MARMICROTOX project: Effects of microplastics in marine organisms and use of mussels to assess their presence in the Scottish coast

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Area being submitted to: Marine Micro-plastic litter

Preferred presentation medium: e-poster format

Are you a student? No

Among the most prominent and ubiquitous anthropogenic changes in the marine environment has been the accumulation of plastic debris throughout the oceans. Small (< 5 mm) pieces of plastic, termed microplastics (MPs), have been reported in some coastal areas of Europe, but few areas, including the Scottish coast, have been evaluated and the extent of this environmental issue is unknown.

Microplastics are ingested by organisms and the prominent concerns of this exposure include accumulation in internal tissues, trophic transfer in the food web and increasing the bioavailability of toxic substances (co-contaminants) that may be associated with microplastics. The abundance and extent of plastic debris in marine environments is now recognised as among the highest priority issues for environmental policy

Currently, there are critical and priority issues that need to be investigated concerning the presence of microplastic debris in marine environments, and these include: 1) evaluation of the extent and severity of microplastic contamination in marine organisms in different locations; 2) investigation of the accumulation, absorption and negative effects of microplastics in lower trophic-level marine invertebrates; 3) examination of trophic transfer of microplastics and pathophysiology in fish and 4) determination of effects of microplastics on co-contaminant bioavailability in marine organisms.

On a first stage, our goal is to assess abundance and type of microplastics in wild mussels collected from sites located in both the East and West coast of Scotland. We are currently evaluating and quantifying the presence of microplastics in mussels within the Mytilidae family: horse mussels, *Modiolus modiolus* (a subtidal filter feeder) and blue mussels *Mytilus edulis* (intertidal filter feeder). We have developed an extraction and quantification method and applied it to individuals collected along the Scottish coast (Atlantic and North Sea).

On a second stage, this study will focus on evaluating microplastic accumulation, absorption and negative effects, including physical tissue disruption, on the mussel *M. edulis*. The project will further assess whether association between co-contaminants and microplastics influences co-contaminant bioavailability in mussels.

Finally, we will artificially expose sea trout individuals (brown trout, *Salmo trutta*) to food items containing known amounts of microplastics. The goal is to investigate the trophic transfer of microplastics by dietary exposure in *S. trutta* and the effects on tissue surfaces, digestive system physiology, as well as overall organism health including growth and food conversion efficiency.

This project, MARMICROTOX, is funded under the European Commission FP7 scheme of the Marie Curie Actions for Intra-European Fellowships (IEF) and has the duration of two years (July 2014 - July 2016). The project also includes a large component of outreach activities and public dissemination that will be developed together with local communities, including schools.

The diversity and value of key European marine habitats: reviewing the use of the 'ecosystem services' concept in marine environmental policy and coastal management.

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The concept of ecosystem services refers to providing essential goods for human welfare. It has been particularly brought to attention by the UNEP publication on the Millennium Ecosystem Assessment (MEA) in 2003. One section in the MEA discussed ecosystems services provided within the marine environment, which have since been subject to further research and scientific discussions (UNEP-WCMC, 2011). Examples for marine ecosystem services, which represent a crucial value to humans, include nursery grounds for commercially valuable fish, habitats providing coastal protection from storms, or ecosystems providing important basis for recreational activities (Beaumont *et al.*, 2007). This study will summarise and review current level of research on marine ecosystem services. It will focus on a selection of key marine habitats, which cover different categories of ecosystem services as defined by the MEA, such as, provisioning, regulating, supporting and cultural services (MEA, 2005). In addition, the use of the ecosystem services concept and the 'ecosystem approach' in the context of marine conservation and protection policy and coastal management will be presented. The benefits and limitations of applying this concept will be discussed and evaluated, to determine their effectiveness under different types of habitats and conditions. In summary, this study addresses the role of this concept in marine environmental management and conservation.

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Vulnerability of *Modiolus modiolus* biogenic reefs to climate change: A population-based approach for effective marine management

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The marine bivalve *Modiolus modiolus* (horse mussel) creates biogenic reefs which are characterized by high species diversity. Additionally, *M. modiolus* biogenic reefs provide a number of ecosystem services including water quality improvements, benthic-pelagic coupling, and seabed stabilisation (Rees, 2009). Decline in the extent of *M. modiolus* biogenic reefs has been noted across the species' European distribution. In the Irish Sea, historical fishing activity, namely scallop trawling and dredging, has caused widespread and long-term damage to *M. modiolus* reefs (UK BAP, 2008; Rees, 2009). Consequently, *M. modiolus* reefs are listed as a threatened and/or endangered species and habitat in all OSPAR regions (OSPAR, 2008) and thus are a conservation priority under the EU Marine Strategy Framework Directive (MSFD, 2008). Likewise, *M. modiolus* biogenic reefs are a UK Biodiversity Action Plan priority habitat (identified as most threatened and requiring conservation action) (UK BAP, 2008).

Increases in global CO_2 concentrations are linked to physical changes in marine environments (e.g. warming, acidification). Key structural or functional species such as *M. modiolus* may be affected by such changes, resulting in a decline in their extent and distribution, and therefore, reducing their value as ecosystem engineers which provide rich habitats for marine life (Doney *et al*., 2012). While some marine species may possess the ability to acclimate to changing environmental conditions over time and hence have the potential to increase tolerances to environmental stress, it remains relatively unclear whether *M. modiolus* can compensate for such changes.

This project takes a population-based approach to identify and characterise those populations of *M. modiolus* most vulnerable to climate change. The project aims to determine the stress response of populations in the field from across the species' distribution including those at the southern limit of the range. The project will also characterise the tolerance limits and acclimatory ability of such populations to abiotic changes under controlled conditions in the laboratory. Preliminary results of responses to thermal stress conditions in populations from across a latitudinal gradient will be presented and discussed alongside genetic analyses of connectivity and variability for the same populations.

Effective management of species of conservation importance requires detailed knowledge about genetic structure (i.e. population connectivity) and insight into population-based differences with regards ability to acclimate to changing conditions. Thus, outcomes of this work will be critical in informing management of these important marine habitats.

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Kinetics of DNA Damage and Repair in Fish, using the Zebrafish *(Danio rerio)* as a model.

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Area being submitted to (1) General science session
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Are you a student? (Delete as appropriate): No

Recent developments in aquatic ecotoxicology are moving away from standardized exposure experiments to sub-lethal, more environmentally relevant biomarker endpoints. DNA perturbations can be a very powerful tool, but usually require *in vivo* exposure, which has negative ethical connotations. Furthermore legislative pressure is driving the refinement of the methods to reduce the number of organisms used, especially, where replacement with *in vitro* or *in silico* methods is not practical.

In this context, the objective of this study was to develop zebrafish *(Danio rerio)* as a model organism for investigating the kinetics of DNA repair in fish, by assessing the progressive decrease of DNA damage following genotoxic insult. DNA damage was induced by exposing larval zebrafish to ultraviolet light (UV-C) (0.33 mW/cm^2) and assessed using the comet assay technique. Single strand breaks (SSBs) were expressed as an increase of % DNA content in the comet tail. DNA damage/repair enzymes (DNA glcolyase; AP endonucleases; DNA polymerase) created SSBs at oxidized base loci and pyrimidine dimers. Through specific enzymatic activity, the relative number of damaged bases can be estimated. It was found that DNA damage was induced by exposure to UV-C irradiation and the amount of damage decreased in proportion to recovery time period. Most DNA damage was observed to be repaired 1- hour post exposure. Future studies aim to analyse the RNA of exposed larvae to determine the kinetics of repair-gene expression, using qRT-PCR methodologies. Further studies will utilise the methodologies and findings from these studies to investigate the DNA damage and expression of repair genes in fish exposed to photoactivated TiO_2 nanoparticles to establish the potential effects of this substance in the environment.

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Estimating discards using fisheries-independent data

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Area being submitted to (delete as appropriate): Fish discards
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Are you a student? (Delete as appropriate): Yes

This PhD research aims to estimate the number of fish discarded at sea, by using fisheries-independent data. It will focus initially on cod and whiting in ICES Area VIa, with a view to extending the methods developed to other areas and other species.

Where discard mortality is felt to contribute to overfishing and to species vulnerability, attempts have been made by both fisheries managers and fishermen to reduce it. However, there are concerns that the forthcoming land-all obligation could mean uncertainty for the observer programme, which until now has been the key source of direct data on discarding. This could make it more difficult to manage the practice.

The obligation may also alter fishermen's target species towards a variety of unregulated species (Rochet, Catchpole et al. 2014). A cursory examination of research survey data shows around 100 species being caught in ICES Area VIa (West of Scotland) by research vessels, although relatively little is known about their commercial catch or discarding. What new species might turn up at the fishmonger?

There currently exists a body of work on estimating unregulated, unreported or illegal fishing mortality around the world, which provides insight into alternative methods of obtaining discard estimates. Broadly, there are two approaches to estimating discards where direct data is limited:

i. Statistical modelling, using known relationships between discarding and other variables to estimate discarding where there is missing data but where data on the other variables is available
ii. Estimating catch directly and then applying a statistical model of discarding behaviour. This approach would be taken where there is no data available on discarding at all, and is found less frequently in the literature.

The PhD will focus on the second of these approaches, to develop a model that uses research vessel data and landings data to estimate levels of discarding. A number of approaches will inform this work, for example Chai (1991), Casey (1996), McBride (1996), Harley (2000), Dingsør (2001), Palsson (2003) and Piet, van Hal et al. (2009), each of which adopts some means of using fisheries-independent data and selectivity information to simulate the commercial catch, and then to compare this with known landings to derive estimates of discarding.

It is recognised that commercial fishing is not a random activity. Fishermen are able to use shared knowledge as well as technological aids to target species with a degree of accuracy, therefore it can be expected that the species and size composition in the commercial catch will differ inherently from survey vessel catch. To address this to some extent, VMS data will be consulted, and statistical rectangles that appear to have been fished will be used as the basis of selecting research vessel data.

It is intended that fishermen will be consulted throughout the process of the research, and that its findings may be of value in informing managers, policymakers and the public about potential effects of the land-all obligation, as well as offering alternative methods of estimating discards for contributing to, for example, ecological modelling.

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East coast marine mammal acoustic study: using multiple modalities to assess habitat usage by harbour porpoises and bottlenose dolphins

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Are you a student?: Yes

The east coast of Scotland is home to a protected population of bottlenose dolphins and a widely distributed population of harbour porpoises. There is a need to monitor habitat use to identify potential impacts on these species in light of planned development along the east Scottish coast, including offshore wind farms. Continuous monitoring will help us to determine whether the construction and operation of such developments will have significant impacts on the behaviour and, ultimately, consequences at the population level of these species. To achieve this goal, arrays of three different acoustic monitoring devices (CPODs, SM2Ms and PAMBuoys) are being deployed. This project aims to integrate these acoustic data with visual observations to 1. Identify patterns in habitat use by these two species 2. Investigate ambient noise conditions in relation to population dynamics in the areas monitored and 3. Develop a cost effective method for the continuous monitoring of these species over the construction and operational phases of renewable energy projects.

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