Microplastic accumulation in a *Zostera marina* bed in Deerness Sound, Orkney: a pilot study

Jones, K. L.  

1 *Institute of Life & Earth Sciences, Centre for Marine Biodiversity & Biotechnology, Heriot-Watt University, Edinburgh, EH14 4AS, UK - kj76@hw.ac.uk*

**Area being submitted to:** Microplastics and marine litter;

**Preferred presentation medium:** e-poster format.

Are you a student? Yes

You must be a student member of IMarEST to be eligible for the student prizes. Join for free here –  
https://www.imarest.org/membership/membership-registration/upgrade-your-membership/student-member-simarest

Seagrass ecosystems exist globally and are considered one of the most productive and economically valuable habitat within coastal waters. In Scotland, their important ecological value and vulnerability has been recognised by the inclusion of seagrass in Scotland’s Priority Marine Features List. Seagrass beds are sensitive habitats and vulnerable to a range of human induced pressures, including their ongoing exposure to marine litter, such as microplastics. Orkney has previously been identified as having comparable microplastic levels to that of urbanised mainland Scotland. In this pilot study, a large and dense *Zostera marina* bed in Deerness Sound, Orkney was selected to determine if microplastics accumulate in seagrass beds. Using systematic sampling methods along a 100m transect 20 sediment samples; 20 seagrass blades samples; biota from the sediment and on the seagrass blades, were collected before taking surface water and water column samples. Microplastics were extracted from the samples using filtration methods, including a super-saturated NaCl flotation technique and chemical digestion (10% KOH) and visually sorted into shape (fibre, flake and fragment) and colour categories. Microplastics were recorded in 87.5% of biota samples collected and identified in all water, sediment and seagrass samples. Furthermore, this study has identified the number of microplastics recorded within the seagrass bed is statistically significant, in comparison to bare sand control sites. This may suggest the occurrence of microplastic loading in seagrass beds. Therefore, further analysis is required to determine the scale and impact of microplastic concentrations in Scotland’s seagrass beds.
The combined effects of ocean acidification and copper on the physiological responses of the tropical coral Stylophora sp.

S. Cryer1 and N. Allison1

1 School of Earth and Environmental Sciences, University of St. Andrews, St. Andrews KY16 9AL, UK, na9@st-andrews.ac.uk

Under the IPCC “business as usual” scenario (RCP8.5), atmospheric CO₂ is predicted to reach 1000-μatm by 2100 and ocean pH will decrease by 0.3-0.32 units compared to the present [1]. Cu is an essential element required by all species but is toxic at high concentrations. Cu speciation in seawater is pH dependent and a 0.3 pH decrease will approximately double the proportion of Cu present as Cu²⁺ (aq) [2], the free metal ion and probably the most bioavailable Cu species. We assessed the impact of ocean acidification and Cu separately and in combination on the physiological processes of the branching tropical coral Stylophora sp. Multiple fragments of a single coral parent colony (i.e. the same genotype) were cultured in ambient seawater (for 2 weeks) and then moved into 4 treatments for another 2 weeks. The treatments were: 400 μatm pCO₂ + ambient seawater Cu (the control), 1000 μatm pCO₂ + ambient seawater Cu, 400 μatm pCO₂ + seawater Cu 5 μg l⁻¹ above ambient and 1000 μatm pCO₂ + seawater Cu 5 μg l⁻¹ above ambient. The total alkalinity of the aquaria seawater was measured 3–4 times per week and the CaCO₃ consumed during calcification were replaced by automated dosing of Na₂CO₃ and CaCl₂.

The total coral calcification (light and dark) was estimated from the aquaria alkalinity and dosing volumes and normalised to the calcification rates observed in the week before the corals were moved into each treatment. Calcification rates increased in all treatments, reflecting the increasing sizes of the fragments and the propagation of branch tips. At the end of the 2 week exposure period the calcification rates of the corals exposed to stressors were reduced by 51% (1000 μatm pCO₂ + ambient seawater Cu), 45% (400 μatm pCO₂ + seawater Cu 5 μg l⁻¹ above ambient) and 61% (1000 μatm pCO₂ + seawater Cu 5 μg l⁻¹ above ambient) compared to the controls. There was visible paling of fragments exposed to 1000-μatm pCO₂ at both Cu levels compared to the corals cultured at 400-μatm pCO₂. Net photosynthesis, respiration and light and dark calcification were measured individually by isolating each coral fragment in a flow through chamber at weekly intervals and determining changes in dissolved oxygen (indicating photosynthesis and respiration) and alkalinity (calcification). In these isolations we were unable to detect a significant effect of any treatment on metabolic processes. In all corals, we observed significant positive correlations between calcification rate and photosynthesis or respiration rate. The seawater pCO₂ and Cu treatments did not significantly alter these relationships.

Dissolved [Cu] in tropical coastal waters can exceed 6-12 μg/L. Our data indicates that seawater Cu concentrations of this magnitude suppress calcification in the branching coral Stylophora sp and increasing seawater pCO₂ enhances the detrimental effect of Cu on calcification. Therefore, it would be likely that as atmospheric CO₂ continues to rise, coastal areas experiencing Cu pollution will see a further decrease in calcification of Stylophora sp. as a result of the combined effects of high pCO₂ and Cu.

Assessing the causes and impacts of deformities in the velvet crab *Necora puber* in the Orkney Islands

Katie Cubbon¹, Angela Capper¹, Joanne Porter¹, Kenneth Boyd², Michael Bell¹, Matthew Coleman¹

¹Department of Engineering, Geoscience, Infrastructure and Society. International Centre for Island Technology, Heriot Watt University, Old Academy, Back Road, Stromness, Orkney, KW16 3AW. kc392@hw.ac.uk

²Environmental Research Institute, University of Highlands and Islands, Castle Street, Thurso, Caithness KW14 7EE

Area being submitted to: Multiple stressors
Preferred presentation medium: oral.

Are you a student? Yes

Fishing and aquaculture are two industries of significant economic and social importance to the Orkney islands. Commercial creel fisheries are engaged in by ~ 303 self-employed fishermen; aquaculture, principally of Atlantic salmon, provides 93 jobs on the islands (Orkney Islands Council, 2016).

The velvet crab (*N. puber*) is the species of second highest commercial value in Orkney, worth £1.2 million at first sale in 2016, (Orkney Islands Council, 2016). In recent years there has been increasing evidence of the incidence of deformities in some areas of the fishery, characterized by claw deformities and black lesions to the external carapace, making them unsuitable for transport or sale at the European market. Higher incidences of these deformities have been observed by local fishermen in locations within proximity to salmon farming facilities at the Bay of Puldrite, Orkney. The cause is unknown, but links to fish farming activity at these areas has been suggested based on this observed proximity.

*N. puber* were sampled in collaboration with local fishermen at seven sites within the Orkney archipelago during June-July 2018. Sampling occurred at varying distances from the Bay of Puldrite salmon farm.

Bacterial swabs of the claws and carapace were performed, and isolated strains were identified using 16S ribosomal DNA sequence analysis. Estimates of fecundity were made for berried females and comparisons made between deformed and non-deformed females.

Substantial numbers of carapace deformities (characterised by black lesions) were observed (38 out of 66 crabs examined), all of which were sampled from three locations in close proximity to the salmon farm facility (within ~ 2km). Almost all crabs sampled from the Bay of Puldrite were affected. Claw deformities were less prevalent with only four out of 66 total sampled crabs displaying these abnormalities, again from the three locations closest to the Puldrite salmon farm facility. No deformities were observed in any crabs from the four locations of increasing distance (~20 to 51.43 km) from the aquaculture facility.

Crabs with deformities were found to have slightly higher fecundity (6.5% greater) compared to non-deformed crabs, suggesting a greater investment in reproductive resources under stress. Eleven species of bacteria were isolated from the exoskeleton of crabs with carapace lesions as well as those without. No single pathogen was isolated from the lesions suggesting that the interaction of several communities of chitinolytic bacteria are responsible for shell deformities in the species.

Although the exact cause of deformities is still unknown, this study highlights the need for further research to identify potential interactions between the fisheries and aquaculture sectors in Orkney.

Acknowledgements

We thank: Sean Dennison for crab collection; Edinburgh University for DNA sequencing.

References

Underwater noise monitoring in Scottish waters

Ewan W. J. Edwards¹, Ross Culloch¹, Kate Brookes¹, Jared Wilson¹

¹ Marine Scotland Science, 375 Victoria Road, Aberdeen – ewan.edwards@gov.scot

Area being submitted to: (delete as appropriate): 2) Multiple stressors
Preferred presentation medium: (delete as appropriate): poster
Are you a student? (Delete as appropriate): No.

There is a growing need to understand sources and environmental impacts of underwater noise in Scottish waters. The introduction of energy, including noise, into the marine environment is listed as a descriptor (D11) of the EU Marine Strategy Framework Directive (MSFD), but until recently there has been very limited knowledge of baseline levels, nor an understanding of how noise is likely to change in future or the associated environmental impact of this.

Underwater noise from anthropogenic sources can be split into two general categories: impulsive noise, such as that generated by pile driving or seismic survey; and continuous noise, of which shipping is the primary component. Over long distances, loud impulsive noise becomes more continuous due to reflection off the seabed and refraction within the water column, so the distinction becomes less apparent. Both continuous and impulsive noise are described as components of D11 under the MSFD.

Marine Scotland Science is a partner in four EU Interreg projects where research into underwater noise will be carried out. These projects are COMPASS (Interreg VA), Jomopans (Interreg North Sea Region), MarPAMM (Interreg VA) and JONAS (Interreg Atlantic Area). Also, the Scottish Government has funded a long-term study into underwater noise and marine mammals off eastern Scotland, primarily related to renewables developments in the North Sea.

The COMPASS project aims to gather data that will characterise and monitor the marine environment in relation to protected areas and species, and improve oceanographic models in Scottish, Northern Irish and Irish waters. In addition to Marine Scotland Science, project partners are the Scottish Association for Marine Science, Agri-Food and Biosciences Institute in Northern Ireland and the Marine Institute Ireland.

The Jomopans project aims to develop a framework for a fully operational joint monitoring programme for ambient noise in the North Sea. Output will be the tools necessary for managers, planners and other stakeholders to incorporate the effects of ambient noise in their assessment of the environmental status of the North Sea, and to evaluate measures to improve the environment. Project partners are in Sweden, Norway, Denmark, Germany, the Netherlands, Belgium and England.

Over the next four years, the Marine Protected Area Management and Monitoring (MarPAMM) project will develop models and management plans for protected habitats and species across the regional seas of Scotland, Northern Ireland and Ireland. One key deliverable will be an assessment of the impact of anthropogenic noise on marine mammals. There are eight partner organisations across Scotland, Northern Ireland and the Republic of Ireland.

The JONAS project is currently in submission, and intends to map continuous underwater noise across the European Atlantic region, from Scotland to Portugal. The lead partner is University College Cork.

In addition to the EU projects the Scottish Government funded East Coast Marine Mammal Acoustic Study (ECOMMAS) project is now in its sixth year of data collection and has contributed to the first baseline assessment of continuous noise levels in UK waters, in association with numerous marine mammal studies.

This poster will provide an introduction to these projects, how they are linked, and some preliminary findings.

Acknowledgements

Thanks to all our EU project partners, especially to Denise Risch at SAMS and Nathan Merchant at CEFAS.
Phototactic response in haddock (*Melanogrammus aeglefinus*) and cod (*Gadus morhua*) to the use of coloured LED lights

Luisa Barros¹, Emma Mackenzie¹, Malcolm Hall²

¹ Fishing Technology, Marine Scotland Science – luisa.barros@scot.gov
² Statistics, Marine Scotland Science

Area being submitted to: 1) General science session; Preferred presentation medium: e-poster format.

Are you a student? No

Vision in fish is used in many important behaviours such as feeding, schooling, and migration (Nightingale et al, 2006) and it depends on environmental conditions such as light intensity. It has been demonstrated in the past that fish behaviour can also be affected by artificial light stimuli (Ben-Yami, 1976; Glass et al, 1989). Many vessels use artificial light to attract pelagic schooling species (Fréon and Misund, 1999) and aggregate them in high concentrations. This behaviour has long been recognized by fishermen which direct their efforts accordingly to improve catches.

Experiments in the North Sea go back to 1989 where Glass and Wardle report that fish, in the absence of vision, are unable to react to an approaching fishing net being captured, unlike in high light levels where fish avoid the net. Research has also been carried out in laboratory conditions. Behavioural effects of artificial light of different frequencies and wavelengths were tested on four Mediterranean species by Marchesan et al (2005) and the results varied among them.

In this study, we investigate the behavioural effects of artificial light in two fish species of commercial interest: codfish (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). Visual behaviour patterns towards artificial light among gadoids in controlled experimental conditions have not been investigated to this point, which emphasizes the importance of this study. Such investigations were aimed at highlighting the potential of using light to enhance fishing selectivity of commercial species in Scotland. The experiment was carried out in laboratory conditions and consisted in turning on a LED light positioned at one end of the tank to stimulate a reaction on fish and compare the results with the control (when the light was off). Data consists on distance in metres for each fish from the light and three colours were tested: red, green and blue. A linear mixed effects analysis of the relationship between distance and colour was carried out.

Results for red light indicate a minor reaction but statistically non-significant to the light for both species. These results are in line with previous studies, which suggest that most fish species are unable to see this wavelength fully. As for the green light results, cod appear to show a strong repulsion to this wavelength, while haddock initially shows attraction. Finally, the results for blue light indicate a similar repulsion reaction to this colour for both species, however at different scales. The overall results presented herein are promising and further investigation should be carried out.

Acknowledgements

I would like to thank the staff within our fish behaviour unit for their support and help throughout the trials. This study was financially supported by the SMARTFISH Project through the Horizon 2020 Programme.

References


The First Quantitative Description of the Sublittoral Faunal in the Falkland Islands: The influence of depth and season at Kidney Island, East Falkland

Emma Beaton13, Frithjof Kuepper1, Pieter van West2 and Paul Brickle3

1 School of Biological Sciences, University of Aberdeen – e.beaton@abdn.ac.uk
2 Institute of Medical Sciences, University of Aberdeen
3 South Atlantic Environmental Research Institute, Falkland Islands

Area being submitted to: 1) General science session

Preferred presentation medium: (ii) e-poster format.

Are you a student?: Yes

Abstract

Information on the ecology of subtidal rocky reefs in the South Atlantic are extremely scarce, particularly in the Falkland Islands. The Falkland Islands are home to extensive Macrocystis pyrifera kelp forests, little is known about the invertebrate communities populating this habitat. Indeed the factors influencing diversity, distribution and community structure have never been studied here. This study has provided the first description of the faunal communities of the shallow benthic environments of the Falklands. Using SCUBA diving, photoquadrats of the benthos were collected along 20m transects by the Shallow Marine Surveys Group at depths of 5m-10m, 10m-15m and 15m-20m. Individual invertebrates within the photoquadrats were marked and counted, with sessile colony forming species counted per colony, to obtain species distribution data. We found 146 species from 10 phyla and 21 classes during the survey, with the most abundant sessile and vagile species being Spirorbinid worms and the hermit crab Pagurus comptus, respectively. Our analyses indicated that changes in season impacted the community structure as a whole, with spring and summer being most species rich, with these differences most evident intraspecifically. Spirorbinids were the main contributing species of these changes. This finding demonstrates a difference between the shallow subtidal regions of South America where it has been reported that species richness is highest in austral autumn and winter. Influence of depth on the community structure was evident, with species richness highest in the middle depth ranges, and strong contrasts between shallow and deep communities. The outcomes of this study are a vital contribution to the knowledge gaps of Falkland Islands shallow benthic environments and biogeography of this region.

Acknowledgements

Thanks are extended to the members of the Shallow Marine Surveys Group for collecting the data used in this investigation.
The effects of pile-driving noise and cadmium co-exposure on the early-life-stage development of the Norway Lobster, Nephrops norvegicus

Craig A. Stenton1, Rob Briers1, Mark G J Hartl2, Karen Diele1,3

1 School of Applied Science, Edinburgh Napier University – craig.stenton@napier.ac.uk
2 Centre for Marine Biodiversity & Biotechnology, Institute of Life and Earth Sciences, School of Energy, Geoscience, Infrastructure & Society, Heriot-Watt University
3 St Abbs Marine Station

Area being submitted to: Multiple stressors
Preferred presentation medium: E-poster format.
Are you a student? Yes

Organisms within our oceans are facing unprecedented pressure as a result of anthropogenic activities. These comprise not only historically recognised chemical pollutants such as heavy metals, but also more recently acknowledged stressors including noise resultant of shipping and construction1.

To date, environmental risk assessments have predominantly assessed pollutants using a single-stressor approach conducted under standardised conditions. Whilst this approach allows better confidence when attempting to determine cause-effect relationships, it lacks environmental realism.

This study is the first to evaluate anthropogenic noise and co-occurring chemical pollution in a multi-stressor context. The Norway lobster (Nephrops norvegicus) was selected as a model species given it is the second most valuable fishery in Scotland with landings worth £75 million in 20142. Larval stages were chosen for observation as early-life stage organisms are often more sensitive and susceptible to stress than their adult conspecifics, and thus at greater potential risk from anthropogenic pollutants3.

The geographical range of N. norvegicus overlaps with a high density of fixed off-shore energy structures. Resultingly, the species is likely to be exposed to noises associated their construction or decommissioning. For this reason, pile-driving was selected as the anthropogenic noise stressor. The heavy metal cadmium was chosen as a chemical co-stressor as it is associated with industrial usage and is a persistent contaminant in marine sediments. Resolubilisation of cadmium into the water column from sediments disturbed by activities such as dredging and construction has previously been established4. Elevated waterborne cadmium concentrations in response to piling are therefore environmentally feasible. Moreover, cadmium is an established mutagen and teratogen with proven ontogenetic effects and thus poses a particular threat to early-life-stage organisms.

A respective multi-stressor laboratory-based experiment is to be conducted at St Abbs Marine Station in due course following N. norvegicus larval release. The larvae will be concurrently exposed to underwater playback of field-derived pile-driving recordings (single-pile zero-peak sound pressure level = 195 dB re: 1µPa, 6:18 hour piling:ambient sound exposure) and one of three nominal cadmium concentrations (1 µg L⁻¹, 10 µg L⁻¹, 100 µg L⁻¹) until either the onset of metamorphosis from planktonic zoea to benthic juvenile stage, or for a maximum of 56 days if metamorphosis is delayed.

Survival, growth (dry mass), and development duration of larvae will be monitored throughout the experiment. Carry-over effects from zoea to first juvenile phase will be assessed by comparing the tail-flick escape response of the treatment groups as a measure of ecological fitness.

Acknowledgements

The work was conducted at the privately owned St Abbs Marine Station. Thanks to station staff and volunteers for practical support, Matthew Wale for advice on sound exposures, and Edward Bolger for assistance rearing N. norvegicus. The study received financial support from the MASTS Small Grant Scheme

References

2. Williams & Carpenter (2016). The Scottish Nephrops fishery: Applying social, economic, and environmental criteria. 73
4. Hall (1989) The effects of dredging and reclamation on metal levels in water and sediments from an estuarine environment off Trinidad, West Indies. Environ Pollut. 56(3):189-207
Climate change and ecotoxicology: re-assessing biomarker baselines in light of a changing environment

Glenn Jakob Bodholdt Jessen¹, Teresa F, Fernandes² and Mark G J Hartl³

¹ MSc/PhD Student, Centre for Marine Biodiversity and Biotechnology Institute of Life and Earth Sciences, Heriot-Watt Uni., Edinburgh EH14 4AS, UK. – gj10@hw.ac.uk

² Associate Professor, Centre for Marine Biodiversity and Biotechnology, Institute of Life and Earth Sciences, Heriot-Watt Uni., Edinburgh EH14 4AS, UK. – t.fernandes@hw.ac.uk

³ Associate Professor, Centre for Marine Biodiversity and Biotechnology, Institute of Life and Earth Sciences, Heriot-Watt Uni., Edinburgh EH14 4AS, UK. – m.hartl@hw.ac.uk

Area being submitted to: 2) Multiple stressors

Preferred presentation medium: (ii) e-poster format.

Are you a student?: Yes; IMarEST membership number: 8069074

The latest Intergovernmental Panel on Climate Change (IPCC) report shows that the average sea surface temperature has been increasing at an average rate of 0.11°C per decade, at the majority of the world’s coastlines since 1971, and that the average pH has decreased by 0.1 during the same period. This trend is predicted to continue. The three major symptoms of marine climate change most likely to have major consequences are as follows: increase in temperature, ocean acidification, and fluctuations in salinity (Wong et al., 2014; Connell, Fernandes and Hartl, 2017).

In ecotoxicology, a biomarker can be defined as a measurable biochemical, physiological or histological indicator of exposure to a xenobiotic (Forbes, Palmqvist and Bach, 2006). However, single biomarkers are rarely able to provide sufficient information for satisfactory assessment of a given hypothesis and ultimately a range of suitable biomarkers should be used to achieve ecological relevance (Handy, Galloway and Depledge, 2003; Connell, Fernandes and Hartl, 2017). Furthermore, it is necessary to gain an understanding of how biomarker responses vary due to changing conditions such as reproductive state, seasonality and climatic factors.

The number of ecotoxicological studies directly related to climate change has been limited thus far (Connell, Fernandes and Hartl, 2017) and a common theme to the changing climatic parameters of ocean temperatures, pH and salinity is the requirement for a greater understanding of how they will impact marker species in representative near-future conditions. Furthermore, it is necessary to investigate each of these variables separately as well as considering potential synergistic effects of multiple stressors to gain a better understanding of the future of biomarker performance and ecotoxicological testing.

Early results have indicated that the sensitivity of certain biomarkers, such as the comet assay, might be affected negatively by increasing sea surface temperatures.

The aim of this ongoing study is to simulate current and predicted near-future conditions for rising temperatures, ocean acidification and fluctuating salinity, and investigate how these can potentially affect a range of established ecotoxicological tests separately and in a multiple stressor setup. This will be achieved by the continued increase in complexity of the experimental setup, to ensure that biomarker responses can be appropriately calibrated and continue to be used in environmental monitoring in the future.

Acknowledgements

The authors extend thanks to the School of Energy, Geoscience, Infrastructure and Society at Heriot-Watt University for providing the James Watt Scholarship, enabling the execution of the project and the Institute of Life and Earth Sciences for providing funding for consumables.

References


Movement of Harbour seals: an individual-based modelling framework as a reliable management tool to study multiple stressors

Magda Chudzinska1, Bernie McConnell1, Sophie Smout1

1 University of St Andrews, School of Biology, Scottish Ocean Institute, Sea Mammal Research Unit, St Andrews, mec21@st-andrews.ac.uk

Area being submitted to (delete as appropriate): 2) Multiple stressors; and 6) Understanding the Influence of Man-made structures in the Ecosystem - progressing the science

Preferred presentation medium (delete as appropriate): (ii) e-poster format.

Are you a student? (Delete as appropriate): No.

Marine environments are threatened by human exploitation, degradation, fragmentation, habitat loss, construction and operation of offshore renewable energy generation (OREG). Such environmental changes can strongly influence movement, behaviour and performance of individuals e.g. foraging, breeding success.

Harbour seals are common residents in the UK waters and although they are a protected species, numbers have substantially decreased in some regions. Reduced prey availability and quality, possibly exacerbated by competition with increasing numbers of grey seals, construction and operation of OREGs, are candidate drivers of this decline. Design of a reliable tool which is able to predict long-term consequences of a combination of such factors on seal movement and population dynamics is therefore important. There is a crucial need for regulators, developers and NGOs to be able to make ‘what if’ scenario predictions and to model the combined effect of marine stressors on Harbour seal populations.

We will present initial results from a behaviour-based, spatially explicit, individual-based model as a tool to simulate harbour seal movement and life history under plausible scenarios of environmental change. The model has been built based on data collected over 20 years by SMRU including telemetry data from over 300 animals, annual counts, data on energetics, and behavioural observations.

We would like to present the key concepts of the model, demonstrate the results obtained from the basic movement component of the model, and to use the opportunity of the presence of various stakeholders and scientists from multiple disciplines on this meeting to discuss the best practice in using modelling tools for management and conservation.
Sea-Loch Bottom Carbon Tales

Anton Edwards

University of the Highlands and Islands

Area being submitted to (delete as appropriate): 1) General science session;

Preferred presentation medium (delete as appropriate): (i) oral

Are you a student? (Delete as appropriate): No.

The abstract should be submitted to masts@st-andrews.ac.uk, in an editable format, by 16:00 Friday 27th July 2018.

This template is an example of how to prepare an abstract for the 2018 MASTS Annual Science Meeting, to be held on 31 October – 2 November 2018 at the Technology & Innovation Centre, Glasgow.

The post-glacial basins of most Scottish sea-lochs are occasionally ventilated by flows of new water than enters from the sea over the entrance sills. These incoming flows take the form of energetic gravity currents that both disturb and redistribute the bottom sediments.

At seaward ends of the basins sediment is coarse and of low organic carbon content; at the landward end it is relatively finer and richer in organic carbon.

Using observations from several varied sea-lochs, a simple physical model of organic carbon content reveals how organic carbon content may be related linearly to the sediment size distribution.

I acknowledge the technical assistance of Crawford Currie and other staff of the Scottish Association for Marine Science in the sea-loch surveys, and in the analyses of sediment size and organic carbon.
Shell integrity and diversity of bivalve larvae at the Scottish Coastal Observatory site at Stonehaven

Hannah Holah¹, Pablo León¹, Eileen Bresnan¹, Margarita Machairopoulou¹, Pam Walsham¹, and Kevin Mackenzie²

¹ Marine Laboratory, Marine Scotland Science, Aberdeen, UK – Hannah.Holah@gov.scot
² Institute of Medical Sciences, University of Aberdeen, Aberdeen, UK

Area being submitted to (delete as appropriate): 1) General science session

Preferred presentation medium (delete as appropriate): (ii) e-poster format.

Are you a student? (Delete as appropriate): No.

You must be a student member of IMarEST to be eligible for the student prizes. Join for free here - https://www.imarest.org/membership/membership-registration/upgrade-your-membership/student-member-imarest

Ocean acidification (OA) and its associated changes to seawater carbonate chemistry are likely to have a significant impact on planktonic calcifiers, including meroplanktonic bivalve larvae of commercial importance for the aquaculture and fishery industries (e.g. mussels, oysters, scallops). Whilst these impacts have been an area of interest for the marine science community field studies on bivalve larvae, as well as studies examining diverse communities of multiple species, are scarce.

This study represents the first investigation into the potential impacts of OA on bivalve larvae at the Scottish Coastal Observatory monitoring site at Stonehaven (56° 57.8´ N, 02 º 06.2´ W), operated by Marine Scotland Science. Phytoplankton and zooplankton samples have been taken weekly at the site since 1997, along with concurrent monitoring of temperature, salinity, and nutrient levels. Since 2009 carbonate chemistry measurements including total alkalinity (TA) and dissolved inorganic carbon (DIC) have also been taken.

During this study bivalve larvae from archived samples were isolated and examined using Scanning Electron Microscopy (SEM) to investigate the diversity of bivalve larvae and to identify evidence of shell dissolution. Preliminary results reveal the presence of a number of bivalve larvae species, including Mytilus edulis, Heteranomia squamula, and Modiolus modiolus. SEM images also showed evidence of shell dissolution in bivalve larvae and a preliminary relationship with OA and environmental variables was examined.

Keyword: Plankton; Ocean Acidification; Bivalves; Shell Dissolution; SCObs
Contact Author: Hannah Holah, Marine Scotland Science, Marine Laboratory, 375 Victoria Road, Aberdeen, AB11 9DB – Hannah.Holah@gov.scot
Monitoring Guidance for Marine Benthic Habitats and R-Markdown Integration

Chris McCabe¹ and Tammy Noble-James²

¹ Joint Nature Conservation Committee, Inverdee House, Baxter Street, Aberdeen, AB11 9QA, Marine Monitoring and Evidence – chris.mccabe@jncc.gov.uk
² Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, PE1 1JY, Marine Monitoring and Evidence

Area being submitted to (delete as appropriate): 1) General science session

Preferred presentation medium (delete as appropriate): (ii) e-poster format.

Are you a student? (Delete as appropriate): No.

You must be a student member of IMarEST to be eligible for the student prizes. Join for free here - https://www.imarest.org/membership/membership-registration/upgrade-your-membership/student-member-imarest

The abstract should be submitted to masts@st-andrews.ac.uk, in an editable format, by 16:00 Friday 27th July 2018.

This e-poster will present, firstly, a document produced by JNCC, entitled “Monitoring Guidance for Marine Benthic Habitats” (Noble-James et al., 2017). Secondly, the poster will detail the innovations JNCC are applying to aid the delivery of benthic habitats monitoring surveys and reports by describing the creation and implementation of an R-Markdown document.

Marine benthic monitoring produces evidence against which the cause and direction of change in the marine environment can be evaluated and can inform management measures, and determine the success of these, when implemented. It is therefore critical that these monitoring programmes are well-designed and statistically robust to allow measurable, accurate conclusions to be made. The Noble-James et al. (2017) ‘best practice’ guidance, presented by JNCC, aims to provide the information and rationale necessary to develop robust monitoring for the marine benthic habitat, by means of a step-wise framework.

The guidance focuses on sampling design, drawing on frequentist theory. The basis of the framework is the development of monitoring objectives, following which the guidance addresses indicator selection, use of existing data, and temporal factors. The importance of statistical power and significance is explored, with guidance on the appropriate levels and ratios for different types of monitoring and the use of power analysis to determine the appropriate sample size. Dependency issues and sampling units are discussed, before guidance on sampling designs is provided. Finally, a statistical analysis section outlines various tests and analyses which can be performed to fulfil a range of monitoring objectives. This summary of the guidance will inform and guide the audience in the processes and rationale which has been applied to the monitoring of the UK’s MPAs, and share this knowledge with the wider community.

The second component of the e-poster will describe the application of R-Markdown in the delivery of monitoring reports. Statistical analysis and modelling have become crucial components to any robust scientific reports and publications, however, these scripts are often unreported, or difficult to replicate or reproduce. With scripting and coding of analysis becoming more complex, the importance of sharing resources and replicable results in the scientific community is becoming more necessary.

R-Markdown is an innovative document type, which allows the integration of code scripts with text-based documents. This allows the integration of coding scripts used in our statistical analyses, such as power analysis and community analysis, to be amalgamated into reports and documentation. This in turn allows the final documents and the often complex and ‘hidden’ analysis behind conclusions to be shown, increasing the transparency of results, ease of replicability, and confidence in conclusions.

Acknowledgements

Thanks to Tammy Noble-James, Joey O’Connor and Elly Hill (all JNCC).

References

Exploring impacts of noise from shipping and acoustic deterrent devices on cetaceans on the West coast of Scotland using an ecosystem modelling approach

Harvey, J.B.1,2, Risch, D.2, and Serpetti, N.2*

1 University of St Andrews, Master of Science - Ecosystem-Based Management of Marine Systems
2 Scottish Association for Marine Science, Oban, PA37 1QA, UK.–*Presenting/Corresponding: Natalia.Serpetti@sams.ac.uk

Area being submitted to E-poster

The abstract should be submitted to masts@st-andrews.ac.uk, in an editable format, by 16:00 Wednesday 5th September 2018.

This template is an example of how to prepare an abstract for the 2018 MASTS Annual Science Meeting, to be held on 31 October – 2 November 2018 at the Technology & Innovation Centre, Glasgow.

Please note that abstracts should be broad and applicable to a wide audience.

Anthropogenic noise in the oceans is increasing and poses a threat to cetaceans, which rely on sound for vital processes such as prey detection, orientation and communication. Shipping and acoustic deterrent devices (ADDs) are two main noise sources on the west coast of Scotland, an important area for cetaceans in UK waters with parts being designated as the Inner Hebrides and the Minches candidate Special Area of Conservation (cSAC). This study mapped the spatial distributions of shipping density and ADDs, and identified ‘hotspots’ where cetacean populations and shipping co-occurred. A novel approach to modelling spatial impacts of shipping and ADD noise on harbour porpoises was employed using Ecopath with Ecosim and Ecospace and best-available knowledge on porpoise responses to shipping and ADD noise. The use of ADDs is widespread and increasing, with >800 in use and multiple devices at many fish farms. Shipping levels are generally low on the west coast although shipping channels in the Firth of Clyde and Northern Channel are hotspots of spatial co-occurrence with cetaceans, with around 1, 10 and 100 daily encounters with minke whales, harbour porpoises and dolphin species respectively. Ecospace modelling showed the potential habitat exclusion of harbour porpoises in coastal areas due to ADD noise and biomass declines of 9% in a high-intensity area compared to a baseline simulation. Shipping did not impact porpoise biomass or distribution apart from in the Firth of Clyde where there were slight declines in biomass (0.8%). Though there were several limitations with the modelling approach due to a lack of knowledge on ADD distribution and long-term porpoise responses to ADD noise, this new approach proved useful in exploring potential scenarios of ecosystem change due to underwater noise.

Acknowledgements

A special thanks to Dr James Waggitt at Bangor University who supplied the temporal/spatial modelled data of cetacean distributions.
The need for a greater understanding of life-style characteristics of *Limaria hians* and the mechanisms behind flame shell bed formation

Kieran Tulbure¹, Daniel Harries¹, Alastair Lyndon¹ and Colin Moore

¹ Institute of Life and Earth Sciences – Heriot Watt University  kt202@hw.ac.uk

Area being submitted to: 1) General science; 2) Multiple stressors

Preferred presentation medium: (i) oral (would like to present e-poster if not chosen to present a talk)

Are you a student? Yes

The flame shell *Limaria hians* is an ecologically important species that acts as an ecosystem engineer by binding the substrate together in a thick turf known as flame-shell beds. These beds support highly diverse associated communities which are comparable with the most species-rich biogenic reefs in UK waters¹. Due to the ecological importance of flame-shell beds they have been recognized as a habitat requiring protection, and in 2012 they were added to the Scotland’s list of Priority Marine Features (PMFs) by Scottish Natural Heritage (SNH).

Work by Heriot-Watt University and SNH on the flame-shell bed at Port Appin in Loch Linnhe has observed a temporal decline in the extent of the bed since observations began. A report estimated the historical extent of the bed based on archived records to be 40 ha, then found that its 2011 extent had declined significantly to 3 ha². More recent surveys have found a continued deterioration of the bed with this summer’s survey only observing *L. hians* nest material from a very restricted area.

Although the cause of this decline is not yet determined, it is thought that mechanical damage from creel fishing may have contributed alongside environmental changes such as increased wave action due to more extreme stormy weather. The present project aims to assess the significance of the decline both spatially by mapping the remaining extent of flame-shell bed, and temporally by assessing long term persistence of the feature. A recent report on current connectivity of PMFs found that flame shell beds in the Loch Linnhe area appear not to receive larvae from other *L. hians* populations around Scotland². The declining status of the Appin bed and the apparent lack of larval supply increase the need for future work on this flame-shell bed in the Loch Linnhe area. Work to determine the extent of the remaining bed and investigation into reasons for its decline could potentially provide useful information for conservation of the habitat more generally.

Gaining knowledge on the connectivity of PMFs has been a focus of attention recently, with hydrodynamic modelling and particle tracking used to determine how these features are linked³. Knowing the connectivity of features can provide insight to the interdependency of populations and highlight those without larval supply from other areas, such as the Port Appin bed. Work on connectivity of PMFs in Scotland has highlighted the need for more work on larval behaviors to refine the models³,⁴.

In order to support the conservation of *L. hians*, this project aims to gather information on their ecological and life-cycle characteristics in aquaria. These investigations will include studies of sexual maturation and gamete fertilization, larval swimming behavior and substratum preferences for larval settlement. Recently, *L. hians* were experimentally induced to spawn in Heriot-Watt aquarium facilities. Adult specimens collected during the period of sexual reproduction were injected with serotonin solution versus a control of injection with filtered seawater. Presented here are the results of this experiment alongside the first known video footage of *L. hians* spawning. Future work will organize frequent monitoring of sexual status of the flame shells to obtain the specimens at peak sexual maturity.

Acknowledgements
I would like to thank SNH for collaborating with the fieldwork and for allowing use of their data.

3 Gallego et al., (2013) “Connectivity of Benthic Priority Marine Species within the Scottish MPA Network.” Scottish Mar Freshwater Science, 4(2)
4 Millar et al. (in prep.), “Connectivity of Selected Priority Marine Features: Both within and Outwith the Scottish MPA Network.” SNH commissioned report
Kinematic and acoustic analysis of herring-eating killer whale feeding behaviour during different prey life-stages

Pablo Chevallard1,2, Dr. Filipa Samarra3, Dr. Gordon Hastie2 and Dr. Patrick Miller2

1 Marine Scotland Science – Pablo.chevallardnavarro@gov.scot
2 Sea Mammal Research Unit, University of St Andrews.
3 Marine and Freshwater Research Institute, Reykjavik.

Area being submitted to: 1) General science session; Preferred presentation medium: (i) oral.
Are you a student? No.

Herring-eating killer whales are specialized on a type of prey that undergoes changes in behaviour throughout the year. Challenges faced in each of herring life-stages may cause killer whales to modify their behaviour accordingly. Sound and movement data registered in archival tags were analysed to assess how variables related to feeding behaviour differed across prey life-stages. Deployments were performed on killer whales in Norway and Iceland during overwintering, feeding and spawning life-stages. Angular deviation in heading over five-minute periods illustrated movement circuitousness degree. Acoustic events were marked. Tail slaps produced by the tagged individual (focal) were identified by a rapid change in pitch, and considered as capture. Tail slaps occurred consistently at higher angular deviation periods in all life-stages, but the proportion of focal tail slaps from the total was higher during feeding and spawning contexts, that registered lower absolute detections of non-focal tail slaps. The depths of focal tail slaps reflected differences across life-stages. Mean depths were $\bar{x}_{\text{overwintering}} = 15.25\text{m} (SD=14.37)$ during overwintering, $\bar{x}_{\text{feeding}} = 66.13\text{m} (SD=17.11)$ during feeding and $\bar{x}_{\text{spawning}} = 33.85\text{m} (SD=10.41)$ during spawning life-stages. Echolocation production was associated with higher values of angular deviation only during overwintering. Buzzes were more commonly produced after a tail slap during feeding and spawning life-stages, suggesting they may assist in the handling of prey when the water is turbid. Roll movements during the tail slap sequence differed across contexts: whales rolled upside-down more often after a tail slap during feeding life-stage, whereas during spawning tail slaps were performed upside down. Roll behaviour could be related to the use of visual cues, but there was no clear statistical support. Feeding using tail slaps appeared to be a commonly employed strategy. Life-stage particularities in the depths where feeding takes place, the use of echolocation and the roll behaviour suggest predator behavioural adaptations potentially advantageous at each context.
Modelling the spatial dynamics of the marine copepod *Calanus finmarchicus* under climate change

**Douglas Speirs**¹, Robert Wilson¹ and Michael Heath¹

¹ Department of Mathematics and Statistics, University of Strathclyde, Glasgow G1 1XH – d.c.speirs@strath.ac.uk

Area being submitted to: The changing Arctic Ocean: identifying and quantifying the Arctic response to climate change

Preferred presentation medium: oral

You must be a student member of IMarEST to be eligible for the student prizes. Join for free here - https://www.imarest.org/membership/membership-registration/upgrade-your-membership/student-member-imarest

The copepod *Calanus finmarchicus* is widely distributed over the North Atlantic, extending into the Arctic, and dominates the mesozooplanktonic biomass in much that region. Through grazing on phytoplankton it contributes substantially to oceanic secondary production, and it is a major species of prey for a wide range of commercially exploited fish. It has been recognized that its geographic has been changing over time, with its southern edge moving northwards as it is replaced by warmer water species. With continued warmer of the Arctic Ocean it is thought that there will be associated changes in the northern limits of its distribution. *C. finmarchicus* has a complex life cycle involving numerous life-history stages, including five copepodite stages preceding a final moult into adulthood. The fifth copepodite stage (CV) is capable of sinking to great depth (in excess of 1000m) and entering a torpid, diapause, state for overwintering before rising again to the surface in the spring to reproduce. Since CVs store energy reserves in the form of lipids, this huge vertical migration involves a large transfer of surface production to the deep ocean. Recent studies have quantified this effect, known as the lipid pump, and have shown that the amount of Carbon sequestered by *C. finmarchicus* alone is approximately the same as the annual sinking flux of detrital carbon. So, warming Arctic waters not only have the potential to change the distribution of *C. finmarchicus*, but also may have an impact on deep ocean carbon sequestration.

In order to improve our predictive capability here we report on the development of new spatially explicit stage-structured model of *C. finmarchicus* populations throughout the North Atlantic, which includes recent advances in understanding *Calanus* biology, including U-shaped relationships between growth and fecundity and temperature, and a new model of diapause duration are incorporated in the model. The model is driven by physical transport and temperature from ocean circulation models, and food fields derived from satellite ocean colour (as a measure of chlorophyll), and it was parameterized using Continuous Plankton Recorder Survey data and tested using time series of abundance and fecundity. The results presented here are a starting point for a study within the DIAPOD (Mechahnistic Study of Diatoms in the success of the Arctic Calanus Complex and Implication for a Warmer Arctic) project of the NERC Charging Arctic Ocean Programme.
A needle in the haystack? Seeking salmon smolt migration routes off the Scottish east coast using surface trawling and genetic assignment

Ross Gardiner¹, Rob Main², Rob Kynoch², John Gilbey¹ and Ian Davies²

¹ Marine Scotland Science, Freshwater Fisheries Laboratory, Pitlochry, PH16 5LB – ross.gardiner@gov.scot
² Marine Scotland Science, Marine Laboratory, 375 Victoria Rd, Aberdeen AB11 9DB

The routes salmon smolts use to pass through the coastal zone, and how quickly they do this, will influence whether developments such as marine renewables could affect salmon populations.

The Norwegian Sea is already known to be an important early staging area for salmon post smolts from Scottish rivers. But how do they reach there? Nothing was known with any certainty about the routes salmon smolts take from Scottish east coast rivers. One hypothesis was that they follow the Scottish coast north, then head north west from the north coast to join other smolts heading north east along the continental shelf edge along a route Irish smolts are already known to use. Another hypothesis was that they would head direct across the North Sea. This poster is on the successful trawling work carried out by Marine Scotland Science in 2017 and 2018 to investigate the outmigration of smolts in Moray Firth and Scottish east coast marine renewables development areas.

The net used is a large, specially designed net, which requires a powerful vessel such as MSS research ship Scotia or a pelagic trawler for deployment. It operates very close to the water surface and can operate either open ended with no fish retained, in potentially continuous use with video and PIT tag recording of entrained fish, or using a small cod end attached to the camera / PIT detector frame in hauls to retain smolts for further examination and obtain samples for genetics assignment work. (Gilbey et al., 2016).

Trawls for salmon smolts were carried out in mid May 2017 in the Moray Firth and in the first half of May 2018 in the Moray Firth and off the east coast of Scotland.

The poster presents the results of the trawls including the genetic assignments of smolts retained in 2017 – the genetic assignment work on the smolts retained in 2018 is still in progress. The results both years indicated that many smolts were moving out in an approximately eastward band in the southern part of the Moray Firth, with no indication of coastal following, supporting the hypothesis that smolts are heading directly across the North Sea. The genetic assignment work showed that this is true for smolts from many rivers; the assignments are particularly informative for smolts from rivers discharging onto the west shore of the Moray Firth, as for many of these rivers the salmon are assignable with confidence to the individual rivers. Three smolts which had been PIT tagged in the Rivers Conon (2 smolts) and Shin (1 smolt) were caught in the 2018 Moray Firth hauls. In 2018, sampling in the Moray Firth took place in two separate periods, and the results and the information on the captured PIT tagged fish (not detailed in the poster) show that salmon smolts move quickly across the firth.

A little information is also presented on the fish other than salmon smolts which were caught, including adult salmon and sea trout (but no sea trout smolts), mackerel, lumpsuckers, sandeels, garfish and sticklebacks.

Maps are presented to illustrate that the route being taken by the smolts allows them to take advantage of east flowing currents which cross the North Sea, and the fast progress away from the coast will limit exposure to the high densities of predators which occur close to the Scottish coast. It will also reduce the potential for interaction with marine renewables developments.

The poster also outlines future plans and mentions how the trawling work complements other work by various parties, including marine Scotland Science, which is taking place in the Moray Firth and off the mouth of the River Dee by acoustically tagging smolts in rivers and monitoring where and...
when the tagged fish cross fixed curtains of acoustic receivers.

References