ScotMER and MREF MASTS Workshop Oct 5, 2019

Addressing the ecological implications of offshore renewable energy developments across receptor groups – shaping future marine energy research

Purpose: To identify the next steps in research required to understand the ecological implications of offshore renewable energy in the UK. This workshop will narrow down the key ecological pathways that link priority evidence gaps between receptor groups to focus research effort.

Key Questions

1. What ecological pathways do we need to focus on to have useful outputs for estimating and monitoring the ecological impacts of marine renewables across receptor groups?
    a. Where are the key linkages between high priority research gaps on receptor evidence maps?
    b. What pathways are feasible to parameterise, and what are the gaps?
2. What ecological models (whole or part) are currently available?
    a. Where are the modelling gaps?
3. What research do we need to take forward to get pathways:
    a. Modelled
    b. Parameterised
    c. Provide useful outputs for policy

Outputs:

1. List of 5 key ecological pathways (decided on, discussed at each table of mixed stakeholders) on cross/link receptor groups to inform marine renewable environmental assessments were identified as the following (in no particular order):

a. Oceanographic change
b. Climate Change
c. Habitat Change
d. Trophic Interactions/Food Availability
e. Fisheries Displacement

2. List of current ecological models + modelling gaps

Summary: There are many excellent models across all 5 of the areas of interest stated above, ranging from physical to bio-physical oceanographic models coupled with full ecosystem models that can provide outputs from past data as well as predict future climate change scenarios. There are individual based, single species population dynamic models that can include behaviour as well as hourly and seasonal movement, and there are models that provide multiple species habitat overlap predictions. However, some of these models are not spatially and temporally explicit and many are run on very different spatial and temporal scales, leaving the outcomes not easily comparable.

Individually based / population models for specific species

For quantifying impacts from offshore developments at the population level, there are various model approaches that deal with the question in different ways. Species-specific individual or agent-based models (IBM's) require large amount of data to inform an array of parameters, from movement and energetics to population data. IBMs such as the Disturbance Effects on the harbour Porpoise population of the North Sea (DEPONS) (Nabe-Nielsen et al., 2018) require detailed spatial information. Conversely, the interim Population Consequences of Disturbance (iPCoD) (Harwood et al., 2014; King et al., 2015) uses expert elicitation methods to estimate the likely effect of disturbance, through considerations of energetics and hearing/sensing of prey, from piling during the construction phase of developments, without any direct data input required apart from population parameters gathered from long term colony studies. While this approach has low data requirements it may also suffer from unknowns when being implemented on less studied sites. The third main alternative for Scottish offshore developments is the SeabORD modelling framework (Searle et al., 2014), which quantifies displacement and barrier effects on four seabird populations. Outcomes of tagging data from multiple colonies near to the wind farm site are used to construct spatial usage and prey density maps and then used to quantify the level of displacement caused by a given development. Barrier effects are classified through a sector process with user interface options to allow a given percentage of the population present entrance into the wind farm development, so collision is still quantifiable, normally through the Band et al. (2012) model. Quantifying impacts at the population level through individual level energetics driven by displacement is the next development in modelling approaches to understanding the population level impact of developments. AgentSeal is an individual-based modelling framework set up to be a management tool to study multiple stressors focused on harbour seals (available soon from University of St Andrews, Led by Prof P Tyack). New Bayesian spatial modelling approaches (Joint modelling with INLA) are also providing methods to assess the effects of both climate change and large scale offshore energy extraction and can be used to predict locations and effects on population size of future top predator-prey habitat overlap. (Sadykova et al. 2017, 2020).

Fisheries information to use for displacement modelling

For spatial fisheries information, Fish1 and ScotMap (Kafas et al 2014, 2017) focused on Scottish inshore fishing activities using vessels less than 12 metres, give accurate coverages and representations of the fishing activities distribution and their relative economic value around Scotland. There is now also a developed Bayesian spatial model that uses vessel monitoring (VMS) data for predicting the fine scale displacement of fishing to optimise multiple development locations and reduce conflict (Kafas 2019).

Oceanographic, climate models and coupled bio-physical models

The most recent oceanographic models are coupled ocean-atmosphere models that have variable grid sizes from meters to 10s of kilometres and can output data at scales of seconds to annual summaries: FVCOM (European) and HYCOM (USA). In particular, the FVCOM model has been used to create the Scottish Shelf Model (SSM) at high resolution for whole UK waters, but has been verified for some nested regions within Scottish waters and used to produce climatological outputs. There are also more simplistic tidal (POLPRED) and wave (SWAN) models. There are older three-dimensional oceanographic models (POLCOMS and NEMO) that have been coupled with ERSEM (European Regional Seas Ecosystem Model) which is an ecosystem model of marine biogeochemistry and the lower trophic levels of the marine food-webs. NEMO-ERSEM includes microbial food webs, major biogeochemical cycles (e.g. carbon, nitrogen, phosphorus, silicate) and benthic communities as well as jellyfish for the North-western European Shelf. The Scottish Association for Marine Science (SAMS) is currently working on projects such as AlterECO to better understand the inter-annual variability of physical, chemical, biological and physiographic factors integrated with anthropogenic activities and their impacts on the functioning of the shelf sea ecosystem. This will provide atmosphere-ocean coverage of physical and chemical conditions to enable understanding of mesoscale (100-150 km) to sub-mesoscale (100s of meters) processes in shelf seas.

Ecosystem models

Ecosystem models can bring the all the above type of information into on modelling framework. A range of new/improved ecosystem-oriented models are available under the newly finished MERP program (Marine Ecosystems Research). They range from those with physical drivers up through nutrients to the benthos while other go from plankton up to top predators such as seabirds and mammals. The Ecopath with Ecospace (EwE) model is one that quantifies food webs and fisheries interactions including sea mammals, seabirds, fish, seaweeds, benthos and zoo and phytoplankton at an 8.5 km scale down to 0.5 km in the UK waters. The Fish-Sums model which is simpler with just plankton, benthos and fish represented has been parameterised for the North Sea and remains in progress for the west of Scotland and is designed to simulate food web changes including benthos and zooplankton through focal fish species (length-based data) dynamics based on harvesting rates or climate-driven changes in recruitment performances at an ICES rectangles spatial scale. What also was discuss that needs doing, one is to develop a common "currency" that works across different disciplines and receptor groups within ecosystem models. Most ecosystem models use some aspect of biological biomass or numbers of animals, or ratios of size of predator to prey as the currency in the model. However, many industries and regulators use the level of risk as the central currency in decision making. A coming together of currencies could be used to communicate modelling outputs with different groups for a more coherent and comprehensive understanding of environmental perturbations following offshore renewables and climate change.

3. List of high-level research ideas to inform 'next steps' to understanding the ecological implications of marine renewable developments.

3 a-c. Habitat/Oceanographic/Climate change

Habitat modifications (from either climate and/or offshore developments) will have repercussions on population dynamics of species at all trophic levels (e.g. plankton, zooplankton, benthos, fish, birds, marine mammals). Understanding habitats-species changes requires a much better baseline for the North Sea than is available at present. Building that baseline (especially the benthic and fish components) could be a rapid process by using historical data, focusing on shipwrecks and utilizing ROV survey data conducted by the Oil & Gas industry to monitor oils rigs (build on INSITE database). It would be useful if the combined information available from EIAs and post consent monitoring (before/during/after) from mature offshore static wind, tidal and wave developments were accessible in an open source database. After a MMO Review of issues in regard to lack of one clear location for environmental data collected for offshore renewables, MEDIN has become a location for EIA/HRA and post-consent data. This information could also help to determine which fish species are likely to be attracted or repulsed by offshore renewables developments. Determining fish distributions and their essential habitats would also contribute to highlight the feeding spots and predators' habitat use as the attraction of some fish species may change the estimates of collision risk for seabirds (wind and tidal) and mammals (tidal) from what was determined at the EIA stage of a development.

Turbine/pylon/wave device location, numbers and array design will effect ocean currents and the local levels of mixing which can have a range of local and down-stream effects on pelagic and benthic habitats (see summary from EPSRC project EcoWatt2050). The changes in habitats can displace species away from areas they have formally used as foraging habitat and attract others such as invasive species, which are hypothesised to use offshore structures as stepping stones for increases in population levels and distributions. Array size and design could cause a physical barrier for mobile animal migrations and/or change larval dispersal. The potential barrier and the new habitat creation effects (e.g. reef effect) could be explored through changes in the foraging distributions of more visible animals such as seabirds and seals.

3 d. Trophic Interactions/Food Availability = Forage fish (prey of many species/critical link between lower trophic levels, bottom-up climate drivers and top predators/fishing industry)

It is essential to define habitats and distributions, at important life history stages (i.e. at what age/size they are prey items) of the main prey species of seabird and mammals, many of which are non-commercial fish species. This could be addressed with indirect data from predators as detailed fish behaviour has been explored by the use of a range of tags on seabirds and mammals (e.g. GPS, light, depth, temperature, accelerometers), as well as using at-sea foraging locations to determine fine-scale caloric mapping from predicted fish distributions of different sizes (particularly juveniles) in those locations. New methods to tackle data gaps for locations and behaviours of forage fish include the use of autonomous gliders and up-ward facing multi-instrumented platforms to take continuous and long-term samples over wide regions and within a range of contrasting habitats. Optimum and useful scales need to be defined. In general, there is a need for information at a scale smaller than an ICES rectangle, for forage fish (e.g. 5-10 km) but bigger scales for birds and mammals (e.g. 10-200km). Exploring seabird and mammal breeding success at site specific and contrasting colonies would help to predict predator/prey match-mismatch. However, assessing demographic changes is a data hungry process that implies using decades of data.

The effects of climate change and offshore renewables on forage fish could be either direct (habitat changes, both benthic and pelagic habitats) or indirect (e.g. fisheries displacement). However, there is not much knowledge about the degree of resilience of forage fish in terms of these pressures. Specifically, there is a need for a better understanding regarding forage fish characteristics (such as spatial distribution, diversity) that would affect their resilience, following climate change and placement of renewables within their benthic and/or pelagic environment. Forage fish resilience under climate change and the significance of bottom-up and top-down drivers needs to be much more clearly understood in order to predict the future spatial population dynamics of seabird and mammal species. Also, knowledge from current fishing industries (e.g. ScotMap) needs to be fully utilised and working with the fishing industry should be encouraged.

3 e. Fisheries Displacement:
The need for optimum use of ocean habitat and to avoid local areas of over fishing.
The fisheries sector is an important industry in Scotland socially, economically, and culturally. The degree of fisheries displacement and their spatial exclusions depend, on one hand, on the offshore development types (i.e. floating wind more problematic than fixed) and, on the other hand, on the fishery types (e.g. currently offshore pelagic and demersal fisheries are less affected than nearer shore fisheries). However, it is most likely that with very large scale development of offshore wind and in particular floating wind, there will be wide spread displacement of the fishing industry as trawlers in particular are unwilling to enter ORE arrays due to the additional risks involved in having gear caught on seabed structures (as current legislation states it would be the trawlers at fault). Scottish National Marine Plan identifies fisheries as an important food producer and industry displacement can also have wider implications (e.g. socio-economics, supply chains) for local and national economies.

To predict the possible impact of the high levels of fishing pressure relocation on current fish distributions, areas of critical habitat use (e.g. spawning and feeding ground) and locations of high bycatch of top predators, the locations of high fishing pressure before/after offshore renewable developments needs to be explored. Mapping fisheries activities using VMS or AIS would contribute to predict the shift of interactions between fishers, top predators and fish around offshore developments. To better predict the routes used by the fishing to get to and from fishing grounds , this mapping should also consider cable routes as well as the presence of oil & gas rigs and others uses of the sea (e.g. MOD, shipping lanes, MPAs, etc).

Fisheries displacement may force more boats into more limited areas causing localised overfishing and damaging grounds. Large scale windfarm developments, especially floating wind, may act like *de facto* MPAs and possibly produce 'spill over' effects. If windfarms are found to increase or concentrate fish populations then they will be targeted by both protected species (e.g. seabirds and marine mammals) and, outside of exclusion zones, by fisheries. Therefore, the change in fisheries effort has implications for both positive and negative multi-trophic interaction.

Investigating vessel behaviour changes around wind farms by using VMS and AIS tracking data is feasible. However, currently vessels smaller than twelve metres are not required to use VMS. Identifying a starting point / baseline in order to define changes should be the first step. Habitat and species sensitivities towards pressures also need to be explored (e.g. which activities lead to the physical loss of sensitive habitats). IBTS survey methods within wind farms suggested that unifying methods across scales needs to be done and two surveys have been completed by the MRV Scotia within the Beatrice wind farm this year and is a potential pilot for designing a new methodology. It is important to mention, as witnessed at this workshop, fishing industries are very willing to be actively involved in the process of assessing displacement and looking for agreeable solutions.

4. Other issues raised during general discussion

4.1 Policy to collect cumulative (ecosystem) level data: General discussion about the possible use of cross over between consent requirements SEA/EIA/HRA/Post-consent monitoring and Good Environmental Status (GES) under OSPAR/MSFD directives. Could current Licencing processes could be made to align with the data needs for ecosystem level understanding of the effects of very large scale cumulative developments? EIA and post-consent policies are not currently designed to answer larger scale ecological/ecosystem, cumulative level questions about impacts. The EIA process concentrates on which species and habitats are present and their distributions. Post-consent issues focus on the need to understand population level changes. Currently there is a wide scope in the exact methods developers have to use to collect data and therefore many developed different methods leaving data outputs less comparable. The MSFD GES/OSPAR framework provides more standardised guidelines on the types of indicators and methodologies of data collection and ultimately allows a much clearer route to assessing cumulative level impacts as it is designed to assess ecosystem level changes. As the move towards very large scale deployments of renewable energy accelerates, adopting monitoring methods more closely aligned with MSFD/OSPAR framework could help to align industry, regulators and academic research in the pursuit of data that will provide predictions of cumulative effects and GES.

4.2 Data and in particular forage fish data needs: Another major issue that was discussed centred around data needs and the need for fit for purpose methods for data collection, database production and open access and use of databases. If all data collected for EIA and post-monitoring were standardised and available through open access (i.e MEDIN), this would support ecosystem level research. Creating such a system is indeed feasible and has been proven to work by German government (MARLIN RAVE) however, it must be noted that that system took several years to set up and needed relatively prescriptive surveys to be agreed for data quality and transferability to be generated.

There is also currently a lack of policy drivers to have forage fish (the fish species that are prey for top predators) data at the spatial and temporal scales that are crucial for understanding them as prey for seabird and marine mammals. Forage fish dynamics and seasonal distributions are the main drivers for at-sea distributions and population dynamics of top predators and are the reason for such high levels of variation in top predators' inter and intra annual distributions.

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