Marine Science Co-ordination Committee (MSCC)
Underwater Sound Forum

Meeting minutes
25th November 2020, 13.00 – 16.15 (virtual)

Meeting Attendees

Chair
Peter Liss …… UEA

Attendees
Adrian Farcas …… Cefas
Alan Curtis …… Thales UK
Alison Brand …… University of Aberdeen/Manta Environmental Ltd
Amanda Hyam …… Seiche Ltd
Amy McHugh …… BEIS
Andrew Brownlow …… SMASS
Andrew Logie …… Innogy Renewables UK
Andy Smerdon …… Aquatec Group
Angela Lowe …… Medley Marine Ltd
Anna Luff …… GoBe Consultants Ltd
Anthony Hawkins …… Loughline Ltd
Brett Marmo …… Xi Engineering Consultants
Caroline Brown …… OGUK
Christina Platt …… Wildlife Trust
Claire Ludgate …… Natural England
Clare Munson …… Conor Tickner …… AECOM
Craig Stenton …… Edinburgh Napier
David Hedgeland …… BP UK
David Hughes …… QinetiQ
David Wrighton …… NPL
Dick Hazelwood …… R & V Hazelwood
Denise Risch …… SAMS
Delphine Byford …… MOD
Duncan Williams …… Dstl
Ed Bolger …… Edinburgh Napier
Ed Harland …… Chickerell BioAcoustics
Elaine Tate …… Marine Scotland
Elena San Martin …… ABPmer
Ellen White …… University of Southampton
Francesca Marubini …… Harley Anderson Ltd
Frank Thomsen …… DHI
Gemma Starmore …… Royal Haskoning
George Taylor …… UKHO
Greg DeCelles …… Ørsted
Guillermo Jiménez Arranz …… Seiche Ltd
Hannah Millar …… Scottish Government
Hannah Towner …… MMO
Harriet Bolt …… UKHO
Harriet Rushton …… MOD

Helen Currie …… University of Southampton
Holly Self …… Natural Resources Wales
Isla Keesje Davidson …… University of Bristol
Jake Ward …… NPL
James Brocklehurst …… RSK
Janelle Braithwaite …… Scottish Government
Jayne Burns …… Scottish Government
Jennifer Brack …… Ørsted
John McKiernan …… Platform 7
Jonathan Gordon …… University of St Andrews
Josh Pysanczyn …… University of Exeter
Julie Cook …… BEIS
Julie Oswald …… University of St Andrews
Karen Diele …… Edinburgh Napier
Kerry Marten …… HR Wallingford
Ken Collins …… University of Southampton
Kirsty Wright …… Scottish Government
Lily Burke …… Scottish Government
Liz Sandeman …… Marine Connection
Lucille Chapuis …… University of Exeter
Maja Nimak-Wood …… Cefas
Mark Calverley …… Blue Ocean Consulting
Martin Lilley …… Defra
Matthew Wale …… Edinburgh Napier
Michael Ainslie …… JASCO
Michele Halvorsen …… CSA Ocean Sciences
Nathan Merchant …… Cefas
Nicholas Chotiros …… University of Texas/NOC
Nicola Harris …… Seiche Ltd
Nienke van Geel …… SAMS
Nicholas Morley …… Intertek
Nikhil Banda …… Seiche Ltd
Niki Piesinger ……
Onno Grefen …… Netherlands Ministry of Defence
Paul White …… University of Southampton
Peter Tyack …… University of St Andrews
Phil Johnston …… Seiche Ltd
Phil New …… GoBe Consultants Ltd
Rachel Antill …… APEM Ltd
Rebecca Faulkner …… Cefas
Rebecca Reed …… MMO
Rebecca Walker …… Natural England
Rene Dekeling …… Netherlands Ministry of Defence
Robert Laws …… Havakustick Ltd
Robert Lees …… Gardline
Ros Putland …… Cefas
Ross Compton …… IAGC
Ross Gardiner …… Scottish Government
Rosy Jones ……
Rute Portugal …… Gardline

Ryan Mowat …… RS Aqua
Sarah Canning …… JNCC
Sarah Marley …… University of Portsmouth
Sonia Mendes …… JNCC
Sophie Nedelec …… University of Exeter
Søren Enghoff …… Ørsted
Stephen Robinson …… NPL
Steve Simpson …… University of Exeter
Terry Sloane …… Planet Ocean Ltd
Tessa McGarry …… RPS Group
Tim Mason …… Subacoustech Environmental
Tom Benson …… HR Wallingford
Tom Stringell …… Natural Resources Wales
Victor Humphrey …… University of Southampton
Vincent Janik …… University of St Andrews
Yvonne Mather …… Dstl
Rod Jones …… MOD - NCHQ

Secretariat
Abigail Marshall …… MSCC/NOC

Apologies
Chris Pierpoint …… Seiche Ltd
Fiona McNie …… Natural England
Gaynor Evans …… BODC
Katie Whitlock …… Environment Agency
Marcus Donnelly …… SEA

I. Welcome & Apologies

Peter Liss (PL) thanked all the USF members for joining the first ever virtual USF meeting. PL was encouraged by the 100+ members who joined.

II. Previous Minutes & Actions

PL asked if members had any feedback or changes to the minutes from the USF meeting in November 2019. The members agreed the minutes to be a true and accurate reflection of the USF meeting on 20th November 2019.

III. General Presentations – Part 1

a. Some trends in low-frequency deep-ocean noise in the last 15 years
Stephen Robinson, NPL

Stephen Robinson (SR) gave an introduction of hydroacoustic data from the International Monitoring System under the CTBTO, including 11 data stations in all major ocean basins, which are suitable for long term trend analysis. Analysis of Wake Island (2008 – 2020) and Cape Leeuwin (2003 – 2020) hydrophones were used for the presentation.

Due to the size of the data (4.5 Tb per hydrophone), data extraction is time consuming and therefore requires parallel computing. Data analysis included separating into frequency bands, sound pressure calculations and removal of non-acoustic outliers (e.g. electrical spikes and calibration tones). Low percentiles were indicative of events far away from the hydrophone and high percentiles were indicative of events close to the hydrophone.

Across the different frequency bands from the hydroacoustic data in Cape Leeuwin, most showed seasonal variation with the lowest band likely to be geophysical and less influence from anthropogenic sources such as shipping. Long term changes were compared to climate variables (e.g. sea surface temperature, ice coverage) with causes being linked to changes in the source, environment propagation and potentially a drift in sensitivity of instrumentation. Hydroacoustic data from Wake Island also showed seasonal variations but becoming more saw-tooth in time and larger in amplitude. The 20 Hz signals were likely to be caused by baleen wales. Impact of Covid-19 on noise is currently unknown as more information is needed.

Attendees asked a range of questions. Firstly it was asked if particle motion was monitored, SR agreed that while particle motion is important it is as of yet unable to be analysed. Secondly it was asked whether patterns in whales had been cross referenced. SR was keen to do that but has yet to have had the chance. Finally, questions around impacts of fishing activity were asked. SR said shipping traffic was known, but not specific to fishing. Given the hydrophone is over 1000 m down, it is unlikely to be sensitive to individual ships.

b. To blow or not to blow? Ask EDGAR (Explosives use in Decommissioning – Guide for Assessment of Risk)

Alison Brand, University of Aberdeen

Alison Brand (AB) gave an overview of Explosives use in Decommissioning – Guide for Assessment of Risk (EDGAR), a model for understanding the harmful impacts of sound. Sound pressure and sound exposure are important for characterising potential effects of sound. Looking across different models used in risk assessment for sound, EDGAR aims to be fit-for-purpose, simple, transparent and user friendly.

During an explosion, a bubble forms, collapses, reforms, collapses and so on until it completely collapses. Peak pressure is determined from explosives and the curve decays exponentially. EDGAR is designed for the UK continental shelf. Underwater noise impact analysis (e.g. number of animals impacted per species) within EDGAR is determined by parameters such as location, activity, explosive characteristics, marine mammal population, where the charge weight is the most important. EDGAR fits between two models, the Marsh-Schulkin and Nedwell, which are the upper and lower limits of predictions.

Analysis of EDGAR showed a small relative bias (~1%) when analysing sound pressure level and sound exposure level. The model calculates impact radii across different animals and gives a marine mammal risk assessment.

One attendee asked about how the model could be used for UXO clearance. AB suggested she was keen to try that but the right data is not currently available.

Another attendee asked about motion on the seabed and how that was captured. AB stated the data is limited and so the model is based on the best available data. A book on computational ocean acoustics was recommended to AB due to data from a military trial, which may be of interest.

c. Seasonal and decade-term trends in ocean sound level
Michael Ainslie, JASCO

Michael Ainslie (MA) spoke of ocean ambient sound from shipping and baleen whales, which provide a low frequency soundscape of the North East (NE) Pacific. Between the 1960s and 1990s, noise levels in the NE Pacific increased by approximately 10 dB. Two questions exist, what is the 10 dB made of (3 dB expected from shipping, the other 7 dB is unaccounted for), and why has there been a levelling off since the mid1990s despite the increase in shipping.

High frequency sounds are likely to be attributed to due to large tonnage ships (3 – 8 dB increase) but the 10 dB increase seen in the NE Pacific is not in the shipping band. Low frequency is likely to be attributed to blue whales that migrate north along the west coast of America. Records show there was a period where the blue whale population was increasing by 6% per year – if this was the case for every year over the 1960s – 1990s (where the 10 dB was seen) then the noise increase could be due the increased blue whale population. Given the population has not grown since the Return to agenda 1990s, this could be why noise levels have been levelling off. Seasonal dependence (e.g. sea surface temperature – afternoon effect) is also a consideration.

Attendees discussed the potential changes in the Atlantic, but no data is available from the CTBTO as recordings only started in 2002 and no other sound data in the Atlantic is known of. Another attendee asked whether ships have been overestimated given they only make noise whilst moving and data is often number of ships rather than time at sea. MA said he does not have that detail of data, though it would be useful.

d. Acoustic Baseline Monitoring of Marine Mammals off São Tomé and Príncipe, West Africa by AutoNaut USV
Phil Johnston, Autonaut/Seiche Ltd

Phil Johnston (PJ) gave an overview of a project that Seiche Ltd did on behalf of BP to improve the understanding of marine mammal presence and movements offshore of São Tomé and Príncipe using fixed passive acoustic recorders and an uncrewed surface vehicle (USV).

An overview was given of potential data acquisition platforms, particularly new technology such as USVs, buoyancy gliders, autonomous underwater vehicles (AUVs) and unmanned aerial vehicles (UAVs), all of which can be used for passive acoustic monitoring (PAM).

AutoNaut USV was used as it is quiet, zero fuel, cost saving, minimal carbon footprint, reduced exposure to risk with fewer personnel required, works through all weather, good navigation control, good track record and has a PAM integration set up (USV/MicroPAM system).

The area surveyed for this project covered 6,800 km2 in mostly deep water (2000 – 3000 m) in a zigzag transect. Continuous sound recording can be for up to 90 days (recording days ranged from 16 – 33 days for this particular survey) and was set to target certain species vocalisations (e.g. humpback whale, other baleen whales, sperm whale, delphinid spp., beaked whales). Some operational challenges included unpredictable surface currents, flat seas (energy is needed from sea chop), cloud cover, rapid bio-fouling.

An attendee asked about regulatory approvals using an unmanned vessel, especially if there are high volumes of shipping. PJ said they follow a code of conduct (international), worked with the local authority and that the USV has an AIS so ships will be aware it is in the water. Another attendee asked about the outcomes of the project. PJ said there was a suite of results, but the papers are currently in press – PJ commented he would be happy to share the results at another USF meeting when the papers have been published.

IV. General Presentations – Part 2

a. The importance of particle motion to fishes and invertebrates

Tony Hawkins, Loughine Ltd

Tony Hawkins (TH) gave an overview of particle pressure motion (vector) compared to sound pressure (scalar), citing the sensitivity of fishes and invertebrates to particle motion as opposed to sound pressure given fish use particle motion to determine sound direction. While particle motion can be determined from sound pressure in freefield conditions, the relationship does not always apply near the source, the sea surface or the substrate.

An overview of historical sea experiments was given, with results showing salmon and dab being sensitive to particle motion whereas cod can also detect sound pressure. An overview of tank experiments was also provided, for example where sound pressure and particle pressure hydrophones are used, or by the use of vibrating tables.

Hair cells within fish are connected to the otoliths, which are connected by nerves to the brain. The hair cells are orientated in different directions and therefore can determine sound direction. Sound pressure is detected via the swim bladder.

Many invertebrates seem to be more impacted by particle motion than sound pressure. Many potential effects of sound (e.g. death, physiological effects, behavioural responses) exist through particle motion rather than sound pressure. It was cautioned that particle motion is often not considered when setting sound exposure criteria and assumed that sound pressure (measured) is directly related to particle motion, which is not the case at the sea surface or substrate. This lack of consideration is particularly worrying given the many noisy human activities going on.

A meeting on 'The Effects of Noise on Aquatic Life' is set for Berlin 10 – 15th July 2022, where particle motion will be considered.

An attendee asked if there is a known level of particle motion that could cause injury and whether that the amount of particle motion required for injury would be a lot higher than sound pressure, particularly for those species with sound bladders. TH

mentioned there are some experiments but there is a need to understand the levels and to monitor particle motion.

Another attendee asked about the relationship between sound level pressure and particle motion, and where that could and could not be used. TH stated it could be used in a free field, but as most fish live at the surface or seabed, the relationship starts to break down.

b. A best practice guide for underwater particle motion measurement for biological applications

Sophie Nedelec, University of Exeter

Sophie Nedelec (SN) opened her talk on a best practice guide for underwater particle motion measurement by thanking the many contributors to the guide.

Noise pollution impacts all parts of the life cycle of species on coral reefs – both directly and indirectly. Particle motion is the element of sound that is heard by the majority of ears in the ocean, many of these species are in habitats that it is difficult to record Return to agenda particle motion. Particle motion measurements are important as they impact on hearing, injury and direction information for species.

A guide is needed to ensure measurements are taken correctly, consistently and are comparable for other studies. The guide is in phase one, where an interim best practice guide was published in August 2020 with a webinar presentation done in September. The expert review is due in February 2021 with the final publication expected in April 2021.

A quick-start Guide overview was given as a 9 step process: 1. Is sound particle motion relevant and can you calculate it from pressure measurements (certain conditions)? 2. Build a team of biologists, physicists and computational programmers. 3. Pick your kit. 4. Calibrate. 5. Plan deployment to ensure representative recordings. 6. Deploy and record 7. Back up data and meta-data so it can be reused. 8. Analyse data. 9. Report data (correct, consistent, comparable) – acceleration, linear and dB units, follow SI standards.

Phase 2 plans include a field practical to put the guide to the test and to develop a standard and publish papers.

c. The nature of seismic interference waves, as may affect crabs, dabs, cockles and mussels

Dick Hazelwood, R & V Hazelwood Associates

Dick Hazelwood (DH) spoke of work conducted over the past decade to measure and explain the nature of seabed sediment vibration.

Seismic interference waves ('Ground roll waves') are generated by seabed impact that vibrate nearby water, seafloor species are sensitive to such vibrations. If a pile is driven into the seabed, different waves form such as conical sound longitudinal waves, compressional waves, sheer waves and seismic interface waves, the latter forming evanescent water waves.

Modelling the seabed to investigate waveforms where particle speed remains as a bell shape, reduces with range and cylindrical energy spreading occurs. If pressures are measured in situ and known to be due to interface waves, it may be possible to predict the motions using a hydrophone array. Work still needs to be done to test the validity of this hypothesis. Predictions on wave particle displacements at the seabed are also untested in practice.

Evidence is growing for the importance of seabed vibrations to benthic species, however given the complexity of vibrations shown in computer models, empirical studies are required to explore how seabed vibrations impact benthic species.

d. New relationships between geophysical and acoustic parameters
Nicholas Chotiros, University of Texas

Nicholas Chotiros (NC) opened the presentation by talking about how the Rayleigh reflection equation predicts a much larger angle of reflection (assuming a fluid seabed) Return to agenda compared to the measured reflection on sand suggesting Rayleigh does not work with a porous medium. The use of Biot theory and derived approximations, however, provided a better fit to the empirical data.

An overview of three types of acoustic models (fluid, visco-elastic and poro-elastic) were given, each having an increasing number of parameters. The focus of the talk was on the poro-elastic model (Biot-Stoll model), which contains both elastic and fluid propagating equations, and physically models the medium as a solid with holes where the water can move independently of the solid. The solid and fluid are, however, coupled.

The Biot-Stoll parameters can be split into three categories: bulk parameters, fluid dynamics and the elastic frame. There are a number of different relationships that can help define the 13 parameters and therefore this should be used rather than Rayleigh when dealing with reflections on porous mediums, such as a sand or silt seabed.

An attendee asked if this approach had been applied to something like the RAM model. NC stated he hadn't but advised using the OASIS model as that has the Biot-Stoll equations built in.

An attendee asked about the different sound frequencies (20 kHz, 40 kHz, 60 kHz, 80 kHz, 100 kHz) and their dispersions from the empirical study, and how dispersion is taken into account under the Rayleigh model. NC stated dispersion is not taken into account in the Rayleigh model as dispersion is typically quite small above 20 kHz, and largest between 1 – 10 kHz.

V. Next Meeting & Any Other Business

PL thanked all the speakers for their excellent presentations and the audience for joining as over 100 people attended throughout the afternoon.

PL and Abigail Marshall (AM) will put out a survey as to what the next steps will be in terms of reconvening. The USF will meet again in May but feedback as to how meetings will look moving forward will be requested