



Marine Ecosystems Research Programme

MERP Ecosystem Services Workshop Report

20th of May 2015

Produced by Stefanie Broszeit, Nicola Beaumont, Icarus Allen, Mel Austen

Contents

Executive summary	2
Workshop aims	4
Sketching the System	4
Colouring in the System	6
MERP and MSFD indicators.....	11
Over-Arching Outcomes.....	11
Summary of outcomes from the discussions.....	11
Next steps on Ecosystem Services led by Module 5	13
Actions	14
Appendix 1 Workshop reports from each group	15
Appendix 2 MSFD Discussion	26

Executive summary

Members from all modules were present as well as members of the Programme Advisory Board.

Workshop Aims

- To agree on a selection of ecosystem services (ES) to be focussed on within MERP.
- To have an exchange concerning ongoing research, focussed around ecosystem services, amongst modules and between empiricists, modellers and ES researchers.
- To understand and discuss which data are needed and likely to be available to bring the project together in the currency of ES.
- To develop shared understanding of Ecosystem Service terminology and concepts.

Approach

The workshop was led and facilitated by members of Modules 5 and 6 and the Programme Advisory Board: Nicola Beaumont, Mel Austen, Icarus Allen, Dave Paterson, Stefanie Broszeit and Stephen Watson. In small groups, attendees discussed the ES, the processes which support these ES, the data available and further data needs.

Over-Arching Outcomes

- The community present in Drymen selected four ES for focus in MERP: Food provision, Bioremediation of waste, Biological checks and balances, and Leisure & recreation. These were selected, because they are important for both policy and stakeholders and there is good expertise on the underlying processes of each of these ES within MERP (Figure 2).
- Key processes supporting these ES were identified.
- The dialogue amongst empiricists, modellers and ES researchers facilitated work towards the goal of having all models and data combined and used in the ES approach.
- Information on data availability and data needs was exchanged within and among the working groups.
- It was identified that some natural scientists need to have a better understanding of what the ES outputs would look like, and how these would fit into the wider academic, policy and management spheres. Methods to address this need were discussed.
- There is now a good basis of understanding of the ES concepts across the MERP community.

Next steps on Ecosystem Services led by Module 5

- The priorities of MERP lie with assessing the role of higher trophic levels in marine ecosystems, which is of particular relevance for food provision and leisure and recreation services. Therefore we will address the services in the following order:
 - **Food provision:** most data will be derived from models and some from sampling in Module 2. Data already accessible through Module 1 will be used to test the conceptual models
 - **Leisure and Recreation:** fewer relevant data sets are immediately available although data gathering has commenced, and model outputs could be adapted for use.
 - **Biological checks and balances:** data on some aspects of this service are available.

- **Bioremediation of waste:** there are many data sets available as this service is underpinned by processes involved in biogeochemical fluxes which are addressed in detail in MERP.
- Module 5 will use the outcomes of the workshop to continue progress on constructing conceptual models of the links between processes, key components of biodiversity and ES
- They will seek feedback and input on the developing models from MERP consortia members: using face to face meetings, small group workshops email discussion, skype etc. (focussing on specific groups such as birds, top predators, fish; specific processes and services; specific habitats etc.).
- Module 5 will continue to compile and access relevant data for the different ecosystem services from across, and in collaboration with, other modules in MERP in order to develop models and undertake preliminary data analysis about changes in indicators of ecosystem services in response to ecosystem changes.
- These analyses will form the basis of a paper for Deliverable 5.1: Conceptual models relating ecosystem structure and processes to ecosystem services.
- To address the policy questions raised by the stakeholders, current MSFD indicators are also being assessed for their usefulness in the evaluation of ecosystem services.
- Possible 'scenarios' or simulations for the models will be explored collaboratively within the next 6 months.
- Briefs will be prepared for MERP newsletters in ES terminology, such as Natural Capital, Stocks and Flows to enable a continued wider understanding of the ES concept, associated outputs, and how these fit into the broader policy context.

Workshop aims

The aims of this workshop were:

- To agree on a selection of ecosystem services (ES) to be focussed on within MERP
- To have an exchange concerning ongoing research, focussed around ecosystem services, amongst modules and between empiricists, modellers and ES researchers
- To understand and discuss which data are needed and likely to be available to bring the project together in the currency of ES
- To develop shared understanding of Ecosystem Service terminology and concepts

The workshop was led and facilitated by members of Modules 5 and 6 and the Programme Advisory Board, specifically: Nicola Beaumont, Mel Austen, Icarus Allen, Dave Paterson, Stefanie Broszeit, Stephen Watson. The participants were split into the following four groups (Table 1).

Table 1: Division of participants

	Group 1	Group 2	Group 3	Group 4
Leader	Icarus Allen	Nicky Beaumont	Mel Austen	Dave Paterson
Rapporteur	Stefanie Broszeit	Tom Webb	Sheila Heymans	Steve Watson
Participants	Ana Queiros	Angus Atkinson	Mark Emmerson	Danny Barrios O’Neill
	Andrew Hirst	Jorn Bruggeman	Sevrine Saillery	Axel Rossberg
	Dougie Speirs	Sarah Wakelin	Francis Daunt	Mike Heath
	Mike Spence	Paul Blackwell	Pierre Hélaouët	Momme Butenschoen
	Natalia Serpetti	Eugene Murphy	Rob Thomas	Kate Searle
	Remi Vergnon	Johan van der Molen	Mike St. John	Kevin Gaston
	Tasman Crowe			

Sketching the System

In the morning session, groups were tasked with developing conceptual models of interlinkages amongst ES and underlying processes. A list of Ecosystem Services and their definitions (Table 2) was given to the groups as well as an example of a model that they might develop (Figure 1). This list of ES had been discussed previously at the SAG meeting in December 2014. Groups could produce either a generic model or a specific case study using arrows to show the linkages between ES and processes. These were annotated to show where data were available or how much expertise exists within MERP. Discussions continued for each service and process, with groups providing definitions of processes as needed.

Table 2: List of definitions of ES (based on Hattam et al. 2014) given to the participants of the workshop.

Service	Definition
Food provision	The availability of marine flora and fauna for human consumption that can be caught from the wild
Climate regulation	The contribution of the marine environment to the maintenance of a favourable climate
Disturbance prevention and coastal erosion prevention	The contribution of the marine ecosystem to the dampening of the intensity of environmental disturbances such as storm floods, tsunamis and hurricanes
Bioremediation (of waste)	The removal of waste input by humans from the marine environment, eg. Excess nutrients
Biological checks and balances	The contribution of marine ecosystems to the maintenance of population dynamics, resilience through food web dynamics, disease and pest control.
Feeding habitat	Provision of habitats supporting enough food for marine species to participate in the trophic web
Migratory habitat	The contribution of a particular marine habitat for migratory species populations through the provision of safe passages for migration, resting and feeding areas
Nursery habitat	The contribution of a particular marine habitat to populations through the provision of critical habitat for juvenile maturation
Gene pool protection	The contribution of marine environments to the maintenance of viable gene pools through evolution. Processes which enhance adaptability of species to environmental change, and thereby the resilience of the ecosystem
Leisure, recreation	The provision of opportunities for tourism, recreation and leisure that depend on a particular state of marine ecosystems
Aesthetic experience	The contribution of the marine environment to the existence of a landscape that generates a noticeable emotional response within an individual observer

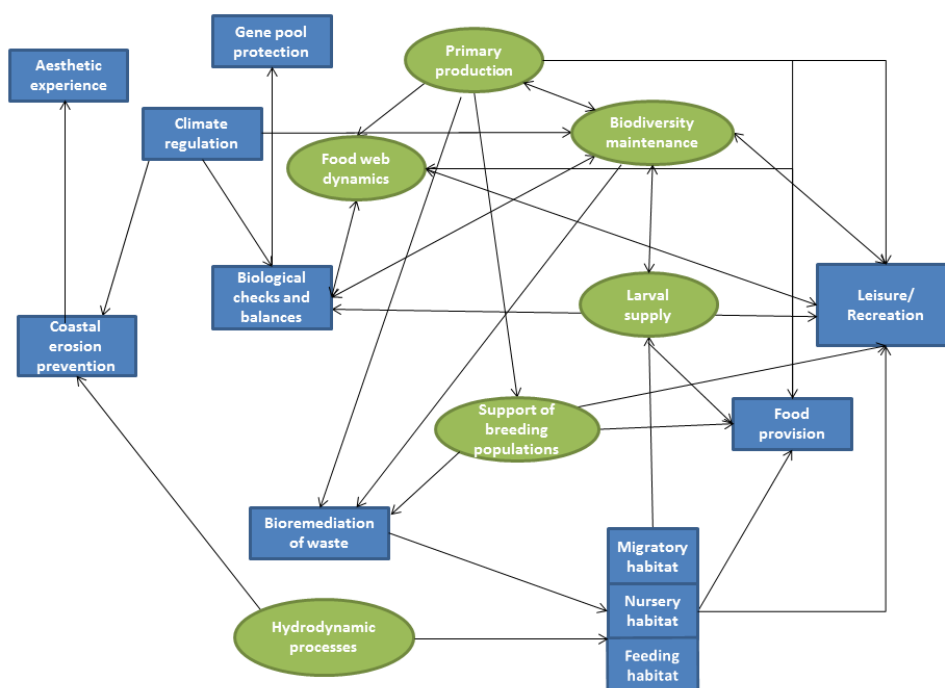


Figure 1: Linkages between ecosystem services and processes Blue boxes are Ecosystem Services, green ovals are Ecosystem Processes. This is the example given to each group as one way of interlinking Services and Processes.

Groups were given 2 hours to prepare these models on the flipcharts. Not all ES were addressed during this session as each group worked on the processes and services they had the most knowledge about. It became apparent at the end of the session that the same set of ES were considered most relevant by all groups as they were both feasible for analysis and of sufficient policy interest, these were:

- **Food provision**
- **Bioremediation of waste**
- **Biological checks and balances**
- **Leisure, recreation**

Colouring in the System

The afternoon session was undertaken by the same groups. This session focused on discussing what data were currently available to support the analysis of the four ES, and which new data would be collected and/or modelled during the course of MERP, who would be responsible for this, and timing of delivery.

The information provided from the “colouring in” workshop is assembled in Table 3 of this document. Reports written by the rapporteur in each group and photographs of each group’s flip chart workings are in Appendix 1.

Table 3: Processes and services added during team discussions, definitions (as provided by the group using the term, or otherwise in italic), where data can be obtained from, and which group added the process.

(DIVERSEM: Diversity in European Regional Sea Ecosystem Model, EwE: Ecopath with Ecosim, ERSEM: European Regional Seas Ecosystem Model, SAHFOS: Sir Alister Hardy Foundation of Ocean Science, WCO: Western Channel Observatory)

Process name	Process (in brackets)/Service it feeds into	Definition	Who can provide data?	Group
Benthic diversity	Bioremediation	The diversity of species living on or in the seafloor	Jan Hiddink, Angus Atkinson, Celtic Sea	3
Benthic fauna	(Bioturbation, primary production)	Animals living in or on the seafloor	Remi Vergnon, ERSEM, EwE, Ana Queiros	1,4
Benthic primary production	(Larval supply)	<i>Benthic contribution to gross primary production</i>	EwE	3
Benthic secondary production	Food provision; bioremediation (higher tropic levels, shellfish)	<i>Benthic contribution to turnover of biomass through consumers</i>	Ana Queiros	3
Benthos	Bioremediation , (nutrient cycling)	Benthic ecosystem processes (in general)	ERSEM, Jorn Bruggeman	2,4
Biodiversity maintenance	Biological checks and balances	<i>Ensuring that biodiversity remains at a similar level through time</i>	Ana Queiros	1
Bioturbation	Bioremediation , (shellfish, sediment stability, nutrient cycling, climate regulation)	<i>Transport processes carried out by animals that directly or indirectly affect sediments</i>	ERSEM, Ana Queiros	1
Erosion, Transport, Deposit, Consolidation	Bioremediation	Hydrodynamic processes caused by humans, e.g. through trawling		4

Process name	Process (in brackets)/Service it feeds into	Definition	Who can provide data?	Group
Fish quality, age and length	Food provision	Fish caught need to be of a certain length, Slow growth can be used as an indicator of low health/quality	ICES	3
Food web dynamics	Bioremediation	<i>Patterns of change or stability of trophic interactions</i>	EwE, ERSEM	1,2,3,4
Habitats (all)	Food provision	<i>The combination of food, shelter and physical/chemical gradients suitable to a species</i>		1,2,3,4
Jellyfish	(Food web dynamics)	Diet, size of jellyfish	Andrew Hirst, EwE, SAHFOS, WCO	1
Larval supply - fish	Food provision	<i>Supply of planktonic larvae to the adult habitat</i>	SAHFOS, WCO, EwE, DivERSEM	3
Macrophyte production	(Sediment stability, bioturbation, habitat provision)	Primary production of macrophytes	EwE, ERSEM, Mike Burrows, Nessa O'Connor	1,3
Microphyte production	Bioremediation; Food provision, (2nd production, nutrient cycling, climate regulation)	Primary production of microphytes	EwE, ERSEM, Remi Vergnon	1
Nutrient cycling	(Macrophyte production, primary production, benthos)	<i>Nutrients are cycled through the food web</i>	ERSEM	1
Pelagic primary production	(Larval supply, Benthic secondary production)	<i>Planktonic contribution to gross primary production</i>		3

Process name	Process (in brackets)/Service it feeds into	Definition	Who can provide data?	Group
Pelagic secondary production	Food provision , (Fish)	<i>Pelagic contribution to turnover of biomass through grazers</i>	ERSEM, EwE	3
Recruitment	Food provision , (Flora and fauna)	<i>Recruitment is a life stage step where fish and shellfish go from larval stages to becoming part of the stock (that can be harvested)</i>		1
Secondary production	Food provision , (charismatic megafauna, fish, nutrient cycling)	Turnover of biomass, Grazers	EwE, ERSEM, Remi Vergnon, Andrew Hirst	1,4
Sediment stability	Bioremediation , (shellfish, bioturbation, habitat provision)	<i>The maintenance of sediments in the place that they assembled which leads to better habitat maintenance for species in sediments and allows burial of wastes and excess carbon until it is moved again</i>		1,2,3,4
Shellfish	Food provision; Leisure, recreation	<i>Invertebrates that can be harvested for human consumption</i>	EwE, ICES, StrathE2E, Angus Atkinson, Jan Hiddink	3
Stock/Fish, Fish biomass	Food provision; Leisure, recreation (charismatic megafauna)	Standing stock of edible fish, (group 4): originally referred to tertiary consumers within a food chain so both carnivores and apex predators (Trophic level 4-5 in Group 3)	MIZER, EwE, Paul Blackwell (module ensemble), ICES, StrathE2E, Jan Hiddink, Angus	1,2,3,4

Process name	Process (in brackets)/Service it feeds into	Definition	Who can provide data?	Group
Support of breeding populations	Food provision; Leisure, recreation	The status of the breeding populations as indicated by male:female ratio, or adult:juvenile ratio	ICES? EwE, also for mammals	3
Top down	Bioremediation	Impacts that influence services from the top down such as fishing, trawling		4
Top predators, charismatic megafauna	Leisure, recreation	<i>The abundance and well-being of top predators and charismatic species</i>	RSPB Sealife survey, EwE, ERSEM, StrathE2E but might have them all joined rather than separated by different species	1,3,4
Toxic blooms	Biological checks and balances; Leisure, recreation	<i>Mass occurrence of harmful algae</i>	DivERSEM, SAHFOS, WCO	3
Trophic cascade	Food provision, (food web dynamics)	Changes in traits and size of lower levels in the food web after removal of top predators	EwE, StrathE2E	1

MERP and MSFD indicators

One new group formed to discuss how MERP can aid in the definition of indicators for the EU Marine Strategy Framework Directive's good environmental status. This group consisted of Axel Rossberg, Tom Webb, Ana Queiros and Icarus Allen and Paul Somerfield. Nicky Beaumont joined at a later stage. This group agreed that there is good coherence between MERP capabilities and MSFD indicator needs. Axel Rossberg therefore recommended to actively seek opportunities to address policy needs within MERP and to frame ongoing work into this framework. Further outcomes of this group discussion are reported in Appendix 2 of the report.

Over-Arching Outcomes

- The community present in Drymen selected four ES for focus in MERP: Food provision, Bioremediation of waste, Biological checks and balances, and Leisure & recreation. These were selected, because they are important for both policy and stakeholders and there is good expertise on the underlying processes of each of these ES within MERP (Figure 2).
- Key processes supporting these ES were identified.
- The dialogue amongst empiricists, modellers and ES researchers facilitated work towards the goal of having all models and data combined and used in the ES approach.
- Information on data availability and data needs was exchanged within and among the working groups.
- It was identified that some natural scientists need to have a better understanding of what the ES outputs would look like, and how these would fit into the wider academic, policy and management spheres. Methods to address this need were discussed.
- There is now a good basis of understanding of the ES concepts across the MERP community.

Summary of outcomes from the discussions

These notes are a reflection of the flip chart workings

Group 1:

In a first attempt the services were split initially into the following types: food provision; leisure, recreation; aesthetic experience) and regulating services. Into this matrix the other services were interspersed. Then Icarus proposed drawing log size vs log biomass and then disperse the respective services and processes onto this function. This map was used to note down where people of group 1 could contribute to.

Group 2:

This group made many comments on each process and service onto the paper. They started off with services and looked which processes are important to understand the service. They defined 'Habitats' as processes rather than

services. They added biofuels as a service and interlinked it with bioremediation and climate regulation as well as food web dynamics. Climate regulation has a top-down effect on hydrodynamic processes. They also have a hierarchy within the processes of hydrodynamic processes, feeding into nutrient cycling feeding into primary production, feeding into food web dynamics. This leads into food provision. Food web dynamics also go circle with climate regulation and back to hydrodynamic processes.

Group 3:

The trophic web underlies the ES model. Therefore, the different processes and services are laid out similar to a trophic web, with top predators and the services they provide on top (Leisure, recreation; food provision). Between them the process of biodiversity maintenance is laid out but unconnected to the rest of the 'web'. The group goes from primary to secondary production, splitting these processes into benthic and pelagic processes. They produce a second web based on the food web in which they only have the ES of bioremediation, leisure and recreation and food provisioning.

Group 4:

The connectivity amongst processes and services was identified in a hierarchical fashion, looking at top-down and bottom-up processes. The arrows were used to show where there are strengths within MERP to address these relationships. MERP has strong skills/knowledge in the following linkages:

With a strength of 4 (out of 5) and above): hydrodynamic processes to primary production, to bioremediation. Food provision has top-down control on some processes: benthos and Erosion, Transport, Deposit, Consolidation (ETDC). Stock was linked to top predators and food provision to Marine Strategy Framework Directive (MSFD), Common Fisheries Policy (CFP) and Water Framework Directive (WFD). Secondary production was linked to primary production.

With a strength of 3: Food provision to ETDC and to Benthos.

Drivers added by the group: Global policy > MSFD, CFP, WFD; Economics split into micro- and macro-economics

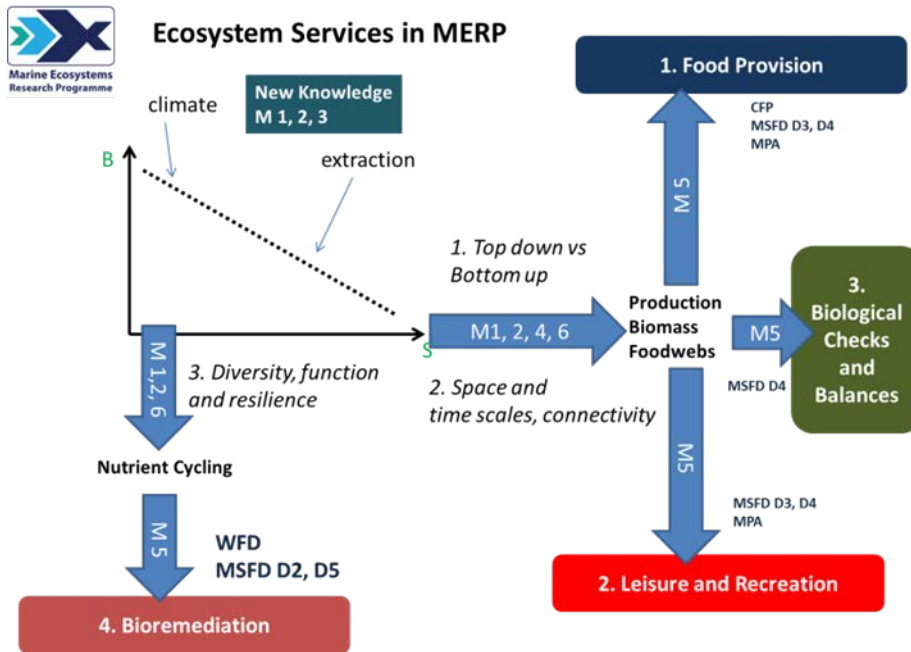


Figure 2. Schematic of the required flow of information through the MERP program in order the transfer new ecosystem knowledge (M1 macroecology, M2 new observations, M3 & M6 enhanced model processes), via model projections (M5 Model ensemble and M6 ERSEM) to support the assessment of ecosystem services (M5).

Next steps on Ecosystem Services led by Module 5

- The priorities of MERP lie with assessing the role of higher trophic levels in marine ecosystems, which is of particular relevance for food provision and leisure and recreation services. Therefore we will address the services in the following order:
 - **Food provision:** most data will be derived from models and some from sampling in Module 2. Data already accessible through Module 1 will be used to test the conceptual models
 - **Leisure and Recreation:** fewer relevant data sets are immediately available although data gathering has commenced, and model outputs could be adapted for use.
 - **Biological checks and balances:** data on some aspects of this service are available.
 - **Bioremediation of waste:** there are many data sets available as this service is underpinned by processes involved in biogeochemical fluxes which are addressed in detail in MERP.
- Module 5 will use the outcomes of the workshop to continue progress on constructing conceptual models of the links between processes, key components of biodiversity and ES
- They will seek feedback and input on the developing models from MERP consortia members: using face to face meetings, small group workshops email discussion, skype

etc. (focussing on specific groups such as birds, top predators, fish; specific processes and services; specific habitats etc.)

- Module 5 will continue to compile and access relevant data for the different ecosystem services from across, and in collaboration with, other modules in MERP in order to develop models and undertake preliminary data analysis about changes in indicators of ecosystem services in response to ecosystem changes.
- These analyses will form the basis of a paper for deliverable 5.1: Conceptual models relating ecosystem structure and processes to ecosystem services.
- To address the policy questions raised by the stakeholders, current MSFD indicators are also being assessed for their usefulness in the evaluation of ecosystem services.
- Possible ‘scenarios’ or simulations for the models will be explored collaboratively within the next 6 months
- Briefs will be prepared for MERP newsletters in ES terminology, such as Natural Capital, Stocks and Flows to enable a continued wider understanding of the ES concept, associated outputs, and how these fit into the broader policy context

Actions

The required flow of information through the project in order to deliver ecosystem services assessments is illustrated in figure 2. Ongoing actions are identified in the table below (ES: Ecosystem services group, PO: Project Office):

Action	Led by	Delivery date
Dialogue between the ecosystem services community and modellers to define scenarios within the next 6 months	ES group and PO	Ongoing initiated immediately
Prepare briefs for MERP newsletters in ES terminology, such as Natural Capital, Stocks and Flows	ES group	Ongoing, for next MERP newsletter
Create a dialogue across the MERP Consortium to establish how to handle uncertainty, heterogeneity, seasonality, vulnerability in the context of ecosystem services	Consortium wide initiated by ES Group	Ongoing initiated immediately
Deliver conceptual models of the links between processes, key components of biodiversity and ES	ES Group	Ongoing, by Month 24
Compile and access relevant data for the different ecosystem services from across, and in collaboration with, other modules in MERP	ES Group	Ongoing, throughout project
Current MSFD indicators will be assessed for their usefulness in the evaluation of ecosystem services.	ES Group with consortium input	Initiated, by month 36

Appendix 1 Workshop reports from each group

Group 1 Workshop Report - Stefanie Broszeit

Sketching the system

The group started with laying out the ES according to how they fit together. This led to a discussion on definitions which were agreed between the suggestions given and the participants. Those ES that 'benefit' directly (though the terminology of this was explained and it was changed to 'use') humans were: food provision, leisure/recreation, aesthetic experience.

All other ES were seen as supporting those three. Regulating services were put together on one side: Bioremediation of waste, climate regulation, disturbance prevention, gene pool protection. Biological checks and balances were left out at first. Primary production was split into microphyte and macrophyte production, to better integrate with the Module 2 work on macrophyte production.

Linking the system

Addition of arrows to connect the system: we started with links in the regulatory services and then connected to the other services, particularly the three 'directly useful' ES: food provision, leisure/recreation, aesthetic experience.

Then, the idea of having a biomass(or size) -trophic level relationship and posting the ES and processes onto those was proposed by Icarus. This led then to a more detailed discussion on the data that are collected within MERP and who can provide them within the group.

It was noted that for natural scientists it is easier to start with processes and then add the services that they lead to.

Harvesting and climate change were added as drivers of the systems.

Colouring in the system

Ana and Icarus joined a group on MSFD indicators. Tasman Crowe had to travel home so could not participate.

Only four ecosystem services were to be discussed: **food provision, bioremediation of waste, leisure and recreation, biological checks and balances**. Each group was to find out what each member can contribute to these services.

Present: Dougie Speirs, Mike Spencer, Andrew Hirst, Remi Vergnon, Stefanie Broszeit

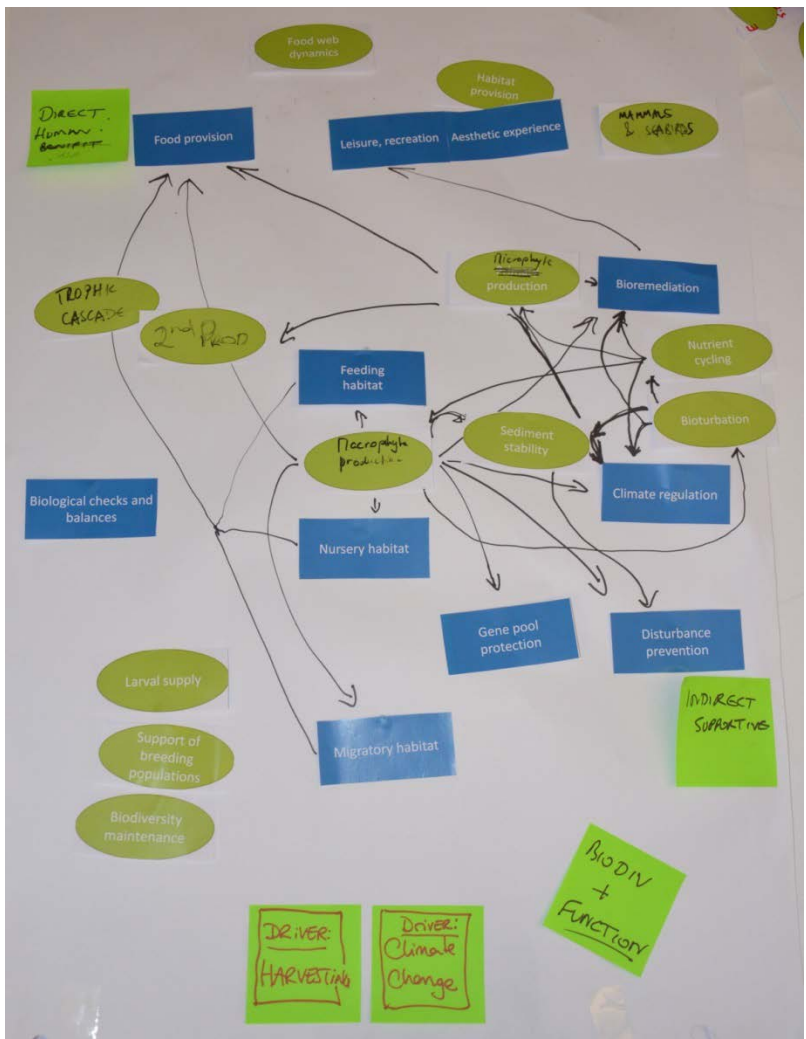
This group can contribute to Food provision and Leisure, recreation but less so for Bioremediation of waste and Biological checks and balances.

ES	Where do data come from?	Comments,
----	--------------------------	-----------

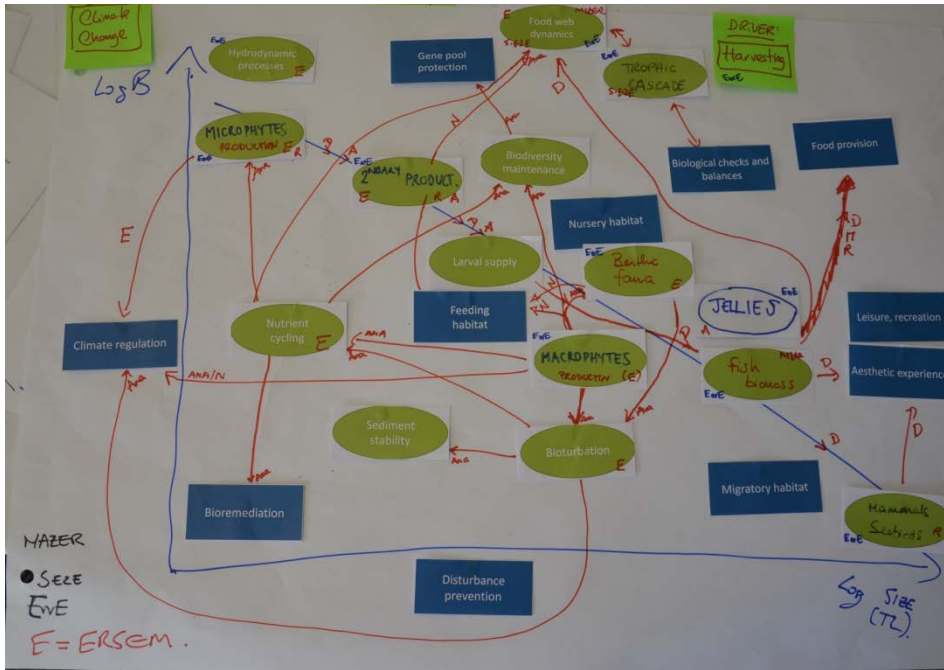
		availability?
Food provision		
Dougie	FISHSUMS: partial ecosystem model, size-structured species	
	Ensemble of 11 species: 1 cod, 2 haddock, 3 whiting, 4 saithe, 5 Norway pout, 6 herring, 7 sandeel, 8 plaice, 9 dab, 10 grey gurnard, 11 Nephrops	
	Quality of the fish not available	
	Filter feeding benthos	StrathclydeE2E
	Only Nephrops for shellfish	StrathclydeE2E
Mike Spencer	MIZER: 12 species	He sent them via email
	species composition, NS, plots and statements	
	LFI (large fish index) uncertainty	
	scenarios	
	Total mortality	
	MIZER: 20 species Celtic Sea	
Natalia	Biomass of 41 groups	
	Data from IBTS	
	Karen paper up to 2008 but now up to 2013	
	also Juvenile/adults for gadoids	
	Algae and microphytoplankton in the 2016 collection (finished)	
	Quality/diseases No	
	estimated M	
Leisure, recreation		
Remi	Abundance of key species	will send me a list
Dougie	Strathclyde has some biomass	need to ask him

Natalia	grey seals, harbour seals, cetaceans	need to ask for the list
---------	--------------------------------------	--------------------------

Dougie Watson also sent a website where the models used in MERP (and others) are described (<http://www.masts.ac.uk/research/marine-ecosystem-modelling/model-summaries/>).



Group 1: First version, generic with added Processes



Group 1: More MERP specific with information of who can provide which data (only within Group 1). The background of the structure is a biomass-abundance relationship (log-log)

Group 2 - Notes Tom Webb, Nicola Beaumont

Sketching the system

All services and all processes are linked – e.g. nutrient inputs influence fisheries, and are related to bioremediation. The risk therefore is that we decide we need to know everything in order to understand anything. The approach was to start with a service(s), and work backwards to processes. And to consider, from a MERP community point of view, which ES we can best address. Generally this seemed to be Fisheries / Food Provision. We discussed potential v realised food provision. Potential food provision is driven by biomass of key fish, shellfish species; MERP can help to understand the wider role of food webs, biodiversity, etc. Realised food provision is much more dependent on macroeconomics, fisheries policy, etc., and as such is less central to MERP core strengths.

We discussed the ability of existing data, models, and new empirical data to contribute to a range of ES:

	Existing data	Models	New data
Food provisioning	YES, core	YES, core	Some – e.g. role of macrophytes
Leisure / recreation / charismatic species	YES	No	No
Biological checks and balances	Maybe	YES	YES
Climate regulation	Maybe	YES	YES
Bioremediation	No	YES	Not really (apart from SSB links)

Colouring In Session

It is noteworthy that this group consisted only of modellers as all other members joined the MSFD group. Each of the ES was discussed in turn.

1. Provisioning services

Biomass – Jorn could provide information on filter feeders and deposit feeders, including crabs using ERSEM, providing 3D fields of biomass with some spatial distribution. This would be at 7km resolution, on the continental shelf for present day and possibly hindcast, but there are currently no plans for future scenarios Paul could provide some species level resolution, and show variation in fishing levels – possibly in 2 years, but depending on scenarios – North Sea and Celtic Sea.

Species composition

Jorn and Johan could not provide species specific information

Paul could provide some species data, including size profiles (length), and a proxy for mortality rate (biomass loss per day?). No information is available on % affected by disease. Catch outputs from Julia and Mike.

General points

ERSEM will show energy moving through the system. The model can be used to explore sensitivity to various parameters, for example to see which parameters shellfish are most sensitive to – spatial variability available in ERSEM. In the next 6 months we should be able show, using ERSEM, which of the parameters the system is most sensitive to and hence which are most likely to be important and impacted.

We need to inform the modellers of scenarios which are of interest in the next 6 months

2. Bioremediation of waste

Indicators discussed included: coliforms and pathogens (no info available); ERSEM can provide data on different N and P sps in mol/vol, as can most of the other models; some information available on Si; data on DOC, POC, and DIC available from ERSEM; currently no info available on HABs, but possible, if we can determine conditions for HABs and use these as a proxy; information on oxygen available from most models. Shellfish data available from ERSEM, although no species level resolution in benthos, only functional group level available. Biodiversity indices available from Paul. No information of toxicity, or shell fish closures.

3. Leisure and recreation

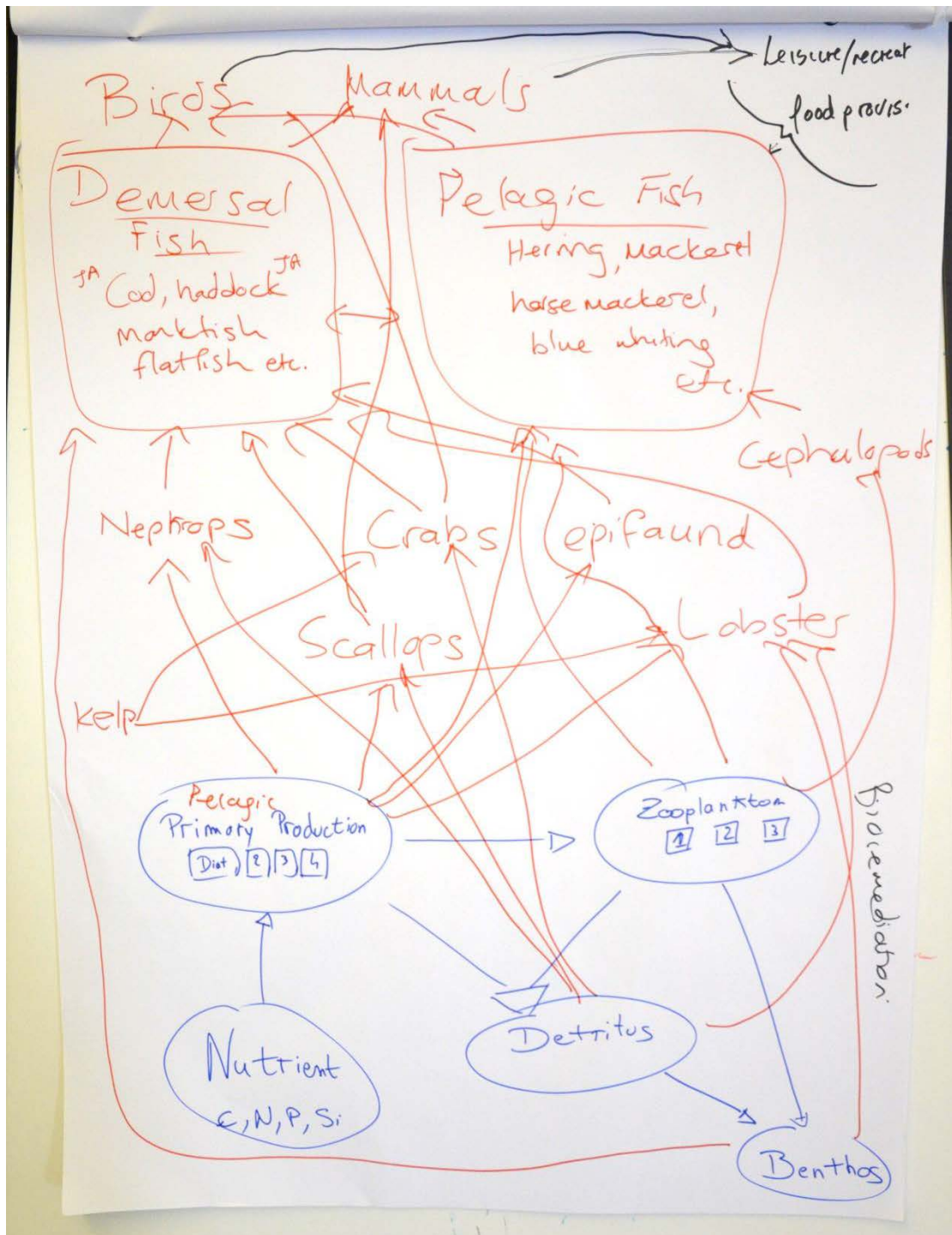
No information on: recreational fisheries, seaspace, water quality.

Some information available on visual analysis: chlorophyll levels available in Ecopath and water colour in ERSEM.

Group 3: Mel Austen, Sheila Heymans

This group started with putting services and functions together, got some links between functions and between those and services (+ and -), but then decided to go the other way and put actual food web on a sheet (ERSEM plus EwE) and added services on top of that.

Service	Models	Empirical
Food provisioning		
Fish biomass/ abundance	EwE models, StrathE2E, ICES stock assessment	Celtic Sea Jan Hiddink/Angus
Shellfish biomass/abundance	EwE models, ICES stock assessment, StrathE2E?	Celtic Sea Jan Hiddink/Angus
Kelp biomass	Mike Burrows models, EwE (WcS), Celtic?	Nessa/Nate
Fish species age/length	Models ICES, stock assessment	
Mortality rates	EwE models, ICES Stock assessment	
Waste assimilation/bioremediation		
	EwE Surplus detritus production	
Benthic biodiversity		Jan Hiddink/Angus, Celtic Sea
Pelagic indicator, fish larvae	EwE WcS fitted to sahfos plankton DIVERSEM	SAHFOS, WCO,
microplastics		SAHFOS, QC issues, PML(WCO) new PhD student
Kelp detritus/kelp production	EwE models	Nessa/Nate estimates
	Mike Burrows models	Nessa/Nate estimates offshore transport experiments
Denitrification	ERSEM STRATHE2E	
HABs	DIVERSEM	SAHFOS WCO
Biological checks and balances		
Redundancy, variability, resilience resistance	Ecopath WcS, CS ERSEM (?)	
Retrospective size spectra analysis in relation to fishing pressure		Mark Emmerson to develop
Jellyfish/HABs		SAHFOS, WCO
Seagulls stealing ice cream		BBC news
Leisure & Recreation		
Key species mammals birds seals	WcS, CS EwE models	Counts from Glasgow RSPB, etc
Fish species, skate, seabass, mackerel, crabs	Estimated by ICES, ecopath	



Group 3: Foodweb underlying the Processes leading to Services

Group 4, Stephen Watson Workshop outcomes (part 1 morning session)

The ecosystem services of **Food provisioning, Remediation of waste, Aesthetic values and Leisure and tourism** were considered to be the most important services that could be covered within the MERP programme, although others could be considered.

There was a general disagreement with many of the habitat “services” classifications with suggestions of grouping these separately or as ecosystem processes.

Gene pool diversity was considered separately as important, with links to biodiversity. Biodiversity was considered to influence all ecosystem processes and subsequently services.

Ecosystem processes were separated into “bottom up” and “top down” configurations with numbered arrows representing the strength of general understanding of the linkages between processes and services.

There was a consensus to separate production in the system into three distinct groups (primary, secondary and tertiary) that could be linked to different aspects of the MERP field data collection.

Hydrodynamic processes were added to the list of processes (i.e erosion, transport and deposition) as important links to services (i.e remediation of waste)

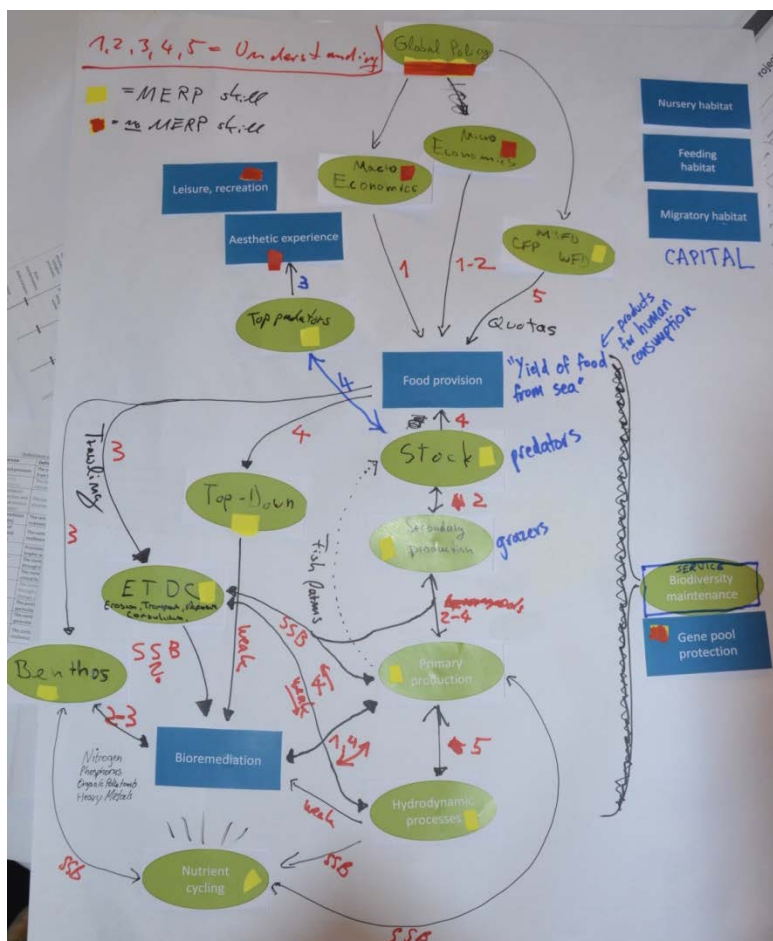
Policy drivers were added as an important link to the social-ecological system

Finally Processes and services were colored based on the groups’ opinion on the in-house knowledge to quantify various process or services within the time of the programme:

Nothing: Neutral

Red: Lack of skills/knowledge

Yellow: We can probably do



Group 4: This group used colour codes to show expertise within MERP to link Processes and Services (see text). It also shows how other projects (Mainly NERC Shelf Seas Biogeochemistry) might

Workshop outcomes (part 2 afternoon session)

Discussions focused on which data was already available within the group along and the suitability of the indicators in the Hattam *et al* paper. Three main ecosystem services were discussed **Food provisioning, Remediation of waste, and Leisure and tourism.**

Food provisioning

Biomass was considered a reasonable indicator of this service although stock/ MSY and harvest rate/harvest MSY were also discussed as suitable indicators that could be captured through various models available to the project.

Predator prey interactions were also agreed to play an important role in this service.

Remediation of waste

Indicators from the Hattam *et al* paper could be added to significantly, depending on the waste type and the scale of input into the environment.

Many of the models ERSEM, Ewe, Strathclyde etc. cover nutrient cycling aspects as does the filed campaigns suggesting a logical link to this service.

Leisure and tourism

Tom Webb identified as having contacts to this service including the appointment of a new post doc in Bangor and discussions on using behavioral indicators.

CEH have seabird distribution maps for distinct areas of the UK, while other MERP partners such as the RSPB could have quantifiable numbers for this service across the UK and beyond.

Trade-offs between the services of food provisioning and tourism services such as marine mammals could be an interesting avenue of exploration.

Appendix 2

MSFD/MERP Discussion – Axel Rossberg

The workshop recognized the importance of addressing policy needs related to the Marine Strategy Framework Directive (MSFD) for the impact of the MERP project. Seven out of 17 policy questions compiled by the SAG in response to a request by MERP related to MSFD. A presentation by Axel Rossberg summarized structure and state of play of the MSFD and provided formulations of policy issues currently faced, in a form that can directly be addressed using MERP models and data. Summarizing, MSFD "... enshrines in a legislative framework the ecosystem approach to the management of human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use." [footnote: http://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy-framework-directive/index_en.htm]. In practice, this is achieved by (1) defining a set of indicators to assess the status of and pressures on the marine environment, (2) assess whether these indicators are currently compatible with Good Environmental Status (GES), (3) adjustment of governance ("measures") by EU Member States (MS) so as to attain GES, and (4) repetition of steps (2) and (3), with the possibility of revision of (1), in 6-yearly cycles. From the perspective of MERP, key players are Defra as the internationally accountable authority in the UK, OSPAR (with help of ICES) as the policy mechanism to harmonize assessments and measure in the North East Atlantic, and the European Commission as a "referee" overseeing the process. The definition of GES as

... the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations, i.e.: [...]
MSFD, Article 3.5

can be operationalized [footnote: Rossberg, A.G., Uusitalo, L., Berg, T., Zaiko, A., Borja, A., Lynam, C., 2015. Choosing indicators and their target ranges to assess sustainable use of marine ecosystems, in: Milestone Report 13, DEVOTES Project. pp. 4–30.] as

1. aiming for efficient current uses of services derived from ecosystem functioning [societal preferences for these uses are known in principle, but the trade-offs need to be understood], while
2. enabling unknown future uses [which can be achieved by ascertaining that fast and certain recovery to the pressure-free state corresponding to the prevailing environmental conditions is always possible].

The policy process to define the set of indicators has largely come to a closure, though well justified revisions are always possible. Acute are policy needs to

- Identify state indicator target ranges
 - ... so that services are well supported (but considering tradeoffs) - or -
 - ... so that mean recovery time of the indicator to its pressure-free range of variation is short (e.g. ≤ 30 years)
- Identify target ranges for pressures consistent with state target ranges (also to inform management)
- Identify ecologically consistent target ranges for state indicators not directly describing vulnerable (slowly recovering) components
- Identify spatial scales appropriate for assessments/mgmt

A set of 11 Descriptors outlines the scope of the MSFD. The competencies of MERP are especially relevant to MSFD Descriptors 4 (Food webs), 5 (Eutrophication), and 7 (Hydrographic conditions), though the latter might not be a major policy concern. MERP competencies also apply to Descriptor 1 (Biodiversity), 3 (Commercial fish and shellfish), 6 (Sea-floor integrity) and 8 (Contaminants). Specific OSPAR indicators addressing these descriptors were listed in the presentation. The natural addressee for MERP results in this context are UK's Healthy and Biologically Diverse Seas Evidence Groups for D1, 4, 6 and the Clean and Safe Seas Evidence Group for D5, 8. The tight timeline of the current assessment cycle, with final sign off for assessments by OSPAR scheduled for mid-2016, was noted, but also the need to develop methodologies further for subsequent assessment cycles.