

Background

In response to the call for PhD proposal to operate under the SUPER DTP, Marine Scotland (MS), offers the projects outlined above. At this time, submission of these proposals does not imply any firm financial commitment.

Any specific queries should be addressed to the Marine Scotland Science (MSS) named lead. Any general queries should be addressed to Colin Moffat (colin.moffat@gov.scot)

PROJECT 1: Monitoring the Environment with DNA

Title:

Novel DNA-based tools for environmental assessment and monitoring of Scottish seas

Specific aims and objectives of the research:

There is an increasing need for rapid and cost-effective approaches for biomonitoring in coastal and offshore environments. In the last five years, rapid technological advances in DN- based techniques has facilitated the detection of species and entire communities from environmental samples such as water or sediment without the need to sort or visually observe individual organisms. The ability to easily and rapidly detect so called environmental DNA (eDNA) from a variety of sources has revolutionised biomonitoring. The proposed PhD student(s) will assess the effectiveness of these approaches in the context of monitoring for invasive species, benthic or mobile marine protected features or organisms negatively affecting the shellfish and finfish aquaculture industry.

MSS lead:

Iveta Matejusova

Policy drivers:

The most important legislative drivers for the monitoring are the European Union Water Framework Directive, Marine Strategy Framework Directive, Habitat and Species Directive, Regulation on Invasive alien species, Ballast Water Convention and national legislations and initiatives such as UK assessment of state in Charting Progress 2, Scotland's Marine Atlas, UK Marine Climate Change Impacts Partnership report cards, Wildlife and Natural Environment (Scotland) Act 2011 and Alien and Locally Absent Species in Aquaculture (Scotland) Regulations 2014.

PROJECT 2: Wild Scottish Salmon

Title:

Immunogenetic consequences of aquaculture to wild Scottish salmon

Specific aims and objectives of the research:

The goal is to understand the potential for different wild salmon populations to respond to pathogens and disease. It will examine the diversity of genes involved in salmon immune responses by utilising a unique library of wild salmon DNA collected

from across Scotland obtained from an introgression study being conducted by Marine Scotland Science.

The aims of the project are to:

- Quantify MHC gene variability between river systems across the whole of Scotland;
- Examine the relationship between environmental factors and immunogenetic variability; and
- Identify immune genotypes specific to the aquaculture zone.

MSS lead:

David Morris

Policy drivers:

The interactions between aquaculture and wild fish is a key policy area. Introgression between farmed and wild stocks is of substantial concern to the wild fish sector. This project will complement and add value to current work by providing key information that is required to understand the impact of introgression on the sustainability of wild fish stocks across Scotland in the face of diverse environmental challenges.

PROJECT 3: Marine Mammals

Title:

Ecology of killer whales in Scotland and their potential role in the harbour seal decline

Specific aims and objective of the research:

To better understand the role that killer whales may play in the significant declines in harbour seals in Scotland. Determine the behaviour of killer whales in the vicinity of known seal haul outs, potential ecotype divisions and prey between killer whale clans.

MSS lead:

Ross Culloch or Ewan Edwards

Policy drivers:

Harbour seal populations, including those identified as qualifying features of Special Areas of Conservation (SACs), have undergone significant declines. The killer whale population is small and vulnerable with several knowledge gaps identified in the cetacean conservation strategy.

PROJECT 4: Seabirds

Title:

Energetic costs of displacement during the non-breeding season on seabird demographic rates.

Specific aims and objectives of the research:

Displacement or disturbance of seabirds due to marine activities e.g. shipping and/or renewable energy developments, has the potential to negatively impact demographic rates such as overwinter survival or breeding success in the subsequent breeding season. This issue is becoming increasingly important due to the potential for disturbance from multiple sites resulting in significant cumulative effects. This PhD will gather data on the energy budgets of key seabird species (guillemot, razorbill, puffin) during the non-breeding season e.g. using GLS and TDR technologies, to better understand the potential cumulative effects of displacement.

MSS lead:

Jared Wilson or Tom Evans

Policy drivers:

A key knowledge gap identified by the ScotMER process, key to understanding how marine activities may impact internationally important populations of seabirds, inform EIA/ HRA for renewables projects. Improved understanding of energetics during the non-breeding season would assist in identifying drivers of recent population declines and how future climate change scenarios may impact the species.

PROJECT 5: Seabirds**Title:**

Seabird behaviour in and around a constructed windfarm.

Specific aims and objectives of the research:

- Explore the ORJIP bird collision avoidance (BCA) study at the Thanet offshore windfarm dataset in detail, describing species specific behaviour in the vicinity of wind turbine generators.
- Analysing whether birds behave differently when approaching from downwind vs. upwind of turbines, whether birds adjust their flight altitude to fly below the turbine swept area (collision risk height), and differences between age classes (where possible to identify visually, e.g. for gannet).

In addition to furthering our understanding of collision risk, the project could contribute to understanding displacement and barrier effects.

MSS lead:

Jared Wilson or Tom Evans

Policy driver:

The potential for negative interactions between seabirds and offshore wind farms is a major risk for the consenting of offshore wind farms, and one that is increasing due to potential cumulative effects from multiple windfarms/ interactions with other drivers. One of the principle interactions of concern is the potential for mortality arising from collision between seabirds and wind turbine generators. This study would increase our knowledge of seabird behaviour around wind farms, and thus reduce uncertainty allowing for more realistic environmental assessments for strategic environmental assessment (SEA) and for development specific

environmental impact assessments (EIA). Addresses ScotMER evidence gap ID: OR.16 (potentially also OR.18, OR.21).

PROJECT 6: Seabirds

Title:

Automated monitoring of cliff nesting seabird populations.

Specific aims and objectives of the research:

- The development of high resolution cameras and other sensors (e.g. passive infra-red) to remotely monitor seabird populations, nest attendance, provisioning rates.
- Develop smart computer algorithms (e.g. deep learning algorithms) to measure e.g. arrival -, laying -, fledging -, and departure-dates; productivity/breeding success, and numbers of breeding pairs.
- Test potential approaches to collecting and analysing such data for a number of key seabird species in Scotland (e.g. common guillemot, razorbill, gannet, and kittiwake)

MSS lead:

Jared Wilson or Tom Evans

Policy driver:

Scotland hosts internationally important populations of breeding seabirds, with many of these populations protected as special protection areas (SPAs). For the conservation of these populations data is required that can inform on the status of these populations (e.g. numbers breeding over time, breeding success/productivity, and phenology). Information required for reporting under EU Birds and Marine Strategy Framework Directives, environmental assessment for offshore renewable developments (SEA, EIA and HRA). Data required to maintain/update seabird conservation strategy. Addresses ScotMER evidence gap ID: OR.11 (potentially also OR.12).

PROJECT 7: Seabirds

Title:

Role of predation by Great black-backed Gulls on Atlantic Puffin populations.

Specific aims and objectives of the research:

Populations of many species of seabirds have declined significantly over the past 30 years, with climate change identified as a primary cause. However, prey switching has also been identified as a compounding factor e.g. Great Skua switching to predate on kittiwake adults and chicks. The PhD would examine the consequences of the significant increase in great black backed gull numbers on the Isle of May and the associated predation of puffins on the population of breeding puffins. This would involve identifying the degree of specialism within the gulls, quantifying the level of predation as well as the age of the predated puffin, and undertaking population viability analyses to understand the population consequences of current or future

great black backed gull population changes on breeding puffin (a species of very high conservation concern).

MSS lead:

Jared Wilson or Tom Evans

Policy driver:

To understand the drivers of seabird population declines, to identify potential mitigation measures, to better inform SEA/EIA/HRA, to deliver a coherent Seabird Conservation Strategy.

PROJECT 8: Plankton and Ocean Acidification**Title:**

Ocean acidification impacts on Marine Plankton

Specific aims and objectives of the research:

Ocean acidification is a significant and growing environmental pressure in the marine environment. Understanding impacts from ocean acidification requires an understanding on how the plankton community responds to changes in carbonate chemistry as well as good baseline information against which future changes can be assessed. This PhD will build on preliminary data from the Scottish Coastal Observatory to assess how environmental parameters, including carbonate chemistry, impact sensitive plankton groups, pelagic gastropod larvae, pteropods, bivalve larvae and coccolithophores using a 20 year plankton archive. Target groups will have their identities confirmed using advanced electron microscopy and molecular techniques and the role of environmental parameters on shell dissolution and calcification will be assessed. Additional plankton archives will also be sourced to allow regional comparisons to be made.

MSS leads:

Pablo Diaz and Eileen Bresnan

Policy driver:

Ocean acidification is a significant environmental pressure on the marine environment and can act in synergy with the warming of the seas and ocean deoxygenation to negatively impact marine biota. Despite this, information about impacts on the plankton community over multidecadal scales is scarce. Some larval stages (e.g. bivalve larvae) are of commercial importance to the aquaculture industry. Ocean acidification is considered a *prevailing oceanographic condition* for the Marine Strategy Framework Directive, considered as a separate pressure by the Marine Climate Change Impacts Partnership and is cited as a major threat to marine biodiversity loss by the UK Government Foresight Report on the Future of the Sea.

PROJECT 9: Sea fisheries

Title:

A sea of change: is deteriorating individual condition affecting the population dynamics of herring?

Specific aims and objectives of the research:

This project aims to determine how condition influences vital rates in herring using information from scientific surveys and catches. The student will model condition changes through the life history of herring using otolith readings combined with physiological information to determine whether growth dynamics can be associated to environmental changes and used as early-warning signal for shifts in population growth rate and age structure. These will introduce informed condition functional responses in the current herring population model to help improve stock assessment.

MSS leads:

Neil Campbell and Susan Lusseau

Policy driver:

As the environment of Scottish seas is rapidly changing, we need to ensure that our stock assessment models account for the way in which our fisheries respond to these changes. We also need to develop new ways to react rapidly to the changing status of stocks as they have to adapt to new environmental conditions. This project will introduce mechanistic functions in stock assessment to help improve predictability. It will also introduce early-warning signals which can be used to engage in preventive management. This will ensure that we can support the sustainable economic growth of our fishing industry.

PROJECT 10: Sea fisheries

Title:

Identifying methods for establishing management advice for Scottish wrasse fisheries.

Specific aims and objectives of the research:

The work will seek to derive fishery-dependent and/or fishery-independent methods for assessing the stock status of five wrasse species caught in Scottish waters and consider how these assessments can be used to provide advice for stock management.

MSS Lead:

Nabeil Salama

Policy driver:

There is a policy driver to provide a sustainable, profitable, well managed aquaculture industry in Scotland, and sustainably managed salmon and recreational fisheries. One of the challenges to both of these policies is the control of sea lice on salmon farms. There has been an increased use of cleaner fish as a biological

control of sea lice on salmon farms, and although there has been an increase in cultured cleaner fish in recent years there has been substantial harvesting of wild caught wrasse, which has become an industry in its own right. Therefore there is a need for information to support profitable and well managed fisheries in Scotland. Currently there is no information on the status of the fisheries nor scientifically informed management.

PROJECT 11: Sea fisheries

Title:

Using biological-physical modelling to establish stock units for wrasse fisheries.

Specific aims and objectives of the research:

The work will seek to identify stock units for wrasse fisheries for informing suitable harvesting activity to avoid over depletion. Wrasse have complex life histories which make their management unusual compared to traditional fisheries. The work will be focussed on biological-physical larval transport models, with population simulation models to identify areas which may be more or less suitable for exploitation based on population recruitment. The project will provide maps of suitable habitat and population susceptibility for each wrasse fishery for informed fishery management

MSS Lead:

Nabeil Salama

Policy driver:

There is a policy driver to provide a sustainable, profitable, well managed aquaculture industry in Scotland, and sustainably managed salmon and recreational fisheries. One of the challenges to both of these policies is the control of sea lice on salmon farms. There has been an increased use of cleaner fish as a biological control of sea lice on salmon farms, and although there has been an increase in cultured cleaner fish in recent years there has been substantial harvesting of wild caught wrasse, which has become an industry in its own right. Therefore there is a need for information to support profitable and well managed fisheries in Scotland. Currently there is no information on the status of the fisheries nor scientifically informed management.

PROJECT 12: Priority Marine Features

Title:

Multi-disciplinary connectivity investigation of Priority Marine Features in Scottish waters using bio-physical modelling and population genomics

Specific aims and objectives of the research:

Marine Protected Areas (MPAs) are designated for the protection and conservation of a range of species and habitats. Effective spatial management of the MPA network relies on understanding the linkages between protected features within MPAs and the relationship that they have with species and habitats out with the

network. This project aims to improve our understanding of sensitive species with regard to their distribution in Scottish waters. The main focus will be on Priority Marine Features (PMFs, species identified as being of conservation importance in Scotland's seas), for example flame shells (*Limaria hians*) and horse mussels (*Modiolus modiolus*). Previous work (Millar et al. 2018) has identified knowledge gaps with regard to these species, which are benthic and sessile as adults, but rely on a pelagic larval phase for transport. This multi-disciplinary project will use bio-physical and habitat modelling in conjunction with population genomics to examine connectivity of benthic species populations since the larvae are transported by currents. The outcome from detailed genomic analyses can be used to explore the role of local adaptation in population persistence and validate the larval dispersal model outcomes, which aim to explain the mechanism behind population connectivity.

MSS Lead:

Berit Rabe

Policy driver:

Scotland's National Marine Plan - sets the objectives and policies for marine planning in Scottish waters and states that development and use of the marine environment must not result in significant impact on the national status of PMFs. Planning and Environmental Advice Programme - aims to provide evidence supporting development of national marine planning, the development and management of a network of Scottish MPAs, and to improve understanding of sensitive species, their habitats and distribution in Scottish waters. Marine Scotland Act - an MPA network contributing to conservation of the UK marine area.

Project 13: Discards

Title: Multi-disciplinary Quantifying discard potential using spatial biodiversity and fisheries-dependent data to benefit the Scottish demersal fleet

Specific aims and objectives of the research:

The aim of this PhD project is to develop novel metrics for quantifying the discard potential of the North Sea and/or Seas West of Scotland using data from scientific surveys and commercial catches. Relevant factors for consideration include background levels of diversity in the fish community, spatial distribution of fish species, regulatory restrictions (e.g., closed areas, TACs and choke species), and the distribution of the fishing fleet.

MSS Leads:

Tanja Miethe / Liz Clarke

Policy driver:

From 2019 onwards Scottish and other European fishing boats will be unable to discard unwanted catch of species that are managed through setting total allowable catches. Instead, skippers must deliver their unwanted catch to port, a regulatory requirement known as the Landings Obligation.

Effective spatial selectivity requires highly resolved spatial information about the potential for catching unwanted species and undersized commercially targeted fish. Locations that are characterised by consistently high diversity could be expected to have greater potential for discarding, particularly where commercial species are also abundant and fishing activity is high. The results of the project will be relevant to addressing current challenges in fisheries management, reduce unwanted fishing mortality to ensure sustainable exploitation and improve fisheries efficiency.

Additional Project suggestion from University of the Highlands and Islands (SAMS)

Title:

Quantifying the extent to which the epifaunal communities that colonise offshore energy infrastructure (renewables and oil and gas platforms) have replaced the ecosystem functions and services associated with historical north sea biogenic reefs (i.e. oysters beds).

Specific aims and objectives of the research:

- Quantifying the habitat provision (i.e. surface area) of different artificial structures
- Using a bio-physical dispersal model to understand the connectivity between structures
- Undertaking an aquarium based study to understand secondary productivity rates of native oysters and common epifaunal species found on energy infrastructure
- Comparing secondary productivity and connectivity of historical biogenic habitats with contemporary/future artificial habitat.

MSS lead:

Pete Hayes & Jared Wilson