Analysing the location/s – the sound stages where the subject/s frequent, because from this we are able to assess the endemic problems found within and their possible effects therefore, at this point it might be prudent to give an indication of what these could be:

- Accessibility
- The elements
- Unwanted sounds for example, humans and motorised transport
- Acoustical characteristics of the location

(b) Subject/s disposition; this tells us about behaviour patterns which may include; foraging, courtship and social status within a particular group, it also gives an indication on the approachability factor. Other important information may include:

- Time arrival and departure to/at the location
- Stationary or nomadic
- Territorial or communal
- Group division for example, family, adults and/or juveniles

(c) The method of approach; is primarily based on the information culminated from the location and subject/s disposition, it allows us to formulate a working plan with the view to recording vocalisation. It tells us if the following strategy may or may not be beneficial:

- Singular microphone positioning
- Multi microphone positioning
- Distance, elevation and angle in relation to subject movement
- The roaming microphone for example, tracking or stalking

(d) Comments – these will include 'on-site' observations of what was/is encountered at each location for example:

- The problems with the elements
- Unwanted noise
- Subject activity
- Analysing the recording on location
- Analysing the recording away from location

### **5.1 Recording equipment to be used in the studies**

The choice of equipment is important, because what is used will have an effect on how the aural image is displayed; meaning, how it will sound in conjunction with the visual setting. For example, a wide perspective, a mid setting or a close-up point of view. Therefore, we need to select the appropriate

equipment that will mirror 'real world' conditions and there is much to choose from for example.

- Monophonic and stereophonic microphones
- Parabolic reflectors
- Analogue, digital audio tape, (DAT) mini disc and computer hard drive recorders.

These vary considerably from low cost devices to expensive high-end instruments, the latter normally found in broadcast organisations and scientific establishments. But does this directive put us at a disadvantage? - in short, the answer is no. Because arguably, the recording device (And these vary considerably in their capabilities) on which the bioacoustic data is stored is; simply a device on which to store the information, which is the last link in the chain. (Prior to editing) The most important factor is the first link in the chain - the microphone – how it is related to the sound source; and the choice of microphone is extremely important. Because, its characteristics (Described in its polar chart) will tell us of its capabilities and whether or not it is suitable for the task.

An average sound recordist's equipment may consist of an analogue or DAT recorder, a shotgun, two omni directional microphones and perhaps a small 45 cm parabolic reflector. Therefore, our equipment will be of a similar nature for example.

- A parabolic mirror purposely built for this study
- A Nagra 4.2 reel-to-reel mono recorder
- Sennheiser 416 RF P48 U3 shotgun and an Octava MC 012 electret condenser microphone

And by following this directive the field studies will be in keeping with what the sound recordist/researcher might encounter whilst attempting to record wildlife vocalisation. A full list of the equipment used in the field studies, is found after the 'Subject behavioural patterns' section in the next chapter 'Field studies'.

## 5.2 Subject information in brief

Now that we have considered albeit in brief the peculiarities of the sound stage, subject/s, approach and equipment (Further discussion on these factors will be given as we proceed with the field studies) it might be useful to know a little of the subject/s chosen for this study. The subject/s selected for the field studies is/are the Eurasian crane *Grus grus* also known as the common crane; a large stately bird with an extremely timorous nature. Its size is approximately 100 to 130 cm with a wingspan of 180 to 240 cm, and has an average weight of 4.5 to 6 kg. It breeds in the wetlands of northern Europe and Asia, with the vast majority nesting in Russia and Scandinavia. The current global population, is estimated in the region of 210,000 to 250,000 birds.

## 5.3 Recording experiment synopsis

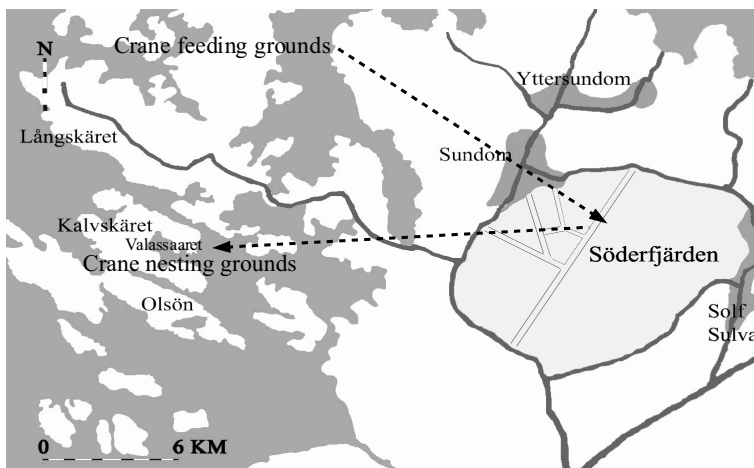
The actual recording experiments will be conducted over a period of 14 days using different methods of approach in an attempt to capture different samples of sounds, which each have different production values. And the findings will be explained in the daily diaries. The reason for this methodology, is to show success and failure - and from this we are able to determine what approach or technique affords for the best results. We now continue the field studies discussion commencing with our first priority - the location/s or sound stage.

## 5.4 The location or sound stage

Although several locations will be used in this study which will be discussed in detail, there are two primary locations or sound stages. The first is Söderfjärden 10 km south of Vaasa in Finland's Ostrobothnia region (Illustrations 34, 35 and 36) and the second, referred to as 'location 6', an area west of Söderfjärden. (Illustration 37)



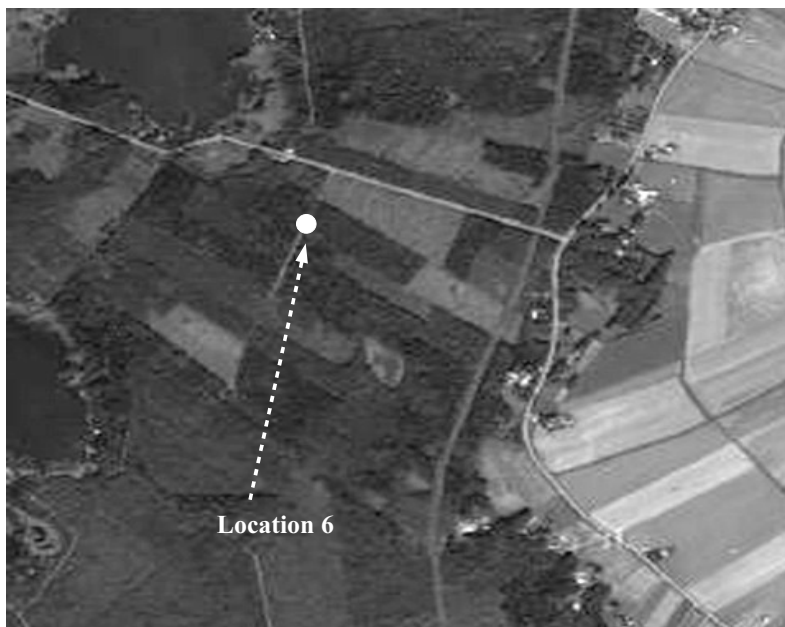
34. Graphic of wide view of study location (Vaasa).



35. Graphic of Söderfjärden study area.



36. Aerial photograph, Söderfjärden.



37. Satellite image of forest area at location 6.

Söderfjärden referred to as the crater or plain, was formed due to a meteorite impact approximately 520 million years ago and according to Andersén its diameter is; “6.4 kilometres with an original depth estimated in excess of 300 meters.”<sup>189</sup> However, this depth has been reduced considerably over the millennia due to debris including vegetation, and “Sediment of different rocks such as Cambrian sandstone”<sup>190</sup> but, the crater still lies below sea level albeit by only half a meter.

“In the beginning of the 19th century Söderfjärden underwent a huge drainage project”<sup>191</sup> - considered the largest in Northern Europe at that time. The purpose was to turn this vast wetland into arable land and to guarantee the drainage, parliament passed a law called *Lex Söderfjärden*. The central ditch or Riddardiket was made deeper and subsequent ditches stretching the length and breadth were dug by hand. The work completed in 1927, resulted in extra land being allocated to the surrounding villages of Sundom and Sulva.

This area of continuous cultivation (2300 hectares) (Illustration 43) is the feeding ground for the Eurasian crane, whose diet according to Johnsgard includes, “Cereal crops of wheat, barley, oats and rye.”<sup>192</sup> This abundance of food is available as the fields are harvested - and during the month of September, it is estimated that between 2000 and 6000 cranes visit Söderfjärden on a daily basis. Their purpose is gaining the much-needed weight in preparation for their October migration to warmer climes. At sunset they take to the wing flying to the archipelago of Valassaaret near Kalvskäret and Olsön.

The main problems associated with Söderfjärden as a sound stage are: (a) motorised vehicles moving within, around and above its perimeter, these are enhanced because of the crater’s shape, in that it demonstrates parabolic attributes due to its “Well formed edges.”<sup>193</sup> Moreover, the reflective properties of surrounding mediums including metal buildings enhance the sound further. (b) Wind within the crater is able to gust unrestrictedly due to the vast open space and in some instances can be quite intense. (c) There is very little vegetation to act as cover – and because the Eurasian crane is extremely timorous with acute eyesight, approaching them closer than 400 metres, causes them to take flight. Therefore, these factors will play an important part when attempting to record subject/s vocalisation.

Location 6 has its own idiosyncrasies and the problems here are: (a) a densely forested area containing a mixture of coniferous and broad-leaved species including pine, *Pinus sylvestris* spruce, *Picea abies* downy birch *Betula pubescens* and silver birch, *Betula pendula* creating problems with phase shift and/or absorption. (Discussed in the chapter the factors influencing wildlife vocalisation

recording) (b) Un-wanted sound including wind through vegetation, motorised transport and human voices. (c) The problem of elevation; positioning the recording device at more than 30 metres.

If a wooden tower was constructed in keeping with the surrounding landscape, it might go some way in solving the elevation issue. But there are 3 factors, which negate this perspective.

- The ground surface where the tower should be erected, beneath the crane's main flight path is prone to water retention and therefore, unstable.
- The crane's flight path can vary as much as 100 to 500 metres depending on weather conditions, taking them away from the tower thus, reducing its effectiveness.
- The cost for such a construction would be expensive and as the land is privately owned permission has to be granted.

As an alternative, using a mobile mechanical lifting device would prove more beneficial and there exists a small track (Approximately 4 metres wide) going through this location. But, as the track is in constant use by vehicles, a mobile crane restricting this thoroughfare for some considerable time could cause problems. For example, it can take more than 2 hours for the cranes to fly over this location depending on numbers and weather conditions. Moreover, the hire cost for such a device would be expensive, because it would be needed on more than one occasion.

## **5.5 Subject behavioural patterns**

The Eurasian crane as mentioned is a large stately bird and extremely timorous and is apt to take flight at the sight of any entity approaching, them including humans, domestic/wild animals and motorised transport. Its colouration is grey, with a white facial streak with black wing plumes and only adults birds sport the distinctive red crown patch. The crane's synonymous loud trumpeting call, a resemblance of 'kruu-kruu' is given in flight and is also associated with courtship, ritual display and aggressive behaviour. In courtship and display - a dancing ritual - leaping with wings uplifted the crane call according to Archibald. "Is linked to movements of the wings and neck carried out in coordination with adult couples."<sup>194</sup>

The crane has a complex social structure and can be aggressive to one another for example. In the 'crouch threat' "The crane bends its legs lowers itself to the ground folds its wings loosely against

the ground and body and places its head forward with the red patch prominent.”<sup>195</sup> In the ‘ruffle threat’ “The crane raises the feathers of its neck, wings and back and partially opens and lowers its wings, the bird then lowers its bill to its breast or leg in a preening movement, often concluding this sequence with a low growl.”<sup>196</sup> And in a ‘charge’ “The crane points its neck and head straight down and lifts the feathers along its neck and back holding this stance for several seconds.”<sup>197</sup> A crane that is confronted by another animal for example, a small predator as in a fox; spreads its wings and arches forward as if ready to strike and approaches the intruder as depicted in the following illustration.



38. Graphic of Eurasian crane defence stance.

A submissive crane by contrast, lowers its neck elevates its body feathers, and diminishes the threatening display of its head features by lowering the feathers, and reducing the size of its comb. In this state of accommodation, the crane walks loosely, warily and quietly and because of this posture there is very little opportunity to record sound.

Crane vocalisations are also used for territorial demarcation to warn off potential intruders moreover, it is not uncommon to observe pairs of cranes making these calls. Meine and George contend that, “During aggressive encounters in which one member of each pair comes in support of another

while issuing this call.”<sup>198</sup> According to Gaunt, Gaunt, Prange and Wasser, the crane’s calling power is due to “The structure of the trachea”<sup>199</sup> its high length and position, are special features in cranes allowing them to communicate over long distances.

Cranes have a social structure, adult birds including established breeding pairs often congregate together; whilst juvenile and single birds who have yet to require social status, tend to keep their distance. And this is the possible reason why many different flocks were located at various points throughout Söderfjärden.

Given the Eurasian crane's complex behaviour and the fact that they are extremely timorous, difficult to approach, and will abscond in an instant, they make a good subject for these field studies although it is necessary to research them at length. In addition, their unapproachability presents a good opportunity to test the recording devices designed to solve the 'Distance' and 'On-axis' issues. Because, the locations they frequent are mostly open areas and these vary according to food variety and availability; and of course social status within a particular flock or group. Therefore, attempts to record their vocalisation/s is an appropriately challenging test for the chosen technical equipment.

During recording sessions, attempts will be made to capture as much diversity in behaviour and sound as possible in keeping within the testing and technique parameters. For example, an agitated crane displaying restless behaviour is most likely to vocalise - a sign to take flight and in so doing, can result in others following suit.

In addition, cranes usually vacate their nesting grounds in the early morning, but some birds will leave sooner or later thus, arriving at the feeding grounds at different times. And when the cranes are ready to return to roost, the pattern is much the same; although weather fluctuations can be a contributing factor causing different departure times. Therefore, observational studies of such activities lets the sound recordist and/or filmmaker know an approximation of when the subject/s will arrive/depart, so that he/she can be in a position with the view to recording vocalisation.

The field experiments lasted for 14 days, from 0600 to 2000 hours commencing on 11/09/05 to 25/09/05, resulting in approximately 187 hours of observation and sound recording and the instrumentation used consists of the following.

- The parabolic mirror designed and constructed for this study
- Nagra 4.2 reel-to-reel mono recorder using Emitec ¼ inch (6.35 millimetres) tape stock
- Microphones included a Sennheiser 416 RF shot guns and an Octava MC 012 electret condenser microphone all complete with windshield protection
- Monitoring device were Beyer DT48 headphones
- Sound transfer from ¼ tape to CD-ROM disc was via audio mixer - Behringer UB802 in conjunction with Apple Mac OS X - Model iMac8,1 - Intel Core 2 Duo - 2.4 GHz using Final Cut Pro version 7.0.
- Vocalisation authentication – all crane vocalisations will be left in their original format during transfer to CD-ROM audio disc.

## 5.6 Parabolic reflector construction consideration

In this section we focus on a selection of technical equipment to be used in the tests, intended to optimise the problems of recording from a distance and the equipment selected was/is a parabola specially constructed for this purpose. At this point, it would be useful to impart information as to our choice of material, size and performance.

There are different types of parabola available including those made from various materials including, vacuum-formed Acrylonitrile Butadiene Styrene, (ABS) transparent polycarbonate, carbon fibre, glass, and coated metal. Those made from a 'plastic' compound are probably perfectly capable for recording wildlife sound, but they were thought too lightweight for our purposes, because of strong winds.

An aluminium reflector is lightweight having high strength and durability with a high corrosion resistance and can be anodized in a variety of colours or coated in powdered glass or in metal; chrome, gold and silver. However, there are disadvantages with aluminium, it is easily dented and requires heat treatment to reform its shape, but in doing so it loses strength rapidly, causing a weakness or brittleness in the affected area.

Coated aluminium parabolic reflectors are quite commonly used especially those fixed at/on permanent exterior locations. But these are subject to acids in rain - sulphuric, nitric and carbonic, which

can destroy the coating. Climate variability; Parker maintains that reflectors are “Highly subject to frost and dew formation.”<sup>200</sup> This is detrimental to its performance, because frost and water damage the coating causing it to pit and crack, affecting its reflective qualities. And continuous frosting or ice build-up in the reflector's bowl to a point where its weight, can permanently distort the dish. However, as our parabola will not remain a permanent fixture, it is not susceptible to the above problems.

Parabolic reflectors vary in construction and many are designed for a particular set up for example, an outward facing omni/uni direction format using an AKG C535 EB microphone. As a range of high-quality directional microphones were/are in-house, we need to ascertain if they could be used for both inward and outward facing set ups, so we need a reflector to work with these.

Size and performance is/was also an important factor, reflectors under 30cm diameter, are considered too small to be particularly effective for wildlife sound recording. Because we cannot expect a parabola to reflect, if it's surface is narrower than the wavelength of the signal for example. 1kHz being approximately 35cms in length would cause a small reflector to under perform.

Another problem with small parabola is that they are normally 'deep-dished' and although acceptable for outward facing omni/uni directional microphones, they are unsuitable for inward facing directional microphones. Because a deep dish causes a resonant cavity effect, meaning amplified sounds that are produced within, much the same as a cello's body amplifies the sound produced by its strings. Deep cavity resonance is an item to avoid and by using a larger 'flatter' reflector, it is possible to avoid this problem, but is harder to stabilise in windy conditions.

Large reflectors have a higher gain, sharper focus definition and greater directivity but, as with any parabola much depends on the sound wave's frequency. For example, reflectors ranging from 60cm to 120cm diameters are directional at high frequencies and at low frequencies become omni-directional. And with frequencies in the intermediate range gain, directivity becomes irregular. However, according to Kettle and Vielliard, for wildlife sound recording, common reflector diameters are: 45cm, 60cm and 90cm, with directionality starting respectively at about 750 Hz, 550 Hz and 375 Hz. Therefore, we should consider a parabola within this range.

A parabola's directivity is another consideration, because if the surface is approximated by a series of minute flat facets, each of these facets must be oriented, to direct reflections to the focal point.

According to Little, “Each flat element must not deviate from the true surface by more than about one percent of a wavelength”<sup>201</sup> in order to maintain phase shift at less than ten degrees. This would suggest that the radius of a facet cannot exceed  $0.1aL^{1/2}$  if deviation is to be less than one percent, where  $a$ , is the parabolic constant and  $L$  is the wavelength of the sound. For a value of  $a = 10$  which is normal for most parabola used by wildlife sound recordists, this would mean that a facet’s radius cannot exceed the square root of the wavelength.

Furthermore, each facet will reflect its particle of sound towards the focal point, but the convergence of these particles will centre at a focal area rather than at a fixed point. Because, the size of this focal region is proportional to the square root of a sound wave's length; which makes directivity proportional to the square root of frequency. Little argues that, “the limit of resolution direction for a parabola of 105cm used together with a microphone having a 2.5cm diaphragm, would be approximately  $10^\circ$  occurring at frequencies of 5 kHz and higher.”<sup>202</sup> This limit determined by the  $L^{1/2}$  formula would give an approximation of  $8^\circ$  at 8.5 kHz. The possible cause for this reduction is probably due to incorrect positioning of the microphone at the focal area. (Discussed in the chapter - The approaches to recording wildlife vocalisation)

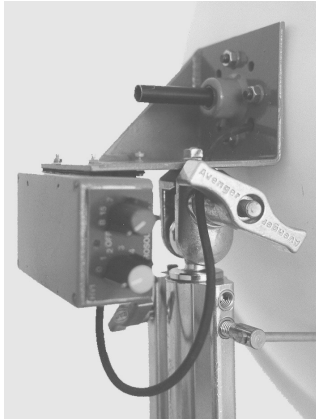
## 5.7 Parabola equipment

The equipment chosen for our device is/was as follows:

- A 2mm white enamelled aluminium 13/13 degrees circular solid parabola with polarization linear mounting in steps of 45 degrees – Reason for choice = robust able to withstand harsh conditions
- Diameter 610mm with a depth of 150mm ket.<sup>¶</sup> - Reason for choice = higher gain, sharper focus definition and greater directivity
- Reflector support a Manfrotto 'Follow Spot Lighting' stand modified to suit – Reason for choice = Heavy duty able to withstand high winds

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<sup>¶</sup>ket = the depth taken from the parabola’s central point on a horizontal plane level with its rim.



39. Parabolic reflector rear view.



40. Parabolic reflector side view.



41. Reflector and stand.

## 5.8 Section summary

To summarise this section, constructing a parabolic reflector does require some thought because there is much to discern. For example, cost, material type, size and performance, microphone choice omni/uni or directional; as this will have bearing on its position at the focal point. In addition, will the reflector stand up to the rigours of field work, especially in extreme temperature conditions. Arguably, a coated aluminium reflector could be the answer providing it is well cared for.

## 6. FIELD STUDIES

In general terms when recording fauna, it is useful to know their location and state of activity for example. A foraging subject will quite happily remain at the food source if undisturbed, allowing more time to record possible vocalisation. Whereas, a subject that is active may wander away from the area thus, minimising the potential. Human presence or intrusion can have a negative effect, causing subject/s to abscond therefore, some sort of cover for example, vegetation is preferable to lessen disturbance.

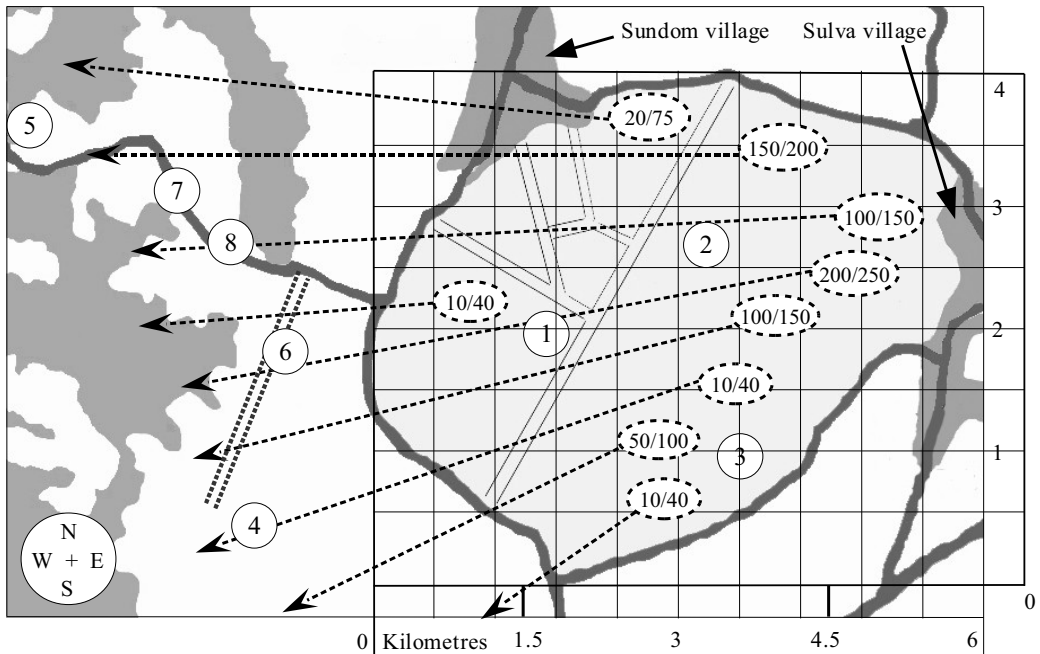
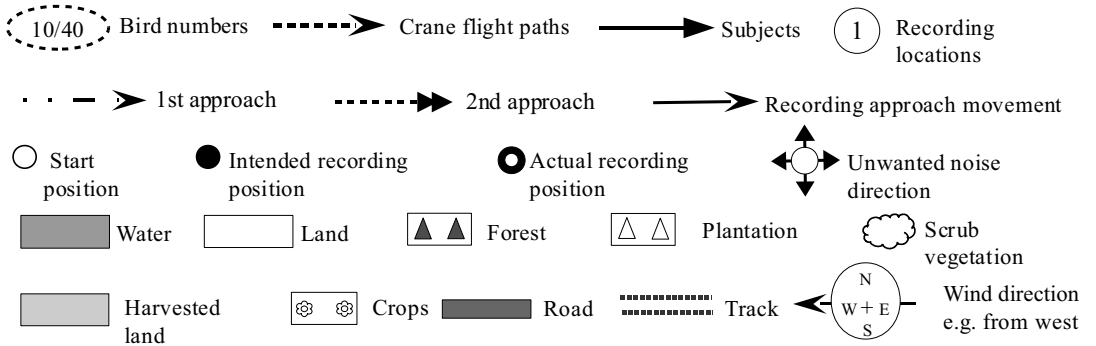
### 6.1 Location or sound stage

But, in this experiment, we are dealing with a vast expanse of open arable land susceptible to the elements; the sparse vegetation consists of grass, scrub birch *Betula glandulosa* and willow, *Salix cinerea* offering very little cover as illustrated below. Therefore, approaching the cranes will cause problems, but it is necessary to do this because by studying their movements, some form of behavioural pattern is obtained that may be useful when planning a recording venture. Moreover, if the subjects do take flight their movements can be tracked and the new positions logged. This information is important because, it will be apparent at evening departure, as the positions would be reflected in the projected flight path; within a 4.5 kilometre corridor.



42. Cranes at Söderfjärden.

Arguably the biggest problem with Söderfjärden is its size (6km x 4km) with cranes scattered throughout; illustration 42 gives an indication of the enormity of the research area. Note: The following legend is not to scale, it is an approximation used to describe what is applicable to each location and applies to all diagrams/illustrations in the field studies diary.



43. Diagram of crane positions at Söderfjärden and projected flight path.

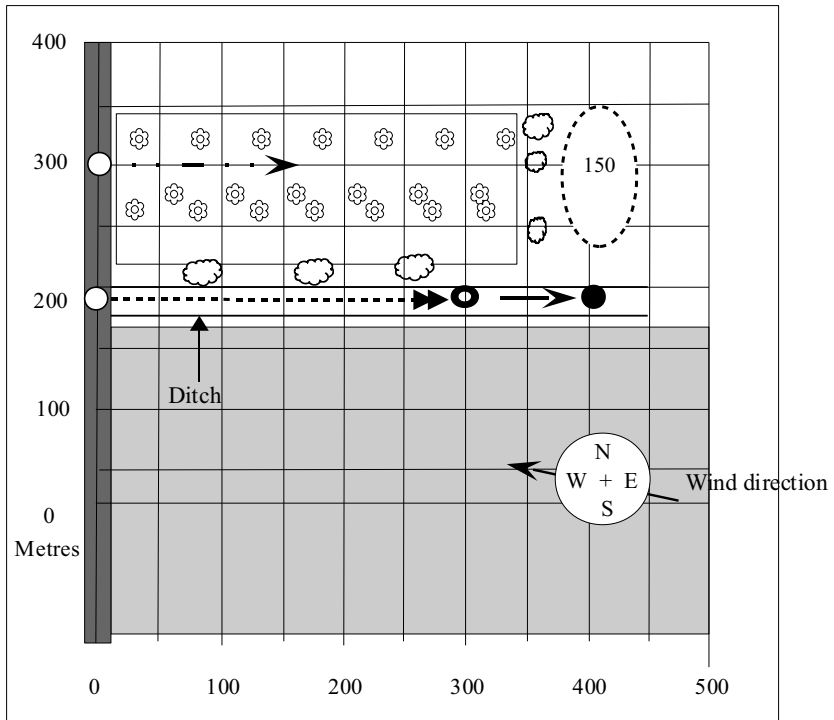


-15db wind noise prevents gain increase.

Recording: None.

Comments: Distance to subjects approximately 400 metres, recording not viable, wind blows across face of microphone, motorised vehicle noise distracting. Must reduce distance and angle - drainage ditch a possible route. Approximately 275 metres covered, exercise a failure, farm vehicle activity causes subjects to take flight. Monitor other flocks within crater, birds continuously moving. Conclusion, recording possibilities nil - day spent studying their movements.

**Recording session 2. - Location 2. - Date: 12/09/05 - Time: 0600 - 1945**



45. Diagram of Location 2.

Location analysis: Access two possible routes - cover minimal, sparse scrub birch. Cold, clear skies wind blustery. Some motorised vehicle noise evident - acoustics - flat sounding, no noticeable reverberation.

Subject analysis: 0930 hours, estimate 150 cranes in situ spread over an area of 140 x 60 metres. Birds are adults, activity is feeding, preening and social displays, sentinels on watch.

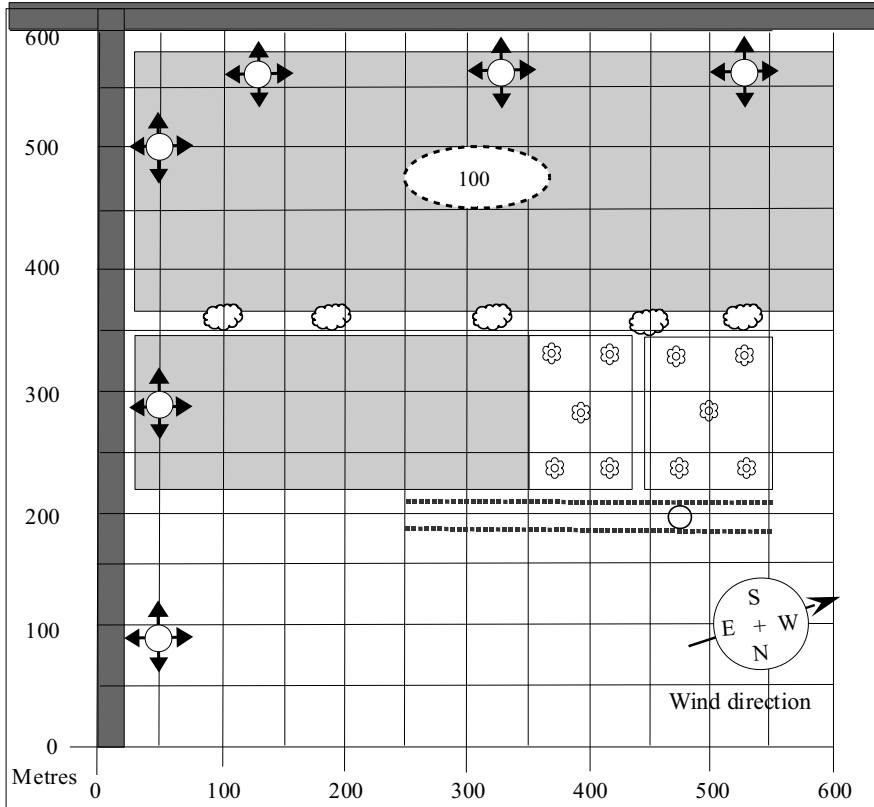
Recording equipment and approach: Nagra 4.2 and Sennheiser 416 shotgun - roaming approach - Microphone 1 metre above ground; angle - horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: CD-ROM track 14 Cranes location 2 – gun shots.

Off location recording analysis: Location, open land, acoustics flat sounding, no reverberation and motorised sound minimal. Elements: wind noise reduced due to microphone angle and shielding, but still noticeable. Subjects audible but distance between source and microphone evident as shown in the recording. Conclusion, will change from 416 to parabola and Octava MC 012. Reason for change to determine if parabola is able to record clear sound allowing for the conditions that prevail.

Comments: Beet field was favoured due to subject position, start point up wind any sound will disturb birds, beet field rejected and drainage ditch used. At 300 metres, study subjects, sentinels alert cannot go closer. Recording made, terminated after 27 seconds, reason firearms discharged, cranes take flight. Wind strength increases, birds continuously moving, no further recording possible; continue to study their movements.

**Recording session 3. - Location 3 - Date: 13/09/05 - Time: 0600 -2000**



46. Diagram of Location 3.

Location analysis: Access via track between beet fields, no cover - will be visible. Elements overcast, blustery wind. Motorised transport sound audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along perimeter.

Subject analysis: 0805 hours, 100 cranes in situ spread over an area of 130 x 50 metres. Subjects a mixture of bonded adults and older adolescents practicing take off and landing skills. Activity is feeding, preening and social display, sentinels on watch.

Recording equipment and approach: Nagra 4.2, parabola and Octava MC 012. Sennheiser 416 shotgun

as backup - static approach - parabola between 1.7 metres above ground; angle - horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: None.

Comments: Subjects active but approach from any direction impossible; no cover. Unwanted sound prominent; inclement weather. No recording, will search for a better site. 1845 hours, subjects start flight to the archipelago – positions logged prior to take-off; must investigate crane departure as information is needed when recording their calls during flight. (Diagram 42)

#### **Recording session 4. - Locations 1, and 2 - Date: 14/09/05 - Time: 0600 - 2030**

Location analysis: Access to some areas restricted due to flooding caused by overnight rain. Elements dull, windy, occasional rain. Sound of motorised vehicles evident - acoustics - slight reverberation due to the crater's unique bowl-shape and reflective mediums along perimeter.

Subject analysis: No cranes at location 1, bird numbers reduced and scattered, feeding minimal probably wet food source. Small flocks (60 birds total) at location 2, position as per 12/09/05 but widely spread.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012. Sennheiser 416 shotgun as backup – roaming and static approach - Microphone 1.5 to 2 metres above ground; angle - horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: None.

Comments: Small flocks scattered. (3 kilometre area) 1200 hours, approximately 60 birds congregate north of location 1. Behaviour agitated taking flight circling and landing. Stay at these locations 10 to 20 minutes, birds moving to other locations east and south. (500 to 600 metres) Conclusion, behavioural pattern indicates no possibility to record. Have decided to explore locations 5, 7 and 8.

#### **Recording session 5. - Location 5, Långskäret approximately 14 km by road from Söderfjärden.**

Location analysis: Harbour flanked north, south, east by forest; sea to west, sheltered from wind.

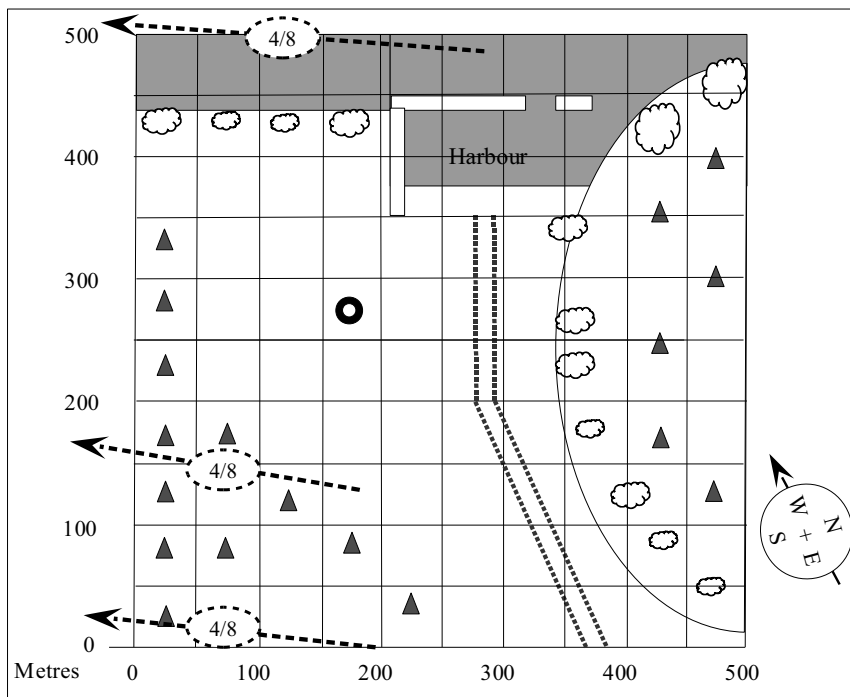
(Illustration 47) Unwanted sound may be a problem, will return and make a recording. 1920 hours recording made.

Subject analysis: Cranes in flight.

Recording equipment and approach: Nagra 4.2, parabolic mirror with Octava MC 012, hand-held roaming 2 metres above ground; angle 40 to 70°, sound intake level set to -10db.

Recording: CD-ROM track 15 cranes location 5. Off location recording analysis: Location acoustics reverberation from forest, flat sounding near water, unwanted sound, boat and small birds. (Species unknown)

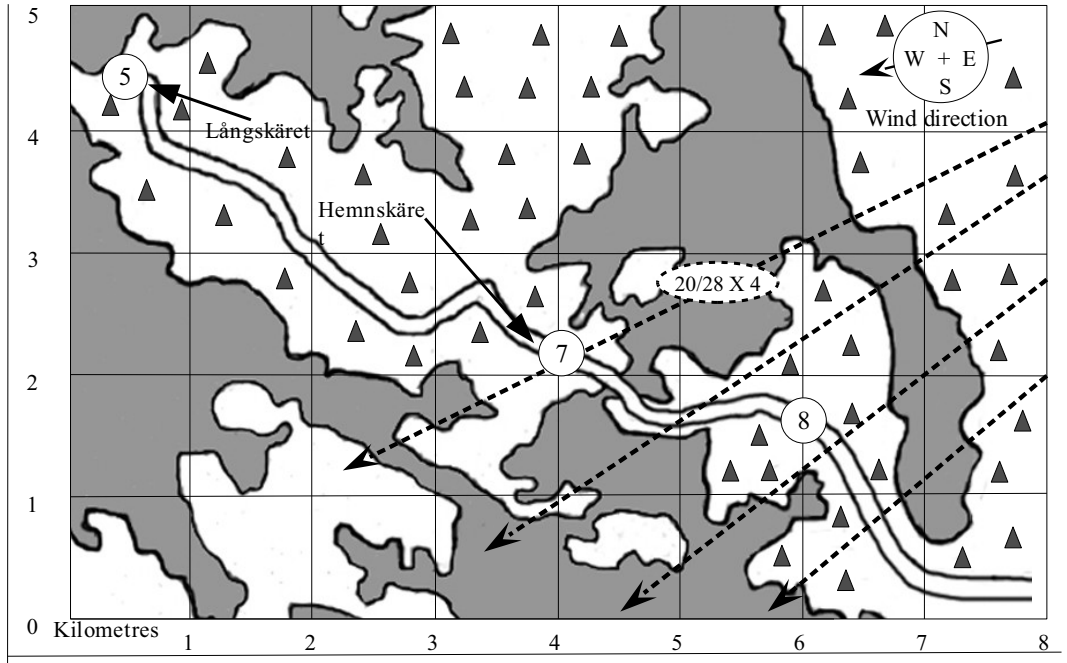
Comments: Elements, overcast. Subjects, 3 flocks 4 to 8 fly past, distance a problem evident in recording. Conclusion, site too far west of main flight path, location 5 redundant.



47. Diagram of Location 5.

**Recording session 6. - Location 7 Hamnskäret** approximately 7 km by road from Söderfjärden.

Location analysis: Open land with water effected by wind. (Illustration 47) Will return to make a recording. 1905 hours recording made 15/09/05.



48. Diagram of Location 7.

Recording equipment and approach: Nagra 4.2, parabolic mirror with Octava MC 012, hand-held roaming 2 metres above ground; angle 45°, sound intake level set to -15db wind noise prevents gain increase.

Subject analysis: Cranes in flight.

Recording: CD-ROM track 16 cranes location 7.

Off location recording analysis: Location acoustics reverberation from forest. Elements, overcast wind blustery evident in recording, reason - parabola pans to track subjects. 4 flocks (20/28 birds) flew

overhead. Crane calls prominent. 1910 hours, majority of cranes fly south, (Altitude estimate, 300 to 400 metres) height and distance unfavourable for recording. (Image 49)<sup>¶</sup>

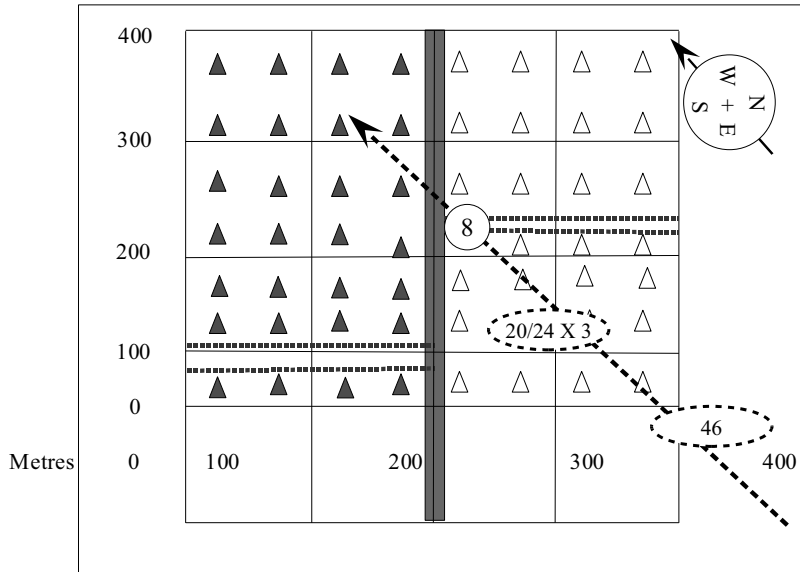
Comments: Site too far north of main flight path, location 7 redundant.



49. Image of cranes flying south of Location 7.

**Recording session 7. - Location 8** approximately 5 km by road from Söderfjärden on a hill crest. Location analysis: South side forest sloping away to sea, north side conifer plantation stretching east and west. Good vantage point due to all-round visibility, wind noise may be problematic. Will return to make a recording. 1925 hours recording made 16/09/05.

<sup>¶</sup>NOTE: image of crane's altitude (300 to 400 meters) was taken using an Olympus U MJU2 ultra compact 35mm camera, thus indication of height in relation to the ground appears greater.



50. Diagram of location 8.

Recording equipment and approach: Nagra 4.2, parabolic mirror with Octava MC 012, static 2 metres above ground; angle 40°, sound intake level set to -15db wind noise prevents gain increase.

Subject analysis: Cranes in flight.

Recording: CD-ROM track 17 cranes location 8.

Off location recording analysis: Location acoustics flat sounding reverberation minimal. Elements, overcast wind blustery evident in recording. 1915 hours, cranes fly by, but majority south of this location. 3 flocks (20 to 24 birds) and 1 flock (46 birds) overhead. Crane calls prominent, but recording destroyed by motorised transport.

Comments: Unwanted sound a problem, location too far north of main flight path, location 8 redundant.

**Recording session 8. - Locations 1, 2 and 3 - Date: 15/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility unfavourable due to extremely wet conditions heavy overnight rain. Elements overcast and windy.

Subject analysis: Crane numbers reduced possibly due to inclement conditions, location 1 empty. 0720 hours, small flocks (40 to 60) adolescents and bonded pairs arrive, approximately 300 to 500 metres east and northeast of locations 3 and 2 respectively. Locations 2 and 3 empty at this time.

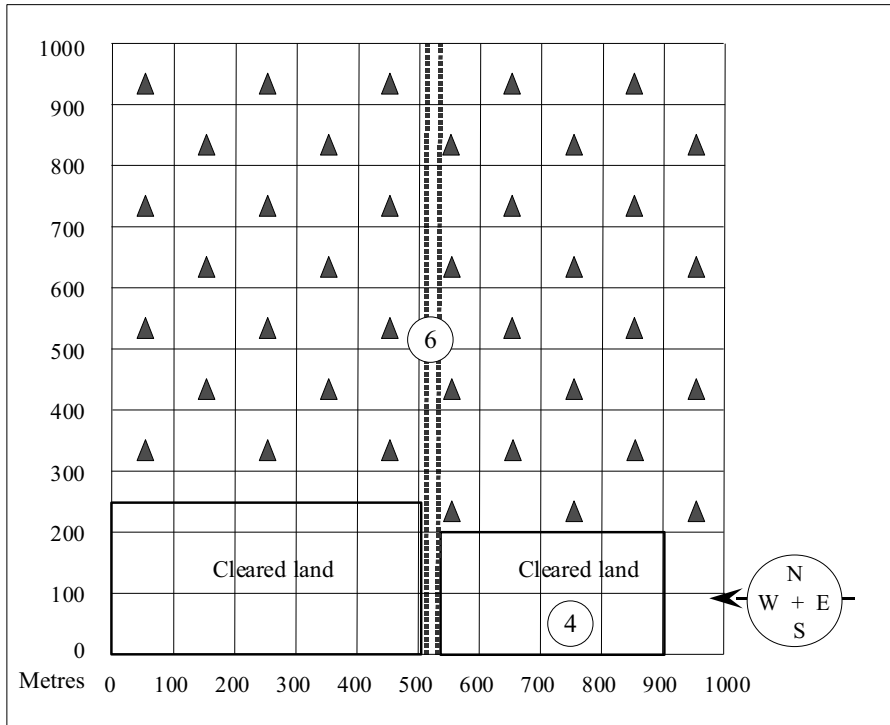
Recording equipment and approach: Nagra 4.2, parabola and Octava MC 012. Sennheiser 416 shotgun as backup. Roaming and static approach - parabola 1.7 metres above ground; angle – horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: None.

Comments: Subjects situated crater eastern end, to record means approaching from road junction north/east of Sulva, area fallow insufficient cover. Behaviour agitated, sporadic airborne movement. Conclusion, no recording due to distance and subject behaviour, will investigate locations 4 and 6.

**Recording session 9. - Location 4 (Illustrated diagram 51)**

Location analysis: Open area approximately 150 x 400 metres. Has possibilities for recording birds in flight. Wind noise may be problematic, will return to record. Re-visit location 7 to make recording.



51. Diagram of locations 4 and 6.

**Recording session 10. - Location 6** (Illustrated diagram 51) 500 metres from main road.

Location analysis: Track heavily forested on both sides. Elements: Wind problematic, reflections from surrounding mediums. 1510 hours, will record this sound to demonstrate situation.

Subject analysis: location ambience and elements.

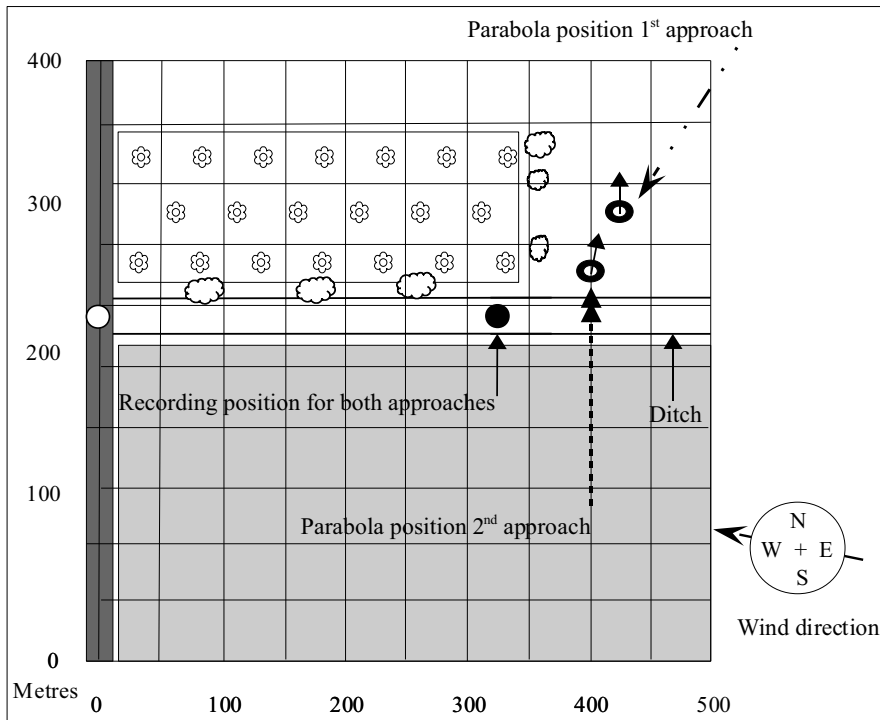
Recording equipment and approach: Nagra 4.2 with Sennheiser 416 and boom, roaming, 5.5 metres above ground; angle 5°, sound intake level set to -15db wind noise prevents gain increase. Reason for change to 416 gun microphone; parabola stand will not go to this height. (5.5 metres)

Recording: CD-ROM track 18 wind at location 6.

Off location recording analysis: Acoustics - reverberation from surrounding mediums. Elements, overcast wind blustery causing a mixed roaring sound of conifer and broad-leaf evident in recording.

Comments: A difficult location cannot get high enough to escape forest ambience. 1545 hours return to Söderfjärden, location 1, no cranes. Location 2 numbers have increased, estimated 200 plus birds over area approximately 160 x 60 metres, activity foraging and social display. No recording, wind too strong.

**Recording session 11. - Location 2 - Date: 16/09/05 - Time: 0600 – 2030**



52. Diagram of intended recording position at location 2.

Location analysis: Accessibility very wet ground underfoot but useable. Elements overcast and windy.

Subject analysis: No subjects, awaiting arrival. Observations have shown, location 2 is popular with

subjects, if hypothesis is correct, they should re-visit. 0630 hours, set up parabola, position close to yesterday's bird location approximately 425 metres from road, 75 metres from ditch. (Recorder position) 0705 hours, subjects enter Söderfjärden, movement is north, east and south east. 0745 hours, 40 cranes circle close to location 2, but do not land. 0800 hours, majority of cranes in situ, no cranes at location 2. Will continue to observe location. 1000 hours, weather improves, cloudy with some sun, cranes now settled, activity feeding, preening and social display. No cranes at location 2, what is the reason? 1100 hours, retrieved recording equipment and inspected area, food variety available, ground conditions acceptable.

Recording equipment and approach: Nagra 4.2, Have changed back to parabola with Octava MC 012 – static, Sennheiser 416 shotgun as back-up - Parabola 2 metres above ground; angle – horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: None

Comments: Possible cause for lack of cranes is parabola position and appearance; conspicuous white mirror on a chrome stand. 1420 hours, 80 cranes land at location 2 near parabola position. Will try same tactics tomorrow to see if parabola is the cause. Rest of day spent monitoring subject movement and positions prior to evening flight; return to location 8 to make recording.

### **Recording session 12. - Location 2 - Date: 17/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility ground underfoot improving. Elements overcast and windy.

Subject analysis: No subjects, awaiting arrival. 0615 hours, set up parabola approximately 400 metres from road and 25 metres from drainage ditch. Reason for new position to make parabola less conspicuous, have also lowered height, recorder position as before. 0655 hours, cranes enter Söderfjärden, movement is north, east and south east. 0715 hours, 8 birds circle close to parabola approximately 40 metres, but do not land - recording made of this activity.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, Sennheiser 416 shotgun as back-up - Parabola 1.5 metres above ground; angle - horizontal. Recording level after initial test -15db wind noise prevents gain increase.

Recording: CD-ROM track 19 location 2 parabola.

Off location recording analysis: Location acoustics flat sounding, unwanted sound other birds (Species unknown) and motorised transport sound, low but audible. Elements, overcast, blustery wind evident in the recording; could not change parabola horizontal axis to compensate due to subject's position, but subject calls are clear. 1500 hours, retrieved recording equipment.

Comments: No cranes at location 2, conclusion, parabola too conspicuous, possible reason why subjects reject this location. Will check site tomorrow to see if subjects re-visit. Return to location 4 to record.

**Recording session 13. - Location 4** (Illustrated diagram 50) Location analysis: described previously. Possible flight path location. Accessibility good. Elements overcast and windy.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle 40°. Recording level after initial test -15db wind noise prevents gain increase.

Recording: CD-ROM track 20 location 4 cranes fly by.

Off location recording analysis: Location acoustics reverberation from surrounding mediums. (Wind in forest) Elements, overcast wind blustery evident in recording. Crane calls prominent.

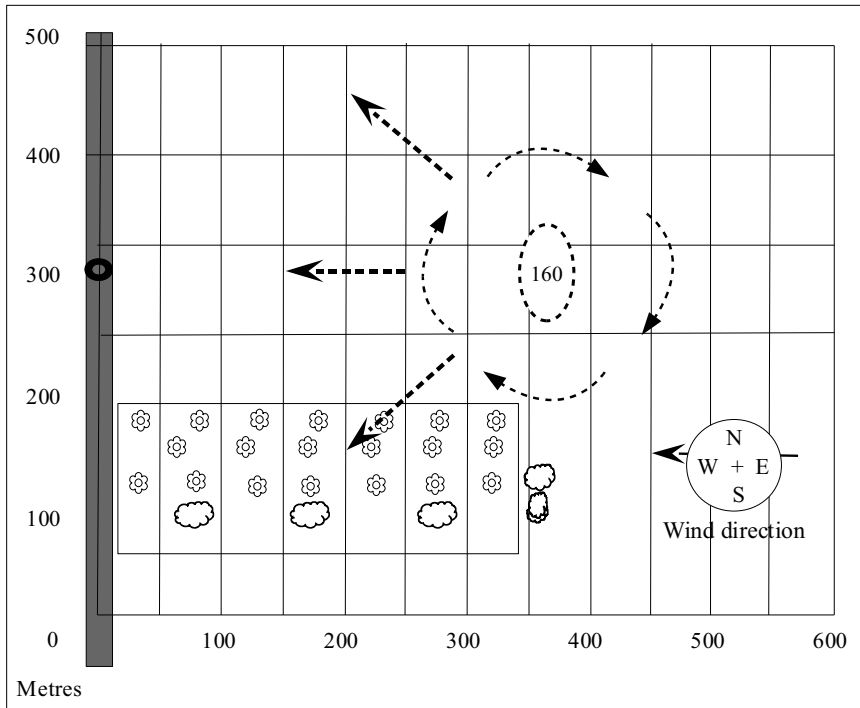
Comments: Only small flocks (12 birds maximum) fly past this site probably those who frequent southern part of Söderfjärden; location 4 relatively close, but not under main flight path.

**Recording session 14. - Location 2 - Date: 18/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility good, damp conditions due to cold night. Elements, Clear with variable wind. Sound of motorised vehicles evident - acoustics - slight reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter.

Subject analysis: Crane numbers estimated 200 spread over an area of approximately 160 x 80 metres. Birds are mixed adolescents and bonded pairs, activity feeding and preening; sentinels active. No recording, farmers crop harvesting, unwanted sound audible, activity may agitate birds, result restless

behaviour, and sporadic movement. If subjects in situ at take off time, will make recording. 1730 hours, numbers have decreased, estimate 160 approximately 150 metres north of beet field 375 metres from road. (Illustration 52)



53. Diagram of Location 2 crane departure.

1850 hours, subjects depart crater, circling in a 200 x 200 metre area gaining altitude, calls prominent. Approximately 80 metres in altitude subjects disperse into 3 flocks taking preferred flight paths. Estimated numbers; 20 north west, 60 west and 80 south west. Recording made.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle 15°. Recording level after initial test -15db wind noise prevents gain increase. Recording: CD-ROM track 21 location 2 take-off 01.

Off location recording analysis: Location acoustics reverberation from surrounding mediums. Wind noise evident in recording. Crane calls prominent, slight clipping due to bird call intensity.

Comments: Will make another recording from this location but will reduce gain intake to avoid clipping.

**Recording session 15. - Location 2 - Date: 19/09/05 - Time: 0600 – 2030**

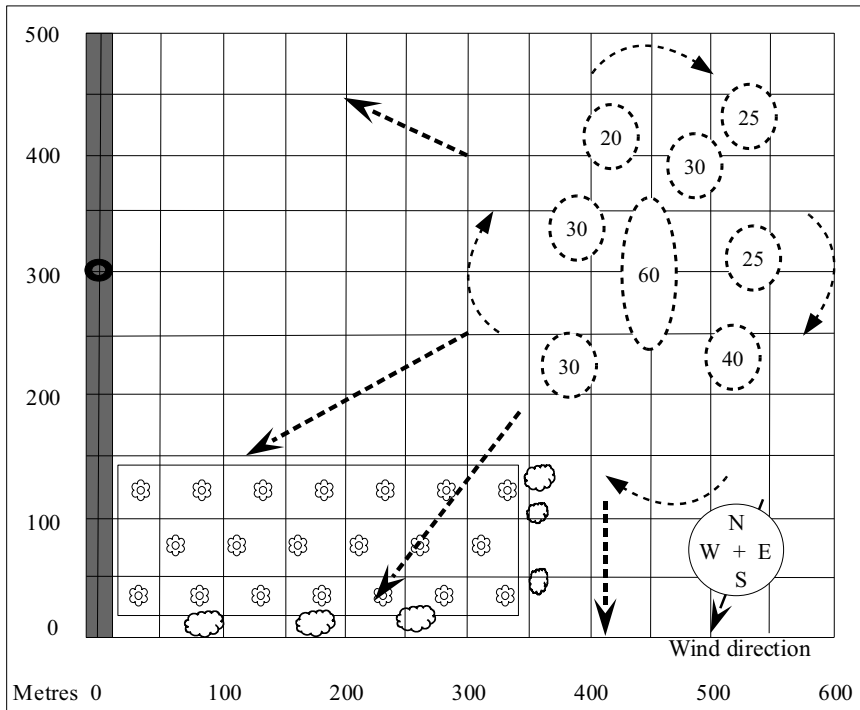
Location analysis: Accessibility wet conditions due to heavy overnight rain. Elements: Cold, cloudy, blustery wind, potential rain. Sound of motorised vehicles evident - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter.

Subject analysis: Location 2 - 0810 hours, subjects arriving dispersing to various areas estimate 50 birds at location 2. Activity sporadic with continuous movement other birds join then depart. 1150 hours, numbers at this site start to increase. 1530 hours, estimate over 260 cranes, positions approximately 400 metres to 550 metres from road, 50 metres from edge of beet field. (Illustration 53) Weather turning, skies now overcast, possible rain. 1830 hours, set up recording equipment. 1840 hours, subjects depart crater, circling in about a 350 x 350 metre area gaining altitude, calls prominent. 80 metres in height (Estimated) subjects divide into 4 flocks taking preferred flight paths. Estimated numbers; 120 due south, 60 south west, 60 west by south west and 20 north west. Recording made.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle 10°. Recording level after initial test - 20db wind noise prevents gain increase. Recording: CD-ROM track 22 location 2 take-off 02.

Off location recording analysis: Location acoustics reverberation from surrounding mediums. Wind noise blustery and increasing evident in recording. Crane calls prominent, but distance between microphone and source noticeable due to subjects position. Mid-way through recording heavy rain begins, wind strength increases, recording terminated.

Comments: Location 2 a good site for recording subjects although prone to variable weather conditions.



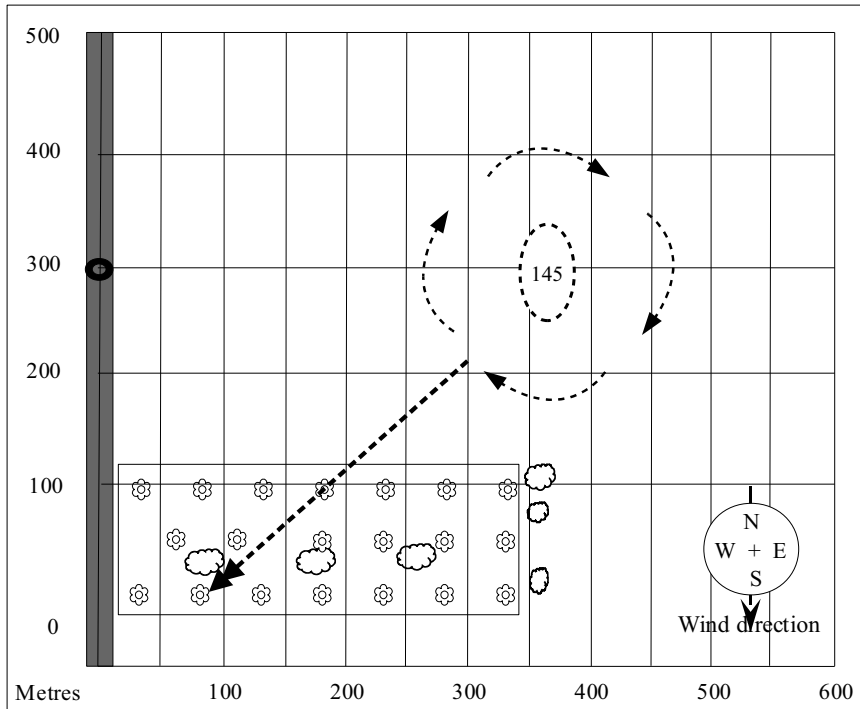
54. Diagram of Location 2 crane departure 2.

**Recording session 16. - Location 2 - Date: 20/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility restricted due to wet conditions. Sound of motorised vehicles evident - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter. Elements: Cold, overcast, variable wind, rain expected.

Subject analysis: Location 2 - 0745 hours, 70 birds over estimated distance 120 x 35 metres, approximately 450 metres from road. Subjects bonded pairs, activity preening, sentinels on watch. Will monitor this site to see if yesterday's activity repeated. 1220 hours, wind strength decreases will investigate locations 4 and 6. Location 4, wind direction southerly can hear motorised transport sound from crater's perimeter, will mar recording/s, site unusable at this time. Location 6, motorised sound reduced due to wider expanse of forest, but wind noise apparent. Will wait for wind strength decrease, return to Söderfjärden. Location 2 - 1600 hours, 90 birds estimated, approximately same position as the 160 flock sited on the 18<sup>th</sup>. (Illustration 52) 1730 hours, 20 birds join followed by a further, 35 at 1820

hours. Wind strength now decreasing will make recording.



55. Diagram of Location 2 crane departure 3.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle  $10^\circ$ . Recording level after initial test -15db slight wind noise and motorised transport evident gain increase not advisable. Elements: weather improving, wind now minimal. 1910 hours cranes depart, pattern is much the same (Cranes circling and calling) except today, 1 large flock flying south west. (Illustration 54)

Recording: CD-ROM track 23 location 2 take-off 03.

Off location recording analysis: Location acoustics reverberation from surrounding mediums minimal as is wind noise. Crane calls prominent, distance between microphone and source noticeable in beginning but reduced as subjects fly near. Unwanted sounds small bird (Species unknown) and human voices evident, would have been an acceptable recording but for these factors.

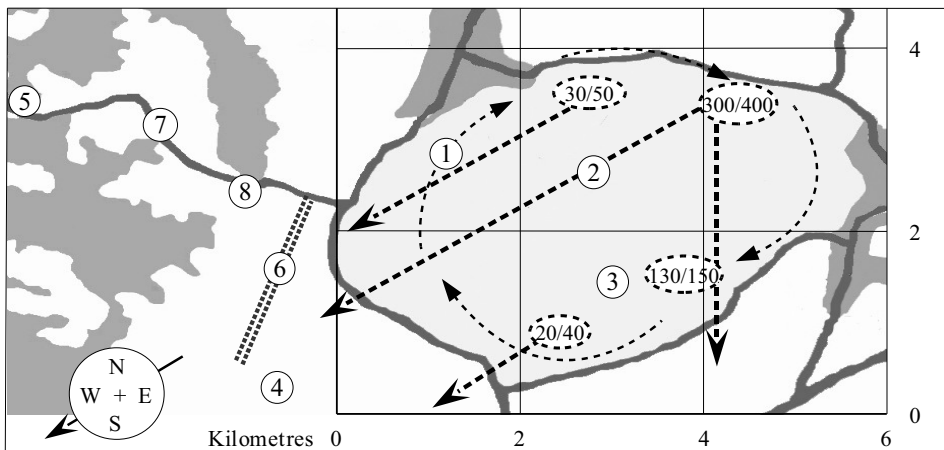
Comments: Location 2 is the favoured site for recording vocalisation but prone to prevailing conditions.

**Recording session 17. - Location – Söderfjärden area - Date: 20/09/05 - Time: 0600 – 2000**

Location analysis: Accessibility acceptable. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter.

Elements: Overcast, blustery wind from south west, rain forecasted.

Subject analysis: 0715 hours, subjects arriving, a mixture, bonded pairs and singular birds. Activity preening, foraging, social display, often on wing visiting other groups; numbers constantly changing. (Illustration 55) 1300 hours large flock north east of location 2, estimate 300 to 400, smaller group 30 to 50 due north. Location 3, 130 to 150, small group 20 to 40 south west; location 1 empty 1500 hours crane movement negates recording possibilities.



56. Diagram of crane positions at Söderfjärden and projected flight path.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 1.7 metres above ground; angle - horizontal. Recording level after initial test -15db wind noise and motorised transport evident gain increase not advisable. Elements, weather dull, cold blustery wind. 1840 hours cranes begin departure, times vary, flock from north east divides, approximately 260 fly south, remainder south west. Other groups merge fly south west; 1925 hours all cranes have left.

Recording: None.

Comments: Nothing to be gained by recording this activity conditions unfavourable, have a recording (CD-ROM track 22 location 2 take-off 03) in place.

**Recording session 18. - Location – Söderfjärden area - Date: 21/09/05 - Time: 0600 – 1950**

Location analysis: Accessibility permissible although wet conditions. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter. Elements: Strong winds and rain.

Subject analysis: 0740 hours, subjects arrive in small groups scattered over entire area. Flocks are mainly bonded pairs. Activity preening, foraging minimal. 1400 hours, estimate 120 cranes at location 2, positions approximately 430 metres from road, 70 metres from edge of beet field. Location 3, 40 to 60 other small flocks to the east. No cranes at location 1. Weather deteriorating, rain in for the day. Will monitor subject/s movements.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 1.7 metres above ground; angle - horizontal. Recording level after initial test - 20db wind noise evident gain increase not advisable.

Recording: None.

Comments: Cold blustery wind. 1835 hours cranes depart, times vary, flock size scattered, routes from south to west. 1920 all cranes have departed. Nothing to be gained by recording this activity conditions unfavourable.

**Recording session 19. - Location – Söderfjärden area - Date: 22/09/05 - Time: 0600 – 2000**

Location analysis: Accessibility restricted due to wet conditions. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter. Elements: Strong winds and rain.

Subject analysis: 0755 hours subjects arrive, groups are small scattered throughout crater. Mixture of bonded pairs and singular birds. Activity restless, foraging minimal. 1300 hours, cranes taking to the wing constant movement throughout area. 1450 estimate 80 birds at location 3, 45 at location 2, widely dispersed, location 1 empty. Weather, dull and windy, rain intermittent light to heavy. Will monitor flock movements. 1810 to 1840 hours 120 birds (Estimated) vacate Söderfjärden in small groups 20 to 40 flying south and south west distance between flocks approximately 275 to 325 metres.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 1.7 metres above ground; angle - horizontal. Recording level after initial test - 20db wind noise evident gain increase not advisable.

Recording: None.

Comments: Cold blustery wind. 1855 hours nearly all cranes have departed, 11 birds remain north east of location 2, 1920 hours these depart flying south. Nothing to be gained by recording this activity conditions unfavourable have a recording of these conditions (CD-ROM track 21 location 2 take-off 02)

### **Recording session 20. - Location – Söderfjärden area - Date: 23/09/05 - Time: 0600 – 2015**

Location analysis: Accessibility restricted due to wet conditions. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter. Elements: Overcast with strong winds.

Subject analysis: 0815 hours, cranes arrive in small numbers (12 to 18) circling locations 2 and 3 but move east; vehicle movement probable cause. Birds mainly bonded pairs and singular. Activity social display, foraging minimal. 1200 hours, cranes take to the wing sporadic movement throughout the crater. 1400 hours estimate 30 birds at location 2, 20 at location 3, widely dispersed, location 1 empty. Weather, no improvement. Between 1820 to 1855 hours, all cranes have left Söderfjärden.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 1.7 metres above ground; angle - horizontal. Recording level after initial test - 20db wind noise evident gain increase not advisable.

Recording: None.

Comments: Cold blustery wind will mar recording. Have recordings of this activity not necessary to record more.

**Recording session 21. - Location – Söderfjärden and 4 - Date: 24/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility minimal due to wet conditions. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter. Elements: Strong blustery wind.

Subject analysis: 0755 hours, subjects arrive in small groups (8 to 16) scattered over entire area. Mixture of bonded pairs and singular birds. Activity restless, foraging minimal. 1000 hours, cranes constantly taking off and landing; sporadic movement denies any recording possibilities. 1300 hours estimate 80 birds at location 3, 45 at location 2, widely dispersed, location 1 empty. Weather inclement, will investigate location 4. 1345 hours location 4, wind in forest and motorised sound audible. 1850 hours single crane fly by, recording made.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle 40°. Recording level after initial test - 15db wind noise evident gain increase not advisable.

Recording: CD-ROM track 24 location 4 - Single crane fly by.

Off location recording analysis: Location acoustics reverberation from surrounding mediums, wind noise apparent, but motorised sound minimal due to parabola angle and position. (Side on to forest) Single crane call prominent, subject flies 40 metres left of parabola, distance between microphone and source approximately 80 to 120 metres.

Comments: Location 4 would seem a good site due to land clearance, but it is not within the cranes main flight path.

**Recording session 22. - Location – Söderfjärden and 6 - Date: 25/09/05 - Time: 0600 – 2030**

Location analysis: Accessibility fair but wet. Sound of motorised vehicles audible - acoustics - reverberation due to the crater's unique bowl-shape and reflective mediums along the perimeter.

Elements: Blustery wind, forecast – should decrease in afternoon.

Subject analysis: 0635 hours, subjects arriving, groups bigger than yesterday (30 to 50) landing areas location 2 and north east; location 3 and east. Variety of bonded pairs, singular birds, older adolescents. Activity preening, social display – foraging minimal. 1130 hours, birds constantly moving about the crater. 1300 hours numbers have increased, 30 birds at location 1, estimate 90 at location 3 and 190 at location 2; others east and north east. Agriculture activity too much unwanted noise. 1545 hours cranes busy, flocks airborne visit other sites and return. 1700 hours, subjects in much the same position as the 20/09/05. Wind from west but strength reduced possible rain. Observations have shown that cranes normally fly in a 'V' formation in a straight line from one point to another therefore, location 6 should see many pass by. Will make a recording.

Recording equipment and approach: Nagra 4.2, and parabola with Octava MC 012 – static, 2 metres above ground; angle 80°. Recording level after initial test - 15db crane calls very loud, peaks can be clipped gain increase not advisable.

Recording: CD-ROM track 25 location 6 -1 and CD-ROM track 25 location 6-2.

Off location recording analysis: Track 24. Location acoustics slight wind noise and reverberation from surrounding mediums, 'whooshing' sound made by subjects flapping wings. Group is small 12 birds, calls are prominent and clear. Unwanted sound small bird (Species unknown) Subjects flying 30 metres right of parabola, altitude approximately 80 to 100 metres, distance between microphone and source approximately 80 to 120 metres. Track 25, reverberation from surrounding mediums, wind noise minimal. Flock estimated 90 cranes fly overhead, altitude approximately 80 to 100 metres calls are loud and clear, first call (2 seconds) clips slightly due to call intensity. 'Whooshing' sound made by subjects flapping wings. Unwanted sound small bird (Species unknown) and rain drops on microphone wind shield. Would have been an acceptable recording but for these factors, recording good example of doppler effect.

Comments: Today (25/09/05) location 6 is in the centre of crane's main flight path but, it cannot be assumed that this information is factual evidence. Much depends on the subjects position within Söderfjärden and the prevailing weather conditions, these factors may alter the crane's position anywhere within the 4.5 kilometre flight corridor.

### **6.3 Sub section summary**

Location/s: Much debate has been given to locations and the problems that occur within and Söderfjärden is no different as we have found therefore, we will refrain from further reiteration. However, it might be prudent to briefly analyse the locations from a recording value viewpoint, as this information may be of use to future recordists and researchers.

Location 1, at face value seemed to offer a chance to record the subjects by an approach via a drainage ditch, but as we know the exercise proved unproductive due to mechanical intrusion. Moreover, unwanted noise from the crater's perimeter was a problem as were the elements. In addition, this site was only favoured on two occasions by cranes therefore, it can be argued that as a potential recording location it has no intrinsic value.

Location 2, fared much better offering more than one occasion to record; it was far enough away from motorised traffic, but at the mercy of the elements. The site quite popular with the cranes only offered minimal cover, future recording ventures here would require a solution to this problem. Location 2 can be recommended as a potential recording site.

Location 3, a favourable destination for the cranes is quite difficult insomuch that unwanted noise and wind predominantly from a south westerly direction are problematic. To record at this location the recordist would have to approach the subjects up wind so as to lessen wind noise, but motorised traffic would still be audible. Moreover, such an approach would increase the distance between subject and microphone and because of these factors, location 3 is not recommended.

Location 4, had good accessibility but was prone to reverberation and unwanted sound and although a few cranes did fly over, the site (During these field studies) was not within the main flight path. However, it should not be rejected entirely on this basis, further monitoring may prove it to be a recording potential.

Location 5, had much unwanted sound and was too far west of the crane's flight path and although a few subjects did pass this location, the recordings made were unsatisfactory. Because of these factors, this location is not recommended as a recording potential.

Location 6, a site with potential for recording cranes in flight as it lies directly beneath the main flight path and when the subjects do fly over, they are at low altitude and calls are prominent. But this location is difficult, because dense woodland abounds on both sides and in windy conditions – this factor will be noticeable. (Refer to CD-ROM track 17 - wind at location 6) To solve the problem one needs the assistance of a mechanical lifting device to elevate the recording apparatus to tree-top level. This action will reduce the unwanted sound's intensity, but the microphone is more exposed to the elements and will require some form of shielding. However, despite these idiosyncrasies, location 6 is recommended as a site for recording cranes in flight.

Location 7, an open area with good visibility but prone to the elements. 100 subjects (Estimated) did fly over this site but their altitude was too high. (Approximately 250 to 300 metres) The main problems with this site are high blustery winds, motorised traffic and human sound and because of these factors location 7 is not recommended as a potential for recording.

Location 8, easy access with good all-round visibility and close to the flight path of birds who frequent the northern part of Söderfjärden. However, this site near a main road was rejected, because of constant motorised traffic destroying the recordings and therefore, is not recommended as a location with recording potential.

Subject/s: The eurasian crane was discussed in detail (Introduction to field studies and field studies) but, it might be useful for future recordists and researchers to have some indication as to what they are likely to encounter albeit in brief. Arguably, the biggest problem was in approaching these birds; at a distance of 400 metres human presence would be tolerated to some degree, but sentinels would be extremely alert – and attempting to move closer causes the birds to abscond. In addition, cranes frequenting certain areas are aware of what is within for example, out buildings and stationary farm vehicles; and will avoid being in close proximity with these. And as we have discovered, positioning the parabola close to their landing sites is a cause for alarm, which results in them locating elsewhere.

Arguably Söderfjärden's biggest drawback is the lack of cover, and employing the use of blinds/hides was considered but rejected. Because of (a) the extremely windy conditions and (b) several would be needed to cover some of the many locations. In addition, the recordist would have to be in situ prior to the cranes arrival; and there is no guarantee that they will alight in the chosen vicinity. Moreover, leaving one's blind/hide for another is not advisable, because if cranes are at that location, the approaching recordist/researcher will be detected and the birds will simply fly away.

Equipment: The Nagra 4.2 reel to reel mono recorder was the device used on which to store the information; tape used was Emitec 6.3mm running at a speed of 19.05 cm/s. The recording response was set to standard 'Flat Cut' meaning no added control to modify the sound and the gain intake (20db to 10db) was adjusted to compensate for the prevailing conditions.

The Sennheiser 416 RF condenser shotgun microphone was used at location 6; mounted on a boom and elevated to 5.5 metres in order to record wind noise and reverberation. But when used at location 2, there were problems with wind blowing across its face. Moving position and shielding it reduced the wind noise, but this meant keeping it relatively close to ones person. The 416 is an extremely versatile microphone and is recommended for wildlife recording, but needs consideration in its use.

The parabola and Octava MC 012 proved to be an acceptable working combination - versatile in capturing crane vocalisation at most locations; and can be considered as a useful tool for recording wildlife sound. However, it does have drawbacks - it is too conspicuous and needs to be toned down. This can be achieved, by spray-painting both sides of the mirror with mat paint in a camouflage pattern and it's chrome stand can be covered by suitable camouflage material. If these simple modifications are achieved then it may not be so noticeable.

But whether we use the Sennheiser 416 or parabola set up, we have to consider two important criteria. (a) The distance between sound source and microphone and (b) the 'on axis' or direct line of reception; discussed in the chapter - the approaches to recording wildlife.

If we concentrate on the 'distance' aspect by placing the recording device near the subject/s and retreating as Bartlett has suggested, (Discussed in the chapter - the approaches to recording wildlife) and demonstrated in recording sessions 11 and 12; then the 'on axis' factor comes into being. Because

immaterial of whether the subject/s abscond/return due to intrusion or have yet to arrive, there is no guarantee that it/they will position themselves in/on the line of 'on axis'; an extremely important consideration - if the aim is to record clear 'on axis' sound. Alternatively, if we choose the 'on axis' as our primary concern, then this does not present too much of a problem, because we are able to manipulate the device to compensate. But this often means the distance factor comes into play.

To find a solution to this problem, what is needed is a recording device, able to solve both 'on axis' and distance issues. One possibility is via the use of radio control, (R/C) which is discussed in the next chapter; a possible solution in solving the distance and 'on axis' issues.

#### **6.4 R/C experimentation - recording session 23. Location – 4 Date: 02/06/2013 Time: 1400 – 1900**

Location analysis: Accessibility permissible although area has been heavily harvested for its timber. Sound of motorised vehicles audible - acoustics – flat conditions. Elements: Dry with variable winds.

Subject analysis: 1400 hours, subjects in situ but are scattered over entire area.

Recording equipment and approach: R/C recording device was placed approximately 100 metres away at 1.7 metres above ground; angle and rotation variable. Nagra 4.2 recording level after initial test -15db wind noise evident gain increase not advisable.

Comments: As mentioned, this location has been harvested for timber, remaining vegetation consists of grasses and Birch saplings; *Betula pendula* widely spread. Subjects are mainly passerines, which include *Parus major* (Great Tit), *Passer montanus* (Tree Sparrow) and *Bombycilla garrulus* (Waxwing) defending territory constantly moving. This behaviour causes difficulty in maintaining the 'on axis' position due to subjects speed and variation of flight. As a result, the recordings are extremely brief (1-3 sec), which from an editing point of view are insufficient for pictorial accompaniment due to their short duration. In addition, the R/C horizontal servo is slightly erratic, probably due to its size and power. In the mean time will have to experiment in order to find the correct pressure when controlling the levers.

Recording: CD-ROM track 26 location 4.

Off location recording analysis: Track 26. Location acoustics slight wind noise and reverberation from

surrounding mediums. Birds include the passerines previously mentioned. Subject's altitude approximately 1.5 to 6 metres, distance between microphone and source approximately 30 to 90 metres. Calls are prominent and clear, but distance is noticeable – will find a new location.

### **6.5 R/C experimentation – recording session 24. Location – 7 Date: 03/06/2013 - Time: 1500 – 1700**

Location analysis: Accessibility permissible although area contains civilisation. Sound of motorised vehicles audible - acoustics – flat conditions. Elements: Dry with light winds.

Subject analysis: 1500 hours, subjects the Great Tit in situ defending territory.

Recording equipment and approach: R/C device device was placed approximately 100 metres away and at 1.7 metres above ground; angle and rotation variable. Nagra 4.2 recording level after initial test -20db.

Comments: Subjects are pairs and single birds defending territory constantly moving. Have located a pair of birds and their favoured area. Moved R/C device within 2 metres reducing distance. This action causes birds to flee. However, the Great Tit is territorial and did return. Servo behaviour not so erratic soft pressure is needed.

Recording: CD-ROM track 27 location 7.

Off location recording analysis: Track 27. Location acoustics reverberation from surrounding mediums and motorised transport apparent. Subjects moving back and forth among the foliage - altitude approximately 1.5 to 3 metres, distance between microphone and source between 1.5 to 2 metres.

Recording shows that distance has been reduced and that the on axis plane has been maintained hence the call's amplitude, which is distinctive, prominent and consistent. In addition, there was no noise from the servomechanisms or any problems with transmission and reception at a distance of 100 metres, nor was there any frequency interference from other products using this 27.145 MHZ band.

## 6.6 Section summary R/C recording device pros and cons

The R/C prototype was designed and built using a particular microphone set up purely to ascertain if it could solve the distance and on axis issues, which it has verified by the recordings taken in tracks 26 and 27 and further explanation is given to support the argument.

**The pros** - the device is a compact, lightweight recording package, that is easy to assemble and operate, it can accommodate an assortment of microphones including radio and be transported quite easily. Moreover, it is relatively inconspicuous - a bonus when working with timid fauna, can be located practically anywhere and once placed in situ, the recordist/researcher retreats away from the zone reducing human presence, which is a major problem when working with wildlife. This device uses 16 AA alkaline batteries giving a working window of over 5 hours. (It should be noted that the recorder's working window is not included in this equation)

To test the working capabilities of this R/C device the distances covered were at intervals of 100, 200, 300 and 400 metres maintaining line of sight between the transmitter and receiver and the device (Using binoculars to monitor the action) functioned without any problems. It was/is possible to extend the device's range to 500 metres and beyond, but this notion was rejected because the device would be less visible; and this same perspective would also apply to the subject/s. For example, a medium sized Eurasian crane (The avian species used in the field experiments) standing at 100 – 130cms looks rather petite at 400 metres and binoculars are required to monitor any behaviour. With smaller subjects it is advisable to reduce the distance in order to be able to monitor their movements.

The combination of the Sennheiser MKH 416 and the R/C device functioned as expected and problems using 100 metres of audio cable did not occur - and when placed in its recording position, was not a deterrent to the subject/s natural activity even when in motion. The tests proved favourable with good results. Thus, it can be argued that this device has a distinct advantage over other singular static microphone set ups when attempting to record wildlife sound.

## 6.7 Section summary R/C recording device pros and cons

**The cons** – one of the drawbacks of this device is that it requires two hands to operate it, because the microphone needs to maintain its alignment with the subjects. Because if one or both of the transmitter's lever/s is/are released, it's connected servo/s will revert back to its/their start point as will the microphone. This is caused by the lack of matching resistance between the potentiometers and the transmitter's control arms. (Discussed earlier in this chapter) which is not a problem with other devices.

Therefore to solve this problem, the subject's vocal amplitude was monitored and the recorder's intake volume was set to a desired level, which in this case was -20db. This method allowed for good recording at a constant level leaving 'hands free' to operate the R/C device and track the subject/s. Nonetheless, some recordist/researchers might find this approach disconcerting, because of the need to control the recorder's intake volume. Meaning one hand will move away from a lever, which then has to be re-set in order to return the servo to its desired position. If having a 'hand-free' to adjust the recording intake level is needed, then, we would have to look at the transmitter lever configuration to see if they can be adapted to stay in position once moved. But what effect this would have on the servos has yet to be determined.

The servomechanisms (2 x HS-1 57BB) were borrowed from a large racing yacht where their purpose was to function against the resistance of wind and water hence, they were quite powerful. And when the transmitter's levers were moved in a normal manner, their behaviour tended to become erratic. This is because of the lack of resistance therefore, a more delicate approach in lever control was needed to maintain smooth operation. Solving this problem could be by using less powerful micro servos.

Arguably the long lengths of audio cable used to transmit the incoming sound from the device to the recorder, could be seen as another drawback. Because they are exposed to the elements and in some cases could be open to damage. The answer to this problem is to use a radio microphone configuration, that would eliminate the need for long lengths of cable. And as radio microphones use different frequencies there would be no interference between them and the R/C device.

It could be argued that in some recording instances, the 5 hour operating time is insufficient and needs to be extended. If this is the case, then we would need to upgrade the choice of powering unit/s and/or use a 'sleep' mode set up (Putting the device on stand by) to conserve battery life. A function

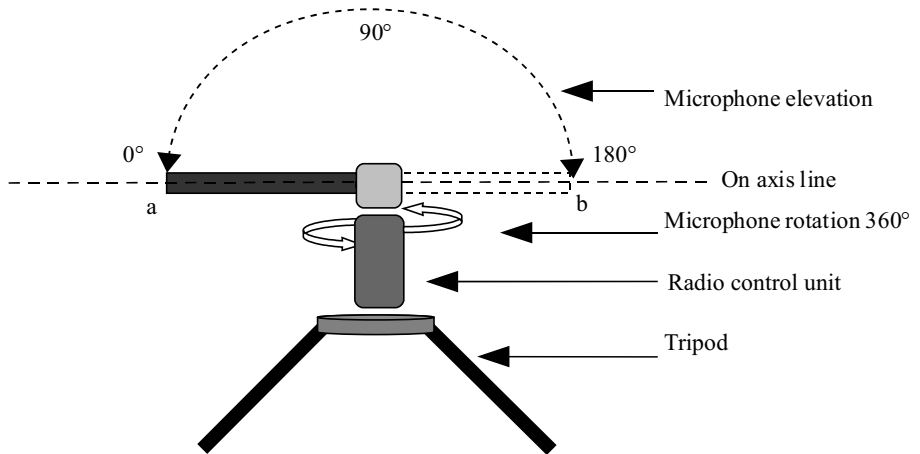
incorporated into the device, that can be then activated from a recording location via a long range photoelectric beam. But much will depend on the overall recording set up in use and the strength or range of the photoelectric beam.

As previously stated, testing the R/C prototype delivered favourable results, which outweighed the negative idiosyncrasies and like all prototypes, there will be room for improvement in one form or another in order to become reliable tools for the purpose they were designed for and this perspective applies to this R/C device.

#### 7. A POSSIBLE SOLUTION IN SOLVING THE DISTANCE AND 'ON AXIS' ISSUES.

To remind ourselves of the problem/s, the issues are distance and on axis as discussed in the previous chapter. (Field studies) Arguably, the distance factor could be addressed by placing an inconspicuous recording device (A directional microphone) in close proximity, bearing in mind subject/s disposition and consequences of intrusion. However, in many cases fauna being territorial may at some point return - although there is no guarantee. But, if it or they do, then the problem with distance will be less pronounced because our directional microphone will be closer to the sound source.

This leaves us with the 'on axis' issue and we need to find a way of manipulating the recording device from afar. One possible solution is by using radio control (R/C) – a system using a transmitter and receiver, which is able to function in both vertical and horizontal planes, (Illustrated below) that will allow us to track the subject/s movements to some degree.



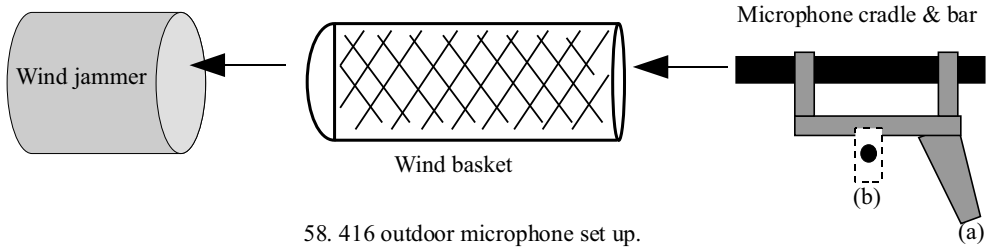
57. The Basic Concept.

The technology to do this is generally available, but the performance of this system has not been tested in the field. Nonetheless, the extent of this test will address the following questions:

- How does it operate mechanically
- If the device is operated during a recording will this be heard by the microphone
- How is it powered
- How is the recorded sound transmitted and received
- Will the R/C transmission and reception be a problem over long distances
- What type of R/C frequency bearing in mind other products using this technology
- Can the operating system be used for other recording equipment

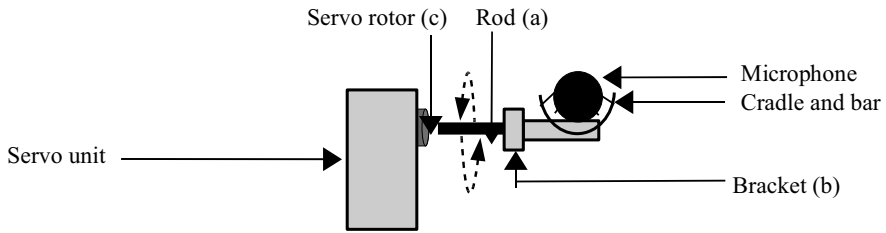
As the Sennheiser 416 RF condenser shotgun microphone was used during the field studies, this will be used again during this test.

The 416 when operational outdoors, normally sits suspended in a cradle attached to bar and pistol grip, which slides into a wind basket covered by a wind jammer. (Illustration 57) We need to retain this set-up, because of the elements, but some modifications are necessary for example. Removing the pistol grip (a) and affixing a bracket at (b) so that the microphone is balanced reducing the torque on the servo.



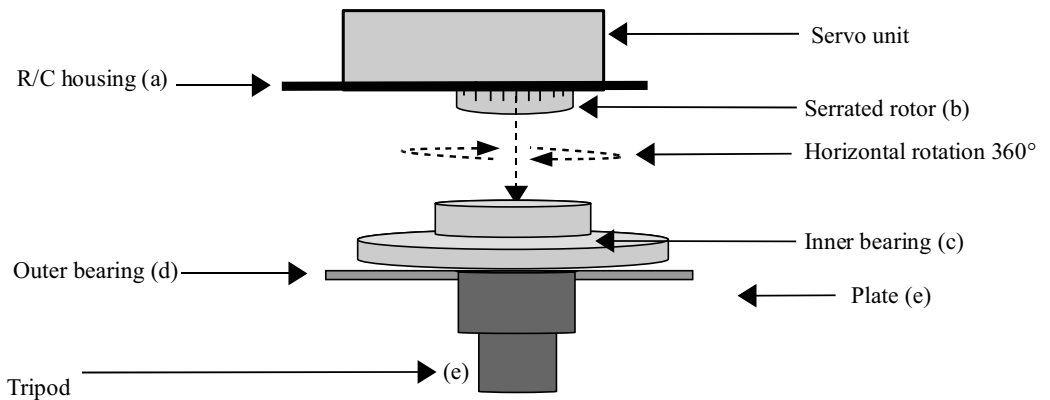
58. 416 outdoor microphone set up.

To achieve our microphone movement from  $0^{\circ}$  to  $180^{\circ}$ , rod (a) is connected to the bracket (b) and servo rotor; (c) activating the servo moves the microphone through  $0^{\circ}$  to  $180^{\circ}$ .



59. Microphone  $180^{\circ}$  elevation.

Horizontal rotation is achieved by a second servo fixed to the bottom of the R/C housing. (a) Its serrated rotor (b) is inserted into inner bearing. (c) The outer bearing (d) is fixed to a plate (e) - attached to an adjustable tripod and when the servo is activated, the unit will rotate.



60. Microphone  $360^{\circ}$  rotation.

## 7.1 Transmitters and servos

In brief the basic operating principle of R/C is a transmitter and receiver/servomechanism, (Servo) that has an assigned radio frequency crystal able to send and receive. Transmitters can be uncomplicated 2 channel analogue units or multi functional 14 channel computerised systems, but as our design only operates two servos; a 2 channel system would suffice.

Servos work on the principle of matching the resistance of potentiometers (Often referred to as a 'Pot') connected to the transmitter's control arms, with the resistance of the servo's potentiometer. Moving the control arm changes the 'pot' resistance in the transmitter causing the servo's motor to rotate. As the motor turns the connected gears operate the device connected to it; when the resistance value of the servo's pot is equal to that of the transmitter, the motor will stop rotating.

The choice of servo is important, R/C models (Boats, cars and small aircraft) normally use durable plastic or nylon bearings made from Acetal, Acrylic and Acrylonitrile-Butadiene-Styrene. (ABS) These are perfectly capable of operating lightweight functions, but may not be adequate for those producing high torque. The 416 fully assembled weighs approximately 878 grams, so a digital servo could be selected to handle this weight and torque produced.

If the device is operated during a recording will this be heard by the microphone – much depends on (a) the servo and (b) what the housing unit is made of. (a) Servo gearing mechanisms are normally encased in a tough plastic housing and when in motion produce a slight humming noise, although some are noisier than others. (b) The housing unit can be constructed from a hard plastic compound. An alternative could be die-cast aluminium for strength and durability - lined with foam to muffle the sound. Moreover, as we are using a directional microphone, (Discussed in the chapter - The approaches to recording wildlife vocalisation) any sound from the servos should be minimal. But until the unit is constructed and tested, it is not possible to give an accurate assessment.

## 7.2 Powering the unit

To power this device, battery packs such as Nano-phosphate 2300mAH designed for hi-torque digital servos could be used and as battery technology improves, other options are or will be available. But regardless of which power source is used, the important factor is the conservation of its energy. To

explain further, our device is designed to be left on location for some considerable time; after positioning, powering and testing, it is put it into 'sleep-mode' to conserve battery life. To activate the unit from our recording location, a long range photoelectric beam or similar contrivance is required. This function can be incorporated into both transmitter and device.

### 7.3 Transmission and reception

Sound transmission and reception is achieved, either by cabling or by radio. Over short distances, (Up to 75 metres) cabling may be preferred; microphone straight to the recorder or storage device. But over long distances (75 metres +) radio transmission would be easier; microphone to transmitter to receiver to recorder/storage device.

The R/C transmission and reception range largely depends on the type of transmission. Previous radio systems utilize amplitude modulation (AM) for radio signals with encoded control positions via the use of pulse **width** modulation.<sup>¶</sup> (PWM) But most of these systems have been upgraded, using frequency modulation (FM) and pulse **code** modulation;<sup>¶</sup> (PCM) enhancing performance by electronic speed control.

FM radio systems are perhaps the most common devices used, but can have restrictions on open ground as opposed to air or water due to electromagnetic interference. (Radio waves interfering with other radio waves) In addition, lower frequencies around the 27 MHz band have shorter range of approximately 100 to 500 metres, which is in the context of the radio control system that we are using. Although higher frequencies in the 2 GHz region will cover greater distances, 800 to 1000 metres, all R/C devices used on open ground, should retain a clear 'line-of-sight' between the transmitter and receiver in order to function. Arguably, opting for greater distances would not be an advantage because, we need to see what is going on; to monitor the sound source's movement/s and adjust the microphone accordingly. Therefore, a 400 metre range would suffice and not be a problem.

The type of R/C control bearing in mind other products using this technology - is divided into two sections; aeronautical and surface/general, with each having their own frequency bands. For Europe, The Science and Technology Unit Radiocommunications Agency have allocated frequency bands for

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¶ Pulse Width Modulation - Method that generates variable-width pulses to represent the amplitude of an analog input signal.

¶ Pulse Code Modulation - A method used to digitally represent sampled analog signals.

R/C devices (Shown in the table below) with the maximum effective radiated power output of the transmitter measured in milliwatts. (These may differ in non european countries)

Frequency (MHz)	Use	Effective radiated power (mW)
26.96 to 27.28	General	100
34.945 to 35.305	Air	100
40.66 to 41.00	Surface	100
458.5 to 459.5	General	100

#### 61. European R/C Frequency Chart.

To define these frequency bands more clearly, the Science and Technology Unit Radiocommunications Agency give the following explanation.

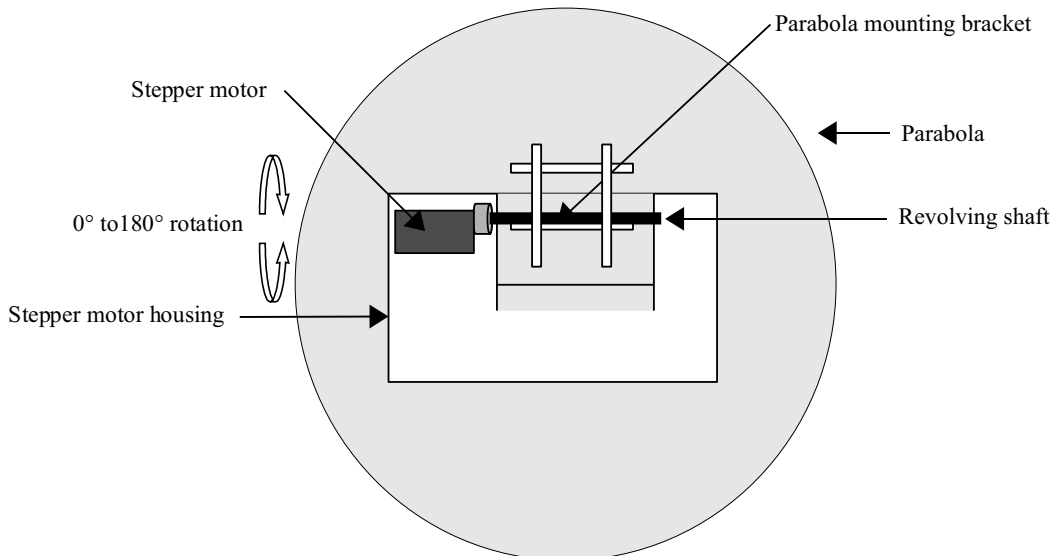
“The 26/27 MHz band is also allocated for Citizens' Band (CB) radio and for low-power telemetry and tele-command devices, as well as for model control. The 458/459 MHz band is also allocated to general telemetry and tele-command devices between 458.5 and 458.95 MHz, and to specialised telemetry between 458.95 and 459.1 MHz. While the potential for mutual interference is minimal, model controllers should avoid the specialised telemetry part of this band. The use of the different bands is important. The 40 MHz band is dedicated solely to surface modelling. It consists of 34 channels with a 10 kHz channel spacing; the centre frequency of the first channel is 40.665 MHz. The 35 MHz is dedicated solely to aeronautical modelling. It consists of 36 channels with a 10 kHz channel spacing; the centre frequency of the first channel is 34.950 MHz.”<sup>203</sup>

Although licenses are not required, all R/C equipment must meet the technical conditions set out in the regulations. According to the Science and Technology Unit Radiocommunications Agency, “All control equipment must operate within the frequency bands allocated and the effective radiated power of the equipment must not exceed that, which is assigned to each category.”<sup>204</sup>

## 7.4 Operating systems and other recording devices

Using the operating system for other recording equipment – if we recall the discussion centred on a design for a fully assembled 416 shotgun microphone, where two servos operate the vertical and horizontal planes independently. But there is no apparent reason why other recording devices could not be adapted/modified to fit. However, consideration must be given not only to size, but also weight for example. As mentioned earlier, a fully assembled 416 when dry is 878 grams, but if its windjammer gets wet this can increase the weight factor by three, which could produce excessive strain on the servo.

Any design intended for location work especially those exposed to the elements, must be able to function in all extremes; working parts should be robust with design simplicity to reduce potential problems. Bigger, equipment such as the parabola used in the field studies, would require servomechanisms with higher torque values to combat the elements. For example, a parabola regardless of size when exposed to wind will act like a sail as Alkin pointed out in the chapter - The approaches to recording wildlife vocalisation. This wind force constant or intermittent will produce torque on the servo, causing undue stress resulting in possible failure. Alternatively a stepper motor could be used and various compatible applications for this system exist; a ball bearing, worm screw or revolving shaft method. (Illustrated below)



62. Stepper motor - revolving shaft method.

## 7.5 Stepper motors and servomechanisms

Before we discuss the differences between servomechanisms and stepper motors, it might be useful to know how the latter functions. Stepper motors can be in three modes, full, half and micro-step; where the type of step mode output is dependent on the design of the driver.

Full step - a standard stepper motor contains 200 rotor teeth, which is equal to 200 full steps per revolution of the motor's shaft. Omega engineering tell us that “dividing the 200 steps into the 360° of rotation equals a 1.8° full step angle.”<sup>205</sup> Thus, “a full step mode is achieved by energizing both windings while reversing the current alternately”<sup>292</sup> meaning a driver's one digital pulse is equal to one step.

Half step – in this mode the motor is rotating at 400 steps per revolution. “One winding is energized and then two windings are energized alternately, causing the rotor to rotate at half the distance, or 0.9°.”<sup>206</sup> This mode provides “approximately 30% less torque and produces a smoother motion than full-step mode.”<sup>207</sup>

Micro-step - “controls the current in the motor winding to a degree that further subdivides the number of positions between poles.”<sup>208</sup> These micro-stepping drives are capable of “dividing a full step (1.8°) into 256 micro-steps, resulting in 51,200 steps per revolution (.007°/step).”<sup>209</sup> The micro-step function is used in applications requiring accurate positioning and smoother motion over a wide range of speeds. Like the half-step, micro-step provides approximately 30% less torque than full-step mode.

We have indicated that the 416 R/C design could use a servomechanism and the parabola, a step motor configuration. But in hindsight we could use either, providing it or they were able to function according to our needs. Which is/are to solve the problems concerning the 'Distance' and 'On-axis' issues for recording wildlife sound. And this design will be tested to ascertain if this can be achieved.

## 7.6 Differences between stepper motors and servomechanisms

In short, the basic difference between a step motor and a servo is the type of motor and how it is controlled. Advance Micro Control state that step motors, “use 50 to 100 pole brushless motors while typical servo motors have only 4 to 12 poles.”<sup>210</sup> A pole being an area of a motor where a North or South magnetic pole is generated, by passing current through the coils of a winding or by a permanent magnet.

Step motors do not need encoders, because of their ability to move accurately between their many poles. Servos having fewer poles do require an encoder in order to maintain knowledge of their position. Moreover, step motors move incrementally using pulses 'open-loop'<sup>¶</sup>, whilst a servo must read the difference between the motor's encoder and the commanded position using 'closed-loop'<sup>¶</sup> and adjust the current required to move.

The performance difference between step motors and servos is the result of their respective motor design. Step motors operate in constant current mode, but this generates a significant amount of heat in both motor and drive, which is a consideration for some applications. The servo solves this by only supplying the motor the current required, to move or hold the load.

Step motors are less expensive in small motor applications than servos, they are easier to commission and maintain; do not lose 'steps' and unlike servos, there is no encoder requirement. Moreover, they are stable at rest and hold their position without any fluctuation. Servo control systems are best suited to high speed, high torque applications that involve dynamic load changes requiring high dynamic response. Whereas step motors are favourable for low speed with low to medium acceleration rates and for high holding torque. But before a system is selected, experimentation would be needed to ascertain which would be suitable for our needs and as our R/C system is lightweight, the servo is the choice.

## 7.7 Radio controlled recording device

To keep matters uncomplicated, our R/C recording device will be simple in its design, incorporating a two channel set up operating the microphone's vertical and horizontal planes. A cable (Microphone to recorder) will be used to transmit the sound. In addition, as this device is only a prototype we will dispense with the 416's basket and wind jammer. The equipment chosen for our device is/was as follows:

- A modified aluminium box
- Two HITEC servomechanisms HS-1 57BB
- A two channel transmitter HITEC Ranger II-N - 27.145 MHZ

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¶ Open loop system is where the communication between the controller system and the motor is one way.

¶ The closed loop has a feedback system to monitor the motor's output with the signal relayed back to the control device.

- General purpose microphone stand
- Sennheiser's MZS 415-3 shock mount, 416 RF condenser shotgun microphone and wind pop
- 100 metres of audio cable
- Nagra 4.2 reel to reel mono recorder set to standard 'Flat Cut' meaning no added control to modify the source and Emitec 6.3 mm audio tape running speed 19.05 cm/s.



63. Prototype R/C recording device (Side view)



64. Prototype R/C recording device (Rear view)

## 8. FIELD TEST CONCLUSIONS

These key questions and main focus of this study is to address the problems of 'Distance' and 'On-axis' when recording wildlife vocalisation and to achieve this goal, we need the following:

- The location/s
- The subject/s
- Technical equipment designed for this purpose

The technical equipment used in these experiments included a parabola and a remote controlled recording device and the idea behind this directive, was ascertain if these devices placed in close proximity to the subjects could solve the 'Distance' and 'On-axis' issues when recording their vocalisation. At this point it should be noted that attention is focussed the devices' ability to function as required and not on any other technical or acoustic issues.

### 8.1 The location/s

The locations comprised of a vast open plain the remnants of a crater that is half a metre below sea level, which in itself would act as a parabola due to its reflective properties. And heavily forested areas that would both absorb and reflect sound. These locations would also be affected by the elements, rain and high winds causing problems during the recording experiments in addition, human intervention and motorised traffic would also have an effect.

### 8.2 The subject/s

The subjects selected as part of the experiments included (a) the Eurasian crane an extremely timorous bird that when approached at less the 400 metres would flee the area and (b), the Great Tit a passerine having erratic flight patterns especially during the breeding season. Therefore, the disposition of these subjects would create challenges when attempting to record their vocalisations.

### 8.3 First technical device: the parabola

There are different types of parabola used for recording sound including those made from various materials for example. Vacuum-formed Acrylonitrile Butadiene Styrene, (ABS) transparent polycarbonate, carbon fibre, glass, and coated metal. Those made from a 'plastic' compound although are perfectly capable for recording wildlife sound, were thought too lightweight for the test purposes, because of strong winds prevailing at the test sites.

Although an aluminium has its disadvantages (Easily dented needing heat to reform its shape which causes brittleness) it is lightweight having high strength and durability with a high corrosion resistance. It can be anodized in a variety of colours or coated in powdered glass or in metal; chrome, gold and silver.

Parabolic reflectors vary with many designed for a particular set up for example, an outward facing omni/uni direction format using an AKG C535 EB microphone. The microphones used in the tests were (a) the Sennheiser 416 P48 an RF condenser directional microphone having rejection qualities for signals coming from the sides and rear. And (b) the Octava MC 012, a compact capacitor microphone with interchangeable capsules to provide a choice of cardioid, hypercardioid or omni-directional polar patterns; and as these microphones were to be both inward and outward facing, a reflector was required to work with these.

Size and performance is/was also an important consideration, reflectors under 30cm diameter, are considered too small to be particularly effective for wildlife sound recording. Because we cannot expect a parabola to reflect, if it's surface is narrower than the wavelength of the signal for example. 1kHz being approximately 35cms in length would cause a small reflector to under perform.

Furthermore, small parabola are normally 'deep-dished' and although acceptable for outward facing omni/uni directional microphones, they are unsuitable for inward facing microphones. Because a deep dish causes a resonant cavity effect, meaning amplified sounds that are produced within. As deep cavity resonance is an item to avoid, a larger 'flatter' reflector will avoid this problem, but is harder to stabilise in windy conditions.

Large reflectors have a higher gain, sharper focus definition and greater directivity but, much depends on the sound wave's frequency. For example, reflectors ranging from 60cm to 120cm diameters are directional at high frequencies and at low frequencies become omni-directional. And with frequencies in the intermediate range gain, directivity becomes irregular. For wildlife sound recording common diameters are: 45cm, 60cm and 90cm, with directionality starting respectively at about 750 Hz, 550 Hz and 375 Hz. Therefore, a parabola in this range should be considered.

Directivity is another consideration, because if the surface is approximated by a series of minute flat facets, each of these facets must be oriented, to direct reflections to the focal point. And "each flat element must not deviate from the true surface by more than about one percent of a wavelength" (Little)<sup>211</sup> in order to maintain phase shift at less than ten degrees. Therefore, the radius of a facet cannot exceed  $0.1aL^{1/2}$  if deviation is to be less than one percent, where  $a$ , is the parabolic constant and  $L$  is the wavelength of the sound. For a value of  $a = 10$  which is normal for most parabola used by wildlife sound recordists, this would mean that a facet's radius cannot exceed the square root of the wavelength.

Furthermore, each facet will reflect its particle of sound towards the focal point, but the convergence of these particles will centre at a focal area rather than at a fixed point. Because, the size of this focal region is proportional to the square root of a sound wave's length; which makes directivity proportional to the square root of frequency. "The limit of resolution direction for a parabola of 105cm used together with a microphone having a 2.5cm diaphragm, would be approximately  $10^\circ$  occurring at frequencies of 5 kHz and higher". (Little)<sup>212</sup> This limit determined by the  $L^{1/2}$  formula would give an approximation of  $8^\circ$  at 8.5 kHz. The possible cause for this reduction is probably due to incorrect positioning of the microphone at the focal area.

#### **8.4 Parabola equipment combination**

The equipment chosen for the device is/was as follows:

- A 2mm white enamelled aluminium 13/13 degrees circular solid parabola with polarization linear mounting in steps of 45 degrees – Reason for choice = robust able to withstand harsh conditions

- Diameter 610mm with a depth of 150mm ket.<sup>¶</sup> - Reason for choice = higher gain, sharper focus definition and greater directivity
- Reflector support a Manfrotto 'Follow Spot Lighting' stand modified to suit – Reason for choice = Heavy duty able to withstand high winds
- Microphones were Sennheiser 416 P48 and Octava MC 012 – Reason for choice = high directivity with noise rejection from sides and rear
- Nagra 4.2 reel to reel mono recorder using Emitec tape 6.3mm running at a speed of 19.05 cm/s – reason for choice = A good all-round robust machine designed for field recording

### 8.5 Parabola performance: advantages

The design of this parabola set-up had/has certain advantages for example:

- Can be positioned anywhere a 'stand alone' function
- Does not need additional support
- Is stable in high winds
- An interchangeable inward/outward facing microphone position
- Good frequency response
- Good directivity with the subject/s
- Able to record clear 'Distant' wildlife sound

This equipment combination was designed to record sound at a 'Distance', from various locations including open plain and forest. The tests had favourable conclusions demonstrating that this particular equipment combination was able to solve the 'Distance' issue. Furthermore, the set up a flatter reflector with an inward facing microphone was not affected by high winds and was able to capture a wide variety of crane vocalisation therefore, this parabola set up has demonstrated its ability and can be used on/at almost any location. The results of the tests are confirmed by the crane recordings found on the CD-ROM audio disc tracks 19 to 25.

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<sup>¶</sup>ket = the depth taken from the parabola's central point on a horizontal plane level with its rim.

## 8.6 Parabola performance: disadvantages

This parabola configuration does have drawbacks for example:

- It is too conspicuous size and appearance are an issue
- It has to be manually operated to maintain 'On-axis'

These factors cause problems when attempting to record fauna vocalisation especially in open spaces for example. The parabola's appearance (White reflector on a chrome stand) needs to be toned down, because its presence is detrimental to the subject's natural behaviour. Moreover, the subject/s will wander as avian species are oft to do thus, 'On-axis' becomes a problem. The parabola needs to be manually operated it in order to maintain this perspective and human presence if seen causes the subject/s to flee therefore, we need to construct a recording device that will eliminate these problems.

## 8.7 Second technical device: the remote controlled unit

To remind ourselves of the problem, we need to solve both the 'Distance' and 'On-axis' issues using a inconspicuous recording device, operated from afar to eliminate the problem of human presence. The solution in this case was to use radio control R/C a system where both the vertical and horizontal planes, 180° and 360° respectively could function allowing the subject/s movements to be tracked and their calls recorded. The technology to construct such a device is generally available, but all options had to be investigated, because the Sennheiser 416 RF condenser shotgun microphone would be used.

## 8.8 Transmitters and servos

In brief the basic operating principle of R/C is a transmitter and receiver/servomechanism, (Servo) that has an assigned radio frequency crystal able to send and receive. Transmitters can be uncomplicated 2 channel analogue units or multi functional 14 channel computerised systems, but as our design only operates two servos; a 2 channel system would suffice.

Servos work on the principle of matching the resistance of potentiometers (Often referred to as a 'Pot') connected to the transmitter's control arms, with the resistance of the servo's potentiometer. Moving the control arm changes the 'pot' resistance in the transmitter causing the servo's motor to

rotate. As the motor turns the connected gears operate the device connected to it; when the resistance value of the servo's pot is equal to that of the transmitter, the motor will stop rotating.

Servos normally use durable plastic or nylon bearings made from Acetal, Acrylic and Acrylonitrile-Butadiene-Styrene (ABS) and these are adequate for our R/C unit. Servo gearing mechanisms are normally encased in a tough plastic housing and when in motion produce a slight humming noise therefore, these will be encased in a die-cast aluminium water protected box for strength and durability - lined with foam to muffle the sound.

### **8.9 Transmission and reception**

Sound transmission and reception is achieved, either by cabling or by radio. Over short distances, (Up to 75 metres) cabling may be preferred; microphone straight to the recorder or storage device. But over long distances (75 metres +) radio transmission would be preferable.

R/C transmission and reception range largely depends on the type of transmission. Older radio systems used amplitude modulation (AM) for radio signals with encoded control positions via the use of pulse **width** modulation. (PWM) But these systems have been upgraded, by frequency modulation (FM) and pulse **code** modulation; (PCM) enhancing performance by electronic speed control.

FM radio systems are the most common devices used, but can have restrictions on open ground as opposed to air or water due to electromagnetic interference. In addition, lower frequencies around the 27 MHz band have shorter range of approximately 100 to 500 metres, but this is perfectly acceptable with our R/C system. R/C devices used on open ground, should retain a clear 'line-of-sight' between the transmitter and receiver in order to function. Opting for greater distances would not be an advantage because, we need to monitor the sound source's movement/s and adjust the microphone accordingly. therefore, a 400 metre range is ample.

### **8.10 Remote controlled equipment combination**

Any design intended for location work especially those exposed to the elements, must be able to function in all extremes; working parts should be robust with design simplicity to reduce potential problems. To keep matters uncomplicated, the equipment selected for this unit is as follows:

- A modified aluminium box
- Two HITEC servomechanisms HS-1 57BB
- A two channel transmitter HITEC Ranger II-N - 27.145 MHZ
- General purpose microphone stand
- Sennheiser's MZS 415-3 shock mount and 416 RF shotgun microphone
- 100 metres of audio cable
- Nagra 4.2 reel to reel mono recorder
- Emitec 6.3 mm audio tape running speed 19.05 cm/s.

### **8.11 The remote controlled unit performance: advantages**

This R/C device has distinct advantages in that it is able to accomplish the following:

- Can be positioned anywhere on a stand or affixed to trees or buildings
- Is a small, compact, lightweight recording unit easily transported
- Is water protected and easy to assemble and operate
- Can accommodate an assortment of microphones including radio
- Is inconspicuous and unobtrusive to fauna
- Can be operated from a distance from 0 to 400 metres
- Able to maintain the 'Distance' and 'On-axis' requirements
- Is able to record good clear sound allowing for the conditions that prevail

This unit was tested at distances from 100, 200, 300 and 400 metres and was able to record 'Distant' sound maintaining 'On-axis' via a 'line of sight' method; although binoculars were required from 200 metres onwards to monitor the action. It is/was possible to extend the distance, but this notion was rejected because the device would be less visible.

The combination of device and Sennheiser 416 functioned as expected and there were no problems using 100 metres of audio cable and when placed in its recording position was not detrimental

to the subject/s natural activity even when in motion. The tests proved favourable with good results and has a distinct advantage over other singular static microphone set ups when attempting to record wildlife sound. Evidence of this is supported by the recordings taken in tracks 26 and 27 the Great Tit found on the CD-ROM audio disc.

### **8.12 The remote controlled unit performance: disadvantages**

This remote controlled unit does have its idiosyncrasies for example:

- It requires two hands to operate it
- The servomechanisms are slightly erratic
- Long lengths of cabling

To explain further, the two handed method is required because the microphone needs to maintain its alignment with the subjects. If one or both of the transmitter's lever/s is/are released, it's connected servo/s will revert back to its/their start point as will the microphone. This is caused by the lack of matching resistance between the potentiometers and the transmitter's control arms. Therefore, in these tests the subject's vocal amplitude was monitored and the recorder's intake volume was set to a desired level. This method allowed for a 'hands free' stance to operate the R/C device and track the subject/s.

The servomechanisms (2 x HS-1 57BB) were borrowed from a large racing yacht where their purpose was to function against the resistance of wind and water hence, they were quite powerful. And when the transmitter's levers were moved in a normal manner, their behaviour tended to become erratic. This is because of the lack of resistance therefore, a more delicate approach in lever control was needed to maintain smooth operation.

Arguably the long lengths of audio cable used to transmit the incoming sound from the device to the recorder, could be seen as another drawback. Because they are exposed to the elements and in some cases could be open to damage. The answer to this problem is to use a radio microphone configuration, that would eliminate the need for long lengths of cable. And as radio microphones use different frequencies there would be no interference between them and the R/C device.

## 9. DISCUSSION

Here we recall the problems regarding the main research question, solving the 'Distance' and 'On-axis' issues. To recapitulate, we know that a sound and picture combination requires each other's support when presenting a particular scene. We also know that the camera is able to capture a variety of visual perspectives through the use of lens changes and that these perspectives cannot be achieved by the microphone. And we are aware that the microphone has to be physically manipulated to capture sound that is related to the picture for example, the wide, the mid and close-up shots.

In looking at this problem the two dominating factors are: (a) 'Distance' - how to get close to the subjects in order to record their sound. (b) How to keep the subject/s 'On-axis' – keeping it/them in direct line with the microphone therefore, we need to understand fauna behaviour. Generally speaking, all wildlife have a tendency to distrust humans and rather than risk a confrontation they will move away. And in many cases the sound recordist has to be in his/her recording position before the subject/s arrive. All wildlife are mobile, their natural behaviour includes foraging, nest building and courtship, so the microphone has to be manipulated to track this mobility in order to keep the subject/s 'On-axis'.

This research has demonstrated that the problems of 'Distance' and 'On-axis' can be solved via the use of the equipment tested in this study.

### 9.1 Comparing the two technical approaches: parabola

This instrument simplistic in its design - an aluminium reflector with a diameter of 610mm has higher gain, sharper focus definition and greater directivity. Allowing the reflector to encompass more sound at the focal point due, to it being larger and flatter than most parabola used in wildlife sound recording. In addition, the microphone mount and 48 volt phantom power supply was constructed to allow (m)any microphone/s to be connected, be they in an inward or outward facing position. The unit was supported by a heavy duty stand able to withstand the onslaught of turbulent wind conditions.

The primary crane location Söderfjärden is a wide open agricultural plain producing cereal crops and has very little natural vegetation therefore, the wind factor is an immense problem. But this parabola configuration was not affected by this, partly due to an inward facing microphone configuration, (Sennheiser 416 and Octava MC 012) which have qualities in rejecting noise and/or signals from the

sides and rear. Partly due to the reflector acting as a shield and partly due to its strength and durability.

The parabola tests showed that when recording crane vocalisation from a 'Distance' at/on locations that included forests and wide open areas, good clear sound can be achieved. Giving the impression that the subject/s are in close proximity although they were more than 300 metres away. This is demonstrated via tracks 21 (Location 2 take off) and 25 (Location 6-1 and 6-2) crane vocalisation.

However, there are issues with this device that need attention for example, it is too conspicuous and when used to record crane calls at Söderfjärden, it did have a detrimental affect. The reason for this consensus is due to observations of crane behaviour whose nature is extremely timorous. The other reason is that although the parabola is capable of recording 'Distant' sound, it is unable to maintain the 'On-axis' parameter, because it cannot be controlled – kept in line with the subject/s.

Suggestions of disguise and motorisation have been made and if these are implemented, it would eliminate these problems. Moreover, it would have a distinct advantage over other manufactured parabola because (a) it would be inconspicuous and (b) its horizontal and vertical axis planes can be controlled from afar. Nevertheless, the device in its present condition has demonstrated its capabilities as a potential instrument for wildlife sound recording.

## **9.2 Comparing the two technical approaches: remote controlled unit**

This device was tested on a passerine species; the Great Tit *Parus major*. A bird with constant mobility, unpredictable flying skills and meticulous approach to territorial defence and to record this subject's calls, speed in operating the R/C device would be a major factor. The unit was tested at two locations a forest environment and a semi-urban area. In its present form the unit uses a cable from the microphone that is relayed back to the recorder. This cable set up is necessary because (a) it feeds the 48 volt phantom power supply needed by the microphone and (b) it is the source for the sound to be relayed back to the recorder.

The tests in the forest were favourable producing sound of various bird calls including the great tit and the sound stage acoustics. (CD-Rom disc; track 26) However, this domain was/is also the territory of predatory birds so a new location would be found where the subject/s (Great tit) were more abundant.

This new location a semi-urban area containing a few pines and small birch trees, was great tit territory and the unit was set up approximately 2 metres from a nest site. And did not appear to be a deterrent as the subject/s continued with its/their routine. The subjects moved back and forth among the foliage at an altitude of approximately 1.5 to 3 metres and the distance between microphone and the sound source was approximately 1.5 to 2 metres.

The recording CD-ROM track 27 although depicts location acoustics and motorised transport, shows that distance has been reduced and that the on axis plane has been maintained. This consensus is supported by the call's amplitude, which is distinctive, prominent and consistent. In addition, there was no noise from the servomechanisms or any problems with transmission and reception, nor was there any frequency interference from other products using this 27.145 MHZ band.

The unit was designed and built using a particular microphone set up purely to ascertain if it could solve the distance and on axis issues which it has. However, there are a couple of issues that need attention. (a) The servomechanisms are perhaps too powerful and alternatives should be investigated for a smoother operation and (b). This device requires two hands to operate it, because the microphone needs to maintain its alignment with the subjects; if one or both of the transmitter's lever/s is/are released, it's connected servo/s will revert back to its/their start point as will the microphone. If having a 'hand-free' stance is needed, then the transmitter lever configuration should be looked at to see if it can be adapted to stay in position once moved. But what effect this would have on the servos has yet to be determined.

This unit is a compact, lightweight recording package, that is easy to assemble and operate, it can accommodate an assortment of microphones including radio. It is relatively inconspicuous - a bonus when working with timid fauna, can be located practically anywhere but, consideration must given to the wind factor. This unit was not protected against wind during the tests because it was not a problem however, in open spaces where wind is a problem, it could be.

To sum up the difference between the two devices remembering that both use the same microphone – the Sennheiser 416 RF condenser:

- The parabola produces a wider aural picture due to more sound waves being directed to the focal point because the reflector is larger and the microphone is inward facing. The remote controlled unit can only produce direct sound if the subject/s remain within the microphone's 'On-axis' plane
- The parabola is a large conspicuous device as opposed to the remote controlled unit being small, compact and unobtrusive
- The remote controlled unit is able to maintain both the 'Distance' and 'On-axis' planes, whereas the parabola can only effectively cover the 'Distance' due to the lack of positioning control
- The parabola is not affected by wind problems, but the remote controlled unit may be

In conclusion, both devices have advantages and disadvantages and both are able to deal with the issues of 'Distance' and 'On-axis'. For some locations the parabola is a better option and for others the remote controlled unit supersedes; it really is a matter of assessing the situation and decide the better option.

### **9.3 The authenticity fidelity problems**

From an authenticity or fidelity point of view both these recording units are able to get much closer to the subject/s and therefore, are able to record and present wildlife sound, which will be in context with the visual. It also presents a distinctive aural picture that allows the listener to decipher what the sound is likely to represent. From a film production viewpoint, optimum wildlife sound recording/s are beneficial to the sound track, because their quality can be appreciated allowing the filmmaker and or editor to adhere to the fidelity issue. And as the natural history film tries to remain as close as possible to the authenticity perspective this can only be beneficial, because these units lead to better production of wildlife recordings of the natural world.

But are such recordings authentic – in short the answer is no and the reason for this statement is because, a listener hearing sounds that appear in 'every day life' will normally hear them radiating from the point of origin. A bus going by, two people in conversation or a bird in a tree and these sounds are natural, because they have not received any electronic modification. In a film regardless of its genre the sound produced has been manipulated or passed through an engineering process. What is heard in the final presentation, is a sound track that although may sound 'Life-like' in its appearance, actually is far removed from authenticity and this applies to the wildlife film. What the spectator actually hears is

'virtual reality'. Nonetheless, most sound recordists do try to record the best sound possible allowing for the conditions that prevail in order to reduce the engineering process.

#### **9.4 The audio profession and scientific community**

Regarding the audio profession – having good quality sound can only be an advantage especially from a film production perspective, because it allows the filmmaker and or editor to reduce the amount of electronic manipulation. We should also remember that no matter who the audience is, at the very least, they expect 'transparent' sound and the better the sound track, the less it is consciously noticed.

The immense popularity of digital video coupled with sophisticated communications medium society has ever witnessed, has allowed filmmakers have access to the production of high quality imagery. Achieved via small affordable high quality camcorders capable of producing the most amazing images and with advanced video editing tools there are virtually no limits.

But what is usually missing from this equation, is a quality sound track, because many practitioners lack the experience and skill in recording location sound. Hence the reason why the majority of independent projects produced today are doomed to suffer, because the sound ranges from unusable to barely average. Furthermore, those considering recording for broadcast sound libraries and/or enthusiasts whom publicly display their results on the internet should be aware of this fact.

In science – sound recording is an important issue, because communication among fauna is the conveyance of information between individuals or groups, it may be deliberate (Courtship or food gathering) or unintentional. (Alarm or confrontation) This interaction in many cases is seen as part of the social structure as in for example the Gelada, *Theropithecus gelada* often referred to as the gelada baboon. These large Ethiopian monkeys use 'lip-smacks' to communicate - a structural rhythm that show striking similarities with human speech. As the study of animal communication is a rapidly growing sector, playing an important part in the disciplines of fauna behaviour including sociobiology, neurobiology and cognition. The need for good quality sound recordings in order to decipher and or comprehend their meanings is paramount.

## 9.5 Problems and solutions

This research has tried to deal with the 'Distance' and 'On-axis' issues and has investigated a way in which to solve them, by the construction of two technical recording devices. Also included was the study of eurasian crane and great tit behaviour. In addition, the scientific principles of acoustics were used as the foundation to support the research, because they demonstrate the various problems found on location. The practice part of this study revealed that the theoretical aspect was an important factor because it allowed for a better understanding when demonstrating the approach to recording wildlife sound. Scientific theory and practice are a vital combination in sound recording and one cannot be without the other.

During the field studies different techniques for recording both the cranes and great tit were demonstrated, using the parabola and remote controlled devices constructed for this purpose. In many cases, the success rate was better than expected for example. The Söderfjärden area (Locations 2 and 3) an area where the cranes would congregate at various times of the day was devoid of cover to aid concealment. Thus the parabola had to be situated 300 to 400 metres away on open ground and subject to the elements. However, by positioning the angle of the reflector's focal point 'down wind' good recordings were achieved.

This contention is supported by the recording/s taken at location 6. (CD-ROM track 25 Location 6-1 and 6-2) This location a small forest track surrounded by dense foliage on both sides also caused difficulties. These include other active avian species and sound stage acoustics as in for example, reverberation from the surrounding mediums. But by careful positioning of the recording equipment these issues were reduced as far as possible. A flock containing approximately 90 cranes flew overhead at an altitude estimated at 80 to 100 metres with their calls loud and clear as are the 'Whooshing' sound made by subject's wings beats.

Using the remote controlled device at/in a forest (Location 4) the sound stage acoustics are audible, but these are a natural phenomenon and would be in context with a visual perspective. Which in this case was a Mid-shot, because the subjects are not in close proximity to the recording device although they are visible. Nevertheless, the avian calls are clear and distinctive. (CD-ROM track 26 great tit and other birds) At location 7 the remote controlled unit was able to record the passerine and these calls are close, (Between 1 and 2 metres) clear and loud although the sound stage acoustics are

apparent. (CD-ROM track 27 location 7 great tit) Therefore both these recording devices have demonstrated that the issues of 'Distance' and 'On-axis' can be resolved.

Could these two devices be used at either or all locations, in some cases yes, but in others no, because each sound stage is different for example. Location 6 is bordered by dense forest and the remote recording unit would need to be elevated to tree-top level in order to minimise the acoustics. Furthermore, as the subject/s are not visible their intended flight path can only be approximated and with the 416's 'On-axis' plain narrower than the parabola's, there could be problems with recording direct sound. Therefore, in this instance the parabola was the correct instrument to use.

However, in open areas the remote recording unit would be the preferred option, because it is inconspicuous as opposed to the parabola which is not. For example, the remote controlled unit could be placed in situ before the subjects arrive and when they are there, the device can be controlled to record 'Distance and 'On-axis' sound. These are the alternatives that a sound recordist has to decide, which of the two devices will give the best results when attempting to record wildlife sound.

Another example of these alternatives is using a 'roaming' microphone technique 'stalking' the subjects. This was tested in the beginning of the field experiments and did not produce useful results, because the subject/s were alerted to human presence. Most fauna particularly those with a timorous nature dislike human presence and will take flight or flee especially in open areas where their visibility is good. The 'roaming' microphone technique may work at or on locations where there is some form of screening to mask the sound recordist's presence, but it does not work at Söderfjärden. Therefore, as this research has argued knowledge of the sound stage, subject/s disposition and technical awareness is extremely important in wildlife sound recording.

Are there possible solutions to solve the problems encountered when wildlife sound recording, much depends on the situation and what one is trying to achieve. In some instances certain fauna for example, the gelada can be in fairly large groups and may remain impervious to activity near or in their vicinity, whilst other may flee or become aggressive. In others recording the calls of particular species as in for example, predatory big cats and bears can be difficult because they seldom vocalise unless provoked or pestered during feeding. Each location regardless of its terrain will pose challenges that the sound recordist has to evaluate and find solutions.

This thesis has looked at a few of these in particular the 'Distance' and 'On-axis' issues and has found ways to address them, but it cannot give answers to every situation, because it is not known what these are and or what the requirements will be. This research has demonstrated that some of the challenges in wildlife sound recording can be solved by using a particular approach for example, the technical instrumentation designed and constructed for the practical experimentation with the eurasian crane and the great tit. And although the research is just a link in a long chain of events, it can be considered as a central peg on, which further research and development can pivot.

## 10. CONCLUSION

The aim of this study is/was to tackle the 'distance and on axis' issues that are major problems when recording sound in wildlife filmmaking. The camera is able to depict the subject/s from a variety of perspectives via lens changes, but the microphone cannot; because there is no microphone that can do this. Attenborough (2004) It has to be constantly manipulated in order to record good bioacoustic data as Ginsburg, (2004) Charif, Mellinger and Dunsmore (2002) et al., have pointed out.

Many filmmakers have demonstrated different techniques in wildlife filmmaking for example. Scientific, (Kingsley Noble) Educational, (Jacques Yves Cousteau) Environment and conservation, (David Attenborough) and The Hollywood approach. (Brady Barr) And as wildlife filmmaking is all about movement, action and dynamism, the above have shown how these are captured and rendered. Which in turn are influenced by audience preferences, media economics, established production practices, viewers expectations and the ways each of these influence others. Bousé (2000)

A film's sound track has many components including, diegetic and non-diegetic sound, music, narration and stereo sound. But as Yewdall (2003) has pointed out sound track creation is all about conceptualising, designing and executing these components into one continuous fluid audio event to support the visual. But there are instances where a missing component can cause problems for example. In *Kingdom of the Ice Bear* (1985) there was no audio accompaniment to support subject movement in one particular scene. Thus, an effect was used to augment the subject's footsteps. Attenborough (2004) A cosmetic effect which according Stirling and Guravich (1998) denies reality. But others contend that sound effects give rise to a sound track's realistic creation and in a utilitarian sense, sound shows its value by creating a ground base of continuity to support the images. Monaco (2000)

The acoustics of the sound stage and subject/s disposition are crucial factors to consider prior to a recording approach. Sound stage acoustics including: distance, direction, amplitude, phase shift, frequency, harmonic content, inharmonicity and masking are natural phenomena. And each recordist will approach these in their own particular way. Two examples were given, the 'killer bees' and 'waterfall' scenarios demonstrated an approach to a particular situation. Subject disposition is a major consideration because, the majority of fauna see human intervention as a cause for alarm and will in most cases abscond. Therefore, new techniques have to be found in order to record wildlife vocalisation. Budney and Grotke, (1997) et al.

Various methods for recording wildlife have been applied. These included recording cetacean vocalisation, which created many unwanted problems. Watkins and Daher, (1992) Charif, Mellinger and Dunsmore. (2002) With terrestrial subjects other problems were relevant because of the subject/s disposition. Kettle and Vieliard, (1991) Dhondt and Lambrechts. (1992) To combat these problems other methods were suggested, but these were considered ineffective. Bartlett (1999) and Wahlström. (1985)

Considering the findings based on previous techniques of Budney and Grotke et al, it was clear that in order to facilitate the recording of good bioacoustic data, the need to push beyond the limits was necessary. To achieve this, a subject (Eurasian crane) had to be researched that would offer challenges so that a technique (Parabolic reflector) could be tailored to accommodate. Research revealed that this avian species is/are extremely timorous and unapproachable, taking flight at the slightest hint of disturbance. Their location by day was a vast expanse of open arable land devoid of vegetation, prone to the elements and human activity. At dusk they would return to their nesting grounds flying over dense forests and swamps. The aims of the experiment were to record a single call, that of a group and vocalisation during flight. The results are found on the CD-ROM audio disc tracks 19 to 25.

The results of this experiment showed the aims were achieved and the technique used a modified parabola and RF condenser shotgun microphone, demonstrated its ability from a static position to record clear 'distant' sound in adverse conditions. Nonetheless, there were idiosyncrasies that reduced the effectiveness for example. The device has to be in situ prior to the subject/s arrival. Its conspicuous appearance deters the subject/s from venturing near. Evidence to support this theory showed that when

the device was removed, the subject/s returned. Repeating this exercise several times produced the same result. A possible solution in solving this problem is to camouflage the device allowing it to blend into the surroundings. In addition, if the device was motorized, this would allow the subject/s to be tracked.

Reviewing the findings of research method 1, a new methodology had to be devised in order to solve the distance and direction issues. To achieve this a subject (The Great Tit) had to be researched offering challenges, which this new technique (A remote controlled microphone) could accommodate. Research showed that this avian species is a non migratory, intelligent bird, territorial and exceptionally quick in flight. It is timorous avoiding confrontation, but is apt to display aggression using various descriptive calls. The terrain frequented by the subject/s - forest, woodland and urban areas would be affected by the elements, motorised transport, human activity and the calls of other avian species. The aims were to record the subject's song/call in keeping with what would be visualised from a pictorial perspective - a wide shot. And to record the subjects song/call in extreme close up. The results can be found on the CD-ROM audio disc tracks 26 and 27.

The unit a radio controlled recording device was tested at various distances from 100 to 400 metres and was able to record sound from various perspectives including; extreme close-up maintaining 'On-axis' via a 'line of sight' method. And when situated in close proximity was not detrimental to the subject/s natural activity even when in motion. The tests proved favourable with good results and evidence of this is supported by the recordings taken in tracks 26 and 27 the Great Tit found on the CD-ROM audio disc.

All prototypes have idiosyncrasies requiring improvement for example. The unit has 2 control levers requiring 2-handed operation in maintaining microphone alignment with the subject/s movement. This issue can be solved by re-designing the unit into a 'single-handed' 'joystick' control system. The unit's experimental servomechanisms are slightly erratic due to their design. To solve this problem micro servomechanisms with less torque can be used. The long lengths of cable are exposed to the elements and in some cases may be susceptible to damage. An alternative is to use a radio microphone configuration. These modifications will improve the device making it an exceptional tool for recording wildlife sound.

The recording equipment used in this study was designed and constructed for particular tasks using readily available components that can be modified by most sound recordists. As stated, radio

control is not a new entity neither is the microphone, but when combined together it brings a new dimension to wildlife sound recording. The benefits of this system are a small, compact, unobtrusive unit able to accommodate (m)any microphone/s. It can be placed in close proximity to the subject/s and operated from afar, thus solving the problems of distance and direction. Which, cannot be achieved using conventional methods. (A boomed or static microphone technique) To give a good example where this device would prove most effective is in the study of Gelada ethology. These primates communicate via their quiescent 'lip-smacks' and this 'stand alone' device should/would not have a detrimental affect on their behavioural patterns whereas human presence would.

For the portrayal of realism, we know the camera is able to depict the subject/s in various modes due to its ability to lens change. But the microphone cannot it has to be physically manipulated and this causes problems, because. (a) It can only record one perspective that of its position in relation to the sound source. (b) Reducing the distance can result in the subject/s absconding due to human intrusion. This device placed in close proximity eliminates these problems allowing for close-up sound to be recorded that will coincide with the visual perspective, thus the portrayal of realism is achieved.

The sound stage acoustics and subject/s disposition will always be problematic no matter what the locale, a concern that present technology is unable to control. And as wildlife cinematography becomes more adventurous due to technological improvement, new ways have to be devised to keep pace. Therefore, it is crucial to research the location, the subject/s and the filmic requirement as far as possible. And if this is carried out, then most problems can be minimised.

This study has shown that technological improvement is able to assist the wildlife sound recordist when confronted with the idiosyncrasies associated with location accessibility, sound stage acoustics and subject/s disposition. These three factors are the main cause in creating the 'distance and direction issues'.

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## SOURCES - ELECTRONIC ARTICLES

### 1. **ADVANCED MICRO CONTROL INC** - Stepper & Servo: Basic Differences

<http://amci.com/tutorials/tutorials-stepper-vs-servo.asp>

The basic difference between a traditional stepper and a servo-based system is the type of motor and how it is controlled. Steppers typically use 50 to 100 pole brushless motors while typical servo motors have only 4 to 12 poles. A pole is an area of a motor where a North or South magnetic pole is generated either by a permanent magnet or by passing current through the coils of a winding. Steppers don't require encoders since they can accurately move between their many poles whereas servos, with few poles, require an encoder to keep track of their position. Steppers simply move incrementally using pulses [open loop] while servo's read the difference between the motor's encoder and the commanded position [closed loop], and adjust the current required to move.

Stepper & Servo: Pros & Cons - Some performance differences between Stepper and Servos are the result of their respective motor design. Stepper motors have many more poles than servo motors. One rotation of a stepper motor requires many more current exchanges through the windings than a servo motor. The stepper motor's design results in torque degradation at higher speeds when compared to a servo. Using a higher driving bus voltage reduces this effect by mitigating the electrical time constant of the windings. Conversely, a high pole count has a beneficial effect at lower speeds giving the stepper motor a torque advantage over the same size servo motor.

Another difference is the way each motor type is controlled. Traditional steppers operate in the open loop constant current mode. This is a cost savings, since no encoder is necessary for most positioning applications. However, stepper systems operating in a constant current mode create a significant amount of heat in both the motor and drive, which is a consideration for some applications. Servo control solves this by only supplying the motor current required to move or hold the load. It can also provide a peak torque that is several times higher than the maximum continuous motor torque for acceleration. However, a stepper motor can also be controlled in this full servo closed loop mode with the addition of an encoder. Steppers are simpler to commission and maintain than servos. They are less expensive, especially in small motor applications. They don't lose steps or require encoders if operated within their design limits. Steppers are stable at rest and hold their position without any fluctuation, especially with dynamic loads.

Servos are excellent in applications requiring speeds greater than 2,000 RPM and for high torque at high speeds or requiring high dynamic response. Steppers are excellent at speeds less than 2,000 RPM and for low to medium acceleration rates and for high holding torque. Stepper vs. Servo: The Verdict - Servo control systems are best suited to high speed, high torque applications that involve dynamic load changes. Stepper control systems are less

expensive and are optimal for applications that require low-to-medium acceleration, high holding torque, and the flexibility of open or closed loop operation.

## 2. **Acoustic Sciences Corporation.** (2010) Acoustic Basics. 1. Comb Filtering

[http://www.asc-hifi.com/acoustic\\_basics.htm](http://www.asc-hifi.com/acoustic_basics.htm)

Sound and music propagate through waves and, therefore, must abide by the laws of wave physics. This means that when 2 waves "collide", they do not bounce off one another as is the case with physical objects. Instead, at that location in space and moment in time, they either add their combined amplitudes to some degree or cancel their combined amplitudes to some degree. In phase add - Waves exactly in phase add to make a wave with twice the amplitude. Exact out phase add - Waves exactly out of phase add to make a wave of zero amplitude. Out phase add - Waves out of phase to a small degree add to make a wave with slightly higher amplitude than either wave individually. The wavelength of the 2 sound waves and the difference in the distances they have traveled determine whether they add to or subtract from the combined resulting amplitude. This means that there are a series of adds and cancels at various frequencies of sound for any given room setup.

There are many potential reflection points that can cause a sound launched from a source to return to that source and interfere with itself. There are also many potential ways for sounds to travel from one source to another and cause interference. Likewise, there are many ways for sounds launched from single or multiple sources to arrive at a central listening position at different times and interfere with one another there. All of these interfering waves cause the resulting amplitude of the sound to either increase or decrease to some degree depending upon the frequency (tone) of the wave. The resulting adjustment to the amplitudes at each frequency is called a comb filter. Comb filtering effects are reduced by placing acoustically absorptive materials at the reflection points responsible for the interfering waves. The materials must be of a size and type to properly address the frequencies of each specific problem. Rearranging the speaker setup will simply shift the locations of reflections and alter the problem frequencies, but does not remove the problem. ASC SoundPanels, SoundPlanks, and Fractional TubeTraps are often used to control comb filter reflections, with the appropriate device chosen based upon the frequency of the problem. Although locating the precise positions of problem reflections can be a complex task, there are a few locations where controlling the reflected wave is sure to make an improvement to the sound.

There are certain paths for sound that produce a repeating loop. Every time the wavefront passes the listener it is heard as the sound is intended, but with a twist. Just as when you "click" the individual prongs on a comb in quick succession, the quickly repeating sound of the wavefront continuously passing the listener produces a distinctive "zinging" tone. This is known as flutter echo and is due to our brain's desire to interpret air pressure fluctuations at some frequency as a particular tone. For this is exactly what is occurring as the wavefront continuously passes your ear at some rapid rate. The flutter paths are most commonly located along lines between parallel surfaces.

Speakers located between parallel surfaces are constantly sending sonic wavefronts into the repeating loops of these flutter paths. Placing ASC TubeTraps, SoundPlanks, or SoundPanels at the reflection points for these flutter paths breaks up the flutter. This removes the tonal discolouration caused by the "zinging" sounds our brain interprets from the repeating wavefronts it encounters.

3. **Dan Brockett** (White Paper) October 21, (2002) Location Sound: The Basics and Beyond  
Big Little Films, Inc. 2955 E. Hillcrest Drive, Suite 121 Thousand Oaks, Ca. 91362 USA  
dan@biglittlefilms.com

The concepts of location sound recording that we will discuss in this article are basically the same, whether you are shooting your tenth independent film or your first project with your first new camcorder. Audio seems to be one of the most challenging areas for beginners and even experienced filmmakers alike. Video professionals typically find sound one of the most challenging aspects of production. Ten years ago, producing professional quality film or video was a much more cut and dried process. If you wanted decent sound for your picture, you either had the knowledge and equipment to record it yourself or you hired a location sound team. This is still true today but the differences are that there are a lot more people producing video today who may not have experience and skill in recording location sound than there were ten years ago. DV users with many different experience levels and widely diverse backgrounds are producing their own projects. The fact is that almost all of the tools needed to produce broadcast quality video and DV "films" have become relatively inexpensive and widely accessible. Final Cut Pro and AVID Express DV both have about 90% of the capability of a \$100,000.00 AVID Media Composer system at a minute fraction of the cost. Camcorders like the Sony PD-150, Panasonic AG-DVX100 and the Canon XL-1S are capable of producing extremely high quality images.

The immense popularity of digital video means that a large majority of users today have access to the most advanced communications medium society has ever seen. We have small, relatively affordable, high quality camcorders that can make amazing images with far less light than ever before. We have very sophisticated and capable video editing tools available on both platforms. Assuming we all want to produce work of quality, what's missing from this equation? You guessed it, the sound. The fact is that most independent, low/no budget projects that are produced today seem doomed to suffer with sound that ranges from merely average to barely usable. Whether you are producing video for your friends and family, to view, weddings and events, corporate audiences, or for broadcast or theatrical release, no matter which category your audience falls into, they expect "transparent" sound from your project's soundtrack. Let's define what "transparent" sound is. Audio conveys almost all of the emotional impact in the visual medium. It's a fact. If you watch your favourite scene from any film or TV show with the sound off, you soon discover that moving images on their own are typically not very emotionally involving. Don't forget, silent films could be scary, sad, happy, dramatic or interesting BECAUSE they were conceived without sound. To be totally fair, most silent films were viewed with either live or pre-recorded music.

Obviously, most of us want to produce projects that will emotionally involve our audience. For most of us, video has become the single most common collective vocabulary in our lives. It is also a given that video is great for communicating almost any message to almost any audience, if done well.

The Experience Economy - What may be less obvious to you if you are new to film and video making, is that audiences of all kinds now expect to be entertained while you are conveying your message. If you are in the entertainment end of this business, this is understood, but for those of you who want to create home video, weddings, events or video for business, your content must also be entertaining and compelling. Emotional involvement from your audience is what defines good entertainment. You may not feel that the Shop Safety training video you are producing can or should be very entertaining, but if the production values and concept are not very high quality, your training video will bore your audience. If it's done well, even a Shop Safety training video can be entertaining. Your sound is largely what will determine if your project is entertaining to your audience. Unless you want to conceive your project as a "silent film", you have to be concerned ('obsessed' might be a better term) with your project's sound.

One of the toughest concepts for many newer DV users to grasp is that the better job you do with your project's sound, the less it will be noticed. I feel that this concept is one of the reasons why most projects don't end up with very high quality soundtracks. We are very used to spending time, effort and money on a better camera, lens, bigger and better lighting, crew and visual effects and seeing an immediate "payoff" when our images are viewed. It's instantly recognizable if a scene is lit effectively or if a visual effect is done well. We feel "justified" in shooting on a higher quality, more expensive format or with a bigger crew because the end result is usually easily identifiable on-screen. Most of us can immediately recognize if a project was shot on 35mm film versus DV or if a project's motion graphics or visual effects were well executed. If we notice a sound mix though, it is usually because the sound was done incompetently. This is the central concept of "transparent" sound. If your location sound is recorded correctly, the easier it will be to work with the basic audio during the post-production process. The better job you do with the sound during video and audio editing, the less the audience will notice it. The only sound that is noticed in a visual medium is usually poorly executed. Great sound works on a subconscious level with the viewer by drawing them into what they are viewing. Great sound supports and enhances the stories you are trying to tell. Now that we have a basic understanding of the goal for your project's soundtrack, let's review what we have covered before we dive headlong into equipment and technique.

Four points to remember about sound for picture

- 1 . The principles of location sound are the same for almost everyone shooting anything.
- 2 . No matter who the audience is, at the very least, they expect "transparent" sound
- 3 . Sound conveys emotion - picture conveys information
- 4 . The better your soundtrack, the less it is consciously noticed

Just as in an actual chain, the audio path is only as strong as it's weakest link. This means that a high-quality, accurate recording device paired with a low-quality microphone will not be able to record anything better than what the microphone is capable of picking up. It means that a great microphone and audio mixer paired with a substandard recording device will only be able to record to the limitations of the device's recording circuit. While it is not practical for most DV users to acquire and use the best quality location sound equipment made, it should be the goal of every user to acquire and use components that match each other in features and quality. Don't buy the best mixer you can afford and then skimp on cables and connectors. Don't buy the best shotgun microphone on the market and then skip using a mixer because you spent your entire budget on the microphone. You get the idea. We'll discuss rental versus buying later in the article but needless to say, buying one or two high quality pieces and then renting the rest as needed is a viable option.

The First Link - Sound Itself - It is not possible to try to give even the basic principles of sound within the confines of this article but let's talk about some basic concepts of what sound is and why sound behaves the way it does. At the most basic level, sound can be described as waves moving through air. The farther apart these sound waves are, the lower the frequencies. The closer the sound waves are to each other, the higher the frequency. In the most basic terms, sound is "messy". It bounces, reflects and behaves in ways that seem mysterious to most us. It cannot be seen and all of us perceive sound differently. There is an entire branch of study and academia called "Psychoacoustics" which is the study of how humans perceive, process and react to sound. Sound is definitely a case of "perception being reality." Sound waves cannot be seen in most cases, but effects of sound waves are evident if you know where to look. Although not actual sound waves, the ripples produced when a rock is dropped into water produce a nice visual approximation of what sound waves would look like if they were visible to us. If you place something lightweight, like a piece of paper in front of a typical transducer, like a two way audio speaker (a two way speaker has only a woofer for generating low frequency sounds and a tweeter for reproducing high frequency sounds), you will probably see the paper physically move if placed in front of the woofer while the speaker outputs sound at a decent volume level. However, if you place the paper in front of the tweeter only, you will probably see either very little or no perceptible movement. This is because the high frequencies generated by the tweeter are much closer together and occur at much more rapid intervals. Too rapidly to perceptibly affect the mass of even something as lightweight as the paper unless the amplitude of the sound is increased to very high levels. Understanding this concept is central to understanding how sound waves behave.

Low frequency sound waves (bass sounds), because of their larger physical size, tend to interact with their surrounding environment in much more perceptible ways than high frequency sound waves (treble sounds) seem to. All sound waves reflect off of physical objects but because of their larger size, lower frequency sound waves reflect and penetrate objects more than higher frequency sound waves do. If you can grasp this idea, you will begin to have an understanding of how to help modify or eliminate undesirable sounds when you shoot in any

location. If your apartment or hotel neighbour is cranking his stereo loudly in the room next door, which frequencies are you hearing through the walls? Obviously, the higher frequency sound waves do not have the strength to penetrate the wall. Few of the mid range sound waves will penetrate the wall. What you will mostly hear through the wall are mostly the low frequency sound waves.

"Preventative Maintenance" - What we deem as "poor quality" sound can be manipulated and adjusted all along the audio path in different ways but in most cases, it is best to adjust and compensate for the "poor quality" sound before it ever enters the audio path. Although this sounds like a simple concept, the reality is that it is much more common for people to hear what will obviously be a sound problem (undesired noise, excess ambient sound, technical sound problems like hum or buzzes, etc.) and to just go ahead and shoot, rather than determining the source of the undesirable sound and fixing it. In some cases, it's just sheer laziness. It's a pain to hunt down an audio problem and fix it before rolling. When shooting with a crew or in limited access or time-constrained situations, this is somewhat understandable but you should know that despite all of the great postproduction technology available, basically, what you hear is what you get. If you record poor quality sound, it will always be poor quality, no matter what types of filters, plug-ins or processes you run it through. It pays to spend a few extra minutes to fix audio problems before you shoot. Below are the top five most common causes of location sound audio problems that most people will run into when shooting. You will notice that several of the categories kind of overlap each other in definition. Such is the nature of sound. Included are some suggestions for mitigating, reducing or correcting the problems before you shoot: Excessive ambient noise. - Too much background noise. Too much traffic noise. People speaking or making noise in the background or in the room next door. Dogs barking in the background. Sirens in the background. Aircraft flying overhead.

Possible solutions. - Excessive ambient noise is one of the toughest issues to work with because often, the excess ambient sound is beyond your control. The solution can be as simple as repositioning your microphones or waiting until the excess ambient sound dies down or goes away to more elaborate steps such as soundproofing a location. Obviously shutting doors and windows can help when shooting interiors. Exteriors are tougher. In the past, I have resorted to "paying off" a tree trimming crew using chainsaws to take a "long" lunch or knock off early. In that instance, I paid to record better sound. You must be creative in your thinking and do whatever is within your power to limit ambient noise when shooting. Microphone choice is extremely important here as well.

**4. Buckingham and Shanee** - Extract – from the Conservation Priorities for the Peruvian Yellow-Tailed Woolly Monkey (*Oreonax flavicauda*): A GIS Risk Assessment and Gap Analysis by Fiona Buckingham<sup>1</sup> and Sam Shanee<sup>2</sup> - *1School of Environment and Technology, University of Brighton, Falmer, Sussex, UK 2Neotropical Primate Conservation, Cheltenham, Gloucestershire, UK (Received for publication: 28 November 2008 Revised: 21 June 2009 - 71 - Conservation Priorities for *Oreonax flavicauda*)*

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The yellow-tailed woolly monkey (*Oreonax flavicauda*) is endemic to the Peruvian Andes, and the largest of Peru's primates (Leo Luna 1987). It is also one of the most threatened; listed as Endangered on Appendix I of CITES (2005) and as Critically Endangered on the *IUCN Red List of Threatened Species* (Cornejo *et al.* 2008). It has also been on the list of the World's 25 Most Endangered Primates since 2006 (DeLuycker and Heymann 2007; Cornejo *et al.* 2009).

Even so, comparatively little investigation or conservation work has been carried out on this species and very little is known about its status. There are no accurate population estimates, but Nowak (1999) wrote that there were only 250 individuals surviving in the wild. Although this is probably an underestimate, the current population will not be much larger than this, and is surely decreasing, making more effective conservation measures critical to the species' survival. *Oreonax flavicauda*, a flagship species for the Tropical Andes Biodiversity Hotspot (Myers *et al.* 2000) has a very limited geographical range (Leo Luna 1987; Shanee *et al.* 2007, 2008). It can be found only in a small area of primary montane and cloud forest in the Peruvian departments of Amazonas and San Martín (Butchart *et al.* 1995) between the altitudes of 1,500 m and 2,700 m above sea level (Leo Luna 1982; DeLuycker 2007).

Early locality records have also shown the occurrence of this species in small areas of the neighbouring departments of Huanuco, Loreto, La Libertad and Cajamarca (Mittermeier *et al.* 1975; Graves and O'Neil. 1980; Leo Luna 1980, 1982, 1989; Parker and Barkley 1981; DeLuycker 2007). The threats that determined the status of *O. flavicauda* as Critically Endangered include hunting and deforestation. 65 *Primate Conservation* 2009 (24): 65–71 Buckingham and Shanee. Despite being prohibited under Peruvian law, subsistence and trophy hunting still occur throughout the species' range. Hunting is made easier by its conspicuous nature and large size. At least 20 monkeys were hunted in the areas surrounding the Bosque de Protección de Alto Mayo and the Zona Reservada Cordillera de Colán over 18 months in 2007–2008 (Shanee *et al.* in prep.).

The rate of deforestation in Amazonas and San Martín is among the highest in Peru (Peru, INEI 2008), fuelled by the need for agricultural land, coffee cultivation and small- and large-scale timber extraction (DeLuycker 2007; Shanee *et al.* 2007; EDGE 2008). The widespread deforestation that has occurred in this region has, in many areas, forced *O. flavicauda* into isolated forest fragments (Shanee *et al.* 2007). Although the area currently occupied by *O. flavicauda* is unknown, in 1981, Leo Luna (1982) estimated its potential forested habitat to be at least 11,240 km<sup>2</sup>, but predicted that this would decrease by 1,600 km<sup>2</sup> by 1991. Based on these figures and projected rates of deforestation, DeLuycker and Heymann (2007) estimated that by 2006 potential forested habitat would have been reduced to 7,240 km<sup>2</sup>.

5. **Cooley and Marshall** (2000). Periodical Cicada: What is a periodical cicada? Insect Division. University of Michigan Museum of Zoology. 1109 Geddes Avenue, Ann Arbor, MI 48109-1079.

jcooley@aya.yale.edu dmarshall@umich.edu - <http://insects.ummz.lsa.umich.edu/fauna/>

What is a periodical cicada? -Cicadas are flying, plant-feeding insects of the Order Homoptera, which also contains groups such as the leafhoppers, aphids, and scale insects. Adult cicadas tend to be large (most are 25-50mm), and most North American species have clear wings, held roof-like over the abdomen. Cicadas have conspicuous long-range acoustic signals produced by specialized abdominal structures called tymbals; in most species only the males have these structures. Most cicadas are active only during the day and/or evening. So far as is known, all cicadas have multiple-year life cycles (4-17 years). Cicadas in which almost all of the individuals in a given location mature into adults in the same year are periodical. Most cicada species are non-periodical, meaning that some adults are present in most or all years, while others show partial periodicity.

The most prominent and best-studied periodical cicadas are six species from eastern North America belonging to the genus *Magicicada* -- three species with 13-year life cycles, and three with 17-year cycles. The three 17-year species are generally northern in distribution, while the 13-year species are generally southern and midwestern. *Magicicada* are so synchronized developmentally that they are nearly absent as adults in the 12 or 16 years between emergences. When they do emerge after their long juvenile periods, they do so in huge numbers, forming much denser aggregations than those achieved by most other cicadas. Entomologists often use the common name periodical cicada to refer to this genus alone.

Periodical cicadas are also known as "17-year locusts," but they are not locusts; locusts are a type of grasshopper. *Magicicada* adults have black bodies and striking red eyes and wing veins, with a black "W" near the tips of the forewings. Most adults emerge in May and June, and live for only a few weeks. Certain other medium- to small-sized late spring and summer cicadas are sometimes mistaken for periodical cicadas, such as those in the genera *Diceroprocta* and *Okanagana*; these cicadas may be present May-July, may have black or orange coloration, and may also be somewhat periodical, though not as dramatically so as *Magicicada*. Other common North American cicadas include the large, greenish "dog-day" cicadas (genus *Tibicen*) found throughout the U.S. in the summer. Non-periodical cicadas are often called "annual cicadas" (even though they have multiple-year life cycles) because in a given location adults can be found every year. *Magicicada* life cycles - Cicada juveniles are called "nymphs" and live underground, sucking root fluids for food. Periodical cicadas spend five juvenile stages in their underground burrows, and during their 13 or 17 years underground they grow from approximately the size of a small ant to nearly the size of an adult.

In the spring of their 13th or 17th year, a few weeks before emerging, the nymphs construct exit tunnels to the surface. These exits are visible as approximately 1/2 inch diameter holes, or as chimney-like mud "turrets" the

nymphs sometimes construct over their holes. On the night of emergence, nymphs leave their burrows after sunset (usually), locate a suitable spot on nearby vegetation, and complete their final moult to adulthood. Shortly after ecdysis (moulting) the new adults appear mostly white, but they darken quickly as the exoskeleton hardens. The cues that determine the particular night on which the nymphs emerge and moult are not well understood, but soil temperature probably plays an important role (Heath 1968). Sometimes a large proportion of the population emerges in one night. Newly-emerged cicadas spend roughly four to six days as "teneral" adults before they harden completely (possibly longer in cool weather); they do not begin adult behaviour until this period of maturation is complete.

After their short teneral period, males begin producing species-specific calling songs and form aggregations (choruses) that are sexually attractive to females. Males in these choruses alternate bouts of singing with short flights until they locate receptive females. Contrary to popular belief, adults do feed by sucking plant fluids; adult cicadas will die if not provided with living woody vegetation on which to feed. The piercing-and-sucking mouthparts are visible just behind the forelegs) Mated females excavate a series of Y-shaped egg nests in living twigs and lay up to twenty eggs in each nest (Marlatt 1923). A female may lay as many as 600 eggs (Marlatt 1923). Below is a photograph of *Magicicada* egg nests. After six to ten weeks, in midsummer, the eggs hatch and the new first nymphs drop from the trees, burrow underground, locate a suitable rootlet for feeding, and begin their long 13- or 17-year development. *Why are there so many of them?* Periodical cicadas achieve astounding population densities, as high as 1.5 million per acre (Dybas 1969). Densities of tens to hundreds of thousands per acre are more common, but even this is far beyond the natural abundance of most other cicada species.

6. **Joseph De Buglio** A Theory For Better Church Speaker System Installations - Comments of the author are not necessarily those of the Audio Community. A Theory - The Sweetspot of a Room - JdB Sound Acoustics 63  
Lockerbie Avenue, Toronto, Ontario Canada M9N 3A3  
<http://www.jdbsound.com/art/art532.html>

What is presented here is just theory about a part of sound system designing that may have been over looked. It has made an impact on how the overall performance of many church sound systems ultimately worked.

What is a Sweetspot - Many professionals in the audio trade use the term sweet-spot for HIFI and Studio Recording systems. It is referred to the spot where the stereo image is in focus for every sound that is in the mix. The idea behind the sweetspot theory in a sound reinforcement system for large rooms is the focal point to broadcast mono/live sounds to many people in a large room. Since people can see where the live sounds are coming from and you don't have to be between two speakers to locate a sound on the stage, reinforcement of live sound become like a HIFI system in reverse. The idea of the stereo system is to be positioned between two speakers and the audio recording is manipulated to create room effects or the impression of sounds coming from more that one place between the speakers. In a stereo system the sweetspot is the focal point of sounds for just

one person between two speakers. For live sound, the opposite is required. No matter where you are sitting, you are expected to hear the same sounds everywhere less any room effects on the listening position. This required a position from where a single focused sound can broadcast into a room that is affected only by the room effects just as the natural sounds from the stage or performance area. Is there such a position? If there is such an area, do you put the speaker system in that spot or do you keep away from it?

For years people have been using a sweet-spot of sorts and they have used it many times. It is a spot in the room where people naturally gravitate to for special music or special presentations of sound. You know .... where the choir sounds best for special music. Where the string quartet likes to play for concerts. In general, you could say that it is the spot where a person's voice projects the furthest into a room before reflections from walls and other surfaces interferes with the original sound. Just about every church I go to, I ask the music director or minister if there is an ideal performance spot where people sound their best when performing. Just about every church has such a spot and it is most often centre stage and anywhere between 6 feet behind the front of the stage to about 5ft. ahead of the front of stage. Center stage is the most common but where along that centre line – it changes from room to room. You can't always hear the sweet-spot. Standing waves and strong early reflections can mask the spot. To the person talking or performing, what sounds heard is most often the ideal picture of how well their sound is covering the room un-amplified or amplified. If there is a string quartet, they often gather around the sweet-spot so that they will be able to play together with less effort.

Can a person hear the sweet-spot without test equipment? What does the sweet-spot sound like? For the average listener and depending on the room, stepping into the sweet-spot is often subtle. Much like a near sighted person putting on glasses to make out the hymn numbers on an overhead. In some churches, it can be very dramatic. In many of the tests that I have done with my MLSSA (Maximum Length Sequence System Analyser), it has shown as high as a 2% difference between standing in the sweet-spot and stepping out of it by a few feet. The question is, does this matter for church sound system design or can we just ignore the effect all together. I first notice the effects of sound getting clearer in 1985 while installing an active speaker on top of a 30-foot scaffold. Someone on the floor noticed the speaker sounding better when it was a few feet further back than the planned hookup point. We cleared the planks and moved the speaker around and the 15 people around the room noticed the effect. As far as those church members were concerned, they made it very clear to me that the sound from the loudspeaker was better in one position over another and they asked me to put the speaker in the better position. As it happens, we were able to move the speaker and the results were as I had hoped with good gain before feedback, coverage and so on.

From that point on, on many installations, I would set up a temporary bracket at the top of the scaffold and slide the speaker back and forth until there was a spot where I or a church volunteer would notice that extra bit of clarity in the sound. If I was by myself I would use a prerecorded tape of a person speaking to find the idea

position to install the speaker. Then, I tried the same thing on the ground. The results were almost the same, but less dramatic. After doing this at about 40 churches, I had found that as long as the ceiling was symmetrical, the "sweet-spot" remained constant on the vertical axis down to the floor. I have done such testing on over 100 other churches too. With my MLSSA and on a few occasion - I use a friend of mine's TEF, these toys confirmed what I was hearing without test equipment - and it gave a quantified test result. All of this work was done only in churches. Before installing the speaker or cluster system, I would ask 20 to 30 people to listen to a person speaking into a mic down below and to listen to some music. These people could hear a definite difference of sound quality, even with just a movement of the speaker of only 6 inches. These experiences have lead me to marking this position as the sweet-spot. In both examples, the speaker cluster can be moved forwards and backwards. First, the speaker location was tested with a test speaker on a pole about 10 feet high.

To see if the location carried up to the ceiling, a custom bracket was installed. Next, using the same technique as on the floor, the new speaker system for the church is moved back and forth to see if one location is better over another. When that location is found, it is then tested for coverage and gain before feedback. This has been tested in many church and churches of many different shapes and acoustical condition. Note - There has been a standing invitation for anyone interested to got to one of these two churches and test the sweet-spot concept themselves or to have a demonstration of the sweet-spot in their own church. There is also an invitation to go to any of the projects design by Joseph De Buglio or Blake Engel to experience the results of the sweet-spot theory and to do independent testing. This invitation is open to all including AES, NSCA, SAC and NAS. The Sweet-spot Theory has been demonstrated and tested at various Bible Colleges and audio experts representing various churches around the world. Many churches and individuals have tested this theory and most of them have used it to design their sound system or the room would not allow the sweet-spot to be implemented due to Architectural limitation. - Some of the Facts - The sweet-spot is only a theory. Just as diffusion is almost impossible to calculate, the sweet-spot seems to be the same.

In every room there are two sweet-spots, one at the front area and the other at the back of a church. The one that concerns us is the one at the front of a church. Regrettably, this does not apply to round or square rooms much. Nor can it be applied to churches with low ceilings. Again, while the sweet-spot exists, you can't always use it and here are just 3 of the exceptions. First of all, you can find the sweet-spot without test equipment or doing any calculation. With two people, a listener and a talker, you can find the sweet-spot in many existing church buildings. The best way to describe the effect is like this. The moment a person steps into the sweet-spot while talking, that person's voice with get just a little clearer. Under some acoustical conditions, it is very apparent. In other rooms, you have to really listen closely. Sometimes you will have to turn off the air or heating system, the lights and other noises in the sanctuary, and you should be able to hear it. Once you have found it, have the listener go to another location. The sweet-spot should be the same spot. If the church is not symmetrical on either side, then the sweet-spot may be off centre. If your church is over 1500 seating, then you may need test

equipment, as it was from our experiences in larger rooms.

With A TEF or MLSSA or JBL SMARTT system, you can find it too. Just place a microphone in the centre of the left or right side of the seating area. Next, using your test speaker on a stand of 8 to 10 feet high and moving it around. Do the RASTI or %Alcons test as you move the speaker from spot to spot. When you see the intelligibility of the test increase by half a percent or more, that is generally the sweet-spot. In some churches, this change was found to be up to 2% in intelligibility. To confirm the spot, you move the microphone to another location forward and do the test again moving the speaker around. You should find the sweet-spot in the same place. In short, the results show a position between 1/3rd to 1/4er from the front and centre of left to right. No one has been able to create a calculation for the sweet-spot. From what I have been told, there isn't one for setting up stereo speaker so I imagine that such a formula will be as elusive as the formula for diffusion is.

What is most interesting is that since human are better at locating sounds on a horizontal plain, the sweet-spot remains constant from the floor to the roof. Now, if there are near by physical structures near the sweet-spot on the roof, it can change the amount of improvement that is hoped to be gained as shown on the floor. However, it is still the better location, from which to start to build your speaker system from, even with a variety of ceiling types. If these obstacles are in the line of sight of the speaker system, common sense would force you to move the speaker system. You may have to raise or lower the speaker system to clear the obstacle. But there are other items you have to consider. If the pulpit is in the sweet-spot and can not be relocated, then your gain will most likely be lower and you will also have excessive feedback problems. If the minister stands were the sweet-spot is, the omni wireless microphone will most likely have less gain and feedback excessively.

It is a paradox many people in sound are often getting stumped with, but don't know how to explain or what to do about it. If the speaker system and pulpit is in the sweet-spot, it just limits the gain all the more. However, since, as stated earlier that the sweet-spot is also the place were you can also hear yourself the best, it would stand to reason that putting a microphone there will also decrease your gain before feedback. It is the place you don't want your microphone to be. While there are other factors that cause feedback, this is an element that testing has shown to support the effect of the sweet-spot in the audio chain. Knowing this can allow the sound system design to anticipate these problems. The sweet-spot is the best place to start the speaker system design but the worship place for minister with hand mics, wireless mics or pulpit mics. The feedback problems was rather consistent no matter where you put the test speaker. This is not a losing problem. It happens with Left Right systems too.

Many audio experts have laughed at the idea of a sweet-spot in the past. Today, when I have a chance to demonstrate to other experts, they become aware of it's existence and find that it really can make for a better system, even though their other systems were already working very well. Overall, the improvement can vary from church to church and in some churches, it can be dramatic. Until now, when a church asks the question, "where

does the speaker system go?" you had to go through a very long explanation. Then a church board member asks, "how come the other 3 contractors want to place speakers in 3 different places? Why should we believe you?" Again, you have a long song and dance ahead of you to prove that you have the better system. In a few cases where other contractors used simulation programs to prove they were the best, all I needed to do was take the church board into the sanctuary and having them hear the sweet-spot and that changed their opinions really fast. It proved that the person using the program didn't consider if one speaker position was better than another nor the impact it can have is system designing.

Finally, there are those who are experts in the field of audio who seem unsure of what to make of all this. For them, I can only say the following. If your systems work as good as a HIS System church sound standard or better, chances are, you have already been placing the speaker system in or around the sweet-spot. I am positive that if you test your own systems, you will find this to be true. The idea of stating that the sweet-spot is the best location for the speakers system helps the layman to better understand a part of sound system designing. We can not ignore the fact that the term sweet-spot is a non-scientific term, but it has been used in Home HI-FI and in recording studios for years and it is accepted by the industry.

Since the live sound reinforcement system is a HI-FI system in reverse, should it not be logic that a sweet-spot exists in a church/ live sound setting be just as important for the listener in the pews. The Sweet-spot should only be looked at as a tool to sound system designing. Some may see it as a short cut to hard work in system designing. It's not. It just cuts down on the guesswork. As stated earlier, the sweet-spot is not an absolute and sometimes I question it until it shows up on the next job. Here is a challenge for you. Try to find the sweet-spot in your church. Test it for yourself. Get someone to help you find it. Then post your results on the CSN discussion group. Your results, good or bad will be posted.

7. **Griswold** - Recording Underwater – Theory -  
[www.pugetsoundman.com](http://www.pugetsoundman.com)

As you may already know, sound originates with a vibration that travels through a medium. Normally, we hear sounds propagating through air and most microphones are set up to receive this airborne signal. Sound waves can travel through both solids and liquids as well. If you stick your head underwater, the water effectively couples with your eardrum to transfer the water-borne vibrations to your inner ear. There's plenty for your ears to hear underwater because sound waves travel five times further through water than they do through air. You may wish to read a tutorial on underwater acoustics. **Waterproofing an existing microphone** You can experiment with underwater recording by waterproofing a microphone you already own. One way to waterproof a mic is to seal it inside a deflated balloon. For greater "sensitivity", try a latex condom (use an un-lubricated one). Seal the open end around the mic cable, making sure to cover the XLR connector. One way to do this is by making rings around

the cable with electrical or duct tape (hint: WD-40 will remove any sticky tape residue). You could also construct a special use cable with a couple of rubber "O" rings around the mic cable. Tie the condom tightly to the mic cable in several spots, stretching the condom over the rings. This method will work well to a reasonable depth (I've only tried it to 25 feet, the length of the mic cable). I used a dynamic omnidirectional mic (the Beyer M58, to be exact, but any microphone will do). I have not tried this technique with electret or condenser microphones, only because I did not wish to risk an expensive mic in salt water. You could also waterproof a microphone by dipping it in 'Plasti Dip' a rubber epoxy used to rubberise handles on metal tools. The coating is flexible enough to transmit sound vibrations. The coating is water proof, but hard to remove. The main disadvantage of the waterproofing techniques is the inefficient acoustic coupling of the mic element to the water. Your recordings might seem a little muffled. You may want to use a hydrophone, which is a specially designed microphone that transduces sounds propagating underwater.

Constructing a hydrophone Typically, a hydrophone contains a piezo electric element, a preamp, and housing. Take the piezo element out of its case and solder the leads to a cable. Waterproof this contact mic with "Plasti Dip." Piezo elements can be found at Radio Shack, Mouser Electronics or All Electronics. Edmunds Scientific may also have hydrophone elements for sale. You could also attach (and waterproof) a commercial contact mic, such as the C-ducer, to a thin plate. For more complex construction plans, Loughborough University has published plans for a homemade hydrophone and an associated preamp.

#### 8. **Tor Halmrast** - SOUND COLORATION FROM (VERY) EARLY REFLECTIONS

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Abstract: Coloration is defined as changes in Timbre/"Klangfarbe". Adding a reflection automatically changes the frequency response of a signal, giving some kind of coloration. This might be looked upon as distortion. However, reflections have been a part of sound distribution since the Greek amphi-theatres, indicating that some coloration must be acceptable, even "wanted". The question is: "Which reflections give disturbing/unwanted coloration"? Most room-acoustic criteria assume that everything happening before/after a certain time is supposed to be good/bad (ex. 50ms/80 ms for speech/ music). We need to take a closer look at the distribution of reflections within these time intervals, to investigate coloration.

This paper will give results from measurements in concert halls (Oslo, Munich, Vienna), and opera houses, and compare them with psychoacoustic studies on coloration. It is shown that measurements should be done with the orchestra present on the stage/in the orchestra pit (TOR, Through Orchestra impulse Response). "Lonesome"/strong reflections with a time delay about 10 ms will give "box-klang-coloration". On the other side: Colorating reflections might be useful and fun, used in the right way, to support bass instruments etc.

## 9. Josephson Engineering - Tech Note 5 - Optimum Stereo Signal Recording with the Jecklin Disk

<http://www.josephson.com/tn5.html>

Photo of a Jecklin-type disk made by MB Electronics in the mid 1980s. The central plate is about 8 mm (a little less than 3/8") thick, covered on both sides with 8 mm thick foam. The foam is probably too thin; there is still too much high frequency energy reflected from the disk. The Jecklin-type disks supplied by Josephson Engineering since about 1995 use 25 mm foam. Jecklin is shown in his book with a disk of the same diameter but covered with lamb's fleece. The NHK (Japanese national broadcasting) version of the disk extends this covering to include the circumference of the disk as well.

The following text is reproduced from Jürg Jecklin's 1980's paper *Microfon Aufnahme Systeme*. Note that Mr. Jecklin's suggestions and dimensions have changed a bit over the years. As of 2009 he was teaching at the *Universität für Musik und Darstellende Kunst Wien* (the Vienna University of Music and Performing Arts) and has published an excellent that contains updated details on the "Jecklin Disk."

A: The OSS technique (OSS = optimum stereo signal)

The idea of a new microphone arrangement is the result of the dissatisfaction about the sound of usual music recordings, which has made itself felt during the course of approximately 4000 recording sessions. Almost any sound engineer knows how it feels when the recording does not sound like he imagines it should, despite the use of a lot of microphones. In such a case, *i.e.*, if the technical expenditure cannot be increased meaningfully, one should start again and look for a new recording concept. The present recording technique of electronic music has grown out of the basic arrangement of two microphones (stereophonics). Since the recordings with only two microphones normally are not satisfactory, additional supporting microphones — often a large number of them — are used. Therefore, the solution of the problems has to start with the two insufficient main microphones. On the one hand, the stereo main microphone arrangement must guarantee an optimum sound; and, on the other hand, it must provide the correct stereo signal for reproduction via two loudspeakers in the room. The procedure for the conception of the OSS technique was therefore as follows:

I. Selection of suitable microphones - Practical experience has shown that condenser sound pressure microphones (omnidirectional characteristic) are superior to all other microphones. Even the sound balance and the spatial sound distribution of very large and complex orchestras (symphony orchestras) are correctly reproduced. This kind of microphone is therefore used for the OSS arrangement.

II. Optimum stereo signal - In the usual stereo recording, mainly intensity differences between the two channel are used as directional information. This so-called intensity stereophonics, however, is a mere simulation method with phantom sound sources between the two reproduction loudspeakers, which do not actually "stand" in the

room as one would desire. When one listens directly, there are differences in delay time, frequency response and intensity between the two ears of the listener and their combination provides the directional information. These three parameters change with frequency and the angle of impact of the sound on the head. In the case of intensity stereophonics, only one of these three parameters is taken into consideration whereas an optimum stereo signal must include all three in the right combination. In the case of the OSS arrangement, all three parameters are used for the directional information and this in a combination which is ideal for the listener when reproduction comes from two loudspeakers in the usual arrangement.

B. Structure of the OSS arrangement (Jecklin disc) - Two sound pressure microphones are arranged at a distance of 165 mm. This distance results in the correct delay time difference between the two channels. The two microphones are separated by an acoustically muffled disc of 300 mm diameter. The effect of this disc is as follows: as the frequency increases, the two microphones are more and more separated. Below the value of approximately 200 Hz, the two microphones record the same. The acoustic muffling of the disc results in a frequency response difference of the two channels depending on the angle of impact of the sound. In addition, there is a sound diffraction around the disc rim which is dependent on frequency and angle.

I. Characteristics of the OSS arrangement - The stereo signal is produced by purely acoustic mixing: on the recording side by the arrangement, and on the reproducing side by the interplay of the two loudspeaker and the reproduction room. The two microphones react only to the sound pressure. The entire acoustic pattern is recorded in one single spot in the room. The result of these clear acoustic conditions is a natural sound and a real spatial acoustic pattern. The simultaneous reproduction of the spatial sound distribution by the two loudspeakers cannot be achieved by any other recording technique. This is audible especially in the case of organ recordings. In the case of orchestra recordings, each instrument can be heard in the place where it is actually played. If the orchestra is arranged correctly, no supporting microphones are required.

II. Working with OSS technique - The technical expenditure is small. Good recordings can be achieved even with simple technology. The two microphones together emit one stereo signal. They must therefore be adjusted to the same output level in the diffuse sound field. Level differences during recording must not be balanced out. In the case of one-sided recording, the OSS arrangement or the arrangement of the orchestra must be changed. Sound control at the mixing desk is not possible in the conventional sense. The sound control is moved into the studio or into the hall (changing of the orchestra arrangement). Supporting microphones may be used, *provided they are admixed with a time lag that corresponds to the delay time of the sound from the supported instrument to the main microphone*. For this recording technique, not only the intensity relationship but also the delay time relationship must be correct.

III. Recording in very reverberant or in acoustically problematic rooms. - In an OSS arrangement, directional microphones cannot be used. When recording in acoustically unfavourable rooms, it is better to accept the room as it is than to fight its acoustics. In practice, natural recording always sounds better than unnatural, so-called improved recording. In any room where it is still possible for musicians to make music, OSS recording is also normally possible.

IV. Range of application of the OSS technique - For the recording of orchestras that are harmonious and are arranged correctly (symphony orchestra, chorus, brass band, chamber music, individual instruments, etc.) The OSS technique is not suited for recordings where the recording technique is designed to co-determine the sound. The OSS technique is especially well suited for the recording of concerts aiming at a very natural sound. The OSS technique may be a step towards a more natural stereo recording. In comparison with conventional recordings, OSS recordings were preferred by all listeners during tests. The professional musicians are especially happy with the “new” sound. Recently, many recordings at radio stations have been made with this technique.

C. The Jecklin disc in practice - I. Microphones for recording with the Jecklin disc - For recording with the Jecklin disc, sound pressure microphones must always be used; *i.e.*, “real” sound pressure microphones. Microphones with a switchable directional characteristic, insofar as they are designed as double diaphragm microphones, may not be used.

II. Operating instructions - -1. General - The disc has two microphone mounts (21mm) and one stand connecting piece. By putting the stand connecting piece into the individual borings, the setting angle of the disc can be adjusted to any situation. The measuring cord located in the centre of the disc serves for the adjustment of the microphones on the disc. The measuring cord can be adjusted on both sides. 2. Mounting of the microphones onto the Jecklin disc

The microphones are pushed from the rear through the holding clamps of the Jecklin disc. Take care that the microphone capsules on both sides are located at a distance of approx 8 cm directly above the disc centre. This can be checked by means of the pulled-in measuring cord. In this case, the angles of the microphones are drawn slightly towards the outside. 3. Mounting of the connecting piece - The Jecklin disc with the microphones is at first held by hand in the position that is required for the recording. By loosening the fastening screws at the stand intermediate piece, the intermediate piece can be removed and set into any of the borings at the disc rim; *i.e.*, the disc is attached at the preselected angle. Thus the balance of the entire arrangement is guaranteed and the adjustment to any situation is made possible.

Note from David Josephson: It isn't mentioned by Jecklin, but “the position that is required by the recording” is determined by the desired tone colour balance. Most microphones are more sensitive toward the front than toward

the sides and rear for high frequency sounds. Rotating the disc maintains the capsules at the correct distance from the disc but allows their angle to the sound to be adjusted for more or less high frequency information.

III. Recording with the Jecklin disc - Since the two microphones together emit a uniform stereo signal, they have to be adjusted prior to the recording in the diffuse sound field to the same output level. This can be checked best by means of a headphone: the spatial impression must be uniform. The room must not “hang” on one side. During the microphone test or the recording, level differences between the two channels must *not* be balanced out. In the case of one-sidedness, the disc must be turned or rearranged accordingly. A sound control in the conventional sense, balancing at the mixing desk, is not possible; *i.e.*, the sound control is moved from the control room into the studio or concert hall. Placing of the Jecklin disc before the sound source is less critical than microphone placement in the case of other recording techniques. Depending on the distance of the disc from the sound source, the recording sounds nearer or more remote without being automatically too close or of too large an auditory perspective. When the disc is being used, the optimum distance from the sound source is larger than it is the case of any other recording technique. The disc must, however, be located within the diffuse-field distance of the room (the diffuse-field distance is the distance at which the direct sound from the source and the diffuse sound portion of the room are equal). The exact position and the correct distance from the sound source, however, must always be determined by ear. Here, one can usually proceed as follows: Too near: Locate the disc at a larger distance, or higher. - Too far: Locate the disc nearer or lower. Wrong spatial sound distribution: if the instruments in the rear of the orchestra are recorded too loud, locate the disc lower. If they are too soft, the disc must be located higher. - Level variations: if the level of one channel of a correctly adjusted disc (adjusted in the diffuse sound field) is higher than the other, the disc must be turned accordingly.

Distance of the disc from the sound source: as already mentioned, the disc must be located within the diffuse field. This distance can be calculated. In the following table, the diffuse-field distance depending on the room volume and the reverberation time for virtually all possible cases is indicated.

Room volume, | R e v e r b e r a t i o n t i m e, s e c o n d s

cubic meters | 1.0 1.5 1.75 2.0 2.25 2.5 3.0 3.5 4.0

500	1.27	1.04	0.96	0.9	0.85	0.8	0.74	0.68	0.64
1000	1.8	1.47	1.35	1.41	1.2	1.14	1.04	0.96	0.9
2000	2.55	2.08	1.93	1.8	1.7	1.61	1.47	1.36	1.27
5000	4.03	3.29	3.04	2.85	2.69	2.55	2.33	2.16	2.02
10000		4.65	4.3	4.03	3.8	3.6	3.3	3.05	2.85
15000		5.28	4.93	4.65	4.42	4.03	3.73	3.49	
20000			5.7	5.37	5.1	4.65	4.31	4.03	

The table shows diffuse field distance, in meters, from the centre of a sound source, as a function of room volume and reverberation time. The disc should be placed closer to the sound source than this distance.

#### IV. Checking the technical equipment

Successful recording depends on the perfect functioning of all of the technical equipment used. In practice, this can be achieved most easily by means of the following check list.

##### Initial Setup

1. Check the correct lateral position of the loudspeakers (headphone): monitor switch at the tape recorder to "tape" (check with a known recording).
2. Adjust the reproduction volume (with a known recording).
3. Check the correct lateral position and the functioning of the microphones (monitor switch to "input").
4. Check the tape run (visually). remove buckled tapes (the tapes are often deformed only at the beginning of the tape reel. Prewind accordingly).
5. Check the recording function (monitor switch to "tape", recording key pushed).

##### During the microphone test:

1. Adjust the channel controller levels for the correct balance and the correct control of a loud passage.
2. Recording test: compare "input" and "tape".

##### During the recording:

1. Do not touch the controllers (short sound overshooting is usually not that bad and is readjusted too late anyway).
2. Always monitor behind the tape (monitor switch to "tape"); do not change the reproduction volume.

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#### 10. **Kuphaldt** (2003) Lessons In Electric Circuits, Volume II – AC: Basic AC Theory.

<http://www.faqs.org/docs/electric/AC/index.html>

##### What is alternating current (AC)?

Most students of electricity begin their study with what is known as *direct current* (DC), which is electricity flowing in a constant direction, and/or possessing a voltage with constant polarity. DC is the kind of electricity made by a battery (with definite positive and negative terminals), or the kind of charge generated by rubbing certain types of materials against each other. As useful and as easy to understand as DC is, it is not the only "kind" of electricity in use. Certain sources of electricity (most notably, rotary electro-mechanical generators) naturally produce voltages alternating in polarity, reversing positive and negative over time. Either as a voltage switching

polarity or as a current switching direction back and forth, this "kind" of electricity is known as Alternating Current (AC): Whereas the familiar battery symbol is used as a generic symbol for any DC voltage source, the circuit with the wavy line inside is the generic symbol for any AC voltage source.

One might wonder why anyone would bother with such a thing as AC. It is true that in some cases AC holds no practical advantage over DC. In applications where electricity is used to dissipate energy in the form of heat, the polarity or direction of current is irrelevant, so long as there is enough voltage and current to the load to produce the desired heat (power dissipation). However, with AC it is possible to build electric generators, motors and power distribution systems that are far more efficient than DC, and so we find AC used predominately across the world in high power applications. To explain the details of why this is so, a bit of background knowledge about AC is necessary. If a machine is constructed to rotate a magnetic field around a set of stationary wire coils with the turning of a shaft, AC voltage will be produced across the wire coils as that shaft is rotated, in accordance with Faraday's Law of electromagnetic induction. This is the basic operating principle of an AC generator, also known as an *alternator*: Notice how the polarity of the voltage across the wire coils reverses as the opposite poles of the rotating magnet pass by. Connected to a load, this reversing voltage polarity will create a reversing current direction in the circuit.

The faster the alternator's shaft is turned, the faster the magnet will spin, resulting in an alternating voltage and current that switches directions more often in a given amount of time. While DC generators work on the same general principle of electromagnetic induction, their construction is not as simple as their AC counterparts. With a DC generator, the coil of wire is mounted in the shaft where the magnet is on the AC alternator, and electrical connections are made to this spinning coil via stationary carbon "brushes" contacting copper strips on the rotating shaft. All this is necessary to switch the coil's changing output polarity to the external circuit so the external circuit sees a constant polarity: The generator shown above will produce two pulses of voltage per revolution of the shaft, both pulses in the same direction (polarity). In order for a DC generator to produce *constant* voltage, rather than brief pulses of voltage once every 1/2 revolution, there are multiple sets of coils making intermittent contact with the brushes.

The diagram shown above is a bit more simplified than what you would see in real life.

The problems involved with making and breaking electrical contact with a moving coil should be obvious (sparking and heat), especially if the shaft of the generator is revolving at high speed. If the atmosphere surrounding the machine contains flammable or explosive vapours, the practical problems of spark-producing brush contacts are even greater. An AC generator (alternator) does not require brushes and commutators to work, and so is immune to these problems experienced by DC generators. The benefits of AC over DC with regard to generator design is also reflected in electric motors. While DC motors require the use of brushes to make electrical contact with moving coils of wire, AC motors do not. In fact, AC and DC motor designs are very similar

to their generator counterparts (identical for the sake of this tutorial), the AC motor being dependent upon the reversing magnetic field produced by alternating current through its stationary coils of wire to rotate the rotating magnet around on its shaft, and the DC motor being dependent on the brush contacts making and breaking connections to reverse current through the rotating coil every 1/2 rotation (180 degrees). So we know that AC generators and AC motors tend to be simpler than DC generators and DC motors.

This relative simplicity translates into greater reliability and lower cost of manufacture. But what else is AC good for? Surely there must be more to it than design details of generators and motors! Indeed there is. There is an effect of electromagnetism known as *mutual induction*, whereby two or more coils of wire placed so that the changing magnetic field created by one induces a voltage in the other. If we have two mutually inductive coils and we energize one coil with AC, we will create an AC voltage in the other coil. When used as such, this device is known as a *transformer*: The fundamental significance of a transformer is its ability to step voltage up or down from the powered coil to the unpowered coil. The AC voltage induced in the unpowered ("secondary") coil is equal to the AC voltage across the powered ("primary") coil multiplied by the ratio of secondary coil turns to primary coil turns. If the secondary coil is powering a load, the current through the secondary coil is just the opposite: primary coil current multiplied by the ratio of primary to secondary turns. This relationship has a very close mechanical analogy, using torque and speed to represent voltage and current, respectively: If the winding ratio is reversed so that the primary coil has less turns than the secondary coil, the transformer "steps up" the voltage from the source level to a higher level at the load: The transformer's ability to step AC voltage up or down with ease gives AC an advantage unmatched by DC in the realm of power distribution.

When transmitting electrical power over long distances, it is far more efficient to do so with stepped-up voltages and stepped-down currents (smaller-diameter wire with less resistive power losses), then step the voltage back down and the current back up for industry, business, or consumer use. Transformer technology has made long-range electric power distribution practical. Without the ability to efficiently step voltage up and down, it would be cost-prohibitive to construct power systems for anything but close-range (within a few miles at most) use. As useful as transformers are, they only work with AC, not DC. Because the phenomenon of mutual inductance relies on *changing* magnetic fields, and direct current (DC) can only produce steady magnetic fields, transformers simply will not work with direct current. Of course, direct current may be interrupted (pulsed) through the primary winding of a transformer to create a changing magnetic field (as is done in automotive ignition systems to produce high-voltage spark plug power from a low-voltage DC battery), but pulsed DC is not that different from AC. Perhaps more than any other reason, this is why AC finds such widespread application in power systems. REVIEW: DC stands for "Direct Current," meaning voltage or current that maintains constant polarity or direction, respectively, over time. AC stands for "Alternating Current," meaning voltage or current that changes polarity or direction, respectively, over time.

AC electromechanical generators, known as *alternators*, are of simpler construction than DC electromechanical

generators. AC and DC motor design follows respective generator design principles very closely.

A *transformer* is a pair of mutually-inductive coils used to convey AC power from one coil to the other. Often, the number of turns in each coil is set to create a voltage increase or decrease from the powered (primary) coil to the unpowered (secondary) coil.

Secondary voltage = Primary voltage (secondary turns / primary turns)

Secondary current = Primary current (primary turns / secondary turns)

11. **Lewallen.** (2004). RMS Power. Article. EZNEC. P.O. Box 6658, Beaverton OR 97007, U.S.A. Pdf: 4.  
w7el@eznec.com.

“RMS Power”

Discussion in the rec.radio.amateur.homebrew newsgroup showed a widespread misunderstanding of the meaning and importance of RMS and average values of voltage, current, and power. So I've put together this explanation which uses as little math as possible, and hopefully explains the concepts in an intuitive way. The Meaning of Average - Before I can proceed, it's important to explain just what average means. Fortunately, its meaning when dealing with waveforms is essentially the same as its common meaning. If we were to sample a waveform (that is, a graph of voltage, current, power, etc. versus time) at equally spaced times, then add up their values and divide by the number of samples, we'd have approximately the average value of that voltage, current, power, or whatever the waveform represents. The smaller the time intervals between samples, the more accurate the average will be. The mathematical operation of integration is a way to find what the value would be if we could shrink the time interval extremely close to zero, and it's needed if we want to calculate the exact average value of some waveforms. But I'm going to use square waves for this explanation, and we can easily see their average values without any math at all.

A periodic waveform is one that repeats in an identical fashion, over and over. The period of the waveform, or one cycle, is the time interval that repeats. If we find the average of one complete cycle of the waveform, then the average of the next cycle will be exactly the same as the first. If we combine the samples from two cycles, add them together and divide by the total number of samples, we find that not only is the average value of one cycle the same as the average of the second, but also that the average value of two cycles is the same as the average of one cycle. In fact, the average value of any whole number of cycles is the same as the average value of just one cycle. So we can easily find the average value of a very long-duration periodic waveform simply by calculating the average value of one complete cycle. Equivalent Power - The next important concept is that of equivalent, or heating power. Let's suppose we put 5 watts into a resistor for 10 seconds. The total amount of energy applied to the resistor is 5 watts X 10 seconds = 50 watt-seconds = 50 joules. This of course raises its temperature by some amount. The actual amount of temperature rise, in degrees, depends on how massive the resistor is, how fast the energy is applied, and how fast the heat can be moved away by conduction, convection, and radiation. So we

won't try to calculate the exact temperature rise. But the important thing here is that *the total amount of heat (energy) the resistor dissipates is the amount of energy that's applied to it.* Put another way, imagine the resistor being immersed in a thermally insulated tub of water.

The Meaning of RMS - RMS is a mathematical function, like average, that reduces a complex function to a single value. And, like average, it has a precise definition. The definition is revealed by the name – it's the squareRoot of the Mean of the Square of the function. Mean is the same as average, so we calculate the RMS value of a function or waveform by first squaring it, then taking the average of the squared function or waveform, then taking the square root of the average. But it has to be done in the proper order! Let's calculate the RMS value of the voltage waveform from the example.

## 12. **Macaulay Library** - Cornell Lab of Ornithology - Audio Equipment - Parabolic Reflector

<http://www.birds.cornell.edu/private/MacaulayLibrary/contribute/equipParabola.html>

The parabolic reflector system is the combination of a reflector dish, typically between 13" and 36" in diameter, and a microphone. The microphone is positioned in the focal point region of the reflector (the area where all the collected sound is concentrated). Parabolic reflectors, by design, yield a tremendous increase in sensitivity without any added electronic noise. Microphones suitable for use in parabolic reflectors range in price from \$300-\$1,200, with the more expensive units yielding flatter frequency response, improved signal-to-noise ratios, and higher signal level overload capabilities.

Listed here are some of the different reflectors manufactured.

1. The Telinga Pro parabolic reflector is a clear, lightweight 22" reflector available in several models that include integral high-quality microphones, or as with the Telinga Universal model, are designed to accept other manufacturers' microphones. All of these models offer excellent rejection to handling noises and can be completely disassembled for easy transport.

2. The Mineroff Electronics SME-PR-1000 (\$375 without microphone) is an 18" epoxy coated aluminium reflector that includes a pistol grip and adjustable microphone mount. It also offers a transparent viewing window at the centre of the dish to assist in aiming. This reflector, coupled with an inexpensive microphone, is a perfect starter system for low-budget applications. For the do-it-yourself, one can purchase high quality 24"-36" spun aluminium reflectors that are designed and sold as satellite receiving antennas. These units are perfectly acceptable; however, they are not supplied with a microphone or microphone mounting hardware. One can easily create a mounting system with aluminium bar stock that is readily available from most hardware stores.

13. **Margoschis** Parabolic reflectors and stereo sound. Published in "Wildlife Sound" - journal of the Wildlife

Sound Recording Society, vol 8, no 3. - Margoschis, In Wahlström. (1985) The Parabolic Reflector as an Acoustical Amplifier. Journal of Audio Engineering Society. Vol 33, number 6.

The PRO III model. To this he has connected our Stereo DATmic. Let me first give a simple information: The PRO III model is now replaced by the PRO 5. The microphone connection is improved and - to allow long cables - the output impedance is lowered to 200 Ohms. People often think that Telinga is a stereo parabola. But this is only because the Stereo DATmic is the most popular microphone. We have mono microphones, omni-directional and directional, and they all fit the PRO series. We also make the Telinga "Universal" - a handle, dish and a "zeppelin" for all stick microphones 15 - 25 mm, - like the Sennheiser.

The concept: A Telinga parabolic microphone should preferably weigh less than 2 lbs. complete - ready to use, including the dish. This means that the battery and two metal XLR plugs on the output cable is 25% of the total weight! Everything necessary shall be integrated into one unit. The Telinga mono designs are quite conventional. Not much to say. To the Stereo DATmic we could use microphone capsules which sound "softer" and more "correct", but they all make too much noise. There are not even expensive ones to use in a stereo design. We have made some interesting experiments with M/S configurations, but weight, hand- and wind noise, not to speak about price - make such a design unrealistic. But now over to the question: Parabolas and stereo sound? I see two questions here: 1/ Is stereo obtainable at all with a parabola, and - if so - 2/ does the Telinga performs such a result?

The first question is easy to answer: In a theoretical paper published by Journal of Audio Engineering Society, - "The Parabolic Reflector as an Acoustical Amplifier" Vol. 33, No 6, 1985 - the author Sten Wahlström concludes: "It is even possible to adopt a reflector for stereophonic recordings by a simple method. The shield separates the front into two sides and will thus create a stereo background when the sound is picked up by the two separate microphones. The sound source in the centre of the sound picture will be equally amplified by the reflector to the microphones....." But - to the second question: Does the Telinga perform such stereo, as described by Wahlström? Yes - the design connects directly to the principal he describes. The plate separates the two sides from each other, while the focused sound will affect the two microphones equally. The focused bird will be recorded mono, while the background will be recorded stereo. The stereo separation depends on the size and characteristics of the separating shield and the distance between the shield and the microphones. For practical reasons, and wind noise reasons, we want to keep the shield as small as possible. Because the microphone elements are very close to the shield - only 1 mm - the shield is still big enough to create a stereophonic "space" of the background sound picture, which disappears completely if the channels are shorted, or if one uses one channel only. A change of paradigm? Traditionally, there has been a tendency to judge a recording as "good" if it is "clean". A recording of a Robin in London traffic, has not been looked upon as "a recording of a Robin in London traffic" - but as a poor recording of a Robin, destroyed by traffic noise.

When telephoto lenses became available for the common man, "everybody" should make pictures of birds, as if they were taken in a studio. If he did not, it only proved that he "couldn't afford buying a telephoto lens".

Today, I claim, we tend to look for other qualities, both in photography and sound recording. A system: I do not claim that stereo sound is "better" than mono or that using a cardioid is better than using an omni directional. I don't claim that a microphone should be facing inwards or outwards. Telinga has a system - mono, stereo, omni-directional or whatever. Of course I advice people, but I can only do so if they give me a fair picture of what it is they want to achieve. I have no "standard recipe" for wildlife recordings. Different aims: A researcher records the information he needs for his analysis equipment. A wildlife film-maker make recordings fit to the pictures. A commercial bird-song CD producer wants to make recordings which people buy. Some ornithologists want to document what they hear, and couldn't care less about "sound quality".

Today, I claim, the tendency among wildlife recordists in general, is to make "quality" recordings of "a piece of wildlife," - not only of a bird or a special animal. It seems as if we have produced enough of "clean" recordings, and that the challenge nowadays is somewhere else. A "good" recording today is a stereo recording not only of the tiger, but also of the all around present echoes of his roar in the jungle and the sounds of his paws in the grass, or his teeth tearing up his prey. If you download a recording of a tiger on Internet, it will not arouse your scientific curiosity of what a tiger sounds like. Instead it will trigger your fantasy and imagination and make you shiver with thrill. The world is asking for emotions. I once said, that "mono sound triggers your sonograms, while stereo sound triggers your fantasy." It is not all together wrong. I have often observed that people smile when they hear a nice stereo recording of a bird in headphones. I can't explain this smile, but I always smile too.

A problem with mono recordings: When you make your excursion, a warm and sunny morning, just feeling fine after a good breakfast, listening to this beautiful blackcap singing in his tree, - you don't bother much about the distant traffic noise or the noise from the wind in the leaves. You might not even notice it. The reason for this easiness in your attitude, is that the blackcap is singing in one direction, with it's own stereo picture - while the noise is coming from "all over", with it's own - and very different! - stereo picture. Since even long before we were hunters and gatherers, we have developed this skill - to separate an important signal from unimportant noise. This is a totally unconscious process, just as our heart beats. But to do so, we need our stereophonic hearing. Everyone busy with sound recording, has noticed that a stereo recording from a noisy pub, still makes it possible for a listener to hear what people say, while the same recording in mono, easily becomes a mess of unreadable voices! This is not a question of technical quality. It is a question of what happens when technical quality meets the human perception. We cannot concentrate on a particular voice, unless we have at least some kind of direction and/or stereo picture to guide us. When we replay a blackcap mono recording in our living room, no such information is present. On the mono recording, the blackcap 'sings' also the traffic noise and the noise from the wind in the leaves. Or-vice versa—the traffic noise and the wind noise is 'singing' the blackcap song! It's the

same! This is a matter of fact, not a matter of opinion. If somebody wants to claim that there also are other qualities than stereo which can guide us to split signal from noise, he is right. But these qualities are also present in a stereo recording. After this extremely depressing description of the fatal errors with mono – how come it works? Or doesn't it? To be provocative, I claim it doesn't! Most people listening to mono recordings which include a background ambience think they are ugly! "It is a pity with all the noise!?" they say. Cross your heart: Isn't that why we always want to exclude the background? Because in mono, almost any background sounds ugly? I admit there are exceptions. But how many? By far, - I claim - the most common "solution" to the mono-problem, is that the recordist doesn't record! Most of the times when wind or traffic noise is present, the traditional mono recordist leaves his equipment at home. "It won't be good anyway....." Mono recordings need ideal circumstances, and - as everybody know - such circumstances are rare nowadays.

Stereo: Making stereo recordings means a truly significant simplification of this problem. Notice carefully, that I do not say that a stereo recording has less errors! But I say that it does NOT have the typical mono-problem that a signal and a background will become "the same". Even if a stereo effect is poor, even really poor, even really distorted! - there will be a difference between the background and the soloist, and this difference will help the human perception to use it's selective skills. What is next? - The typical "Telinga-sound" as it comes from a DAT recorder often sound a bit "hard". This is a consequence of our efforts to keep the inherent noise down as much as ever possible. It is not difficult to equalize a bit and "soften up" the sound, but then you get more inherent noise instead. Telinga is now developing a variable filter to use in post production of a DAT recording. It softens up the sound a bit by equalizing, and also by limiting the dynamics a little.

14. **Morelle** - Venomous mammal caught on camera. Rare footage of one of the world's most strange and elusive mammals has been captured by scientists. Story by Rebecca Morelle Science reporter, BBC News.  
<http://news.bbc.co.uk/go/pr/fr/-/2/hi/science/nature/7791989.stm> Published: 2009/01/09 06:22:48 GMT - © BBC 2011

Large, and with a long, thin snout, the Hispaniolan solenodon resembles an overgrown shrew; it can inject passing prey with a venom-loaded bite. Little is known about the creature, which is found in the Caribbean, but it is under threat from deforestation, hunting and introduced species. Researchers say conservation efforts are now needed. The mammal was filmed in the summer of 2008 during a month-long expedition to the Dominican Republic - one of only two countries where this nocturnal, insect-eating animal (*Solenodon paradoxus*) can be found (the other is Haiti). - "It is an amazing creature - it is one of the most evolutionary distinct mammals in the world" -Dr Sam Turvey, ZSL The researchers from the Durrell Wildlife Conservation Trust and the Ornithological Society of Hispaniola were able to take measurements and DNA from the creature before it was released. Dr Richard Young, from Durrell Wildlife Conservation Trust, said: "My colleagues were excited and thrilled when they found it in the trap. "But despite a month's worth of trapping effort, they only ever caught a single individual."

Specialised teeth - The Hispaniolan solenodon is one of the creatures highlighted by the Zoological Society of London's (ZSL) Edge of Existence programme, which focuses its efforts on conservation plans for animals that are both endangered and evolutionarily distinctive. Dr Sam Turvey, a ZSL researcher involved with the programme, told BBC News: "It is an amazing creature - it is one of the most evolutionary distinct mammals in the world. "Along with the other species of solenodon, which is found in Cuba (*Solenodon cubanus*), it is the only living mammal that can actually inject venom into their prey through specialised teeth.

"The fossil record shows that some other now-extinct mammal groups also had so-called dental venom delivery systems. So this might have been a more general ancient mammalian characteristic that has been lost in most modern mammals, and is only retained in a couple of very ancient lineages." Dr Turvey and other scientists working for the Edge programme recently discovered a population of solenodons living in a remote corner of Haiti. The researcher said that the team was surprised to find them; previously it had been feared that the creatures had become extinct in this country because of extensive deforestation, recently introduced mongoose and dogs, and hunting by humans for food. - He said: "They are still incredibly vulnerable and fragile. So it is really important to get back out there to work how how these animals are surviving."

Conservation efforts are now needed in both Haiti and the Dominican Republic, the teams believe, but the first step would be to find out more about the animal. Dr Young said: "We know little about its ecology, its behaviour, its population status, its genetics - and without that knowledge base it is really difficult to design effective conservation." The research will be undertaken by ZSL's Edge programme, Durrell, the Ornithological Society of Hispaniola, the Audubon Society of Haiti, and the Dominican Republic's National Zoological Park and Agency for Protected Areas and Biodiversity.

15. **Moulton.** (1994). - About Comb Filtering, Phase Shift and Polarity Reversal. The Art of Science and Sound. [http://www.moultonlabs.com/main/cat/recording\\_magazine](http://www.moultonlabs.com/main/cat/recording_magazine).

1. Generating a comb filter response - 2. "Polarity" and "Phase"

The phenomena of comb filtering, phase shift and polarity reversal are surrounded in myth and are a bedrock topic for audio engineers. The View from 2005: *Nothing's changed! We're still as confused as ever!*

About Comb Filtering, Phase Shift and Polarity Reversal

There's a lot of loose language around the recording industry and some of the least understood and most abused of such jargon has to do with "being out of phase" and "comb filtering." Now, these terms represent some really important concepts that are central to recording craft, but the mythology surrounding them is so loaded with misconceptions and misstatements that a careful and thorough understanding of what they actually are and mean is vital to your recording success. So button down your brain cells, campers! We're goin' thinkin'! We'll start by

considering an audio signal and a single delayed reiteration of it. Electronic equivalent of the flow of a signal and its delayed iteration, recombined into a single signal. In the case we will be looking at, the delay line has a delay of 1 millisecond, the levels of both the original and delayed signals going into the mixer are equal, and the signal is a 1 KHz. sine wave.

The simplest case in audio is a sine wave. Let's pick one with a frequency smack in the middle of the audio spectrum, say, 1 KHz. And let's set the delay line to a 1 millisecond delay time. In this case there are a thousand cycles of the wave each second, and we are delaying the sound in time by exactly one-thousandth of a second, so that the sound and its delayed iteration have the following relationship: A sine wave of 1 KHz. frequency (1 ms. period) and its delayed iteration, at 1 ms. delay. The resulting mixed signal will be a 1 KHz. sine wave 6 dB louder. When you sum or mix these two signals, the result is a 1 KHz. sine wave that is 6 decibels louder than the original sound by itself. Because the phase shift is exactly  $360^\circ$ , which is functionally equivalent to a  $0^\circ$  phase shift, the original signal and the delayed signal overlay exactly and their amplitudes added together result in a doubling of overall amplitude at each point in the waveform (which results in an overall increase in amplitude of 6 dB). Because it results in a signal that is louder than the original, this is called constructive interference. By the same token, if we use the 1 millisecond delay with a signal of 2 KHz. we get the same constructive interference, because now the phase shift is  $720^\circ$ , which is also equivalent to  $0^\circ$ : However, when we delay a sine wave signal of 500 Hertz by 1 millisecond, the phase shift is only  $180^\circ$ , so we get the infamous “ $180^\circ$  phase-shift cancellation.”

A sine wave of 1500 Hz. frequency (.67 ms. period) and its delayed iteration, at 1 ms. delay. The resulting mixed signal will be (in theory) a signal with no amplitude, or a complete cancellation of signal. Several things should be apparent. First, the amount of phase shift varies for a given delay time as a function of frequency, so that lower frequencies have less phase shift, higher frequencies have more phase shift, and each frequency has a unique amount of phase shift. One quirky part of this is that for any repeating wave shape,  $360^\circ$  of phase shift is the functionally the same as  $0^\circ$  of phase shift, so we usually don't worry about the multiples of  $360^\circ$ , just the number of degrees between 0 and 360. The phase shift for any frequency with a delay of 1 millisecond. The diagonal line represents the increasing phase shift as a function of frequency. Note that we can think of  $540^\circ$  as being effectively the same as  $180^\circ$ . Second, all *whole number multiples* of the frequency whose period is the same as the delay time (1 KHz. in this case, so we are talking about 2 KHz., 3 KHz., 4 KHz., etc.) will have delayed iterations that will be “in phase” with the original.

Third, the frequency whose period is twice as long as the delay time (500 Hz. in this case) will have a delayed iteration that will be “out of phase” with the original. All frequencies that are above that frequency by the amount of the original frequency (as noted above) will also be “out of phase” with their original signals. Boiled down, this means that the broad-band frequency response of the mixed result of a signal and its delayed

version will be extremely lumpy, with 6 dB boosts interspersed with total cancellations (also called “nulls”) at frequencies across the spectrum that are related to the period of the delay time.

Frequency response curve resulting from the mix of a signal at 0 dB and a 1 ms. delayed iteration of that signal at 0 dB. Peaks will be at +6 dB and nulls will be <-100 dB. The graph is drawn with a linear horizontal axis for frequency, as opposed to the more conventional logarithmic or octave-based scale. This frequency response curve is the famous “comb-filter” response. Obviously, it is dramatically different from the response of the original signal, which is represented by the dotted line at 0 dB. It is **very** audible(!) and, interestingly, has a pretty obvious pitch, which in this case is the pitch of a 1 KHz tone. This pitch will impose itself on whatever material is playing through our little single-delay circuit. When we do effects like phasing and flanging (see my article on Early Delays for more information of this), the whooshing sound is due to the frequency of the comb filter being varied, which in turn is done by varying the delay time.

#### 16. **Omega Engineering** Technical reference – Stepper Motors.

[http://www.omega.com/prodinfo/stepper\\_motors.html](http://www.omega.com/prodinfo/stepper_motors.html)

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Every revolution of the stepper motor is divided into a discrete number of steps, in many cases 200 steps, and the motor must be sent a separate pulse for each step. The stepper motor can only take one step at a time and each step is the same size. Since each pulse causes the motor to rotate a precise angle, typically 1.8°, the motor's position can be controlled without any feedback mechanism. As the digital pulses increase in frequency, the step movement changes into continuous rotation, with the speed of rotation directly proportional to the frequency of the pulses. Step motors are used every day in both industrial and commercial applications because of their low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment. Stepper Motor Advantages

1. The rotation angle of the motor is proportional to the input pulse.
2. The motor has full torque at standstill (if the windings are energized)
3. Precise positioning and repeatability of movement since good stepper motors have an accuracy of 3 to 5% of a step and this error is non-cumulative from one step to the next.
4. Excellent response to starting/stopping/reversing.
5. Very reliable since there are no contact brushes in the motor. Therefore the life of the step motor is simply dependant on the life of the bearing.
6. The stepper motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.
7. It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

8. A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

Types of Step Motors - There are three basic types of step motors: variable reluctance, permanent magnet, and hybrid. This discussion will concentrate on the hybrid motor, since these step motors combine the best characteristics of the variable reluctance and permanent magnet motors. They are constructed with multi-toothed stator poles and a permanent magnet rotor (See figure A). Standard hybrid motors (such as the models offered by Omegamation™) have 200 rotor teeth and rotate at 1.8° step angles. Because they exhibit high static and dynamic torque and run at very high step rates, hybrid step motors are used in a wide variety of commercial applications including computer disk drives, printers/plotters, and CD players. Some industrial and scientific applications of stepper motors include robotics, machine tools, pick and place machines, automated wire cutting and wire bonding machines, and even precise fluid control devices.

Step Modes - Stepper motor "step modes" include Full, Half and Microstep. The type of step mode output of any stepper motor is dependent on the design of the driver. Omegamation™ offers stepper motor drives with switch selectable full and half step modes, as well as microstepping drives with either switch-selectable or software-selectable resolutions.

FULL STEP - Standard hybrid stepping motors have 200 rotor teeth, or 200 full steps per revolution of the motor shaft. Dividing the 200 steps into the 360° of rotation equals a 1.8° full step angle. Normally, full step mode is achieved by energizing both windings while reversing the current alternately. Essentially one digital pulse from the driver is equivalent to one step.

HALF STEP - Half step simply means that the step motor is rotating at 400 steps per revolution. In this mode, one winding is energized and then two windings are energized alternately, causing the rotor to rotate at half the distance, or 0.9°. Although it provides approximately 30% less torque, half-step mode produces a smoother motion than full-step mode.

MICROSTEP - Microstepping is a relatively new stepper motor technology that controls the current in the motor winding to a degree that further subdivides the number of positions between poles. Omegamation microstepping drives are capable of dividing a full step (1.8°) into 256 microsteps, resulting in 51,200 steps per revolution (.007°/step). Microstepping is typically used in applications that require accurate positioning and smoother motion over a wide range of speeds. Like the half-step mode, microstepping provides approximately 30% less torque than full-step mode.

17. **Pook** - UK News - Steve Irwin a showman, claims BBC producer Steve Irwin: 'Larger than life'

By Sally Pook 12:01AM GMT 02 Nov 2006 --claims-BBC-producer.html – Telegraph - UK News  
<http://www.telegraph.co.uk/news/uknews/1533024/Steve-Irwin-a-showman>

The executive producer of the BBC Planet Earth series has branded Steve Irwin, the Australian television star known as the Crocodile Hunter, a "showman" more interested in his own stardom than the animal kingdom. Alastair Fothergill launched an extraordinary attack on the naturalist who was killed by a stingray while making a programme in September. "What Steve Irwin did for a living was as different from what we do as it is possible to get," he told the Radio Times. "Let's face it, Steve was a showman. Yes, he introduced a lot of people to natural history, but his basic stock in trade was, 'Aren't I brave, and aren't animals dangerous?' The fact is, I am not interested in human stars. I am only interested in animal stars." Australia was plunged into a state of shock when Irwin was killed by a stingray barb to the heart while being filmed snorkelling off Queensland.

He was swimming about 3ft above a large bull ray, probably weighing around 220lb, when it lashed out, piercing his chest with the venomous barb on its tail. Mr Fothergill said: "The first thing we tell our crews is that if they are in danger, then they are not doing their job. "The first rule of natural history film-making is that you are there to film the animals' natural behaviour, and attacking humans isn't natural behaviour. "If they are doing that, it means you have intruded on their world and made them feel threatened."

18. **Robjohns (1)** Published in SOS March 1997 - Email: Contact SOS Telephone: +44 (0)1954 789888 Fax: +44 (0)1954 789895 - Registered Office: Media House, Trafalgar Way, Bar Hill, Cambridge, CB23 8SQ, United Kingdom. Sound On Sound Ltd is registered in England and Wales. Company number: 3015516 VAT number: GB 638 5307 26  
[http://www.soundonsound.com/sos/1997\\_articles/mar97/stereomictechs2.html](http://www.soundonsound.com/sos/1997_articles/mar97/stereomictechs2.html)

Stereo Microphone Techniques Explained, Part 2

PART 2: HUGH ROBJOHNs continues his history of stereo recording techniques with a look at the development of spaced microphone arrays. Last month we investigated the various coincident techniques for stereo recording developed by Alan Blumlein in the early 1930s; this time we'll be covering some alternative techniques using spaced microphone arrays.

WALL OF SOUND - Some of the earliest stereophonic experiments were made in America under the direction of Dr Harvey Fletcher at Bell Laboratories, as mentioned in the first part of this feature. One of the techniques investigated was the 'Wall of Sound', which used an enormous array of microphones hung in a line across the front of an orchestra. Up to 80 microphones were used, and each fed a corresponding loudspeaker, placed in an identical position, in a separate listening room. The operating principle was that the array of microphones

'sampled' the wave-fronts of sound emanating from the orchestra, and these exact wave-fronts were recreated by the loudspeakers in the listening room. The results were extremely good, with remarkably precise imaging and very realistic perspectives. However, the technology of the '30s was such that recording or transmitting 80 discrete signals was simply not practical. Consequently, the initial microphone array was systematically simplified to find the minimum number of microphones that produced acceptable results. The general consensus was that three microphones and three loudspeakers represented the best compromise between high-quality imaging and practicality. Today, the three-spaced-microphone technique is still in widespread use (one form being the Decca Tree) and the three-loudspeaker arrangement is the standard method of frontal sound reproduction in every cinema!

MONO COMPATIBILITY - So, what is the disadvantage of spaced microphone techniques compared with the coincident systems? Well, the main problem has to be mono compatibility. Any array that has multiple microphones spaced apart from each other will capture the sound from a given source at different times. If the outputs from all of the microphones are mixed together (to produce a single mono signal), the sound will become coloured because of a process known as 'comb filtering' -- the beginnings of phasing or flanging. In a severe case, the comb filtering may alter the sound to such an extent that an orchestra will sound as if it's at the other end of a long cardboard tube. The greater the number of combined microphones, the worse the effect is likely to be. However, if you can guarantee that recordings produced with a spaced microphone array will not be combined to make a mono signal, the comb-filtering problem becomes totally irrelevant -- the argument adopted by many of the organisations that record classical music. Since virtually all of the classical music catalogue is on CD or cassette these days, mono replay is no longer an important consideration -- when was the last time you saw a mono CD or cassette player? Whether you're listening on a serious hi-fi, in the car, on a mini-system, or through a 'Brixton briefcase', it will almost always be in stereo. Even broadcast music is in stereo on Classic FM or Radio 3 for the vast majority of listeners.

LOVELY OMNIS - So classical music, in particular, is often recorded with spaced microphone arrays because mono compatibility is not an issue -- but why would anyone want to use spaced arrays? What is wrong with coincident systems which offer mono compatibility as standard? As we saw last month, all coincident systems have to use directional microphones in order to create the necessary level differences between the two channels of the stereo system. Directional microphones rely on the pressure-gradient principle, which has an inherent problem with low frequencies. The mechanical design of the microphone diaphragm assembly has to compensate for the inadequacies of the pressure gradient by making the diaphragm resonate at very low frequencies. Although this can achieve an acceptable frequency response, it generally compromises the sound quality, restricting the smoothness and extension of the very lowest frequencies. "The principle of binaural recording is to replicate the way our ears capture sounds, and replay those sounds directly into the corresponding ears." On the other hand, omnidirectional microphones do not suffer from any of these compromises. They have very

smooth and extended low-frequency regions, with very even off-axis responses, both of which are very desirable characteristics. The only problem, of course, is that omnidirectional microphones do not work terribly well as coincident pairs because they do not produce level differences proportional to the angle of incident sound. Omnidirectional microphones can only be used to record in stereo if you space them apart and deliberately record timing differences.

SPACED STEREO - I mentioned last month that reproducing the kind of timing differences captured by a spaced microphone array over a pair of loudspeakers would confuse our hearing system and therefore not produce good stereo images. This was only a half-truth, I'm afraid! It is true that replaying a stereo recording with timing differences between the two channels leads to a confusing set of time-of-arrival differences for our ears, but the sound is normally still perceived as having width and a certain amount of imaging information, and it usually sounds a lot more spacious than a coincident recording. The problem (as far as Alan Blumlein was concerned, anyway) is that, apart from the mono compatibility issues, the imaging is not very precise and often seems to huddle around the loudspeakers rather than spreading uniformly between them. In really bad cases, the recording may even appear to have a hole in the middle! If I were to compare the two main types of stereo recording as if they were paintings (a ludicrous thing to do, but I'm going to anyway!), then good coincident recordings are like etchings or line drawings -- very precise imaging, lots of detail, leaving nothing to the imagination. On the other hand, spaced microphone recordings are more like water colours -- the detail is blurred, and the essence is more about impression than reality. Many people specifically prefer the stereo presentation of spaced-pair recordings, finding them easier to listen to than coincident recordings. There's nothing wrong in that -- as far as the recording engineer is concerned, this is just another technique with a collection of advantages and disadvantages over the alternative formats. It's up to you which technique you use, and as long as you are aware of the characteristics of each system, you are in a position to choose wisely and should be able to achieve the sound quality you seek very quickly.

PRACTICAL SPACED TECHNIQUES - The simplest spaced-microphone technique is to place an identical pair of omnidirectional mics a distance apart in front of the sound source; most engineers would generally choose a spacing of between a half and a third of the width of the actual sound stage. For example, if you set out to record an orchestra, typical positions might be a quarter of the way left and right, either side of the centre line. The distance between orchestra and microphones will depend on the acoustics of the environment and the kind of perspective you want to achieve. For the recording, each microphone feeds its corresponding track on the stereo machine. The potential problem with this arrangement is a hole in the middle of the stereo representation. The simplest way to avoid this disastrous situation is to bring the mics closer together, but this will affect the spaciousness of the recording, the whole thing tending to become rather narrow and lifeless. The optimal position is often a little harder to find than might be imagined at first. Although most people use the spaced technique purely so that they can take advantage of the qualities inherent in omnidirectional microphones, there is no reason

why you should not use directional microphones in a spaced array -- a very well-known classical music recording engineer, Tony Faulkner, often uses figure-of-eight microphones, for example. The advantage of using directional mics is that it is possible to reject some unwanted signals (typically reverberation) while retaining most of the other advantages of spaced-mic recordings. - "Binaural recording effectively transports our ears directly to the recording venue."

Other spaced techniques that use directional microphones include the ORTF format and the NOS system (both named after the European broadcasting companies that developed them). These are often called 'near coincident' techniques because they combine the level difference recording characteristics of directional coincident microphones, with spaced arrays. In the case of the ORTF technique, the basic configuration uses a pair of cardioid microphones with a mutual angle of  $110^\circ$ , spaced about 17cm apart. The NOS variant has a  $90^\circ$  mutual angle and a spacing of about 30cm, and -- just for the record -- the Faulkner array uses a pair of figure-of-eights, both facing directly forward, but spaced by about 20cm. I often use the ORTF or NOS techniques, generally with good results, and I recommend that you experiment around these basic arrangements to find out what works best for you.

**BINAURAL RECORDING** - Binaural recording is one of those techniques that seem to have a cyclical life. It becomes very popular for a while, then seems to disappear without trace, only to be re-invented a few years later... Binaural recording is a basic two-microphone spaced-pair technique, but it is rather specialised in that it only works effectively when listened to through headphones. The principle is to replicate the way our ears capture sounds, and replay those sounds directly into the corresponding ears. Our ears have a hemispherical polar pattern, largely dictated by the lump of meat cunningly positioned between them. As we saw last month, the head creates sound shadows and timing differences for the two ears, so a binaural recording format has to replicate those actions. The easiest technique is simply to clip a couple of small omnidirectional microphones (tie-clip mics are perfect) to the ears of a willing victim (the arms of a pair of glasses would be less painful!). If recording an orchestra or band, the human mic stand would have to be persuaded not to move their head, but stunning results can be obtained if the microphones are recorded on a cassette or DAT Walkman as you go about your daily chores. Crossing a busy road can cause very entertaining reactions in the listener -- and see what happens if the recording includes your morning ablutions: listening to the binaural sound of someone brushing their teeth is an experience in itself!

A rather more practical method is to use a Jecklin Disc (also known as a 'Henry' in some circles), which mimics the fundamental acoustic aspects of the average head. The disc can be made from perspex or plywood, typically about 25-30cm in diameter, with a mounting point for the microphone stand on one edge, and fixings for a pair of microphones arranged through its centre. The surface of the disc should be covered in some kind of absorbent padding to avoid reflections from the disc surface back into the microphones, and the mic capsules should be

mounted about 15-18cm apart on opposite sides of the disc. The operating concept is that the microphone-spacing matches that of our ears, and the disc provides the sound-shadowing effects of the head; thus the whole technique should be able to capture signals in the microphones which will closely match those of our own ears. When replayed over headphones, the signals from the disc mics are fed directly into our ear canals, bypassing the effects of our own head- and ear-spacing -- effectively transporting our ears directly to the recording venue. "Placing spaced microphones is really a black art."

In practice, the results vary from being incredibly three-dimensional and realistic, to forming a stable and solid image behind, but not in front of, the listener's head. The differences are probably due to the difficulty of accurately matching the dimensions of the recording system to the listener's own physique. If you really want to go overboard, the state-of-the-art binaural technique uses a fully bio-accurate dummy head (a common alternative name for the binaural system is 'dummy-head recording'). Several manufacturers produce anatomically accurate heads, often with the complete torso. Even greater accuracy can be achieved by using carefully shaped pinnae around the microphone capsules and even replicating the various mouth, nose and sinus cavities within the human head! Interestingly, binaural recordings replayed over loudspeakers manage to convey a sense of stereo width and movement without having any accurate imaging qualities. This facet of the technique is often used to advantage in the production of sound effects for radio and television. In general, sound effects -- especially atmospheric effects -- should convey the environment, but must not distract from the foreground dialogue or action. Imagine a scene from a radio drama where two actors appear to be conversing on a busy town street. If coincidentally recorded effects were used, the sounds of footsteps and buses travelling across the sound stage could be intensely distracting. However, a binaural recording of the same atmosphere, while being very realistic over headphones, is far less distracting over loudspeakers. Scale, width, perspectives and movement are all conveyed to the listener, but in a laid-back manner that is often far more effective.

SUMMING UP - Spaced techniques allow the engineer to take advantage of the inherent quality of omnidirectional microphones in stereo recordings, particularly their extended and even low-frequency response, and their smooth off-axis pick up. The only problem to be aware of is the potential for comb-filtering effects when spaced microphones are combined, and the more the mics, the worse the effect is likely to be, although it is very hard to predict the audible results. There are no rules about spacing microphones -- it really is a case of trying an arrangement and listening carefully to the results, then moving things about until you find what you are after.

Thinking about the physics of the whole thing helps but, in practice, placing spaced microphones is really a black art, and the best results are almost always obtained by trial and error. Binaural techniques are a lot of fun, and can be stunningly realistic, but most people prefer to listen over loudspeakers rather than headphones, so the technique is of limited practicality. Most of my own best recordings have used spaced systems to overcome the weaknesses of coincident techniques (generally, excessive precision and a lack of spaciousness), and my personal

favourite arrangement is the near-coincident ORTF setup. This rarely fails to provide the kind of sound I like, and is usually a good starting point from which to build the final sound. I have used variations on this theme to form the basis of recordings of everything from solo acoustic guitars, complete drum kits, Leslie speakers on Hammonds, and live jazz bands in clubs, up to full concert orchestras. However, your likes and dislikes, in terms of stereo sound stages and imaging details, are bound to be different from mine, so don't take my word for it, go out and experiment -- it really is the only way!

DECCA TREES - The most commonly used spaced-pair technique is probably the Decca Tree. This was developed many years ago (some time in the early '50s, in fact) to allow the use of omnidirectional microphones to record in stereo. The basic arrangement is to mount three microphones in a triangular pattern, the central microphone being forward of the others. Dimensions are not particularly critical but, typically, the two rear microphones are about 140cm apart, with the central microphone about 75cm forward of them. The exact dimensions may be varied to suit the size of the sound stage being recorded, and, depending on the polar accuracy of the omnidirectional microphones used, it may help to angle the outer microphones towards the edges of the sound stage so that the microphones' best high-frequency response favours these parts.

The left microphone is recorded on the left channel of the stereo recording, and the right mic on the right channel, as you would expect; the central microphone is distributed equally between the two channels. Although combining the central microphone with the two edges is potentially risky in terms of comb-filtering effects, the hazards are far outweighed by the advantage of a very stable central portion of the sound stage, avoiding any possibility of a 'hole in the middle'. This extra stability is not only due to the mere presence of an additional microphone covering the centre of the sound stage, but also because the central microphone is forward of the others. The slightly closer proximity to the sound stage means that it will capture sounds before they arrive at either of the other microphones. On replay, this will cause the sound stage to build from the centre, expanding to the edges as the out-rigger microphones capture the sound fractionally later. It is a very subtle effect -- one that works at a subliminal level -- but is crucial to the effectiveness of the Decca Tree format.

COMBINATION TECHNIQUES - In most cases, one primary technique rarely produces the results we want in our recordings. Last month we saw how combining a coincident pair with spot microphones was an effective technique. A similar combination of spaced mics and spot mics also works well, but many engineers prefer to add a spaced array to the full coincident/spot combination. This adds more spaciousness and ambience to the recording and is simply achieved by placing a pair of omnidirectional out-riggers towards the left and right edges of the sound stage. The effect of the omnis is to provide a much richer and more substantial sound, while the coincident pair provides most of the imaging accuracy and the spot mics highlight the inner detail and lift the weaker instruments. The idea can be used on a drum kit, where spot mics are placed close to each drum head to capture the slap and attack of the sticks on the skins, and a pair of omnidirectional microphones is placed some

distance away to give a broad and spacious stereo image. If the microphones are placed low down, towards the floor, they will tend to favour the drums rather than the cymbals, and if they are higher up the reverse is true.

19. **Robjohns (2)** Email: Contact SOS Telephone: +44 (0)1954 789888 Fax: +44 (0)1954 789895

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<http://www.soundonsound.com/sos/jan12/articles/qand1-0112-3.htm>

Q. How can I create a 'fake' M/S setup that is mono compatible?

I thought I had the whole M/S thing down until I listened to a commercial record and realised their stereo image was wider than mine and yet still perfectly mono compatible! In order to convert a mono source to an M/S pair, I bus the source audio to two separate tracks. On one track, the audio is unchanged and routed to the stereo bus centre (which I label 'Mid'). The other I delay by around 10ms, then split it to the left and right stereo bus, with the right side inverted (I label this track 'Side'). The 'Side' track cancels when I sum to mono. The problem I'm having is that the stereo image is not very wide. While it is clearly in stereo, it does not reach the extremes of the stereo field as it would by utilising the Haas effect. When I use a simple Haas trick, I achieve the width I desire (i.e. A hole in the middle), but it is not acceptably mono compatible. Is there a trick I am missing to achieve the width that I desire in my pseudo-M/S setup, yet also maintain mono compatibility?

Via SOS web site

SOS Technical Editor Hugh Robjohns replies: When you use this method of creating a fake stereo signal from a mono source, the apparent width is determined entirely by the amount of Side signal relative to the amount of Mid signal. No Side means mono. Loads of Side means wide perceived stereo image. Too much Side signal means a hole in the middle and quiet mono!

So you should be able to make the track as wide as you want — even to the level of a hole in the middle — just by further pushing the level of the Side signal. Changing delay time also affects perceived width and size. Larger delays (30-70 ms) create more hall-like effects, while shorter delays (5-30 ms) are more subtle and less 'roomy'. However, this kind of M/S-based fake stereo is never as convincing as real stereo. You inherently end up with a mush of frequencies spread across the sound stage; your original mono source is spread across the image like butter on bread. There is no discrete spatial positioning, and no coherent imaging. Basically, it isn't real stereo, it never can be real stereo, and comparison with a real stereo recording is pretty pointless and always disappointing! Moreover, created in the way you describe, the stereo image will tend to be bass-heavy on the left-hand side, because the relatively short delay you are using will tend to allow low frequencies to sum in phase on the left and out of phase on the right. This can be cured by inserting a high-pass filter before (or after) the delay line to

remove bass from the Side signal. Set it to about 100-150 Hz to ensure the bass content stays central.

The Haas effect — which you can employ by panning the original source to one side and a short-delayed version of it to the other — can sound very wide indeed, but usually isn't very mono compatible. The only way to make a single source fill a stereo sound-stage in any kind of convincing way — in my humble opinion — is to record it in stereo in a decent-sounding acoustic space, or use a really good reverb processor to achieve a similar thing. There are other techniques that can be used to create pseudo-stereo effects using dedicated stereo-width enhancers and variations on the distortion and chorusing theme, but they all tend to change the tonality to some extent, which may not be what you're after. The arrangement our reader is currently using to produce a wider stereo image, which results in reduced bass on the right-hand side. The fake stereo image arises because some frequencies are stronger in one side than the other, due to the offset comb-filtering resulting from combining the original and delayed signals with the same and opposite polarities. More 'fake Side' ('S') level results in a wider perceived image. In the lower diagram, the fake 'S' signal has been high-pass filtered, avoiding bass cancellation in the right-hand side.

20. **Skeoch** - Nature Recording with Andrew -

[http://www.listeningearth.com/pages/Andrew\\_Skeoch.htm](http://www.listeningearth.com/pages/Andrew_Skeoch.htm)

I have been recording nature sounds professionally since 1993. I recall that when I was about 10 years old, a friend and I went off to a local park armed with a cheap portable cassette recorder. We managed to record a Wattlebird screeching from a few yards away and returned with much excitement to listen to this distorted squawk lost amidst a sea of tape hiss. I can't recall being inspired to a career by this experience, so I'll put it down to one of the adventures of childhood. Needless to say, recording these days is a little more sophisticated...

The Right Technology for the Purpose - Often, when one thinks of nature recording, one envisages parabolic dishes or highly directional microphones. These are designed to focus on and 'pull in' birdsong from a distance - sort of an audio equivalent of a telephoto lens. This kind of equipment does a wonderful job if one wishes to record a single songbird without distracting background sound. In documenting the repertoire and dialect of birds and animals, this is the objective, and hence a commonly employed technology.

However, in our work, I am trying to record the whole landscape with each sound in a natural balance. I need a 'wide-angle lens' approach. Actually getting a good stereo image out of a real 'surround sound' landscape is not as easy as it may seem. There are all kinds of subtleties around phase coherence and psychoacoustics that I shan't go in to here. If you're interested further, there is a lot of information on the net about various microphone systems that achieve stereo, most notably binaural, ORTF, Mid-side (MS), co-incidentally mounted pairs or just a single stereo capsule microphone. For many years, and for our early albums, I used a pair of Sennheiser MKH60 microphones, most often hand-held in pistol grips, with Rycote 'Softy' wind protectors. These mics are what I

refer to as 'sawn-off' shotgun mics; shorter length directional microphones. They each have an optimal field of around 30 degrees around centreline before they begin muffling off. So a pair, deployed at an angle of around 60 degrees from each other, gives an optimal field of around 120 degrees, with progressively muting as sounds move to the side or rear. This optimal field is similar to the field of view of the human eye, and is surprisingly good at giving a realistic stereo image. Whilst this microphone system had to be used sensitively and had its limitations, I found it to give remarkably good results.

Firstly, the stereo image was good, with the roll-off mimicking what the ear does with sounds coming from behind the listener. Secondly, one could be quite targeted about what one is recording, without losing the ambience and space of a landscape. And most importantly, the system was versatile in many different environments, and was easy to use and carry. When we began in 1993, DAT (digital audio tape) was the only digital option for quality field recording. All our early albums were recorded on a Sony D10 Pro DAT recorder, using custom pre-amps from Moortronics. The Latest Digital Technology - More recently, I have moved to a quasi-binaural microphone system, known as a SASS (Stereo Ambient Sampling System). This is a commercially available microphone housing manufactured by Crown, originally designed to mount a pair of Crown omni microphones.

I have had my SASS modified to adapt the housing to fit a pair of Sennheiser MKH20 omni-directional microphones, one of the quietest and most sensitive microphones available, and a favourite of nature and field recordists. The SASS captures a wider field than my MKH60 system, and with greater stereo integrity. The sense of space is absolutely lovely, and using the MKH20s gives a highly sensitive pickup with extremely low microphone self-noise. Because the SASS has a wider field, it is not so important to anticipate where the action is coming from, or follow it, and hence the optimal way of using this microphone is on a tripod. I usually run a long cable (20 metres) back to my recorder, and monitor from there. Technology has thankfully moved on from the days of DAT tapes, and now there are a variety of hard disc audio recorders on the market. I now use a Sound Devices 722, a professional, dedicated audio recorder.

This is the most wonderful gadget; built like a brick, 40 Gb hard drive (that's about 60 hours of record time; easily enough for our recent 3 month field trip in India), baby simple to use and functional in a wide range of climatic conditions. But best of all, Sound Devices have had a reputation for making the sweetest, quietest microphone pre-amplifiers in the business, and now it is built into the 722 as standard. So I just plug in the SASS, and I'm ready to record. The quality of sound is spectacular; crystal clear digital audio. This complete rig is slightly more cumbersome than my earlier one, but the advantages of tripod mounting, gaining a wider field, and the improved sound quality, are well worth the extra lugging around. Plus, once back in the studio, the audio is transferred as WAV files directly onto our computers, ready for editing - no more real-time transcribing of DAT tapes. The Art of Nature Recording - Having the finest professional equipment is only one part of getting a good nature

recording though - and probably not as important as many would believe.

Every year, professional sound recordists - the kind used to working on TV studios and film sets - are sent out with top-of-the-line gear, to get 'some outdoor location sound' to accompany feature films and documentaries. Later, when it comes to post-production where sound effects and ambiences get added, the film editors and producers find that after months of filming on location, their sound guys haven't got what is needed. They often end up contacting dedicated nature recordists like ourselves to supply the required audio. Recording nature is not as easy as it seems! It is an art, not a science, and most often it is the skill and ear of the nature recordist that captures the most evocative recordings. This field craft is difficult to talk about, because it is gained through experience.

It comes down to an empathy with nature, gained with time and experience, and a sense of how one's equipment will record what is in the environment. And each time one enters a new environment, you have to begin again, getting to know what is there and how to record it. For me, the most rewarding part of this process is exploring my relationship with what I am hearing. Imagine the beginning of a day's recording; in the predawn it is often quite still, a good time to collect one's thoughts and tune in to the landscape. As one does so, one begins to be aware that it is not totally silent; maybe there are quiet insects calling, or a distant owl every now and then. It is actually a magical time, and the temptation is to fire up the recorder. However, the magic and stillness that is there rarely translates to a recording, which just sounds empty. At some point though, things will begin to get lively. Good, some activity! The first birdsong is often lazy and spacious, but as the dawn proceeds and (particularly in spring) a full dawn chorus develops, the birdsong can become overwhelming. Often a bird's territorial dawn song is highly repetitive, and each bird calls from one location. The result is a recording that can be both overly busy and boring. So I've often found that later in the morning, once birds are moving around and feeding, some of the best birdsong can be recorded.

What I am describing here is the aesthetics of nature sound; what sounds engaging to our ear. This is a personal and emotional response to the environment, there is nothing scientific or objective about it. It is all about developing our relationship with life around us, and being engaged as a listener, rather than a removed and dispassionate 'scientific' observer. It is also about hearing the relationships between other living things, hearing a living landscape, rather than a collection of separate animals. And the paradox is that these relationships - an acoustic ecology - turns out to be crucial to understanding the organisation of nature's sounds, and how each creature fits into the whole. So for me, nature recording is a personal journey, an exploration of the music of our living planet. Nature sounds are more than simply nice or interesting, they can touch one's soul.

Breaking the trade-off: rainforest bats maximize bandwidth and repetition rate of echolocation calls as they approach prey. Daniela A. Schmieder<sup>1</sup>, Tigga Kingston<sup>2</sup>, Rosli Hashim<sup>3</sup> and Bjorn M. Siemers<sup>1</sup>,

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Both mammals and birds experience a performance trade-off between producing vocalizations with high bandwidths and at high repetition rate. Echolocating bats drastically increase repetition rate from 2 – 20 calls s<sup>-1</sup> up to about 170 calls s<sup>-1</sup> prior to intercepting airborne prey in order to accurately track prey movement. In turn, bandwidth drops to about 10–30kHz for the calls of this ‘final buzz’. We have now discovered that Southeast Asian rainforest bats (in the vespertilionid subfamilies Kerivoulineae and Murinineae) are able to maintain high call bandwidths at very high repetition rates throughout approach to prey.

Five species of *Kerivoula* and *Phoniscus* produced call bandwidths of between 78 and 170 kHz at repetition rates of 140 – 200 calls s<sup>-1</sup> and two of *Murina* at 80 calls s<sup>-1</sup>. The ‘typical’ and distinct drop in call frequency was present in none of the seven species. This stands in striking contrast to our present view of echolocation during approach to prey in insectivorous bats, which was established largely based on European and American members of the same bat family, the Vespertilionidae. Buzz calls of *Kerivoula pellucida* had mean bandwidths of 170 kHz and attained maximum starting frequencies of 250kHz which makes them the most broadband and most highly pitched tonal animal vocalization known to date. We suggest that the extreme vocal performance of the Kerivoulineae and Murinineae evolved as an adaptation to echolocating and tracking arthropods in the dense rainforest under-storey.

22. **Walker** - Elusive golden cat caught on film by Matt Walker Editor, Earth News - One of the most elusive of all wild cats has been photographed deep in the jungle of Uganda. Story from BBC NEWS:

[http://news.bbc.co.uk/go/pr/ft/-/earth/hi/earth\\_news/newsid\\_8259000/8259573.stm](http://news.bbc.co.uk/go/pr/ft/-/earth/hi/earth_news/newsid_8259000/8259573.stm) - Published: 2009/09/16

15:50:29

GMT - © BBC 2011

Three images of a wild African golden cat were taken by a digital infrared camera trap set up by biologist Dr Gary Aronsen of Yale University in the US. To his knowledge, just one other image of a wild African golden cat has ever been published. Although taken in black and white, the new photos reveal this particular golden cat actually has a dark coat. The cat is so rare few researchers working in African forests have seen it. There is very little known about this felid, what kind of habitat it prefers etc Dr Gary Aronsen - A colleague of Dr Aronsen's has worked for years in Kibale National Park, Uganda where the photos were taken, and has seen the animal only

once, while Dr Aronsen knows of only one other published photograph of the cat in the wild, taken in the Democratic Republic of Congo. - "Anecdotal evidence suggests that while many villagers and locals may see the cat crossing roads, or maybe raiding domesticates, there are just not that many researcher sightings. We're usually looking for other things." As a result, says Dr Aronsen, there are no direct field studies of the African golden cat (*Profelis aurata*). Most studies that have been done are based on scat analyses. "There is very little known about this felid, what kind of habitat it prefers etc," he says. "It is spread across equatorial Africa, but it is cryptic and we presume solitary, making observations few and far between." The African golden cat is a medium-sized cat, about 80cm long, that lives within forest across central and west Africa. Despite its name, its fur colour is variable and it can be either spotted or not. "The golden cat is melanistic, meaning that its colour varies over its lifetime, and across the continent," explains Dr Aronsen. "I was disappointed that the cameras could not give me more data on [the cat's] colour, but the images suggest it is a 'dark phase' cat." It is one of two cat species known to live within Kibale National Park, the other being the serval. Servals are slim, long cats, while the golden cat is muscular and compact.

Dr Aronsen originally set up his camera trap to take images of primates living within the park. "For the most part, the cameras capture amazing images of elephants, monkeys, chimpanzees, duiker and buffalo. The cameras also can record movies, so you can see multiple animals in a group, such as chimpanzees." But he was still surprised when it recorded three separate images of a golden cat, which are published in the African Journal of Ecology. "That meant that the camera was located within the cat's core area," he says. The images were taken in an old-growth forest patch located within a place called Mainaro, which is a patchwork of old-growth, regenerating, and replanted forests, Dr Aronsen explains. Given that three images were captured within an old-growth patch, I'd say that the Kibale golden cats may prefer this habitat. But the range of any cat is large, and so they can go anywhere to hunt." Aronsen himself saw his first and only wild African golden cat this summer, when one looped along in front of his motorbike as he travelled to conduct field work in a remote area of replanted forest.

### 23. **Ward** - Wildlife Sound Recording Society - Parabolic Stereo

[http://www.wildlife-sound.org/equipment/stereo\\_parabol/index.html](http://www.wildlife-sound.org/equipment/stereo_parabol/index.html)

For every adage there is an equally apt one saying the opposite; for example, many hands make light work - unless they happen to be cooks! So it is with parabolic stereo - to divide or not, to use two reflectors, or to use a Siamese twin version of the very same thing. It is true that there has been much work and experiment put into this problem, but a certain mystique has developed in this area and the real issues have become obscured. It is felt, therefore, that in order to understand the complexities involved it might be useful if we went back to basic principles and examined the way in which a parabolic reflector works, and the pros and cons of the various methods advocated for stereo.

A parabolic reflector is constructed to the formula  $y^2 = 4ax$ , 'x' and 'y' being the two axes and 'a' the focal point. The parabola has the property that whatever the angle 'ba' makes to the axis 'x', 'cb + ba' is a constant. Thus, sound waves travelling as a plane wave will, after reflection, arrive at the focal point at the same instant, i.e. in phase. The position of the focal point will determine the shape of the reflector - the shorter the focal length, the deeper the dish. When using a parabolic reflector for reflecting sound, the reflector does not behave in quite the same way as one used for reflecting light or radio waves.

Because the sounds we wish to record range from 100Hz to 20,000 Hz, a range of 200 : 1, at some frequencies the wave length can be equal to the diameter of the reflector, or the microphone, or have a relationship to the focal length of the reflector. This can cause interference or cancellation problems. This effect does not occur with light or microwaves since the range of frequencies, and therefore the wavelengths, is of the order of about 2 : 1, and are very small compared with the dimensions of the reflector[1]. Another property which occurs when using sound reflectors is that of foreshortened perspective. The reflector acts in much the same way as a telephoto lens so that sounds that are more distant than the subject, if they are on the same axis, are brought forward, and if they are already at a high level they can overpower the recording of the subject. This compression can usually be overcome by the choice of a different recording position so that the unwanted sound is well off axis.

Mono recording with a parabolic reflector - If one supposes that the purpose is to single out one sound, say for example, a thrush singing his Spring song, with the exclusion or suppression of other sounds, then if it is not possible to get close enough to the subject with a conventional microphone, a reflector of suitable size and shape coupled with a matching microphone is an appropriate way of achieving that. A reflector will convert a relatively cheap omni-directional microphone into a highly directional and sensitive transducer with a forward gain possibly better than a more expensive gun microphone. Why? Well, size and shape of reflector are factors - the bigger your ears, the better you hear. what one is in fact doing is collecting sound along a 'beam' from a 'sound stage' consisting of a circle the same diameter as the reflector. The singing bird is a point source, and sounds outside the circle of maximum sensitivity may be heard but not with the same strength. The collected sound is focussed on to the microphone by the reflector. Collecting power in terms of surface area of the reflector compared with cross-sectional area of the microphone explains where the gain is obtained, and the benefit is that recording levels need not be set at maximum thus reducing HISS. The response curve of a typical omni-directional microphone such as the Grampian DP6 in a 24 inch reflector with a focal length of 7 inches is shown in figure 2. The frequency response of the microphone itself has been subtracted, so the change in gain achieved by the reflector is shown.

When the test sound source is shifted 10 degrees off axis the result is as in figure 3, and illustrates just how directional the reflector is, particularly at higher frequencies. Both diagrams show one of the problems mentioned earlier; the dip in response between 500 Hz and 1000 Hz ( i.e. between one and two octaves above middle 'C' ), is thought to be ,due to cancellation of the reflected wave by the direct wave, since the omni-directional microphone

will receive both. The reflected wave arrives at the microphone a little later than the direct wave, and the distance involved, twice the focal length, corresponds to half a wavelength at around those frequencies. This problem is aggravated further as the diameter of the reflector is reduced., indeed below 19 inches the curve dips progressively below the zero gain axis to a negative value, thus causing the microphone to perform less well in the reflector than out of it. Audio spectrograms, or Sonograms, of the calls of many birds contain elements within this suppressed range, so their calls will sound not quite natural. A deeper reflector, i.e. with shorter focal length, appears to go some way towards overcoming this problem.

Figure 4 is the response curve of the same test - a DP6 microphone in a 24 inch reflector but with a focal length of 4 inches. The dip should now occur at about 900 Hz. It does, but is not very pronounced, and apart from a more uniform response, the deeper reflector goes some way towards protecting the microphone from the effects of the wind and from sounds coming from behind the reflector.

Microphones - omni or cardioid? - An omni becomes very directional when used in a reflector, except at the lower frequencies, and if the reflector is deep enough, it will, as just mentioned be shielded to a degree from sounds behind the reflector. A cardioid, on the other hand, is directional to start with - but in the wrong direction in this instance, since to mount it in a reflector it has to face to the rear, and it will pick up low frequencies (breathing, coughing, motor noise, etc.) better in that direction than via the reflector! Also, a glance at figure 5 will show the steep curve, which means that when setting the recording level to achieve good results in the mid-range of frequencies, there is a real danger of over-modulation at the top end - those 'sudden high transients.

Roger Boughton with his stereo parabolic rig made along the general principles of this article  
STEREO - It cannot be done with reflectors! At least, not without some modification. Consider what we said about mono - the sound stage is a circle the same diameter as the reflector, and maximum signal from that circle along a parallel 'beam'. If we use two reflectors, and try to cover a reasonable field of view, we shall end up with two unconnected mono images - hardly satisfactory. What if we could find a way of enlarging the two sound stage circles from a pair of reflectors, each to cover a group of subjects instead of a single one, and then arrange these two circles horizontally side by side, so that they overlap to give a good centre image? The 'beam of receptivity' can be made to diverge by moving the microphone head away from the focal point towards the reflector. If we could determine the amount of divergence required to obtain a given amount of combined spread to cover a reasonable field of view at a given distance, and provided there was an overlap of circles, we would get a stereo image which did not suffer from the Polo effect. There is a loss in gain, of course, for you never get owt for nowt, and the reflectors are now not so sharply directional as they were previously, but for this application that is an advantage. A recording in one of the recent circulating tapes was made with two reflectors, and the stereo was favourably commented upon. Somebody else is also having a go! However, there can be phase cancellation problems if the left and right channels are combined for a mono playback, because the microphones are so far

apart.

Research has established that to overcome phase cancellation, the microphones for stereo should coincide, but since that is physically impossible, a compromise position vertically one above the other, angled left and right, provides an acceptable solution. Unfortunately this is not convenient in a reflector. One system that does seem to work, is to place the heads of the microphones close together in the reflector, and to separate them with a baffle plate, figure 6a & 6b. Each microphone receives a reflected signal via the baffle plate and reflector, the left half of the reflector and the left microphone receiving signals from the right, and vice versa. Again, owt for nowt comes into play, for there are three disadvantages with this system. First, the two reflector principle described earlier has been used, but each reflector has been cut in half, baffled, and joined to its opposite number in order to get the two microphones as coincident as possible. The result is that each microphone can only receive sound from half the reflector surface, so the gain is halved and recording levels have to be turned up. Second, the dividing baffle itself masks out some of the desired sound, causing a further reduction in gain due to the reduced reflecting surface. Third, weight and bulk have been increased.

A further solution presents itself. Taking the example of the car headlamp, which uses a parabolic reflector, it is possible to get two diverging beams from the same reflector, each going in different directions, without using a divider. Also, if one considers how close together the two filaments are in the head lamp bulb, it will be realised that accurate positioning is essential. Accordingly, two omni-directional microphones were positioned with the centres of the heads one inch apart on either side of the focal point (4") of a 24 inch reflector.

The result was a very confused 'stereo' image. On analysis, by reconstructing this on the drawing board, and working backwards. from the position of the microphones, it was found that the two 'beams', whilst going in the correct direction left and right, were not themselves even parallel. They each converged to points some distance in front of the reflector, and then spread out again, in other words each became laterally inverted - no wonder the stereo image was confused, with the ears and brain working overtime trying to make sense of it! After further experiment. it was found that by repositioning the microphones one inch closer to the reflector, i.e. at a 'focus' of 3 inches instead of 4 inches, with centres still one inch apart, two diverging beams were obtained, giving a total horizontal spread of 25 degrees with 6 degrees of overlap in the centre.

The results were very encouraging, and a further series of tests will determine the optimum position. With reflectors of different focal lengths it is felt that a good basis for experiment would be to place the microphones at 75% of the focal length. Considerations of weight and bulk give this system distinct advantages over other systems, but the main advantage is that of GAIN; each microphone uses the whole reflector surface, so the gain is doubled. Some researchers advocate cutting off the top and bottom of a divided reflector. It is understood that this is to eliminate some of the top and bottom sound, presumably to improve separation? Would they then fit

horizontal baffles to cut off some of the top and bottom sound reaching a pair of guns or cardioids? So what is so different about a telephoto version of the same thing?

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Editors note: This article by Ron Ward appeared in Wildlife Sound in the early 1980s. Gerry Patchett's article also appeared in Wildlife Sound No6 Sept 1972 - To complicate matters further, sound waves are an example of longitudinal propagation, as opposed to electromagnetic waves which are an example of transverse propagation. Analysis of one mode can not necessarily be applied directly to the other, and much more work has been done on light and radio reflection with parabolic dishes than has been done with sound reflection.

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- 1992 – *Killer Bees*. Peruvian television. (VHS)
- 1993 - *Life in the Freezer*. David Attenborough. British Broadcasting Company U.K. (VHS)
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Tracks 1 to 5 and 12 to 27 were recorded by N. Van-Eckmann tracks 6 to 11 were collected from DIGIMODE Ltd. The David Attenborough (Michael Faraday) lecture can be found on the following website.

<http://www.royalsoc.ac.uk/portals/attenborough/msh.htm>

Track No.	Description	Duration Seconds
01	Amazon Night 1.	0.46
02	Amazon Night 2.	0.46
03	Amazon Morning	1.04
04	Distant Howler Monkey	1.02
05	Natural wind	0.47
06	Indian Elephant in the jungle	0.53
07	Lion's Roar	1.22
08	Red fronted Conure (Parrot)	0.53
09	Monkeys (Species unknown)	0.25
10	Macaw and other birds	0.53
11	Indian Elephant	0.34
12	Herring Gulls	1.02
13	Cranes overhead	1.02
14	Cranes location 2	0.08
15	Crane location 5	0.28
16	Location 7	0.32
17	Location 8	0.11
18	Location 6	0.36
19	Location 2 Parabola	0.12
20	Location 4 cranes fly by	0.30
21	Location 2 take off 01	1.02
22	Location 2 take off 02	0.52
23	Location 2 take off 03	0.13
24	Single crane vocalisation	0.06
25	Location 6-1 & 6-2	0.25
26	Location 4 Great tit & other birds	0.23
27	Location 7 Great Tit	0.15

It should be noted that full absorption is 1 whilst full reflection is 0

Absorption coefficients of common building materials and finishes

Floor materials	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Carpet	0.01	0.02	0.06	0.15	0.25	0.45
Concrete (unpainted rough finish)	0.01	0.02	0.04	0.06	0.08	0.1
Concrete (sealed or painted)	0.01	0.01	0.02	0.02	0.02	0.02
Marble or glazed tile	0.01	0.01	0.01	0.01	0.02	0.02
Vinyl tile or linoleum on concrete	0.02	0.03	0.03	0.03	0.03	0.02
Wood parquet on concrete	0.04	0.04	0.07	0.06	0.06	0.07
Wood flooring on joists	0.15	0.11	0.1	0.07	0.06	0.07
Seating materials	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Benches (wooden, empty)	0.1	0.09	0.08	0.08	0.08	0.08
Benches (wooden 2/3 occupied)	0.37	0.04	0.47	0.53	0.56	0.53
Benches (wooden fully occupied)	0.5	0.56	0.66	0.76	0.8	0.76
Benches (cushioned seats and backs empty)	0.32	0.4	0.42	0.44	0.43	0.48
Benches (cushioned seats and backs 2/3 occupied)	0.44	0.56	0.65	0.72	0.72	0.67
Benches (cushioned seats and backs fully occupied)	0.5	0.64	0.76	0.86	0.86	0.76
Theatre seats (wood empty)	0.03	0.04	0.05	0.07	0.08	0.08
Theatre seats (wood 2/3 occupied)	0.34	0.21	0.28	0.53	0.56	0.53
Theatre seats (wood fully occupied)	0.05	0.03	0.04	0.76	0.08	0.76
Seats (fabric – upholstered empty)	0.49	0.66	0.8	0.88	0.82	0.7
Seats (fabric – upholstered fully occupied)	0.6	0.74	0.88	0.96	0.93	0.85
Reflective wall materials	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Brick (natural)	0.03	0.03	0.03	0.04	0.05	0.07
Brick (painted)	0.01	0.01	0.02	0.02	0.02	0.03
Concrete block (coarse)	0.36	0.44	0.31	0.29	0.39	0.25
Concrete block (painted)	0.01	0.05	0.06	0.07	0.09	0.08
Concrete (poured, rough finish, unpainted)	0.01	0.02	0.04	0.06	0.08	0.1
Doors (solid wood panels)	0.1	0.07	0.05	0.04	0.04	0.04
Glass (0.25mm plate, large pane)	0.18	0.06	0.04	0.03	0.02	0.02
Glass (small pane)	0.04	0.04	0.03	0.03	0.02	0.02

Plasterboard (12mm paneling on studs)	0.29	0.1	0.06	0.05	0.04	0.04
Plaster (gypsum or lime, on masonry)	0.01	0.02	0.02	0.03	0.04	0.05
Plaster (gypsum or lime, on wood lath)	0.14	0.1	0.06	0.05	0.04	0.04
Plywood (3mm paneling over 31.7mm airspace)	0.15	0.25	0.12	0.08	0.08	0.08
Plywood (3mm paneling over 57.1mm airspace)	0.28	0.2	0.1	0.1	0.08	0.08
Plywood (5mm paneling over 50mm airspace)	0.38	0.24	0.17	0.1	0.08	0.05
Plywood (5mm panel, 25mm fibreglass in 50mm airspace)	0.42	0.36	0.19	0.1	0.08	0.05
Plywood (6mm paneling, airspace, light bracing)	0.3	0.25	0.15	0.1	0.1	0.1
Plywood (10mm paneling, airspace, light bracing)	0.28	0.22	0.17	0.09	0.1	0.11
Plywood (19mm paneling, airspace, light bracing)	0.2	0.18	0.15	0.12	0.1	0.1
<hr/>						
Absorptive wall materials	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
<hr/>						
Drapery (10oz/yd <sup>2</sup> , 340g/m <sup>2</sup> , flat against wall)	0.04	0.05	0.11	0.18	0.3	0.35
Drapery (14oz/yd <sup>2</sup> , 476g/m <sup>2</sup> , flat against wall)	0.05	0.07	0.13	0.22	0.32	0.35
Drapery (18oz/yd <sup>2</sup> , 612g/m <sup>2</sup> , flat against wall)	0.05	0.12	0.35	0.48	0.38	0.36
Drapery (14oz/yd <sup>2</sup> , 476g/m <sup>2</sup> , pleated 50%)	0.07	0.31	0.49	0.75	0.7	0.6
Drapery (18oz/yd <sup>2</sup> , 612g/m <sup>2</sup> , pleated 50%)	0.14	0.35	0.53	0.75	0.7	0.6
Fibreglass board (25mm thick)	0.06	0.2	0.65	0.9	0.95	0.98
Fibreglass board (50mm thick)	0.18	0.76	0.99	0.99	0.99	0.99
Fibreglass board (75mm thick)	0.53	0.99	0.99	0.99	0.99	0.99
Fibreglass board (100mm thick)	0.99	0.99	0.99	0.99	0.99	0.97
Open brick pattern over 75mm fibreglass	0.4	0.65	0.85	0.75	0.65	0.6
Page board over 25mm fibreglass board	0.08	0.32	0.99	0.76	0.34	0.12
Page board over 50mm fibreglass board	0.26	0.97	0.99	0.66	0.34	0.14
Page board over 75mm fibreglass board	0.49	0.99	0.99	0.69	0.37	0.15
Perforated metal (13% open, over 50mm fibreglass)	0.25	0.64	0.99	0.97	0.88	0.92
<hr/>						
Ceiling material	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
<hr/>						
Plasterboard 12mm in suspended ceiling grid)	0.15	0.11	0.04	0.04	0.07	0.08
Underlay in perforated metal panels (25mm) batts	0.51	0.78	0.57	0.77	0.9	0.79
Metal deck (perforated channels (25mm) batts)	0.19	0.69	0.99	0.88	0.52	0.27
Metal deck (perforated channels (75mm) batts)	0.73	0.99	0.99	0.89	0.52	0.31
Plaster (gypsum or lime on masonry)	0.01	0.02	0.02	0.03	0.04	0.05
Plaster (gypsum or lime, rough finish or timber lath)	0.14	0.1	0.06	0.05	0.04	0.04
Sprayed cellulose fibre (16mm) on solid backing)	0.05	0.16	0.44	0.79	0.9	0.91

Sprayed cellulose fibre (25mm) on solid backing)	0.08	0.29	0.75	0.98	0.93	0.76
Sprayed cellulose fibre (25mm) on timber lath)	0.47	0.9	1.1	1.03	1.05	1.03
Sprayed cellulose fibre (32mm) on solid backing)	0.1	0.3	0.73	0.92	0.98	0.98
Sprayed cellulose fibre (75mm) on solid backing)	0.7	0.95	1	0.85	0.85	0.9
Wood tongue and groove roof decking	0.24	0.19	0.14	0,08	0.13	0.1
<hr/>						
Miscellaneous surface material	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
<hr/>						
People – adults (per 1/10 person)	0.25	0.35	0.42	0.46	0.5	0.5
People – high school students (per 1/10 person)	0.22	0.3	0.38	0.42	0.45	0.45
People – elementary students (per 1/10 person)	0.18	0.23	0.28	0.32	0.35	0.35
Ventilating grilles	0.3	0.4	0.5	0.5	0.5	0.4
Water or ice surface	0.008	0.008	0.013	0.015	0.02	0.025
<hr/>						

RT60 relates to intelligibility. Diffractors reduce pronounced reflection by breaking up the sound wave before reflecting it back. This does not reduce reverberant energy, but does reduce echo spikes that may otherwise exceed -60db of direct, thus lowering RT60 and improving intelligibility, but not necessarily improving the listening environment for music.

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Rumsey. Stereo Sound for Television  
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Sinclair. Audio Electronics Reference Book  
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### APPENDIX 3. Copyright law

1. Parabolic mirror and remote control recording device copyright: The information concerning construction of the parabolic mirror and remote controlled recording device is protected under the copyright laws and all rights are reserved. Any unauthorized copying hiring lending or modification to part or parts thereof of these designs is strictly prohibited.
2. CD-ROM audio disc copyright: The information on this disc is protected under the copyright laws and all rights are reserved. Any unauthorized copying hiring lending exchanging radio television broadcast public performance of any part or parts thereof without prior consent are strictly prohibited.

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