Marine Ecosystems Research Programme

Biannual Science Report

November 201

Report on science and communication activities | May-November 2015

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MERP Biannual Science Report November 2015

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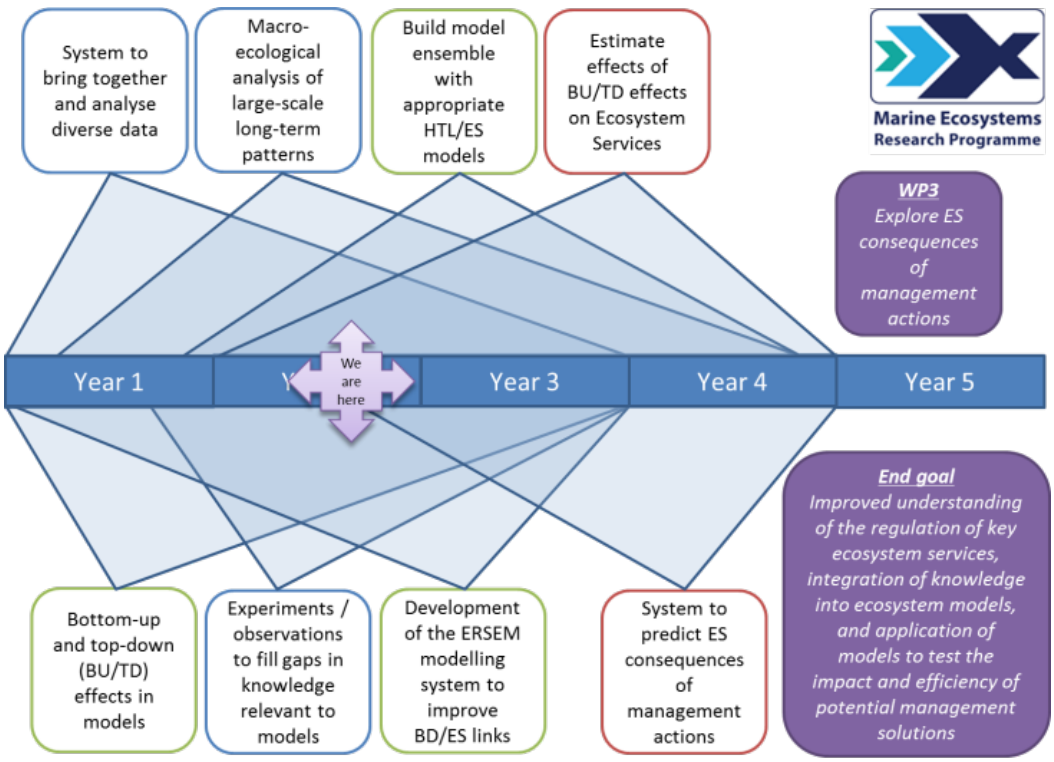
Executive summary

The Marine Ecosystems Research Programme is now approaching half-way through its second year of activity. The overall end goals of the programme, to be achieved over the next 3 to 4 years, are to improve understanding of the regulation of key ecosystem services by marine ecosystems, to integrate that knowledge into ecosystem models, and to apply the improved models to test the impact and efficiency of potential management solutions.

Work to deliver the first two of these goals is funded and in progress. Ongoing work is developing systems to bring together and analyse diverse data with a macro-ecological focus, conducting experiments and field work to gather new data and information, integrating data and knowledge into models, developing existing models, using an ensemble approach to improve our understanding of uncertainty in model outputs and developing an approach to use knowledge and models to address changes in ecosystem services moderated by changes in marine ecosystems. The main thrust of work to date has been on improving our understanding, of marine ecosystems and how they vary, especially over the last few months when major components of the field work and experimental studies have been progressed, and incorporating this improved understanding into ecosystem models. Work linking knowledge about ecosystem change to changes in services is progressing and will increase in importance as the programme moves forwards. The services that the programme focuses on are food provision, leisure and recreation, biological checks and balances, and bioremediation of waste. We continue to await information about the third work-package within the programme.

We are actively engaging with our policy partners, especially through the Stakeholder Advisory Group chair. Discussions have taken place with the MMO, Defra, the Natural Capital Committee and others within the UK, Europe and wider afield. While among our partners Ecosystem Services approaches are seen as developing needs, most of the ongoing work is seen as highly relevant to evidence needs. Many MERP personnel were involved in a recent workshop and paper synthesising modelling approaches for policy. We are currently prioritising a list of policy questions which will provide a basis for discussion with the SAG and for ongoing work across the programme. KE activities have included news items on television, activities to engage the public, newsletters and growth and evolution of the programme website (www.marine-ecosystems.org).

There have been no major delays in the programme, and small delays and changes are being managed. Delivery of key components is on track, and integration across the programme continues to improve.



Key Achievements

MERP Fieldwork 2015

An extensive period of fieldwork was carried out with collaborations across the programme. In autumn 2015, offshore transects near Oban, Bangor, Belfast and Plymouth were completed to explore the input of kelp detritus to the food web in relation to distance offshore. At a time-series site near Plymouth, seasonal mini-cruises (day and night coverage) were run at about six-week intervals to examine jellyfish/fish larvae interactions, pelagic biomass spectra, pelagic-benthic coupling and benthic processing. Regional coverage of the full size-spectrum of the food web (including cetacean distributions) was achieved in autumn cruises of the *Prince Madog* (benthic components) and *Cefas Endeavour* (pelagic). Data and knowledge gained from these cruises, as well as other MERP field and laboratory experiments, will be used by the modelling teams to develop and improve various ecosystem models.

Impact of bottom-up process on fisheries yield

Analysis of outputs of the MERP Model Ensemble revealed good consistency among models in the elasticity of bottom-up effects. A small proportional change in the abundance of primary producers leads to a relative change in the abundance of fish that is approximately 4 times larger. For decades a constant ratio between primary and fish production or abundance has been assumed. This absence of amplification is now ruled out by the model ensemble results. Our results thus suggest that the impacts of climate change on fisheries yield might be being grossly underestimated.

MERP Science in the news

MERP scientists were filmed during their benthic sampling cruise by the news station Al Jazeera for a news segment looking at marine science across the UK. The programme explored how different research methods are being bought together to understand the complexity of the marine environment. Filming took place in the Plymouth Sound in September 2015, with the footage aired on Saturday 26th November every hour for a 24hr period.

Engagement with policy makers

MERP PIs have been engaging with the policy community through participation in meetings and workshops, presenting and discussing the progress made within the Programme as well as possible impacts from the work in the future. Examples include:

- The European Parliament's Committee on Fisheries invited MERP's Prof. Mike Heath (UoSt) to present his research on "An ecological approach to implementing the discard ban" to a hearing of experts entitled "How to improve selectivity in the context of the discard ban". Representatives of the Commission were highly interested and engaged in the proceedings.
- Mel Austen participated in the Natural Capital Committee workshop: Identifying metrics for natural capital (Defra, London) to discuss MERP ecosystem service research in June 2015.
- Nicola Beaumont gave a presentation on using Ecosystem Service research in policy and management to the UK government Productive Seas Evidence Group meeting in London, September 2015.
- Sheila Heymans and colleagues gave a talk on 'Using ecosystem models for sustainable management of the Irish Sea' at the ICES WKIRISH (Workshop on the impact of ecosystem and environmental drivers on Irish Sea fisheries management) in Dublin, September 2015.
- Paul Somerfield presented the MERP programme at the Healthy and Biologically Diverse Seas Evidence Group (*HBDSEG*) in October 2015.
- MERP (through Mike Heath) co-funded the 'Modelling the whole-ecosystem impacts of trawling' report to Fisheries Innovation Scotland.
- A number of MERP PIs attended the MMO Science Alignment Workshop on the 9th of September 2015 in London. The aim of the workshop was to "foster collaboration between academia and marine managers, developing both

research projects and programmes to create excellent science that has maximum impact." MERP PIs who participate included Mel Austen, Jorn Bruggeman, Mark Emmerson. Shelia Heymans and Tom Webb.

- Axel G. Rossberg became UK expert delegate to IPBES and started work as Lead Author for the IPBES Regional Assessment for Europe and Central Asia, with a focus on status and trends in marine ecosystem services. He attended the first author meeting in Switzerland in late September.
- A workshop was organised by Adam Cook and the evidence team of the MMO at Defra to discuss how MERP and the MMO could best work together. Attendees from MERP were Paul Somerfield, Mark Emmerson, Tom Webb, Paul Blackwell, Mel Austen and Icarus Allen. A report from the meeting, held on 5th November, is in preparation.

Actions related to project goals

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

Progress in M1 has continued to focus on the key programme goal of collating major datasets across all functional groups. However as these start to come online more specific analyses aimed at delivering key MERP objectives, including collaborations across the consortium, are beginning to develop. For specific groups, especially top predators and benthic and pelagic invertebrates, intensive data collection and processing (Bangor, Glasgow, CEH, QMUL) has already allowed significant progress towards M1 deliverables. For instance, long term abundance data for multiple species of breeding seabirds in UK waters have been collated and are being used to formulate, test and fit alternative models of density dependence within population dynamics models, and will ultimately help to refine how ecosystem models to parameterise density dependence in top predators, and how this affects the dynamics of lower trophic levels and the potential for top-down cascades. Work on the relationship between intra-specific body mass-scaling of N-excretion rates of diverse pelagic invertebrates and the degree to which body shape elongates or flattens over ontogeny has been completed and will shortly be submitted. Considerable progress has been made on extending this work into benthic organisms, with the new data allowing for comparative analyses of unprecedented scope, addressing fundamental ecological questions such as the role of foraging dimensionality on various scaling relationships. This work has led to wider discussions of the macroecology of body shape, which can be addressed in part using data generated within MERP and which have led to a new PhD studentship proposal between Sheffield, Liverpool and QMUL currently advertised within the ACCE NERC DTP. More generally this focus on the spatial structure of variation in physiological scaling relationships represents a new link between data synthesis and new data collection (broadly speaking modules 1 and 2).

Work between Sheffield and Cefas has brought three large data sets (UK macroinvertebrate trait data, Celtic sea fauna, fish stable isotope data) that were not previously widely accessible to the MERP community via the FileShare system. These data have been cleaned up and fully documented. They include data on macroinvertebrates identified at the Drymen meeting in May as important gaps in marine ecosystem models, and which will also help deliver wider impact as they will form a major part of the Sheffield team's contribution to the proposed marine chapter in the forthcoming RSPB State of Nature 2016 report. In ongoing discussions with the ERSEM team at PML we are working out how best to enrich these abundance and occurrence data with existing and newly-collated (especially via QMUL as well as M2) key biological traits information of interest to macroecologists and modellers alike.

A particularly satisfiying development is the formation of the Rfoodweb team, led by PDRAs from Sheffield and QUB and aimed at creating an R package allowing the automated production of food webs from food web predator-prey databases linked to taxonomic and occupancy data. This work will provide a novel means to combine spatial data with newly available diet data, such as the seabird diet database collected within MERP (Glasgow, CEH) and the DAPSTOM stomach content dataset (Cefas) which is now more readily accessible. This work involves collaborative coding on GitHub and uses Slack for team management, and not only brings together researchers across MERP institutions and modules, but also across NERC programmes including MERP, CBESS (Coastal Biodiversity and Ecosystem Service Sustainability) and SSP (Soil Security Program).

Finally, valuable discussions at Drymen, and subsequently with other organisations (especially the MMO), have helped to clearly focus data collation efforts on variables most relevant to key gaps and priorities for marine policy in an ecosystem services framework.

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

May-October saw an intensive period of field-laboratory work for MERP, with our first major cruises taking place and inshore boat programmes continuing. The extensive fieldwork programme saw widespread collaboration across the programme as partners came together to gather new data. Cruise and fieldwork programmes were developed in collaboration with members from the modelling groups to ensure data gathered would be suitable for later use. Several modellers joined in the cruises including Mike Burrows (SAMS), Mike Spence (Sheffield) and Natalia Serpetti (SAMS), along with Programme Coordinator, Paul Somerfield. Due to the wide range of fieldwork that has occurred recently this report includes an extended section on these activities. The sub sections are mapped onto the deliverables with sub-objectives listed as subsections.

D2.1 Report on the quantification of trophic and non-trophic benthic-pelagic coupling pathways for macroalgae-derived carbon sources

Offhore transects to measure rate of decrease of kelp subsidy to food web

Mike Burrows, Natalia Serpetti (MERP PDRA) and Gail Twigg (MERP PDRA) from SAMS successfully completed an ambitious programme of four inshore sampling cruises that extended about 20 km offshore. This work involved close cooperation with the various hosts' institutes with their personnel helping with fieldwork. They successfully collected grab samples, water samples and epifauna and fish target species (beam trawl) to quantify the macrophyte versus phytoplankton contribution to the food web in relation to distance offshore in UK. These multiple sampling techniques were used to catch many species from small worms in the mud to large fish and crabs. The tissue of the animals will be analyzed (isotopes, fatty acid signatures) to see what part of their diet originates with kelp and what part comes from plankton. Transects (typically 4 stations per each transect) have now been carried out at Oban, Bangor, Belfast and Plymouth during the autumn of 2015. This will be repeated in spring 2016.

The primary focus for the Belfast group (Barrios- O'Neil, Geraldi) over the summer was on determining the contribution of kelp subsidy to food web stability and productivity experimentally. Using the same experimental mesocosm facility as used for their size-based functional response work, they altered the presence of predators (crabs or amphipods), fast growing macroalgae, and detritus (dried kelp)—useful proxies for fast and slow energy pathways—to quantify relative contributions to the stability of food webs and the production of animal biomass. Initial results suggest that kelp detritus may be of similar importance to secondary productivity as fast growing macroalgae. This work is linked to experimental isotope work to be done at PML.

D2.2 Report on the dynamics of interactions between gelatinous zooplankton and fish larvae

Seasonal pelagic mini-cruises at the Plymouth L4 site

Mini-cruises were run in February, April, June, August, and late-September to deliver data for both D2.2 and 2.3 (pelagic biomass spectrum). Efficiency of sampling led to a change in the original plan for joint benthic-plankton sampling cruises. Each plankton mini-cruise runs to the L4 station, off Plymouth, and conducts a co-ordinated sampling program lasting approximately 8 hours from leaving port to returning. Day and night samples are collected in order to compare the densities of plankton, larval fish and jellyfish species rising into the water column after dark. Afternoon sampling of the water column uses three net mesh-sizes (63 µm, 200 µm and 500 µm), with four net samples of each mesh size. Each net is split in half, allowing samples to be preserved for genetic diversity of the plankton (frozen), and for analysis by more traditional microscope techniques (Formalin and Ethanol preservation) or measurement of live organisms (jellyfish species). Once darkness has fallen, another series of four nets at each of the three mesh sizes is undertaken and preserved in the same manner. Sampling can be effectively conducted by three scientists with a workload highly dependent on the density of gelatinous material in the plankton. Cruise reports for each trip are available through StrathCloud sharepoint. Most trips are run by Martin Lilley (QMUL), Angus Atkinson and Pennie Lindeque (both PML), with assistance when required from others.

Sampling issue and remedial action

Differences in the densities of fish larvae and jellyfish between 500 (towed obliquely) and 200 µm (towed vertically) nets at L4 led to questions about filtering efficiency or water column coverage during sampling. For the most recent MERP plankton mini-cruise (PQ9/15; Sept 2015) a depth logger was fitted to the 500 µm net. This showed that the net was only sampling the top 2/3 of the water column. This may have been due to the rough conditions at the time, but demonstrated that not all the water column was sampled on each tow. Rather than change the sampling programme half-way through the depth sampled will continue to be monitored and data corrected where necessary to account for the known depth coverage.

Genetic analyses of material from the mini-cruises

During MERP plankton mini-cruises individual jellyfish and fish larvae have been isolated from samples and flash-frozen in liquid Nitrogen for genetic analysis of their gut contents. Due to their small size and fragility it is not possible to remove the gut from the jellyfish tissue, therefore methodologies using predator and prey tissue together need to be developed. DNA-easy kits were tested by Helen Parry (PML) and Martin Lilley (QMUL) in Plymouth and yielded very little DNA from gelatinous tissue. Subsequent tests with the more laborious, but traditional techniques of DNA extraction using Phenol and Chloro-iso-alcohol yielded much greater DNA levels. PCR analysis by HP showed that the primers were extracting the relevant DNA and that it was worth sending the initial samples away for sequencing. We await the results to see whether the DNA present is only from the predator (usually a Ctenophore) or whether other prey DNA is also visible.

D2.3 Report on "end to end" pelagic and benthic biomass spectra across regional gradients and seasons

Benthic Size spectra: Prince Madog cruise

The size spectra of marine ecosystems is a poorly understood area of research. This is because the majority of size spectra studies tend to focus on just one size class of animals, focusing on just the plankton or the fish for example. However, in September 2015, we gained over 640 hours at sea whilst working aboard the RV Prince Madog, a research vessel operated by Bangor University. This research cruise involved a variety of MERP scientists from a number of research institutions including Plymouth Marine Laboratory (PML), Sheffield University, Scottish Association for Marine Sciences (SAMS) and Bangor University. During the cruise we sampled 20 stations around Pembrokeshire, the Bristol Channel, Devon and Cornwall using a range of gears including niskin bottles, day grabs, anchor dredges, 2m and 4m beam trawls. Together, these different sampling gears successfully captured the full size of the benthic ecosystem ranging from the smallest nematode worm, to the largest monk fish. The samples obtained from this research cruise are currently being analysed at Bangor University. The entire cruise is due to be repeated in April 2016. Results will then be supplied to other MERP scientists who require the data in order to construct their ecosystem models.

Higher predator distributions

James Waggitt (PDRA from Bangor) conducted the predator transects on the Madog cruise. During this they managed to collect almost 100hr of concurrent top-predator, prey and current information from observations, echosounder and ADCP deployments respectively. Surveys covered a broad range of habitats throughout the region, covering gradients in current speed, seabed depth and seabed complexity. Initial inspection reveals potentially strong links between the abundance, biomass and diversity of top-predators with areas of higher current speeds. Subsequent analysis will seek to understand whether these links can be explained by an effect of strong and dynamic currents on prey characteristics including the size and depth distribution of fish shoals. Aside from the research cruise, Bangor is also continuing to assemble observational, prey and physical datasets to start explaining long-term and regional distributions of top-predators throughout the North-West continental shelf. This work thus forms a natural link between M1 and the spatial biomass spectra component of M2.

Cefas Endeavour Cruise: Pelagic biomass spectra – regional picture

On October 3rd the RV Cefas Endeavour set sail from Portland to begin surveying pelagic food webs off the southwest coast of the UK. This is the fifth year of pelagic surveying in this region (known as the 'PELTIC' surveys) funded under the Defra project POSEIDON with further support from MERP. Primary aims were to carry out a combined acoustic

and trawl survey to determine the distribution and abundance of small pelagic fish species; to collect plankton samples and ichtyoplankton; to record hydrographic data (temperature, salinity, chlorophyll, pCO_2, O_2) and to quantify the abundance of jellyfish. In addition, locations, species numbers and activities of seabirds and marine mammals were recorded. The pelagic fieldwork campaign was timed to coincide with the autumn plankton bloom (with satellite images downloaded each day), and this year concurrent demersal and benthic sampling was carried out aboard the RV Prince Madog as part of MERP. The survey was completed on 21st October, when RV Cefas Endeavour docked in Swansea. The methods used to construct the PELTIC cruise biomass spectra were harmonised as far as possible with those from L4, following prior discussions among the Co-I's.

Generation of a seasonal plankton biomass spectrum at Plymouth L4

A dedicated 2-week stay at PML in August by Martin Lilley (QMUL) allowed all the 500 µm and 200 µm plankton samples from the minicruises to be analysed with the assistance of Angus Atkinson (PML). All gelatinous species were identified by Martin, with biomass and densities calculated. Differences were observed between day and night samples, confirming the importance of this wider view of the plankton than previously observed during the long-term day-time sampling at L4. These data will inform an analysis of the biomass spectrum of the whole plankton community at L4 for integration into MERP modelling activities. Atkinson generated length-mass relationships (with input from ML on the jellies) and thus a prototype biomass spectrum. While this spectrum will be tweaked in the next 6 months as data sources are refined, it was sent to MERP Module 3 (Rossberg) and M6 (Bruggeman) for initial data analysis and feedback.

Plankton functional trait allocation: Plymouth L4

MERP affiliated PhD Kristian McConville submitted to Limnology and Oceanography a meta-analysis paper on how gelatinousness of zooplankton interacts with their body size to modulate their growth rates. At the same time AA coded the ~400 taxa regularly enumerated at the standard weekly L4 monitoring site to one of 12 basic traits, for feedback at the annual meeting. This dataset is also being processed to provide a water content value for each taxon. This will allow the trait of gelatinuosness to be modelled or treated as a continuous variable. This process has been discussed and refined during the regular bi-monthly meetings between the plankton member of M2 and the modellers in M6.

D2.4 Report on the parameterisation of functional responses of feeding and mortality related to traits

Effects of body size on key pelagic processes: predator prey size ratios

Analysis of 11 seasonal copepod feeding experiments is now near completion (9 done). Visiting scientist Nicolas Djeghri counted the upper size limits of items in the experiments (nauplii, big diatoms etc). Processing of our flow cytometry data in early November will provide lower ends to ingestible size spectra, after which we can also determine optimum size ratios in relation to both body size and feeding trait (filterer, raptorial predator, ambush feeder). A compilation of existing food size data for pelagic filterer feeders is now accepted for publication as part of a book chapter.

Deriving relationships for mortality rates.

A case study of *Calanus helgolandicus* population dynamics has been published by MERP-affiliated PhD student Jackie Maud in Progress in Oceanography. Another paper looking at sources of mortality using vital stains is in progress.

Size-based approaches to benthic functional responses

Data acquisition for size-based generalisations of benthic consumer feeding rates has continued on an opportunistic basis throughout the summer. In addition to the pilot data on *Carcinus maenas*, we now have data for *Cancer pagurus*, *Necora puber*, and the echinoderms *Asterias rubens* and *Marthasterias glacialis*, as well as number of other consumer-resource pairs.

D2.5 Parameterization of trophic and non-trophic pathways of carbon assimilation in coastal benthic-pelagic systems in ecosystem models

Benthic-pelagic mini-cruises at the Plymouth L4 process site

This work has the key aim to understand how macrophytes (c.f. phytoplankton) become incorporated into the sediment ecosystem in coastal areas, and how these mechanisms may change through the seasonal cycle. This activity adds detail to the work led by SAMS, providing it with temporal resolution, identifying key pathways through which the seabed benefits from these food sources, and providing an understanding about whether the carbon in those food sources becomes "locked up" in the sediment habitat, or whether it is recycled and lost again to the water column through respiration. To this end, 4 benthic-pelagic mini-cruises (Queiros) were undertaken on board the RV Quest at the L4 station (February, May, July, September 2015), and 3 more are planned until March 2016 (November 2015; and January and March 2016). This work will provide a good coverage of the seasonal dynamics of macrophytes as a potential food source to sedimentary coastal communities at the L4 station. We have acquired samples for the determination of d13C in POC in the water column, at the sediment/water interface and at 3 depths within the sediment; DIC; macrofauna at three depths within the sediment; and meiofauana at the surface. d15N will also be estimated where relevant. Laboratory incubations of natural sediment cores have provided estimates of bioturbation and bioirrigation rates to determine potential rates of burial of deposited macrophyte detritus by macrofauna via non-trophic routes, associated sedimentary oxygen consumption, and d13C of DIC of produced by the sediment community(both important to determine carbon re-mineralisation). Macroalgae samples onshore and plankton samples at the study site were collected at the same time to provide seasonal variability in isotopic signature of algal and plankton material through the year, and provide the resource information for the isotope mixed model. DNA barcoding is being undertaken on sediment and seaweed material from all time points at the study site to help corroborate the isotope model. Modelling is being used to help understand potential routes and rates of dispersion of coastal macrophyte debris within the Plymouth coastal ecosystem. Isotope data of macrofauna will be acquired on size bins to support Obj.4 (2.3) and ERSEM model development.

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

Early in the reporting period, the lead of Module 3 (Axel Rossberg) was offered a new position at Queen Mary University of London, which he took up in late August. Cefas has commissioned a sub-contract to QMUL so that Axel Rossberg can continue to lead and deliver against Module 3 as outlined in the MERP programme of work. This transition led to delays in work on Module 3, in particular for T3.1 (elasticity analysis of data) and T3.3 (elasticity analysis of model outputs), and also impacted Cefas' contributions to Module 4. Nevertheless, some significant progress in has been made in Module 3.

MERP Model Ensemble outputs generated based on previously agreed scenarios were used to compare the strengths of top-down and bottom up effects between models. Elasticity analysis provided a unifying framework for this comparison. While top-down effects differed in their strengths between models, a clear pattern of weak amplification emerged for bottom-up effects. This has immediate consequences for fish abundance and production, and so directly contributes to the ecosystem service considerations in Module 5. Analysis of outputs of the MERP Model Ensemble revealed good consistency in the elasticity of bottom-up effects with a median increase of elasticity along the size axis of 0.05 per ln(body mass) unit. This implies that a small proportional change in the abundance of primary producers will be amplified and will lead to a relative change in the abundance of fish that is approximately $(M_{Fish}/M_{PrimProd})^{0.05}$ = $(10^{12})^{0.05}$ = 4.0 time larger. The assumption of a constant ratio between primary and fish production or abundance, persisting in the literature since Sheldon et al. (1977) to the present day, corresponds to an amplification factor 1. This absence of amplification is ruled out by the models. Our results thus suggest that the impacts of climate change on fisheries yield might be grossly underestimated.

The members of the MERP Model Ensemble are continuously being refined and developed. Recent examples are an expansion of StrathE2E to resolve several ecologically distinct compartments (e.g. seabed habitats and fleets), an update of the Ecopath with Ecosim West Coast of Scotland (WCoS) model using new data up to 2013, and the implementation of a non-linear generalization of the Species Size Spectrum Model.

There have been a number of developments of specific models. In the Cefas spatial ecosystem model, GIS data layers for habitat fisheries and the association of species and fisheries to their habitats have been added, and progress made on spatial segmentation the fisheries. The StrathE2E model has been extended to incorporate variation in seabed habitat, characterised by porosity, permeability and depth, and detailed spatial modelling of fishing fleets, their gear

and their distribution of effort. Some of this work was supported by additional external funding from a Fisheries Innovation Scotland grant. The Ecopath with Ecosim West Coast of Scotland (WCoS) model has incorporated new and updated data on ecosystem functional groups and bottom-up functional drivers (biological and environmental). These model-specific developments contribute to M4.2,4.3 and D4.2, 4.3.

Hayley Bannister (joint University of Sheffield/Cefas PhD student) is reviewing approaches to the communication of predictions and uncertainty in ensemble modelling, with her supervisors Tom Webb and Paul Blackwell, leaders of MERP modules 1 and 4 respectively, Julia Blanchard (Module 4) and Kieran Hyder (Cefas). This work will contribute to the reports 4.2, 4.3, 4.4. Mike Spence supervised an undergraduate intern, Joseph Hunt, during June/July, extending ideas from a recent methodological paper (Spence & Blackwell, in press; *Statistics and Computing*) to higher-dimensional models, including Julia Blanchard's Mizer size-spectrum model, building on Spence et al. (in press; *CJFAS*). This work contributes to the report (D4.1) on statistical methodology for ecosystem models.

Mike Spence and Paul Blackwell have continued the development of Bayesian modelling techniques and algorithms for inference for multi-model ensembles. A key step over this period has been improved representation of covariance structures, permitting increased flexibility without prohibitive computational cost. They have also been developing techniques for elicitation of expert beliefs, particularly for correlation structure, needed as inputs to the ensemble analysis, and working with MERP scientists to test and refine them. These continuing activities form the basis of M4.2. Mike Spence one of the PDRAs in MERP joined the Prince Madog cruise in September, gaining first-hand knowledge of some of the techniques providing data that inform the modelling with Module 4, and refining statistical elicitation techniques at the same time.

Developing the ERSEM modelling system

With the modular version of ERSEM ("FABM-ERSEM") complete (task 1), we have shifted focus to the development of the new standard organisms (task 4) and the traits that best characterize interspecific variability (task 5). Together, these will enable us to start model experiments on emergent biodiversity and its impact on ecosystem functioning (task 6; month 18 onward)

Standard models for primary producers, zooplankton (fixed or variable stoichiometry) and benthic fauna are all complete, and a new unified description of prokaryote suitable for pelagic and benthos has been delivered. Future work will focus on improved descriptions of multicellular heterotroph physiology and life history, and on the representation of mixotrophy in eukaryotic unicellulars.

Based on Skype meetings with all module 6 partners (PML, Cefas, NOC) we have compiled a protocol for collecting and analysing trait data for modelling purposes. These data will be sourced from MERP partners (modules 1 and 2), literature, and international collaborators (http://www.oceanlifecentre.dk and participants of the "trait-based approaches to ocean life" workshop – see dissemination). Analysis of trait datasets will enable us to identify the key traits (e.g., size) of the standard organisms that need to be varied to best describe the diversity in communities.

Over the next six months (January 2016 onward), collected information on key traits will be used to design model experiments that explore pelagic and benthic biodiversity in water columns. For this purpose, the first sites (L4, Oystergrounds) to run the 1D model for have been selected, and the availability of community structure data for pelagic and benthos has been assessed.

The 3D modelling work, including analysis of the ERSEM hindcast (task 2) hinges on the readiness of version 3.6 of NEMO, the code of which has been delivered in June 2015. Test simulations for the first MERP domain (7 km Atlantic Margin Model) have been completed and validated by NOC. Additionally, a new 1.5km-resolution hydrodynamic model of the Celtic Sea and English Channel has been set up; validation is underway. The first coupled setups with NEMO 3.6 and ERSEM for the AMM domain will be run within the Shelf Seas Biogeochemistry (SSB) program near the end of 2015; outputs of these will be used for the analysis of the ERSEM hindcast (task 2). A new strategy for optimizing advection of many variables (task 3) has been devised by NOC; work on this will start in June 2016.

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

Work in Module 5 has concentrated on developing conceptual models, maintaining and improving communication with other MERP members and writing a research paper drawing on the outcomes of the AGM in Drymen in May 2015. In particular, in Drymen information on ecosystem processes involved in the four ecosystem services (Leisure/recreation, Food provision, Bioremediation of waste and Biological checks and balances) was collected. This information included definitions of processes, measurable units for each process and where measurements can be taken from within MERP and outside. The list was then further extended with information relating to each process. The collated information was used to create more specific conceptual frameworks for each of the services and to discuss these with researchers from other modules within MERP and outside, specifically, discussions were had with Peter Evans, Sarah Wanless, Francis Daunt, Jorn Bruggeman and Sevrine Sailley within MERP and Peter Miller from the remote sensing group in Plymouth Marine Laboratory. CEH has for example provided input on primary species and colony locations with intense public attraction, general biological and ecological data for each species of relevance to ecosystem models (diet, foraging ranges, distributions, life history etc), and the primary external pressures on different species (human disturbance in key habitats, mammalian predators, etc).

Continuous consideration of the availability of empirical (linking to macroecology and cruise observations) and modelled data is used to reality-check the utility of the developing conceptual models.

Building on the MSFD discussion group at Drymen a manuscript is being drafted which explores the indicators that have been proposed by EU member states for the assessment of Good Environmental Status as required for the MSFD. Each indicator will be assessed in terms of its usefulness to assess ecosystem services.

Delays and remedial actions

There have been no major delays incurred during this period, those that have occurred are generally due to staffing issues as explained. Resignation of one of the skilled plankton analysts at PML in spring 2015 has impacted MERP and needed a patch fix. Nicolas Djeghri helped analyse some samples as visiting scientist (D2.4), but we have had to re-think how we integrate the jelly and zooplankton catches into the biomass spectrum to adjust for this skills shortage. Nate Geraldi (QUB) has handed in his resignation for the 31st of December. QUB is currently in the process of re-advertising the PDRA position.

Details of the third work package within the programme (*Application of model development to test the impact and efficiency of potential management solutions.*), supposed to be a closed call building on the outputs of Work Packages 1 and 2 to test the impact of potential management solutions on the structure and function of marine food webs across scales and explore the efficacy of specific indicators of good environmental status, have yet to appear. If this work package is to be fully integrated with the rest of the programme it would be useful to see some progress on this.

Collaboration with socio economics

In order to improve clarity and communication about the ecosystem services work within the project, articles have been published in the MERP Newsletter. This is significant as there were misunderstandings in the terminology among different researchers, it is hoped that the contributions to the newsletter will improve understanding and communication. The M5 team is working in collaboration with Mike Heath to fine tune the definitions of ecosystem services, natural capital, stocks and flows and aim to publish an overview of these discussions on the MERP website in the near future.

Conceptual models of charismatic species have been discussed with members of Module 2: Peter Evans, Francis Daunt and Sarah Wanless. Ecological models used in MERP and the use of their outcomes has also been discussed with Module 6. Peter Miller from the Remote Sensing group in PML was consulted about data on oceanic fronts. Finally, ES definitions have been further developed in collaboration between Strathclyde, particularly Mike Heath and PML.

Knowledge Exchange

MERP communication and dissemination activities are first and foremost guided by MERP Impact and Pathways to Impact plans, which outline potential users of MERP science and routes to communicate with these beneficiaries. It is acknowledged that these plans will evolve as the programme progresses and activities will be adjusted accordingly.

- The programme website continues to be regularly updated and developed, in light of feedback from users. A "Register your interest" form has been added to the website to allow website users to sign up for updates, and to help MERP build a database of interested contacts. Since launch, the website has received over 10,000 visits with an average session time of 2.5 mins. During the last reporting period there were 5,000 unique visitors with a session time of about 2 mins.
- A new, more user-friendly events calendar has been added to the MERP website.
- The 2nd MERP newsletter has been distributed to the MERP mailing list, following a high article response from MERP participants. In addition to the MERP mailing list, the newsletter has been circulated to the Marine Science Co-ordination Committee (MSCC), Marine Ripple network and the Communications and Management for Sustainability organization.
- Twitter feed now has 131 followers. New followers include The Wildlife Trusts, Nick Baker (BBC wildlife correspondent), EnviroNews, Severn Estuary Partnership, European Centre for Nature Conservation, Ocean Leadership, plus many individual scientists. Since the April 2015 report there were approximately 12k impressions, 1437 profile views and 87 mentions. Tweets about fieldwork (specifically those that have associated media) have the highest engagements.
- Programme leaflet has been updated and sent out to partner institutes, a PDF version is also available on the MERP website.
- Defra 2-page summary has been updated.
- Filming of the Marine Ecosystems Research Programme video has been completed and editing of the footage is now underway. Delays were caused by fieldwork, scheduling issues and sickness.
- Discussion forum has been updated with the MERP media policy and audio/video guidelines.
- Evaluation of online communications has begun; looking at website and Twitter engagement. It has been noted that there has been a drop in impressions on Twitter but a slight increase in engagement ratio.
- Added MERP to the marine ecosystems page on Wikipedia
- QUB was awarded funding from NERC's Summer of Science fund to create a "Rockpool Roadshow", which they took to stakeholders to promote engagement with MERP science. Newsletter article about the event. Further events will be taking place in Giant's Causeway in November there are plans to continue the Rockpool roadshow throughout the duration of MERP.

PDRA Danny O'Neill at the NERC summer of science event at Stormont, Belfast.

Scientific plans for next 6 months

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

Additional data sets will be made available to MERP users. They will include Cefas infauna data from UNICORN data set, meiofauna data from MANUELA data set, JNCC and in-house MERP bird data, as well as the Cefas diet data base DAPSTOM.

We will continue to investigate the best ways to visualise new data compilations, for instance as maps of diversity for UK waters across trophic levels, as animportant starting point for addressing policy-relevant questions including: Where are biodiversity hotspots, what species or biotopes are driving particular biodiversity hotspots, why are they

important and what is their sensitivity to environmental change (natural and anthropogenic)? Some issues surrounding hotspots in UK marine biodiversity will be examined by a Sheffield MBiolSci student.

Newly collated predator databases will be used in conjunction with environmental data to address scale-dependent relationships between the distribution of foraging predators and physical processes, and also relationships between the distribution of foraging predators and that of their key prey species. This will integrate the use of existing data with data from MERP cruises

A budget has now been approved by the BES to hold an Aquatic Macroecology meeting sometime in 2016. The organising committee assembled including MERP post-docs Vergnon, Queiros and O'Neill, and full planning of the meeting will proceed over the next six months.

An OBIS data hack co-organised by TJW and involving PDRA Vergon, as well as MERP project supporters ROpenSci, will be held in December 2015, aiming at improving the pipeline from raw OBIS marine biodiversity data to full macroecological analyses, using R and other tools.

Calculations of long-term trends in components of marine biodiversity (especially benthic macroinvertebrates) will contribute to the 2016 State of Nature report

First analyses of CPR data will be conducted, using processed time series of relative abundance and/or biomass of key zooplankton taxa, and of the PCI index, for MERP's focal regions (the western seas of the UK, including the Western Channel, Celtic Sea, Irish Sea, and seas of the West of Scotland), as well as data on key biological traits of major zooplankton taxa. Thermal ecology, and environmental tolerance more generally, is considered key, and so understanding the relative dominance of stenotherm vs. eurytherm taxa through time and space will be very useful.

Targeted field sampling and experimental studies

By April 2016, all sediment, water and invertebrate samples generated by the September cruises will have been processed by Bangor University and PML. The April 2016 cruise is already being planned by Bangor, PML and SAMS and will take place from 28th March to 24th April 2016. Following completion of the Defra-funded PELTIC survey aboard the RV Cefas Endeavour on 21st, Cefas will continue to process the available data (and water samples) on pelagic food webs in the coming weeks, and feed this information into other MERP Modules. The predominant aim of the PELTIC surveys has been to inform Defra and ICES on the status of pelagic fish resources around the southwest of the UK. However, the information will be of utility for other MERP partners, most notably the detailed information collected on jellyfish, marine mammal and seabird abundance, as well as derived pelagic size spectra, which encompass all organisms from phytoplankton and fish up to fin whales. Jeroen Van Der Kooij (Cefas) will communicate some of the results from this survey to the ICES Working Group on Acoustic and Egg Surveys for Sardine and Anchovy in ICES Areas VII, VIII and IX (WGACEGG) that is scheduled to meet in Lowestoft 16-20th November. Results will also feed into ICES stock assessments and scientific advice.

Mesocosm experiments: Preparation of pulse chase experiments is underway where the above mechanisms will be investigated in finer detail in the lab, using labelled macrophyte detritus. This work will be undertaken in Feb-April 2016. Mechanisms will be investigated using baseline conditions for the L4 site at the time of year, and under environmentally stressful conditions, which have relevance at the site in the context of known seasonal dynamics (hypoxia) and long-term climate change (ocean acidification). The investigation of the effect of stressors (not initially foreseen in the DOW) will be supported as an added value-activity, and undertaken by a visiting PhD student from the University of Pisa (Ravglioli, supervised by Bulleri and Benedetti-Cecchi). The student will be supervised by Ana Queiros (MERP), McCoy and Findlay at PML.

Pelagic work: The biomass spectrum and body size-feeding relationships as well as trait based allocation of the taxa sampled at L4 will be completed by next spring to get the data to the modellers at the earliest opportunity. A near final version has already been sent out to M3 and M6 for feedback at the November meeting. We are planning to write about two papers on this biomass spectrum next year.

The Pelagic L4 mini-cruises will run at lower resolution this winter and increase around the time of the spring bloom 2016. They will cease after the bloom.

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

In the next 6 months period, spatially and temporally resolved size-spectrum data from Module 2 will be used to test the predictions of the elasticity analysis of MERP Ensemble outputs. Suitable archive data available through Module 1 will be included in this analysis as available. Specific members of the model ensemble that showed atypical behaviour in the elasticity analysis will be probed for the reasons for these deviations, to understand whether these are model artefacts due to simplifying assumptions in these models or due to plausible ecological phenomena not captured by other models. Time permitting, we also plan to conduct further comparisons and analyses of top-down effects in selected members of the MERP Model Ensemble, especially because these can, if strong, imply trade-offs for the ecosystem services considered in Module 5.

Refinement and development of the MERP Ensemble will continue. For example, SAMS will finalise the temporal model calibration and start the data collection for a spatial model parameterisation. CEH will finish the development and fitting of models in the density-dependence analysis and share outputs from this analysis with modellers to then explore how density dependence in top predators may affect the dynamics of lower trophic levels. CEH will also begin work on developing predation pressure maps for breeding UK seabirds. Any outputs will be shared with modellers for potential incorporation/model validation in ecosystem models including top predators.

Cefas will establish an equilibrium model and carry out simulations for specific scenarios. Natalia Serpetti and Sheila Heymans will finalise the EwE temporal model calibration and start the data collection for the spatial model parameterisation, moving towards inclusion of these models in the final ensemble. In general, all models potentially to be included in the ensemble will continue to incorporate newly available data arising from the ecoinformatics activities of Module 1 and the fieldwork in Module 2. As above, this will contribute to M4.2,4.3 and D4.2, 4.3.

Mike Spence and Paul Blackwell will continue to develop and collate statistical methodology for complex models, for report D4.1

They will also continue the elicitation of prior beliefs on inter-model variability, not only from modellers but also from scientists across MERP, and through discussions with individual modellers of within-model uncertainty. They will update their illustrative analyses using a small ensemble of models, for an initial proof-of-concept publication, moving towards an understanding of the factors affecting model skill and hence the determination of the model ensemble to be used (M4.2, D4.2). As part of this process, an elicitation session and a plenary session on uncertainty are planned for the November MERP science meeting.

Develop the ERSEM modelling system

- Initial analyses of traits of phytoplankton, zooplankton and benthic fauna will be completed during the next six months, resulting in a per-group ranking of traits in order of importance, along with estimated quantitative relationships between those key traits and model parameters. The result of these analyses is expected to be refined further over the course of the program as more data become available.
- Based on feedback during November's integration workshop, we will decide on organizing a workshop dedicated to bridging the gap between empirically collected traits and the needs of models that represent diversity. This workshop would be held in 2016.
- 1D water column simulations of phytoplankton, zooplankton and benthic faunal diversity will begin in December 2015, and initial results will be available in June 2016. These simulations will build upon the analyses of species vs. trait data, and leverage the existing DivERSEM framework for ensemble simulations of high-diversity communities.
- Analysis of the ERSEM hindcast will begin when the first AMM-FABM-ERSEM are delivered by the SSB programme (end 2015); 12 months have been allocated to that.

Develop ecosystem services science

The conceptual models will be disseminated to the MERP consortia to give researchers from all modules the opportunity to provide feedback, and to suggest ways of integrating these models with data. This is to be done before the meeting in Manchester in November 2015 so that models can be discussed there further.

In Manchester further face to face discussion are scheduled between HTL scientists who were not at Drymen to further bring Module 2 into Module 5, and to better understand how data collected over this past fieldwork season can be used in the assessment of ecosystem services within MERP.

The manuscript on the effect of ocean acidification on the service of Bioremediation of waste carried out by *Mytilus edulis* has been accepted after minor revisions for publication in the journal Marine Pollution Bulletin. This paper was under MERP and the UKOA project.

We aim to finish the paper on MSFD indicators. This will depend, to some extent, on how quickly indicators from the UK collection become available. We are working on resolving this issue.

Knowledge Exchange

- Produce and circulate April 2016 newsletter.
- Further evaluation of online analytics will continue, to try and improve engagement stats.
- Continue website development.
- Finalise production of the MERP introduction video plus at least one shorter, more focused, update video.
- Produce first feature article about MERP science.
- Preparation for a MERP-incorporated National Science and Engineering Week activities.
- Contribution to marine ecosystems and ecosystem services Wikipedia pages.
- Begin scoping MERP informal seminars at key stakeholder venues.
- A Cefas-led MERP briefing for Defra is planned for January 2016 where we will show how current MERP outputs can be used to address policy questions concerning the sustainable use of the marine environment. During the MERP winter workshop in November 2015, we will identify a number of key examples across Modules to demonstrate where the MERP programme delivers scientific knowledge that is policy-critical, underpins a range of decisions and meets wider information needs.
- OBIS data hack co-organised by Tom Webb and involving PDRA Remi Vergon, as well as MERP project supporters ROpenSci, will be held in December 2015, aiming at improving the pipeline from raw OBIS marine biodiversity data to full macroecological analyses, using R and other tools.

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. The Project Steering Committee (PSC) continues to meet regularly, usually bimonthly to share developments across the modules and different work areas. Minutes are kept and made available to the entire consortium through the Sharepoint file sharing site. This is a private file sharing site that all members of the MERP consortium have access to, allowing everyone to upload and share project relevant documents. As appropriate additional MERP PIs are invited to join the PSC teleconferences to report on their activities and share any issues or concerns they may have. A workshop report was completed shortly after the June Ecosystem Services workshop and distributed to the whole consortium, PAG, SAG, NERC and Defra. Month 12 deliverables were completed as reported in Year 1 report. Discussions towards completing the next deliverable (D1.3 Joint meeting with BES) have been initiated; suggested meeting dates are in Spring 2016. No milestones were due in this period.

Action 2. Value added scientific interaction: The additional workshop being held in November 2015 was planned as a means to engage with those who were unable to join the annual meeting in June due to fieldwork commitments and to maintain the close collaboration across the consortium. The agenda has been planned with input from PIs. All vital topics were included.

A budget has been approved by the BES to hold an Aquatic Macroecology meeting sometime in 2016. The organizing committee includes several MERP PDRAs Vergnon (Sheffield), Queiros (PML) and O'Neill (QUB). Tom Webb received funding to supervise a MBiolSci dissertation and project using MERP data to address MMO gaps and priorities on hotspots of UK marine biodiversity.

A new postdoc-lead collaboration was recently initiated by Mark Emmerson and Tom Webb to create the "Rfoodweb" R package allowing the automated production of food webs from food web predator-prey data bases. The package would be used for similar activities taking place across a range of NERC projects including MERP (Marine Ecosystem Research Program), CBESS (Coastal Biodiversity and Ecosystem Service Sustainability) and SSP (Soil Security Program). Finally a PhD project in the ACCE DTP is currently advertised, building on the MERP collaboration (and using datasets made available by MERP) between Tom Webb (Sheffield) and Andrew Hirst (QMUL) together with David Atkinson (Liverpool) investigating the macroecology of body shape.Sevrine Sailley presented FABM-ERSEM (modular modelling infrastructure suitable for biodiversity modelling) to PML plankton group, including several Module 2 participants.

Jorn Bruggeman has been in contact with Andrew Hirst and Martin Lilley to discuss the availability of zooplankton and benthos physiological rates and their relation to size.

Nick Stephens has attended the planning meeting in Bangor for the MERP research cruise in September 2015.

Pierre Cazenave and james Waggitt are discussing a collaboration using FVCOM to predict cetacean and seabird aggregations.

Action 3 Peer review: There are now a total of nine MERP publications as reported in the Publications section. Several more have been submitted and are in preparation.

Action 4 Impacts: The Second stakeholder Advisory Group meeting is being held imminently. This meeting will focus on discussions of the key policy questions MERP intends to feed into, and we will be seeking the SAG's help in how best to do this. Regular meetings are held with the Chair of the SAG Matt Frost (generally every 2-3 months(attended by Matt Frost, Paul Somerfield/Programme Coordinator, Jessica Heard/Project Officer and Kelly-Marie Davidson/KE Officer) to maintain contact and keep him abreast of project developments. The Chair then communicates with the SAG as appropriate. As the programme continues to progress and produce results collaborative impacts will start to emerge. A joint MERP/MMO workshop took place on the 4th November to discuss amongst other points how MERP understanding and modelling can be used to build projections on the environment and its services into Marine planning and delivery. Discussions from this workshop will feed into the SAG workshop in Manchester.

Action 5 PDRA Networking: Following a meeting of the PDRAs in Drymen they have continued to network well, collaborating on various projects, participating in cruises and sharing best practice. The PDRAs work in collaboration with each other as well as project PIs both at their institutes and across the consortium. A few examples include: Mike Heath (PI) and Mike Spence have been working together on estimating parameter uncertainty in StrathE2E, Leigh Howarth (PDRA, Bangor) works closely with Kate Searle (PDRA) and Francis Daunt (PI, CEH) and Rudie Nager (PI,

Glasgow) on developing fieldwork programmes, exchange of datasets and joint publications. Martin Lilley (PDRA, QMUL) regularly visits PML to work on the mini cruises collaborating with PDRAs and PIs at PML. Ana Querios (PDRA, PML) worked with Danny Barrios O'Neill (PDRA, QUB) on how to include benthic traits in their experiments on energy pathways in kelp.

MERP Publications

Acevedo-Trejos E, Brandt G, **Bruggeman J** and Merico A (2015). Mechanisms shaping size structure and functional diversity of phytoplankton communities in the ocean. Scientific Reports 5, Article number: 8918 doi:10.1038/srep08918

Atkinson A, Harmer R, Widdicombe C, McEvoy A, Smyth TJ, Cummings D, **Somerfield PJ,** Maud J, McConville K (2015). Questioning the role of phenology shifts and trophic mismatching in a planktonic food web. Progress in Oceanography, Volume 137 Part B, 498-512. doi:10.1016/j.pocean.2015.04.023

Coll M, Shannon L J, Kleisner KM, Juan-Jordá MJ, Bundy A, Akoglu AG, Banaru D, Boldt JL., Borges MF, Cook A, Diallo I, Fu C, Fox C, Gascuel D, Gurney L J, Hattab T, **Heymans JJ,** Jouffre D, Knight BR, Kucukavsar S, Large SI, Lynam C, Machias A, Marshall KN, Masski H, Ojaveer H, Piroddi C, Tam J, Thiao D, Thiaw M, Torres MA, Travers-Trolet M, Tsagarakis K, Tuck I, van der Meeren GI, Yemane D, Zador SG & Shin YJ (2016). Ecological indicators to capture the effects of fishing on biodiversity and conservation status of marine ecosystems, Ecological Indicators. 60, 947-962. doi:10.1016/j.ecolind.2015.08.048

Glazier DS, **Hirst AG and Atkinson D** (2015). Shape shifting predicts ontogenetic changes in metabolic scaling in diverse aquatic invertebrates. Proc. R. Soc. B 282: 20142302. doi.org/10.1098/rspb.2014.2302
Link http://rspb.royalsocietypublishing.org/content/282/1802/20142302

Horne CR, **Hirst AG, and Atkinson D** (2015). Temperature-size responses match latitudinal-size clines in arthropods, revealing critical differences between aquatic and terrestrial species. Ecology Letters. doi: 10.1111/ele.12413. Link http://onlinelibrary.wiley.com/doi/10.1111/ele.12413/abstract

Hyder K, **Allen JI, Austen A**, Barciela RM, **Blanchard J, Burrows MT**, Defriez E, Edwards K, Garcia-Carreras B, **Heath M**, Hembury DJ, **Heymans JJ, Holt J**, Houle J, Jennings S, **Mackinson S**, McPike R, Mee L, Mills DK, Montgomery C, Pearson D, Pinnegar JK, Popova EE, Rae L, Rogers SI, **Rossberg AG, Speirs D, Spence M**, Thorpe R, Turner RK, **van der Molen J**, Yool A & Paterson DM (2015). Making modelling count - increasing the contribution of shelf-seas community and ecosystem models to policy development and management. Marine Policy 61, 291–302

Sailley SF, Polimene L, Mitra A, **Atkinson A, Allen JI** (2015). Impact of zooplankton food selectivity on plankton dynamics and nutrient cycling. Journal of Plankton Research 2015.
doi: 10.1093/plankt/fbv020

Spence M, Blackwell P and **Blanchard JL** (2015). Parameter uncertainty of a dynamic multi-species size spectrum model. Published in the Canadian Journal of Fisheries and Aquatic Sciences, and available online at http://www.nrcresearchpress.com/doi/abs/10.1139/cjfas-2015-0022
DOI: 10.1139/cjfas-2015-0022

Queirós AM, J Bruggeman, N Stephens, Artioli Y, Butenschön M, Blackford JC, **Widdicombe S, Somerfield PJ, and Allen JI**. (2014). Placing biodiversity in ecosystem models without getting lost in translation. Journal of Sea Research. DOI: 10.1016/j.seares.2014.10.004

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

External presentations

Author	Title	Activity (poster, oral, demonstration etc)	Name of event and location	Date	Relevant Module(s)
M. Austen	Discussion of MERP ecosystem service research	Discussion	Natural Capital Committee workshop: Identifying metrics for natural capital, Defra, Nobel House, London	02-06-2015	**M5 and general**
M. Austen	Discussion of MERP ecosystem service research	Discussion	Natural Capital Committee meeting to identify research priorities for natural capital	12-06-2015	**M5 and general**
M. Austen	Discussion of MERP ecosystem service research	Discussion	MMO visit to PML	12-06-2015	**M5 and general**
T. Webb		Oral Presentation	EUMacro European macroecology conference	June 2015	**M1**
Bruggeman, Bolding, PML modelling group	Towards custom built models for water and sediment biogeochemistry based on reusable components	Invited oral presentation	Gordon Research Conference - Coastal Ocean Modeling, Biddeford, Maine, USA	11 June 2015	**M6**
S. Broszeit	Linking ecology to ecosystem services – The approach taken in MERP	Oral presentation	Southwest Ecosystem Services meeting	08/07/2015	**M5**
M. Spence	How many fish are in the sea	Oral presentation	National Centre for Statistical Ecology 2015	July 0215	**M4**
N. Beaumont	Introduction to Ecosystem Services	Oral presentation	Attendance of Marine Alliance for Science and Technology for Scotland (MASTS) Annual Meeting, Glasgow	September 2015	**M5**
N. Beaumont	Using Ecosystem Service research in policy and management	Oral presentation	UK government Productive Seas Evidence Group meeting, London	September 2015	**M5**
M. Austen	Discussion of MERP ecosystem service research	Discussion	MMO Science Alignment Workshop	September 2015	**M5 and general**
F. Daunt	Integrating economies and conservation in UK seascapes: the role of seabird research	Oral	SEASCAPE ECOLOGY: CONNECTING LAND, SEA & SOCIETY. International Association for Landscape Ecology. Edinburgh,	8-9 Sept 2015	**M2,5**
Heymans, Serpetti, Burrows	Using ecosystem models for sustainable management of the Irish Sea	Talk	ICES WKIRISH, Dublin	14-15 Sept. 2015	**M3&4**
Heath, M.R., Wilson, R. & Speirs, D.	Modelling the whole ecosystem impacts of trawling	Oral	MASTS Annual Science Conference	30 Sept – 2 Oct 2015	**M4**
Brownlie, C., K. Hyder, Anson, S., Speirs, D.	How to value fish as a provisioning service	Oral	MASTS Annual Science Conference, Special Session on 'Ecosystem	30 Sept – 2 Oct 2015	**M5**

And Heath, M			services'		
A.G. Hirst (invited)	*Body size patterns in contrasting ecological systems*	Oral	Invited Seminar, University of Saint Andrews	Sept 2015	**1**
Bruggeman, Stephens, Queiros, Hirst	Traits of benthic fauna: from observations to community models	Oral presentation	"Trait-based Approaches to Ocean Life" workshop, Waterville Valley, New Hampshire, USA	7 October 2015	**M6, M1**
AG Hirst, Glazier DS, Lilley MKS, Atkinson D. (Invited)	'New insights from body surface area: a major trait in pelagic invertebrates'	Oral, Workshop contribution	Trait-Based Workshop: exploring traits of marine organisms, USA	Oct 2015	**1**
Paul Somerfield	The Marine Ecosystem Research Programme	Oral presentation	HBDSEG Meeting, Defra	14 October 2015	**All**
M. Austen	Ecosystem services	Discussion including MERP with representatives of CSIRO	CSIRO visit to PML	1 October 2015	**M5**
M. Austen	Discussion of MERP ecosystem service research	Discussion	NCI Dialogue: Natural Capital without boundaries: integrating catchments, coast and the sea. CEH Wallingford	12 October 2015	**M5**
R. Vergnon		Workshop	EMODnet open conference	20 October 2015	**M1**
H. Bannister		Workshop participant	IMBER modelling workshop, Trieste	26 October 2015	
Nager RG, Grecian J and O'Hanlon NJ	**Change in between- and within-individual variation in resource utilisation in gulls over the last 4 decades**	**oral**	**2nd World Seabird Conference. Cape Town**	**26-30 October 2015**	**M1**