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

Meeting minutes
18th May 2021, 13.00 – 16.15 (virtual)

Meeting Attendees

Chair

Peter Liss	………	UEA

Attendees

Adrian Farcas	………	Cefas
Alison Brand	………	University of Aberdeen/Manta Environmental Ltd
Amy McHugh	………	BEIS
Andrew Logie	………	Innogy Renewables UK
Anna Prior	………	RPS
Anthony Hawkins	………	Loughline Ltd
Ben Thomas	………	Bath University
Brett Marmo	………	Xi Engineering Consultants
Carol Sparling	………	SMRU
Caroline Carter	………	NatureScot
Charlotte Miskin-Hymas	………	BODC/MEDIN
Chris Sweeting	………	MMO
Christ de Jong	………	TNO
Christina Platt	………	Wildlife Trust
Claire Ludgate	………	Natural England
Clare Embling	………	University of Plymouth
Conor Tickner	………	AECOM
Dan Jarvis	………	BDMLR
David H	………	

Denise Risch	....	SAMS
Ed Harland	....	Chickerell BioAcoustics
Eilidh Siegal	....	MMO
Ewan Edwards	....	Marine Scotland
Ellen White	....	University of Southampton
Fiona Mackintosh	....	Marine Scotland
Frank Thomsen	....	DHI
Gary Heald	....	Dstl
Hannah Millar	....	Marine Scotland
Harriet Bolt	....	UKHO
Harriet Rushton	....	MOD
Harry Harding	....	UKHO
Helen Hiley	....	
Helene Soubies	....	Xodus
Holly Self	....	NRW
Jake Ward	....	NPL
James Brocklehurst	....	RSK
James Crowcombe	....	Dstl
Janelle Braithwaite	....	Marine Scotland
Jayne Burns	....	Marine Scotland
John Goold	....	JNCC
Julie Cook	....	BEIS
Julie Oswald	....	University of St Andrews
Karen Diele	....	Edinburgh Napier
Ken Collins	....	University of Southampton
Leah Trigg	....	University of Bristol
Lucille Chapuis	....	University of Exeter
Maja Nimak-Wood	....	Cefas
Marcus Donnelly	....	SEA
Martin Lilley	....	Defra

Matthew Wale	………	Edinburgh Napier
Michael Fraser	………	ERM
Mika Peck	………	Sussex University
Natalia Lopez	………	Ørsted
Nathan Merchant	………	Cefas
Nicholas Chotiros	………	University of Texas/NOC
Nienke van Geel	………	SAMS
Nicholas Flores Martin	………	NRW
Nikhil Banda	………	Seiche Ltd
Paul Bowerman	………	Xodus
Paul White	………	University of Southampton
Peter Ward	………	Award Environmental Consultants
Phil New	………	GoBe Consultants Ltd
Rachel Antill	………	APEM Ltd
Rebecca Faulkner	………	Cefas
René Dekeling	………	Netherlands Ministry of Defence
René Smidt Lützen	………	Vysus Group
Robert Laws	………	Havakustick Ltd
Robert Lee	………	Gardline
Rod Jones	………	MOD
Ros Putland	………	Cefas
Ross Compton	………	IAGC
Ryan Mowat	………	RS Aqua
Samantha Davidson	………	Ultra Electronics CSS
Sarah Canning	………	JNCC
Sarah Marley	………	University of Portsmouth
Sei-Him Cheong	………	NPL
Simon Stephenson	………	Seiche Ltd
Sonia Mendes	………	JNCC
Stephen Cook	………	Seiche Ltd

Stephen Robinson	………	NPL
Steve Simpson	………	University of Exeter
Tessa McGarry	………	RPS Energy
Tim Mason	………	Subacoustech Environmental
Tom Stringell	………	NRW
Ursula Verfuss	………	SMRU Consulting
Victor Humphrey	………	University of Southampton
Vincent Janik	………	University of St Andrews
Yvonne Mather	………	Dstl

Secretariat

Abigail Marshall	………	MSCC/NOC

Apologies

Andy Smerdon	………	Aquatec Group
Gaynor Evans	………	BODC/NOC
Phil Gibbs	………	Swale Technologies Ltd
Rebecca Reed	………	MMO

1. **Welcome & Apologies**

Peter Liss (PL) welcomed the USF members to the second virtual USF meeting and was encouraged by the 70+ members who joined. PL spoke of the poll that was conducted across USF members last December regarding meetings moving forward. Face to face was the top choice and that will return when allowed. If a face to face meeting next time can take place, there will be an attempt to have a live link to the presentations so those who do not travel will still be able to attend.

2. **Previous Minutes & Actions**

PL asked if members had any feedback or changes to the minutes from the USF meeting in November 2020. The members agreed the minutes to be a true and accurate reflection of the USF meeting on 25th November 2020.

3. **General Presentations – Part 1**

3.1. Resonant insonified bubble curtains with different size distributions as behavioural deterrents for fish
Nicholas Flores Martin, NRW

Nicholas Martin (NM) started the presentation by describing the use of guidance technologies to divert fish away from intakes (e.g. power station cooling system), with physical deterrents most commonly used, despite their limitations. The use of combined barriers (e.g. mesh nets, bubbles, strobe lighting) can be effective. Bubble curtains have had a variable history in terms of research and though improvements have been made in recent years, resonance and coalescence are still overlooked. Small (large) bubbles pulsate with high (low) frequency, and both attenuate sound well and can be used to deter fish.

Bubble size can be altered by the nozzle and air flow speed, so the aim of this study was to test the feasibility of resonant acoustic bubble curtains as behavioural deterrents, compare resonant vs non-resonant acoustic bubble curtains and determine the stimuli responsible for common carp to be deterred. Methods described included the bubble certain, underwater speaker, use of groups of common carp, different frequencies tested (1750 Hz and 4000 Hz) and bubble size distributions.

Results showed resonant barriers were more effective than non-resonant barriers at deterring fish, when the sound was lowest and the gradient highest, the fish would turn away. Particle displacement and hydrodynamics appear to be responsible for passage rejection. Bubble size distribution is needed alongside gas flow rate and aperture size.

Two questions were raised, one asking if salinity had been taken into account and one asking about the impact of organic material that bubbles entrain in the natural environment. NM stated salinity had not been taken into account and that bubbles coated in organic materials would be dampened but no data exists to quantify that.

3.2. *The exposure and behavioural response of grey seals (Halichoerus grypus.) to shipping noise*

Leah Trigg, University of Bristol

Leah Trigg (LT) opened the presentation by stating that globally there are now 98,140 large ships resulting in an increase of low frequency noise in the ocean. Shipping density is high meaning noise is a chronic pollutant. While policy makers must mitigate, there is a need to know how much noise is being experienced and what the impact is on ocean wildlife.

Seals listening range is 50 – 80 Hz, so there is a significant overlap with ships, and they are known to react to the noise of approaching vessels. Pups are particularly vulnerable as their first water entry is independent. Seals forage on the sea floor, which is an energetic process, and sound propagation through the water column varies.

The aim of the study was to predict noise exposure of diving seals (9 adults and 9 pups) and compare to best evidence thresholds for auditory damage and how diving behaviour might be influenced. AIS ship location data was retrieved and used within the RANDI model to calculate ambient noise. GPS tracking data was retrieved from tags on the seals. An acoustic propagation model that took into account various parameters, such as sediment and water characteristics, was used to calculate sound between ships and seals.

It was found that the sound levels did not exceed thresholds for seals. Diving behaviour (e.g. dive duration, maximum depth, ascent/descent rate, bottom time, diving intervals) was assessed using a Generalised Additive Mixed Model (GAMM), focussing on before, during and after high noise events. In the English Channel, noise category and dive class were significant explanatory variables for the ascent rate. For Celtic Sea pups, noise category and dive class were significant in decent rate. The impact of small behavioural changes on individuals and populations is unknown. While the increase in low frequency sound in the ocean is not high enough to cause auditory damage, some behaviour changes have been noted.

Members asked about the impact of communication between grey seals given they are loud with low frequency. LT stated the tags did not have sound recording, though it is an interesting approach and, in the future, more sophisticated tag data and development of tags that closely link behaviour and noise levels are being considered. Another important consideration is whether the small behavioural changes impact the individuals and populations.

3.3. *Measurement of radiated underwater noise due to land-based impulsive piling at the harbour front, and impact considerations*

Nikhil Banda, Seiche Ltd

Nikhil Banda (NB) spoke about Seiche Ltd who conduct impact assessments, including the impacts of noise. Most noises are from within in the ocean, which can be very loud, but there is growing evidence of sound from operations on land, and it is important to assess the impact of sound coming from both ocean and land.

An opportunity from Denmark to measure impulsive noise arose. One high frequency (to detect clicks for the harbour porpoise) and one low frequency hydrophone was deployed 200 m off the coast, along with an underwater camera and webcam, with the noises being streamlined on YouTube. The original objective was to calculate the population density of the harbour porpoise, but it was also used opportunistically to assess the other noises.

Signals in the data appeared to show pile driving noises and signals coincided with pile driving on land where new flats were being built 900 m away. The impact assessment for the building work stated there would be no impacts underwater. This study wanted to consider that statement further.

On three days where land pile driving were recorded, SEL measurements were calculated. Two of the days were between 126 – 140 dB, one day they were up to 160 dB, which coincided with the shortest pulse length. Pile and hammer information (e.g. hammer energies, file diameter) is currently unknown. The SELs are not high or above TTS thresholds for marine mammals, but they are of concern as it is only one hydrophone over 900 m away. Sea floor and water characteristics are unknown so attenuation could only be estimated, but do not appear to impact TTS. The natural environment is noisy, but increased dB occurred particularly at 50 Hz during piling.

Future work will look to collect information on pile size, shot timings, creating a propagation model to estimate acoustic levels in the river, avoidance impact assessment for the harbour porpoise and hopefully more studies.

A number of questions and comments were put to NB:

- The importance of recording particle motion was raised, given the impact of that on fishes and invertebrates.
- The difficultly of modelling the impact of land noise underwater, despite having empirical recordings, though NB spoke of more hydrophones and geophones to allow empirical relationships between land noise and underwater noise to be determined
- Important that land noise impacts are quantified, even if the impacts are low

3.4. Windfarm constructions in Moray Firth: Unexpected variation of pile-driving noise level with pile penetration depth

Adrian Farcas, Cefas

Adrian Farcas (AF) opened by thanking colleagues who have contributed to this study. The work presented today includes a review of noise levels during the installation of pin piles for jacket foundations at two windfarms and the relationship between hammer energy and noise energy.

Piles can be installed first, then the jacket, or the other way around. For these windfarms the piles were installed first. Beatrice windfarm is 13 km from the coast, 35 – 45 m depth, 84 turbines. Four monitoring stations were deployed to record noise. Maximum noise was found to be at the beginning of the pile driving. The received SEL decreased as the hammer energy increased, and this was seen across a number of observations. Using a lined mixed effects model, the relationship between SEL and parameters were considered such as distance from source (negative), hammer energy (interestingly positive) and pile penetration (negative). Spatial models were also run, using a source level model where the hammer energy is typically assumed constant (~1%) whereas the data suggested it should vary from 1 – 10%.

Moray East windfarm data came from three monitoring stations, though the results are preliminary. Negative relationship between SEL and distance from piling, and positive relationship between SEL and hammer energy.

Hammer energy and pile penetration are correlated. Hammer energy is similar at both sites, though noise levels are ~3 dB higher at Moray East but uncertainty as to why, potentially due to the follower characteristics.

A discussion followed with some comments:

- Unusual inverse relationship between hammer energy and SEL, perhaps the vertical pile displacement or penetration per blow could be considered, though the expectation is the pile displacement should be kept constant at the site
- Stop-start is said to happen to warn animals and give them an opportunity to move away if possible before increasing hammer energy, it's interesting however that the highest SEL are at the beginning of the process
- There is the intent for energy to increase as piling continues
- In airborne piling the hammer energy increases with reduction in sound power level as pile gets further into the seabed, potential to compare datasets
- Potential changes to biological impact assessments
- Importance of monitoring particle motion

4. General Presentations – Part 2

4.1. Mud as a porous medium

Nicholas Chotiros, University of Texas & NOC

Nicholas Chotiros (NC) introduced his talk by considering mud as a porous medium, rather than how it is usually thought (i.e. a fluid), as it is saturated with seawater and supports shear waves through an elastic, fragile frame.

Mud and clay can be used interchangeable. A stack of water, alumina and silica forms an elastic solid known as a domain or tactoid, which is solid. Sodium ions (cations) hold the tactoids together, forming a larger floc. Quantifying the volume fraction in the skeletal frame and fraction of unattached solid particles suspended in the water is required. The effective density and effective porosity of the frame and pore fluid can be defined by the mixture theory. Two loss mechanisms exist: motion between frame and pore fluid (Biot theory) and creep (approximated with the same mathematical expression as squirt flow, and may be modelled as parallel Maxwell elements).

Primary input parameters are the fluid volume fraction and mean grainsize. Data can be sourced from the High-Frequency Seafloor Acoustics book to calculate inverted parameter values (solid fraction of fluid, fluid fraction of solid, HF frame bulk mod, creep relaxation frequency), other parameters computed by CREB.

Clay, silty clay and clayey slit (data taken from sites) were compared to find the best fit parameters and tested by wave speeds and attenuations. Clay has an electrostatically supported skeletal frame with a large water fraction, silt has a mechanically supported frame with a low water content. CREB has a better fit in the viscous region, VGS has a better fit in the creep region. Including the generalised squirt flow model (i.e. Maxwell elements) into the CREB model results in a better fit than CREB or VGS.

One attendee asked whether the model addresses sound speed gradient. NC stated that it does not but it could be adapted to do so, the aim of this initial work was to encourage others to consider marine mud as a porous solid because of the ionic forces that hold it together. NC also highlighted that attenuation follows different power laws depending on the frequency. Another attendee highlighted that in reality the particles will have organic coatings on them that control the surface charge, whereas this system was treated as an inorganic system. NC agreed that there is a huge amount of organic content in the mud, impacting skeletal frame, but this is a theoretical framework that should be able to accommodate organic, real-world examples.

4.2. A reference spectrum model for estimating source levels of marine shipping based on automated identification system data

Christ de Jong, TNO

Christ de Jong (CdJ) started the talk on JOMOPANS, the Joint monitoring programme for ambient noise in the North Sea, and the Canadian ECHO programme (enhancing cetacean habitat and observation). The ECHO programme has underwater listening station tetrahedral hydrophone arrays 170 m depth on inbound shipping lane to Vancouver (water depth 173 – 250m). In 2017 there was a voluntary vessel slow down. ECHO collected 1862 ship monopole source level measurements over 4 months.

Hydrophones measured the sound pressure level where the radiated noise level can be calculated (correction for distance of ship passing), though source level is a better estimate of ship noise, which can also be estimated assuming a fixed source depth.

The RANDI 3.1 model is commonly used to calculate ship source level and depends on frequency, ship speed and ship length. An alternative model is the Wales and Heitmeyer (WH02) model but depends on frequency alone. The ECHO data set was compared to the RANDI and WH02 models. The models both overestimated when frequency was below 200 Hz and underestimated when over 200 Hz. Trends in the RANDI model seemed to be present in the ECHO datasets, but both models were quite different to the data. Different ship type data also showed different relationships compared to the models, suggesting one model for all ships may not be suitable.

The RANDI model was updated to include reference speed per vessel class and to remove the correction factor. Cargo vessels with low frequency (< 100 Hz) had additional modifications to the baseline spectrum. The parameters of the updated RANDI model were fitted using the ECHO data. The updated model mean residual was <2 dB over a frequency range of 20 Hz to 20 kHz and much smaller deviations were found across the vessel classes when the model was compared to the ECHO data. Comparisons were made with other source level models but none of the studies used standardised measurements (different locations, ship populations, different measurements, analysis procedures), making spectra hard to compare and test.

A number of uncertainties were cited, included AIS data, impractical for large scale sound mapping, independent validation is hampered by the lack of standardised data.

One attendee asked about the real-world variation of the source depth for the ships and the impact on the model predictions. CdJ stated the effects of source depth mainly occur at lower frequencies but taking into account the source depth variation does not lead to less variability in ship radiant noise predictions. Another attendee asked about the low standard deviation, if that was due to directivity, but CdJ stated that is not included in the modelling. Higher levels of higher frequencies occur in the new model compared to the older models, but it is currently not known as to why.

4.3. Oscillatory whistles – the ups and downs of identifying species in passive acoustic recordings

Julie Oswald, Scottish Oceans Institute

Julie Oswald (JO) started her presentation by thanking her colleagues for their contributions to the study. This work focuses on different whistle types from dolphins. Historically the assumption has been there are underlying features in all whistles that provide species identity. This study looks at whether species information is carried in specific whistle types, focussing on short-beaked and long-beaked common dolphins. Previous work has shown significant overlap in time-frequency characteristics, the study here focuses on modulation/contour pattern shapes between species.

Sound data came from surface drifting buoys with hydrophones, visual identification of species came from visual observers, biopsy samples and aerial drones. Contours traced manually using ROCCA module in PAMGuard, with 56 variables automatically measured from each contour (e.g. frequency, slopes, inflection points). ARTwarp used to categorise contours with a similarity index of 96%.

229 whistle recordings came from more than one school, of which 74% came from both short-beaked and long-beaked common dolphins ('shared'), 14% from short-beaked common dolphins and 12% from long-beaked common dolphins (latter two 'species-specific'). For short-beaked common dolphins, nearly half were found to be oscillatory whistles, whereas only 4% of long-beaked common dolphin whistle types were found to be oscillatory. The most common shared whistle types were not oscillatory, only 1% of all whistles in shared were oscillatory. Therefore oscillatory whistles can be a helpful diagnostic of short-beaked common dolphins. Using a model to classify whistle type found: 69% correctly classified when all whistles were assessed, 64% correctly classified when shared whistles were assessed, 88% correctly classified when species-specific whistles were assessed. Therefore basing classification on species-specific whistles will give more accurate results compared to looking at all whistles from a school. Classification should therefore be focused on identifying species-specific whistle types and modulation patterns.

5. **USF and the UK Acoustics Network (UKAN)**
   Stephen Robinson, NPL

Stephen Robinson (SR) spoke of UKAN, a network funded by UKRI setup in 2017, which has a wide membership (800+ members), is very active (70+ sponsored events, 15 special interest groups, early careers, learned bodies links internationally) and produced a report in 2019 citing the value and breadth of the UK acoustic industry.

SIGUA – Special Interest Group for Underwater Acoustics – is chaired by Duncan Williams (Dstl). Monthly webinars on underwater acoustics take place with plans to have weekly podcasts/webinars. There is also an active ECR group within SIGUA.

UKAN is evolving into UKAN+ this summer. UKAN+ has many similar goals to UKAN, but a stronger focus on Equality, Diversity and Inclusion (EDI), Early Career Researchers (ECR), and increased funding to support proof of concept studies. Calls will be through the website. The focus of UKAN+ and the subgroups will feed into the UKRI/BEIS grand challenges.

A number of USF members are also part of the UKAN+. There is the potential for joint activities, such as meetings and workshops, as well as members contributing to webinars. This is an opportunity to consider what joint events could take place.

A discussion on the differences between UKAN+ and USF took place. Differences included the lack of environmental focus within UKAN+, where USF could fit, and that UKAN+ have greater visibility to a wider audience.

USF members were encouraged to reach out to Peter Liss with potential ideas on topics and ways to engage more with UKAN+ and SIGUA.

6. Next Meeting & Any Other Business

PL thanked all the speakers for their excellent presentations and the members for joining as over 80 people attended throughout the afternoon.

The USF will meet again in November, either online or kindly being hosted by the UKHO.