Marine Ecosystems Research Programme

Annual Science Meeting

Highlights Report

4-6 October 2016, York

Annual Science Meeting 2016

York, 4-6 October 2016

Contents

MEETING SUMMARY

The Marine Ecosystems Research Programme (MERP) held its Annual Science Meeting at the Park Inn by Radisson York City Centre, 4th-6th October 2016. As the programme is approximately at its half-way point there was a clear shift in emphasis compared to previous ASMs, from discussions of work to be done and how to do it to presentations of results and plans for work to be delivered by the end of the programme. This was also reflected in the overarching theme of the meeting, which was to promote thoughts within the consortium about how to enhance and promote the overall impact of our work.

As the meeting was attended by a number of people who are not involved in the day-to-day activities of the programme, including members of the programme advisory board and stakeholder advisory group, the meeting began with an introductory session where the main achievements to-date across the programme as a whole and in each main area were outlined.

We then had an important integrating session between the MERP and another NERC programme, Biodiversity Ecosystem Service Sustainability (BESS; http://www.nerc-bess.net/). The aim was to compare approaches to ecosystem services science in marine (MERP), terrestrial and aquatic (BESS) systems, and the session was led by Prof. Raffaelli the co-ordinator of BESS, with lively discussions based around presentations from PIs within the BESS programme. Phil Williamson (science co-ordinator of other NERC programmes SSB and OA) was also in attendance.

The day was rounded off with a discussion of the ecosystems services science within MERP, focusing on progress to date and how progress is to be made in the near future.

The second day began with a session on maximising MERP impact, which included feedback from stakeholders. This led to widespread and sometimes passionate discussion, and set the scene for the science presentations which took up the rest of the day. The covered highlights and results from across the programme ranging from the decomposition of seaweed to predation pressure of seabirds, from sizes of worms to distributions of whales, and from analyses of data to ensembles of models. Extracts from these presentations form the bulk of the report that follows.

The third (half) day was deliberately left as a space and time for consortium members to interact and plan. Discussion included a check on programme deliverables and timetables, and a discussion of succession plans for work delivery as PDRAs complete their contracts. No major issues were identified. Plans are in train for a policy briefing for NRW, and for the delivery of SSB ERSEM scenarios to the MERP modellers. The meeting concluded at mid-day.

SUMMARY MERP SCIENCE ACTIVITIES

Adding to marine data

A primary objective of MERP is bringing together existing datasets to maximise their usage. An extensive fieldwork programme has also been carried out to close gaps in our knowledge and understanding of the marine environment.

Collating and enriching marine data (University of Sheffield)

Concentrating on the Celtic Sea newly released data significantly add to Ocean Biographic Information System (OBIS) global database, currently the largest and most complete database for marine data. For a number of benthic taxonomic groups that are relatively poorly documented in OBIS for this area, the amount of available data has doubled.

The developing Rmerp coding package currently contains a dozen functionalities that allow fetching data or metadata from different databases, as well as facilitating the visualizing, mapping and pairing of biological and environmental variables.

Seabird diets (University of Glasgow)

Temporally- and spatially-explicit quantitative data on 10 seabird species that represent 95% of the total UK seabird biomass have been collected. Using morphological diet information gives the best taxonomic resolution, but risks underestimating certain prey. We have information on what breeding adults and their chicks consume in the breeding season, but we have almost no idea what juveniles, or any individuals during the non-breeding season, eat. The data is richer for some species than others, and much comes from three long-term diet monitoring sites. The data shows that a species' diet can vary both between years and between sites within a year. This suggests that at least some of the seabirds have a plastic response in their foraging response to changing prey communities. We may be able to establish the relationships between prey availability and what seabirds take where both are known, and apply this to other areas where only prey availability is known. This will allow us to enhance the temporal and spatial cover of the existing database for species with more variable foraging behaviour where such a broader cover would be particularly valuable. We may also be able to use the information of what seabirds consume to estimate their impact on their main prey stock.

Trophic Understanding and model accuracy (Queen Mary University of London, Plymouth Marine Laboratory)

MERP funding has allowed the comprehensive search and compilation of previously published disparate data on pelagic and benthic species into a single accessible database, along with summary analyses of this data. As a result relationships between metabolic rates, length and mass of organisms are now better understood at taxonomic, rate specific, trophic and feeding method levels. These data are increasingly being required to explain population trends, energy requirements and detailed patterns in mathematical model simulations. Scientific publications should allow this data to be publically accessible as well as feeding into other MERP activities.

Sample collection has informed body size measurements of plankton in the waters off Plymouth, which have resulted in a conversion of the plankton abundance timeseries at station L4 into a taxonomically resolved time-series of carbon biomass. These data are particularly useful for creating biomass spectra that will be utilised within the MERP community to integrate with estimates of benthic biomass spectra, and for model simulations. These sample collections have also facilitated development of a cutting-edge analysis of diet composition of small jellyfish and fish larvae using next-generation genetic sequencing. This methodology allows understanding of the diet and interactions between species for which little information is known, without dissecting the small and/or fragile organisms. Early results suggest that new linkages within the food web may be identified, adding detail to trophic understanding and the accuracy of ecosystem models.

Top-down or bottom-up? (Bangor University, Plymouth Marine Laboratory)

The importance of top-down (e.g. predation, fishing) and bottom-up (e.g. primary production) processes on marine ecosystems remains a strongly debated area. This is partly because marine ecosystems are incredibly complex and dynamic, which can make the analysis and interpretation of traditional indices of ecological structure (e.g. species diversity) very difficult. "Size spectra" based approaches confront such complexity by omitting information on species composition, and focusing solely on body size and abundance. As many ecological traits and metabolic processes are strongly related with body size, size spectra are an ataxonomic way of describing the structure and function of ecological communities.

We set out to capture the full benthic size spectra in the Celtic Sea across interactive gradients of fishing pressure and primary productivity. After several month-long research cruises, we found that: (1) primary productivity had a significant effect on size spectra, but only in areas of low fishing pressure; (2) predators had a higher size spectra than detrivores, suggesting that detrivores have access to less energy, unable to support larger body sizes; and (3) that seasonality had strong effects on all these relationships.

By following a size spectra based approach, we have effectively reduced an entire complex ecosystem to a single graph, able to indicate levels of energy flow, production and disturbance. The results from our study therefore have the potential to be used as an indicator of fisheries exploitation and to provide insight into management practices.

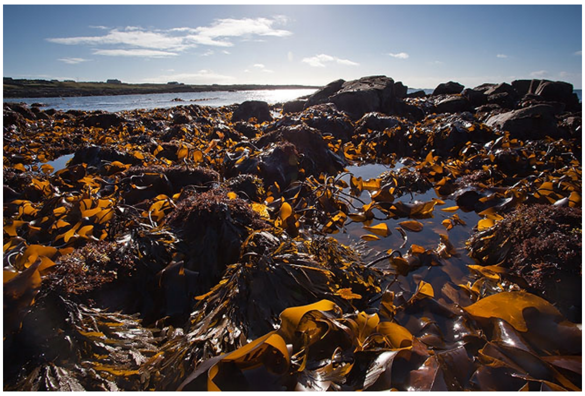
Zooplankton feeding behaviour (Plymouth Marine Laboratory, Queen Mary University of London)

Substantial progress has been made towards giving modellers a better idea of what to focus on, and what not to, in their parametrisations for zooplankton feeding. Microzooplankton acted as major control elements on zooplankton at an open shelf site (E1), but this control was strongly seasonal, supporting the "loophole hypothesis" of bloom formation. Grazing experiments with major copepods in natural seawater assemblages suggested lack of switch-feeding behaviour and only subtle effects of selectivity according to prey type (e.g. motile v non-motile). However the copepods could tackle much larger prey items than suggested by some existing size-based parameterisations. A MERP-funded meta-analysis suggested that for suspension feeders ranging from copepods to sardines, optimum and range of predator-prey size ratios increased with prey size. Two implications of size selection without strong selectivity have also been studied: firstly the ingestion of suspended sediment, leading to mobilisation of iron in the acidic guts of zooplankton; secondly the potential for zooplankton to ingest microplastics alongside their normal food.

Blue carbon service (Plymouth Marine Laboratory)

The overarching aim of this task was to quantify the 'blue carbon service' provided by coastal areas. In particular we investigated the locking away of carbon dioxide in coastal sediments taken from the ocean by the base of the foodweb (plankton and seaweeds). The focus was on collating highly temporally resolved information of the fates and stores of this primary production in coastal sediment and more importantly how it is buried and locked away in the sediment or quickly turned over to be released back into the water column. Drivers exacerbated by climate change and local human activities that affect these processes (coastal low oxygen conditions and ocean acidification) were also considered. Ancillary information, collated during MERP, allows us also to better understand how benthic size structure changes in response to these primary producer inputs, particularly though changes in the trophic level of benthic organisms. The new information will now allow us to improve representation of these mechanisms that drive the final part of the seaweed and plankton blue carbon service in coastal sediments mathematically, in ecosystem models. These model developments improve our ability to forecast this ecosystem service now and in the future, as well as the services of waste remediation and food production, contributing to a better understanding of the natural capital held by coastal sediments. This information is therefore pertinent to the Natural Capital Committee of the UK and spatial managers of the marine environment such as the MMO.

Kelp and marine food webs (Queens University Belfast)



Aimed at quantifying the role of seaweed (kelp) in marine food webs, surveys and field-based experiments to quantify kelp production (primary production and detrital) at several exposed and sheltered sites are being carried out. Potential biotic and abiotic drivers of kelp detrital input (e.g. microbial communities, algal species identity, plant-animal interaction strengths, temperature, wave action) are also ongoing. In addition a large aquatic mesocosm experiment (LAME) to quantify 'fast' (fresh Ulva) and 'slow' (dried kelp) channels of energy flow in artificially assembled benthic communities has been completed. Further work involves manipulating ocean warming in the field to test for future impacts on kelp production while also quantifying kelp and wrack biomass across a latitudinal gradient from NW Ireland to SW Portugal.

Improving model performance

MERP is improving the performance of marine ecosystem models by better representing real life community structure and function. Part of this is to better model the diversity of organism functional types and sizes to reflect their importance in communities, food webs and the overall marine ecosystem.

Modular model structure (Plymouth Marine Laboratory)

An early output of MERP has been the development of a new modular structure of the European Regional Seas Ecosystem Model (ERSEM). Now, instead of a fixed food web we can remove, add, and duplicate the modelled organisms to improve representation of key species and have a clearer picture of the functional biodiversity for a specific ecosystem and/or location.

As a further development we are in the process of adding a size-based module that will represent fish population dynamics. This achievement is unique within the marine ecosystem modelling field, as models focus either on the lower or on the upper trophic levels, and combination of both requires extensive coupling work between two models. With this, it will be possible to run ERSEM for the whole of the food web.

These two developments give ERSEM a unique facility to explore impacts of climate change and human activity over the whole food web and highlight any resulting impacts on ecosystem functioning (clean water, food supply) and the diversity of marine species.

Ensemble modelling (University of Sheffield)

The ensemble model, developed through MERP aims to combine outputs from different marine ecosystem models to improve predictions about the fate of marine ecosystems and their services under different past and future scenarios. One of the major difficulties is that marine ecosystem models have different outputs and are on different scales, for example in the StrathE2E fisheries model species are grouped by their living habitat whereas in the LeMans model the species are modelled explicitly. The ensemble model uses correlations in other ecosystem models to determine what the models that group species would have predicted for individual species, for example what StrathE2E would predict for Sole given its prediction for demersal species. A proof of concept case study has been demonstrated in which the ensemble model examined what would happen to demersal fish if we were to stop fishing in the North Sea.

Better benthos (Centre for Environment, Fisheries and Aquaculture Science, UK)

Filter and deposit feeders are key functional groups within the benthic system but until now have only been represented by the two class and size-based groups in the ERSEM. As part of MERP these have now been divided into five sub-groups with varying degrees of mixed feeding to better align them with feeding behaviour observed in the field. Each subgroup has been further divided into five size classes to allow for size-based interactions, creating 25 groups in total to replace the original 2. These new groups were populated with theoretically derived differences in characteristics. They were then tested in a water column model to investigate sensitivity to the level of available nutrients, and seasonal changes. We found that the response was less dynamic than expected. Theoretical considerations indicate that further refinement through an additional level of competitive interactions is required to remedy this. These will be implemented in the next stage of the work.

Added plankton (Plymouth Marine Laboratory)

Zooplankton is a key component of the marine pelagic environment linking primary producers (phytoplankton) to larger predators such as fish. Up to now, in most models, it was represented with only one or two generic groups. Now based on data and new insight gained from the field and experimental work done in MERP, we've created the capacity to expand the number of zooplankton represented to have a combination of different sizes as well as types (e.g. small crustaceans and larger jellyfish). This now facilitates better projections of the prey field available to zooplankton predators, while also improving indicators of ecosystem health and services.

StrathE2E improvements (University of Strathclyde)

New developments and improvements to the StrathE2E model include relatively simple upgrades of our representation or understanding of existing processes represented in the model, to some more challenging and time consuming developments. Now, the model can represent migratory fish and elaborate the representation of top-predators. A kelp model has been developed while a separate model of fishing fleets which is now coupled to the ecological model, has been built. The migratory fish model is intended to represent a group or species like mackerel which forms one large stock occupying the NE Atlantic region; one part of its distribution spills onto the UK shelf at certain times of year, to form the UK's most valuable fishery. We can model the mackerel that come into UK waters like a 'raiding party' which swims in and impacts the shelf ecosystem, some get caught, and the survivors swim away until next year. We are using a similar 'raiding party' concept to elaborate the representation of top-predators as well. In the model the current single 'birds and mammals' group is divided into six, representing different feeding types of birds, seals and cetaceans, some of which are migratory and only come into our model area to feed and/or breed in the summer. We are also working to model the development of a forest of individual kelp plants, in order to be better able to make a much simpler bulk biomass model of forest dynamics, suitable for inclusion in the whole-ecosystem model. In relation to fishing fleets, we have reached the limits of what can be done with StrathE2E in its current form where fishing is specified as an external 'driving' value of harvest rates on each resource group in the model. A separate model of fleets of different fishing gears (e.g. different types of trawls, long-lines, dredges, pots), each of which has different catching properties, has now been developed. This model generates the harvest rate data that we need to drive the ecology model. Using a new 'model management' scheme, we can now pause our StrathE2E model at, say, annual intervals to feed data into the fleet model and re-compute adaptive harvest rates, and then restart the ecology with these new rates. This important development paves the way to new possibilities for integrating social, economic and ecological models in future work.

Temperatures up, fish down (Scottish Association for Marine Science, University of Aberdeen)

Overexploitation of fish stocks and the process of 'fishing down the marine food web', the gradual decline in sizes and mean trophic levels of fish communities, are impacting the structure and functioning of marine ecosystems. Such changes have been observed in UK and other seas and in recent years an ecosystem approach to fisheries management has been deemed a useful tool to assess the environmental status of marine ecosystems and to test potential fishing management scenarios. However, climate change and rising temperatures are superimposed on ecosystems and also have to be taken into consideration. Using the Ecopath with Ecosim ecosystem model of the West Coast of Scotland, species-specific optimum temperatures and tolerances were included that, in relation to the observed water temperature data, affected species' consumptions; these in turn affected temporal biomass and catch predictions. Subsequently, we tested the impact of rising temperature under IPCC climate change scenarios, while keeping fishing pressure constant at rates consistent with maximum sustainable yields. The results showed a higher impact of rising temperature for cold water species such as grey seals, cod, haddock, whiting and herring, which all declined by 2100 under the worst case climate change scenario.

Driving top marine predator population dynamics (Centre of Ecology and Hydrology UK, University of Bangor, Sea Watch Foundation, BioSS)

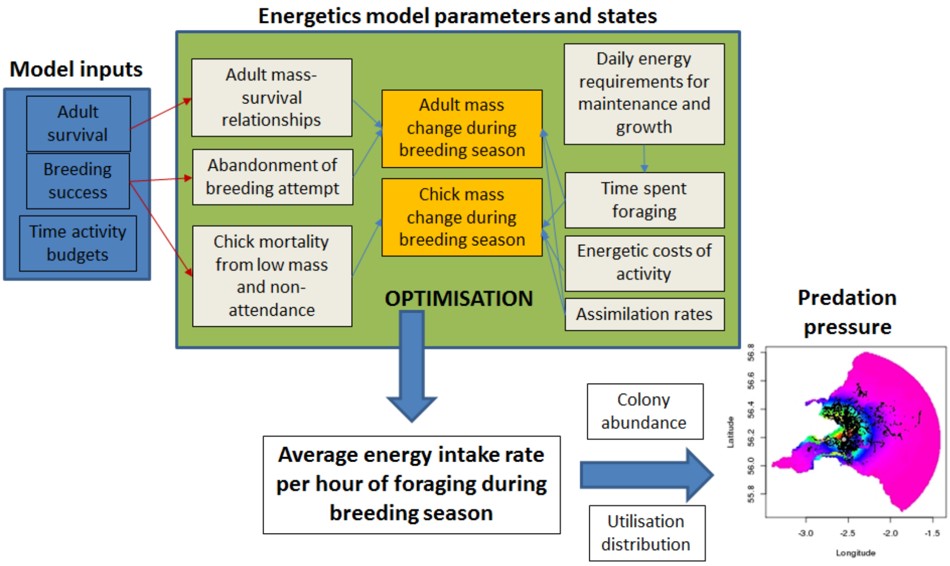
In contrast to marine systems, two fundamental drivers of density dependence have been identified in terrestrial systems; 1) temporal variation in climate strengthens negative density dependence feedbacks to population growth, whilst 2) spatial variation in resources weakens negative density dependence feedbacks to population growth. Within MERP, we have built a consortium of marine top predator ecologists, terrestrial ecologists and statisticians. We have sought to understand if these same central tenets hold in marine systems for top predators. We tested these relationships across nine species of seabirds breeding in UK waters using population abundance data covering three decades. Preliminary results suggest strong evidence for a strengthening of negative density dependence in population growth rates with increasing variation in temperature, in line with terrestrial studies. However, in contrast to terrestrial studies we only found evidence for an attenuation of negative density dependence with increasing spatial variation in resources in one species, whilst the opposite trend was detected in four other species. We are currently exploring alternative parameterisations for proxies of spatial variation in resources for seabirds to establish if these preliminary results hint at a real departure from terrestrial ecological theory and evidence.

Spatial-temporal variations in seabird and cetacean distributions (Bangor University and SeaWatch Foundation)

Preliminary maps of seabird and cetacean communities across Europe have been constructed from collated dataset, along with initial investigations into the drivers of spatiotemporal variations in species densities, foraging guild densities, overall abundances and species diversity. The next stage is to fine-tune our analysis to: (1) answer fundamental questions concerning top-predator ecology; (2) provide the measures needed to collaborate with empirical-based colleagues to address questions on marine community structure, most notably size-spectra within the Celtic Sea; (3) provide the inputs needed by modelling colleagues to incorporate top-predators at the appropriate stages. Outputs so far demonstrate that this work has uses throughout the Programme, and outputs can be provided in a range of formats suited to specific needs.

Predation pressure maps for breeding seabirds (CEH, RSPB, BioSS, University of Glasgow)

We have developed a framework for converting seabird distributions around breeding colonies (developed by the RSPB) into spatially-explicit estimates of predation pressure using an energetics model (developed by CEH and BioSS). The energetics model uses life history and demographic data from seabird colonies to estimate an average energy intake rate for breeding birds, optimised against empirical observations of breeding success and adult survival. When combined with regional seabird diet data (University of Glasgow), this method allows for a spatially explicit prediction of predation pressure exerted upon key prey species around seabird colonies to identify hotpots of potentially strong top-down effects in marine food webs.



Marine Ecosystem Services (Plymouth Marine Laboratory)

MERP is improving understanding of four ecosystem services that the UK marine seas provide: food provision, climate regulation, bioremediation of waste, and biological checks and balances. Conceptual models have been prepared with input from all MERP researchers to encompass the complexity of the marine ecosystems and the services they provide. These models take into account current understanding of the relationships between the different biodiversity components, their functions and the different ecosystem services as well as the sensitivities of these relationships to environmental change. One holistic conceptual model has been constructed that can depict the relationships between all four ecosystem services and the processes that support them. This is being used as a baseline to set up Bayesian networks which are useful in modelling uncertain and complex domains and allow for the inclusion of a variety of datasets, such as spatially and temporally explicit, modelled or empirical data, but also expert knowledge. This functionality will enable us to model the effects that different management scenarios can have on ecosystem service delivery. Bayesian networks have been used to model ecosystem services before but MERP data sets and expertise will allow a more thorough understanding of ecosystem services and the associated trade-offs, for example by modelling outcomes of different management scenarios. Data for these management scenarios have been, and are being produced in other modules of MERP.

Knowledge Exchange

Various internal and external communication channels for the programme have been established to facilitate the exchange of knowledge to stakeholders and other interested parties, as well as geographically-dispersed MERP participants:

- Website: http://www.marine-ecosystems.org.uk/
- Introduction video: http://www.marine-ecosystems.org.uk/News/Video_introducing_the_work_of_MERP_is_now_availabl
- Leaflet: http://www.marine-ecosystems.org.uk/getattachment/e6749f2c-d70f-4cb2-b6da-df97bfb9d751/Programme_leaflet
- Newsletter and general news: http://www.marine-ecosystems.org.uk/News
- Twitter: @merp_updates
- Defra programme summary: http://www.marine-ecosystems.org.uk/getattachment/33fe0c22-3af9-4a4f-908b-fc585949311a/33fe0c22-3af9-4a4f-908b-fc585949311a

- Related videos: http://www.marine-ecosystems.org.uk/Resources

In the next stage of the programme, as the science develops even further, a more targeted approach will be taken to identify aspects of the MERP programme that will be of benefit to specific stakeholders.

Stakeholder engagement

A selection of Stakeholder Advisory Group (SAG) members was interviewed to ascertain their expectations, on behalf of the wider stakeholder communities of MERP.

All were very supportive of the programme and its aims, noting that such research was important to ‘plug gaps’ in current understanding. All recognised that they represented a broader cascade of stakeholders and while there were differences in requirements between different SAG members, there were some common threads including a need for more information on what is happening rather than what is planned and more regular updates. More specifically:

- Any products, such as maps, should dovetail with existing information and materials currently being used, so comparisons and amalgamations became possible.
- There is a need for more accessible language, especially in modelling, and an explanation of the virtues of the various models and how they work together. The information rather than/in addition to the data should be made accessible and useable by non-specialist end-users.
- Face-to-face meetings with key stakeholder groups was seen as the best method of highlighting any outputs

- All outputs should relate to reality if they are to be useful, although different regions have differing requirements i.e. Scotland may need broader geographical coverage for strategy management, while England may be more concentrated on MPAs etc.
- The overarching request is that all data/information should help users to better understand the marine environment.
- A series of short videos dealing with specific practical outputs was suggested as was a (no more than 40 page) report with a 2 page summary. Infographics were suggested as a quick way of getting basic information across.

Further comments related to if and how the ‘project’ and its data would be maintained in future, and whether it would be added to after the programme had officially finished.

ACTIONS: various members had offered to help with some of these points including: the creation of a simple explanation of the various models “A beginners’ guide to MERP modelling”. Short video topics were identified and will be followed up. Summary paragraphs of work-so-far would be produced, collated and circulated.

Meeting Participants

MERP Consortium

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Angus Atkinson (PML)
Mel Austen (PML)
Hayley Bannister (University of Sheffield)
Arwen Barger (BODC)
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Julia Blanchard (University of Tasmania)
Kelvin Boot (PML)
Stefanie Broszeit (PML)
Jorn Bruggeman (PML)
Michael Burrows (SAMS)
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Kelly-Marie Davidson (PML)
Peter Evans (Sea Watch Foundation)
Jessica Heard (PML)
Mike Heath (University of Strathclyde)
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Leigh Howarth (Bangor University)
Martin Lilley (QMUL)
Rudolf Nager (University of Glasgow)
Nessa O'Connor (QUB)
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Sevrine Sailley (PML)
Michaela Schratzberger (Cefas)
Kate Searle (CEH)
Natalia Serpetti (SAMS)
Paul Somerfield (PML)
Johan van Der Molen (Cefas)
James Waggitt (Bangor University)
Sarah Wakelin (NOC)
Sarah Wanless (CEH)
Tom Webb (University of Sheffield
Steve Widdicombe (PML)

Observer
Phillip Williamson (UEA, Coordinator of the SSB Programme)

Stakeholder Advisory Group
Kirsten Ramsey (Natural Resources Wales)
Apologies from Matt Frost (MBA), unable to attend

Programme Advisory Board
Kevin Gaston (University of Exeter)
Tasman Crow (University College Dublin)
Eugene Murphy (British Antarctic Survey)
Dave Patterson (University of St Andrews)
David Raffaelli (University of York)

BESS Delegates
Tom Oliver (University of Reading)
Guy Woodward (Imperial College London)

Funders
Carole Kelly (Defra)
Rachel Leader (NERC)
Jess Surma (NERC)

Publications

Below is a list of current publications from the MERP Consortium

2016

Alexander KA, Meyjes SA, **Heymans JJ**. 2016. Spatial ecosystem modelling of marine renewable energy installations: Gauging the utility of Ecospace. Ecological Modelling Volume 331, 115-128. Doi:10.1016/j.ecolmodel.2016.01.016

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Peck MA, Arvanitidis C, **Butenschön** M, Melaku Canu D, Chatzinikolaou E, Cucco A, Domenici P, Fernandes JA, Gasche L, Huebert KB, Hufnagl M, Jones MC, Kempf A, Keyl F, Maar M, Mahévas S, Marchal P, Nicolas D, **Pinnegar** JK, Rivot E, Rochette S, Sell AF, Sinerchia M, Solidoro C, **Somerfield PJ**, Teal LR, Travers-Trolet M, van de Wolfshaar K (in press). Projecting Changes in the Distribution and Productivity of Living Marine Resources: A Critical Review of the Suite of Modeling Approaches used in the Large European Project VECTORS. *Est. Coast. Shelf Sci.* doi:10.1016/j.ecss.2016.05.019

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