

MASTS Marine Stressors Forum Event – 4 Feb 2016 at Heriot Watt

The Marine Stressors Forum Steering Committee is holding a workshop in order to engage with the wider MASTS community. This workshop is open to all MASTS members who are undertaking some form of marine environmental stress-related research (ecotoxicology, noise, endocrine disruption, chemical pollutants, climate change, physical changes etc...) or are involved in related policy matters. All stakeholders are welcome.

The overall aim of the workshop is to facilitate greater discussion and open communication between MASTS members. In particular we are aiming to create a database of marine stressors expertise amongst the MASTS community in order to be able to put together a team to act as a MASTS partner on consortium funding bids (H2020 etc).

The first part of the workshop will be a brief overview of the forum, whilst the second part of the workshop will give attendees an opportunity to show case their research areas, expertise and available equipment as well as provide information on relevant funding calls.

Attendees

Dr Mark Hartl – MASTS Marine Stressors Forum Convenor (based at HW)

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Dr Hartl is an Associate Professor of Marine Biology, specializing in Marine Ecotoxicology in the Centre for Marine Biodiversity & Biotechnology, School of Life Sciences, at Heriot-Watt University. He is also Senior Director of Studies responsible for the MSc cluster in Marine, Environment and Climate Change (<http://marinemsc.sls.hw.ac.uk>). Dr Hartl received an MSc from the University of Vienna (1996) in Biology (Zoology/Marine Ecology) and a PhD from the University of

Southampton (2000). Following a Postdoctoral Fellowship at University College Cork (2001-2006), he took up a position as Lecturer in the School of Life Sciences at Heriot-Watt University, Edinburgh. Dr Hartl was President of the Physiology Section of the American Fisheries Society (2010-2012) and served on the Environmental Pollution Review Panel for FORMAS (2011-2014).

Research interests: Dr Hartl is interested in ecophysiology & ecotoxicology of near-shelf deep-sea organisms, the general ecophysiology of benthic organisms, the effects of anthropogenic activity on community structure and the fate of organic and inorganic pollutants in the marine and estuarine environment. Recent research activity has focused on sediment-associated organotin compounds and oilfield chemicals, bioaccumulation capacity of clams for metals and importance of exposure history, as well as the potential impact of manufactured nanoparticles and microplastic contamination of the marine environment.

Dr Mhairi Alexander (UWS)

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I am a lecturer in Animal Behaviour based at the University of the West of Scotland, Paisley. My research to date has focussed on biotic interactions, mainly between predators and prey, in aquatic environments. In marine

systems I have interests in intertidal ecology whereas my freshwater work has spanned a number of different habitat types. My most recent research effort has been focussed on invasive species and I have been involved in developing a methodology that allows prediction of impacts by non-native species under a range of environmental contexts. This work continues to develop. I have been interested in how multiple stressors associated with drivers of global change may facilitate spread, establishment and subsequent impact of invasive species and current research plans aim to develop these ideas further.

Dr Nicola Allison (USTAN)

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I research the impact of climate change (rising seawater temperatures and nutrients and ocean acidification) on calcifying organisms. I study how climate change affects metabolic processes and the production of some stress biomarkers but I am particularly interested in effects on calcification. I operate a controlled CO₂ aquarium culture facility which is currently used for the culture of tropical corals and other invertebrates over variable seawater pCO₂, alkalinity and temperature scenarios. The facility includes a dissolved inorganic carbon analyser and an alkalinity titrator for the precise characterisation of the seawater carbonate system. This is a highly controlled system ideal for the assessment of the effects of increasing seawater pCO₂ (ocean acidification) on marine organisms. The system is unique in allowing maintenance of organisms at seawater pCO₂ lower than ambient allowing researchers to explore organism responses to the CO₂ atmospheres which occurred over glacial-interglacial time scales.

Prof William Austin (USTAN)

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Dr Caroline Carter (SNH)

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Prof John Craft (GCU)

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Effects of environmental oestrogens on reproduction in aquatic organisms

- Environmental oestrogens such as the pharmaceutical ethinyl estradiol (EE2) cause endocrine disruption by activating inappropriate cell signalling through the oestrogen receptor (ER). This disrupts reproductive output in both male and female fish and various studies have focused on

the testicular effects of exposure in male fish and to some extent on ovarian effects. I am currently working with collaborators from Finland (Lindstrom & Saaristo, Turku) and Australia (Wong & Saaristo, Monash, Melbourne) to characterize effects of environmental oestrogens on reproductive behaviour in fish. In previous studies we have used the sandgoby (*Pomatoschistus minutus*) as our model but are currently using the invasive fresh-water guppy (*Poecilia reticulata*). We have used Next Generation Sequencing to characterize the transcriptome of the guppy brain and are currently identifying genes that are differentially expressed between male and female brains from control and EE2 treated animals and to correlate this with observed behaviour. While this analysis is on-going an early observation is

the sex-specific bias and treatment-specific effect of EE2 on transcripts from transposable elements (LINEs). Maybe not just junk DNA after all.

Dr Kirsty Crocket (SAMS)

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My research focuses on continent-ocean trace metal fluxes and the transport pathways these take in high latitude environments. The rationale is to provide a better understanding of how these might change under future climate scenarios and to improve palaeoceanographic data interpretation. As the main instigator of climate change, atmospheric CO₂ influences all aspects of continent-ocean trace metal cycling: the rate and style of release within terrestrial drainage catchments, the removal processes in estuarine environments, and ultimately their concentration and bioavailability in coastal and open ocean environments.

My currently funded research includes:

- Examining the role and efficiency of dissolved organic matter from peat bogs as a transport vector of trace metals across salinity gradients in Scottish sea lochs.
- Determining the partitioning of dissolved seawater rare earth elements into coral skeletons under different seawater pH treatments to establish their potential as proxies for the marine carbonate system.
- Identifying the sources, sinks and cycling of rare earth elements in seawater in a well-defined part of the NE Atlantic, the Extended Ellett Line, to address the underlying question of how seawater acquires its composition and to provide a baseline to monitor change as the marine carbonate system shifts in response to increasing atmospheric CO₂.

Dr Karen Diele (ENU)

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Reader in Marine Science at Edinburgh Napier University, Co-Director of Research St Abbs Marine Station <http://marinestation.co.uk/>. Focus on (i) dynamics and management of coastal ecosystems and associated benthic fauna/fisheries resources, (ii) life cycles/behaviour and functional ecology of mostly marine invertebrates and (iii) their responses to environmental stressors. Lab and field-based approach. Currently working on, e.g.:

'Effects of underwater sound on marine invertebrates' New working group established at Napier in 2014; Experiments involving anthropogenic noise and natural sounds and early life history stages (e.g. forthcoming PhD project) and adult stages (e.g. ongoing PhD project). Response parameters: behaviour, metabolism, development duration & survival, oxidative stress, structural DNA damage, gene expression (the latter three with Heriot-Watt University). Well-equipped labs (e.g. shaker table, Auditory Brainstem Response, underwater speakers, particle motion sensors (developed with St Andrews), 25m² aquarium at the University and 700 l to 100,000 l tanks at St Abbs Marine Station.

'Effects of ecotourism on behaviour and breeding success of nesting seabirds': Multiannual project at St Abbs in collaboration with NTS. Investigating effects of visual and auditory stressors.

'Effects of tidal amplitudes, salinity and temperature on crustacean phenology and early development': Running project in Brazil on the linkage of reproductive timing with various geophysical cycles and potential phenological mismatches through environmental change.

Prof Teresa Fernandes (HW)

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Dr Catriona Harris (USTAN)

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I have been carrying out research on the impact of anthropogenic noise on marine mammals for 10 years, and specifically behavioural responses of marine mammals to noise for over 5 years. I will be representing colleagues in the Centre for Research into Ecological and Environmental Modelling (CREEM) and the Sea Mammal Research Unit (SMRU) at the University of St Andrews who have been working on cetacean behavioural responses studies (BRS) in relation to naval sonar. One focus of research efforts to date has been Controlled Exposure Experiments (CEEs) on free-ranging cetaceans (see Harris and Thomas 2015 for overview - <http://hdl.handle.net/10023/7741>). BRS studies are difficult and expensive to conduct, and so sample sizes are necessarily small meaning that traditional statistical methods for analysis do not make best use of the available data. We, at CREEM, have been developing and implementing statistical methodologies and tools for the analysis of BRS data (including methods for detecting change-points in time-series data, methods for fitting dose-response functions, and process-based time-series models to investigate behavioural states and state-switching in response to sound – see <http://www.creem.st-and.ac.uk/mocha/>).

Tegan Hartley (HW)

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Prof John Harwood (USTAN)

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I'll be attending the MASTS Marine Stressors workshop on behalf of a group of researchers at St Andrews (myself, **Cormac Booth, Rob Schick, Len Thomas and Peter Tyack**) who have been developing a framework for assessing the population consequences of exposure to different stressors. Until recently, our work has focussed on modelling the population consequences of exposure to anthropogenic noise (see New et al. 2014, King et al. 2015). However, we are now expanding that framework so that it can be used to investigate the cumulative effects of exposure to multiple stressors as part of the work of a Committee established by the National Academies of Sciences on Assessment of the Cumulative Effects of Anthropogenic Stressors on Marine Mammals (see <http://www8.nationalacademies.org/cp/projectview.aspx?key=49715>).

King, S.L., Schick, R.S., Donovan, C., Booth, C.G., Burgman, M., Thomas, L. & Harwood, J. 2015. An interim framework for assessing the population consequences of disturbance. *Methods in Ecology and Evolution* doi: 10.1111/2041-210X.12411

New, L.F, J.S. Clark, D.P. Costa, E. Fleishman, M.A. Hindell, T. Klanjcek, D. Lusseau, S. Kraus, C.R. McMahon, P.W. Robinson, R.S. Schick, L.K. Schwarz, S.E. Simmons, L. Thomas, P. Tyack and J. Harwood. 2014. Using short-term measures of behaviour to estimate long-term fitness of southern elephant seals. *Marine Ecology Progress Series*. 496, 99-108

Dr Gordon Hastie (USTAN)

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My research interests focus on how marine mammals' respond to man-made perturbations of the marine environment. As we see the increasing urbanisation of the sea, I am particularly interested in how marine mammals perceive and respond to novel man-made noises in the ocean. For example, many countries have set ambitious targets for renewable energy, with offshore renewables anticipated to form an important part of this; this has led to the proposed installation of wind, wave, and tidal energy converters around the coast. However, the noise produced by these are potentially hazardous to marine mammals and understanding how they perceive and respond to noise is critical to ensure that they can co-exist at the scales currently being envisaged for the industry. My research includes studies of the impacts of noise from wind farm construction on harbour seals and behavioural responses of seals to noise produced by tidal turbines. There is also increasing evidence that man-made noise can compromise foraging efficiency and ultimately individual fitness of a range of species. I am interested in understanding how the foraging efficiency of marine mammals, which have relatively rigid physiological constraints, can be affected by underwater noise.

Dr Suz Henderson (SNH)

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Short summary of my role: Marine Policy and Advice Officer in Coastal and Marine Ecosystems Unit (CMEU) within SNH. My roles include: Input into the SNH work on the Scottish Marine Protected Areas Programme; providing conservation advice on the implications from activities and development in the marine environment either through casework (statutory consultations), policy development, supporting Marine Scotland or other strategic initiatives; providing advice on aquaculture issues; coordinating SNH input into sensitivity, activity and pressure matrices; lead contact for basking shark research and conservation. Stressor research provides the evidence base with which to base our advice - so we have a key interest in helping to steer research to help fill gaps.

Dr Natalie Hicks (SAMS)

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My broad research interests encompass the effects of environmental change, predominantly ocean acidification, increasing temperature and hypoxia, on marine benthic systems. I am particularly interested in the effects of future oceans on coastal and intertidal sediments, with a strong focus on benthic carbon cycling of different sediments. Recent work has included examining the effects of a simulated CO₂ leak from a carbon capture storage (CCS) site on benthic biogeochemical cycling. I'm currently involved in the Shelf Seas Biogeochemistry programme, and my aim is to quantify the seasonal carbon cycling and total sequestration of different shelf sediment types, through a series of cruises in 2015. I've also got an interest in 'blue carbon', and how the abilities of our different marine ecosystems to store blue carbon may change under future climate scenarios.

Dr Mark James (MASTS Operations Director)

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Thodoros Kampouris (HW)

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Thodoros' project is on the biodiversity and commercial restoration potential of the spiny lobster *Palinurus elephas*. The European spiny lobster is, now, a relatively rare crustacean, known from south Norway to the Mediterranean and as far east as Hellas. Fisheries for spiny lobsters using tangle-nets, pots, trammel nets and diving have reduced spiny lobsters from a common shallow coastal species to largely remnant populations. Fisheries for this species have now virtually disappeared throughout their range, but Marine Protected Areas (MPAs) as successful at enhancing their stocks. The species is included in the IUCN red list and it is considered as vulnerable. Furthermore, in the UK coordinated efforts on the species protection and monitoring had begun since 2015 for the first time. Thodoros is a MASTS PhD candidate jointly registered with Heriot-Watt University and the University of St Andrews. He will also spend time working at the recently established St. Abbs Marine Station which will offer unique opportunities to study habitat selection based mesocosm experiments.

Dr Joseph Kenworthy (USTAN)

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My main research interests include marine benthic and coastal ecology. I am particularly interested in manipulative field experiments analysing stressor impacts. I have recently completed a joint PhD at the University of St Andrews and Macquarie University in Australia where I conducted a project analysing the impact of selected multiple stressors on intertidal sedimentary communities, comparing responses between regions. More recently, through a placement with the Valuing Nature Network, I am investigating how stressor impacts in coastal environments alter ecosystem services, thereby creating knock on effects to societal wellbeing.

Joanna Kershaw (USTAN)

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Dr Michael Leaver (Stirling)

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- Understanding mechanisms of susceptibility and resistance to environmental pollutants and mixtures of contaminants, with particular interests in the application of genomic techniques.
- The discovery and application of molecular biomarkers of exposure for aquatic contaminants.
- Research focuses on the marine environment and uses fish such as flounder as a model and sentinel species, and to a lesser extent also uses invertebrates.
- Further interests in lipid homeostasis in fish, particularly under aquaculture conditions.

Dr David Lusseau (Abdn)

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I am interested in understanding how individuals make decisions when uncertain and what the consequences of those decisions are for their health, their social life, and the demographic contributions they can make to their populations. Within the context of this workshop, I particularly work on finding ways to predict the population consequences of disturbances. Our work focusses on developing condition-mediated population models using information from individual-level adaptation to anthropogenic perturbations to link behavioural dynamics to 'condition'. We use these models to appraise the potential conservation impacts of wildlife cumulative exposure to human activities. We are also developing first-principle approaches to categorise the propensity for conservation issues to arise non-lethal effects of human activities. Finally, we are developing socioecological system models to assess under which conditions sustainable developments can be achieved. We particularly are exploring how to understand the long-term behaviour of those systems in data poor conditions.

Dr Simon Mackenzie (Stirling)

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Dr Simon MacKenzie obtained his PhD at the University of St Andrews and currently holds the position of Reader in Marine Biotechnology at the Institute of Aquaculture, University of Stirling. His research interests are anchored in immunology and recently how environmental conditions, particularly temperature, modulate the plasticity of the immune response and drive adaptive variation. An integrative suite of methods are employed both experimental and theoretical spanning across the fields of behavioural ecology, evolution and immunity underpinned by state of the art genomics. Over the past 15 years his research team has contributed with >90 papers spanning multiple aspects of immunity, welfare and disease in fish with an underpinning focus upon transcriptomic regulation. Recent work directly related to aquaculture includes several translational projects with the salmon industry developing on-site diagnostic systems for aquaculture, targeted nanotechnology systems for antigen delivery. A major objective for the coming years is to approach the concept of herd immunity and individual variation (animal personality) in both cultured and wild fish populations

Clara Mackenzie (HW)

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My key research interests are marine organismal physiology in response to climate change stressors and associated changes over time and space. I am interested in examination of a variety of responses (e.g. oxidative stress, homeostatic functioning, energetic shifts) across varying levels of organisation (from molecular to whole organism) and life stage so as to move towards a more comprehensive understanding of impacts. I am also interested in investigation of adaptive capacities of given populations and the role of genetic connectivity in shaping particular vulnerabilities/resiliencies to climate change stressors. My past research

efforts have focused on the impacts of ocean acidification (OA) on growth and reproduction in a keystone echinoderm species (*Psammechinus miliaris*) and the impacts of coinciding warming and OA on the physiology (immune response, acid-base balance, oxygen consumption, protein synthesis) of a commercial bivalve species (*Mytilus edulis*). Currently, I am investigating population connectivity and the impacts of warming and hypoxia to stress response and energetics in horse mussels (*Modiolus modiolus*).

Dr Tania Mendo Aguilar

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I have recently relocated from Australia, as my partner was awarded a scholarship to pursue doctoral studies at St. Andrews University. I have recently obtained my PhD on a project exploring early post-settlement factors affecting the recovery of exploited scallop populations, and I am looking for job/research opportunities in Scotland. I am particularly interested in the effect of noise on development, reproduction and settlement of invertebrates.

Dr Daniel Merckel (SEPA)

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Dr Les Noble (Abdn)

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Elasmobranch spatial ecology and population genetics are areas we currently focus on, investigating white, blue, bull, and basking sharks, tope, spur dog, porbeagle, thornback and common skate, many of which are endangered or in decline. We have produced molecular tools, such as microsatellite and SNP markers, to address questions of population connectivity, stock assessment, and local adaptation; information crucial for marine spatial planning. A natural extension of this work is to examine gene-environment interactions using genomic and transcriptomic approaches we have employed. Therefore, environmental stressors and their impact on shark conservation is a concern – climate change is one aspect but a more proximate issue is the influence of pollutants on elasmobranch reproduction. We would like to integrate environmental -omics, parasitology and stable isotope approaches to determine the overlap between spatial ecology and environmental stressors (particularly exposure to pollutants such as EDCs), to realize their impacts on elasmobranch conservation. Contradictory indications of pollutants in elasmobranchs are provided by our thornback ray surveys – preliminary analysis suggests variance of sexual characters with pollution – and evidence basking sharks from diverse populations are attracted to focal feeding grounds where microplastics collect, several autopsies revealing alimentary tracts packed with plastic waste.

Dr Brian Quinn (UWS)

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I am an ecotoxicologist and my research focuses on investigating the impact of novel contaminants on the aquatic (both freshwater and marine) environment. This includes aspects



of analytical chemistry, but primarily biological impact. Previously my work was more biochemistry focused investigating the toxic impact on an individual organism, generally a bivalve mussel (marine *Mytilus edulis* and freshwater *Dreissena polymorpha*), by investigating biomarker expression. However more recently I am interested in the bigger picture, taking a more ecological approach.

Currently my research is focusing on:

1. Microplastics in the aquatic environment: developing methods for their separation, identification, biological impact, interaction with chemicals and ability to act as vectors of exposure.
2. Invertebrates tissue culture: developing primary tissue cultures from bivalve invertebrates (primarily the zebra mussel *Dreissena polymorpha*) for toxicity testing.
3. The adaptation of human diagnostic medical techniques for environmental monitoring and assessing the fish of health in aquaculture.

Dr Craig Robinson (Marine Scotland)

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I work within MSS's Marine Environmental Assessment Group, leading a small team of analysts working on marine contaminants and biological effects monitoring and research. Our current work includes environmental status assessments, analytical methodologies for the determination of elemental composition of fish otoliths by laser-ablation Inductively coupled Plasma Mass Spectrometry (LA-ICPMS), and on the use of partition-based (passive) sampling and dosing in environmental monitoring and assessment of hydrophobic contaminants. Our techniques include silicone rubber passive sampling and GCMS, LA- and solution-ICPMS, fluorescence spectroscopy, comet assay, micronucleus, lysosomal membrane stability, enzyme assays, qPCR. I am co-chair of the ICES Working Group on Marine Sediments in relation to pollution (WGMS), member of the ICES Working Group on Biological Effects of Contaminants (WGBEC), and I co-chaired the ICES Workshop on the application of Passive Sampling and Passive Dosing in marine media (WKPSPD, 2013). I provide advice to both the Scottish and UK Governments on the environmental effect of, and monitoring methodologies for, contaminants and their biological effects. I am a UK nominee to the European Commission Marine Strategy Framework Directive (MSFD) Expert Network on Contaminants, advising on the revision and implementation of Descriptors 8 and 9 of the MSFD.

Dr Armin Sturm (Stirling)

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My current research interests include sea louse treatments in salmon farming, particularly regarding resistance formation and adverse effects on non-target species. Despite the increasing implementation of non-medicinal approaches, anti-parasitic drugs are still essential for sea louse control in industrial salmon mariculture. The recent development of genetically based resistance in sea lice constitutes a threat to such chemical control strategies. The presently incomplete understanding of drug resistance mechanisms in sea lice and the paucity of diagnostic markers

hinder the development of effective resistance management strategies. An ongoing BBSRC-funded research project lead by Dr Sturm and further involving the groups of Drs K Gharbi and R Houston at the University of Edinburgh aims to unravel resistance mechanisms and isolate molecular markers. Improved understanding of resistance mechanisms and a wider range of molecular markers to detect resistance will assist designing optimal rotational strategies between drug treatments and non-medicinal approaches. Furthermore, a key consideration for sustainable parasite control is to minimise the risk of adverse effects on non-target species. A recent mixture toxicity study from my group suggested that a toxic unit approach may be useful to balance between costs and benefits of different therapeutants and binary mixtures of compounds.

Matthew Wale (ENU) - Not able to attend the event
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Member of a new research group at Edinburgh Napier University investigating the effects of underwater sound on marine invertebrates. My PhD focuses on how anthropogenic noise affects adult stages of selected species, including behavioural, physiological, and genetic processes, to help evaluate whether and how the increasing noise levels in the coastal and oceanic habitat are affecting these animals. Currently I am running experiments with the blue mussel *Mytilus edulis*, in collaboration with Heriot-Watt University, investigating whether noise causes DNA damage, triggers oxidative stress, or changes the behaviour. I am also planning to apply Q-PCR to create a more complete picture of the effects of noise. Similar experiments will be performed this year with crustaceans, such as *Nephrops norvegicus*, and *Cancer pagurus*. In addition to this we are developing a low cost particle motion sensor, with the help of The University of St Andrews, which can be employed in both my research and that of others in this field.