Marine Ecosystems Research Programme

Report from the Annual Science Meeting 2017

10-12 October 2017, Sheffield

This report provides a summary of the presentations given at the 2017 Annual Science Meeting of the Marine Ecosystem Research Programme. The meeting, held in Sheffield, had 55 delegates including stakeholder representatives from Natural Environment Research Council (NERC), National Resources Wales and the Marine Biological Association.

Most components of the Marine Ecosystems Research Programme have less than a year still to run. With the fieldwork completed the focus of this work has moved to processing data and developing publications. For further details or to be put in contact with any specific MERP scientists for follow up information please contact marine.ecosystems@pml.ac.uk . We can also provide copies of the full presentations upon request.

Full details of the Programme can be found at www.marine-ecosystems.org.uk

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General introduction

Over a decade ago, the Millennium Ecosystem Assessment drew attention to the importance of the direct and indirect contributions of ecosystem services to supporting human well-being. Since then, the scientific community has amassed evidence that human actions are leading to declines in many ecosystem services. As a result, the protection of ecosystem services is beginning to be an important part of environmental management practice, to ensure ecosystem services are sustained for human benefit.

Bringing ecosystem services into the active management of marine ecosystems requires an understanding of how key processes which determine the ecological state of ecosystems affect the provision of the goods and services valued by society. The focus of MERP lies in understanding marine food webs, and in particular how changes in interactions amongst organisms affect the delivery of ecosystem services. MERP scientists integrate improved environmental and ecological understanding with social and economic dimensions to examine options for the sustainable use (present and future) of aquatic living and non-living resources and related processes.

Identifying, describing, understanding and quantifying feeding (and other) relationships amongst marine organisms through space and time were key objectives during the earlier stages of the programme. Existing and new data and knowledge, and modelling results brought together by MERP scientists over the past 3 years, now allow us to show trends in the distribution of food web components under varying environmental regimes. The new information and modelling approaches underpin development of scenarios reflecting future states of marine food webs with which to explore ecosystem service provision on spatial and temporal scales that are relevant to management and policy. These include scenarios that take account of impacts of climate change or different management regimes.

The following section includes short summaries of the science presented during the ASM.

New MERP projects

Understanding trade-offs to maximise the benefits from living marine natural capital - Mike Heath (University of Strathclyde) – project funded in Jan 2017

'What's the trade-off between a fish on a plate and a fish in the sea?' This is the issue at the heart of the 'Trade-offs' module of MERP. Our research involves coupling together some of our models of marine ecology, with models of fishing fleets, monetary valuation, and ecosystem-based management strategy. Building on concepts in the NERC Valuing Nature Programme, **we have been engaging with stakeholders to develop scenarios reflecting different 'world-views' of macro-economics , society and politics, and are using our model systems to determine what the consequences of these might be for marine ecosystems**.

Cumulative Impacts and the Management of Marine Ecosystems – Tom Webb (University of Sheffield) - project funded in Jan 2017

A major challenge of marine management is that things don't happen in isolation. This underpins much of MERP science, which is concerned with how pressures at one level of the food web result in changes at other levels. It also implies that trade-offs are necessary and inevitable in marine

management. One way to address this is through the lens of cumulative effects assessment - the idea that individual pressures affect multiple facets of the ecosystem; and that management actions too may act cumulatively (which could be a good thing or a bad thing). Understanding such cumulative effects is often flagged as an evidence gap, and is one we are addressing in this new work, **using a risk management approach to identify and quantify links between indicators of ecosystem state, and the major anthropogenic pressures affecting them**. We use MERP's strengths to tackle this, employing empirical data where possible and supplementing this with insights from ecosystem models and from the expert knowledge of our scientific and stakeholder communities. In this way, we are **using the key strengths of MERP - data, models, and our network itself - to generate pragmatic and useful outputs for those tasked with managing our complex marine ecosystems**.

Session 1: Incorporating MERP's new information to develop models of marine ecosystems

Dynamic multi-model ensembles for ecosystem prediction

Paul Blackwell (University of Sheffield)

When multiple models are available to predict the outcome of an ecological scenario, they need to be combined efficiently, according to their different strengths. We describe a statistical method for doing this in a coherent way, which can incorporate diverse models representing the ecosystem in very different ways. We illustrate our method with two examples, looking at recovery times of GES indicators and at the dynamics of fish populations in response to reduced fishing pressure. In each case, **we can get improved predictions which are not dependent on the assumptions of any one model.**

Ecological indicators: a comparison between West Coast and Scotland and the Celtic Sea

Sheila Heymans (Scottish Association for Marine Science)

This presentation looks at the indicators that can be obtained through the ECOIND plugin in Ecosim. We used the 41 compartment West Coast of Scotland model, fitted to time series from 1985-2013 and being used for spatial modelling, and the 65 compartment Celtic Sea model, fitted only to biomass and being used in 2 different Ecospace models. We concluded that:

- Indicators are useful for getting your message across and creating impact from your science
- But they are dependent on the models used to create them
  - ✔ You cannot compare indicators from ecosystems with different topologies. Heymans et al. (2014) and many other papers show this.
- These indicators are also influenced by your assumptions and understanding of the ecosystem
  - ✔ Celtic Sea fitted two ways give very different results.
- None of these indicators showed any regime shifts (STARS)
  - ✔ due to the short time series.

Concluding that we need to have confidence in the model parameterisation before we use model-derived indicators for management.

Fitting the StrathE2E ecosystem model using Bayesian methods

Aidan Hunter (University of Strathclyde)

The StrathE2E marine ecosystem model was originally fitted to data using simulated annealing. This produced estimates of the highest likelihood parameters, but did not return information on the uncertainty associated to those parameters. Fitting StrathE2E with a Bayesian method called Kernel Adaptive Metropolis Hastings returns distributions for each parameter. These distributions contain the highest likelihood parameter set and credible intervals around each parameter. **This allows us to derive the uncertainty associated with all model outputs. Having access to these uncertainties means that the model can be used to provide estimates of credible ranges which were not previously available.**

Modelling how top-down effects in pelagic communities become stronger as nutrient levels increase - Axel Rossberg (Queen Mary, University of London)

From the onset, a fundamental goal of MERP was to understand and quantify top-down and bottom-up effects in marine food webs. This presentation argued that, **while in general top-down effects in marine food webs are weak, they can become stronger as nutrient supply increases.** At chlorophyll-a concentrations exceeding around 1mg/m^3, top-down effects can become amplifying, indicated by pronounced periodic modulations of pelagic size spectra along the logarithmic body-mass axis.

Temporal dynamics and functioning of benthic macrofauna: integrating data and models

Gennadi Lessin (Plymouth Marine Laboratory)

Response of benthic macrofauna to pelagic food availability and consequences of the resulting community structure and dynamics for ecosystem functioning were studied by utilising capabilities of the modular ERSEM model and its integration with observational data, using Trait Explorer for inferring feeding modes and conversions of biomass. Implementation of a simplified model version with an optimised parameter set allowed investigation of characteristic temporal responses of major macrofaunal groups to primary production at L4. Benthic macrofauna in ERSEM was further diversified to include more functional groups, and **this allows further exploration of the role of individual groups in shaping fluxes within benthic environment and beyond.**

The effects of model resolution on the ecosystem of the Celtic Sea

Sarah Wakelin (National Oceanography Centre)

For the Celtic Sea region, **three 3-dimensional models, are used to investigate how increasing horizontal resolution (from 7km to 3km to 1.5km) changes the model physics and ecosystem**. Comparisons between the models and observations are not strongly affected by resolution. The 1.5km and 3km-resolution models show finer spatial variations in hydrodynamics, leading to differences between models in the onset and duration of thermal stratification. This influences the nutrient supply to surface waters and changes the model net primary production; increasing resolution increases net primary production in the open shelf region but decreases it along the French coast. Phytoplankton community structure is also affected.

Spatial/temporal coupling of Ecospace/NEMO-ERSEM: the West coast of Scotland example

Natalia Serpetti (Scottish Association for Marine Science)

The Ecopath with Ecosim model of the West coast of Scotland ecosystem have been updated and temporal simulation under rising temperature scenarios have been also performed (Serpetti et al., 2017, in press). We are now updating the spatial module of the model: Ecospace. To improve the model performances on simulating the distribution of phytoplankton the model was coupled with NEMO-ERSEM net primary productivity using a new spatial/temporal plug-in. **Temporary results showed an improvement of the phytoplankton spatial distribution that cascades through the entire food-web. Top-predators (cetaceans and seabirds) and kelp spatial distributions** developed by Evan/Waggitt and Burrows respectively **will be coupled in a similar way to improve the model performance** of reproducing the spatial pattern of these functional groups.

Reducing circularity: building a multi-species model from the ground up

Michael Spence (Centre for Environment, Fisheries and Aquaculture Science)

Spence presented a multispecies size spectrum model of the Celtic Sea. This included 17 stocks and was fitted to survey data and landings data. The aim of the project is to fit the model without using single-species stock assessment models. This means that the fishing mortality rates, maximum recruitment and background resources are all fitted within the model. A survey vessel was included in the model as a fleet and the simulated survey was compared to the actual survey. **Early results showed that the model was able to fit trends in fishing mortality along with trends in the survey data however it was unable to find absolute values.** This work will soon be finished and will go into the multi-model ensemble in additional MERP projects on trade-offs and cumulative effects.

Towards ERSEM-mizer coupling

Jorn Bruggeman (Plymouth Marine Laboratory)

To track bottom-up and top-down trophic cascades throughout the marine ecosystem, we develop an online coupling between ERSEM and mizer. The resulting model allows plankton abundance to influence fish, and vice versa. As a demonstration of the possibilities this opens up, we demonstrate spatially explicit results from our new mizer implementation, driven with NEMO-ERSEM results at 7 km resolution. **Results show strong seasonal variability and coast-offshore gradients in fish stock, which are intriguing but merit further validation.** We subsequently drive the model with a riverine nitrogen reduction scenario, and quantify spatial variation in the response of fish to such reduction.

Session 2: Using new information and models to understand changes in services

Determination of the impact of fishing on the richness of large marine species

Axel Rossberg (Queen Mary, University of London)

Protection of marine species richness is a central policy goal, both in the UK and internationally. However, because of high geographic variably of species richness, it is has remained unclear how to determine targets and reference values for richness indicator. As a result, **impacts of pressures such as fishing on richness have also been difficult to determine**. In this presentation **a new indicator is**

proposed, which, in a statistically optimal manner, compares the richness of small and large species in a region. **Because of food-web interactions, the richness of small and large species is related in undisturbed communities. It is shown that deviations from this relationship are associated with fishing pressure.**

Fitting complex food-web models: a new paradigm

Axel Rossberg (Queen Mary, University of London)

Building on the presentation on "A Celtic Sea version of mizer", a group of modellers met to discuss **a new paradigm for fitting complex food-web models to data**. The paradigm shift consists in fitting pressures on populations for given population biomasses, rather than population biomasses for given pressures. **Initial numerical results and theoretical arguments suggest that this new paradigm overcomes barriers that have long held back applications of food-web models for the management of interacting populations.** Because of the inherent structural instability of ecological communities, the paradigm shift transforms the fitting of food-web models from an ill-posed into a well-posed numerical problem.

Modelling ecosystem consequences of denying access to areas of seabed for trawling

Mike Heath (University of Strathclyde)

Eighty percent of the landings by bottom-contact fishing gears in the North Sea come from the 20% of seabed area which is most intensively trawled. These core fishing areas are now relatively insensitive to further increases in fishing. In contrast, the lightly trawled peripheral areas are highly sensitive. **ICES have recommended that displacing effort away from the peripheral areas into the core fishing zones can lead to an overall improvement in seabed status. But what would be the consequences for landings and the wider ecosystem? Here we describe use of the Strathe2E ecosystem model to address these questions.**

A new tool to examine natural capital and ecosystem service trade-offs under different stresses and management measures – Tara Hooper (Plymouth Marine Laboratory)

This work aims to translate the improved understanding of the dynamics of marine ecosystems that will be obtained from the wider MERP programme into the currency of ecosystem services. A conceptual framework has been developed that links biodiversity, ecological processes and ecosystem services. This has been used to build the structure for a Bayesian Belief Network (BBN) that will synthesise MERP model outputs and empirical data, together with additional data and expert judgement. Working with stakeholders in the case study sites, **the BBN will be used to assess the trade-offs between, and cumulative effects on, ecosystem services under different scenarios.**

Visually communicating model outputs and their uncertainties

Hayley Banister (University of Sheffield)

We have created a survey aimed at **identifying the most effective methods for visually communicating model outputs and their uncertainties**. A preliminary analysis of the results (based on 160 university graduates in the UK) indicates that respondents interpreted the data presented in their preferred visualisations with lower accuracy than some of their least-preferred visualisations. The **visualisation with the highest accuracy and preference score was a dot plot with error bars**.

The infographic and heat plot had the lowest accuracy and preference scores. However, an increased number of respondents and a more in-depth analysis of the results are required.

Delivering renewable energy targets while minimising impacts on top predators

Francis Daunt (Centre for Ecology and Hydrology)

Marine renewable energy is a key contributor to the UK's energy security and decarbonisation objectives. A critical challenge for the future viability of the industry is the potential negative effects on legally protected species including seabirds. This challenge has arisen because the key processes linking these activities and protected wildlife have been poorly understood and studied in isolation. Research in **MERP has filled key knowledge gaps**, underpinning a novel framework integrating all key processes. **This framework constitutes a step-change in the quantification of renewable energy installation effects, providing key end-users with strategic planning tools for future sustainable industrial development.**

Integration of economics into ecological models to assess marine ecosystem services in the West of Scotland (WoS) and Celtic Sea (CS)

Simone Martino & Jasper Kenter (Scottish Association for Marine Science)

This presentation shows how ecological outputs from *Ecopath/Ecosim/Ecospace* and *StrathE2E* can feed economic models to assess consumers' preferences for different ecosystem services [fisheries, aquaculture production (salmon), kelp (from harvesting) and marine recreation], and how this information can be used to calibrate drivers of impacts (fishing effort). It **shows how fish price can be modelled under a market clearing price approach to assess price flexibilities** (variation of prices as a function of landings) and how to model preferences for anglers, divers and marine wildlife watchers as a function of changes in biomass of charismatic species to produce a new behavioural pattern in the number of trips in the WoS and CS.

Using Top Predator Studies to Address Policy Related Questions

Peter G.H. Evans (Sea Watch Foundation / University of Bangor) & James Waggitt (University of Bangor)

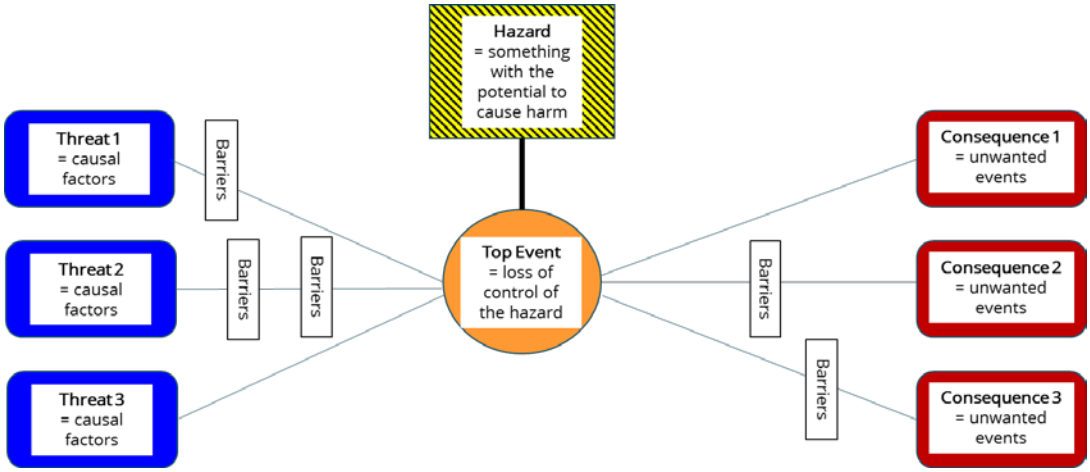
Environmental policies for the NW European marine environment are shaped by a number of international agreements and directives. Of particular relevance to marine mammals and birds are the EU Habitats and Birds Directives, Marine Strategy Framework Directive, OSPAR, and two UNEP/CMS Agreements - ASCOBANS related to small cetacean conservation and ACAP related in Europe to conservation of an endangered species of shearwater. There are two major outputs from our synthesis and analysis of top predator survey data: the first is absolute density & abundance estimates at a 10km resolution for every month across the last three decades; and the second is a better understanding of the environmental drivers of observed spatio-temporal patterns of distribution and abundance on both a species and community basis. Following the acquisition of data on human pressures (e.g. bycatch, noise) and an assessment of their specific impacts, these **allow us to undertake risk mapping that can then inform more cost-effective mitigation measures**. Amongst the other potential policy related outcomes are **identification of key locations for marine protected areas for top predators under the Habitats & Birds Directives**; contribution to the assessment of Good Environmental Status under OSPAR/MSFD through measures of annual changes

in distributional range and abundance; and **improved understanding of the ecological mechanisms affecting population structure informing species management in support of a variety of conservation objectives.**

Using bow tie analysis to undertake indicator based cumulative effects assessment

Adrian Judd (Centre for Environment, Fisheries and Aquaculture Science)

Applying risk assessment principles greatly simplifies cumulative effect assessments to both inform and communicate management options & decisions. Bow tie analysis is one of the International Standards Organisation risk assessment tools and chained bow ties for each indicator form the cumulative effects assessment for the North East Atlantic as part of the OSPAR Quality Status Report 2023. **MERP are applying and further developing the bow tie approach to cumulative effects**. The outputs from all the MERP modules provide supporting knowledge and evidence for the **bow tie analysis to describe the hazards, the causal factors and consequences, preventative and mitigating management measures and the effectiveness of those measures**. The outputs from MERP can also help to identify and fill gaps when the suites of indicators are chained at the species, habitat and ecosystem level.



Example of bow-tie analysis

Cultural values, places, practices, identities, experiences and capabilities relating to marine ecosystem services - Gill Ainsworth (Centre for Ecology and Hydrology)

This study assesses non-monetary values of marine ecosystem services in the Celtic Seas. Using the Community Voice Method, we investigated cultural ecosystem service values through the lens of the UK NEAFO cultural services and IPBES valuation frameworks. We describe the cultural values, places, practices, identities, experiences and capabilities derived by people using inshore and offshore marine environments and stakeholder attitudes towards NEAF policy scenarios developed elsewhere in MERP. The **findings address pertinent knowledge gaps** (e.g. Garcia Rodrigues et al. 2017) **and increase understanding of marine users' shared values, competing interests and potential trade-offs to guide implementation of appropriate marine management strategies.**

From fish communities to community impact: potential indicators of fishing and climate change
Robert Thorpe (Centre for Environment, Fisheries and Aquaculture Science)

We used the StrathE2E end-to-end ecosystem model to consider the potential impact of changes in fishing mortality from historic to proxies for FMSY, and climate warming of 2 or 4 degrees C on the relative biomasses of broad functional groups across the ecosystem. StrathE2E is a good model for this task because it spans the whole ecosystem and includes both top down and bottom up processes in a credible manner, with enough functional groups to offer useful insights for OSPAR, but with a compact enough ecosystem representation to run quickly and allow the use of a) ensembles, b) multiple scenarios, or c) long-timescale simulations. We found that **biomasses of broad functional groups can be used as indicators of ecosystem form and function that are sensitive to both fishing pressure and environmental change**. The key result was that **both pelagic fish and birds and mammals were sensitive to demersal fishing rates, particularly if pelagic fishing mortality was high**. We also found that changes in fishing and climate warming could interact, with warming favouring demersals at the expense of pelagics. This may be because warming shifts energy from the pelagic to the scavenging food web, which can be accessed by demersals but not by pelagics. Thus **in the future pelagic fisheries may become more prone to collapse, unless due allowance is made in determining fishing strategies**.

Assessing the cumulative impacts of management strategies on biodiversity in Marine Protected Areas - Miriam Grace (University of Sheffield)

Dr Miriam Grace (University of Sheffield) is new to MERP and so her work is in its infancy. Alongside work on data integration, she will be looking at the cumulative effects of management actions in Marine Protected Areas (MPAs) on a range of ocean biodiversity metrics, including functional diversity. Further work will look the locations of marine biodiversity hotspots based on biodiversity metrics in different ecological functional groups. These projects utilise the Trait Explorer developed at Plymouth Marine Laboratory, and involve collaborations with Cefas and Bangor University. Finally Dr Grace is working developing an ontology of MPAs, which will be extended to marine ecosystems in general. This will capture the findings of the MERP consortium and enable their integration into the semantic web, aiding their discovery and uptake. This ontology will bridge the Environment Ontology and the Sustainable Development Goals Interface Ontology; the latter is being developed in cooperation with the United Nations Environment Programme.

Modelling top predator distributions from an understanding of key environmental drivers
James Waggitt (University of Bangor)

Quantifying spatial and temporal variations in the absolute densities of cetaceans and seabirds provides useful inputs into ecosystem models, and has great importance for conservation and marine management practices. Here, we describe analyses of our **unique collation of ~3 million kilometres of at-sea survey data within the north-east Atlantic**. **Predictive maps of 20 species have been produced at monthly and 10km resolution across approximately 30 years**. Predictions are based on an understanding of the oceanographic processes influencing the distributions of these species. Several different products originating from these maps are presented.

Session 3: Realising MERP's Potential

Half way through the meeting we ran a session to discuss MERPs communication and stakeholder engagement activities. This included a series of presentations, as summarised below, along with a series of flash presentations where MERP scientists talked about their engagement with the global stakeholder community including amongst others:

Achieving uptake: MERP briefings to Defra

Michaela Schratzberger (Centre for Environment, Fisheries and Aquaculture Science)

The scientific evidence generated by MERP takes many forms ranging from the analysis of existing and new data and observations to expert interpretations of such. Each form or piece of evidence, however, is not equally persuasive in making the case that it should play a role in a policy or management decision. In order to be effective, MERP scientists met Defra policy-makers in 2016 and 2017 to discuss and highlight policy-relevant MERP outputs. The key aim of these briefings was to maximise the relevance of the scientific evidence so that it can compete in the decision-making environment. 2017 Briefing and meeting report now available.

Data: Management, Access and Discoverability

James Ayliffe (British Oceanographic Data Centre)

Marine data are not always easy to collect and are fundamental to our understanding of the natural environment making them precious and expensive. BODC's premise is to ensure data are secure and readily usable in the long-term without reference to the data originator. This is done through the promotion of **good data management and robust checks helping to make data open and available, for use now and into the future**. BODC can also provide an impact through greater data discoverability, traceability and accountability. This is achieved through various tools including data partnerships, controlled vocabularies and data publication.

Products and Stakeholder Engagement

Kelly-Marie Davidson and Kelvin Boot (Plymouth Marine Laboratory)

The Knowledge Exchange Office (KEO) presented the work that has occurred over the last year, including continued website maintenance, an update newsletter, social media activity and preparation for stakeholder products.

Digital communications: Since the programme began the website has received over 42k unique visits and an average of 2 mins is spent on each page. 115 people have registered through the website to receive updates about MERP research, consisting 57% science, 21% student, 10% policy 6% business and 6 % other. There is a need to increase the policy and business contacts, particularly for the planned stakeholder event in 2018. Twitter followers (@merp_updates) have nearly doubled since last year and new followers are beginning to be from outside of MERP's immediate circle of interest. The latest newsletter was opened by 33% of MERP participants and 44% of stakeholders, both above average for newsletters of this type. JNCC have been in contact about some work that was featured in the last newsletter, providing evidence of engagement through communication materials.

Stakeholder materials: A series of short, accessible summaries of MERP's work and its relevance across a range of topics of interest to stakeholders, and taking consideration of Defra's "Defra Group

Areas of Research Interest" are being compiled. Issues being addressed include: Services and policy; Fisheries and food provision; Changes in productivity; Spatial planning; Model advancement and connections, and a MERP overview. A group of infographics will illustrate how changes in one parameter will affect others and how they are linked. Interactive versions of these infographics are being developed for use by MERP participants, stakeholders and other interested parties.

Other: Future work was also highlighted including the stakeholder event and associated stakeholder materials, feature articles in popular science and environmental publications and the development of impact stories, followed by a recap of optimising the impact of MERP science.

Flash presentations

- European Marine Board workshop: Shaping future research agendas in Marine Ecosystem Modelling
- Involvement in numerous ICES working groups
- COP22
- STG14 UN OCEANS
- Online engagement
- International Group for Marine Ecological Time Series
- Defra policy Briefings
- UNEP & the European Parliament

Session 4: New information about marine ecosystems to develop models

Linking occurrence, traits, and environment to map the diversity of UK marine life

Tom Webb (University of Sheffield)

The aim of this talk was to explain how two superficially unremarkable charts - one showing how the typical sediment size in which benthic species occur is related to their body size, the other showing how thermal afinity of fish species is related to body size - actually represent both the culmination of a huge amount of collaborative work across the MERP consortium, and a launchpad for new research activities. To produce these charts required data on which species occur where. After some data cleaning and additional quality control we are left with 5.9 million occurrence records of 7394 valid marine spcies, distributed throughout UK seas. We then assigned these to broad 'functional groups' of species which tend to be sampled together using similar methodologies, and matched occurrence records to data produced within MERP on sediment size, species body size, and sea temperature. The point to stress is not that the charts I was able to show were particularly striking in their own right, but that they are possible. And everything presented is (or soon will be) reproducible: in principle, thanks to MERP support and a whole host of collaborators, anyone can reproduce these unremarkable plots, and use them as a basis for more remarkable science.

The Trait Explorer

Jorn Bruggeman (Plymouth Marine Laboratory)

The Trait Explorer (www.marine-ecosystems.org.uk/Trait_Explorer) is an online tool to query MERP datasets for the most likely trait values of any marine species. Over the past year, this service has seen its official online release, after which it processed over 800 queries from 101 unique IP addresses from 20 countries. A key function of TE is to facilitate integration among modellers and

empiricists: it currently supports three cross-module collaborations within MERP and features in one published paper. Work is ongoing to provide quality metrics of Trait Explorer results (cross-validation), identify patterns in trait variation among taxa, and integrate additional datasets.

Making the most of survey data: Incorporating age uncertainty when fitting growth parameters

Michael Spence (Centre for Environment, Fisheries and Aquaculture Science)

- A new method has been developed that enables the uncertainty in age to be quantified
- Ignoring uncertainty can lead to inconsistent models which management decisions are sensitive to this.
- **The method leads to better fitting of models and a more robust way of fitting the model that allows data from different sources to be included**.

See Spence and Turtle (2017) for more details, doi 10.1002/ece3.3280

Differences in biodiversity-environment relationships among ecologically similar taxa of cetaceans and seabirds

James Waggitt (University of Bangor)

The ecological processes creating biodiversity gradients remain a fundamental question in ecology. Here, we use our unique collation of at-sea surveys introduced in previous presentations to test hypotheses concerning the ecological processes enhancing the diversity of cetaceans and seabirds. We present differences between taxa in their conformity to conventional hypotheses at a European and seasonal scale, and suggest reasons for these differences. **The awareness of clear differences between ecologically similar taxa has consequences for anticipating how these communities may respond to environmental changes, as well as for the environmentally sustainable management of our shelf seas**.

The dynamics of interactions between gelatinous zooplankton and fish larvae: using Next Generation Sequencing to provide insights

Martin Lilley for Pennie Lindeque (Plymouth Marine Laboratory)

New techniques in molecular sequencing are allowing host and prey identification from DNA fragments. Such methods do not require the stomach to be isolated and can instead sequence the organism as a whole. Fish larvae and small hydromedusa jellyfish have received little attention on their diet preferences, but can now be studied in more detail. This **work highlights the potential importance of jellyfish prey for fish larvae, and fish prey for jellyfish**. Such **interactions and competition between fish and jellyfish for zooplankton prey provide additional trophic linkages in the planktonic foodweb and should be considered when designing ecosystem models**.

Zooplankton grazing dynamics

Angus Atkinson (Plymouth Marine Laboratory)

This presentation examines the balance of top-down and bottom-up controls that govern the abundance and seasonal distribution of phytoplankton and zooplankton. It links time series analysis at the Plymouth L4 site, modelling and experimentation. A variety of models based on bottom-up and/or top-down control have been suggested based on this time series, emphasising that we still don't know how the system works. **In MERP we investigated this by reinforcing the time series with experiments**. Key findings were a) the producers and consumers had different temperature sensitivities of their phenology; b) prey/predator maximum ratios among copepods were very high c) cannibalism and intraguild predation was identified as a density-dependent mechanism for population stabilisation and d) microzooplankton rather than mesozooplankton were the key grazers .

Predicting variations in the plankton biomass at an offshore English Channel site

Marin Lilley (Queen Mary, University of London) in collaboration with scientists from Plymouth Marine Laboratory

A long-term plankton abundance timeseries has been converted to a Carbon-based timeseries during the MERP programme, which is now available to partners and externally. This high resolution interannual marine timeseries has been analysed as a biomass size spectrum. This has revealed strong monthly patterns in the relative composition between small and large organisms at the Plymouth L4 site. Predictable annual patterns in total biomass and size composition are present, with seasonal and monthly variations in the taxonomic breakdown. **Severe weather disturbances have only a short term (few months) impact before the resilience of the system reasserts the standard patterns**. Therefore **these data provide robust patterns in the plankton for testing model simulations**.

Individual metabolic traits

Marin Lilly and Andrew Hirst (Queen Mary, University of London)

Metabolic rates are predictable in all marine organisms. Individual mass is a key variable from which metabolic rates can be predicted. To reduce variability in mass-dependent metabolic predictions it is also important to understand behavioural and lifestyle traits of the species in question. Significant differences in rates are observed between 1) **Habitat** – is the species Benthic or Pelagic? 2) **Feeding Method** – does the species act as a predator, a Suspension feeder or a Deposit feeder? And 3) **Biological Process** – are you quantifying respiration, excretion or feeding rate? Therefore these **are the key processes to understand in invertebrate organisms**.

Modelling zooplankton diversity: including jellyness and size

Sevrine Sailley (Plymouth Marine Laboratory)

Representation of plankton size spectra and diversity at the mesozooplankton level is important as they form the first of the food web link between primary production and higher trophic levels of interest. Consequently, we developed a modelling framework to represent both the size spectrum (through the carbon mass of the organisms, and its impact on metabolic rates) and trophic position (physical size of predator and prey). This is exemplified by comparing copepods with jellyfish, two

organisms with similar carbon mass but different physical size. As a result, **we now have a modelling framework full of potential for the inclusion of further groups and more traits to improve on the diversity within ecosystem models**.

The effects of bottom trawling and primary production on the macroecology of benthic ecosystems

Leigh Howarth and Jan Geert Hiddink (Bangor University)

Bottom trawling has increased over the last century. Alongside this, ocean acidification, eutrophication and climate change are altering global levels of primary production. As changes in primary production will affect how resilient seabed communities are to trawling, Dr Leigh Howarth and Prof Jan Hiddink of Bangor University conducted a large field study into their interactive effects. They found that **trawling had negative effects on community biomass, function and resilience, and that these effects strengthened with increasing primary production**. Future changes in primary production could therefore make marine ecosystems less resilient to the impacts of fishing, particularly in areas where primary production increases.

Seabird Diet Database

Ruedi Nager (University of Glasgow)

The aim of this part of MERP was to compile data of spatially- and temporally-resolved quantitative information on resource utilisation by seabirds. Such information is important to assess the role of top predator consumption on different regional scales. This **database is now complete and contains information for the 10 most abundant seabird species that represent 96% of seabird biomass in UK waters**. All seabirds predominately feed on a small number of energy-rich fish taxa, but there were clear temporal and spatial differences in the proportion of key prey species in the diet both within the UK as well as more broadly across the North Atlantic. **This provides a synthesis of seabird diets that is useful for conservation and management planning**. The data will are also be used to better understand the drivers of seabird distribution and estimate spatially-explicit predation pressure. Ultimately that information will directly enter into the ecosystem models that consider the highest trophic levels.

Connectivity between seaweed carbon and coastal sediment stores – trophic and non-trophic pathways - Ana Queirós (Plymouth Marine Laboratory)

Before MERP, we were aware that seaweeds are an important part of the primary productivity of UK coasts, that as much as 80% of that annual production is lost into the coastal ocean, but we didn't know whether that is an important subsidy to UK coastal foodwebs. A 13 month study sampled seaweeds from the shores in Devon and plankton, water, sediments and animals off the coast of Plymouth. Using stable isotopes as tracers, we found that **seaweeds indeed contribute up to 15% of the organic carbon used as food by fauna in the coastal ocean, especially during winter, when seaweed detritus export from the shore is high, and plankton availability is low**. We have estimated the amount of this carbon that is buried annually in coastal sediments, and suggest that understanding these rates better, and the location of these stores could improve the ability of the UK to manage its carbon budget within the UK Climate Change Act and carbon accounting. An additional collaboration with U Pisa (Ravaglioli) has allowed us to assess the effect of global (ocean

acidification) and local stressors (hypoxia) on the uptake rates of seaweed C by coastal sediments, and their impacts for the conservation of ocean organic carbon stores.

Introducing new maps of the sedimentary environment of the northwest European Shelf

Robert Wilson (University of Strathclyde)

Maps of seabed sediment are necessary to efficiently understand and manage benthic communities. Here we introduce new and open-access high-resolution maps of the sedimentary environment of the northwest European continental shelf. A number of important variables are mapped including the mud, sand and gravel percentages of seabed sediment, median grain sizes, tidal and wave velocities, carbon and nitrogen content, and natural disturbance rates. **These maps will allow ecosystem and species distribution modellers to more accurately understand how benthic communities might change**. Further, they **will enable more realistic estimates of carbon stored in the seafloor**.

Further details about any of the presentations summaries in this report, or for copies of the full presentation please contact marine.ecoystems@pml.ac.uk

Delegate List

Name		Institute	Role
Gill	Ainsworth	CEH	Scientist
Angus	Atkinson	PML	Module 2 Leader
Mel	Austen	PML	Module 5 Leader
James	Ayliffe	BODC	External guest
Hayley	Bannister	University of Sheffield	Scientist
Paul	Blackwell	University of Sheffield	Module 4 Leader
Kelvin	Boot	PML	Communications
Jorn	Bruggeman	PML	Scientist
Mike	Burrows	SAMS	Scientist
Tasman	Crowe	University College Dublin	Programme Advisory Group
Francis	Daunt	CEH	Scientist
Kelly-Marie	Davidson	PML	Communications
Mark	Emmerson	QUB	Scientist
Peter	Evans	Bangor University and Sea Watch	Scientist
Matt	Frost	Marine Biological Association	Stakeholder Advisory Group
Eva	Garnacho	Cefas	Scientist
Miriam	Grace	University of Sheffield	Scientist
Jess	Heard	PML	Programme Manager
Mike	Heath	University of Strathclyde	Trade-Offs Project Leader
Sheila	Heymans	SAMS	Scientist
Tara	Hooper	PML	Scientist
Leigh	Howarth	University of Sheffield	Scientist
Aidan	Hunter	University of Strathclyde	Scientist
Adrian	Judd	Cefas	Scientist
Rachel	Leader	NERC	Funder
Gennadi	Lessin	PML	Scientist
Martin	Lilley	previously QMUL	Scientist
Simone	Martino	SAMS	Scientist
Ruedi	Nager	University of Glasgow	Scientist
Agnes	Olin	University of Glasgow	Scientist
David	Patterson	St Andrews	Programme Advisory Group
Ana	Queirós	PML	Scientist
Kirsten	Ramsey	National Resources Wales	Stakeholder Advisory Group
Chiara	Ravaglioli	PML	Scientist
Axel	Rossberg	QMUL	Module 3 Leader
Sevrine	Sailley	PML	Scientist
Michaela	Schratzberger	Cefas	Scientist
Kate	Searle	CEH	Scientist
Natalia	Serpetti	SAMS	Scientist
Paul	Somerfield	PML	Programme Coordinator

Dougie	Speirs	University of Strathclyde	Scientist
Mike	Spence	Cefas	Scientist
Mike	St John	DTU Aqua	Programme Advisory Group
Robert	Thorpe	Cefas	Scientist
Remi	Vergnon		External guest
James	Waggitt	University of Bangor	Scientist
Sarah	Wakelin	NOC	Scientist
Sarah	Wanless	CEH	Scientist
Tom	Webb	University of Sheffield	Cumulative Impacts Project Leader
Piran	White	University of York	Programme Advisory Group
Steve	Widdicombe	PML	Scientist
Robert	Wilson	University of Strathclyde	Scientist

Marine Ecosystems Research Programme

Annual Science Meeting 2017 Agenda

10-12th October, 2017, Rutland Hotel, Sheffield

Day 1: Tuesday 10th October

9:00	Welcome and Introduction to MERP Welcome to new MERP members	Paul Somerfield (PML)
9:40	WP3: Trade Offs Project	Mike Heath (Strathclyde)
9:55	WP3: Cumulative Impacts Project	Tom Webb (Sheffield)

Session 1: Incorporating MERP's new information to develop models of marine ecosystems

Chair: Tom Webb

10:00	Multi-model ensembles for ecosystem prediction	Paul Blackwell (Sheffield)
10:10	Ecological indicators: a comparison between West coast of Scotland and Celtic Sea Ecopath models	Sheila Heymans (SAMS)
10:20	Fitting the StrathE2E ecosystem model using Bayesian methods	Aidan Hunter (Strathclyde)
10:30	Modelling how top-down effects in pelagic communities become stronger as nutrient levels increase	Axel Rossberg (QMUL)
10:40	**Discussion Session**	
11:00	**Coffee**	
		Chair: Icarus Allen
11:30	Temporal dynamics and functioning of benthic macrofauna: Integrating observations with models	Gennadi Lessin (PML)
11:40	The effects of model resolution on the ecosystem of the Celtic Sea	Sarah Wakelin (NOC)
11:50	Spatial/temporal coupling of Ecopath/ERSEM: the West coast of Scotland example	Natalia Serpetti (SAMS)
12:00	A Celtic Sea version of mizer	Mike Spence (Sheffield)
12:10	Fish modelling: coupling ERSEM with MIZER	Jorn Bruggeman (PML)
12:20	**Discussion session**	
12:45	**Lunch**	

Session 2: Using new information and models to understand changes in services

		Chair: Mark Emmerson
13:50	Determination of the impact of fishing on the richness of large marine species	Axel Rossberg (QMUL)
14:00	Modelling the ecosystem consequences of denying access to areas of seabed for trawling	Mike Heath (Strathclyde)
14:10	A new tool to examine natural capital and ecosystem service trade-offs under different stresses and management measures	Tara Hooper (PML)
14:20	Visually communicating model outputs and their uncertainties	Hayley Banister (Sheffield)
14:30	**Discussion session**	
14:50	Mapping predation pressure from breeding seabirds in UK waters	Kate Searle (CEH)
15:00	Delivering renewable energy targets while minimising impacts on top predators	Francis Daunt (CEH)
15:10	Integration of economics to ecological models to enhance marine ecosystem services in the West of Scotland and Celtic Sea	Simone Martino (SAMS)
15:20	Using top predator studies to address policy related questions	Peter Evans (Sea Watch)
15:35	**Discussion session**	
15:50	**Coffee**	

		Chair: Mel Austen
16:20	Using bowtie analysis to undertake indicator based cumulative effects assessments	Adrian Judd (Cefas)
16:30	Cultural values, places, practices, identities, experiences and capabilities relating to marine ecosystem services	Gill Ainsworth (CEH)
16:50	Using simulations of functional group responses to projected warming and changes in fishing pressure to inform selection of indicators for "Good Environmental Status	Robert Thorpe (Cefas)
17:00	Assessing the cumulative impacts of management strategies on biodiversity in Marine Protected Areas	Miriam Grace (Sheffield)
17:05	Modelling top predator distributions from an understanding of key environmental drivers	James Waggitt (Bangor)
17:15	**Discussion session**	

Day 2: Wednesday 11th October

Session 4: New information about marine ecosystems to develop models

		Chair: Sheila Heymans
9:00	Linking occurrence, traits, and environment to map the diversity of UK marine life	Tom Webb (Sheffield)
9:10	The Trait Explorer	Jorn Bruggeman (PML)
9:20	*Combining pelagic and benthic size spectra from meiofauna to whales (cancelled)*	*Jan Hiddink (Bangor)*
9:30	Discussion Session	
9:45	TBC	Mark Emmerson (QMUL)
9:55	Making the most of survey data: Incorporating age uncertainty when fitting growth parameters	Mike Spence (Sheffield)
10:05	Cetaceans and seabirds use different environmental determinants for persistent hotspots of biodiversity and biomass	James Waggitt (Bangor)
10:15	**Discussion Session**	
10:30	**Coffee**	

Session 3: Realising MERP's Potential

11:00	Products and Stakeholder Engagement	Kelly-Marie Davidson and Kelvin Boot
11:20	MERP Out and About	

Flash presentations about MERP scientists' engagement with the wider community (2 mins, 2 slides per person)

- European Marine Board
- ICES/MSFD
- COP22
- STG14 UN OCEANS
- Filamo workshop
- Online engagement
- International Group for Marine Ecological Time Series
- Defra Briefings
- EMODnet link
- UNEP & the European Parliament
- Going global – getting diversity and evolution in earth system models
- **Plus more**

12:00	Data: Management, Access and Discoverability	James Ayliffe (BODC)
12:15	Pathways to OSPAR and MSFD assessments via CefMAT	Eva Garnacho (Cefas)
12:35	**Discussion Session**	
13:00	**Lunch**	

Session 4 continued: New information about marine ecosystems to develop models

		Chair: Michaela Schratzberger
14:00	The dynamics of interactions between gelatinous zooplankton and fish larvae: Using Next Generation Sequencing to provide insights	Martin Lilley (QMUL) and Pennie Lindeque
14:10	Zooplankton grazing dynamics	Angus Atkinson (PML)
14:20	L4 plankton biomass spectrum & metabolic traits of benthic and pelagic organisms in relation to their mass	Martin Lilley (previously QMUL)
14:30	Modelling zooplankton diversity: including jellyness and size. Results and perspective	Sevrine Sailley (PML)
14:40	**Discussion session**	
15:00	**Coffee**	
		Chair: Stephen Widdicombe
15:30	The effects of bottom trawling and primary production on the macroecology of benthic ecosystems	Leigh Howarth (previously of Bangor)
15:40	Seabird diets	Ruedi Nager (Glasgow)
15:50	Connectivity between seaweed carbon and coastal sediment stores – trophic and non-trophic pathways	Ana Queirós (PML)
16:00	**Discussion**	
16:20	Introducing new maps of the sedimentary environment of the northwest European Shelf	Robert Wilson (Strathclyde)
16:30	The impact of regional and climate related stressors on the uptake of seaweed carbon by coastal sediments	Chiara Ravagliooli (PML)
16:50	Kelp	Mike Burrows
17:00	**Discussion**	
17:30	Close of science meeting	Paul Somerfield