Marine Ecosystems Research Programme

Report on MERP Integration Workshop November 2015

17-18 November 2015

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MERP Integration Workshop November 2015

17-18 November 2015, Manchester

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Executive Summary

To deliver the overall and specific aims of the Marine Ecosystems Research Programme successfully it was recognised from the outset that integration is key. MERP integration workshops bring together individuals and groups from across the MERP community, providing a space to discuss key issues within areas of work and to connect different groups across the consortium. This report captures discussions held, and decisions made, during a two-day integration workshop held at Cheadle House, Manchester, 17-18 November 2015.

A general update on progress across the consortium, and a detailed presentation of work being delivered on higher-trophic level organisms (mammals and birds), were followed by a session on the development of common scenarios on which to focus activities. There was a session on interlinking models and data, and several short presentations of scientific progress from across the programme. In the afternoon general discussions were focused in a series of breakout group sessions. Topics were selected for discussion across the consortium to address the perceived integration needs of the participants, and included continued discussion of scenarios, improving data flows among groups, moving macroecological analyses forward, integrating macrophyte work with other benthic and modelling work, how to define and collate information on traits and the relative importance of size as a driving trait in pelagic and benthic systems, improving models linking ecosystem services and higher predator distributions and improving functional responses in models using experiments and meta-analyses. On the second day the focus was on uncertainty in models and achieving impact. The latter session lays out the groundwork for a Defra briefing planned in early 2016. This report summarises the key points arising from those sessions and lists agreed actions. Specific actions related to each discussion group are listed per section, and summarised in full in Appendix 1. Documents relating to achieving impact are given in Appendix 2.

In order to address many of the questions raised during this workshop it is was agreed that there was a need for a further model/empiricist integration workshop where the two communities could have space and time to address some of the questions raised during this session. An organisation committee was agreed to prepare a detailed working plan for this workshop, to be held in March 2016.

General actions

1. **Model/observation workshops:** 2 day workshops bringing people together for discussions around the data needs of each particular model. Linking model groups with those working on: process rates, parameters, patterns in size spectra.
   Workshop planning committee: Icarus Allen, Stephanie Broszeit, Mark Emmerson, Peter Evans, Jessica Heard, Leigh Howarth, Kate Searle and Natalia Serpetti
2. Paul Blackwell and Mike Spence to write some explanatory text about the Bayesian reasoning and connectivity with modelling and ecosystem services. A case study of a subset of scenarios.
3. Monthly E bulletins of updates to the website, StrathCloud (previously known as SharePoint) and other areas of interest to the community to serve as a reminder for consortium on recent activities. Jessica Heard

Setting Common Scenarios Plenary session

Session aim: To develop and agree a preliminary list of MERP scenarios driven by the policy questions as discussed with the SAG.

What are we going to do with these scenarios…

Model sensitivity analysis

of multiple ecosystem services,

with respect to multiple anthropogenic factors (individually and cumulatively),

over given time and space scales,

in a given geographic and climate context.

Key issues…

Policy/societal relevance/motivations

What are the tensions and trade-offs between services – ie. Cascading trophic effects?

Do different models tell different stories?

Identify remaining knowledge and modelling gaps

High impact publications

Figure out how to frame and present advice to stakeholders

Reminder of ecosystem services agreed at Drymen meeting:

- **Food provision**
  - Yields of fish/shellfish/macroalgae…
- **Leisure and recreation**
  - Top-predator populations, fish populations (sea angling), eutrophication (water quality)…
- **Bioremediation**
  - Denitrification, organic burial, phosphorus immobilisation..
- **Biological checks and balances**
  - Disease and parasite dynamics as population regulation processes…

Each MERP model needs to be able to output simulated data enabling quantification and/or valuation of one or more of these services and processes

Anthropogenic factors

The factors were suggested by the SAG and generally agreed by the workshop group:

- Top issue – physical disturbance of the marine environment by – towed fishing gears, aggregate extraction, dredging, disposal and cable laying, offshore structures
- Harvesting of biomass, gear selectivity, landing obligation, by catch mortality
- Disturbance by leisure and tourism, shipping, noise
- Nutrient inputs (rivers, atmospheric, direct discharges)

Each MERP model needs to include external driving factors which mimic or represent multiple anthropogenic factors from an agreed list

The group discussed which areas they could best feed into:

- **Fisheries:** most models could provide information. Population consequences models are being developed, particularly with respect to top predators
- **Disturbance: it is difficult to** deal with the multiple impacts of multiple uses over small spatial scales e.g tidal lagoons, dredging. How do small scale regional impacts interact with each other and are there broader regional impacts. The Consortium needs to think about at what scales we can apply disturbance? Benthic disturbance can be explored at whole shelf scale. Need to take different approaches to different impacts for example wind-farm scales. MERP does not model noise but does model the effects of noise. Could do a sensitivity analysis to look at impacts at whole system scale. However, noise not a key priority for MERP as this is not an area we have expertise in. Lots of impacts about sub lethal effects but these are very hard to model.

Moving forward discussion:

- What can our models tell us already? E.g. how can we model noise with what we have?
- Not all models have to be dynamic. Different models can tell us different things.
- Need a taxonomy of models, and mapping exercise to understand what each model does, how they map on to the scenarios. Match our model understanding to key questions - this has partly been done through the Hyder paper.
- How do we tweak our models to give us the answers we need?
- What the models can do depends on the type of model – it is necessary to look at perturbations in aggregated groups.

Time, space and taxonomic resolution (graininess)

These are dictated by policy drivers/motivations:

- MSFD/Good Environmental Status
  - Assessments at regional sea scales, annual time scales, maybe at aggregated taxonomic resolution, but data and models also need to integrate variability occurring at smaller scales
- Habitats and species
  - Requirement to resolve key species of interest/concern, and key habitats, but potentially at annual time resolution?
- Marine Protected Areas/Spatial Planning
  - Specifically addressing questions at the scale of individual MPAs – 1-10s of km, and key species, at fine time resolution

It was agreed that there were basically two temporal scales the modellers could work at with a whole system view (something with a climate drive) to get large scale regional averages. From that there is a subset of perturbations that could be done at different scales.

Geographic and climate context

Dictated by the space and time scale of policy motivations …

- MSFD/Good Environmental Status

  - Generally regional sea space scale, longer/strategic time scales (20-50 years) – hence requiring consideration of shifting temperature / salinity / advection / diffusion / CO_2 context
- Habitats and species
  - Generally regional sea spatial scale, longer/strategic time scales (20-50 years)?
- Marine Protected Areas/Spatial Planning
  - Generally small scale and shorter time scales – effectively disregarding climate trends

Different MERP models for large and small scale geographic context. Where relevant, MERP models will need to be capable of reflecting trends on environmental conditions reflecting climate changes.

Other comments

- Assembly of VALIDATION data sets of each geographic/climate context
- Need to horizon scan the models to determine what time/space and taxonomic graininess of validation data are needed
- With regards to the model ensemble: it does not rely on all the models producing outputs in the same form, there are mechanisms to pull outputs together that are the same scenario but producing different information on that scenario.

Next steps

- List the anthropogenic factors
- For each MERP model…
  - What input data are needed to set/mimic/caricature the agreed anthropogenic factors
  - What regional and climatic context is possible and what input data are needed to enable these configurations?
  - What space/time and taxonomic graininess is possible?
  - Exactly what outputs are available to inform on ecosystem services?
- Which models can be 'clustered together' and run with common/equivalent/comparable geographic/climate setup and anthropogenic drivers?

Continued discussions on how to develop and agree common scenarios took place in a smaller break out group, outcomes of which are provided below.

Discussion sessions: summaries and actions

To kick off the focused discussion series of 5 min presentations were given to highlight recent work particularly focused on the extensive fieldwork that was carried out over the past 6 months. Presentations are available in StrathCloud (Meetings/Manchester Workshop).

Developing Common Scenarios

Present: Icarus Allen, Mel Austen, Mike Heath, Sheila Heymans

The group discussed how best to develop suitable scenarios for the MERP community, summarised in the table below:

					What aspects can models output on?	
Components of scenarios to be simulated in models	scales			**notes** *things* that could be simulated in models	spatio-temporal scales	habitats and species
Fleet model (Mike Heath example)				12 different fishing gears, activity rate per gear, selectivity per gear, effort proportional to harvest ratio, plough rate per gear, area dredged per gear, spatial distribution of activity across 6 habitats of model, proportion of area ploughed, spatial distribution of discard deposition on seabed, whole system harvest rate per fish group, catch removed as landings, climate context from ERSEM model		
Demersal trawl fisheries	low intensity	medium intensity	high intensity	target species/aggregated biomass extraction, aggregated bycatch changes, species specific bycatch change, physical impacts on sediment/benthos/benthic process, landing obligations - proportion of catch returned to sea (offal and non quota species not subject to landing obligations)		
Static fisheries	low intensity	medium intensity	high intensity	target species/aggregated biomass extraction, bycatch changes, specie specific bycatch change, landing obligations		
Landing obligation						
By catch mortality						
Spatial exclusion through MPA - highly restricted activity	small area	large area	multiple areas	spatial effects?	far field/near field	
Exclusion through MPA weakly restricted activity	small area	large area	multiple areas	spatial effects?	far field/near field	
Spatial exclusion due to structures (Marine renewable energy)	small area	large area	multiple areas	spatial effects?	far field/near field	
Closure of UK sea space (MPA as % of UK waters)	30%	20%	10%			
Climate scenarios	1	2	3			
Nutrient enrichment	1	2	3			
construction phase noise	small area	large area	multiple areas	spatial effects?	far field/near field	

Domains

where (domain)	spatial scale	0/1/2/3d	what can/will be manipulated (e.g. of Mikes list)	what can/will be manipulated additional to Mike's list
			• 12 different fishing gears, • activity rate per gear, • selectivity per gear, • effort proportional to harvest ratio, • plough rate per gear, • area dredged per gear, • spatial distribution of activity across 6 habitats of model, • proportion of area ploughed, • spatial distribution of discard deposition on seabed, • whole system harvest rate per fish group, • catch removed as landings, • climate context from ERSEM model	

Additional comments:

- ERSEM hindcast of disturbance of seabed trawling - to drive models forward, but no feedback from models back into ERSEM
- ERSEM forward of different climate change/land use/trawling management scenarios - to drive other models forward, but no feedback from models using ERSEM
- ERSEM scales of 10-15km; FVCOM still only to zooplankton
- Closure of sea space and other what ifs? Questions not for at least 1 year

Related actions

4. Construct and circulate example process trees for simulation. Mike Heath
5. Discuss and agree core and extended sets of fishing scenarios (core to be run by all fish models). Mike Heath and Sheila Heymans
6. Relating models/scenarios discussed to cetaceans/birds needs more consideration
7. All modellers to extend Hyder et al. table of model descriptions to include the following scenario related information to see what models will be appropriate to tackle which scenarios. All model groups

Best practice in sharing data across modules

Present: Peter Evans, Remi Vergnon, Stefanie Broszeit, Pierre Hélaouët, Ruedi Nager, Francis Daunt, James Waggitt

Discussion focused on how to improve data sharing across modules, examples of best practice and how to best use the services already available to the consortium.

Related actions

8. Agreed that the existing MERP file sharing and discussion forum are the obvious tools to communicate and exchange ideas and data across modules effectively. We need to make better use of them! A suggestion was made to send a list email to remind MERP members of what data are already on the file sharing system, and also to visit the site regularly and set up email alerts when new activity takes place within the Data folder. Remi Vergnon
9. Create a "data needs" table where data users can describe their requirements and data owners can in turn point out what is available (both in terms of data itself and in terms of expertise to interpret that data). Remi Vergnon

10. Make a document available (again via MERP file sharing) detailing the practicalities of data sharing, including what BODC could offer in terms of holding the data long-term, issues with data restriction, ways to both cite data and receive appropriate credit when providing it (for example how to obtain a DOI, what are the advantages of depositing data in public data repositories such as Dryad, how and where to publish data papers…) Remi Vergnon
11. Make tools to access a number of existing datasets from R available on github, with an initial feedback phase to identify bugs and what functionalities are useful/not useful/missing. Remi Vergnon

Macroecology derived from the data available

Present: Axel Rossberg, Tom Webb, Jorn Bruggman, Andrew Hirst, Michaela Schratzberger, Paul Somerfield.

Discussion focused on body size, with a framework to allow rapid progress which included an estimate of maximum body size for each system. The group also discussed the following points:

- Spatially derived species list would be interesting to compile
- Strengths and limitations of measures like max body size: what it shows you and what it conceals. How can it be combined?
- Compiled lists of data we already have to be shared with the community

Related actions

12. A species list using survey data and external data to populate it with body size data and see where the gaps are. Dataset ready by Mid-December. Tom Webb
13. Paul Somerfield to find data underpinning papers from the Celtic Sea

Macrophytic and benthic pelagic knowledge

Present: Mike Burrows, Steve Widdicombe + others

Discussion on what modellers need to know in terms of kelp. There is a need to figure out the estimate of total carbon input into regional seas to answer the following questions:

- Could this input be treated as a constant or is it dynamic?
- If dynamic then the basic ecology of kelp needs to be included e.g. effects of light on production.
- Is kelp a slow release energy source, what impact would that have on the system?
- What level of detail is required?

Related action

14. Field validation of models

Benthic/Pelagic traits and sized based relationship and traits

Present: John Aldridge, Angus Atkinson, Jan Hiddink, Sarah Wakelin, Nick Stevens, Martin Lilley, Pennie Lindeque, Elaine Fileman, Leigh Howarth

Discussion on actual definition of traits, since within the community people's understanding of traits varied. Jorn's approach to traits may be different to a benthic ecologist's trait. Need to be careful

that modellers and ecologists are using the same terms. Traits could also be a genetic characteristic. Also traits are shared amongst different species and can change as a species develops (for instance a larva and adult of a single species can have fundamentally different sizes, feeding modes etc.). **Jan summarised a trait as any characteristic of an organism that you can define.**

Whilst it was agreed that size is a the primary trait in pelagic models, there was discussion as to whether in the benthic system the primary trait was indeed size or another factor such as feeding mode which could be more important for ecological structures. In ERSEM, feeding mode is already included as a trait but size may be important when looking at anthropogenic impact and other scenarios etc.

The benefit of size based modelling can be seen when other parameters/traits such as food size, growth rate, feeding rate etc. are correlated to size. Such correlations could be used to simplify/characterise the system. Size itself only gives indication of how much carbon is in an organism or indicates an organism's potential e.g. bioturbation.

Currently 'rates' are fixed with scale in the ERSEM model but if more information was available in relation to changes in size then this could be included e.g. if a rate responds to volume - the model is becoming more dynamic to include many functional groups and if these are important they will remain.

Discussion re which units to work in e.g. PML use unit of C; others use wet mass to convert to carbon but this could be problematic in gelatinous species. Modellers pointed out the importance of providing as much information as possible on how to convert abundance into biomass e.g. guidance on which conversion factors to use, methodology used, etc. In addition to the content it is important to have another measurement of mass per individual such as length or volume. Important to have this information for a particular time point as size can vary with time of year, development stage. Currently, ERSEM model doesn't take into account juvenile stages.

It was recognised that information on size was important in recognising ecosystem resilience; also useful to consider body content e.g. gelatinousness. There are a number of different scenarios which can be used to explain the variability in jellyfish, and models can be used to test different hypotheses.

It was agreed that the more effort we can put in to provide additional data sources the more useful it would be to make models more robust. But if we want to test how an ecosystem responds we would need more information on processes e.g. relationships.

Have there been attempts to link current pelagic and benthic size spectra? So far the 1980s papers by Warwick and co-workers remain as one of the few attempts – very often this is not possible as samples do not overlap. What would be the benefits of this? Demonstrate trophic coupling. Benthic flux in between the two systems is a big unknown. Modellers felt it would be useful to have information about flux of faecal pellets and feeding rates.

Related actions

15. Maintain communication with Cefas (contact is Jeroen) to examine the feasibility of a large scale regional synthesis paper(s) examining the full biomass spectra including the larger

predators (fish upwards) enumerated on Cefas Endeavour cruises and incorporating the seasonal perspective provided by the L4 sampling. Angus Atkinson

16. As the benthic samples are enumerated, look into the scientific merit of examining pelagic and benthic size spectra together, as per Warwick et al papers. Jan Hiddink, Angus Atkinson
17. Continue to refine the L4 trait data/biomass spectrum files that Angus sent as prototypes to Jorn and Axel in August 2015. Work with Axel and Jorn to make the data more valuable from a modelling perspective (e.g. addition of water content, better formulation of functional groups and taxonomic relatedness etc). Angus Atkinson, Jorn Bruggeman, Axel Rossberg
18. Continue to investigate the "gap" in the L4 biomass spectra at the transition from protists to metazoa. (Is this gap filled at certain times of year by zooplankton eggs or chain-forming diatoms?). Likewise attention needs to be placed in the benthic spectra as they are analysed for determination of whether gaps are real or due to sampling methods. Elaine Fileman, Angus Atkinson, Jan Hiddink
19. Organise a meeting with Jorn to discuss incorporation of plankton data/traits into models. Particularly how to incorporate large/rare taxa such as jellyfish. Elaine Fileman, Martin Lilley et al.

Ecosystem Services: Leisure and Recreation service

Discussion group: Mel Austen, Peter Evans, James Waggitt, Francis Daunt, Ruedi Nager, Stefanie Broszeit

Shared information of different species of relevance to the service:

- Puffins: climate change may cause sandeel changes, other stressors can be managed.
- Gannet: stressors more related to changes in fisheries.
- Herring gulls: on the red list, but no money/tourism in them. Gap: breeding, non-breeding differences in food and geographic range, use of space. Latitudinal shifts, birds will move north – 2 species (great and arctic skuas) may be gone from the UK mainland.
- Auks and kittiwakes are doing poorly largely because of a lack of prey which is in part linked to climate change in the Arctic.
- Common dolphins: sardine and pilchards are amongst favoured prey and these are moving north in response to climate change; common dolphin range is extending into the North Sea.
- Two main coastal populations of BND: Moray Firth/Eastern Scotland where pelagic prey such as salmon frequently taken. These may have a different ecology to those in Cardigan Bay/West Wales, which appear to feed more on benthic species.
- A number of seabird species e.g. gannets, auks and herring gulls also may have a lot of terrestrial subsidies.

Related actions

20. Revise the models for up to 8 species, adapt for the species decided upon. Led by Stefanie Broszeit
21. Reiterate models with Francis, Peter, Ruedi, James. Led by Stefanie Broszeit

Functional responses

Discussions focused on benthic functional responses to improve parameterization of ERSEM

Related actions

22. Jorn B. will be in contact with Martin Lilley & Andrew Hirst to explore joint taxonomic and allometric (intraspecific and interspecific) patterns in their metabolic rate dataset using phylogeny-aware methodology. This will feed into the parameterization of ERSEM generic heterotrophs.
23. Danny O'Neill will begin literature mining for functional responses in 2016 and will share that dataset with Jorn B./M6 during compilation to feed into parametrization of predator-prey interactions in ERSEM.

Uncertainty in model ensemble

The majority of this session was spent discussing subjective probability. Mike Spence and Paul Blackwell showed the preliminary results (plots were shown from a CJFAS paper to illustrate how the results could be summarised) of their recent elicitation work and then discussed the ensemble modelling approach.

A lot of discussion was made, including potential biases of experts, which the model tries to account for. This work is ongoing and will be discussed further at future workshops.

Related actions

24. Continue with elicitation.
25. Visit modellers to discuss parameter/internal uncertainty – explored further in the March workshop.
26. Meet/work with Stefanie Broszeit on implications for ecosystem services.
27. Ensure that some of the scenarios from Mike Heath's scenario planning are identified as soon as possible, so that we can get output from multiple models to help with development of methodology.

Achieving impact

The focus of this session was how best to develop the impact of MERP, particularly in the policy arena. Feedback from the SAG discussions on policy questions was provided and discussed. Full details of the agreements and discussions from the SAG are provided in Appendix 2.

The group discussed the use of a traffic light system to show progression towards MERP's ability to answer key questions as well as the potential to use REF case studies produced by some partners to highlight impact.

Cefas will be giving a MERP briefing to Defra policy customers in January 2016. Current plans are to develop a couple of examples of policy-relevant MERP science which addresses key policy questions and several workshop participants showed interest in being part of this process. Areas of MERP research which will be presented to Defra relate to the following questions (see Appendix 2 for detail):

What is the state of food webs (or its components) in relation to specified targets?

Examples from Remi Vergnon et al. Work in Modules 1 and 2 which has been bringing together existing data and new observations. Demonstrate to Defra that this provides a more complete

picture of how food web components, pressures, environmental variables etc. are distributed and how they interact in space and time.

Policy-relevant outputs: New maps and other data products that underpin advice on the state of food webs and the environmental conditions required to maintain them.

What are the effects of natural and anthropogenic change on the state of marine food webs and the services they provide?

Examples from Francis Daunt, Peter Evans et al.: Combining extensive field work from aerial and ship surveys with novel macro-ecological analyses of existing data improves understanding of the effects of natural and anthropogenic change on the state of marine food webs and its components.

Example from Mike Heath: He used his model to compare the food web effects of different fishing practices. This provides scientific evidence which is feeding into a judicial review.

Policy-relevant outputs: Information that helps to identify which aspects of the marine environment are most at risk and informs management measures to mitigate risks. It also informs effective marine spatial planning of human activities.

What are the likely future states of marine food webs and ecosystem service provision under scenarios reflecting management situations in UK waters?

Examples from Stefanie Broszeit et al.: In order to meet societal needs for preserving ecosystem services, managers need to take account of a range of scenarios for the future state of marine food webs. MERP is developing scenarios reflecting future states of marine food webs and ecosystem service provision on different spatio-temporal scales that are relevant to management and policy.

Policy-relevant outputs: To be discussed primarily with Stefanie et al as a specific example develops.

Related actions

28. Traffic light system of progression towards key questions.
29. A revised draft of key policy questions to be sent out to the group and made available on StrathCloud.
30. Michaela to agree date for briefing with Defra and follow up with Paul S. and those named above re examples. If available, MERP scientists to present specific examples to Defra in London in January.

Appendix 1

Actions from the MERP Integration workshop, November 2015

Action number	Action	Responsible	Related session
1	Model/observation workshops	Organisation Committee: Mark Emmerson, Leigh Howarth, Peter Evans, Icarus Allen, Natalia Serpetti, Stephanie Broszeit, Kate Searle and Jess Heard	General
2	Explanatory text about the Bayesian reasoning and connectivity with modelling and ecosystem services. A case study of a subset of scenarios.	Paul Blackwell and Mike Spence	General
3	Monthly E bulletins of updates to the website, StrathCloud and other areas of interest to the community to serve as a reminder for consortium on recent activities	Jessica Heard	General
4	Construct and circulate example process trees for simulation	Mike Heath	Developing scenarios
5	Relating models/scenarios discussed to cetaceans/birds needs more consideration	Mike Heath and Sheila Heymans	Developing scenarios
6	Discuss and agree core and extended sets of fishing scenarios (core to be run by all fish models)	Mike Heath and Sheila Heymans	Developing scenarios
7	Construct and circulate example process trees for simulation	All model groups	Developing scenarios
8	Visit Strathcloud regularly and set up email alerts when new activity takes place within the Data folder	Remi Vergnon	Best practice in data sharing
9	Create a “data needs” table where data users can describe their requirements and data owners can in turn point out what is available (both in terms of data itself and in terms of expertise to interpret that data)	Remi Vergnon	Best practice in data sharing
10	Make a document available (StathCloud) detailing the practicalities of data sharing	Remi Vergnon	Best practice in data sharing
11	Make tools to access a number of existing datasets from R available on github, with an initial feedback phase to identify bugs and what functionalities are useful/not useful/missing.	Remi Vergnon	Best practice in data sharing
12	Create a species list using survey data and external data to populate it with body size data and see where the gaps are. Dataset ready by Mid-December	Tom Webb	Macroecology derived from the data available
13	Find data underpinning papers from the Celtic sea	Paul Somerfield	Macroecology derived from the data available
14	Field validation of models	As appropriate	Macrophytic and benthic pelagic

			knowledge
15	Maintain communication with Cefas (contact is Jeroen) to examine the feasibility of a large scale regional synthesis paper(s) examining the full biomass spectra including the larger predators (fish upwards) enumerated on Cefas Endeavour cruises and incorporating the seasonal perspective provided by the L4 sampling	Angus Atkinson	Benthic/Pelagic traits and sized based relationship and traits
16	As the benthic samples are enumerated, look into the scientific merit of examining pelagic and benthic size spectra together, as per Warwick et al papers.	Jan Hiddink, Angus Atkinson	Benthic/Pelagic traits and sized based relationship and traits
17	Continue to refine the L4 trait data/biomass spectrum files that Angus sent as prototypes to Jorn and Axel in August 2015. Work with Axel and Jorn to make the data more valuable from a modelling perspective.	Angus Atkinson, Jorn Bruggeman, Axel Rossberg	Benthic/Pelagic traits and sized based relationship and traits
18	Continue to investigate the "gap" in the L4 biomass spectra at the transition from protists to metazoa. Likewise attention needs to be placed in the benthic spectra as they are analysed for determination of whether gaps are real or due to sampling methods	Elaine Fileman, Angus Atkinson, Jan Hiddink	
19	Organise a meeting with Jorn to discuss incorporation of plankton data/traits into models. Particularly how to incorporate large/rare taxa such as jellyfish	Elaine Fileman, Martin Lilley et al	Benthic/Pelagic traits and sized based relationship and traits
20	Revise the models for up to 8 species, adapt for the species decided upon (northern gannet, Atlantic puffin, kittiwake, herring gull, bottlenose dolphin, minke whale, Atlantic grey seal and harbour seal)	Led by Stefanie Broszeit	Ecosystem Services: Leisure and Recreation service
21	Reiterate models with Francis, Peter, Rudi, James.	Led by Stefanie Broszeit	
22	JornB will be in contact with Martin Lilley & Andrew Hirst to explore joint taxonomic and allometric (intraspecific and interspecific) patterns in their metabolic rate dataset using phylogeny-aware methodology. This will feed into the parameterization of ERSEM generic heterotrophs	Led by Jorn Bruggeman	Functional responses
23	Danny O'Neill will begin literature mining for functional responses in 2016 and will share that dataset with JornB/M6 during compilation to feed into parametrization of predator-prey interactions in ERSEM.	Danny O'Neill	Functional responses
24	Continue with elicitation work.	Mike Spence/Paul Blackwell	Uncertainty in model ensemble
25	Visit modellers to discuss parameter/internal uncertainty – explored further in the March workshop.	Mike Spence/Paul Blackwell	Uncertainty in model ensemble
26	Meet/work with Stefanie Broszeit on implications for ecosystem services.	Mike Spence	Uncertainty in model ensemble
27	Ensure that some of the scenarios from Mike	Mike Spence/Paul	Uncertainty in

	Heath's scenario planning are identified as soon as possible, so that we can get output from multiple models to help with development of methodology.	Blackwell	model ensemble
28	Traffic light system of progression towards key questions	TBC	Achieving impact
29	A revised draft of key policy questions to be sent out the group and made available on StrathCloud	Jessica Heard	Achieving impact
30	Agree date for briefing with Defra and follow up with Paul S and those named above re examples. If available, MERP scientists to present specific examples to Defra in London in January	Michaela Schtratzberger	Achieving impact

Appendix 2

Marine Ecosystems Research Programme: Addressing key policy questions

Michaela Schratzberger (Cefas) & Paul Somerfield (PML)

A healthy and stable ecosystem that delivers desired ecosystem services is one that is able to sustain the energy flow between trophic levels within a food web. When positions in the food web are eliminated (as a result of natural or man-made pressures), trophic relationships are lost or put at risk and the ecosystem may experience imbalance and negative cascading effects throughout the food web. This can have important knock-on effects on the delivery of ecosystem services. The exact nature and significance of such effects is largely unclear. The scientific focus of MERP lies in improving the understanding of the processes that govern the dynamics of marine ecosystems, and in particular marine food webs, and how changes in them affect delivery of ecosystem services. The nature and significance of these effects is largely unknown to scientists and therefore this information is currently not available to decision-makers in a comprehensive way.

Expectations on MERP science

Stakeholder expectation on MERP is to deliver scientific evidence to aid decisions regarding the management of marine ecosystems. Scientific evidence may take many forms ranging from the analysis of existing and new data to expert interpretations of such. Each form of evidence, though, is not equally persuasive in making the case that a certain piece of evidence should play a role in a policy or management decision. In order to be effective, MERP scientists are maximising the quality and relevance of their scientific evidence so that it can compete in the decision-making environment.

MERP's progress towards prioritising and feeding into key policy areas

Rather than aiming to simply translate scientific knowledge into policy-relevant information, the MERP consortium provides input in all stages of the cycle below which depicts multiple levels of exchange between decision-makers and scientists. The first step on the right hand half of the cycle encompasses the identification of critical information needs. In the second step on the left hand half of this cycle, the identified science needs are prioritised and policy-relevant science is delivered.

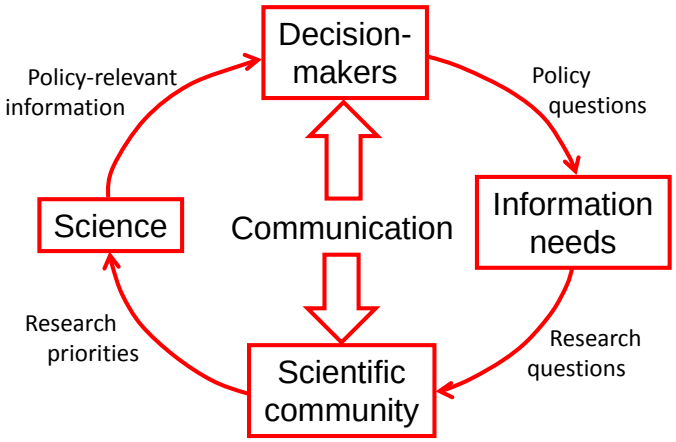

Fig 1. Cycle showing multiple levels of exchange between decision-makers and scientists.

a. Identification of information needs (Fig. 1)

We compiled a list of policy questions/demands on the MERP consortium from various sources including:

- Policy questions/needs identified by the MERP Stakeholder Advisory Group in December 2014
- Discussions at MSCC level surrounding the contribution of shelf seas models to policy development. This has been summarised in a paper published by Hyder et al. (2015), co-authored by many MERP scientists, in Marine Policy [Hyder K et al. (2015). Making modelling count-increasing the contribution of shelf-seas community and ecosystem models to policy development and management. Marine Policy 61: 291-302].
- A gap analysis by the Marine Management Organisation carried out as part of their Evidence Strategy 2015-2020 (draft of Part 2 of the MMO Evidence Strategy: Detailed gaps and Issues).

The original list in Appendix 1 illustrates that policy developments put demanding requirements on the MERP consortium. The list includes 54 questions, many of which are interrelated. A number of key themes emerged from this list. The most pressing policy questions translate into the following research questions:

- How are food web components, pressures, environmental variables, etc. distributed in space and time?
- How have and will feeding relationships change(d) through space and time in response to natural and human pressures?
- How are food webs regulated under different environmental scenarios?

… and integrating elements of the three questions above:

- How do changes in food webs drive changes in ecosystem service provision at different scales of space and time?

Following discussions with SAG members on 16 November 2015, we aligned the research questions above with key policy questions (Appendix 1) and identified where MERP science can feed into high-priority decision-making. Existing and planned MERP work is brigaded under the following research priorities, all of which have high policy-relevance (Appendix 2):

What is the state of food webs (or its components) in relation to specified targets?

Considerable progress is being made in MERP to develop ecoinformatics tools to bring together existing data relevant to marine ecosystems from around the UK. Combining analyses of existing data with new observations collected in MERP will provide a more complete picture of how food web components, pressures, environmental variables, etc. are distributed and how they interact in space and time.

This evidence (incl. new maps and other data products) directly underpins advice on the state of food webs and the environmental conditions required to maintain them. It also improves understanding of natural variability in space and time. This has direct applicability to assessing state of food webs (or its components) against specified targets and addressing policy questions including:

- *Are we achieving Good Environmental Status (GES) for MSFD Descriptors at regional scales?*
- *Are we achieving Conservation Objectives (COs) for species and habitats at local MPA scales?*

- *What is the relationship between ecosystem services and Good Ecological/Environmental Status?*
- *Identification of areas of particular importance to fish populations*
- *How can we define and describe biodiversity hotspots?*
- *Information on seasonal bird and mammal densities and key foraging areas*

What are the effects of natural and anthropogenic change on the state of marine food webs and the services they provide?

Extensive fieldwork from ships and controlled experiments in the laboratory is gathering vital information on marine ecosystems that is not available at present. Combining this with novel macro-ecological analyses of existing data will improve understanding of the effects of natural and anthropogenic change on the state of marine food webs. The empirical data feeds directly into key elements of the MERP modelling work which includes understanding the certainty of model predictions, improving the performance of existing models and developing new models linking marine life and how it changes to the products and various benefits society derives from the sea.

The resultant evidence helps to identify which aspects of the marine environment are most at risk and informs management measures to mitigate risks. It also informs effective marine spatial planning of human activities and addresses policy questions including:

- *How does the removal or alteration of benthic habitat affect populations of marine mammals and birds (those mammal and bird species included in Habitats and Birds Directives)?*
- *What are the impacts of removal of fish prey species on marine bird and mammal populations (Habitats and Birds Directives)?*
- *How to evaluate cumulative impacts, especially for mobile species (capacity of marine mammal and bird populations to cope with cumulative impacts across their biogeographic range)?*
- *How do impacts on rare and/or threatened habitats and species affect ecosystem services (especially for BAP/OSPAR habitats and species but also Habitats Directive/SSSI habitats and species)?*

What are the likely future states of marine food webs and ecosystem service provision under scenarios reflecting management situations in UK waters?

In order to meet societal needs for preserving ecosystem services, managers need to take account of a range of scenarios for the future state of marine food webs. MERP will be developing scenarios reflecting future states of marine food webs and ecosystem service provision on different spatio-temporal scales that are relevant to management and policy. This will help address policy questions including:

- *What are the effects of changes in fisheries management on the environment, in particular through food web effects?*
- *What are the responses of indicators to specific management measures for MSFD Descriptors?*

- *What are future changes in ecosystem services in response to different management scenarios?*
- *What is the impact of (multiple) MPA closures on fisheries and recreation?*

Next steps

We are planning a MERP briefing to various Defra policy customers in January 2016 with the aim to highlight specific MERP outputs that are directly relevant to policy development in the short to medium term

Table 1. MERP priority list of policy questions/demands from various sources

Policy question/need	Org.	Spatial scale	Timeline
State of food webs (or its components) in relation to specified targets			
Are we achieving Good Environmental Status (GES) for MSFD Descriptors at regional scales?	MBA	UK/Celtic Seas & Greater North Sea subregions	First nat. assessm. due 2018 (Ospar IA in 2017)
Are we achieving Conservation Objectives (COs) for species and habitats at local MPA scales?	IFCAs?		Ongoing
What is the relationship between ecosystem services and Good Ecological/Environmental Status?	NRW	UK	Ongoing
Identification of areas of particular importance to fish populations	MMO	UK	Indeterminate
How can we define and describe biodiversity hotspots?	MMO	UK	Indeterminate
Seasonal bird densities and key foraging areas	MMO	UK	Indeterminate
Effects of natural and anthropogenic change on the state of marine food webs and the services they provide			
How does the removal (e.g. by tidal lagoon projects) or alteration (e.g. by towed fishing gears) of benthic habitat affect populations of marine mammals and birds (those mammal and bird species included in Habitats and Birds Directives)?	NRW, SNH	UK	Ongoing
What are the impacts of removal of fish prey species on marine bird and mammal populations (Habitats and Birds Directives)?	NRW, SNH	UK	Ongoing
How to evaluate cumulative impacts, especially for mobile species (to ultimately create the ability to carry out strategic assessments through marine planning or SEA that consider the capacity of marine mammal and bird populations to cope with cumulative impacts across their biogeographic range)?	NRW, SNH	UK	Ongoing
How do impacts on rare and/or threatened habitats and species affect ecosystem services (especially for BAP/OSPAR habitats and species but also Habitats Directive/SSSI habitats and species)?	NRW	UK	Ongoing
Future state of marine food webs and ecosystem service provision under scenarios reflecting management situations in UK waters			
What are the effects of changes in fisheries management on the environment, in particular through food web effects?	MSCC etc.	UK	Indeterminate
What are the responses of indicators to specific management measures for MSFD descriptors?	MSCC etc.	UK	Indeterminate
What are future changes in ecosystem services in response to different management scenarios?	MMO	UK	Indeterminate
What is the impact of (multiple) MPA closures on fisheries and recreation?	MMO	UK	Indeterminate

Table 2. List of policy questions/demands on the MERP consortium compiled from various sources

	Policy question/need	Detail/comment	Org.	Spatial scale	Timeline
Policy questions identified by SAG					
1	How do we achieve Good Environmental Status (GES) for European Seas by 2020?	Observed and predicted changes in state across ecosystem components could help interpret whether a failure to meet a target for one component has a knock on effect with others.	MBA	UK/Celtic Seas & Greater North Sea subregions	Ongoing first nat. assess. In 2018 (Ospar IA in 2017)
2	What proportion of primary and secondary production is extracted through fishing, by region/national region? What changes have occurred?	MSFD regional approaches	ICES	See above	by 2017
3	What are the likely food web cascade effects of the landing obligation?	Impact of CFP reform on the MSFD	ICES	See above	by 2016
4	What is the impact of reduced trawling on the release of nutrients from the seabed and primary production?	MSFD regional approaches	ICES	See above	by 2018
5	What are the appropriate scales to assess foodweb indicators?	MSFD regional approaches	ICES	See above	by 2016
6	How to predict the way in which removal (e.g. by tidal lagoon projects) or alteration (e.g. by towed fishing gears) of benthic habitat might affect populations of marine mammals and birds (those mammal and bird species included in Habitats and Birds Directives)	Assessing impacts of proposed or existing activities on SACs, SPAs and the wider marine environment	NRW, SNH	UK	Ongoing
7	How to predict impacts of removal of fish prey species on marine bird and mammal populations (Habitats and Birds Directives)	Assessing impacts of proposed or existing activities on SACs, SPAs and the wider marine environment	NRW, SNH	UK	Ongoing
8	Diet of marine mammals, especially bottlenose dolphin, harbour porpoise and grey seal (linked to 1 & 2)	Assessing impacts of proposed or existing activities on SACs, SPAs and the wider marine environment	NRW, SNH	UK	Ongoing
9	Impacts of removal of fisheries target species (including crabs & lobsters) on the rest of the ecosystem (e.g. infaunal and epifaunal benthic species) (aims to help assess fishing impacts on SACs)	Assessing impacts of proposed or existing activities on SACs, SPAs and the wider marine environment	NRW, SNH	UK	Ongoing
10	Further interpretation of phytoplankton data to increase the understanding of the nutrient algae response relationship (and then improve WFD assessment tools)	Improve WFD tools	NRW	UK	Ongoing

11	Improve understanding of human pressures on WFD fish community tool to ensure that measures are fit for purpose	Improve WFD tools	NRW	UK	Ongoing
12	Developing MSFD food web indicators	Implementation of MSFD	NRW, ICES, SNH	UK	
13	Understanding how impacts on rare and/or threatened habitats and species affect ecosystem services (especially for BAP / OSPAR habitats and species but also Habitats Directive / SSSI habitats and species)	BAP / OSPAR biodiversity	NRW	UK	Ongoing
14	Understanding the relationship between ecosystem services and Good Ecological/Environmental Status	Implementation of MSFD & WFD	NRW	UK	Ongoing
15	How to mitigate / compensate for impacts and develop licence conditions for proposed activities	Evaluate suitable compensation/mitigation enhancement for developments (e.g. coastal construction, renewables etc) in terms of ecosystem services	NRW	UK	Ongoing
16	How to evaluate cumulative impacts, especially for mobile species (to ultimately create the ability to carry out strategic assessments through marine planning or SEA that consider the capacity of marine mammal and bird populations to cope with cumulative impacts across their biogeographic range)	Assessing impacts of proposed or existing activities on SACs, SPAs and the wider marine environment	NRW	UK	Ongoing
17	Climate change resilience and marine planning	Which habitats and species may contribute most to resilience to climate change	NRW	UK	Ongoing
Making modelling count - increasing the contribution of shelf-seas community and ecosystem models to policy development and management (Hyder et al 2015)					
18	What are the spatial and temporal scales that the MERP can address and do these match policy requirements?	Policy area: natural variability and monitoring	MSCC etc.	UK	Indeterminate
19	How long would it take to quantify the uncertainty of model-based predictions?	Policy area: natural variability and monitoring	MSCC etc.	UK	Indeterminate
20	Can the MERP improve models to get better estimates of state of system?	Policy area: natural variability and monitoring	MSCC etc.	UK	Indeterminate
21	Can the MERP quantify distributions, baselines and natural variability?	Policy area: natural variability and monitoring	MSCC etc.	UK	Indeterminate
22	How will a network of MPAs deliver objectives and outcomes in relation to environmental impacts, ecosystem structure and function?	Policy area: management measures	MSCC etc.	UK	Indeterminate

23	What are the effects of changes in fisheries management on the environment, in particular through food-web effects?	Policy area: management measures	MSCC etc.	UK	Indeterminate
24	How are different ecosystem functions and services dynamically coupled?	Policy area: ecosystem goods and services	MSCC etc.	UK	Indeterminate
25	Can the MERP contribute to the ecosystem approach through interactions between models and data?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
26	What are the responses of indicators to specific management measures for MSFD descriptors?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
27	What are the interactions between biodiversity (Descriptor 1) and other descriptors of GES Status under MSFD?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
28	What are the interactions between commercial fish (Descriptor 3) and other descriptors of GES under MSFD?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
29	What are the interactions between food web structure (Descriptor 4) and other descriptors of GES under MSFD?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
30	What are the interactions between sea floor integrity (Descriptor 6) and other descriptors of GES under MSFD?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
31	Are there useful indicators that can be derived from models but not from direct observation?	Policy area: Good Environmental Status	MSCC etc.	UK	Indeterminate
32	What are the impacts of regional scale climate patterns on ecosystem state (GES), or on ecosystem services	Policy area: environmental change and climate adaptation	MSCC etc.	UK	Indeterminate
33	Can a change in environmental status be attributed to a combination of drivers?	Policy area: environmental change and climate adaptation	MSCC etc.	UK	Indeterminate
34	What are the impacts of changes in biogeochemistry on ecosystem state (GES)?	Policy area: environmental change and climate adaptation	MSCC etc.	UK	Indeterminate
35	What is the impact on land/sea transition zone?	Policy area: environmental change and climate adaptation	MSCC etc.	UK	Indeterminate
36	What are the impacts of wind farms and other offshore structures?	Policy area: environmental change and climate adaptation	MSCC etc.	UK	Indeterminate
MMO gap analysis as part of their evidence strategy					
37	Identification of areas of particular importance to fish populations	R088	MMO	UK	Indeterminate
38	How can we define and describe biodiversity hotspots?	R004	MMO	UK	Indeterminate
39	Broad level environmental change in response to climate change	R009	MMO	UK	Indeterminate
40	Disentangling natural variability and anthropogenically-driven change in MPAs	R117	MMO	UK	Indeterminate

41	Improved distribution and condition data, including temporal variability	R018, R023, R110	MMO	UK	Indeterminate
42	Marine species migration pathways	R005	MMO	UK	Indeterminate
43	Seasonal bird densities and key foraging areas	R007	MMO	UK	Indeterminate
44	The intensity of impacts of marine recreation	R090	MMO	UK	Indeterminate
45	Improved spatial data on activity distribution	R001	MMO	UK	Indeterminate
46	Pressures of different fishing gear	R045	MMO	UK	Indeterminate
47	The impact of recreational fishing on fish stocks	R121	MMO	UK	Indeterminate
48	Thresholds for significant environmental/social impacts	R106	MMO	UK	Indeterminate
49	Environmental carrying capacity (multiple pressures)	R020	MMO	UK	Indeterminate
50	Impact of (multiple) MPA closures on fisheries and recreation	R013	MMO	UK	Indeterminate
51	Improved knowledge of ecosystem services	R031	MMO	UK	Indeterminate
52	The direct and indirect impacts of implementing 'days at sea' scheme	R050	MMO	UK	Indeterminate
53	Future changes in response to different management scenarios	R056	MMO	UK	Indeterminate
54	Adaptive management approaches to bottom towed gear and MPAs	R122	MMO	UK	Indeterminate

Appendix 3

MERP Participants list

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