New Zealand Acoustics

Volume 31, 2018 / # 3

"*It is impossible for a man to learn what he thinks he already knows*"

Epictetus 55-135AD - Greek Stoic philosopher

Underwater Acoustics

Abundance estimation from different distributions of Damselfish using cross-correlation and three sensors

Taking it slow can help reduce impacts of Arctic shipping on whales

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Features

Regulars

Cover Image: Cropped from A line drawing of Epictetus writing at a table with a crutch draped across his lap and shoulder.

Source: Image scanned by the John Adams Library at the Boston Public Library. https://archive.org/details/epictetienchirid00epic

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Contributions to the Journal are encouraged, and may be sent directly to the Editors by email (journal@acoustics.org.nz) or by post c/o, the Acoustical Society of New Zealand Incorporated, PO Box 1181, Shortland Street, Auckland 1140.

From the President and the Editors

Editor's Column

Welcome to the final edition of New Zealand Acoustics for 2018 (Vol 31, #3). Its been a busy few months since our last issue with a highlight being the Society's Conference held in Auckland during November. We have a newly elected Board which is set out in the inset of the cover page of this edition of the journal.

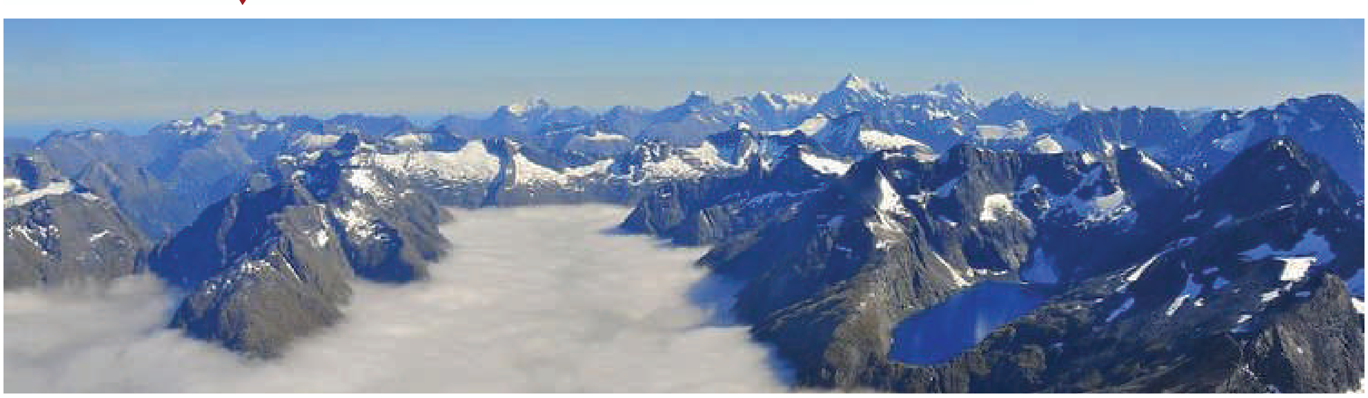
The edition also has its regular pieces including a selection of papers, news, reviews and RMANet. There is a distinctly underwater acoustics theme in this issue, with significant contributions from Dr Matt Pine and an original overseas paper. We have also prepared a quiz that has a few extra questions compared to usual with the hope of keeping you all busy over the break!

As this is the final edition for the year we once again wish to take a moment to thank all those persons who give their time and effort to help prepare the Journal this includes Dr Sarah Brand, Dr Grant Emms, Tessa Phillips and Robbie Blacklock. We also make a special thanks to our advertisers for their unwavering support.

Finally, we want to thank you for our members, we hope you all have a safe and enjoyable break and we will see you all back in 2019 with Vol 32 #1.

Lindsay and Wyatt.


Lindsay & Wyatt journal@acoustics.org.nz



Vern Goodwin inducted as New Fellow of New Zealand Acoustical Society

At a special ceremony held in Christchurch on 8th August 2018 Vern Goodwin was inducted as a new fellow of the Acoustical Society of New Zealand. Vern becomes the 9th fellow of the Society and joins a prestigious list of fellows including Sir Harold Marshall and Professor Cliff Stevenson (deceased.). Vern was joined at the ceremony by his family, along with South Island members, Jon Styles, the NZAS Society President and James Whitlock the Societies Secretary. Vern retired in July of this after working for over 50 years in the industry. For the past 18 years Vern have been advising Public Health Services and the Ministry of Health about environmental noise. Vern has represented the Ministry on various inter-agency committees and through various Standards New Zealand projects. Vern was involved in New Zealand acoustic standards review committees from 1985 onwards. We wish to congratulate Vern and wish him all the best with his retirement.

Graham Warren inducted as new Fellow of New Zealand Acoustical Society

Graham Warren was inducted as a new fellow of the Acoustical Society of New Zealand. Graham became the 10th fellow of the Society. Graham was inducted at the Acoustical Society of New Zealand Conference dinner recently held in Auckland during November. We congratulate Graham on becoming our latest fellow of the Society and wish him all the best with his retirement

Journal Feedback and Comments

If you have any feedback on what you would like to see in future issues or even things you don't like to see, please share with us via email to journal@acoustics.org.nz, we would like to hear from you! All comments and feedback is treated as confidential by the Editors.

The Acoustical Society of New Zealand

www.acoustics.org.nz

The ASNZ webpage contains a host of information including information on Membership, Journal Information and Journal Articles, Continuing Professional Development, Cafe and Restaurant Acoustic Index, Standards Committees and Standards, the Latest News and Discussion and Contact details of the Society.

Why not visit for yourself?

The Chartered Association of Buildings Engineers (CABE) - Formalised New Zealand Chapter

cabe chartered association of building engineers

The Chartered Association of Building Engineers (CABE) has formally signed the application to establish the New Zealand Chapter. With the Association increasing its membership year on year through international development, CABE's fully functional New Zealand Chapter is testament to the growing role the association has with building engineering across the globe. For more information about CABE visit www.cbuilde.com

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[1]Matt Pine

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Originally published in SUBMERGE, August/September 2015

1. The Ocean is noisy

The undersea acoustic environment is made up of two predominate components: biological (biotic) and physical (abiotic). Biotic sounds vary hugely from place to place and are produced by animals that are engaged in social or reproductive behaviours, feeding, territorial defences, communication (including echolocation) and general movement. Abiotic sounds are less diverse and are largely generated by wind and waves, though they may also include physical processes such as breaking glaciers and seismic activity. Each source produces sounds at particular levels and frequencies and are therefore distinguishable – much like traffic noise is distinguishable over construction noise.

Using hydrophones, we can hear these underwater sounds come together to produce a cacophony of sound that our human ears cannot make any sense of. However, when we study this natural sound over time, patterns begin to emerge. Sound levels are highest during the dawn and dusk and lowest during midday and midnight. These increases in sound levels are called dawn and dusk choruses and are created by the increased crepuscular activity of the many reef inhabitants. If we extend the time window, we observe lunar and even seasonal patterns in reef sounds. Marine creatures can obtain a great deal of information from natural underwater sounds concerning the type, quality and direction of a habitat.

2. Finding a home

Sound travels roughly four times faster underwater than in air and can therefore travel huge distances with minimal loss in intensity (especially low-frequency sounds, such as the songs of humpback whales [< 20 Hz]). Researchers have measured natural reef sound tens of kilometres from the source reef; thus suggesting that marine larvae & adult fishes may use underwater sound as an orientation cue.

During the late 1990s and early 2000s, researchers experimenting with light traps discovered that a significantly greater number of fishes were being captured in light traps that were coupled with speakers (broadcasting reef sound) compared to the traditional (silent) light traps. Early experiments using simple choice chambers saw fishes actively swimming toward the chambers that were playing reef sounds. These early works led to the theory that underwater sound may actually be used by fishes as an orientation cue. In 2005, researchers discovered significantly higher fish diversity and abundances on artificial reef patches that had underwater loudspeakers broadcasting reef sound, compared to silent artificial patches. This study was one of the first to confirm the use of underwater sound as an orientation cue in fishes.

3. Navigating a fishy world

Filled with the sounds of life and the movement of the ocean, the sea is a very noisy place and the ocean's inhabitants are keen listeners. Equipped with highly-sensitive lateral line systems and perfectly-adapted inner ears, fishes are capable of detecting even the slightest pressure differentials that are generated by a sound wave.

The detection of sound by your typical fish has two key components: the inner ear and the swim bladder. The inner ear is composed of semi-circular canals, otolithic organs and sensory epithelia. Also within the inner ear are otoliths, which are small, dense bony structures that are surrounded with setae (hair-like extensions), which are accompanied by numerous mechanoreceptor cells. When sound passes through the water, the otoliths displace the water particles and any free-drifting materials (including larvae). As the otolith does not move in synchrony with the seawater due to its density, it brushes against the setae and stimulates the mechanoreceptor cells.

The degree of stimulation correlates to the intensity and frequency of the sound. The sensitivity of hearing is increased by anatomical adaptations that can transform sound pressures into displacement movements, which create movement in the otolithic organs. Air within the fish's swim bladder allows for this transformation and the compression of the gas within the bladder causes the surrounding tissues to vibrate; thereby providing the necessary particle motion to cause otolithic stimulation. Some fishes have a slightly different system in which the swim bladder is connected to the auditory system by a chain of small bones, called Weberian ossicles. Energy from the pulsating gas within the swim bladder is transferred down these ossicles and to the inner ear.

Interestingly, fishes are not the only animals known to be capable of listening to the ocean's secrets. Researchers have found that many cephalopods, corals, crustaceans, gastropods, turtles and, of course, cetaceans are also capable of detecting underwater sound and all of them show distinct behavioural responses to it.

Using their perfectly-adapted ears, fishes navigate their world using sound. They use sound to avoid predators, navigate at night, and find food, mates and shelter.

4. Sound production in fishes

Fishes are noisy – some more so than others. Depending on the situation, fishes will either intentionally produce sound as signals to potential mates, predators or competitors, or as a fright response. They may also produce sound incidentally during feeding or swimming.

Sound travels roughly four times faster underwater than in air and can therefore travel huge distances.

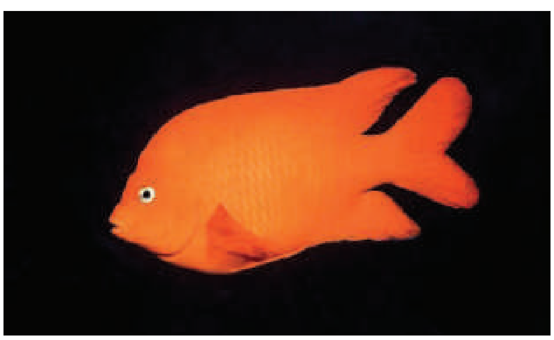
Underwater sound is particularly useful for communication, as information can be conveyed quickly and over long distances. Many fishes generate sounds, and the idea of fishes talking to one another in a deliberate manner has created a new branch in the field of bioacoustics.

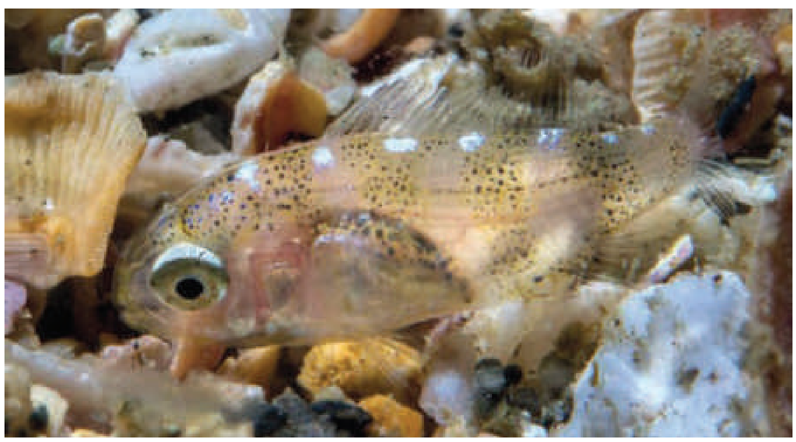
Fishes typically vocalise using low-frequency sounds (< 1 kHz), as these sounds travel greater distances. Their vocal repertoire includes grunts, croaks, clicks and snaps that are typically used during reproduction or to ward off predators. Courtship calls for the most vocal fishes to come out of hiding – the majority of fish calls are associated with reproduction, including spawning, and are usually generated by the male. Some of the most well-known vocal fishes include the sciaenids and toadfishes; large groups of these fishes congregate during the early evening and vocalise for hours. Their mating calls dominate the environment they inhabit, including out of the water. Many places around the world are subjected to loud and continuous low-frequency hums produced by these vocalising fishes. In some cases, people are unable to sleep and have paid large amounts of money to solve the mystery – only to find that the source is a fish and that it cannot be turned off.

Other situations that warrant fishes to talk include territorial defence or other stressful situations, such as aggression. A common example of this is in the fiercely territorial damselfish. When an intruder or potential threat encroaches their territory, they will emit spontaneous short bursts of sound until the threat leaves their area.

Using hydrophones, we can hear these underwater sounds come together to produce a cacophony of sound.

How these animals actually vocalise is relatively simple. There are three main ways in which fishes produce sounds: rubbing together skeletal components or teeth (termed stridulation); using sonic muscles on or near their swim bladders (termed drumming); and/or by





The distance that sound travels underwater depends on the water temperature and pressure

Top left: Toadfishes are well-known vocal fishes that use a drumming method of communication. Image by Dennis KingReefs

Bottom left: Boat noise has been found to mask communication signals between vocal fishes like damselfishes. Image by Keoki Stender marinelifephotography.com

Right: The grey snapper larva produces knocking and growling sounds. Image by Paul Caiger quickly altering their swimming direction and speed. Sometimes, the chosen method of vocalisation depends on the situation, for example, stridulation often occurs during feeding (when the teeth or pharyngeal teeth and jaws are being used) or maybe during territorial displays or as a fright response. Often, the swim bladder acts to amplify stridulation-generated sounds. The best known fish mating calls (those low-frequency hums and croaks) are produced by drumming.

The sonic muscles located on or near the swim bladder cause the swim bladder to contract and expand at a very rapid rate and thus create the low-frequency sounds. Often short and intense, this method is seen in sciaenids and toadfishes.

Most of our understanding is based on adult fishes, however, in 2014, researchers discovered that even fish larvae produce sounds. Similar to their adult counterparts regarding the length and frequency of the larvae vocalisations, the grey snapper larva is known to be quite vocal at night when it produces knocks and growls. The mechanisms used to produce these sounds are unknown, however, it is believed that by vocalising, the fish larvae are able to maintain group cohesion, namely safety in numbers.

5. Where we fit in

It is becoming more and more evident that, for fishes, underwater sound is the key to finding that perfect home, perfect meal, perfect shelter and perfect "someone" to fertilise your eggs.

Modern technology has enabled us to visualise the underwater world through sound, just as fishes would (as well as invertebrates and cetaceans), by turning real-time or recorded acoustic data into imagery on a computer screen.

We are now able to see the complexity of underwater sound as well as the incredible amount of information a single recording can tell us. We now understand that life in the ocean is dependent on organisms' abilities to hear natural underwater sounds.

Man-made noise (termed anthropogenic noise) is estimated to double in intensity every decade in coastal waters in some regions of the world with intense shipping activity. Sources of anthropogenic noise are wide-ranging and include ships, boats, petroleum exploration devices like air guns, construction activities like pile-driving, sonars, explosions, undersea dredging, fishing, seabed mining and renewable-energy-generating devices such as tidal turbines. Since the 1960s, motorised shipping alone has increased the ambient levels at frequencies below 100 Hz in the deep sea by approximately 15 dB (approximately a 30 times increase in sound power).

There is an ever-increasing concern for the impact these sounds may have on marine mammals, fishes and invertebrates.

While there is currently not enough data to say for certain how anthropogenic noise will affect whole ecosystems, there are plenty of data to suggest detrimental impacts on marine organisms. Some of the most commonly listed impacts include disrupted communication, hearing loss, habitat exclusion or avoidance and acoustic masking whereby an anthropogenic noise may prevent a receiver (a fish or another organism) from hearing biologically important sounds.

In fishes, hearing loss and increased mortality have been linked to high sound levels, such as with the shiner surfperch. Loud anthropogenic sounds cause stress responses and hearing loss in goldfishes, while air-guns were found to severely (and evidence suggesting permanently)

Reefs are noisy, filled with the sounds of life & movement of the ocean. Image by Michael Hindley

> Sound can travel about four times faster underwater than in air.

Hearing loss & increased mortality in the shiner surfperch have been linked to high sound levels. Image by Keoki Stender damage the hearing structures of fishes. High-intensity sounds have been found to affect behaviour and act as a distraction to important sounds, such as those given off by predators. For example, boat noise had a significant effect on the behaviour of the Caribbean hermit crab with simulated predators getting closer during sound playback experiments. Similarly, three-spined sticklebacks showed poorer foraging performance (measured by decreased discrimination between food and non-food items and food handling errors) when exposed to artificial sound. Boat noise has been found to mask communication signals (vocalisations) between vocal fishes, such as the damselfish, the brown meagre, the red-mouthed goby and the Lusitanian toadfish. In addition, boat noise has also been found to disrupt the schooling behaviour of the bluefin tuna and increase the secretion of the stress hormone cortisol in some freshwater fishes. It is not all bad news though, as vessel sound was found to induce settlement in mussels, although this may lead to new biosecurity problems as ship noise may be an important factor in exacerbating biofouling on ship hulls.

Modern technology has enabled us to visualise the underwater world through sound, just as fishes would.

Perhaps on your next dive you will think about the noise that is produced from your regulator as you exhale whilst coming face to face with a reef inhabitant.

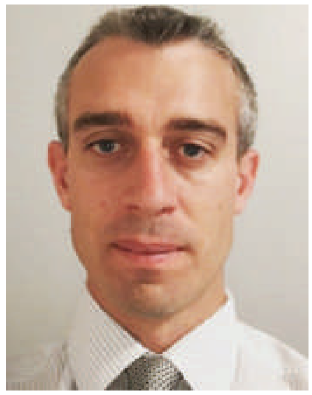
Do not worry; the sounds from your scuba equipment will not have a detrimental effect on the sea creature, although it might explain why some fishes are seen more frequently when using a rebreather.

...Continued from Page 3

First-time committee member Bio's

Dr Mathew Legg: He is a lecturer at the School of Engineering, Massey University (Albany campus). A main focus of his research has related to the development of acoustic/ultrasonic measurement systems and techniques for acoustic imaging, non-destructive testing, and remote sensing. He was previously a postdoctoral research fellow in the Physics Department, University of Auckland where he worked on two MBIE projects related to acoustics/ultrasonic non-destructive measurement of pasture biomass and wood properties. Prior to this, he was a research fellow at Brunel Innovation Centre, Brunel University in Cambridge, UK where he worked on several European Union FP7 projects related to ultrasonic non-destructive testing and acoustic biofouling inhibition. Mathew's PhD and MSc were performed at the University of Auckland and respectively related to acoustics camera imaging and acoustic radar wind/rain profile remote sensing.

Tracy Hilliker: She is an Associate Acoustic Engineer with Acoustic Engineering Services Ltd (AES) based in Christchurch. She joined AES in 2007, after graduating with a Bachelor of Engineering with Honours in Mechanical Engineering, from Canterbury University in 2001 and spending a number of years as a Mechanical and Hydraulics Engineer within the building services sector. As a consultant, Tracy is involved in all aspects of building and environmental acoustics, and has contributed to, and managed projects covering a wide range of applications; including schools, fire stations, function centres, quarries, hotels and apartments, churches, sporting facilities, cinemas, retail and office spaces, hospitals, and audiology test facilities. She specialises in educational and health facility design, and analysis of mechanical plant noise. Tracy is also The Acoustical Society of New Zealand's representative on the joint New Zealand / Australian Standards Committee EV-010 Acoustics - Community Noise.



Michael Kingan: He obtained BE(hons) and PhD degrees from the University of Canterbury in 2002 and 2006 respectively. Following his graduation he worked as a postdoctoral fellow and then as a lecturer at the Institute of Sound and Vibration Research at the University of Southampton. His current appointment is as a Senior Lecturer in the Department of Mechanical Engineering at the University of Auckland where, in addition to his teaching and research, he manages the acoustical laboratories. The majority of his research activities lie within the general field of acoustics and, in particular, he is currently leading a Smart Ideas project investigating the development of a Wave and Finite Element method for predicting sound transmission in lightweight building structures.

George van Holt: He holds a Bachelor of Building Science from Victoria University of Wellington and a Masters in Engineering from the University of Canterbury, bringing a knowledge of acoustical modelling, and an understanding of the external environment on the internal design of buildings. Since joining the AES team in June 2014, George has successfully contributed to a wide range of building projects for Building and Green Star applications. These include the acoustic design of commercial office buildings, residential multi-unit buildings, churches, and schools. George has also been involved with numerous environmental projects including helipads, preschools, Fire Stations, music events, and commercial developments.

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Abundance estimation from different distributions of Damselfish using cross-correlation and three sensors

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Abstract

Damselfish are small, tropical, marine fish of the family Pomacentridae (order Perciformes). They are mostly popular for their aquarium significance. Most damselfish species have bright colors or strongly contrasting patterns which makes them precious for aquarium uses. Beside aquarium values, they are valuable because of their ecological and economic worth. Therefore, an appropriate estimation of their abundance is an important task. In fact, proper abundance estimation is a prerequisite for environmental monitoring and commercial fishery activities. However, conventional techniques of such estimation suffer from several drawbacks. In this paper, we propose an acoustic signal processing technique for estimating the abundance of damselfish that can overcome the major drawbacks of the conventional techniques. In the proposed scheme, the estimation is based on the vocalizing nature of this fish species and cross-correlation technique. Our goal is not only proposing an efficient estimation technique but also measure its performance from different distributions of fishes. We have considered four different distributions - Exponential, Normal, Rayleigh, and Gamma. Among these four distributions, the Exponential distribution of damselfish produce better results in MATLAB simulation for the proposed technique.

Keywords: *Damselfish, bins, chirp signal, cross-correlation, abundance estimation.*

Original peer-reviewed paper

1. Introduction

Damselfish are familiar for their vocalizing nature [1]. In fact, Damselfish are among the best studied soniferous fish with at least eight of around 29 genera reported to generate sounds [1-3]. Different types of sound production mechanisms are available in fish and mammals. Some of those are swim bladder mechanism, stridulatory mechanism, cavitations mechanism, hydrodynamic mechanism, respiratory mechanism, etc. [4]. The mechanism of sound production in damselfish is hypothesized to involve stridulation of the jaw apparatus or other hard parts [5-6]. Chirp, a sound, commonly produced by males of bicolor damselfish (family: Pomacentridae) possesses an anatomical constraint [7]. In response, females make aggressive sounds. Two types of aggressive sounds, i.e., pops and chirps, are generated by the females. Pops are more commonly generated towards heterospecifics and chirps are usually generated towards conspecifics [8-9].

Damselfish have immense significance in aquarium purposes because of their variable colors and suitable body size. In addition, they are also important for food purposes in the Indian subcontinent and ecological purposes such as cleaning sea water [10]. Consequently, the process of searching and estimating damselfish abundance is paid a colossal importance. Inauspiciously, estimating the actual abundance of fish is tangled. Dynamics of fish population and harsh condition of the ocean are the main obstacles in obtaining accurate data. Many studies have been conducted to estimate the fish abundance. Such estimation techniques can be classified into two types, i.e., non-acoustic and acoustic. Major non-acoustic techniques are removal method of population estimation, minnow traps techniques, visual sampling techniques, environmental DNA technique, prediction-based macro ecological theory, etc. The removal method of population estimation has been applied to estimate small-mammal abundance; certain number of kill traps are set for numerous trapping periods, stated in [11]. The minnow trap is a passive gear for catching small fish species, has long been used in order to estimate fish population [12]. In reference [13], visual census consists of many techniques used to estimate reef fish populations. It has been adopted by the long-term monitoring program (LTMP) to assess reef fish abundance. An attempt to estimate the abundance of aquatic species using environmental DNA concentrations in large stream and river ecosystems is presented in reference [14]. This technique can ensure accuracy but suffers from complexity, high-cost, and dependency on previous data. In reality, most of the non-acoustic techniques are suffered from several problems including some common ones like time consuming nature, poor accuracy, mostly human interaction, costly instruments, etc. Consequently, nowadays, the researchers emphasize on acoustic techniques for fish abundance estimation. The conventional acoustic techniques are echo integration technique, dual-frequency identification sonar

(DIDSON) technique, dual-beam transducer technique, etc. An echo-integrator equation relates fish abundance to echo energy integrated over a time gate corresponding to the depth channel of interest. Parameters include the equivalent beam angle, the expected backscattering cross section per fish, equipment sensitivity, and a time-varied gain correction factor [15]. The DIDSON has been used in environmental management for a decade [16-17]. The limitations of this method are automatic dataset recording and the low range of the detection beam, which decreases accuracy [17]. The aspects of using a narrow wide-beam acoustic transducer for estimating fish abundance are illustrated in reference [18]. In this technique, the acoustic pulse is transmitted with a narrow beam and the echo is received on both the narrow and wide beams [18]. However, the acoustic methods also have some limitations like use of high frequency that harms the inhibitions of fish and mammals, requirement of large number of fishes for proper estimation, and requirement of costly electronic instruments and monitoring. To get rid of these difficulties, in this paper, a straightforward cross-correlation based abundance estimation technique is proposed. In the proposed technique, each damselfish in the estimation area is considered a source of chirp signal and three acoustic sensors are deployed to receive these signals. In the case of three acoustic sensors, two types of topologies are possible. One is acoustic sensors in a straight line and another is acoustic sensors in triangular shape. In this research, we have worked with three acoustic sensors in straight line (ASL) case. The technique is based on cross-correlating the chirp signals which is quite similar to the signal processing approach of node estimation [19-20]. In this article, we have analyzed the results for four different distributions, i.e., Exponential, Normal, Rayleigh, and Gamma, of damselfish to evaluate the performance of the proposed technique.

2. A brief analysis on cross-correlation function

The cross-correlation function (CCF) of time-delayed version of infinite length and unity strength Gaussian signal is to be expressed by a delta function, whose amplitude relays on the attenuation. At the same time, its position will be the delay difference of signals from the center of the CCF.

Then, the CCF for 1st signal source is:

$$(\tau) = \alpha_{11}\alpha_{12}\delta\left(\tau\left[\frac{d_{11}-d_{12}}{S_p}\right]\right) \quad (1)$$

where, d_{11} is the distance between the 1st signal source and 1st receiver, and d_{12} is the distance between the 1st signal source and 2nd receiver.

Assuming the strength of source signal is high enough to overcome attenuations. So, neglecting the attenuations, the CCF for the 1st signal source become:

$$C_1(\tau) = \delta\left(\tau - \left[\frac{d_{11}-d_{12}}{S_p}\right]\right) \quad (2)$$

Likewise, the CCF for Nth signal source is:

$$C_N(\tau) = \delta\left(\tau - \left[\frac{d_{N1}-d_{N2}}{S_p}\right]\right) \quad (3)$$

Then, the CCF for N number of signal sources

$$C(\tau) = \sum_{n=1}^{N} \delta(\tau - \left[\frac{d_{n1}-d_{n2}}{S_p}\right]) \quad (4)$$

It is innate that if N is larger than the number of bins, b and the bins are occupied by more than one delta due to the same delay differences. This increases the amplitude of the deltas of the bins, and thus the CCF is expressed in terms of bins as

$$C_i(\tau) = \sum_{m=1}^{b} p_i\delta_i \quad (5)$$

where, p_i is the amplitude of the delta, δ_i in the i^{th} bin.

The above analysis is verified by simulation in Figure 1, where, 32 sources and 19 bins are considered. Since, signal sources are larger than bins; there is possibility that some bins can be occupied by more than one source and some bins can be empty for time-delay difference. From Figure 1, p_i values are: $p_1 = p_{19} = 4$, $p_4 = p_{10} = p_{13} = 3$, and so on.

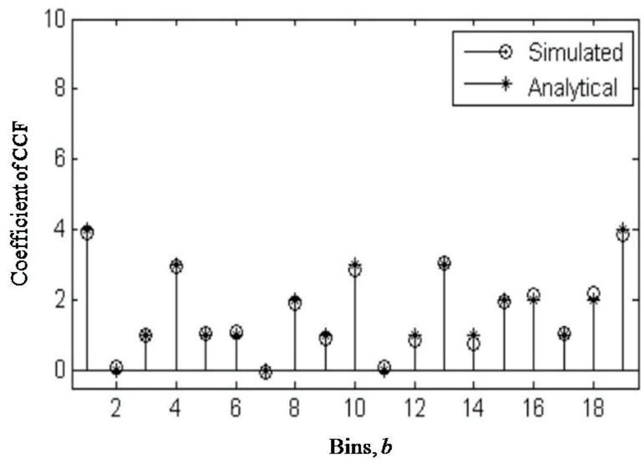


Figure 1: CCF for 32 sources and 19 bins

Using moving average technique of cross-correlation [21-22], we can express the CCF generally by the expression bellow:

$$C(\tau) = \frac{1}{N_s - \tau}\sum_{i=1}^{N_s-\tau} x_i y_{i+\tau} - \left(\frac{1}{N_s}\sum_{i=1}^{N_s} x_i\right)\left(\frac{1}{N_s}\sum_{i=1}^{N_s} y_i\right) \quad (6)$$

where, N_s is the signal length in terms of samples, τ is the time delay of cross correlated signals, x_i and y_i are the i^{th} samples of the two sensor's signals.

We assume Gaussian signal contains zero mean. So, the product of their mean is zero. Hence, the CCF in equation (6) becomes:

$$C(\tau) = \frac{1}{N_s - \tau} \sum_{i=1}^{N_s-\tau} x_i y_{i+\tau} \quad (7)$$

This gives the peaks for the desired bins as follows:

$$\frac{1}{N_s + \tau} \sum_{i=1}^{N_s+\tau} x_i y_{i-\tau}, \quad \dots, \quad \frac{1}{N_s + 1} \sum_{i=1}^{N_s+1} x_i y_{i-1},$$

$$\frac{1}{N_s - 0} \sum_{i=1}^{N_s-0} x_i y_{i+0},$$

$$\frac{1}{N_s - 1} \sum_{i=1}^{N_s-1} x_i y_{i+1}, \quad \dots, \quad \frac{1}{N_s - \tau} \sum_{i=1}^{N_s-\tau} x_i y_{i+\tau}$$

where, the peaks are the strengths of the deltas of equation (5) that can be expressed by following equation [19]:

$$P_1 = \frac{1}{N_s - \tau} \sum_{i=1}^{N_s+\tau} x_i y_{i-\tau}$$

$$P_2 = \frac{1}{N_s + (\tau - 1)} \sum_{i=1}^{N_s+(\tau-1)} x_i y_{i-(\tau-1)}$$

$$\vdots$$

$$p_b = \frac{1}{N_s - \tau} \sum_{i=1}^{N_s-\tau} x_i y_{i+\tau} \quad (8)$$

Theoretical CCF is developed by putting these values in the equation (5) [19].

3. Formulation of CCF

The formulation of CCF of chirp signal is like the formulation of CCF of Gaussian signal [23] which is the starting materials and method to estimate the abundance of damselfish. All the transmitted signals are received by the acoustic sensors and recorded in the associated computer in which cross-correlation is executed. Transmission and reception of signals are performed for a time frame, called "signal length" throughout this paper. Damselfish are considered as the sources of chirp signals, and N damselfish are distributed over the volume of a large sphere, the centre of which lies halfway between the acoustic sensors. A distribution of damselfish by simulation is shown in Figure 2, where, the three reds (+) indicates the acoustic sensors and each damselfish is considered as a source of chirp signal. A constant propagation velocity is considered, called the sound velocity, S_p in the medium. During the formulation of CCF for three acoustic sensors, i.e., H_1, H_2, and H_3, and a damselfish, N_1 the coordinates are considered at (x_1, y_1, z_1), (x_2, y_2, z_2), (x_3, y_3, z_3) and (a, b, c), respectively.

Distance between sensors H_1 and H_2 is

$$d_{DBS_{12}} = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \quad (9)$$

Distance between acoustic sensors H_2 and H_3 is

$$d_{DBS_{23}} = \sqrt{(x_2 - x_3)^2 + (y_2 - y_3)^2 + (z_2 - z_3)^2} \quad (10)$$

We have considered, $d_{DBS12} = d_{DBS23} = d_{DBS}$, which implies that two CCFs are possible.

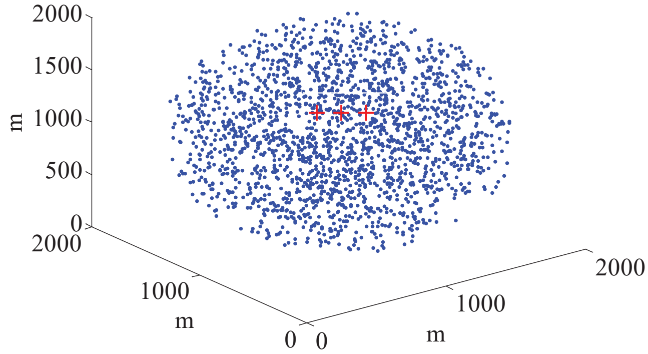


Figure 2: A distribution of damselfish in 3D space with three acoustic sensors.

Figure 3 shows a 3D space of a single damselfish N_1 and three acoustic sensors H_1, H_2 and H_3

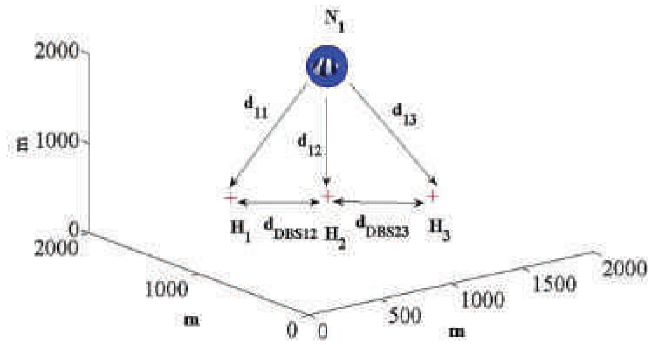


Figure 3: From a distribution of damselfish in 3D space, we consider one fish with three acoustic sensors

Here, we consider that the chirp signal coming from N_1 is S1(t), which is finitely long. The signal received by acoustic sensors H_1, H_2 and H_3 are S_{r11}, S_{r12}, and S_{r13}, respectively:

$$S_{r11}(t) = \alpha_{11} S_{11}(t - \tau_{11}) \quad (11)$$

$$S_{r12}(t) = \alpha_{12} S_{12}(t - \tau_{12}) \quad (12)$$

$$S_{r13}(t) = \alpha_{13} S_{13}(t - \tau_{13}) \quad (13)$$

where, α_{11}, α_{12}, and α_{13} are the attenuation due to absorption and dispersion in the medium, and τ_{11}, τ_{12}, and τ_{13} are the respective time delays for the chirp signals to reach the acoustic sensors.

The CCFs for three acoustic sensors in ASL case are:

$$C_1(\tau) = \int_{-\infty}^{+\infty} S_{11}(t) S_{12}(t - \tau_{11}) d\tau \quad (14)$$

$$C_2(\tau) = \int_{-\infty}^{+\infty} S_{12}(t) S_{13}(t - \tau_{12}) d\tau \quad (15)$$

To find out the CCFs for N damselfish, we have to take the total chirp signals received by the three acoustic sensors.

Now the composite signals received by H_1, H_2 and H_3 are:

$$S_{rt1} = \sum_{j=1}^{N} \alpha_{j1} S_j(t - \tau_{j1}) \quad (16)$$

$$S_{rt2} = \sum_{j=1}^{N} \alpha_{j2} S_j(t - \tau_{j2}) \quad (17)$$

$$S_{rt3} = \sum_{j=1}^{N} \alpha_{j3} S_j(t - \tau_{j3}) \quad (18)$$

Therefore, the total CCFs are:

$$C_{12}(\tau) = \int_{-\infty}^{+\infty} S_{rt1}(t) S_{rt2}(t - \tau)\, d\tau \quad (19)$$

$$C_{23}(\tau) = \int_{-\infty}^{+\infty} S_{rt2}(t) S_{rt3}(t - \tau)\, d\tau \quad (20)$$

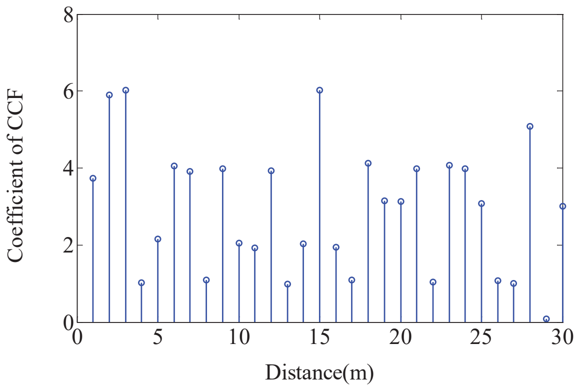


Figure 4: Bins in the cross-correlation process of the proposed technique

These take the form of series of delta functions, as it is a cross-correlation of two signals which is the summation of several chirp signals where one signal is fundamentally a delayed copy of the other. Figure 4 shows the bins of cross-correlation process of the proposed technique.

4. Estimation process of damselfish

We have known that chirp pulses are generated by a school of damselfish during swimming within their territory. A relationship between sound characteristics and swimming behaviour during the signal jump is described in [7]. However, for simplicity, in the simulation, a negligible amount of power difference among the chirp pulses transmitted by each damselfish was considered.

4.1 Different distributions of damselfish

Different distributions of fishes are practical phenomenon. In our research, we have considered four distributions, i.e., Exponential, Normal, Raleigh, and Gamma of damselfish. For exponential distribution the Probability density function (PDF) is $y = f(x|\mu) = 1/\mu \times e^{-x/\mu}$, where μ is the mean parameter, for Rayleigh distribution the PDF is $y = f(x|\mu) = x/\beta^2 \times e^{-x^2/2\beta^2}$, where, β is the scale parameter, and for Normal distribution the PDF is $y = f(x|\mu, s) = 1/\alpha \times \sqrt{2}e^{-(x-\mu)^2/2s^2}$, where, s is the standard deviation. In Gamma Distribution, three types of parameter are commonly used. They are a shape

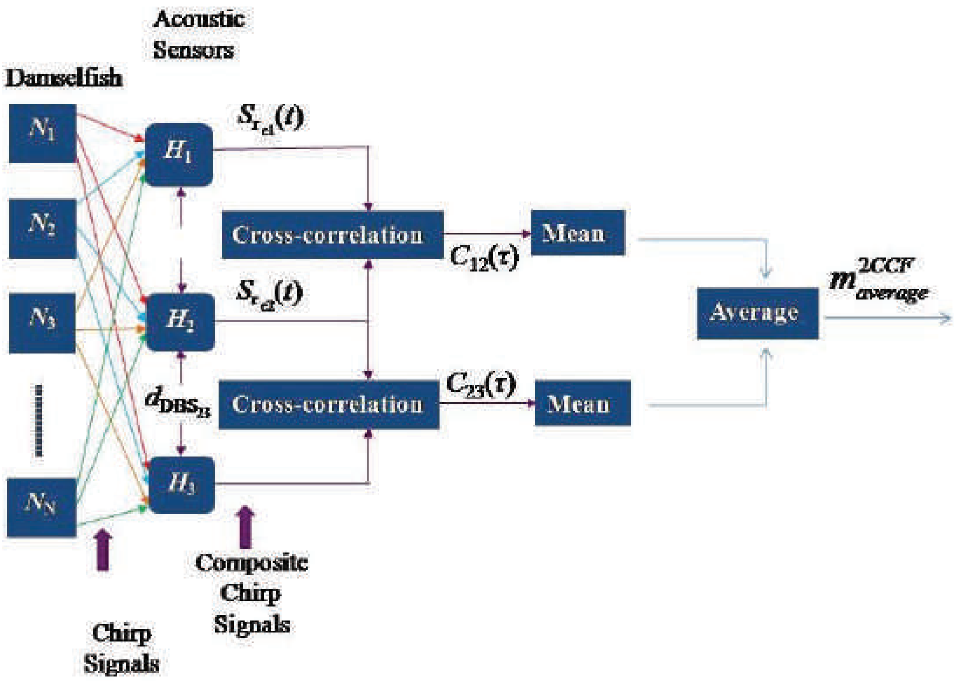


Figure 5: Block diagram representation of cross-correlation formulation process

parameter k_1, scale parameter β, and a mean parameter $\mu = k_1/\beta^*$, where, β^* is an inverse scale parameter and $\beta^* = 1/\vartheta$. However, every parameter is positive and real number.

4.2 Chirp Signal

Generally, croaker kinds of fish produce a sound, which is akin to a chirp signal. From a sound analysis of *Plectroglyphidodon lacrymatus* and *Dascyllus aruanus* species of damselfishes, it was found that their generated chirps consisted of pulse trains of 12–42 short pulses of three to six cycles, with durations varying from 0.6 to 1.27 ms; peak frequency varied from 3400 Hz to 4100 Hz [24]. However, a chirp signal is a swept-frequency signal, which has a time varying frequency. Such a signal can be expressed as [25]:

$$X(t) = A\cos\left[\left\{2\pi\left(\frac{(f_2 - f_1)t^2}{2d} + f_1 t\right)\right\} + P\right] \quad (21)$$

where, f_1 is the starting frequency in Hz, f_2 is the ending frequency in Hz, d is the duration in second, P is the starting phase, and A is the amplitude.

4.3 Abundance estimation from theory

It is acknowledged that the CCF follows the binomial probability distribution [19]. Consequently, here N damselfish and b bins were used. Then the expected value, i.e., the mean, m of the CCF is defined as [20, 26].

$$m = \frac{N}{b} \quad (22)$$

In the cross-correlation process, b can be achieved from the following equation [19, 27].

$$b = \frac{2 \times d_{DBS} \times S_R}{S_P} - 1 \quad (23)$$

where, S_R is the sampling rate, d_{DBS} is the distance between equidistant acoustic sensors, and S_p is the speed of sound propagation.

So, we can rewrite the equation (22) as follows.

$$N = b \times m \quad (24)$$

This is the relationship between the abundance of damselfish N and the mean m of the CCF. Since b is known and m be measured from the CCF, we can estimate the number of damselfish N. For three acoustic sensors in ASL case, the estimation parameter $m_{average}^{2CCF}$ is attained by following equation:

$$m_{average}^{2CCF} = \frac{m_{12}+m_{23}}{2} = \frac{\frac{N}{b_{12}}+\frac{N}{b_{23}}}{2} \quad (25)$$

where, m_{12} is the mean of CCF from the acoustic sensors H_1 and H_2 and m_{23} is the mean of CCF from the acoustic sensors H_2 and H_3.

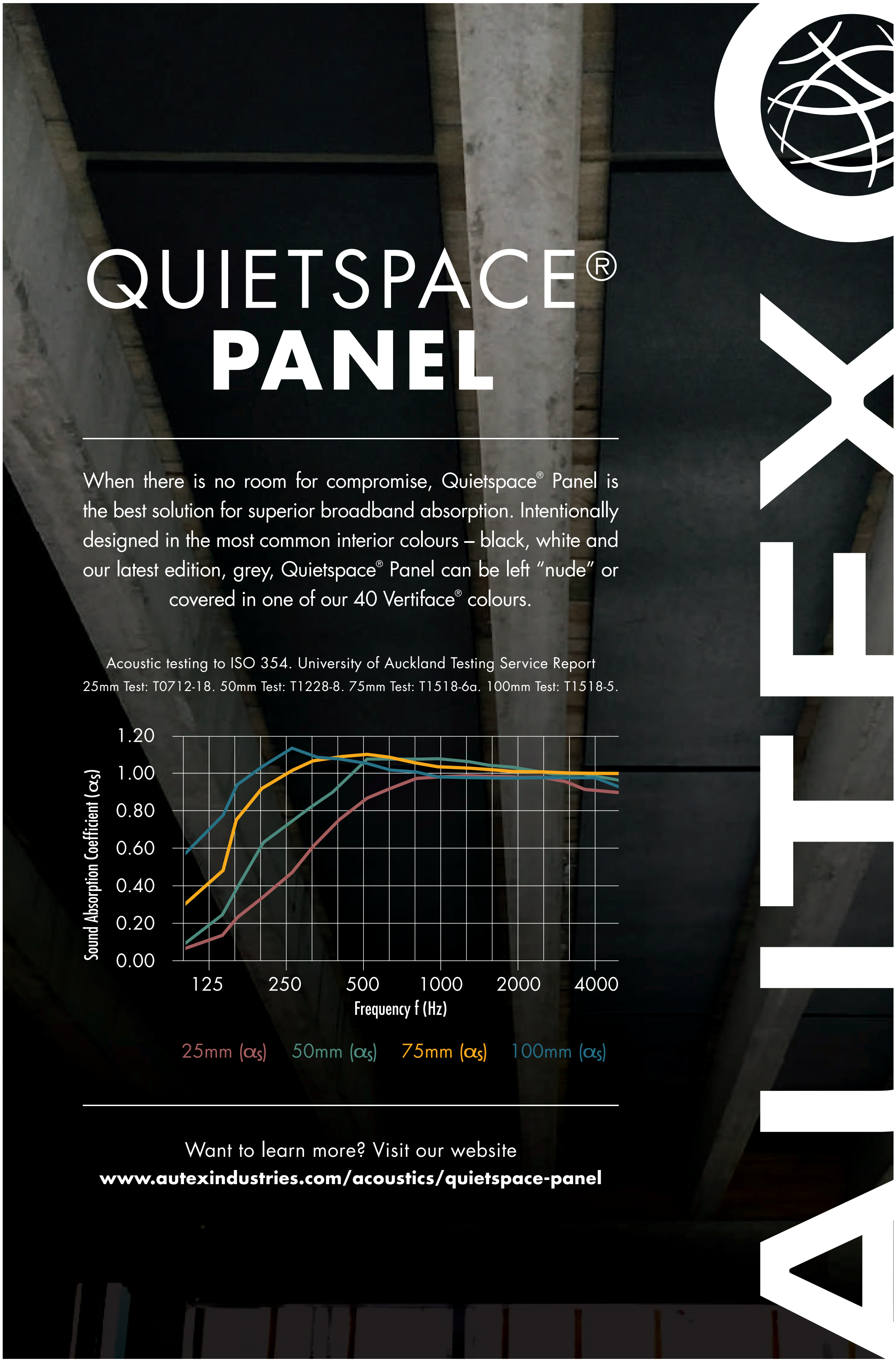
If b_{12}= b_{12}= b, then equation (25) can be simplified as follows:

$$m_{average}^{2CCF} = \frac{m_{12} + m_{23}}{2} = \frac{N}{b} \quad (26)$$

The block diagram in Figure 5 shows the process of cross-correlation formulation for damselfish estimation with three acoustic sensors in a line.

4.4 Abundance estimation from simulation

In this section, simulations were executed considering that three acoustic sensors were deployed in a line on the centre of a 3D sphere. The plots are found for four different distributions, i.e., Exponential, Normal, Rayleigh, and Gamma. All the simulations were accomplished by MATLAB programs. The parameters in the table 1 are common for all the four types of distributions. The simulation results were obtained by averaging 500 iterations.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Sound Absorption Coefficient (αs)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
125
250
500
1000
2000
4000
Frequency f (Hz)
25mm (αs)
50mm (αs)
75mm (αs)
100mm (αs)
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Table 1: Parameters in Simulation

Parameters	Values
Dimension of the sphere	2000m
Distance between the equidistant acoustic sensors, d_{DBS}	0.5m
Speed of propagation, S_p	1500 m/s
Sampling rate, S_R	60 KSa/s
Absorption coefficient, a	1
Dispersion factor, k	0
Number of bins, b	39
Mean parameter μ for all the three distributions	5
Standard deviation s for normal distribution	2
Scale parameter β for Rayleigh distribution	2
Scale parameter β for Gamma distribution	1
Shape parameter k_1 for Gamma distribution	5

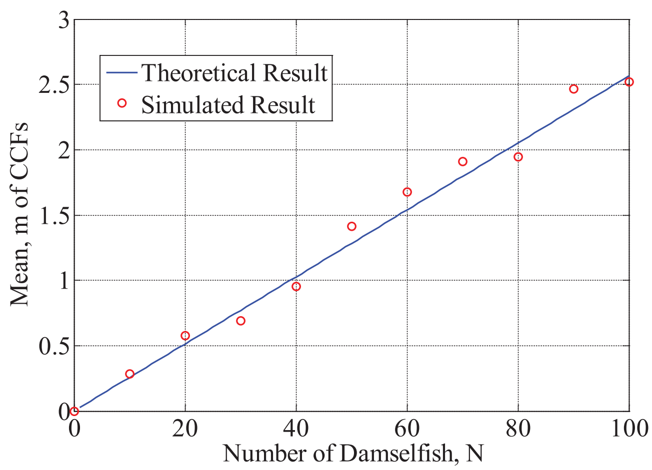

Figure 6(a) - Exponential distribution

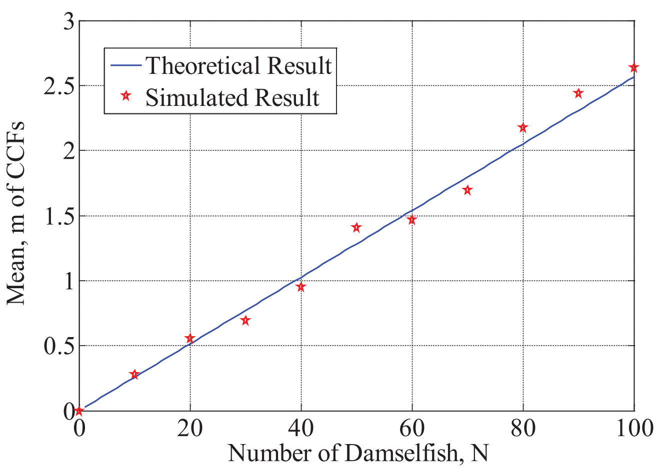

Figure 6(b) - Normal distribution

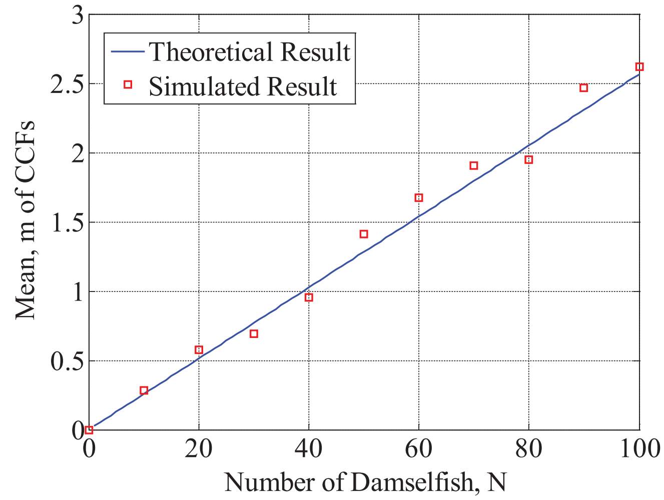

Figure 6(c) - Rayleigh distribution

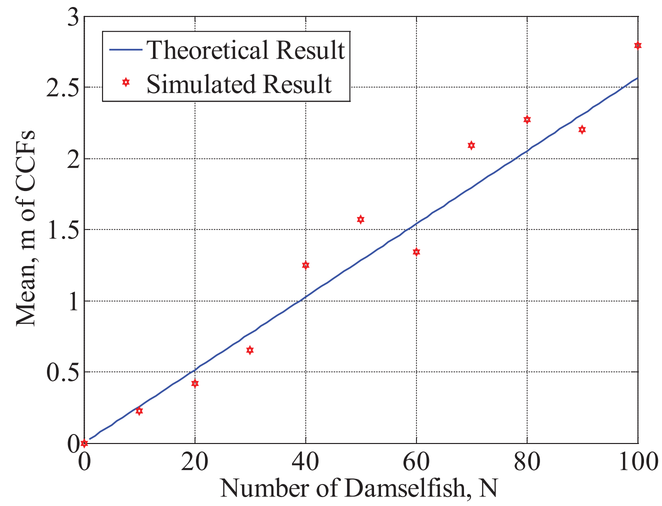

Figure 6(d) - Gamma distribution

Figure 6: Number of damselfish, N vs. mean, m of the CCFs

In Figures 6 and 7, straight lines (blue) correspond the theoretical results and reds (circles, pentagons, squares, & hexagons), in the Figures (a)-(d), respectively, correspond to simulated results for four different distributions.

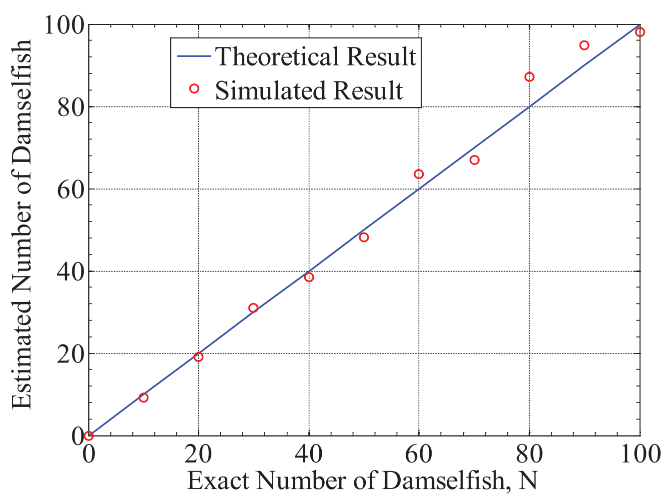

Figure 7(a) - Exponential distribution

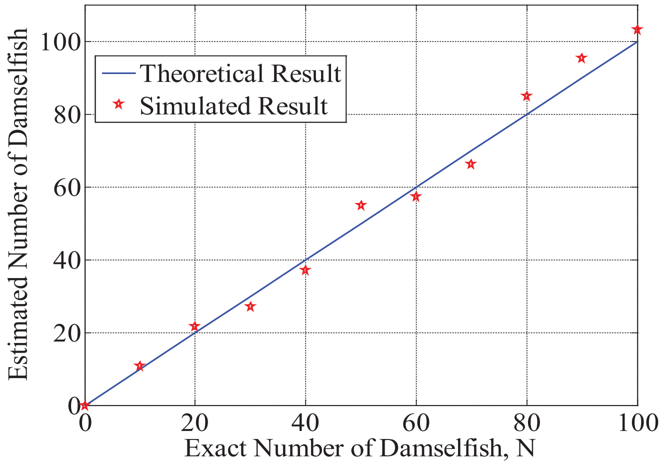

Figure 7(b) - Normal distribution

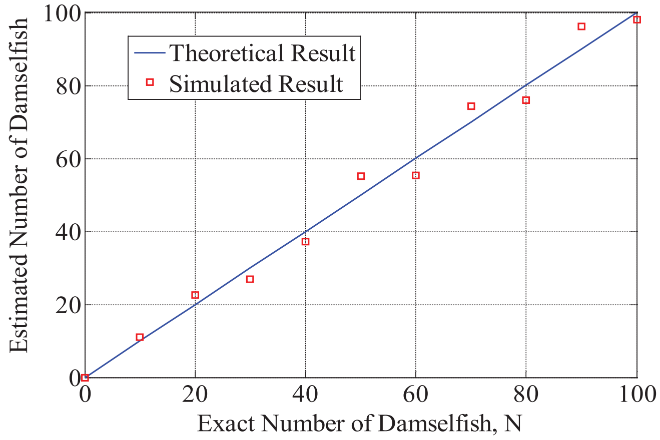

Figure 7(c) - Rayleigh distribution

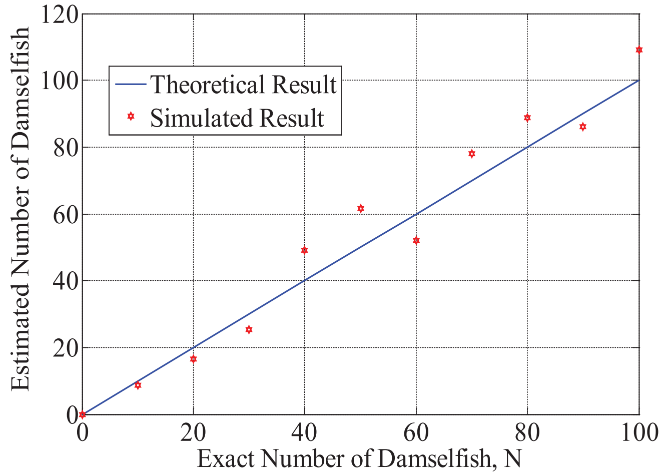

Figure 7(d) - Gamma distribution

Figure 7: Actual number of damselfish versus estimated number of damselfish

Figure 6 shows the mean, m of CCFs with respect to the number of damselfish, N for different distributions. On the other hand, Figure 7 shows a variation between the estimated number of damselfish from actual quantity. From the two Figures 6 and 7, it is seen that the theoretical and simulated results are very close to each other, which signifies the strength of the proposed abundance estimation technique.

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Hacking motion control

The Register has reported that a group of university researchers have developed a way to remotely control motion-sensing devices using only sound waves. Study authored by Yazhou Tu and Xiali Hei of University of Louisiana Lafayette, Zhiqiang Lin of Ohio State University, and Insup Lee of University of Pennsylvania, found that embedded sensors and gyroscopes in things like VR controllers, drones, and even hoverboards can be manipulated with resonant sound. The idea, say the researchers, is to use acoustic waves that vibrate at the same frequency as a MEMS gyroscope, tricking the capacitive sensors on the device into receiving commands as if they were sent by the accelerometer.

Among the tested systems that were found to be susceptible were the Oculus Rift, both iOS and Android VR controllers, and gyroscopic screwdrivers from two different manufacturers. "Under resonance, the sensing mass is forced into vibrations at the same frequency as the external sinusoidal driving force (sound pressure waves)," the group writes." Therefore, the mass-spring structure of inertial sensors could serve as a receiving system for resonant acoustic signals and allow attackers to inject analog signals at specific frequencies." In short, the researchers used a sound played through a speaker to send analog signals to the gyro sensors and create the illusion that the signal was the result of movement. While previous studies have found that exposed accelerometers and gyros to be open to this type of interference, this is the first to show that embedded sensors could also be affected. This means that sensors installed in devices could be targeted and used to manipulate that device.

Put your audio interface where your mouth is: Sonitus technologies 'Molar Mic' personal communication system

Sonitus Technologies announced that it has been awarded Phase II of its contract with the U.S. Department of Defense (DOD) which is structured to provide the U.S. Air Force with a novel new personal communication system that Air Force personnel have nicknamed the 'Molar Mic.' The innovative two-way, personal communication system, ATAC™, fits a miniaturized traditional headset into a device that clips to a user's back teeth.

The DOD, via its Defense Innovation Unit (DIU), has contracted Sonitus for a multi-million dollar, multi-year agreement, to complete development of the Molar Mic for purposes of transition to Fielding and Deployment of the system upon successful conclusion of the first segment of the contract which is funded by the U.S Air Force. Subsequently, other qualified branches of the U.S. defense community may leverage the technology as part of the DOD's program to enhance communications capabilities and operational safety of its personnel. Sonitus was introduced to the DOD by In-Q-Tel, the not-for-profit strategic investor that identifies and partners with startup companies developing innovative technologies that protect and preserve U.S. security.

"Sonitus Technologies is honoured to bring this game changing technology to our country's elite military, making them safer and more effective by enabling them to communicate clearly – even in the most extreme situations," said Peter Hadrovic, CEO of Sonitus Technologies. "The voice interface sustains communications in dangerous and challenging environments. The Molar Mic is the first in our family of solutions that conventional approaches are unable to address."

Pararescuemen (commonly known as PJs) from the Air National Guard 131st Rescue Squadron based at Moffett Field in Mountain View, CA, participated in early field testing of the Sonitus prototypes, including rescue operations during Hurricane Harvey last summer in Houston.

"*The ability to communicate by radio is crucial for our mission*," said a PJ and DIU Warrior in Residence. "*It enables us to execute in extreme conditions and save lives. But despite having amazing technology, communication still commonly breaks down*

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We have two Environment Court decisions to bring you this issue. Firstly, concerning an application for consent to establish a quarry near Takaka to supply the Tasman District Council with suitable rock for river and coastal protection in the Golden Bay area, and secondly, an appeal against the grant of retrospective consent for a second restaurant, kitchen and outdoor dining area at a vineyard on Waiheke Island

Following is a summary of these decisions, full copies can be found on the RMA Net website at: www.rma.net

In the Environment Court

LEE VALLEY LIMESTONE LIMITED – Appellant

TASMAN DISTRICT COUNCIL – Respondent

[2018] NZEnvC 122, 47p, [85] paras, 3 August 2018

Summary of Facts

Lee Valley Limestone Ltd (LVLL) applied to the Council to subdivide a property at 1177 Takaka Valley Highway by boundary adjustment and amalgamate the balance with another lot to create a new title containing 18.4 ha and to establish a quarry on the site. The Council refused consent on the grounds that adverse noise and traffic effects would reduce the amenity to an unacceptable level at a property at 1072 Takaka Valley Highway owned by Ms Price. LVLL was a subsidiary of Taylors Contracting Ltd which was a preferred contractor for the TDC, providing rock protection and other services along parts of the District's rivers and coastline. Issues with obtaining a secure supply of suitable rock for river and coastal protection in the Golden Bay Area led LVLL to investigate alternative quarry sites along the western hills of the Takaka Valley which consisted of suitable marble rock outcrops.

The Court detailed the environment of the site, noting the land was zoned Rural 2 with a Rural Residential zone approximately 400 m to the south, and as such the proposal, on a bundled basis, was a discretionary activity and required consideration under s 104(1) RMA. The Court discussed the effects of the proposal on the local amenity values, focusing on noise, dust, traffic, landscape, stormwater and silt management.

The acoustic expert for LVLL recommended post-construction phase noise levels at neighbouring dwellings of 50 dB L_{Aeq} and that noise from blasting would not exceed 115 dB L_{peak}. Modelling of noise generated at the quarry area assumed all noise to be generated at current ground surface level and as such was considered as worst case. The LVLL expert predicted that actual levels would likely be lower as the quarry became increasingly deeper with screening provided by the quarry walls. Modelling suggested that drilling operations and removal of extracted rock from the site were generally in the 40 to 43 dB L_{Aeq} range with only two properties exceeding those levels, and blasting noise levels would be below the 115 dB L_{peak} noise limit. Dealing specifically with noise from vehicles, LVLL's expert considered that measured noise levels from existing daytime traffic would mask predicted noise levels from quarry operations, including truck entry and exit from the site. Overall, he considered there would not be any significant adverse effects over and above that already experiences by traffic on the road.

The Court placed significant weight on the expert evidence on the level of effects on amenity, which concluded that any potential off-site effects would be contained within acceptable limits and there would be no significant adverse effects on the character and amenity value of the area within which the proposed quarry was located. As such the Court found that when objectively appraised, any adverse noise, dust, visual and traffic effects on lifestyle amenity at properties in the immediate vicinity of the quarry would be no more than minor.

The Court then turned to look at conditions of the consent and was satisfied that the conditions identified the performance standards to be met by the proposed management plans. The Court was also satisfied that all matters which were identified during the hearing as requiring attention through amended or additional conditions had been appropriately addressed in the final draft conditions submitted to the Court.

Court held:

Appeal upheld.

Subdivision and resource consent granted subject to conditions.

Costs not reserved.

In the Environment Court

CABLE BAY WINES LIMITED & MOTUKAHA INVESTMENTS LIMITED – Appellant

AUCKLAND COUNCIL – Respondent

[2018] NZEnvC 226, 6p, [27] paras, 21 November 2018

Summary of Facts

The appellants owned ten hectares of land near the western end of Waiheke Island at 12 Nick Johnson Drive, Church Bay. The land was partly planted in grapes and contained a large gently-sloping grass area and buildings which included the original restaurant, winery, tasting room, meeting room and staff facilities. More recently a second restaurant, large kitchen containing a pizza oven and outdoor facilities including a bar, table, chairs, umbrellas and open-air dining and drinking on the lawn were added and undertaken without consent. The appellants applied for retrospective consent in April 2017, but this was rejected by Council commissioners. The neighbouring rural residential properties alleged that shortly after the consent refusal, the appellants further expanded the illegal activities and the Council reacted by bringing enforcement proceedings.

The case for the neighbouring property owners, who became s 274 parties, was primarily on allegations of significant adverse noise effects from the restaurant and outdoor hospitality activities on the lawn and that the unconsented activities were strongly contrary to the key objectives and policies of the rural residential zone. The Court held that the strong evidence about the acoustic environment and the agreement of the three acoustic engineers, particularly regarding low frequency music noise, and the extent to which such might be capable of being controlled by conditions, were pivotal to the Court's conclusion that consent be refused to the outdoor hospitality activities.

After hearing all the evidence, the Court held that the site was over-developed and the subject of too much intensive activity which seriously disrupted the neighbours' amenity. However, the Court gave a tentative indication that the operation of the kitchen/restaurant could be the subject of consent subject to steps to achieve adequate noise attenuation and the outdoor activities sacrificed. The Court found the effects on the environment were considerably more than minor and it set the acoustic witnesses and planners the task of refining the draft conditions of consent to meet the needs of avoiding or acceptable mitigation of the adverse acoustic effects and general loss of amenity being suffered by the s 274 parties.

The Court confirmed that consent had been refused for the outdoor hospitality activities and in the enforcement proceedings the Court would make orders for the physical removal of facilities and the control of outdoor patrons. The Court then went on to note the indication of possible consent for the restaurant and kitchen, subject to satisfactory conditions being finalised.

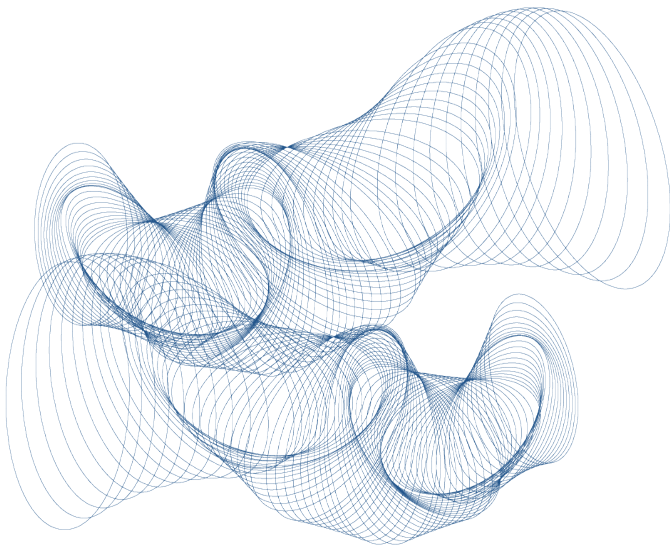
Court held:

Court refused part of the application for retrospective resource consent and made further directions about refinement of conditions for consent.

A more detail interim decision to issue later, which the Court anticipated would confirm consent and set out detailed reasoning on the matter.

Costs reserved.

Disclaimer - *This article has been provided to help raise an initial awareness of some recent cases involving acoustic issues. It does not purport to be a full listing of all decisions which have acoustic issues, nor does it replace proper professional advice.*



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4.5 Discussion

From the analysis of simulation results in Figures 6 and 7, we can come to a decision that the Exponential distribution of damselfish provides better results for the proposed abundance estimation technique.

Table 2: Experimental and Theoretical Data of CCF and Percentage of Error for Exponential Distribution

Actual number of damselfish, N_a	Mean of CCF from simulation	Estimated number of damselfish, N_e	Percentage of error, $(N_a - N_e)/N_a * 100\%$
0	0	0	0
10	0.238	9.27	7.3%
20	0.490	19.13	4.35%
30	0.796	31.05	3.5%
40	0.987	38.48	3.8%
50	1.235	48.16	3.68%
60	1.631	63.61	6.02%
70	1.714	66.87	4.47%
80	2.133	83.18	3.98%
90	2.431	94.71	5.23%
100	2.514	98.06	1.96%

From Table 2, we find the simulated results for Exponential distribution of damselfish. For the case of 30 and 100 damselfish, the simulation results provide 31 and 98 damselfish, consecutively. The percentage of errors is 3.5% and 1.96%, consecutively. This shows a good indication of accuracy of our proposed estimation technique.

However, this method has some limitations like negligence of multipath interference, assuming the delays to be integers and analogous, and assuming a negligible amount of power differences among the chirp pulses transmitted by each damselfish.

5.0 Conclusion

As a precious fish species, abundance estimation of damselfish carries a great significance. In the past, such estimations were precluded by several impediments. Our goal was to investigate a suitable technique that can overcome the major limitations of conventional techniques. Performance analysis of the proposed technique using different fish distributions was also our similar aim. Therefore, we have proposed straightforward and statistic-based techniques that can erudite major obstacles of the conventional techniques of abundance estimation. From the analysis of the simulation results using four different distributions of damselfish, we found that the Exponential distribution of damselfish provide better performance.

Acknowledgement

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Acoustics Quiz

Q1 What is 'bioacoustics' the study of?

Q2 Yes or No? The white noise spectrum is flat?

Q3 What does the following formula solve? $1449.2 + 4.6*T - 0.55*T_2 + 0.00029*T_3 + (1.34-0.01*T)*(s-35) + 0.016*z$ (m/s)?

Q4 What is the approximate. speed of sound in salt water?

Q5 Who was the founder of the deciBel scale (dB)?

Q6 What is the Fresnel Number?

Q7 True or False? Snell's law is also known as law of reflection.

Q8 Briefly describe what is meant by the 'free field region'.

Q9 True or False? - Loudness is a subjective perception.

Q10 Briefly describe the concept of pitch.

Q11 What is the hearing range humans are most sensitive to?

Q12 What is meant by the term 'Binaural' ?

Q13 What is the Franssen Effect?

Q14 What is the Lombard Effect?

Q15 What is a direct drive hearing system?

Q16 What does Misophonia mean?

Q17 Why don't we like the sound of our own voice?

Q18 True or False? - Permanent hearing loss can occur suddenly if a person is exposed to very loud impact/explosive sounds.

Q19 In the field of occupation noise what is mean by the concept of 'over protection'?

Q20 What is the Speech Interference Level (SIL)?

...Continued from Page 18

because of the extreme environments where we operate."

In one case during Hurricane Harvey, a PJ was involved in airlifting an injured civilian into a helicopter hovering directly overhead and was attempting communication with the helicopter flight engineer and pilot using the Sonitus system. The crew was amazed that they could clearly hear the PJ in these conditions. Parachuting from high-altitude aircraft, working under a hovering helicopter, swimming in open water, and similar conditions, interfere with traditional communication devices precisely when they are needed most. What is needed is an entirely new approach.

Queenstown Airport wants to increase noise limits to allow for massive expansion

Stuff has reported July 17 2018 Queenstown Airport wants to increase noise limits to allow for expansion. The airport has revealed proposed new noise boundaries to accommodate the growth and will offer to buy some homes and spend 'tens of millions' on noise mitigation packages for others if the changes proceed. The Stuff article notes that Airport chief executive Mr Colin Keel said it is expected to reach the limits of its current noise boundaries in the next three or four years. The boundaries specify the maximum amount of noise the airport can produce in a 24 hour period in a specific area. "It's not an option for us to breach those boundaries. It's the critical part of our social licence to operate as an airport." Therefore, the airport is proposing to extend the existing boundaries to include large parts of Frankton, Kelvin Heights, Queenstown and Shotover Country as areas recognised as affected by aircraft noise. A new inside noise boundary, featuring houses that will be subjected to over 70 decibels, is proposed and the airport will offer to acquire the 34 homes in that zone. It would not seek to make the acquisition compulsory. The airport would not seek to extend its operating hours outside the current 6.00 am to 10.00 pm limits.

Helicopter noise at Franz Josef called 'elder abuse' as spotlight thrown on enforcement

Stuff July 20 2018 has reported that Helicopter traffic at a West Coast tourism hot spot has breached noise limits to the point of becoming a health issue, some residents say. The Stuff article states that 'Anje Kremer, 75, has lived in Franz Josef since 1971 – long before a helicopter operation moved in next door. She likened the situation to "elder abuse", saying she had measured the noise well above accepted limits. Kremer did not believe the Westland District Council [WDC] was properly monitoring helicopter operations to ensure they met resource consent conditions. "*There are helicopters taking off one every minute. They do flip-flops over my house. It's not healthy. In town you can smell the fumes from the fuel. They fly where they want over houses to annoy people. It now looks like elder abuse the way they behave in the Waiho Valley. I have written to the Government about it but locals have got no say in this. Tourism has now become a public nuisance in my book.*" WDC only sent letters to operators suspected of flying outside the rules, she said.

The importance of audio quality

Researchers from the Australian National University and the University of Southern California recently published a study describing how audio quality has a significant impact on whether or not people believe what they hear.

...Continued on Page 28

Taking it slow can help reduce impacts of Arctic shipping on whales

A commentary by Dr Matt Pine

Mitacs Elevate postdoctoral fellow with WCS (Wildlife Conservation Society) Canada, the University of Victoria and JASCO Applied Sciences

For 19th-century adventurers like Sir John Franklin, navigating a path through the ice-choked Northwest Passage — the Holy Grail of Arctic exploration — was a treacherous and often deadly undertaking. Today, thanks to climate change, travelling through the passage is quickly becoming another exotic option for cruise ship passengers — and an enticing shortcut for cargo ships.

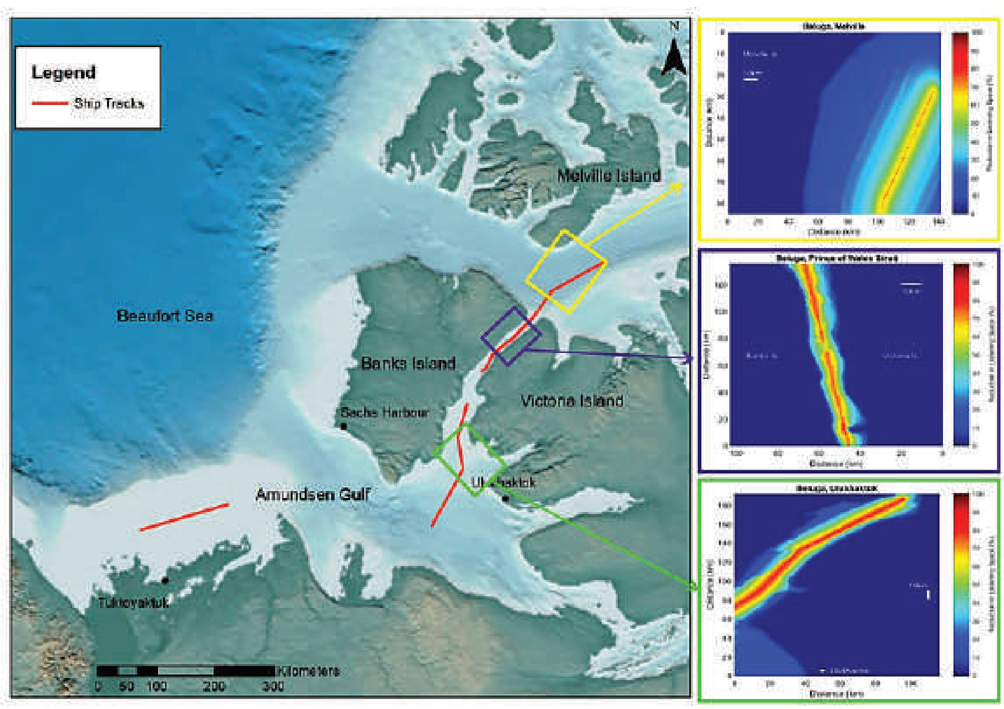
But an increasingly ice-free Arctic means more than just a chance for a new sightseeing adventure: Significantly increased ship traffic is altering the submarine calm of one of the quietest places on Earth. That could have serious implications for marine mammals and fish that rely on sound for group cohesion, socializing, finding mates, navigating, and detecting threats.

For a study just published in the Marine Pollution Bulletin, my colleagues and I sought to determine just how intrusive ship engines are on the Arctic soundscape and whether or not there are any changes ships can make to improve the aural environment for wildlife there.

Marine mammals and fish make a variety of sounds for a variety of purposes. Bowhead whale songs intended to attract mates are complex and broadband. Other vocalizations (to navigate, for example) fall in a narrower range. Beluga whale vocalizations are highly variable, with tonal sounds and echolocation clicks in different sound ranges. Bearded seals also emit several different call types and fish have their own suite of grunts and pulses.

Audiograms (hearing profiles) of marine mammals and fish show that their hearing ranges often overlap with those of vessel noise, which can "mask" the animal calls from their intended recipients. Think of the difficulty of hearing a friend at a noisy party compared to at the library – except that loud vessel noise can potentially mask vocalizations over a much larger area than your local library.

Unfortunately, routing ships away from areas heavily used by marine mammals is often not an option in the Canadian Arctic. Most traffic there follows fixed southern routes along the mainland.



Map of the study region, showing the prospective sail track for future vessel traffic (red line) that was modelled, and the corresponding reduction in listening spaces expected for beluga whales with distance from those sail tracks. These maps are from a container vessel underway at 25 knots under median noise conditions (the 50th percentile ambient level between August and September 2015). Courtesy of WCS.

Vessel transits through Canada's Northwest Passage have increased from four per year in the 1980s to as many as 30 per year. With ship traffic steadily growing in Arctic waters, our WCS Canada research team, in close collaboration with JASCO Applied Sciences and the University of Victoria, decided to investigate whether reducing vessel speeds could lower the impact of ship noise.

In our study, we chose to focus on "*listening space*" — essentially, the volume of ocean within which the listener can detect biologically important sounds. We then measured the impact of ship noise on the size (radius) of this space.

Calculating the amount by which ship noise reduces the size of an animal's listening space requires an understanding of how well a call or sound travels through Arctic waters, the change in masking noise levels (from vessels), and the species' audiogram. The overlap in sound frequency (perceived as "pitch") for each of these factors is the key.

Our listening areas were selected based on areas known to attract bowhead and beluga whales, as well as bearded and ringed seals (fish species were assumed to occur at all sites).

We found that vessel speed reductions significantly reduced loss of listening space. Under quiet conditions, beluga whales experienced a 50 percent listening space loss when they were 7 to 14 kilometres (4.3 to 8.7 miles) away from a ship travelling at 25 knots. When ships slowed to 15 knots, whales could get as close as 2 to 4 kilometres before they experienced the same loss of listening space.

In other words, when a ship was going faster, the area over which it cut a beluga's listening space in half might be more than three times larger. This difference is important because there are many places where whales cannot distance themselves from ships in the Arctic (in the narrow Prince of Wales Strait, animals can maintain a maximum distance of just 7 to 10 kilometres).

We also found that slowing vessels will have even larger benefits when ambient noise is higher and ships are farther away. This finding is especially important since ambient noise from waves and winds is increasing in an Arctic environment that is experiencing ever longer periods without sound-dampening ice.

The Arctic Council has been grappling with the implications of increased shipping operations in the Arctic in areas with high marine mammal densities. Our research finds that vessel slowdowns could indeed be a viable strategy for lowering noise impacts on whales, seals, and fish, with the added benefit of reducing the likelihood of collisions.

While negotiating the Northwest Passage may be less treacherous in the future for cruise ship passengers who thrill at the sight of whales plunging through Arctic waters, melting ice that opens up new sea lanes comes with a new threat for marine life. As we grow sensitive to plastics and other toxins that plague ocean species, we must remember that while noise is the one form of pollution that we cannot see, we can work together to turn down the volume.

WCS Canada researchers Dr. Matt Pine and Dr. William Halliday return to shore after retrieving an underwater acoustic recorder in the Prince of Wales Strait in 2018. These recorders provide data on natural background sounds, marine mammal activity, and vocalizing fish that are uploaded directly into predictive noise effects models. Photo credit: WCS Canada.

Reproduced from Taking it slow can help reduce impacts of Arctic shipping on whales (commentary) https://news.mongabay.com/2018/08/taking-it-slow-can-help-reduce-impacts-of-arctic-shipping-on-whales-commentary.

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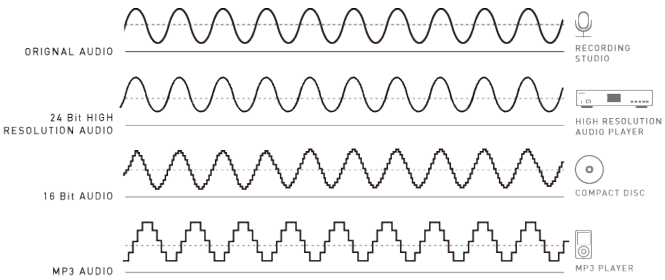
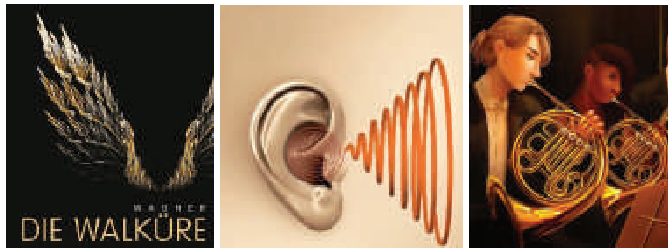


The paper "Good Sound, Good Research: How Audio Quality Influences Perceptions of the Research and Researcher" was recently published in Science Communication. In the study, the researchers played identical conference talks and radio interviews in high- or low-quality audio and asked people to evaluate the research presented. For further information see http://journals.sagepub.com/doi/abs/10.1177/1075547018759345?journalCode=scxb&

Viola player wins Royal Opera House case for hearing damage



The Guardian has reported that classical musician Christopher Goldscheider's has won a landmark case for damages against the Royal Opera House after claiming his hearing was irreparably damaged by the horn section during a thunderous rendition of Wagner's Ring Cycle. In the first case of its kind (in the UK), Christopher Goldscheider, a viola player, claimed he was exposed to unacceptable noise levels in the pit at Covent Garden as the orchestra rehearsed Die Walküre (The Valkyrie) in 2012. Goldscheider, 45, said he suffered "*acoustic shock*"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after a blast from the 18-strong brass section, situated directly behind him, caused the overall volume in the pit to reach at least 137 decibels. Justice Nicola Davies ruled in his favour on the issues of breach of duty and causation of injury, with damages to be assessed. Goldscheider's claim for lost earnings alone is £750,000. The decision leaves insurers for the Royal Opera House responsible for a £750,000 compensation claim, and legal costs in addition, an urgent need to rethink its policies and procedures, a possible re-design of 'The Pit', and probable claims against them by other musicians.

New EPA (NSW) noise policy publication

The New South Wales Environmental Protection Agency (EPA) has published the Noise Policy for Industry, replacing the existing Industrial Noise Policy, to ensure that the policy settings for the EPA's regulation of noise from large, complex sites is up to date, clear and effective. The Noise Policy for Industry has been developed taking into account the latest scientific research and consultation with state holders. For More information sett http://www.epa.nsw.gov.au/publications/noise/17p0524-noisepolicy-for-industry

Sound wave-based printing could be a game changer

Liquid droplets are used for many applications, from printing ink on paper to creating microcapsules for drug delivery. But the most common droplet patterning technique, inkjet printing, is limited to liquids roughly 10 times more viscous than water. That doesn't work for other areas of research interest such as bio-pharmaceuticals and bio-printing: biopolymer and cell-laden solutions are at least 100 times more viscous than water. Some sugar-based biopolymers with a honey-like consistency are even 25,000 times more viscous than water. Add this to the fact that fluid viscosity changes dramatically with temperature and composition, and it's clear that an alternate solution is needed. Harvard University researchers have addressed that challenge with a new printing method that relies upon sound waves to generate liquid droplets. "*Our goal was to take viscosity out of the picture by developing a printing system that is independent from the material properties of the fluid,*" said Daniele Foresti, a materials science and mechanical engineering researcher who served as first author of a paper on the research.

While sound waves have been used to defy gravity (see the previous issue of this Journal for a demonstration of acoustic levitation), the researchers used them instead to assist gravity. Any liquid can drip because of gravity, but the rate and size of the droplet is difficult to control. Pitch, the sticky resinous substance used for waterproofing, has a viscosity of roughly 200 billion times that of water — and, as a result, it drips at the rate of one drop per decade. But through the use of a sub-wavelength acoustic resonator that generated a force exceeding 100 times normal gravitation, the team was able to pull droplets of specific sizes from the tip of a printer nozzle and eject them toward a printing target. Using higher amplitude sound waves resulted in smaller droplet sizes, and the success of the technique was not hampered by the viscosity of the liquid.

"*The idea is to generate an acoustic field that literally detaches tiny droplets from the nozzle, much like picking apples from a tree,*" explained Foresti.

The researchers dubbed their new technique "acoustophoretic printing," and they tested it on a wide range of materials from honey to stem-cell inks, biopolymers, optical resins and even liquid metals. The method is safe to use with sensitive biological cargo such as living cells or proteins, because the sound waves don't travel through the droplet. This technique could be a game-changer for a number of industries, enabling the manufacture of new biopharmaceuticals, cosmetics and food, and expanding the possibilities of optical and conductive materials.

Why we can't hear our footsteps

You're walking down a deserted street and suddenly you hear footsteps. Someone might be following you, you think. Because, although the street is quiet, your own footsteps would never register with you — just those of a stranger's. So why is it we can't hear the noises we make ourselves?

Scientists have long known that we are capable of tuning out our own personal noises, but were previously in the dark about how the brain accomplishes this feat, exactly. The results of a new study, published in the journal Nature, aims to amp up our understanding of this phenomenon by focusing on footsteps.

"*We wanted to understand how the individual cells in our brains – our neurons – work together to make that happen,*" lead researcher Dr. David Schneider, an assistant professor with the Center for Neural Science at New York University (NYU), explains in an email. "*To do that, we studied mouse brains. And we built an augmented reality system so that when mice ran, we could experimentally control the sounds they heard. We could give them a couple of days with their walking making one sound, then we could unexpectedly switch the sound.*"

Research was conducted at Duke University's School of Medicine. The scientists soon discovered that when the mice expected their walking to sound a particular way, the neurons in the auditory cortex (one of the main hearing centres of the brain) stopped responding to the noise. "*It was almost like they were wearing special headphones that could filter out the sound of their own movements,*" Schneider explains. "*In contrast, when we played an unexpected sound, neurons in their auditory cortex had large responses.*"

The scientists soon realized that, as the mice were becoming familiar with the sounds of their own walking, there were some important connections being changed between the auditory cortex and the motor cortex, which is the part of the brain responsible for moving.

"*The connections strengthen onto inhibitory neurons in the auditory cortex that are active when the mouse heard the footstep sound,*" Schneider says. "*The end result was that every time the mouse walked, a group of inhibitory neurons were active to create a photo-negative of the sound the mouse expected, which could cancel out the expected sound when it was heard.*"

Sounding the alarm on aquatic noise

A collaborative team led by University of Victoria doctoral student Hakai Scholar Kieran Cox and fish ecologist Francis Juanes has found that human-caused noise is changing the ability of fish to forage, reproduce and avoid predation. The team analyzed 42 studies from across the globe on the effects of aquatic noise on fish behaviour and physiology and found anthropogenic noise to be the most compromising factor affecting the ability of fish to feed, avoid predators and reproduce. "*Fish understand their environment through sound*," says Cox. "*Mining activities and sea vessels interfere with what they need to hear in order to thrive. The results indicate that fish are stressed and have difficulty hearing over the noise.*" The paper, 'Sound the alarm: A meta-analysis on the effect of aquatic noise on fish behaviour and physiology', can be read in the journal Global Change Biology. Juanes is involved in another UVic research project announced last week that will study the impact of underwater noise on British Columbia's Southern Resident Killer Whale population and the whales' primary food fish, chinook salmon.

Asona wins Waste Minimisation Fund grant to recycle ceiling panels

Congratulations to Asona who have won a Waste Minimisation Fund grant to recycle ceiling panels. Asona Ltd is a New Zealand manufacturer of acoustic ceiling and wall panels serving the commercial interior construction market. Ceiling panels are used as a decorative finish and to control unwanted noise in schools, offices, retail, hospitality and civic buildings.

Answers

To the Acoustics Quiz (on page 23)

A1 Bioacoustics is the scientific study of the hearing and calls of animals, as well as how animals are affected by the acoustics and sounds of their habitat such as the ocean.

A2 Yes, the white (power) spectrum is flat.

A3 The Medwin Formula is the formula to solve the speed of sound in water.

A4 The approximate speed of sound in salt water is 1520m/s @ 21 degrees C.

A5 Alexander Graham Bell.

A6 The Fresnel number (F), named after the physicist Augustin-Jean Fresnel is a dimensionless number which is used in acoustics relating to outdoor barrier attenuation, the Fresnel number expressed as $N = 2d/\lambda$ where N = Fresnel number (dimensionless) d = source to receiver distance and λ = wavelength of the sound.

A7 False. Snell's law is also known as the law of refraction not reflection.

A8 The free-field region is where sound propagates free from any form of obstruction i.e. no reflection.

A9 True, Loudness unlike level or intensity, which are physical or objective quantities, is a listener's subjective perception of the sound level

A10 Pitch depends primarily upon the frequency of the sound stimulus, but it also depends upon the sound pressure and waveform of the stimulus. It is important to note Pitch is the subjective response to frequency.

A11 The range humans are most sensitive to is 1 to 5 kHz, the area where consonants or beginning of words are located, making it easier to detect the beginning of a word.

A12 Binaural is having or relating to two ears.

A13 The Franssen effect is an auditory illusion where the listener incorrectly localizes a sound. The Franssen Effect can be a very impressive demonstration in a live room.

A14 In a noisy environment, the Lombard or Cafe effect is the instinctive tendency of speakers to increase their vocal effort when speaking in (loud) noise to enhance the audibility of their voice.

A15 Direct Drive Hearing System is a conventional hearing aid which operates by amplifying sound and delivering the sound to the eardrum.

A16 Misophonia literally means "*hatred of sound*".

A17 Most people don't like to hear the sound of their own voice because it normally gets filtered out by our brain. When listening to a recording of your voice, you may wonder: Do I really sound like that?

A18 True, permanent hearing loss can occur suddenly if a person is exposed to very loud impact or explosive sounds. This type of damage is known as acoustic trauma.

A19 Over protection refers to the selection and wearing of hearing protection with unnecessarily high attenuation.

A20 SIL is a calculated quantity providing a guide to the interference of a noise with the reception of speech. It is the arithmetic average of the mid-frequency (500, 1000, 2000 Hz) octave band levels of the interfering noise.

Future Events

2019

13-17 May, Louisville, Kentucky, USA. 177th Meeting of the Acoustical Society of America
www.acousticalsociety.org

12-14 June, Lisbon, Portugal. International Conference on Wind Turbine Noise (WTN2019)
www.windturbinenoise.eu/content/conferences/8-wind-turbine-noise-2019

16-19 June 2019, Madrid, Spain. 48th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2019)
https://internoise2019.org

24-27 June, Toru, Poland (ICA Endorsement). 14th School on Acousto-Optics and Applications
https://saoa.fizyka.umk.pl

7-11 July, Montreal, Canada. 26th International Congress on Sound and Vibration (ICSV26)
www.icsv26.org

8-13 September 2019, Aachen, Germany. 23rd International Congress on Acoustics (ICA 2019)
www.ica2019.org

13-17 September, Detmold, Germany. International Symposium on Musical Acoustics (ISMA 2019)
www.isma2019.de

15-17 September, Amsterdam, Netherlands. International Symposium on Room Acoustics (ISRA 2019)
www.isra2019.eu

30 November - 6 December, San Diego, California. 178th Meeting of the Acoustical Society of America
www.acousticalsociety.org

2020

11-15 May, Chicago, Illinois. 179th Meeting of the Acoustical Society of America
www.acousticalsociety.org

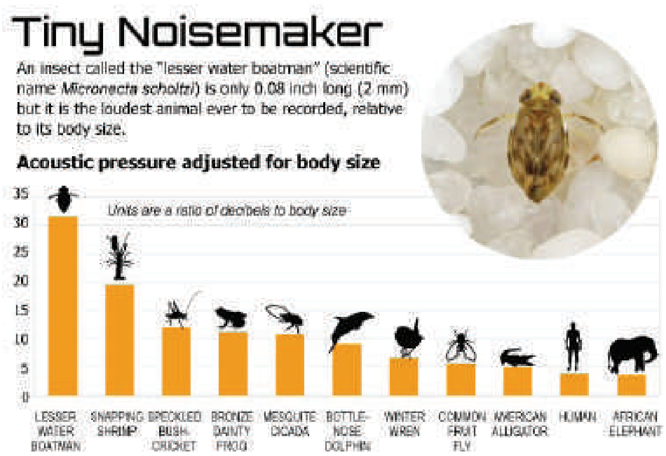
15-18 June, Karolinska Institutet, Stockholm, Sweden. 13th ICBEN Congress on Noise as a Public Health Problem
www.ICBEN2020

Over time they become soiled and after an average usable life of 5-15 years they are consigned to landfill.

Neil Ridgway, Managing Director of Asona Ltd has welcomed the Hon. James Shaw, Co-leader of the Green Party & Minister for Climate Change to Asona's Penrose factory today (24 October 2018) during which the Minister announced a grant from the Waste Minimisation Fund to assist Asona to develop its ceiling panel recycle & renew program. "*We are honoured to receive this grant and very excited by the potential our project will bring to the New Zealand ceilings market*" said Neil Ridgway. The project aims to provide a cost-effective system to refurbish soiled and damaged ceiling panels with new decorative finishes and have them reused in commercial buildings. The outcome of which will extend the useful life of the ceiling and reduce landfill waste. Currently there are over one million square-metres of ceilings being imported annually, a significant proportion of which are to replace panels demolished during building refurbishment and refit.

Ultrasonic waves

Live Science recently interviewed Professor Timothy Leighton, from the University of Southampton in England, to discuss the prevalence of ultrasonic sounds surrounding us. Professor Leighton spoke about his work at the 175th meeting of the Acoustical Society of America. Ultrasonics are not well-defined Professor Leighton said in an interview with Live Science before his talk. In theory, Professor Leighton said, they're sounds that are too high-pitched for people to hear. But in practice, they're sounds that are right on the edge of hearing for infants, young people, some adult women and other groups with particularly acute hearing. And for those people, ultrasonics represent a growing problem that is not well studied or well understood. A number of people were coming to me, and they were saying, '*I feel ill in certain buildings*', Leighton said. "*No one else can hear it, and I've been to my doctor, and I've been to have my hearing checked. And everybody says it's in my mind; I'm making it up.*" Part of the problem, according to Leighton, is that very few researchers are studying this issue. Professor Leighton was one of two co-chairs of an invited session on high-frequency sound at the ASA meeting & has received The Royal Society's Clifford Paterson Medal for separate research into underwater acoustics.



Directory of New Zealand Acoustics Advertisers

Publication Dates and Deadlines

New Zealand Acoustics aims for least three issues per year, in April, August and December.

The deadline for material for inclusion in the journal is the 1st of each publication month, although long articles should ideally be received at least 4 weeks prior to this.

Advertising

Enquiries regarding advertising are welcome. For a list of current prices and any further information please contact: advertising@acoustics.org.nz

Society Membership

Affiliate Membership of the Acoustical Society of New Zealand is open to anybody interested in acoustics. Members receive benefits including:

- Direct notification of upcoming local events
- Regular mailing of Noise News International
- Reduced charges for local and national Society events
- Priority space allocation for trade stands at Society events
- Discounted rates on selected acoustic products

To join the Society, visit www.acoustics.org.nz or contact the Secretary: secretary@acoustics.org.nz