



The UK and Ireland Regional Student Chapter of the Society  
for Marine Mammalogy

 #UKIRSC21



# 23<sup>rd</sup>-25<sup>th</sup> June 2021

Our 15<sup>th</sup> annual conference will be hosted ONLINE  
by the Sea Mammal Research Unit

## Abstracts



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Session 1a

## Acoustics Part A

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### Temporal acoustic occurrence of sperm whales *Physeter macrocephalus* and long-finned pilot whales *Globicephala melas* off western Ireland

Cynthia Barile,

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Sperm whales *Physeter macrocephalus* and long-finned pilot whales *Globicephala melas* are the most abundant species among the community of deep-diving cetaceans occurring off the west coast of Ireland, northeast Atlantic. To address a knowledge gap on these elusive species in an area subject to increasing levels of anthropogenic noise, fixed bottom-mounted autonomous acoustic recorders were deployed from 2014 to 2016 at 13 locations. Acoustic data were collected over 2410 cumulative days, for a total of 9179 h of recordings, with sperm whale clicks and pilot whale whistles detected on 79 and 53% of the days monitored, respectively. Diel, lunar and seasonal effects on the acoustic occurrence of sperm whales and long-finned pilot whales were investigated for individual recording sites and for each recording year using generalised estimating equations. Large differences in acoustic occurrence across stations for both species highlighted the existence of more critical locations throughout the year, especially to the north of the shelf edge. Temporally, significant modulations were found for both species at all scales investigated, but the lack of consistency across the study area emphasises the need to exercise great caution when inferring general tendencies based on local patterns. The variability of spatio-temporal patterns indicates a flexibility in the distribution of sperm whales and long-finned pilot whales off the west coast of Ireland, highlighting the challenge in establishing management and mitigation measures and stressing the need of long-term, year-round monitoring.



## Acoustics Part A

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### Dolphins and Deep Learning: Automating the detection of biological and anthropogenic marine sound sources from long-term PAM data in West Scottish waters

Ellen White,

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The use of Passive acoustic Monitoring (PAM) for studying marine mammals has led to a rise in the scale of acoustic datasets. Automated detection and classification algorithms for marine mammal acoustic signals are crucial for mining 'Big data', and for use in conservation and population management. Existing methods often require knowledge of species-specific vocalisation spectral content, and focus solely on biological cues. Soundscape ecology relies on a 'whole-site' approach to the analysis of PAM data, spanning the entire bandwidth of acoustic recordings, to extract contextual information. The North Atlantic waters of West Scotland are home to many species of the delphinid family. Due to a lack of suitable abundance estimates, MPA effectiveness is not currently quantifiable for the delphinid family in this locality. Long-term PAM data from SoundTraps, collected as part of the EU INTERREG COMPASS project, record the soundscapes of 12 sites around West Scotland and Ireland. This work aims to automate the detection of delphinid species present in long-term recordings from the array of COMPASS moorings, as well as anthropogenic sound sources which contribute to localised soundscapes. Research output aims to inform marine management on the habitat use of delphinids, and provide open-source soundscape detection algorithms. Deep neural networks offer a solution for mining big data where spectral content is unknown, or variable. Using Magnitude-spectrograms fed into Convolutional Neural Networks (CNNs), the power of deep transfer learning is harnessed, coupled with the knowledge of site-specific soundscapes to build effective detection algorithms where minimal labelled training data exists. PAM data collected on a range of platforms, across variable soundscape conditions, are manually annotated for CNN development. Weighing up accuracy, computational power and speed, models are evaluated for their suitability to a long-term goal of implementation on low power autonomous vehicles for monitoring marine mammals.



Session 1a

## Acoustics Part A

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### Effects of the COVID-19 lockdown on the soundscape of a heavily used coastal bay home to a resident bottlenose dolphin population

Emma Longden,

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*University of St Andrews*

During the Spring of 2020, various lockdowns were imposed across the globe to prevent the spread of COVID-19. Economic activity decreased which led to a reduction in human-induced noise in many terrestrial and marine areas. However, in Sarasota Bay, Florida, anecdotal evidence suggests that recreational vessel use increased compared to the same season in previous years. This project aims to document changes in the soundscape of Sarasota Bay during the COVID-19 lockdown. Despite this being an unforeseen event, a rich acoustic dataset exists documenting the acoustic soundscape of Sarasota Bay owing to a hydrophone network being installed in 2017. Three hydrophone stations with the following properties will be analysed: 1) high bottlenose dolphin mother-calf use, 2) high vessel use, 3) low dolphin and vessel use. Changes in recreational vessel use will be measured using Third Octave Bands (TOBs) and quantifying the number of vessels passing hydrophone stations by visually scanning for Lloyd's Mirror patterns. The response of dolphins will be assessed by analysing patterns of whistle presence/absence before and during the lockdown period. Whistles will be further analysed to identify signature whistles: a learned, individually distinctive whistle type that broadcasts the identity of the whistle owner (Janik and Sayigh 2013). Signature whistle characteristics such as frequency properties, duration and number of loops will be modelled against ambient noise. As the owner's identity of almost all signature whistles in the population is known, comparisons between the three main social groups – nursery groups (mother-calves), juvenile groups, adult males – may be conducted to identify any differences in how social groups vocally respond to changes in ambient noise.



Session 1a

## Acoustics Part A

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### Behavioural reactions of harbour porpoises (*Phocoena phocoena*) to startle-eliciting stimuli: Movement responses and practical applications

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Acoustic deterrent devices are frequently used as a mitigation method to exclude harbour porpoises (*Phocoena phocoena*) from areas of potential harm such as wind farm construction sites. However, there is increasing evidence that the devices themselves have the capacity to cause hearing damage. Here, we investigated the response of harbour porpoises to a 15 min sequence of 200 ms sounds (peak frequency at around 10.5 kHz, 27 sounds total) which elicit the acoustic startle reflex. The duty cycle (0.6%) and sound exposure level (SEL) is significantly lower than in conventional acoustic deterrent devices. Harbour porpoises were exposed to startle sounds from a small vessel and groups were visually tracked during 13 sound exposure sequences and 11 no-sound control trials. Porpoises showed a significant avoidance reaction during sound exposure travelling to a mean distance of 1.78 km (maximum 3.21 km). In all cases, they left the area within 1 km of the sound source in the first 15 minutes after the start of the startle sequence. No avoidance was exhibited during control trials. Results are consistent with the startle reflex mediating this behaviour at low response thresholds. Our method can be used for mitigating collision risk and the risk of hearing damage from renewable energy installations, their construction and the deterrence device itself.



## Acoustics Part A

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### Temporal change in Caribbean humpback whale song

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Evidence of cultural transmission of behaviours in animals has been found in primates, birds, and cetaceans. During these transmissions' traits are passed on to other individuals, either vertically from parent to offspring, or horizontally within a generation. The song of male humpback whales (*Megaptera novaeangliae*) is stereotyped, hierarchically structured, and functions as a form of sexual selection. Song in the Caribbean is known to undergo cultural evolutions with changes occurring year to year, however comparison over large time scales is lacking. This study analysed 15 recordings of humpback whale song from 1972, 2012, 2019 and 2020 collected from the Lesser Antilles and assessed similarity temporally. Levenshtein distance analysis was undertaken to assess how similar songs and themes were from different years, and similarity index was hierarchically clustered to visualise the results. Qualitatively, themes in the 2019 and 2020 songs had been identified as similar, and when this was considered in the analysis it resulted in 3 distinct clusters: the 1972 songs as one song type, the 2012 song as a second song type, and the 2019 and 2020 songs as a third song type. Analysis at the theme level also clustered recordings from 2019 and 2020 together, implying cultural evolution occurred between breeding seasons. Comparison of the song type 2 with song type 3 resulted in no similarity between the themes, which suggests there is a high turnover rate in the Lesser Antilles over a 7 year period. These results support the evidence that cultural evolution is an observable phenomenon in humpback whale song in the Caribbean. Combining knowledge of how song evolves temporally, with how it varies geographically, could be used to help define the sub-structures within the Caribbean population, improving management of this stock.



Session 1b

## Acoustics Part B

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### Spatial and temporal distributions of sperm whales in the Balearic Sea using a Deep Learning click detector

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Wide-ranging species like sperm whales (*Physeter macrocephalus*) often adapt their spatial distribution as a response to environmental changes. Understanding which factors come into play and how they change with time is crucial to inform management decisions towards their protection. Acquiring the necessary data for these studies can be challenging in the sea, as animals only spend a fraction of their time on the surface, and visual surveys are highly dependable on weather conditions. Passive Acoustic Monitoring (PAM) is an increasingly popular tool to study marine mammals, especially in the case of sperm whales, who emit frequent and easy detectable echolocation clicks. However, PAM studies often generate huge data sets of acoustic data, and complete human analysis is becoming logistically impossible. There is therefore a growing need for automated detection and classification systems to reduce the amount of manual processing to feasible levels. This study aims to apply state-of-the-art machine learning techniques to develop an automatic detector of sperm whale echolocation clicks with precision and recall rates that make it suitable for abundance statistical analysis. For this, a neural network has been trained using both moored and towed hydrophone data containing sperm whale clicks. The output of said detector will now be used to draw inference on seasonal variations in sperm whale occupancy around the Balearic Archipelago.



## Acoustics Part B

Can common bottlenose dolphins (*Tursiops truncatus*) exhibit species recognition based on whistles alone?

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Species recognition plays an important role in sexual selection and inter-species interactions. Although the exact mechanisms differ across species, it is generally accepted that most animals can distinguish between species, presumably to avoid mal-adaptive encounters or hybridisation. In wild cetaceans, however, a surprisingly high number of hybrids have been observed, including between different delphinid genera. Additionally, whilst many dolphins use complex acoustic signals for communication, the whistles of some species often overlap in time and frequency characteristics. It has, therefore, remained unclear whether dolphins perceive whistles from other species as such. Using data from playback experiments on bottlenose dolphins (*Tursiops truncatus*), the present study aims to address this knowledge gap. Playback trials were conducted on 14 resident bottlenose dolphins in Sarasota Bay, Florida, during temporary-capture health assessments. Individuals were exposed to alternating blocks of ten whistles, from one of three species: Pantropical spotted dolphin, *Stenella attenuata*; melon-headed whale, *Peponocephala electra*; and bottlenose dolphin. The sound was played through underwater speakers, and the individual's head-turning responses were recorded. The playbacks followed a habituation-dishabituation paradigm, in which repeated whistles, (each separated by 15 seconds), were used to elicit habituation to one species. On introduction of a different species' whistle, a change in response (dishabituation) would therefore demonstrate discrimination between stimuli. Crucially, every whistle was unique, to avoid confounding individual with species recognition. Preliminary results from Wilcoxon's paired tests, comparing the dolphins' responses immediately before and after the species whistle changeover, suggest that dishabituation did occur ( $V=63$ ,  $p=0.0432$ ). Full analysis using a bootstrapping approach is underway; if further analysis corroborates these findings, this study will present novel evidence that bottlenose dolphins can discriminate between species solely using the information encoded in their whistles, independent of the whistle type being used. Future research can then investigate which acoustic parameters convey species identity.





Session 1b

## Acoustics Part B

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### Automatic classification of echolocation clicks of the Southern Resident Killer Whales (*Orcinus orca*)

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Passive acoustic monitoring (PAM) techniques have been widely used to study vocalising animals in their natural environment and automated classifiers can enhance the monitoring process by finding signals of interest in large datasets. This study presents a set of automated detectors and a trained machine learning classifier designed to identify the echolocation clicks of the endangered Southern Resident killer whales (SRKWs) from the North-eastern Pacific Ocean, using information from both individual echolocation clicks and click trains. The PAM process starts with identifying individual clicks that match a given set of acoustic properties via a detector in PAMGuard. Twenty-five features are extracted from the waveform and frequency spectrum of each click using a custom routine in Matlab and are then used as input to a random forest classifier, which was trained using equal samples of 13,000 observations for four distinct classes: SRKW clicks, Pacific white-sided dolphin clicks, vessel cavitation noise, and other sources of false alarms. This classifier has an accuracy of 85% and the acoustic recordings used for feature extraction were collected in the presence of visually confirmed marine mammals. A second independent classifier, integrated in a PAMGuard module, identifies trains of pulses and labels them as SRKW click trains based on the variations in inter-click interval and the average energy distribution in the frequency spectrum. A second classification category for vessel cavitation noise aims to identify false positive train detections with similar spectrum shapes but distinct inter-pulse intervals. Individual clicks labelled as SRKW must be part of a train with the same label, for the encounter to be validated, to minimise overall classification error. This set of tools will be used in ongoing mitigation and monitoring activities in the Salish Sea and could act as template for future classifiers for other species of toothed whales or bats.



Session 2

## Marine mammals and human interactions

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### Spatial overlap between cetaceans and shipping in the north-east Atlantic

James R Robbins,

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Shipping is on the rise globally and is well documented to have negative impacts on cetaceans. Ship strikes are of particular concern due to the potential for permanent physical injury or mortality. Despite being known as one of the busiest shipping areas in the world, little information exists on the co-occurrence of ships and cetaceans throughout the north-east Atlantic. In this study, we capitalised on a multi-year ship tracking dataset to map the spatio-temporal overlap between ten ship types and twelve cetacean species across an ocean area of 1.1 million km<sup>2</sup> between northern Spain and Norway. We also used hierarchical generalized additive models to test for changes in shipping densities through both space and time, over the period 2013-2017. Our analysis includes small cetaceans, which are often overlooked in similar modelling exercises. Overall, shipping densities increased by 52% over the study period, with the largest increase found for high-speed craft, passenger vessels, and vessels characterized by small sizes and slow speeds. Operations vessels were the only group to show reduced densities over time. Shipping traffic also showed a seasonal pattern, with highest densities during summer months. Similarly, the degree of overlap between ships and cetaceans was strongly seasonal, driven by species-specific migrations and shifts in shipping distribution and densities. Mean measures of relative overlap were highest in the English Channel (28.2% relative overlap), followed by the Irish Sea (18.1%), North Sea (13.6%), Bristol Channel (10.7%), Celtic Sea (9.0%), west coast of Scotland (8.3%), Bay of Biscay (7.1%), wider North Atlantic (3.4%), and Norwegian Sea (1.7%). Our work provides the first in-depth assessment of regional shipping activity in the north-east Atlantic, and provides an important blueprint for the management of risk to cetaceans from vessel collisions and noise exposure.





Session 2

## Marine mammals and human interactions

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### Distribution, demography and disease status of white dolphins: Combining marine strandings with genomic data to inform conservation management

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White-beaked dolphins (*Lagenorhynchus albirostris*) and Atlantic white-sided (*L. acutus*) dolphins are endemic to the North Atlantic and North Sea and represent the only members of their genus in the Atlantic Ocean. Although thought to be abundant, large data gaps remain in terms of their population structure, dietary choices, habitat use and disease status. Hence, a reliable classification of their conservation status is not yet available. Dolphins represent important indicator species in marine ecosystems and face a variety of anthropogenic threats such as contamination, entanglement and different problems resulting of warming sea surface temperatures. Therefore, assessing the status of these species is essential for understanding the health of the entire ecosystem. In this study, tissue samples from animals that have stranded on the Scottish coast will be analysed via a reduced representation sequencing (RRS) approach to investigate fine-scale genetic population structure. Further, data regarding contaminant and pathogen load as well as stomach content data derived from post-mortems will be used to investigate potential correlations between differences in these factors and population structure. Lastly, RSS and openly available whole-genome sequencing (WGS) data will be used to investigate the demographic history of both species. The results of this study should increase our overall knowledge about these species and inform conservation management about potential threats to their long-term viability.



Session 2

## Marine mammals and human interactions

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### ‘Many a mickle makes a muckle’: Considering cumulative stressors on marine mammals

Emily Hague,

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Alastair Lyndon, Teresa Fernandes & Lauren McWhinnie

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Marine mammals are vulnerable to a variety of acute and chronic anthropogenic impacts, including underwater noise disturbance, ship strike and entanglement. The effects of these impacts can vary both inter- and intra-specifically, with some populations and species more vulnerable to certain impacts. However, knowledge of the associated thresholds for disturbance, how often multiple (and simultaneous) exposures occur, how stressors interact, and ultimately what the individual and population consequences of disturbance are for marine mammals is extremely limited. As such, the approach to evaluating this within a formal Cumulative Effects Assessment (CEA) is often to consider the impacts of each stressor separately, though it is evident that assessing stressors independently does not constitute a true appraisal of their cumulative effects. We present the results of a review of >90 CEAs from eleven maritime industries considering potential cumulative impacts on marine mammals. Using an objective framework to examine the quality of each assessment allowed for comparison over time and across industries. We found inconsistency in the language used to define and describe cumulative effects, a lack of routinely applied methodology, and an overall disparity in CEA quality across industries. For >70% of CEAs the decision whether impacts were significant (and so requiring appropriate mitigation measures to be taken) was based on practitioner opinion rather than quantitative analysis. The lack of replicability, and the variation in quality between industries, raises uncertainty around the effectiveness of these assessments in preventing significant cumulative impacts to marine mammals around the UK.



Session 2

## Marine mammals and human interactions

### Modelling spatio-temporal characteristics of breeding-sites and pup production in the endangered ice-dependent Caspian seal (*Pusa caspica*)

Harrison Tan,

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Ice dependent pinnipeds are potentially vulnerable to negative impacts from climate warming in the 21st Century. Understanding the consequences of environmental change is important to meet conservation objectives. The ice-breeding Caspian seal (*Pusa caspica*) is endemic to the land-locked Caspian Sea, which lies at the current southern limit for sea ice formation in the northern hemisphere and has been identified as one of the marine mammal species with the greatest vulnerability to climate change globally. Here we use breeding distribution data from aerial surveys, remote sensing data sets, and an ice-feature tracking algorithm to construct hierarchical Bayesian models which investigate the spatial and temporal dynamics which influence pup density and breeding site use. Distribution models were constructed for 4 breeding seasons between 2008 and 2011. Within each individual breeding season and between each consecutive season there was a high degree of variability in the distribution of ice-habitat and the total amount of time where conditions remained suitable for successful breeding. We detected a non-linear relationship between pup density and ice concentration and used smooth random effects to investigate specific mechanisms which could result in the non-linearity. We found that models which accounted for the ice dependent relationship as a function of an explicit temporal mechanism scored most favourably during model selection, when compared to models which could account for non-linearity due to selection for ice concentration close to the median of the variables range. Our results demonstrate that continuity in ice breeding habitat within a season is important, and a high degree of temporal stochasticity in environmental conditions is associated with lower pup densities and lower annual pup production. This suggests that future Caspian seal population dynamics may be sensitive to projected decreases ice sheet duration and stability during the key January-March breeding period, through the coming Century.





Session 2

## Marine mammals and human interactions

### The drivers of resting behaviour in sperm whales (*Physeter macrocephalus*) in north Norway: Behavioural, environmental and anthropogenic context

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Resting behaviour, characterised by animal posture and activity, is important in both terrestrial and marine mammals. The adaptive significance of choosing when to rest, and how long to rest for, depends on several factors such as physiological state, ecological interactions (i.e., food availability or the presence of predators and competitors), and environmental conditions (i.e., light levels or temperature). Resting in marine mammals may mean animals are less vigilant, missing opportunities to forage or increasing their risk to predation. Whilst the stereotypical characteristics of resting behaviour in sperm whales have been reported widely and meet the behavioural criteria of sleep, little is known on what drives this behaviour. In this study, existing data collected using acoustic and movement tags (DTAGs) provide a unique opportunity to begin to quantify correlates of resting behaviour in sperm whales in north Norway. Solar declination, daylength and the frequency of foraging clicks/buzzes will be used as environmental and behavioural proxies respectively. Further, the study will investigate resting in relation to experimental sonar sounds, attempting to interpret what the potential impact the interruption or stimulation of resting behaviour may be. The underwater activity of 32 sperm whales were measured for a total of 414.6 hours. Twenty-nine resting dives were identified from a total of 827 functional dives. For 89.6% of recording time, tagged whales conducted dive bouts with layer-restricted search (LRS), associated with foraging. Non-foraging active (NFA) bouts accounted for 5.0% whilst bouts of resting accounted for 5.4% of recording time respectively. Understanding what drives resting behaviour in sperm whales and on their responses when exposed to sonar, will be used to improve the assessments of behavioural responses.



Session 2

## Marine mammals and human interactions

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### Does anthropogenic noise influence foraging efficiency in grey seals?

Philippa Wright,

Gordon Hastie & Chris McKnight

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Marine mammals have rigid physiological constraints imposed by the need to load oxygen at the water's surface. They must utilise their oxygen stores effectively to maximise the time spent foraging for patchily distributed prey. Any external factors that compromise the time spent foraging may reduce foraging efficiency and ultimately an individual's fitness. There is growing literature demonstrating that noise can affect the behaviour of marine mammals, which can lead to fewer successful prey captures. The physiological consequences of these behavioural responses are not fully understood. Is a decrease in prey capture offset with a reduction in oxygen consumption or does the individual incur higher energetic costs in response to the noise? This study uses existing open circuit respirometry data and foraging successes (fish eaten) from simulated foraging scenarios to quantify the energetic expenditure and foraging efficiency of five captive grey seals. The metrics were calculated for three sound treatments: 1) silent control, 2) playbacks of a tidal turbine, and 3) playbacks of pile driving. Foraging context using prey quality was investigated through high density and low density prey patches. The resulting six scenarios will bridge the gap in our understanding of the true costs of the behavioural responses to anthropogenic noise.



Session 3

## Health, physiology and genetics

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### Effects of polychlorinated biphenyls on insulin-induced Akt (PKB) phosphorylation in blubber of grey seal juveniles

Alexandra Tranganida,

Holly Armstrong, Simon Moss, Georges Scholl, Gauthier Eppe, Cathy Debier, Ailsa J Hall & Kimberley A Bennett

*Abertay University*

Grey seals (*Halichoerus grypus*) and other marine mammals, rely heavily on blubber for metabolic fuel during prolonged fasting, periods of increased energy expenditure and when food is limited. Blubber accumulates lipophilic environmental contaminants, such as persistent organic pollutants (POPs), which can alter fat tissue function. Recent research suggests that exposure to dioxin-like polychlorinated biphenyls (DL-PCBs) lead to altered metabolic profiles, including impaired glucose uptake in blubber of grey seal pups. One possible cause of the impaired glucose uptake by DL-PCBs could be altered insulin signalling. We used an explant model to investigate short exposure effects of PCBs on insulin-induced Akt phosphorylation in fat from wild juvenile grey seals. We also investigated whether animals in different physiological states experienced differences in sensitivity to insulin, and thus to POP disruption. Akt phosphorylation in matched inner and outer blubber explants from pre-moult and moulting grey seal juveniles (n = 17) was determined after an overnight exposure to control or PCB mixture-contaminated media, followed by 30 minutes in the absence / presence of insulin. Protein content of phosphorylated Akt (Ser473 and Thr308) relative to total Akt were measured by Western blot. Akt phosphorylation was activated by insulin. No significant difference in phosphorylation was observed between controls and PCB-treated samples. Akt content was higher in inner compared to outer tissue in moulting animals, suggesting higher insulin sensitivity in inner tissue. Our data suggest low dose overnight PCB exposure does not affect Akt phosphorylation in this vulnerable life history stage, but we cannot rule out possible impact of chronic exposure or higher doses.



Session 3

## Health, physiology and genetics

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### Evolution of lactation-related adaptations of Pinnipeds

David T. Orr,

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Pinnipeds have evolved extensive variation in life-history strategies since their origins around 40 Mya. Much of this variation is related to the constraints imposed by combining terrestrial parental care with marine foraging. Many of the key differences in ecology and adaptations between species are underpinned by lactation related traits, however, the genomic basis of these trait differences is still poorly understood. We assembled high quality de novo genomes for Caspian (*Pusa caspica*) and Hooded (*Cystophora cristata*) seals employing a combination of long and short read sequencing data, and with an additional 15 publicly available pinniped genomes, we derived a fully resolved phylogeny for pinnipeds and Carnivora. Using this phylogeny, we performed genome-wide scans for genes under positive selection across different Pinnipeds clades to identify candidates which may contribute to the extreme phenotypes we observe in extant species today. This analysis has identified 112 genes under positive selection in Pinnipeds, and 105 uniquely under positive selection in the Phocid lineage. Gene functional annotations suggest these candidate genes have vital roles in lipid metabolism, diving physiology, sensory perception and anatomical morphology. Many of the gene candidates (e.g., FASN, SPHK2, CSN1S1 and HMGCS2) have previously been found to influence lactation performance and milk composition in cattle and mice, suggesting that the evolution of many key life-history traits in pinnipeds is driven by selection on lipid metabolism pathways conserved across the mammalian phylogeny.



## Health, physiology and genetics

### Wearable near-infrared spectroscopy as a physiological monitoring tool for seals under anaesthesia

Eva-Maria S. Bønnelycke,

J. Chris McKnight, Gordon Hastie, Simon E. W. Moss, Ryan Milne, Alexander Ruesch & Kimberley A. Bennett

*University of St Andrews*

Chemical immobilisation of pinnipeds is a routine procedure in research and veterinary practice. Yet, there are inevitable risks associated with chemical immobilisation, and the physiological response to anaesthetic agents in pinnipeds remains poorly understood. The current study used wearable continuous-wave near-infrared spectroscopy (NIRS) data from 10 trials of prolonged anaesthesia (0.5 to 1.4 hours) induced through ketamine and midazolam in five grey seals (*Halichoerus grypus*) involved in other procedures. The aim of this study was to (1) analyse the effect of each compound on heart rate, arterial oxygen saturation (SpO<sub>2</sub>), and relative concentration changes in oxygenated [ $\Delta$ O<sub>2</sub>Hb] and deoxygenated haemoglobin [ $\Delta$ Hb] in cerebral tissue and (2) to investigate the use of NIRS as a real-time physiological monitoring tool during chemical immobilisation. Average group responses of ketamine (n = 27) and midazolam (n = 11) administrations were modelled using generalised additive mixed models (GAMM) for each dependent variable. Following ketamine and midazolam administration, [ $\Delta$ Hb] increased and [ $\Delta$ O<sub>2</sub>Hb] remained relatively stable, which was indicative of apnoea. Periods of apnoea were confirmed from respiratory band data, which were simultaneously collected during drugging trials. Given that SpO<sub>2</sub> remained at 97% during apnoea, we hypothesized that increasing cerebral [ $\Delta$ Hb] was a result of venous congestion as opposed to decreased oxygen delivery. Changes in heart rate were limited and appeared to be driven by the individual pharmacological actions of each drug. Future research should use broadband NIRS to simultaneously measure the relative change in concentration of cytochrome-c-oxidase; a measure of metabolic rate, which could guide operators in determining when apnoea should be considered prolonged if changes in [ $\Delta$ Hb] and [ $\Delta$ O<sub>2</sub>Hb] occur beyond the limits recorded in this study. Our findings support the use of NIRS as real-time physiological monitoring tool during pinniped chemical immobilisation, which could assist veterinarians and researchers in performing safe anaesthetic procedures.



Session 3

## Health, physiology and genetics

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### Population genetic structure of seals in Irish waters – Informing the delineation of appropriate Assessment Units

Kristina Steinmetz,

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Two pinnipeds species inhabit Irish waters, the grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*), both of which are listed in Annex II and V of the Habitats Directive (Council Directive 92/43/EEC). Under the EU Marine Strategy Framework Directive (2010/477/EU), Member States are required to establish environmental targets and associated state indicators, for which the identification of population structure and appropriate Assessment Units (AU) for a species is crucial. At present, both species are managed as single populations in Irish waters, however this is mostly due to lack of data rather than based on scientific evidence. Thus, this study sets out to provide the first genetic characterisation and population genetic structure analysis of both grey (n = 131-2060) and harbour seals (n = 93-401) in Irish and adjacent waters using a combination of mitochondrial (control region, up to 488bp) and nuclear markers (up to 11 microsatellites). Samples were collected in the field via non-invasive approaches in combination with sampling carcasses, as well as individuals in rehabilitation. These were augmented with data from international collaborations combining datasets for assessments at a broader geographic scale. As expected, levels of genetic structuring were lower in grey seals compared to harbour seals, which is reflective of their reproductive behaviour and dispersal patterns. However, evidence of finer scale genetic segregation was also found within Irish waters for at least one marker type for both species. These findings indicate that current management practices do not reflect the true population structure of these species in the studied area. Further considerations and recommendations for the delineation of Irish AUs for these species will be outlined during this presentation.



Session 3

## Health, physiology and genetics

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### Molecular shifts induced by hypoxia in grey seal blubber: An in vitro approach

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Joel Rocha, Ailsa Hall, James Turton & Kimberley Bennett

*Abertay University*

Grey seal blubber undergoes oxygen restriction during diving and fattening. In humans, hypoxia has been suggested to activate inflammatory markers, oxidative stress and alter fat cells metabolism. However, little is known about how seal fat copes with restricted oxygen. We prepared explants from blubber biopsy samples from 5 day post-weaned pups to investigate changes in hypoxia inducible factor (HIF 1  $\alpha$ ), lactate production and the electron transfer chain proteins (OXPHOS) during pseudohypoxia. One explant was immediately snap frozen. We mimicked hypoxia in vitro, by incubating the explants with or without CoCl<sub>2</sub> for up to 8h, collecting tissue and media every 2h for analysis. Explants showed a significant increase in HIF1 $\alpha$  protein in treated explants after 2h incubation that returned to baseline levels after 4h (LME:  $p < 0.05$ , R<sup>2</sup> marginal = 0.70, R<sup>2</sup> conditional = 0.75,  $n = 4$ ). These results suggest pseudohypoxia is successfully induced by CoCl<sub>2</sub>. Media lactate concentration ranged from 1.10 - 1.54 mmol/l (mean =  $1.32 \pm 0.09$  SD). Lactate was independent of time and treatment (LME:  $p_{\text{time}} > 0.05$ ,  $p_{\text{treatment}} > 0.05$ , R<sup>2</sup> marginal = 0.17, R<sup>2</sup> conditional = 0.17,  $n = 6$ ). Although oxygen was not limiting, pseudohypoxia drove an increase in mitochondrial complex I protein that peaked at 4h of incubation (LME:  $p < 0.05$ , R<sup>2</sup> marginal = 0.49, R<sup>2</sup> conditional = 0.49,  $n = 6$ ). No other OXPHOS complexes showed any variation. Investigation of downstream effects on inflammatory and oxidative stress markers is underway. Our results will shed light on how seals avoid detrimental effects of hypoxia.



Session 3

## Health, physiology and genetics

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### Pinnipeds as sentinels of antimicrobial resistance: An analysis of antimicrobial resistance genes from pinniped faecal samples in UK waters

Lauren Arkoosh,

Scott Cameron, Kimberley Bennett & Debbie Russell

*Abertay University*

Antimicrobial Resistance (AMR) is a pressing concern to human and animal health. Bacteria harbouring antimicrobial resistance genes (AMRG) are present in the environment, and can spread rapidly in human and industrial waste, agriculture, and aquaculture. Many of the waste products from these processes eventually make their way to river and ocean waters, providing bacteria carrying AMRG ample opportunity to disseminate. Pinnipeds are apex predators in UK waters, sampling the entirety of the water column when they forage. These animals regularly return to haul out on shore which makes their faecal matter accessible and provides a way to examine AMR in the food web and the wider environment. Previous studies have examined a limited and biased number of known pathogens for AMRG in marine mammals, resulting in a limited understanding of which specific AMRGs are present and prevalent in the marine environment. AMRG have the capacity to be transferred between bacteria, allowing genes that are not currently found in pathogenic bacteria to be identified and used as an early warning of the potential for transfer to pathogens of clinical and zoonotic concern. This work has developed a medium-throughput screen to test for the presence of 90 different AMRG of clinical and environmental importance in seal scats, independent of the bacteria they are found in to characterize the seal gut resistome. Seal telemetry data will be overlaid with AMRG profiles from grey seals from different regions to produce a predictive map of AMRG spread by seals in UK waters that can be used to model transmission risk, as a basis for monitoring environmental AMRG, and as a tool for evaluating mitigation strategies.



Session 3

## Health, physiology and genetics

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### Polychlorinated biphenyls are associated with reduced testes weights in harbour porpoises (*Phocoena phocoena*)

Rosie S. Williams,

David J. Curnick, Andrew Brownlow, Jonathan L. Barber, James Barnett, Nicholas J. Davison, Robert Deaville, Mariel ten Doeschate, Matthew Perkins, Paul D. Jepson & Susan Jobling

*Institute of Zoology at Zoological Society of London*

Polychlorinated biphenyls (PCBs) are highly toxic and persistent aquatic pollutants that are known to bioaccumulate in a variety of marine mammals. They have been associated with reduced recruitment rates and population declines in multiple species. Evidence to date documents effects of PCB exposures on female reproduction, but few studies have investigated whether PCB exposure impacts male fertility. Using blubber tissue samples of 99 adult and 168 juvenile UK-stranded harbour porpoises (*Phocoena phocoena*) collected between 1991 and 2017, here we show that PCBs exposures are associated with reduced testes weights in adults with good body condition. In animals with poor body condition, however, the impact of PCBs on testes weights was reduced, conceivably due to testes weights being limited by nutritional stress. This is the first study to investigate the relationship between PCB contaminant burden and testes weights in cetaceans and represents a substantial advance in our understanding of the relationship between PCB exposures and male reproductive biology in cetaceans. As testes weight is a strong indicator of male fertility in seasonally breeding mammals, we suggest the inclusion of such effects in population level impact assessments involving PCB exposures. Given the re-emergent PCB threat our findings are globally significant, with potentially serious implications for long-lived mammals. We show that more effective PCB controls could have a substantial impact on the reproductive health of coastal cetacean species and that management actions may need to be escalated to ensure adequate protection of the most vulnerable cetacean populations.



Session 3

## Health, physiology and genetics

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### Quantification of Domoic Acid in stranded marine mammal species around Scotland

Noah Locke,

Mariel ten Doeschate, Andrew Brownlow, Nicholas Davidson, Bernie McConnell,  
Ailsa Hall & Jo Kershaw

*University of Plymouth*

Domoic acid (DA) is a neurotoxin produced by certain toxic species of algae *Pseudo-nitzschia*, which has been found to cause amnesic shellfish poisoning in humans, and a range of neurological symptoms in marine mammals. DA is present through the marine food web, and while there have been well documented accounts of effects of DA on marine mammals such as the California Sea Lion in the Pacific, studies of its effects on animals in UK waters are limited. Since 2000, it has been observed that certain harbour seal populations around Scotland are in decline, and some studies have suggested this could be due to DA toxicity. The aim of this study is to investigate levels of DA concentration in samples taken from stranded marine mammals around Scotland between 2012 and 2019, as well as fish from similar Scottish regions between 2010 and 2019, to establish the spatial and temporal scale of DA exposure in Scottish waters. Preliminary results suggest that DA concentrations in mammal and fish species were generally higher in regions where harbour seal populations have been declining in Orkney and along the east coast of mainland Scotland. Concentrations of DA in fish were particularly high in the summer months, and exposure appeared to be similar across pelagic, benthic, and demersal species. These results indicate broad spatial and temporal exposure which could lead to effects of DA toxicity impacting a wider range of marine species around Scotland.





Session 4

## Population biology and foraging ecology

Estimates of population-level resilience in the grey seal (*Halichoerus grypus*) may be affected by the spatial scale of census data aggregation

Andrew J. Roberts,

Søs Engbo, James C. Bull, Luca Börger, Thomas B. Stringell, Kate Lock, Lisa Morgan & Owen R. Jones

*Swansea University*

A species' ability to withstand external perturbations may be characterised by quantifying its resilience. This may be estimated from annual changes in the probability of survival from one developmental stage to the next, with these rates used to construct a matrix population model. From this it is possible to calculate indices to quantify how resistant a population is to change, and how quickly a population is likely to recover from perturbation, as well as to simulate population trajectories following potential future change. Estimates of local grey seal population size are often based upon census counts of individuals on land during the pupping season, when females spend time hauled out with their pups. In all censuses, sampling method, landscape characteristics, monitoring schedule, observer experience, and sample size may affect the accuracy of estimates. Further, the spatial scale over which observations are interpreted may introduce local-scale biases to inferences made at the population level, with possible implications for conservation management decisions. Data were collected over 25 years, from 51 beaches in three known pupping areas in SW Wales. Annual pup survival rates were calculated from census surveys conducted throughout the pupping seasons, and these were compared between years, at the beach, area and regional level. Survival probability was observed to be highly variable (and poorly correlated) between beaches, with observations at less-frequently used beaches likely to introduce variability and uncertainty into wider scale population estimates. The choice of sampling sites, and the spatial scale over which observations are aggregated, is important in obtaining accurate population estimates, and will have downstream impacts upon the calculation of survival rates and resilience indices, and the projection of population trajectories.





Session 4

## Population biology and foraging ecology

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### Investigating population parameters of blue whales in the Gulf of California

Georgina Whittome,

& Philip Hammond

*University of St Andrews*

Estimating population size and dynamics over time provides a foundation for the conservation of any species. Blue whales (*Balaenoptera musculus*) remain endangered following decades of over-exploitation so robust research is critical to inform conservation management decisions. The Eastern North Pacific (ENP) sub-population of blue whales has been routinely studied in their summer feeding grounds off the coast of California. The population appears to have stabilised at ~1,500 individuals but information about the whales as they migrate south in winter is patchy. Some whales are known to travel to the Gulf of California (GoC) where a long-term photo identification study has been run since 1984 by the Mingan Island Cetacean study in collaboration with the Great Whale Conservancy. During that time, over 500 individual blue whales have been identified and this study aims to investigate the population dynamics within this group. Mark recapture methods will be used to estimate survival rate, temporary emigration/immigration rates into and out of the study area and annual estimates of abundance. Additionally, birth rates will be estimated for females in the area. The sightings histories and calving data will also be supplemented with sightings of the GoC whales off California through collaboration with the Cascadia Research Collective. Comparisons of annual abundance estimates over time will identify any trends in population size, allowing the study to confirm whether the number of blue whales in the GoC shows stability in line with the broader ENP population. Estimates of survival and birth rate could inform what is driving any trends and this insight will be shared with key stakeholders so action can be taken to ensure the future of this population.





Session 4

## Population biology and foraging ecology

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### Dietary niche overlap among pelagic dolphins in Scotland

Tessa Plint,

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*Heriot-Watt University*

The distribution of cetacean species (whales, dolphins, and porpoises) around the UK is changing in response to ocean warming and prey stock availability. Over the past three decades, sightings of warm water dolphin species (short-beaked common dolphin and striped dolphin) have become increasingly common around the British Isles. Meanwhile, sightings of cold water species (Atlantic white-sided dolphin and white-beaked dolphin) have decreased. In this study, stable carbon and nitrogen isotope ( $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ) measurements from dolphin skin samples are used as a proxy for diet to illustrate the isotopic niche of four dolphin species regularly reported from Scottish waters. Isotopic niche size and overlap (as modelled using SIBER) will elucidate generalist vs. specialist feeding behaviour and interspecific competition for resources. Our goal is to better understand the competition imposed by recent range overlap of warm and cold thermal tolerance dolphin species and to inform marine policy makers regarding the potential impact on dolphin populations.



Session 4

## Population biology and foraging ecology

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### Understanding foraging ecology of a marine predator: Drivers of feeding activity within passive acoustic monitoring derived occurrence data

Nicole Todd,

Mark Jessopp, Emer Rogan & Ailbhe Kavanagh

*University College Cork*

Understanding the distribution of marine mammals is important for effective conservation through designation of protected areas. However, most approaches to monitoring often fail to differentiate between areas used for important activities such as breeding, feeding, or resting, which may undermine conservation objectives. For echolocating cetacean species, passive acoustic monitoring can be used to differentiate between general 'occurrence' in an area, and feeding activity. This is achieved through classification of feeding buzzes, where prior to a prey capture attempt the rate of echolocation clicks drastically increases. We use a nine-year acoustic dataset from northwest Ireland and a generalised additive modelling approach to examine the spatiotemporal distribution of harbour porpoise (*Phocoena phocoena*) foraging behaviour at a range of temporal scales. Within periods when harbour porpoise were detected in the area, complex interannual and seasonal variation was found. More intensive foraging activity occurred in autumn and winter, and varied over the diel cycle with a strong preference for nocturnal foraging. Despite other studies finding a negative relationship between the occurrence of porpoise and dolphins, we found increased foraging activity when co-occurring with dolphins. Construction activity negatively influenced foraging intensity. In contrast to previous studies, tidal state did not have an effect on foraging activity across our extensive time-series. The study highlights the value of using a long acoustic time-series, showing that harbour porpoise foraging behaviour is likely site specific and more complex than previously understood. This approach, if utilised on a larger spatial scale, has the potential to identify foraging hotspots for a range of odontocete species, which would better inform marine spatial planning.



Session 4

## Population biology and foraging ecology

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### Diversification in the dietary niche of harbour seals: Evidence of competition with grey seals?

Izzy Langley,

Philip S Hammond, Paul M Thompson, Graham J Pierce, Gordon D Hastie & Debbie JF Russell

*Sea Mammal Research Unit, University of St Andrews*

Around the UK, grey seal numbers are stable or increasing alongside harbour seal populations which have declined in areas on the north and east of Scotland. Potential drivers behind this decline remain unclear, but it is possible that harbour seals have experienced increased levels of competition with grey seals. Competition can be inferred through changes to an organism's niche and so here, we investigated how the dietary niche of both species has changed through time. We used the most recent digestion correction factors and calculated diet composition from archival scat datasets; using these to estimate the dietary niche breadth of regional populations of both seal species over two decades. We also measured the overlap in their dietary niches. In the Moray Firth, harbour seals are at least 40% below their pre-2002 numbers and have shown no sign of recovery, whilst grey seals in the region have remained stable. Between 1987-2011, the dietary niche (Levins' index,  $B$ ) of harbour seals in the summer (June, July & August) was broader than grey seals each year, and increased from 1.022 in 1987 to 3.430 in 2010 (compared to 1.000 to 1.044 for grey seals). Harbour seal diet diversified from >98% sandeels in the summer of 1987 to a diet comprised of sandeels, gadids, flatfish, and pelagic species in the summer of 2010. The dietary niche overlap (Pianka index,  $O_{jk}$ ) between the species was relatively high in the Moray Firth but decreased from 0.997 (almost complete overlap) to 0.860 between 1987 and 2010. These summer months represent the harbour seal pupping season, and a time when grey seals are predominantly foraging prior to their own breeding season. It is therefore possible that harbour seals, whilst somewhat tied to breeding colonies, have broadened their summer diet in response to increased competition with grey seals.



Session 4

## Population biology and foraging ecology

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### Enigmatic apex predators: Investigating the ecology of tropical killer whales in the Indian Ocean

Maeva Terrapon,

Philip S. Hammond & Sascha K. Hooker

*University of St Andrews*

Very little is known about the ecology of killer whales (*Orcinus orca*) in tropical oceans worldwide, and more particularly in the Indian Ocean, where limited information is available and where the presence of killer whales is unpredictable. In the tropical southwest Indian Ocean, most information on their ecology is inferred from opportunistic records and in the last two decades, killer whales were reported to visit a few locations, including the Seychelles (n=6), Mozambique (n=3) and Mayotte Island (n=15). In Mayotte, seven sightings included observation of predation events and highlighted that killer whales in this region feed on a wide range of taxa, including marine mammals and elasmobranchs. However, the impact these apex predators have on prey communities in this region is difficult to assess without understanding their range and frequency of occurrence, their abundance and their diet. This study will use Passive Acoustic Monitoring (PAM) data from multiple locations (Mozambique, Mayotte, Madagascar, La Réunion, and Mauritius) to provide baseline information on the presence, distribution and seasonality of killer whales in the tropical southwest Indian Ocean, and will use opportunistic photo-identification data to determine individual movements throughout this region. To better estimate the occurrence and impact of killer whale predation on their prey, and more specifically on humpback whale populations, methods such as rake-mark analysis will be applied and contrasted with other locations. This study will, hopefully, shed light on the ecology of enigmatic tropical killer whales in the Indian Ocean and will provide baseline information on the predation pressure faced by their prey in a region where anthropogenic threats are increasing.



## Posters

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### Assessment of ovarian asymmetry and potential endpoints of reproductive toxicity in small cetaceans

Bianca Melita Palmas,

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*Galway-Mayo Institute of Technology*

Marine mammals are sentinels of ocean and human health, being top predators with long spans that present with chronic diseases, developmental disorders, and reproductive failure, as well as accumulation of lipophilic contaminants in their subdermal blubber layer. Previous studies have observed that a combination of stressors, including pollutants, nutritional and immune, could be the cause of the decline in reproductive health in small cetaceans in Irish and British waters. However, work in this regard is hindered due to the lack of evaluation of potential reproductive toxicity endpoints, resulting from a lack of understanding of normal ovarian form and function within small cetaceans. Ovarian follicular counting (oocyte quantification) has been identified as an endpoint marker for the assessment of female reproductive toxicity in humans and other mammals, where the effects of contaminants are assessed against the number of primordial and primary follicles and their potential for causing premature reproductive senescence. To undertake this approach, qualitative and quantitative evaluation of "normal" follicular counts is required, particularly in small cetacean species that exhibit marked ovarian asymmetry, such as the harbour porpoise (*Phocoena phocoena*). As little is known on whether asymmetrical ovarian function is present at birth or develops later in life. Using histological analysis and image acquisition and analysis software to investigate ovarian form and function on a set of stranded neonatal and juvenile harbour porpoise and common dolphin (*Delphinus delphis*) ovaries this study will evaluate (1) ovarian asymmetry in these species and (2) methods for quantifying ovarian follicular numbers that could be used as an endpoint for assessments of chemically-induced ovarian toxicity in small cetacean studies.





## Posters

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### Seasonal occurrence of Icelandic killer whales in herring spawning grounds

Eilidh O'Brien,

Julie Oswald, Filipa Samarra & Paul Wensveen

*University of St Andrews*

Icelandic killer whales are the subject of ongoing research as there is much about their movement patterns and diet that remains unknown. Previous observations have indicated that certain individuals travel to the archipelago of Vestmannaeyjar, a herring spawning ground, over summer. This research used data from bottom-moored autonomous recorders (96 kHz sampling rate;  $\pm 3$  dB flat response up to 150 kHz) and land-based visual surveys to investigate the temporal patterns in occurrence of killer whales in Vestmannaeyjar over summer. Visual surveys for sightings of killer whales were carried out by observers equipped with binoculars and a theodolite, stationed at a fixed point with a wide outlook over the study area. The occurrence of killer whales was logged in 15-minute windows for each data type (acoustic and visual). Using generalised linear models and backwards selection of covariates including data type, the model which best described the data was identified. Killer whale occurrence peaked in mid-July (predicted 11 July), coincident with the peak in herring spawning (19 July  $\pm$  15 days), supporting the hypothesis that these killer whales travel to Vestmannaeyjar in summer to forage on herring. There was no significant difference in seasonal trends in killer whale occurrence between the two data types ( $p > 0.5$ ) but diurnal variation in killer whale occurrence was significantly different between acoustic and visual data ( $p < 0.001$ ). Visual survey methods can provide informative data on seasonal trends of killer whale occurrence, but generally cannot provide a comprehensive account of diurnal activity. Passive acoustic monitoring can provide information on killer whale occurrence over wider spatial and longer temporal scales than is possible with visual observations alone. More widespread use of acoustic methods would be of great benefit to the study of killer whale ecology in Iceland.



## Posters

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### A simulation workflow to optimize environmental DNA sampling strategies from commercial vessels to support marine conservation planning for marine megafauna

Elizabeth Boyse,

Maria Beger, Elena Valsecchi & Simon Goodman

*University of Leeds*

Collecting fine-scale occurrence data for marine megafauna across large spatial scales is logistically challenging, but is important for modelling species distributions and marine spatial planning. Inaccurate descriptions of species ranges could result in important habitats remaining unprotected or inappropriate prioritization of areas with few species occurrences. Optimizing sampling strategies therefore is a priority for scaling up survey approaches using tools such as environmental DNA (eDNA) to support conservation planning. eDNA can detect diverse taxa simultaneously, but to date has rarely been applied across large spatial scales in the marine environment. Commercial vessels, such as ferries, could provide sampling platforms allowing access to undersampled areas and repeatable sampling over time to track community changes. However, sample collection from commercial vessels could be biased through not representing environmental diversity in the area of interest. Here we evaluate stacked-species distribution models of marine megafauna, including mammals, sharks, and predatory fish, in the Mediterranean as an example of perfect knowledge to optimize sampling strategies along commercial shipping routes. Simulations were carried out representing different sampling strategies (random vs systematic), frames (ferries vs Mediterranean) and number of sampling points. We recovered important biodiversity patterns, such as gradients of species richness, from samples collected along ferry routes when the ferry routes chosen were not climatically biased. Across a range of sample sizes and strategies, ferry routes consistently accumulated more species and more occurrences per species compared to the whole Mediterranean. Simulations incorporating random and systematic detection bias via eDNA can estimate sample sizes necessary to evaluate species occurrences within specified probability thresholds. The workflow presented here can be used to design effective eDNA sampling strategies using commercial vessel routes. This has potential to provide a cost-effective method to access remote oceanic areas on a regular basis, and can recover meaningful data on spatiotemporal biodiversity patterns.





## Posters

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### Vocal network analysis provides novel insight into bottlenose dolphin social complexity

Emma Chereskin,

Frants H. Jensen, Simon J. Allen, Richard C. Connor, Michael Krützen & Stephanie L. King

*University of Bristol*

Social network analysis is an increasingly applied tool for quantifying an individual's social interactions and characterising a group's dynamics. To date, many social network studies have been constructed using physical proximity or interaction data. Acoustic signalling interactions, however, have frequently been overlooked, even though such signals are intrinsic features of many social groups. Here, we use vocal network analysis to shed new light on social network complexity in Indo-Pacific bottlenose dolphins (*Tursiops aduncus*). The dolphin population in Shark Bay, Western Australia, exhibits a fission-fusion grouping pattern in an open social network. Here, males form decades-long, multi-level alliances, in which individuals cooperate in the pursuit and defence of females. Proximity-based association networks of these alliances have been studied extensively over the past 35 years but, their vocal networks have not been characterised. In this study, we construct weighted vocal networks of five core alliances (35 males) using signature whistle exchanges. Signature whistles were identified using acoustic localization and exchanges were defined as events in which two signature whistle types occurred within three seconds of each other. Here, we aim to compare the vocal networks to the proximity-based association networks. Preliminary results suggest that males tend to vocally interact with alliance members with whom they spend less time. Our preliminary results reveal novel insight into bottlenose dolphin social complexity and suggest that incorporating vocal interaction data is an important aspect in the characterization of social structures.



## Posters

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### Evaluating the population trend of the common bottlenose dolphin (*Tursiops truncatus*) in Montenegro: an apparent decline

Evie White,

Sian McGuinness, Laura Rudd, Tim Awbery, Selina Brouwer & Aylin Akkaya

*University of Plymouth*

The common bottlenose dolphin (*Tursiops truncatus*) is the most regularly sighted cetacean in the Adriatic. However, anthropogenic and environmental pressures are accelerating the decline of this species. Prior to this study, there was a lack of long-term monitoring in Montenegrin waters; much like other Southern Adriatic countries which are considered data deficient. To identify population trends, data was collected over a period of four years from September 2016 to August 2020, through both land and boat surveys. The current study reveals no significant effect of season on the sighting rate or group size of the bottlenose dolphins. Yet, group size shows significant variation under the effect of year ( $p=0.0034$ ), as fewer large groups were observed than expected from 2017 to 2020. Current results highlight a significant 15% decline in the presence of bottlenose dolphins between 2016 and 2020. A multinomial logistical regression was used to test the effect of year, season, and group size on sub-adult presence. Initial tests showed that the decline in sub-adult presence was evident but not significant, so year was removed from the final model. However, season and group size affected sub-adult presence. Sub-adults were most likely to be present in the summer, and in larger groups (18 times more so than small groups). This result, in conjunction with the apparent decline in observed group size is concerning, as the presence of sub-adults in larger groups is thought to be associated with alloparental care. Further monitoring of bottlenose dolphins in Montenegro will allow trends to be recognised and suitable protective measures to be implemented. Well established conservation actions will encourage population recovery.



## Posters

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### The IMMA Project: Developing a monitoring protocol

Hannah Lightley,

Erich Hoyt, Nicola Hodgins & Brendan Godley

*University of Exeter*

Developing a monitoring protocol is crucial for spatial-based conservation of marine mammals in order to obtain information about habitat degradation, species diversity, species decline and the effects of climate change in a given site. Important Marine Mammal Areas (IMMAs) are defined as discrete portions of habitat, important to marine mammal species that have the potential to be delineated and managed for conservation. The protocol will be based on understanding states, pressures, and responses within each IMMA and will include the minimum and optimum baseline data to collect. Pressures that will be monitored will include plastics, microplastics, acid concentration, contaminants and temperature alongside monitoring for activities in the area that could also be a threat to marine mammals such as tourism, fishing, shipping lanes, aquaculture and noise pollution. Existing conservation efforts and their success will also be monitored. The protocol will be structured so that it can be repeated every 1-3 years and be performed with very little training necessary.



## Posters

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### Exploring the social structure of the Balearic sperm whale population

Isobel Carr

& Luke Rendell

*University of St Andrews*

With an abundance estimate of 400 individuals, the genetically isolated sub-population of sperm whales (*Physeter macrocephalus*) that occupy the Mediterranean is classified as endangered on the International Union for the Conservation of Nature Red List. Importantly, the Balearic Archipelago is one of the few areas in the Mediterranean Sea in which both females and males have been observed, suggesting it is a breeding site for the Mediterranean sperm whale population. This population has been previously studied around the Balearics, revealing hotspots of sperm whale abundance in the south, east and north east of Mallorca and Menorca. Information is known about this population's distribution and habitat use, and stable isotope differences between the sexes which both suggest segregation between males and females. Although remarks have been made about solitary individuals and social groups of females and their calves as found in other populations across the world, no study has defined any social organisation or network present in the Balearic Archipelago sperm whale population. This project will analyse 15 years of photo identification data of sperm whales sighted around the Balearic Archipelago that has been collected by Association Tursiops and aims to create a social network of the sperm whale population. In addition, group sizes and stability, and sex differences in both these factors, will also be investigated. This research will be beneficial in developing understanding of the connectivity of this population, and will provide valuable data towards the understanding of its ecology. Additionally, the Balearic population has a relatively small spatial distribution compared to open ocean populations. It has been suggested to have a different social structure to the 'global norm' of solitary males and female groups, due to observations of juvenile male 'bachelor' groups, and therefore may require different conservation strategies than those applied to other populations around the globe.





## Posters

### The silent treatment: Inter- and intra-individual differences in silent durations in humpback whale song

Isobel E. Morgan,

Ellen C. Garland, Olivier Adam, Anjara Saloma & Luke Rendell

*University of St Andrews*

Singing humpback whales (*Megaptera novaeangliae*) produce sound patterns which contain a wide range of sound types, called units. Anatomical investigations hypothesise that these sounds are produced by unidirectional egressive airflow, meaning the silences between sounds are occurring as air is directed back to the lungs after the laryngeal sac has been fully inflated following sound production. It is unknown whether this system causes constraints in the timing of unit production. Investigating the variation of silent durations associated with different sound units may help determine whether silences are influenced by anatomical constraints, or if the silences are varied voluntarily as part of the song's structure. In this study, we compare the intra- and inter-individual silent durations preceding and following different sound units from seven individuals recorded in Sainte Marie, Madagascar in August 2018. Within an individual's song, consistencies in unit-specific silences would suggest constraints in silent durations relating to anatomical constraints, whereas variation would suggest silent durations may be subject to voluntary control. Consistencies among individuals may reveal a population wide constraint to unit-specific silent durations, whereas variation may imply that the factors affecting silences are specific to each individual. These findings will aid insight into the extent to which singing humpback whales actively control the timing of unit production within song. This can offer potential hypotheses regarding the function of song and will advance our growing understanding of sound production in humpback whales.



## Posters

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### A comparison of statistical techniques for evaluating body condition in New Zealand leopard seals (*Hydrurga leptonyx*) using citizen science data

Jodie Warren,

Krista Hupman & Dean Waters

*University of York*

Unlike other southern continents where leopard seals (*Hydrurga leptonyx*) are considered vagrant visitors from Antarctica, sightings of leopard seals in New Zealand have been increasing, resulting in a re-classification from a vagrant to resident species in 2019. However, their ability to adapt to northerly environments still remains relatively unknown. Assessments of leopard seal body condition within this northern part of their range is one way in which scientists can understand their health status and thereby adapt strategies to protect populations. This study presents four non-invasive procedures to examine body condition of leopard seals found in New Zealand waters, designed to assist with understanding their health status following such a substantial habitat shift. A body condition scoring system allocated leopard seal sighting records into body condition groups based upon presence/absence of bony protrusions and identified that sighting records of New Zealand leopard seals (n=80) were predominantly in Good condition (71.25%). Using these body condition groups, machine learning classifiers were successful in predicting sighting records of New Zealand leopard seals into Good, Moderate and Poor body condition using differences in body shape defined by photogrammetry. Whilst highest classification accuracy was obtained using a Linear Discriminant Analysis based upon photographic measurements of body width (87.5%), an Artificial Neural Network based on leopard seal silhouettes (81.25%) was also identified as being suitable for examining body condition in New Zealand leopard seals due to its ability to utilise large, complex datasets and flexibility with lower quality images. Methodologies developed here were enabled by a large photograph library collated by citizen scientist and volunteer researchers and can potentially be applied to assess body condition of leopard seals in other regions as well as other pinniped species.



## Posters

### Do humpback whale song revolutions continue to spread from the central into the eastern South Pacific?

Josephine N. Schulze,

Judith Denkinger, Javier Oña, M. Michael Poole & Ellen C. Garland

*University of St Andrews*

Each breeding season, male humpback whales sing a highly stereotyped, repetitive song that functions in sexual selection. While most males in a given population sing the same song with some inter-individual variation, the population's song slowly evolves over several seasons. Rapid song change events, called song 'revolutions', have been observed in South Pacific humpback whale populations. During song revolutions, the previous song type performed by a population is replaced by an entirely novel song over the course of two or less breeding seasons. These song revolutions were found to transmit through the South Pacific populations in an eastward manner, starting from western Australian (located in the Indian Ocean) and spreading through the South Pacific to the French Polynesian population within seven years. Song learning may be facilitated through contact of individuals from differing populations during the summer feeding season or overlapping migratory stopovers, but the underlying drivers remain as elusive as the extent of eastward song transmission in the Southern Hemisphere. This study will explore whether humpback whale song from French Polynesia spreads to Ecuador over a period of three years (2015-18). The possible outcomes are: 1) the same song types are found in both populations within a season, indicating direct transmission; 2) the Ecuadorian population sings old French Polynesian song, suggesting delayed easterly transmission; 3) the French Polynesian population sings old Ecuadorian song, suggesting delayed westerly transmission; 4) song types do not match among any seasons, indicating no contact between the populations. The results of this study will provide insights into the underlying mechanisms driving cultural revolutions in humpback whales as well as better understanding of the connectivity between French Polynesia's and Ecuador's populations. The new knowledge will further aid management bodies in both regions to make more informed and effective decisions regarding humpback whale conservation.





## Posters

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### Dolphins, barnacles and sharks: Use of photographs to examine intra- and inter-specific interactions in bottlenose dolphins in Mozambique

Laura McConnell,

Chloe Allen, Thomas Hunt, Shaye Wettner, Diana Rocha, Angie Gullan & Sarah Marley

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Understanding interactions both within (intra-specific) and between (inter-specific) species is crucial to ecological research. However, for marine mammals such interactions can be difficult to observe in the field due to challenges imposed by species characteristics, environmental conditions, and logistical constraints. Photographs offer an opportunity to study intra- and inter-specific interactions, by capturing 'snapshots' of their occurrence over space and time. A long-term photographic-identification catalogue of over 200 bottlenose dolphins (*Tursiops aduncus*) inhabiting Ponta do Ouro, Mozambique was used to examine evidence of interactions with other dolphins (tooth rake scars), ectoparasites (barnacles), and predators (shark bites). Significant differences in intra-specific scarring levels existed according to both sex and age class. Male dolphins exhibited higher levels of tooth rake scarring than females in terms of number of rake directions, scarring percentage, and nick percentage; similarly, adult dolphins exhibited higher levels of scarring than juveniles or calves. The presence of barnacles on dolphins showed strong seasonal trends, which were closely associated with sea surface temperature. Barnacle presence also significantly varied according to dolphin body area, with some areas (i.e., fluke, dorsal and pectoral fins) being particularly prone to infestation. Shark bites showed significant differences in their distribution across the dolphin body areas, with the dorsal side being more frequently wounded than the ventral side. However, the severity of shark bite wounds did not vary according to dolphin body area. Overall, this study demonstrates the utility of photographs for examining ecological interactions. It provides the first insights regarding dolphin social behaviour, health, and predation risk for this population. These in turn will support future research into the population dynamics and conservation of the Ponta Do Ouro dolphins, which is urgently required in the face of increasing anthropogenic pressures in this area.



## Posters

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### Fine-scale acoustic and movement behaviour of bottlenose dolphins in Cardigan Bay, Wales

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Whilst the overall size of the bottlenose dolphin population in Cardigan Bay, Wales, has remained stable over the past decade, the number of individuals using the Special Areas of Conservation (SACs) appears to be declining. It is hypothesised that this could be a consequence of range-shifts or expansions, however, the movement patterns of individual dolphins are not known. To address this knowledge gap, I will deploy a network of seven passive acoustic recorders (SoundTraps) throughout Cardigan Bay for a period of two years. Bottlenose dolphins produce identity signals (termed “signature whistles”) which have a frequency modulation pattern specific to one individual. I will use the SIGnature IDentification (SIGID) method to identify signature whistles in free-ranging individuals and use these vocal labels to track individuals through time and space. I will also evaluate the potential drivers of space-use, including an individual’s social environment, prey availability, and spatio-temporal variation in anthropogenic noise. Here, I will outline the aims of my PhD research and how the findings can be used to support future management and conservation actions.



## Posters

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### Respiration cycle duration and seawater flux through open blowholes of humpback (*Megaptera novaeangliae*) and North Atlantic right (*Eubalaena glacialis*) whales

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Little is known about the dynamics of baleen whale respiratory cycles, especially the mechanics and activity of the blowholes and their interaction with seawater. In this study, the duration of complete respiration cycles (expiration/inhalation events) were quantified for the first time in two species: North Atlantic right whale (NARW) and humpback whale (HW) using high resolution, detailed imagery from an unoccupied aerial system (UAS). The mean duration of complete respiration cycles (expiration/inhalation event) in the NARW and HW were 3.07 s (SD = 0.503, n = 15) and 2.85 s (SD = 0.581, n = 21), respectively. Furthermore, we saw no significant differences in respiration cycle duration between age and sex classes in the NARW, but significant differences were observed between age classes in the HW. The observation of seawater covering an open blowhole was also quantified, with NARW having 20% of all breaths with seawater presence versus 90% in HW. Seawater incursion has not been described previously and challenges the general consensus that water does not enter the respiratory tract in baleen whales. Prevalent seawater has implications for the analysis and interpretation of exhaled respiratory vapor/mucosa samples, as well as for the potential inhalation of oil in spills.



## Posters

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### Passive acoustic monitoring: Determining cetacean diversity within the Chagos Archipelago and surrounding Marine Protected Area

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Cetaceans are under increasing stress from a variety of human-induced pressures. To facilitate their protection, we must understand their distribution and behaviour. Cetaceans are highly mobile and spend large proportions of their time underwater, making them difficult to survey using visual methods. Passive acoustic monitoring (PAM) allows for the detection of cetacean vocalisations with a more cost-efficient methodology, if long-term sound recorders are used. Cetaceans in the Indian Ocean are diverse, yet threatened primarily by high bycatch rates. The British Indian Ocean Territories (BIOT) MPA is one of the largest marine protected areas in the world spanning an area of 640,000 km<sup>2</sup> and is a no-take MPA, so could provide a refuge from human threats in the Indian Ocean. However, there is a lack of published literature on cetacean abundance and diversity within the BIOT region. Including numerous atolls of the Chagos Archipelago and surrounding deep ocean waters, the region has the potential to support populations of large whales and other cetaceans. The remote nature of the Chagos Archipelago, coupled with the vulnerable classification of species potentially inhabiting the area such as the recently discovered Omura's whale (*Balaena omurai*), highlights a crucial knowledge gap that must be filled. In this project we aim to investigate cetacean vocalisations detected in the BIOT MPA during 2019-2020 from static acoustic recorders deployed at a coral island atoll (Egmont Atoll) and seamount (Sandes) to determine diversity, seasonal and oceanographic patterns, and provide some of the first data on cetaceans in this region.



## Posters

### Monitoring cetaceans and noise along the Malin to Islay front using innovative acoustic technologies as part of the SeaMonitor project

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Cetaceans are highly mobile, often wide-ranging, nomadic, or migratory species, oblivious to human boundaries. This poses serious challenges to their conservation, requiring transnational monitoring efforts and implementation of coherent measures across population range. Often, for logistical, financial, and jurisdictional reasons, data collection programs are restricted to national waters and tend to leave marginal areas under-surveyed. The Malin Shelf in the Northeast Atlantic straddles Irish and UK EEZs. Despite being located between two known cetacean hotspots (Northwest Scotland & Southwest Ireland), information on species occurrence, movements and ecology in the area remains relatively scarce. In the Republic of Ireland in particular, the north coast has received little monitoring effort compared to other coastal sites or offshore deep slopes habitats. SeaMonitor is a cross-border collaborative EU INTERREG VA funded research project aiming to improve the understanding and conservation of mobile marine species between Ireland, Northern Ireland, and Scotland. Yearlong continuous datasets are gathered from an array of five static listening stations deployed at the outer mouth of the North Channel, between Malin Head (Co. Donegal, Ireland) and Islay (Co. Argyll, Scotland) from 2020 to 2022. Monitored with C-PODs or SoundTraps, temporal patterns in cetacean habitat-use and ocean soundscape are modelled and compared across sites. Spatial coverage is enhanced by complementary glider-based passive acoustic monitoring over the Malin Shelf, particularly near a dynamic tidal front, the Islay front. Outcomes of this project will contribute to address knowledge gaps and will feed into the MPA designation process for Annex II species (Habitat Directive), such as the harbour porpoise *Phocoena phocoena*. Noise levels will be reported following the Marine Strategy Framework Directive guidelines. Together, data on cetacean occurrence and potential threats should inform management to minimise disturbance from on-going and future activities in the area.



## Posters

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### The relationship between PCBs in blubber and levels of nematode infestations in harbour porpoises around the UK

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Post-mortem examinations of harbour porpoises, *Phocoena phocoena*, regularly reveal heavy parasitic worm burdens. These same post-mortem records show varying levels of polychlorinated biphenyls (PCBs) accumulating in the blubber of porpoises. Using a data set comprising harbour porpoises stranded in the UK between 1989 and 2002, previous research has shown a positive relationship between parasitic worm burdens and PCB accumulation in harbour porpoises. However, overall levels of PCBs declined sharply during that period and may be below proposed concentration thresholds for negative health effects. Here, we ask the question whether the relationship between parasitic worm burden and PCB accumulation still exists, using data gathered between 2002-2012. Overall, we find that there is still a positive relationship but this is more pronounced in parasite burdens recovered from the cardiac stomach than bronchi or pulmonary arteries. Suppression of the immune system is the proposed mechanism for increased parasite susceptibility and our findings suggest that the legacy of PCB pollution continues to have adverse effects on harbour porpoise health in UK waters.



## Posters

### The epibiont *Xenobalanus globicipitis* as a multifaceted indicator of cetacean biology: A review

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The commensal epibiont *Xenobalanus globicipitis* occurs on the trailing edge of the fins of about 40 cetacean species worldwide, being ecologically ubiquitous and easily detectable even in free-ranging cetaceans. Here we review the use of *X. globicipitis* as a valuable indicator of cetacean biology. First, recent evidence suggests that this species is relatively intolerant to cold waters; e.g., only dead and degraded individuals were found on Antarctic whales, suggesting that the barnacles were recruited in warmer areas at lower latitudes. Thus, *X. globicipitis* could be used to trace latitudinal migrations of cetaceans for which distribution patterns are not well known (e.g., minke whales) and/or that may need special conservation measures. Second, infection patterns have been observed to differ in the same cetacean species at smaller geographical or ecological scales; this evidence has been used for stock discrimination in some dolphin and whale populations. Third, on individual hosts, *X. globicipitis* preferentially attaches to some sections of the tail flukes, with overall settlement patterns differing between cetacean species. Apparently, this is due to differential water flow over the host's body rather than active habitat selection, enabling the use of *X. globicipitis* as an indicator of cetacean hydrodynamics. Finally, an increased prevalence of this epibiont, coupled with the occurrence of newly recruited individuals, may reveal impaired swimming and/or disease in the host, thus providing information on the health status of cetacean populations. The examples illustrate the high potential of *X. globicipitis* as an indicator of hosts' migrations, population structure, hydrodynamics, and health status. Gaining more insight of the biology of this poorly known barnacle may also provide a great deal of knowledge on numerous cetacean hosts.





## Posters

### Moving in a moving medium: Tidal drivers of harbour seal (*Phoca vitulina*) fine-scale movement and behaviour

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Quantifying the environmental drivers of the movement and behaviour of wild animals is essential for informing their management. For marine predators, an understanding of how they use tidal currents is limited, yet this information is crucial for determining the impact of new anthropogenic threats associated with these hydrodynamic features, such as marine renewable energy (MRE) devices. Here, we use a hidden Markov modelling (HMM) framework to analyse GPS and dive data collected on 24 harbour seals (*Phoca vitulina*) from 3 sites in a tidally energetic environment in the North Sea, combined with tidal current data. Our results show that whilst individual variation is high, broadly consistent patterns emerge in the movement and behavioural responses of seals to tidal currents. Specifically, we observed that seal movement speeds increased in tail-currents, suggesting these facilitated travel to foraging sites and favourable drift whilst at rest, and that seals were also more likely to exploit tail-currents for foraging. Furthermore, we found a higher probability of behavioural state-switching under tail-currents and greater state persistence under head-currents, suggesting behavioural plasticity in advantageous conditions versus an all-or-nothing approach when conditions are less favourable. No clear differences arose between sites and sexes, though juvenile responses were more acute than for adults, suggesting the former are more susceptible to currents, likely owing to their reduced movement capacity or skills. These results offer novel insights into how marine predators respond to tidal currents, and indicate that depth-usage, prey availability and prey capture events are key additional factors that need to be investigated to fully understand these responses. Our findings provide important information for the management of marine predators in areas targeted for MRE developments, including facilitating site-specific predictions, with broader implications for understanding the general optimising strategies that marine predators adopt to exploit tidally energetic environments.

