Biannual Science Report

February 2017

Report on science and communication activities | June 2016 – January 2017

MERP Biannual Science Report February2017

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Executive summary

Most components of the Marine Ecosystems Research Programme have less than a year and a half still to run. With the fieldwork near completion the focus of this work has moved to processing data and developing publications. Model development is ongoing. New NERC funding will support three additional bodies of work. The ERSEM development work led by Jorn Bruggeman (PML) is funded for an additional two years. This will build on developments made within the Shelf Seas Biogeochemistry (SSB) programme and MERP to address questions concerning the role of species diversity, understanding spatio-temporal variability (e.g., macro-ecological patterns), system function (top-down and bottom-up controls, trophic transfer), and the interaction between diversity and spatial heterogeneity. Two other new bodies of work, to run alongside current activities, have also begun. The first considers trade-offs within marine systems and is led by Mike Heath (Strathclyde). It aims to expose the monetary and non-monetary implications of potential trade-offs among different uses of the sea, to determine the ways in which trade-offs may be exacerbated or alleviated by social, economic and cultural factors, and to work with stakeholders to scope the potential of a range of marine management options to alleviate conflicts and to maximise the overall value of marine natural capital. The second focuses on cumulative impacts and is led by Tom Webb (Sheffield). This will explore how extensive empirical data, statistical and mechanistic modelling, and expert judgement, can be translated into both context-specific guidance and generic principles for marine management. While much of this additional work involves people already working within MERP, we are also pleased to welcome new members to the programme who bring specific expertise to help us deliver our goals.
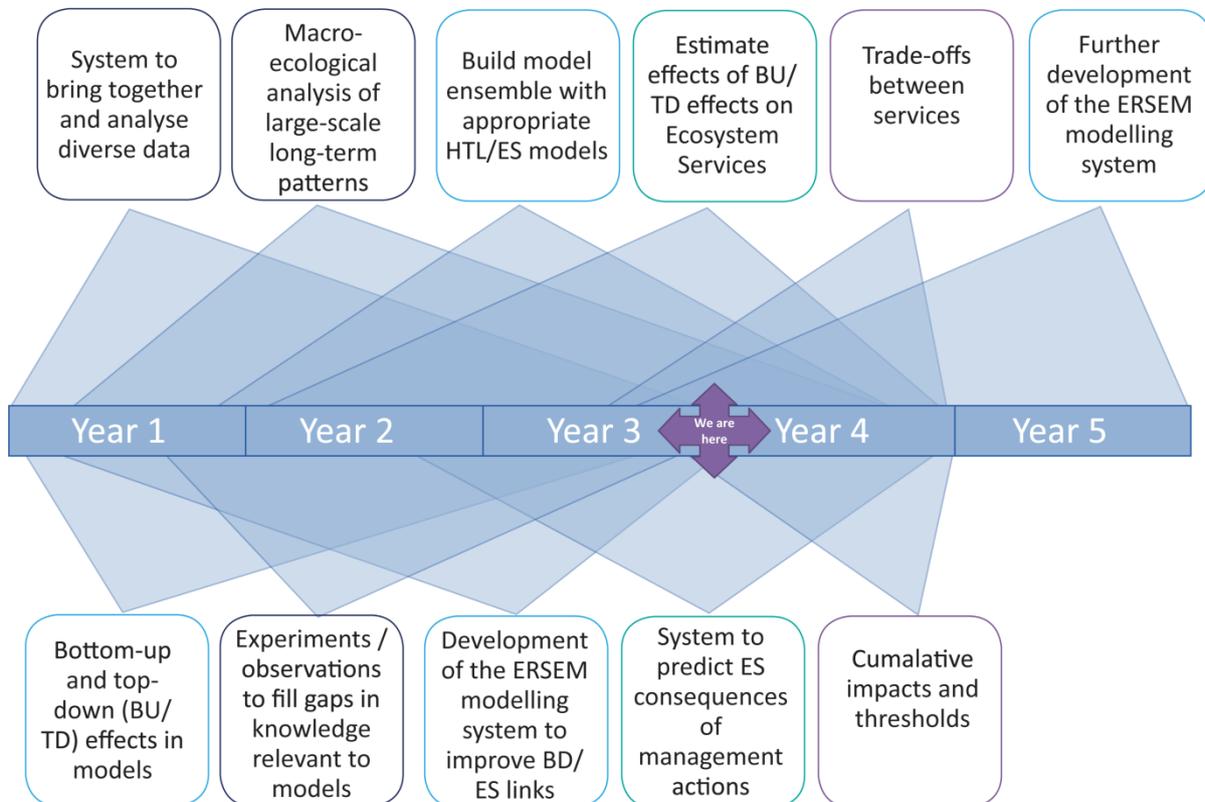
Science Highlights

Predation pressure maps for breeding seabirds (CEH, RSPB, BioSS, University of Glasgow)
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) has been developed. 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, which may be used to identify potential hotpots of strong top-down effects in marine food webs.

MERP cruises show contrasting effects of bottom-up and top-down processes in benthic ecosystems (Bangor, PML).
Extensive data on the sizes of benthic organisms from a number of contrasting sites sampled from MERP cuises on the RV Prince Madog have been analysed. These analyses show that fishing pressure and primary productivity have strong effects on benthic size spectra, but that fishing is the more dominant force (see figures below). In addition, results indicate that fishing can reduce functional diversity of marine ecosystems and that intensively fished sites tend to have fewer bioturbating organisms, while low-fished sites tend to be associated with erect, suspension-feeding organisms attached to the seabed. This new dataset covers abundances of organisms in a range of body sizes across 11 orders of magnitude, making it unique. It will be further used to address several key questions in aquatic macroecology.
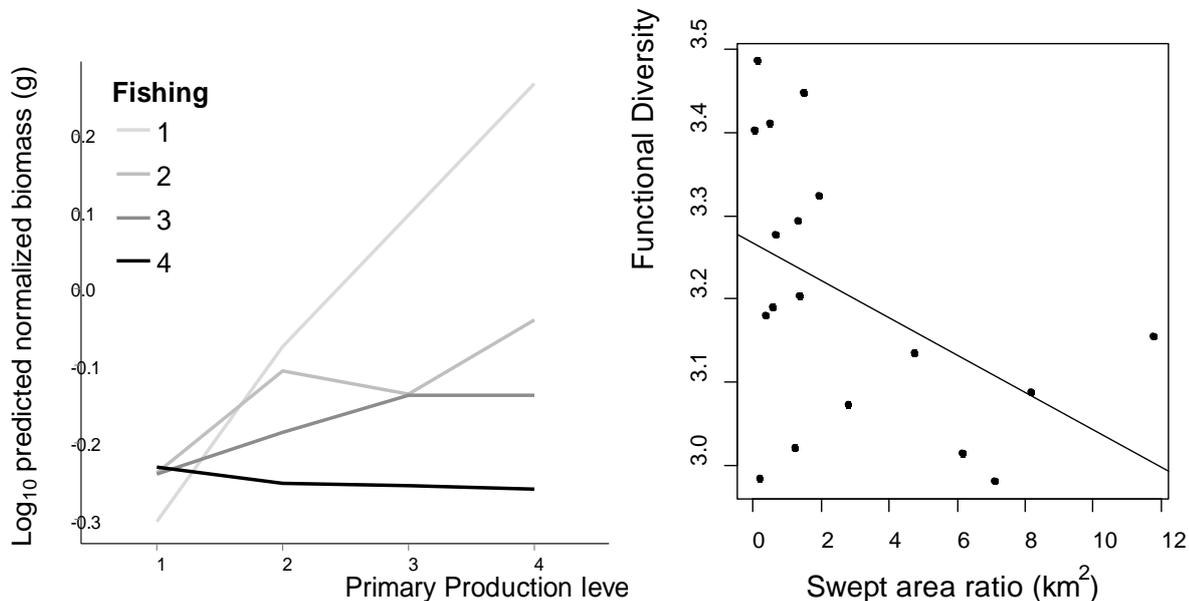
Figures: (left) increasing fishing pressure masks the effects of primary production on benthic size spectra, suggesting fishing to be the more dominant force in marine ecosystems (right). Functional diversity significantly declines with increasing fishing pressure (i.e. Swept Area ratio).

Trait Explorer: traits for any marine species (Plymouth Marine Laboratory)
We have developed the Trait Explorer (http://www.marine-ecosystems.org.uk/Trait_Explorer), a web server that infers trait values for any marine species. It provides a form of "automated expert judgement"

that combines the taxonomic position of the species and any information on its traits, to provide the best possible estimate of all traits of interest. For instance, estimates of mass conversion factors take into consideration that some taxa (e.g. jellyfish, sea cucumbers) tend to have a higher-than-average water content. Estimates of maximum mass consider the maximum length of the species, if available, to exploit the fact that length and mass are strongly correlated.

Increasing amounts of data collated and collected through MERP are being made available within the Trait Explorer, while simultaneously improving its accessibility, for instance by adding a web service API that allows programmatic access.

Trait Explorer is currently used within MERP and the Shelf Seas Biogeochemistry programme to infer carbon:wet weight ratios for benthic species on the UK shelf. Within the next months, it will also be used within module 3 (Rossberg) to characterize species size distributions in the Celtic Sea and North Sea.
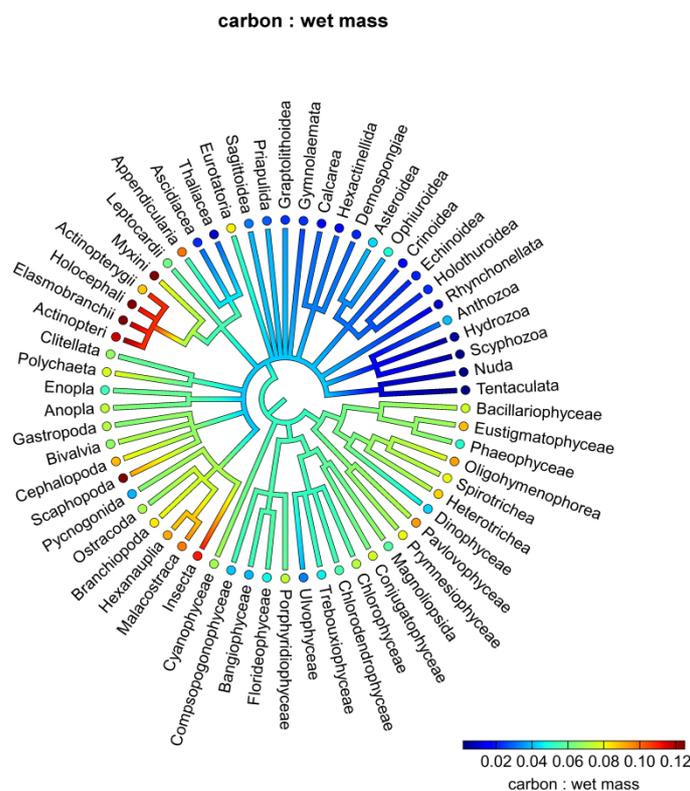
Fig. Predicted carbon mass : wet mass ratio (CM : WM) across the taxonomy, from common evolutionary ancestor (centre) up to the class level (rim). Branch colours indicate the predicted CM : WM of an arbitrary species from the associated taxon. Filled circles show the average observed CM : WM per class.

Engagement with policy makers

- Paul Somerfield (PML) participated in MMO workshops in Plymouth relating to developing the Southwest Marine Plan. July 2016

- Natural Resources Wales (NRW) webinar: Held in November 2016, MERP hosted a webinar with NRW to target discussions around key issues of interest to Welsh stakeholders. Feedback about this webinar was extremely positive and this approach to stakeholder engagement was supported by all

involved. A report was produced, available on the MERP website, and further webinars as well as more targeted stakeholder sessions will be held with stakeholder groups.

- **MERP @ COP22** Scientists in MERP are researching the sources, fates and stores of primary production in coastal sediment, and how it is buried and locked away in the sediment or quickly turned over to be released back into the water column. In related work drivers exacerbated by climate change and local human activities that affect these processes (such as coastal low oxygen conditions and ocean acidification) have also been explored. The new information gathered by MERP is used to improve representation of coastal sediments and trophic pathways in ecosystem models, which in turn enhance our ability to project changes in various ecosystem services such as waste remediation and food production. Dr Ana Queiros from PML went to COPP22 (Marrakech, November 2016) to disseminate information about MERP and the role of the marine ecosystem in mitigating climate impacts through locking away carbon dioxide from the atmosphere. She gave presentations, spoke with national and international media outlets and had a strong twitter presence throughout COPP22 promoting the work she has been doing through the Marine Ecosystem Research Programme.

- Cefas (Axel Rossberg) used the MERP model ensemble to predict recovery times for key ecosystem indicators, including estimates of model uncertainty, and reported these results to Defra for use in policy planning and decision making.

- Discussions with Defra policy customers are underway, regarding a MERP briefing in March 2017. The policy landscape and MERP science have been evolving since the last MERP briefing in February 2016. In consultation with the MERP Steering Committee, Michaela Schratzberger has put forward suggestions for topics that take account of Defra's feedback on the 2016 briefing:
  (1) Understanding environmental drivers and anthropogenic pressures. This would showcase MERP work integrating environmental, ecological and pressure data to examine the role of those factors in influencing, for example, vulnerable species; impacts of MPAs on top predators and species of conservation concern etc.
  (2) Understanding sources of uncertainty and how these drive variation in the response of ecosystems to management measures.
    We expect feedback from Defra w/c 13 February.

- CEH (Dr Francis Daunt, Dr Kate Searle, Prof. Sarah Wanless) attended a Fisheries Innovation Scotland (FIS) workshop designed to understand how interactions between top predators and their prey may affect the implementation of an ecosystem approach to fisheries management in Scotland. This workshop and its subsequent report (see outputs below) will help to shape future funding by Scottish Government and FIS, having specific relevance to policy questions including:
  - How can we define and describe biodiversity hotspots?
  - How are populations of vulnerable species (cetaceans, seabirds, elasmobranchs etc.) distributed in space and time?
  - Where do key foraging areas for sea birds occur in space and time?
  - How to evaluate cumulative impacts, especially for mobile species (to ultimately create the ability to carry out strategic assessments through marine planning or SEA that consider the capacity of marine mammal and bird populations to cope with cumulative impacts across their biogeographic range)?

Achievements related to work programme

Marine macroecology, through applying the latest ecological theory coupled to novel integration of existing data using ecoinformatic approaches

Databases and data portals

The Rmerp package developed by Sheffield University is now available to MERP members on GitHub, while two additional packages (merpWS and merpData) have been created on Github to provide a publicly available resource accessible to all (see https://github.com/MarineEcosystemResearchProgramme/). These packages are accompanied by a basic application making use of CEFAS web services to access temperature data. Possible collaborations with the CEFAS data manager have been discussed aimed at creating an R package specifically dedicated to serving data from the new CEFAS data hub. Code is being developed code to interact with major marine biodiversity and environmental datasets, in collaboration ROpenSci and OBIS, with resulting methods demonstrated on both the OBIS (http://www.iobis.org/2016/11/22/sorbycollection/) and ROpenSci (https://ropensci.org/blog/blog/2017/01/25/obis) sites.

There has been extensive engagement across the MERP community, working with colleagues to answer queries and provided them with the dedicated data products they needed to best tackle their research questions. Sheffield continues to collaborate with the researchers running the UK Shelf Sea Biogeochemistry (SSB) project at PML to deliver a composite data set for benthos in a large area around SSB stations. Historical and current occurrence data for the Celtic sea and the North sea has been provided to colleagues at QMUL. This was part of a project making use of the Trait explorer tool developed by the PML MERP modellers to generate species body size distributions. Maps of benthos data sets for the North sea have been created and delivered to CEFAS collaborators. Sheffield is currently in the process of providing ecosystem-wide data to module 5 (focused on Ecosystem Services).

Bangor has continued to collate and process top-predator and environmental datasets, and now have one of the largest collations of at-sea vessel and aerial surveys ever collated into a single database. At the latest count there was 2181777km of survey effort, covering 7725 days over 39 years and 4890537 animals from 127 species. Initial analyses have focussed on explaining and predicting distributions of top-predator diversity/abundance/biomass using ecologically relevant environmental variables. Preliminary results highlight associations between seabed roughness and cetacean communities, and frontal regions and seabird communities. The influence of static variables (seabed roughness and frontal regions) exceeded that of dynamic variables (temperature, productivity) indicating an importance of predictable foraging areas for these species. Further work is examining differences in habitat associations among species and functional groups, with consequences for predicting guild and species-level responses to climate change. Such analyses could also offer insights into the processes underlying niche divergence. Research on top-predator communities at a local-scale (North Wales) continues, complementing the aforementioned research at broader-scales. These results are being communicated to a wide audience (students, academia, and general public) at a national and local level.

Data Application

Policy-relevant studies enabled by the integration of existing data within MERP and more widely have been identified by Cefas. Over the past 3 months, existing faunal, environmental and pressure data collected in the North Sea has been combined to establish key characteristics of benthic communities in response to

natural environmental drivers (physical and hydrodynamic environment), climate drivers (temperature) and anthropogenic drivers (fishing pressure). This information will be used to distinguish between community changes brought about by single (and combined) natural or manageable anthropogenic drivers, thereby helping to develop scenarios under which shifting, rather than static, baselines and targets are appropriate for management.

Seabird predation pressure maps

Colleagues at CEH have been focused on developing an energetics modelling framework for mapping predation pressure from breeding seabirds around UK colonies. The RSPB has developed a method to empirically estimate seabird utilisation from GPS tracking data (Wakefield et al. *in press*), and has applied this method to data for three important species (black-legged kittiwakes, common guillemots, and razorbills). A key part of this research lies in developing an energetics model for each species that allows the determination of the amount of energy required by breeding birds at specific colonies. Through earlier work individual simulation based bio-energetics models for these five species (Searle et al. 2014, 2017) were developed. The energetics component of this model has now been adapted through MERP, retaining the section that translates energy intake per hour of foraging, along with time-activity budgets, into subsequent adult and chick survival. This model can now be combined with estimates of adult and chick survival to estimate prey intake per hour of foraging. Work is ongoing to obtain species-specific estimates for these parameters around the UK in preparation for applying the energetics framework together with the utilisation maps to produce spatially explicit predation pressure maps for these three important species in UK waters.

# Targeted field sampling and experimental studies of key features that are currently understudied

Cefas has conducted an analysis into the environmental drivers of the dominant pelagic fish of the Celtic Sea and western Channel. Further work is required but preliminary results, presented at the Challenger Society Conference in November 2016, suggest that temperature plays an important role in driving both anchovy and sardine distribution. Phytoplankton and frontal features also appear important. In collaboration with the MERP PDRA at Bangor, Cefas is processing the acoustic data collected aboard the Prince Madog during the 2016 MERP field campaign. Data on forage fish distribution will be analysed in combination with available environmental variables in order to explain the drivers of apex predator distribution in the waters of the Celtic Sea. In October 2016, the fifth and final PELTIC survey was completed successfully, further extending the time series of data on the pelagic component of the Celtic Sea ecosystem.

The final MERP mini-cruise organised by PML was cancelled due to weather and a decision that sufficient samples for sequencing of fish larvae and jellyfish had already been obtained. DNA has been extracted and amplified from fish larvae, jellyfish and plankton samples collected on the series of night-time and day-time MERP pelagic mini-cruises. This was then sent for high through-put sequencing. The resulting data (23.5 million sequences) has been received and the taxonomy assigned using NCBI Blastn. Analyses of these results are ongoing.

PIs at Glasgow have collected temporally- and spatially-explicit quantitative data diets of 10 seabird species that represent 95% of the total seabird biomass. Using morphological diet information gives the best taxonomic resolution but risks underestimating certain prey. Information has been gathered on what breeding adults and their chicks consume in the breeding season, but as of yet there is limited information

on 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 sites and years. 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. From this information we may also be able to use the information to estimate the impact on their main prey stock.

All planned lab and fieldwork at Bangor University has now been completed and the team is now in the final stage of data analysis. Overall, it has been found that fishing pressure and primary productivity have strong effects on benthic size spectra, but that fishing is the more dominant force (see figures below). In addition, results indicate that fishing can reduce functional diversity of marine ecosystems and that intensively fished sites tend to be associated with fewer bioturbating organisms, while low-fished sites tend to be associated with erect, suspension-feeding organisms attached to the seabed. As this new dataset covers a range of body size differing in size by 11 orders of magnitude, the dataset is unrivalled and will address several key questions in aquatic macroecology.
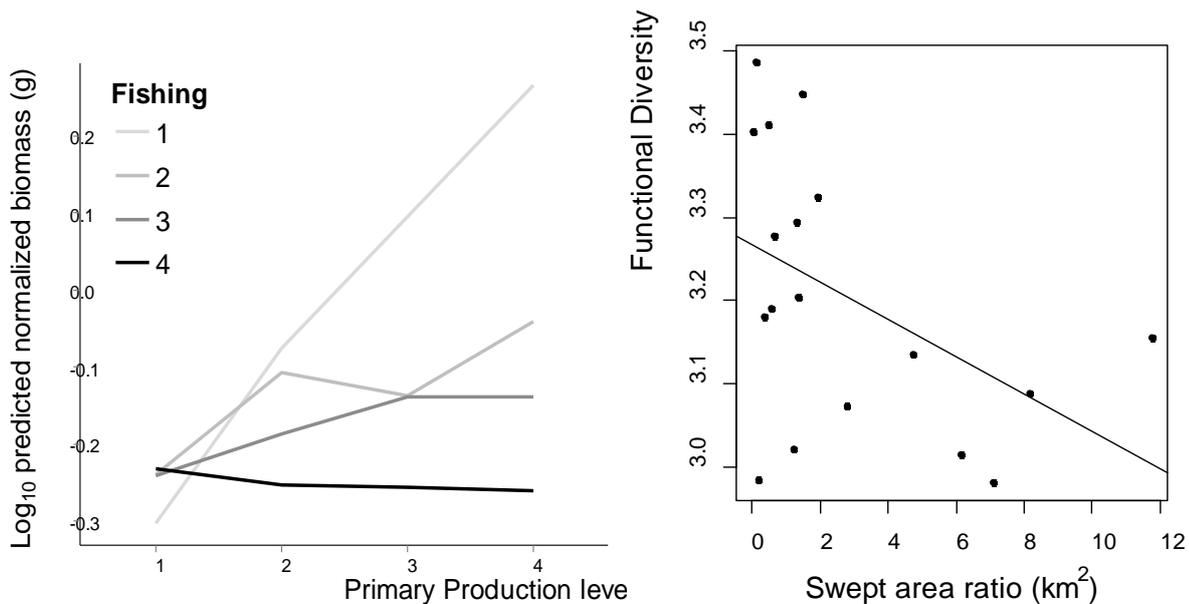
Figures: (left) increasing fishing pressure masks the effects of primary production on benthic size spectra, suggesting fishing to be the more dominant force in marine ecosystems. (right) Functional diversity significantly declines with increasing fishing pressure (i.e. Swept Area ratio).

A number of dataset and parameters from MERP fieldwork activities have been shared across the Consortium and submitted to BODC. The organic carbon dataset from MERP seasonal benthic field surveys ran by PML (Queiros lead) were shared with the ERSEM developers, as well as a list of 87 parameters measured during seasonal benthic field surveys which were sent to model developers at SAMS, Strathclyde and PML and Sheffield University. These dataset and associated methods were also submitted to BODC.

Ecosystem modelling through state of the art application of an ensemble of ecosystem models

The extensive modelling work in MERP has continued with advances being made in model development and application.

The EwE model of the west coast Scotland (SAMS) has been updated with the main changes including temporal coupling with ERSEM and the inclusion of temperature as an environmental ecosystem driver. Results show that 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.

In close cooperation with SAMS, Cefas has calibrated the spatial ecosystem model so that species co-exist in space and persist over time. Predicted distributions of species and the effort of the fishing fleet have been compared with observed data and Cefas' contribution to the modelling work (Ecopath, Ecosim and Ecospace) has been quality-controlled and documented. The model, all relevant documentation and files have been handed over to SAMS for further use in MERP.

A significant upgrade of the main StrathE2E model system, incorporating spatial aspects, a completely new fishing fleet model, and other additional features, is now complete and will be released as an R-package to make uptake by new users much easier. The original version of StrathE2E will also be released as an R-package. In preparation for parameterising the new StrathE2E model, a re-analysis of the raw BGS seabed sediment data has been carried out, to extract spatial distributions of grain size data rather than categorised habitats. The analysis has also enabled mapping of the natural disturbance rates of seabed sediments across the whole NW European shelf by tides and waves. A significant aspect of the task has been the re-analysis of the entire BGS data set on occurrence of exposed bedrock. This work is being carried out in collaboration with an EPSRC funded project on the impacts of tidal and wave energy extraction (EcoWatt).

Model Ensemble

Sheffield University developed a method that improved the fit of the von Bertalanffy growth function when fitting it to survey data, with a manuscript submitted on this work to Ecology and Evolution. This method has been used to find inputs to the Mizer model for the Celtic Sea. The ensemble model developed by MERP was used to combine the indicator sensitivity runs with other MERP models. QMUL further used the model ensemble to predict recovery times for key ecosystem indicators, including estimates of model uncertainty, and reported these results to Defra for use in policy planning and decision making.

Developing the ERSEM modelling system

The development of ERSEM within MERP is a collaborative effort between PML, Cefas and NOC. NOC has been working on the coupled hydrodynamics-ecosystem model NEMO-FABM-ERSEM, developed for the SSB programme, which was implemented in a high-resolution 3D model (CS15) covering the Celtic Sea and English Channel. The CS15 model has horizontal resolution of ~1.5km and uses 50 terrain-following coordinates in the vertical. The model was one-way nested into a NEMO-FABM-ERSEM implementation of the 7km-resolution AMM7 model that covers the European shelf and extends into the deeper Atlantic. The models were run for the year 2010 and validated against satellite-derived surface chlorophyll-a data in May-June 2010 and vertical profiles of temperature, salinity and chlorophyll-a data from a mooring in the Celtic Sea during June 2010. In these preliminary results, the CS15 model showed finer horizontal details and a better representation of the subsurface chlorophyll maximum than AMM7.

Cefas has reviewed the existing relationships between current regime and benthic community structure, and concluded that the available information was too fragmented and incompatible to construct an empirical framework. Instead, a synthetic benthic community structure was implemented for testing competition between a suite of mixed filter feeder and deposit feeder characteristics in the model, as a function of size. A series of model runs was carried out, highlighting that an essential inter-species feedback mechanism was missing in the model at the level of the FABM framework. Results were presented at the MERP ASM in York and included in a draft publication. Work was started to achieve 2-way offline coupling between a size-based fish model and an ERSEM-type model to inform the Phase II developments. Implementation of temperature-dependence in Mizer has been delayed but will soon commence. A proposal for Phase II work was written, accepted and funded to complete and apply both these strands of work.

The team at PML working with colleagues across the Consortium, especially those in Module 1, have developed **"Trait Explorer"** (http://www.marine-ecosystems.org.uk/Trait_Explorer), a web server that infers trait values for any marine species. It provides a form of "automated expert judgement" that combines the taxonomic position of the species and any information on its traits, to provide the best possible estimate of all traits of interest. For instance, estimates of mass conversion factors take into consideration that some taxa (e.g. jellyfish, sea cucumbers) tend to have a higher-than-average water content. Estimates of maximum mass consider the maximum length of the species, if available, to exploit the fact that length and mass are strongly correlated. Working closely with module 1, more and more data collected within MERP are becoming available within the Trait Explorer. Simultaneously we are improving its accessibility, for instance by adding a web service API that allows programmatic access. Trait Explorer is currently used within MERP and the Shelf Seas Biogeochemistry programme to infer carbon:wet weight ratios for benthic species on the UK shelf. Within the next months, it will also be used within module 3 (Rossberg) to characterize species size distributions in the Celtic Sea and North Sea.

Modelling zooplankton diversity

Using the new modular version of ERSEM, the zooplankton community in has been diversified in ERSEM by splitting its mesozooplankton type into 30 different groups characterized by their size. Data collected by MERP partner (QMUL) was used to parameterize the physiological rates of each group as a function of its size. The zooplankton community model was tested in isolation by providing it with time series of 277 observed prey species at the L4 station; initial results suggest that the model reproduces both the annual mean zooplankton size spectrum, as well as key aspects of the seasonal changes in slope.

In future work, the trait set of zooplankton will be expanded by including a "jellyness" factor, which makes it possible to capture both "regular zooplankton" (e.g., copepods) and jellyfish within the same modelling framework. These ideas will be developed together with module 2 (Atkinson et al.), based on their recent paper on this topic (https://doi.org/10.1093/plankt/fbw094)

Develop ecosystem services science through use of macroecology and models to hindcast and forecast ecosystem states, indicators, and estimates of goods and services

The conceptual framework developed by PML for the ecosystem services work is now in place. The framework combines ecosystem processes, components and indicators of ecosystem services and the linkages between them. It reduces the complexity of the ecosystem and facilitates exploration of consequences of ecosystem changes for the four ecosystem services addressed in MERP (Bioremediation of waste, Biological checks and balances, Food production, Leisure and recreation). The framework has been incorporated into a probabilistic graphical model (Bayesian network) which has been trialled using MERP model output.

Colleagues at CEH have been looking at the density dependence analysis of seabird population dynamics and have finalised the analytical framework and derivation of environmental drivers to estimate and understand how direct and delayed density dependence operates in populations of 13 species of breeding seabirds in the UK. Working with colleagues at Colorado State University CEH have developed a Bayesian hierarchical model to estimate the strength of direct and delayed density dependence in 13 species of breeding seabirds in the UK (representing approximately 75% of the total seabird biomass in UK waters), and to relate the strength of density dependence to environmental drivers (in conjunction with MERP colleagues at University of Bangor). These models use data from the Seabird Monitoring Program, tracking changes in population size over five decades. Initial results suggest similar patterns to terrestrial systems in relation to temporal variation in the environment, but potentially opposing relationships to spatial variation in the environment.

CEH has also been working closely with the University of Strathclyde to adapt and provide parameters and validation data for the StrathE2E ecosystem model. As a result of this collaboration StrathE2E (*M. Heath*) has been adapted to include three guilds of seabirds, for which we are providing empirical parameter estimates and validation data for model fitting in three regions (whole of North Sea, Celtic Sea, west of Scotland sea). We have extracted long-term monitoring data for seabird colonies in these three model regions and are currently compiling this data into guild level metrics to be used in model validation. We are also working with SAMS to help adapt and provide input and validation data for the EcoPath/EcoSim models.

This work has been provided to colleagues at PML to provide data and information for an analysis of ecosystem services provided in UK waters, specifically leisure and tourism services related to seabirds.

Delays and remedial actions

Martin Lilley's postdoc finished Dec 2016, curtailing resources for biomass spectrum work. Several other PDRA contracts are coming to an end as well but plans are in place to ensure work continues as required.

Axel Rossberg incurred a major injury in late July 2016, requiring hospitalisation and rehabilitation. This led to delays in delivery of Mod 3. He has now fully recovered.

Communication activities

- Newsletter: The 3rd newsletter was distributed and, from feedback, was well received. The newsletter was opened by 34% of MERP participants and 46% of stakeholders, with respective engagement rates of 22% and 21%. The 4th newsletter is currently in production and will be circulated the stakeholder database (127 contacts) and the MERP participant database (85 contacts).

- Website: Continues to be regularly updated and work to improve navigation and general user experience has been completed. In the last reporting period there were 5272 sessions by over 3823 users. To date there have been 20,527 sessions by 15,060 users. Since adding the registration function to the website in October 2015, the site has received 84 registrations.
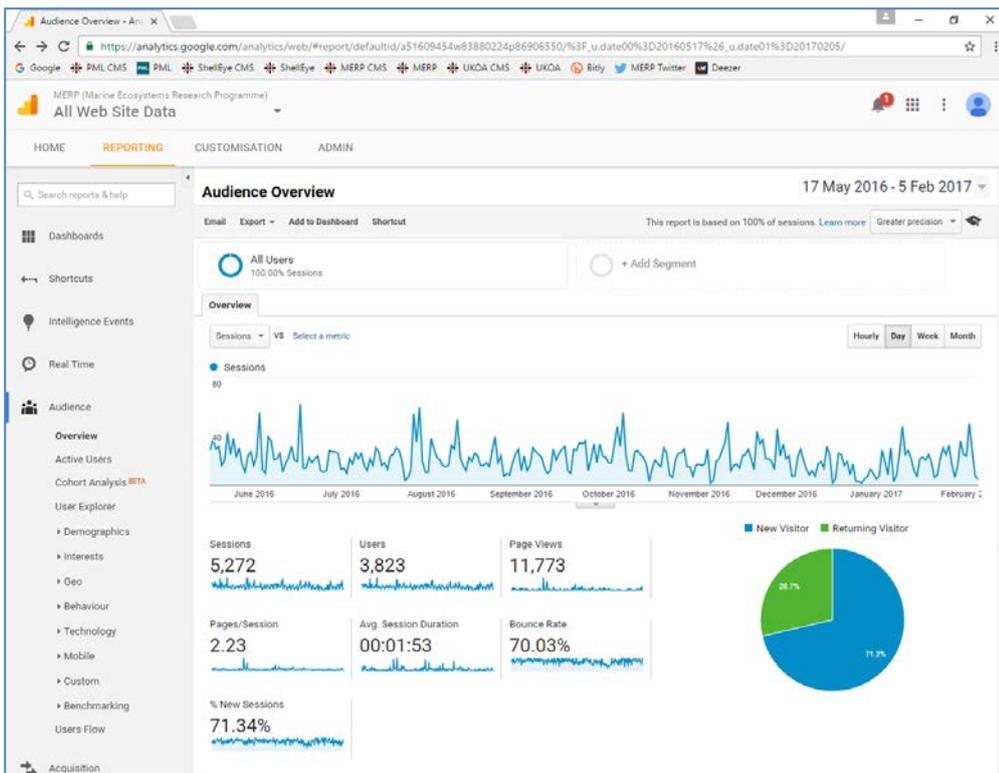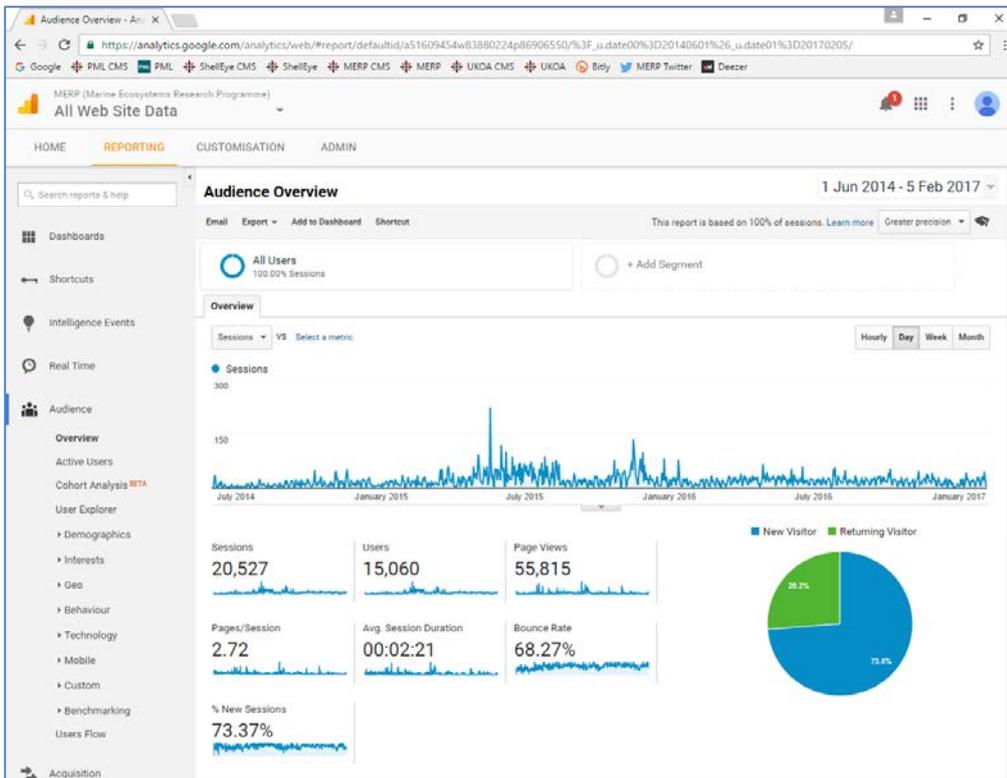
- MERP Twitter (@merp_updates): The feed now has 322 followers and new followers Paul Rose (NatGeo), Natalie Bennett (Green Party), UN Environment (Caribbean), Frontiers in Marine Science, Marine Climate Change Impacts Partnership (MMCIP) plus many individual scientists. The Top Follower was Seagrass Ecosystems and Top Tweets were benthic images (https://twitter.com/DrAnaQueiros/status/739818531546632192) and CommOcean (https://twitter.com/merp_updates/status/806077129511366656). In the last reporting period there were 12,172 impressions, 1738 profile views and 185 mentions.
- Video: A new version of the MERP video was produced and published. Feedback has been very positive, including positive appreciation from a representative from the Lloyds Register Foundation. This is available on the MERP website and YouTube as well as being publicised through Twitter and Facebook.
- Stakeholder perception survey: a survey was conducted with MERP stakeholders to investigate their perception and expectations of MERP and to gather valuable feedback on how the programme can improve its activities. Key messages from this survey surrounded more accessible language when referencing modelling, more targeted interactions with stakeholders and the accessibility of MERP-compiled data past the end of the project.
- Annual Science Meeting: The Knowledge Exchange team gave presentations on the KE activities of MERP, achieving impact and the stakeholder survey. These presentations initiated a lively and constructive discussion on the timescales of impact and how to maximize impact opportunities throughout the programme.
- In November 2016 MERP Scientist Ana Queiros attended COP22 and discussed her work in MERP on a range of platforms, and was interviewed by Laurie Goering, Head of Climate Programme at Thomson Reuters, resulting in the following article published by Reuters on 25 November 2016 (Figure 3): http://news.trust.org/item/20161125090402-u92xa

Over the next 6 months the following activities are planned:

- 4th newsletter will be circulated.
- Defra 2-page summary will be reviewed.
- Website will be updated with information of Work Package 3.
- Databases will be updated with new and potential stakeholders.
- Bespoke stakeholder interactions will be fleshed-out for the key stakeholder groups.
- Initial development of a short video on modelling will begin.
- An article for Marine Biologist will be progressed and a feature in Planet Earth will be investigated.
- Integration between Work Packages will be facilitated.
- Participation in the Plymouth School of Creative Arts Careers Fair 2017

Scientific plans for next 6 months

Marine macroecology, through applying the latest ecological theory coupled to novel integration of existing data using ecoinformatic approaches

Sheffield University will refine MERP-related R products to ensure that they run stably and speedily on mainstream operating systems (Mac/Windows). We will also flesh out the documentations for these packages. This may take the form of an R vignette or an online tutorial.

Sheffield will also submit a manuscript on size-specific changes in depth distributions of marine species in the North Sea, and progress analyses based on multiple data sets to track changes across trophic levels in UK marine ecosystems.

Cefas will be exploring the feasibility of using the traits-based data, brought together through MERP, to support activities of the ICES Working Group on Biodiversity Science. The group will meet in Italy from 6-10 February 2017 to develop life-history-trait-based biodiversity indicators for various taxonomic guilds (incl. benthic invertebrates, fish and phyto/zooplankton).

CEH are developing final predation pressure maps for three species of breeding seabirds in UK waters, working closely with RSPB partners and University of Glasgow. The methodological framework is complete and we have acquired colony level predicted utilisation distribution maps from RSPB. The framework and energetics model is now being applied for each species and we anticipate maps being ready to share with MERP partners in the next 2-3 months.

Targeted field sampling and experimental studies of key features that are currently understudied

The following activities are planned by PML:

- Finalising analysis of molecular data from MERP seasonal benthic field surveys (Feb 2015-May2016) ran by PML (Queiros and Tait lead).
- Finalising analysis of data from MERP lab experiments on C uptake by coastal systems under anthropogenic pressures of ocean codification and hypoxia (March-June 2016) which were a collaboration with University of Pisa.

- New experiment on the role of bioturbation in C burial in coastal sediments (April-June 2017) as an added value collaboration with PhD student co-supervised with bath University Astrid Bohemer. (filming opportunity on ship and lab?
- Collaborating with M6 to model zooplankton size spectra
- Initiating a bentho-pelagic budget-modelling paper for L4

QMUL and PML will be working closely on further DNA sequences and gut contents analysis

Cefas will collaborate with Plymouth to provide pelagic fish biomass (expressed in carbon values) for the L4 area to be combined with multi-trophic data for a carbon budget study. In addition, statistical analysis exploring the environmental drivers of the small pelagic fish community (sprat, sardine and anchovy) will continue following on from the initial analyses described above.

Glasgow University will focus on confirming whether there are robust cases of plastic foraging response of seabird diets to changes in prey community for a few example species where we have a particularly good coverage. If this exercise is successful we want to try to extrapolate a diet map for those species across UK waters, and combined with the distribution data create a pressure up of seabird predation on prey stock populations.

Results from Bangor's analyses of the collation of cetacean and seabird data will be presented at the *Conference of the European Cetacean Society* in May 2017 and a *JNCC workshop* in March 2017. These results will then contribute to two papers looking at community and species/guild level responses to environmental conditions; we aim to complete drafts by May 2017 at the latest. We will continue to increase spatial and temporal coverage of our collation of data by sourcing and processing new surveys. A cetacean and seabird "Atlas" will be compiled and prepared for publication, illustrating recorded sightings of all species. Analyses aiming to produce density maps for key species and areas will also be started. Datasets will be submitted to the BODC. Leigh Howarth expects to present the results at two international conferences in the next 6 months.

Ecosystem modelling through state of the art application of an ensemble of ecosystem models

Sheffield University will work to fit the Celtic Sea version of mizer to data and submit a paper about finding fishing effort from landings data in a multi-species model. We also plan on submitting the ensemble model paper. Colleagues at QMUL are working on the application of new statistical methods to improve interpretation of MERP model ensemble outputs.

CEH is working with partners at Bangor University (James Waggitt and Peter Evans) to finalise modelling of the effects of spatial and temporal environmental variation on population dynamics of seabirds. We are currently fitting final population models to multi-decadal time-series for 12 seabird species, and are collaborating with Bangor to derive and assess how independent measures of environment variation affect the spatial patterns in population dynamics observed around the UK coast. A draft manuscript is in preparation and will be submitted to an ecology journal in Summer 2017.

Strathclyde University will be very busy over the next 6 months working towards completing a statistical modelling analysis of seabed sediments across the whole NW European shelf (not just UK waters) as the basis for parameterising StrathE2E models of the west of Scotland and Celtic Seas (February 2017). This was supposed to be completed in August 2016, but the necessity to reanalyse all the BGS raw data on bedrock

has set the time table back. There will be a complete the write up of the new version of StrathE2E for Methods in Ecology and Evolution. An advanced draft is completed. R-packages of both the original and the new versions of the model will be released (early March 2017).

Other StrathE2E advancements include:

- Return to working on modelling kelp forest dynamics and merge into the new version of Strathe2E.
- Return to working on top-predator sub-model and merge into StrathE2E. Renew work with CEH, Bangor and Glasgow to assemble data sets on the biomass and diets of these predators in the North Sea, west of Scotland and Celtic Seas.
- Re-parameterise, rerun and write up the StrathE2E modelling study of the ecosystem impacts of trawling completed as a contract report in 2015, and submit for publication.

Developing the ERSEM modelling system

Cefas will add the missing competition mechanism for the benthic diversity work, and the model test runs will be repeated. Temperature-dependence will be implemented in the size-structured fish model Mizer, and work on coupling Mizer to FABM will commence.

At NOC the latest SSB ERSEM-v0 release will be used in new NEMO-FABM-ERSEM runs of the 1.5km-resolution Celtic Sea and 7km AMM7 models for 2014 to 2015. The model results will be compared to observations (including from the SSB Celtic Sea moorings and cruises) to study the impacts of model resolution on hydrodynamic/ecosystem coupling. Results will be presented at the AMEMR conference in Plymouth in July 2017.

Further development of Trait Explorer in collaboration with module 1 (Webb, Vergnon) is planned. The implementation of size structured fish model (MIZER) within modular ERSEM will be completed, including temperature dependence, and testing under different prey availability scenarios (e.g., Western Channel) and NEMO-ERSEM scenarios (hindcast, trawling, nutrient regulation, climate change) for forcing of fish modeling in module 4 will be delivered.

Develop ecosystem services science through use of macroecology and models to hindcast and forecast ecosystem states, indicators, and estimates of goods and services

The ecosystem services work developed during MERP will be discussed at the Southwest Ecosystem Services workshop, 17th of February, 2017. The Southwest Ecosystem Services workshop is organized by one of the ecosystem service groups working in the UK, and takes place every 6-12 months, the aim of which is to stimulate discussion within the SW and exchange of ideas on ecosystem services and how to academically approach this subject.

Model outputs from scenarios run across MERP are expected during the spring for input to the Bayesian networks to be able to compare ecosystem service outcomes under different scenarios and management options, and to look at thresholds for ecosystem services.

Integration activities

The MERP integration strategy aims to engender an ethos of integrative science by encouraging collaboration and measuring outcomes as defined below:

Action	Measure
1. Collaborations formally identified in the work program	Project workshop reports, successful completion of milestones and deliverables
2. Value added scientific interaction	Extra workshops/meetings, new proposals, additional funding
3. Peer review	Collaborative publications
4. Impacts	Collaborative impact stories, stakeholder engagement
5. PDRA networking	PDRA workshops, joint publications, extended working visits, placements

Over the last 6 months the emphasis has been on actions 1, 2 and 5 work. With regards to 3 and 4 work is ongoing.

Action 1 Collaboration formally identified in the work program.

- Scientists from PML visited Sheffield University to discuss ensemble models and Bayesian Network models with MERP colleagues from Module 4 (Mike Spence, Paul Blackwell) and data and data access with Module 1 colleagues (Tom Webb, Remi Vergnon). Further skype conversations took place with Paul Blackwell, Mike Spence (both Module 4), Paul Somerfield, Stefanie Broszeit, Jose Fernandes, Tara Hooper (PML, Module 5) to further discuss the use of ensemble models in Bayesian network models.
- Bangor and CEH work closely together on the collation of resources, analyses of datasets and potential publications. Analysis of data collected during cruises was been performed with colleagues from CEFAS and Marine Scotland Science. Analysis involved scientists from Bangor University, PML, IMAS and Sheffield. Specifically, these were Dr Leigh Howarth, Dr James Waggit, Dr Jan Hiddink, Dr Paul Somerfield, Dr Julia Blanchard, Dr Tom Webb, and Dr Remi Vergnon. The dataset has also been contributed to wider projects, looking at whole marine communities, led by Dr Julia Blanchard and Dr Tom Webb.
- The extensive datasets collected and collated by Glasgow University have been shared across the MERP community to help integrate distribution, population and diet information for a better understanding of marine top predators.
  CEH has been working across the MERP community to integrate their data on top predators into models (StrathE2E), and other datasets on marine mammals (Bangor) as well as the ecosystem services group (e.g., empirical data and review of evidence for fisheries by-catch etc.) to whom they have provided data and expert advice to help them advance their developing models.

- Organic carbon dataset from MERP seasonal benthic field surveys ran by PML submitted to M6 for inclusion in ERSEM, as well as list of 87 parameters measured during MERP seasonal benthic field surveys ran by PML and associated methods to BODC.

Action 2. Value added scientific interaction:

Strathclyde University led a bid including several MERP partners (CEH, CEFAS, SAMS, Bangor/Seawatch) to Fisheries Innovation Scotland for funding to conduct a project "Scoping the background information for an Ecosystem Approach to Fisheries in Scottish waters – review of predator-prey interactions with fisheries, and balanced harvesting". This project is directly related to MERP. During the reporting period, the partners involved attended two workshops, one on mapping predator-prey relationships, and one on balanced harvesting. The final report has been submitted to FIS. Regarding predator-prey interactions, the report identifies ten research priorities, illustrated by three case studies. The central point of these priorities is the need for much better information on where and when the key food concentrations for top predators occur, and how these can be protected from the effects of fishing so that Scotland's natural capital of birds, seals, cetaceans and elasmobranchs can co-exist with productive fisheries. Regarding balanced harvesting, the report finds that little empirical information is currently available to examine the balance of exploitation to production of fish of different species and body sizes in the seas around Scotland. An Ecopath analysis of the west of Scotland shelf ecosystem in 1985 showed no relationship between fishing mortality rate and production rate of species and broader groups. This implies a major imbalance across species, because BH requires fishing mortality rate to be proportional to the production rate. In addition, production rate was seen to fall as fish become large for their species, whereas fishing mortality rate does not; fishing is therefore also unbalanced with respect to body size within species. There are many assumptions built into this analysis, and it should be treated with caution.

In September 2016 the BES Aquatic Macroecology meeting took place in London, this event organised by MERP members and provided an opportunity to integrate for the MERP and BEC research communities to integrate.

Further integration with other programmes took place at the MERP ASM, October 2016 in York where we 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.

MERP scientists have been working with colleagues from the NERC Shelf Sea Biogeochemistry Programme to write papers on feeding size selectivity (Djeghri et al.), microzooplankton control of phytoplankton dynamics (Fileman et al. 2016), and spatial patterns in the benthos (McClennand et al.).

CEH has been facilitating liaison between the organisers of the 2018 Round Britain and Ireland Yacht Race and the MERP community to explore if the MERP community can contribute ideas and capacity for citizen science and promotion of marine science during the event.

MERP scientists also work with colleagues external to MERP to add value and extend work. For example: PML is doing collaborative added-value work with Netherlands Institute for Sea Research and Marine and Environmental Sciences Centre (Portugal) on the use of biological traits to predict ecosystem functions. PML also works University of Exeter and others on the use of gender as a trait to predict the impacts of ocean acidification.

Action 3 Peer review: There are now a total of 22 MERP publications as reported in the [Publications section](). Several more have been submitted and are in preparation including:

- Queirós AM et al. Seasonality of blue carbon uptake in coastal sediments: sources, sinks, trophic and non-trophic pathways. PML
- Paper in preparation *Predicting fauna vulnerability to ocean warming and that of their contributions to ecosystem processes*. Bangor, Sheffield, PML
- Paper resulting from added-value experiments (March 2016) on bioturbation interactions with sedimentary oxygen uptake. PML
- Paper examining pelagic size spectra at L4. PML
- Papers on zooplankton feeding selectivity (Djeghri et al) and microzooplankton feeding. PML
- Two zooplankton mortality papers. PML
- Development of conceptual frameworks for marine ecosystem services. PML
- MSFD indicators and their usefulness for ecosystem service assessment will be submitted to 'Ecological Indicators' February 2017. PML
- A manuscript on size-specific changes in depth distributions of marine species in the North Sea. Sheffield University
- Finding fishing effort from landings data in a multi-species model. Sheffield University
- Ensemble Modelling. Sheffield University
- Biological rate scaling paper to be completed and submitted. QMUL
- Completion of biomass spectrum paper. QMUL
- Publication on dome formation in pelagic size spectra. QMUL
- Harbour porpoise distributions in north Anglesey has been prepared, and will be submitted to *ICES Journal Of Marine Science* in February 2017. Bangor
- Paper on Ecosim to be submitted. SAMS
- Ecospace model updated including ERSEM temporal-spatial coupling. SAMS
- Paper exploring benthic size spectra. Bangor
- Paper exploring functional traits. Bangor
- Paper linking changes in pressures to changes in services (PML)
- Paper exploring relationships between ecosystem services indicators and indicators of good environmental status (PML)

Action 4 Impacts: since the last report there has been continued engagement with the MERP Stakeholder Advisory Group who plan to meet again in 2017. In November 2016, MERP hosted a webinar with NRW to target discussions around key issues of interest to Welsh stakeholders. Feedback about this webinar was extremely positive and this approach to stakeholder engagement was supported by all involved. A report was produced, available on the MERP website, and further webinars as well as more targeted stakeholder sessions will be held with stakeholder groups.

In November 2016 MERP Scientist Ana Queiros attended COP22 and discussed her work in MERP on a range of platforms, and was interviewed by Laurie Goering, Head of Climate Programme at Thomson Reuters, resulting in the following article published by Reuters on 25 November 2016 (Figure 3):

http://news.trust.org/item/20161125090402-u92xa

Action 5 PDRA Networking: The PDRAs work in collaboration with each other as well as project PIs both at their institutes and across the consortium, their work continues. As the programme it enters its final period much of the PDRA time will be spent on analysis and writing up of their science activities.

Additional Funding

Proposals were submitted by MERP consortiums to the call from NERC for "Application of models developed to test the impact and efficiency of potential management solutions". Two projects were successful, both kicking off in January 2017.

Project 1: Understanding trade-offs to maximise the benefits from living marine natural capital (MERP Module 7).
Lead by Mike Heath, University of Strathclyde.

This project looks at the trade-offs between economic and cultural services in the UK marine environment.

Project 2. Cumulative Impacts and the Management of Marine Ecosystems (MERP Module 8)
Led by Tom Webb, University of Sheffield.

This project seeks to understand in particular how multiple activities interact to affect marine ecosystems, and what the cumulative effects of management actions are.

Full details of these projects will follow in future reports.

MERP Publications

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A number of additional MERP associated publications have been submitted and are under review. These will be reported once published.

External presentations from June 2016 – January 2017

Author	Title	Activity	Name of event and location	Date	Relevant Module(s)
L Howarth	Top-down or bottom-up? Investigating the effects of fishing pressure and primary productivity on benthic size spectra	Oral	ASLO 2017, Hawaii	27/02/2017	**M2**
M. A. Spence	Report of the Working Group on Multispecies Assessment Methods (WGSAM)	report		February 2017	**M4**
Waggitt	When, where and why: mapping and understanding the distribution of European Cetaceans	Oral	Meeting of the Bangor University Marine Mammal Society, Bangor, UK.	30/01/2017	**M1**
Waggitt		Invited Participant	Seabirds and Renewables Workshop, Glasgow, UK.	18/01/2017	**M1**
Waggitt	Life in the fast line: Seabirds and Tidal Energy	Oral	Meeting of the CoCoast Project, Bangor, UK.	14/01/2017	**M1**
Axel G. Rossberg, Adrian Farcas (Cefas) and Robert Thorpe (Cefas)	Meeting with Defra staff to advise on multispecies fisheries management in the Brexit context.	Briefing meeting	Defra, London	11/01/2017	**M3**
R. Vergnon	Rmerp/merpWS/merpData	R packages and accompanying documentation	Github	Dec 2016 - Jan 2017	**M1**
M. A. Spence	Ageing elephants from the sky: lessons from fisheries	oral	Behavioural ecology seminar - University of Sheffield	20/01/17	**M4**
A Rossberg, A Farcas	How to achieve maximum sustainable yield from interacting fish stocks	Oral presentation	In Thematic Topic Session: "What will sustainable fisheries look like in 2025?" at British Ecological Society annual meeting, Liverpool, December 2016	11-14/12/16	**Mod 3**
Daunt, F. & K. R. Searle	Integration of research into effects of offshore renewable developments on breeding seabirds	Meeting and report provided to Scottish Government (Liam Kelly)	CEH Edinburgh	December 2016	**M1**
Mel Austen	Valuing marine ecosystems	Oral (remotely via webex)	JPI Oceans Ecosystem Goods and Services	24/11/2016	**M5**

			workshop, Brussels		
Jose Fernandes	Communicating results and uncertainty to policy makers and stakeholders	Oral	ICES, Copenhagen, Denmark	23/11/2016	**M5**
Sarah Wakelin	The effects of model resolution on the Celtic Sea ecosystem	Poster	The 2nd Challenger Society Coastal Ocean Special Interest Group workshop, UK Met Office, Exeter	22-23/11/2016	**M6**
A Rossberg, M Heath, S Heymans, N Serpetti, D Speirs, M Spence, P Blackwell	MERP policy brief on predicted times to achievement of improved environmental status after implementation of CFP reform	Policy brief		10/11/16	**Mod 3 &4**
Mel Austen	Marine science and policy: match and mismatch	Opening Keynote	North Sea Science Conference, Ostend,	08/11/2016	**M5**
Stefanie Broszeit	How to assess ecosystem services?: Using conceptual models to capture complexity	Seminar	Sheffield University, Department of Animal and Plant Sciences	09/11/2016	**M5**
J van der Kooij	Disseminating survey derived biomass estimates of pelagic fish pelagic	Presentation and discussion	ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG), Sicily	14-18 Nov 2016	**All**
J. Bruggeman	Modelling plankton adaptation: from the individual to the world ocean	oral	Dialogue on methods for ecology, University of Cambridge, UK	15 November 2016	**M6**
AM Queiros (Presented by Carol Turley, PML)	Building resilience to Ocean Acidification: Blue carbon and C-farming	Presentation (COP22 report attached)	United Nations Climate Change Conference (22nd Conference of Parties, Marrakech, Morocco). "Small Island Developing States" event, Oceans Action Day.	12 Nov 2016	**M2**
J van der Kooij	Habitat drivers of small pelagic fish in the Celtic Sea	Presentation and discussion	Challenger Society Conference, Liverpool	5-8 Nov 2016	**All**
Serpetti et al.	Predicting cumulative effects of fishing and rising temperature on a marine ecosystem	Oral presentation	SAMS – PIES seminar	4/11/16	**M4**
AM Queiros. M Burrows, N O'Connor	Blue Carbon + Climate-ready Conservation	Presentation (COP22 report attached)	United Nations Climate Change Conference (22nd	10/11/16	**M2**

	= Climate Action		Conference of Parties, Marrakech, Morocco). "Climate readiness –Ocean based adaptation and mitigation" event, UK pavilion.		
Mel Austen		Oral participation	Government Office for Science Ocean Foresight Project Advisory Group meetings	24/10/16, 15/12/16	**M5**
G. Lessin	Modelling benthic processes and benthic-pelagic coupling in shelf seas: understanding interactions and predicting potential change	oral	Workshop on Modeling on Coastal and Shelf Ecosystems, East China Normal University, Shanghai, China	24-25 October 2016	**6**
J. Bruggeman	FABM-ERSEM: a model toolbox for water and sediment biogeochemistry	oral	Workshop on Modeling on Coastal and Shelf Ecosystems, East China Normal University, Shanghai, China	24-25 October 2016	**6**
M. A. Spence	A dynamic multi-model ensemble for ecosystem simulators	Oral	WG-SAMS	10/10/16	**M4**
Atkinson	UK Pelagics MSFD assessment workshop,	(Atkinson was PML host). The meeting was to use the phytoplankton and zooplankton time series and traits Partially developed within MERP) to complete the UK MSFD assessment	Plymouth Marine Laboratory	10-11 October.	**M1 M2**
Wanless, S	Forty years of Auks on the Isle of May	Oral presentation	Scottish Ornithologists' Club Annual Conference	September 2016	**M1**
Searle, K. R., …, F Daunt & S Wanless	Use of SMP count data to test how intrinsic and extrinsic processes combine to drive patterns of seabird population dynamics in UK coastal waters	Oral presentation	Seabird Conference, Edinburgh	Sept 2016	**M1**
R. Nager	Spying on Scottish Seabirds at their Dinner Table	Invited talk	Scotland's Ornithologist Club Annual Conference	23/09/2016	**M2**

Mel Austen		Oral participation	Canadian Healthy Oceans Network CHONE 2 Directors meeting, Montreal	16/09/2016	**M5**
TJW	State of Nature	Report	State of Nature 2016	Sept 2016	**M1**
Atkinson	Oral paper: A view from the south: use of composite time series data to understand how recruitment and mortality govern populations size	Session co-convenor for Session "The role of zooplankton in exploited ecosystems: the role of top down and bottom up controls on pelagic food webs	ICES Annual Science Conference, Riga, Latvia	Sep 2016	**M2, M6**
M. A. Spence	A dynamic multi-model ensemble for ecosystem simulators	Oral	ICES ASM	20/9/16	**M4**
Sarah Wakelin	The effects of model resolution on hydrodynamic-biogeochemical interaction in the Celtic Sea	Poster	Challenger Society 2016 Conference, University of Liverpool	08/09/2016	**M6**
Waggitt	Understanding and predicting spatio-temporal variations in marine top-predator distributions in European Waters, at regional and decadal scales.	Poster	13th International Conference Of The Seabird Group, Edinburgh, UK,	08/09/2016	**M1**
J Waggitt	Quantifying top-predators' use of hydrodynamic features in coastal regions; applied and ecological consequences.	Oral	Biannual Challenger Society Conference, Liverpool, UK.	06/09/2016	**M1**
Searle, K. R.	Predator-prey interactions affecting Scottish fisheries	Ran 2 day workshop with Fisheries Innovation Scotland and other stakeholders	FIS Predator-Prey Interactions workshop St. Andrews	24-25th August 2016	**1,5,6**
M Heath	Modelling the whole ecosystem impacts of trawling	Oral	Fisheries Innovation Scotland Annual Symposium, St Andrews	22-23 August 2016	**3 & 4**
M Austen		Oral participation	Sir Charles Hendry Tidal Lagoon Inquiry Round table, UKERC London	26/07/2016	**M5**
M Austen		Oral participation	Expert workshop for the Foresight	27/07/2016	**M5**

			Future of the Sea project, London		
L. Polimene, S. Sailley, D. Clark, S. Kimmance, A. Mitra, I. Allen	Are we able to model the microbial carbon pump? Current state and future prospective	Poster	Gordon Research Conference on Ocean Biogeochemistry, Hong Kong, CN	12-17 June 2016	**M6**
M Austen	Marine ecosystem services: Linking indicators to their classification	Oral	DEVOTES-EUROMARINE Summer School San Sebastian	07/06/2016	**M5**
M Austen	Predicting ecosystem service change in the future: the developing role of socio-ecological modelling	Oral	DEVOTES-EUROMARINE Summer School San Sebastian	09/06/2016	**M5**
S. Sailley		[participation only]	ICES Working Group on Integrated, Physical-biological and Ecosystem Modelling (WGIPEM) meeting, Brest, FR	6-8 June 2016	**M6**
TJW	Comparative Macroecology	Oral	Invited seminar, University of Nottingham	June 2016	**M1**
TJW	Integrating biological traits in biodiversity research	Oral	EMODnet biological traits workshop	June 2016	**M1**
M Lilley, A Atkinson, R Harmer, A McEvoy and A Hirst	Do abundance time series identify the same Hydromedusae bloom events as biomass estimates?	Oral presentation	5th International Jellyfish Blooms Symposium, Barcelona	30/5/16-3/6/16	**M2**