European Commission

Report of the 6th meeting of the Network of Experts for ReDeveloping Models of the European Marine Environment

The North East Atlantic EwE models and the MSFD scenarios

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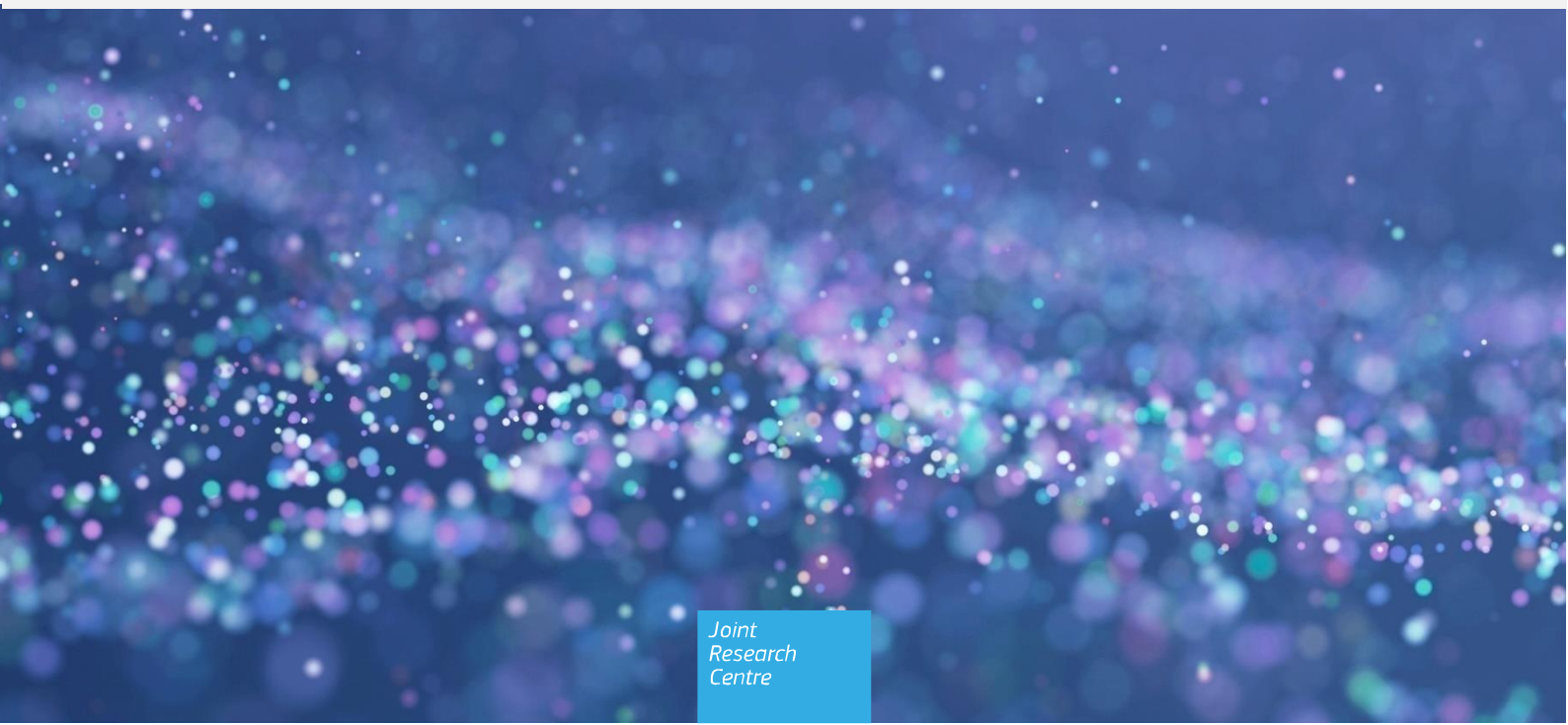

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Contents

Abstract

The sixth workshop of the "Network of Experts for ReDeveloping Models of the European Marine Environment" was held on 6-7 June 2023 in Ispra, Italy, jointly organized by DG Environment and DG JRC (Ocean and Water Unit) within the framework of the Administrative Agreement (N° 090202/2023/894429/AA/ENV.C.2- " BLUE2.3 2023-26").

This workshop, as part of the Deliverable 1.2 “Expansion of the ecosystems models for the North Western European Seas and for the South Western European Seas” of the AA, focused on the high trophic levels (HTL) modelling of the North East Atlantic (NEA) regions. The goal was to learn about existing work, using the software EwE, in coastal/continental shelf/deep areas, and assess the potentiality of the models to be used for policy scenarios testing. Part of the discussion was on models set-up (for the policy scenarios) and on possible collaborations to implement a regional NEA HTL model. This report summarizes the workshop and provides further detail on the presentations, discussion and conclusions.

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1 Introduction

Over the past ten years, the EU Commission, and particularly its science DG, the Joint Research Centre (JRC), has dedicated efforts to developing strong and reliable "earth system models". These models, which are part of the Blue2 Modelling framework (Blue2MF), aim to simulate the various elements that constitute the structure and functioning of marine ecosystems at different EU basins (e.g., Macias et al., 2019; Piroddi et al., 2021). The Blue2MF has been specifically built to explore the consequences of various management and policy options in marine ecosystems. This tool allows testing *what-if* scenarios regarding EU water policies (e.g., revision of directives) and help policy makers to evaluate the impacts on environmental variables of different management options.

To date, the JRC-Blue2MF-Food web component (also called Higher Trophic Level [HTL]), which uses the software Ecopath with Ecosim (EwE), has been fully developed and implemented for the Mediterranean Sea region (Piroddi et al 2017, 2022), and for the Black Sea (Serpetti et al in preparation) while the Baltic Sea is on its way (Piroddi et al 2023). The North-East Atlantic region remains uncovered (Piroddi et al 2023). This refers, particularly, to the North Western European Sea and to the South Western European Seas (NWES and SWES).

This workshop is part of the Deliverable 1.2 “Expansion of the ecosystems models for the North Western European Seas and for the South Western European Seas” of the AA N° 090202/2023/894429/AA/ENV.C.2) (BLUE2.3 2023-26"), which focuses on the high trophic levels (HTL) modelling of the MSFD North East Atlantic (NEA) regions.

This workshop aimed at 1) learning about existing work on HTL modelling, using the software EwE, in North East Atlantic (NEA) (coastal/continental shelf/deep) areas; 2) assess the potentiality of these models to test policy scenarios in support of the impact assessment and review process of the Marine Strategy Framework Directive.

Following the format of previous meetings (Macias et al., 2016, 2017, 2018, 2020, Duteil et al. 2023), this sixth workshop of modelling experts group (MEME) was organized as a 1.5 days workshop with selected presentations from invited scientist (see details below). Joint sessions of discussions were organized with a three-folded aims; (1) to fully understand where the ecosystem modelling community stands at EU level in terms of NEA models’ development and application; (2) to explain actual and future policy scenarios testing; (3) to investigate possible collaborations to fulfil Commission needs.

This report also includes two Annexes: (i) the list of participants, and (ii) the Workshop Agenda.

2 Tuesday morning. Blue2MF and Celtic Seas

The morning session included six presentations, by A. Stips (DG JRC), D. Macias (DG JRC), C. Fox (SAMS), S. Heymans (EMB), J. Bentley (Natural England) and D. Gascuel (Agrocampus Ouest).

A. Stips (DG JRC) opened the workshop by outlining the EU Commission's goals for developing "earth system models". He emphasized the necessity and significance of an 'integrated policy assessment capacity' in freshwater and marine environments to assess the effectiveness of EU policies and measures. In this context, he introduced the Blue2 modelling framework (Blue2MF), which has been initiated to evaluate a broad spectrum of EU policies.

The second talk, delivered by **D. Macias** (DG JRC), presented the general structure of the Blue2MF, which incorporates freshwater quality and quantity and marine models, a schematic representation on how such tool could be used in the policy evaluation cycle and a general overview of current implementations and progress of these approaches at EU scale and some specific examples of present and past applications of the Blue2MF.

C. Fox presented the ecosystem modelling of the West Coast of Scotland. The model represented the continental shelf of the ICES area Via, an area of approximately 110,000 km^2. This model was initially developed to investigate the temporal decline of gadoids in the area (Alexander et al., 2015) and to assess the temporal impact of climate change in terms of rising waters temperature on sustainable fisheries management (Serpetti et al., 2017). In space, the model was used to investigate the capability of Ecospace to gauge the impacts of renewable energy installations (Alexander et al., 2016), and the impact of low and high frequencies noise on the ecosystem (Harvey 2018). Recently was also used to evaluate the cumulative impacts of an aquaculture site (eutrophication) co-located to an offshore wind farm (low frequency noise) (Serpetti et al., 2021). The model is currently constituted by 43 functional groups, fitted to time-series (1985-2013), and resolved in space at two different grid resolutions. An updated version of the model (until 2021) is currently in development in collaboration with the JRC.

S. Heymans presented the ecosystem approach to deep-sea management off the West Coast of Scotland. This work, based on the Deepfish project, and described in Heymans et al (2011), showed that there was enough data to construct and nominally fit the model but with large uncertainties. The results highlighted that shark fishing has impacted the biomass of sharks and their diets have changed over time. However, some of their prey species (Baird's smooth-head and blue whiting) have also been impacted by fishing. Sharks were able to switch prey to some extent, but they did not necessarily change to the highest biomass species. There seem to be cumulative effects of the shark fishery and the fisheries of their prey. The presenter highlighted that the model should be re-run with the addition of newer data to reduce the uncertainties and for a possible use in policy support.

J. Bentley presented the Irish Sea ecosystem. The Irish Sea Ecopath with Ecosim (EwE) model was constructed as part of the International Council for the Exploration of the Sea (ICES) Irish Sea benchmark workshop (ICES, 2020). The objective of the model was to improve our understanding of the drivers underpinning the failed recovery of important commercial fish stocks and identify routes for the integration of ecosystem information into fisheries advice. The model includes 41 functional groups and runs from 1973 to 2020. The model was parametrised using a combination of fisheries dependent data, fisheries independent data, and fishers' knowledge (Bentley et al., 2019). In 2019 the model underwent review by the ICES Working Group on Multispecies Assessment Methods (WGSAM) and a resultant key run was published for use in ICES advice. The model has since been used to assess the impact of environmental change on ecosystem function (Bentley et al., 2020)

and develop an ecosystem-based reference point for catch advice (Bentley et al., 2021). A spatial component (Ecospace) for the Irish Sea model is currently in development in collaboration with the JRC.

D. Gascuel presented the Celtic Sea on behalf of **M. Potier**. The EwE Celtic Sea (ICES subdivisions 27.7.e, f, g, h, j2) has been built to assess the impacts of climate change and mixed fisheries on the ecosystem. This model is based on previous works from Hernvann et al. (2020, in prep) and was mainly used to assess climate impacts by 1) simulating a fishing status quo management scenario and 2) forcing the EwE model with parameters of sea temperature and primary production from the regional POLCOMS-ERSEM climate model, under both RCP4.5 and RCP8.5 scenarios. Simulations were carried out until 2100. Results show a drastic decrease of Boreal species over time compared to the current period but also a generalized decline of all ecosystem compartments. A decline which goes steeper with increasing trophic levels, suggesting a trophic amplification of the signal. Results also show a redistribution of total biomass due to changes in primary production which could lead to a higher dependence on coastal production in the following century.

The model currently developed aims at understanding several issues that were not addressed in the works of Hernvann et al. (2020, in prep). The impact of benthic compartments and their evolution in the frame of climate change will be studied by forcing the EwE model with parameters of secondary production from the POLCOMS-ERSEM model. Then, the current and future impacts of mixed fisheries will be explored by refining the fleets within the model and forcing the model parameters by fishing effort time series by fleet. Finally, adaptative fishing management scenarios will be tested in order to face climate change and head towards Ecosystem-Based Fisheries Management (EBFM) including EBFM scenarios based on effort by fleet and based on fish sizes.

3 Tuesday afternoon. Greater North Sea, Bay of Biscay and Iberian coast

The afternoon session had five presentations, by J. Bentley (Natural England), C. Lynam (CEFAS) and M.C. Villanueva (IFREMER) in relation to the Greater North Seas ecosystems, and X. Corrales, and D. Szalaj respectively for the Bay of Biscay and the Iberian coast.

J. Bentley gave a presentation on the use of Ecopath with Ecosim (EwE) models and the need to have regional-sub-regional models for the Greater North Sea.

EwE models are most frequently developed through research grants in response to policy questions. They have been operationally used to support fisheries advice (catch and regulations), provide indicators of environmental status, simulate climate impacts, guide marine spatial planning, engage with stakeholders, and estimate the downstream impacts of ecosystem change on socio-economic factors and ecosystem services. There are growing opportunities for ecosystem models to be developed in-house by scientific government advisors, as well as in-conjunction with larger research projects. The in-house use of ecosystem models is often reactive to policy requests and can be constrained by short delivery windows. There is therefore a need for a more proactive and systematic approach to develop and update marine ecosystem models so that they can be more readily deployed in response to policy requests. An opportunity has been identified for models in the North Sea and Celtic Seas: there are models available for multiple regions in this area however the capacity to rapidly deploy them, particularly for evidence needs that bridge multiple areas, is limited due to their different structures and operational status'. Options are currently being explored to 1) develop a systematic pipeline that enhances the operational capacity of an ensemble of models for the Celtic Seas and North Sea and 2) develop regional models that cover the extent of the Greater North Sea and Celtic Seas in line with ICES ecoregions, OSPAR areas, and MSFD areas.

C. Lynam showed the substantial progress that has been made for the North Sea EwE model e.g., developing an Ecospace module through multiple EU and UK projects. Grey seals, harbour seals, and harbour porpoise have been explicitly modelled through the UK Ecostar project (with the University of St Andrews) and scenarios are being developed in relation to change in the distribution of man-made structures (in particular oil and gas infrastructure and offshore wind turbines). Model scenarios have also been developed to investigate the effectiveness of Marine Protected Areas and the restoration of oyster beds to improve biodiversity in a changing climate within the FutureMARES project, with similar studies in all European regional seas (due to complete June 2025). Within project GES4SEAS, model outputs will be used to improve quantitative inputs to Cumulative Impact Assessments following the SCIARM approach. For GES assessments a comparative model approach has been developed across regional seas within the project SEAwise. Together these projects demonstrate the benefit of model scenarios to inform on the MSFD status and pressures assessments to inform managers with evidence-based advice of potential management measures.

M.C. Villanueva gave a presentation on the English Channel and sub-regions EwE models. The English Channel is facing major challenges due to human actions and climate change that are causing unprecedented impacts on ecosystem health. This is an environmental crisis that needs to be understood as it threatens the collapse of its living resources and the ecosystem benefits to human society. This model was built to understand ecosystem responses and adaptation to cumulative stress. She showed the main static, dynamic and spatial-dynamic set up of the model, and a set of indicators and network analysis methods that were used to assess changes in the ecosystem functioning. The time-dynamic simulations and ecological indicators over the years showed winners and losers, driven by fishing pressures and/or climate change. Spatial dynamics

have been used to highlight future distributions under different scenarios (Reference state: actual ecosystem state, Scenario 1 : closed zone [15 % of wind farms; reserve effect]; Scenario 2 : study of the reserve effect [add an optimal habitat for bivalves]; Scenario 3 : reserve effect + reef effect + climate change). focus on how to better sustain and conserve this fragile ecosystem. It focuses on "new" habitats created from the installation of offshore wind farms (OWFs) in order to project changes and potential future impact of these technology on the occurrence, distribution and ecological responses of living resources that lives in it as well as how the current exploitation can be affected in terms of production and/or economic losses.

The OWF installations showed the development of "exclusion zones". Several biomass, catch and trophic level-based indicators were calculated to evaluate how the these new habitats could affect fishing activities and main components of the food web. All the indicators were estimated and summarized by subarea. Findings suggested that the spillover effect could mitigate the negative impact of access loss on fishing activities, in a scenario of simulated closure of the area of the wind farm. The Ecospace model predicted minor catch increases near the installations as well as a slight increase in the proportion of high trophic level species. However, these spillover effects were observed to be limited in space, where projected increases in both biomass and catches are highly localized in areas adjacent to these installations. Ecologically, spillover effects seem advantageous to only highly mobile predators once an exclusion zone is effectively implemented. The presentation concluded with the need to bring experts and managers together to synthesize their ideas into a scenario simulation.

In terms of societal and economic benefits, the impacts of OWFs installations are not as advantageous as they were advertised to be. Aside from the long and complex administrative process linked to their installation, current number of OWFs installed in the English Channel seems very low to provide significant contributions for clean energy at the national level.

X. Corrales presented the EwE model for the Bay of Biscay, which was developed to evaluate fishing and climate change impacts. The food web model was fitted to available time series of data from 2003 to 2019 using the time dynamic module Ecosim considering the impact of fishing (i.e., fishing effort and fishing mortalities for those species with available stock assessment), temperature (i.e., sea surface temperature (150m depth - SST), sea bottom temperature (SBT)) and primary production (PP) (Amate et al., in preparation). The time dynamic model was fitted using environmental data from the POLCOMS-ERSEM model (Plymouth Marine Laboratory – PML) and with the downscaling ensemble modelling from the FutureMARES project.

The time dynamic model has been used to (1) evaluate, in economic terms, the different services provided by the mesopelagic layer in the Bay of Biscay to weight them against the societal benefits of its commercial exploitation, and (2) evaluate future scenarios of climate change and alternative fishing scenarios and their cumulative impacts. The spatial-temporal model Ecospace for the study area is under development. It will have different spatial resolutions (0.063° and 0.125°) and the basic input maps will include bathymetry, seabed habitat types, main fishing ports, MPAs and environmental drivers (PP, SBT and SST).

Future plans for the modelling effort in the Bay of Biscay include steps to move towards an ecosystem-based fisheries management. This could include the further application of the ecosystem-based fishing mortality reference point (Feco) in the Bay of Biscay (applied preliminary for hake) or the link between EwE outputs with stock assessment such as natural mortality (M). Finally, the consequences of climate change and the implementation of Nature-Based solutions (conservation, restoration, and sustainable fishing) on the biodiversity, ecosystem functions and service provision will be assessed using the Ecospace model and general scenarios developed by the FutureMARES project and downscaled to the Bay of Biscay.

D. Szalaj presented the Portuguese Shelf ecosystem model. The Ecopath model, parameterized for the year 1986, comprises 34 functional groups, including three fishing fleets (Veiga-Malta et al. 2019; Szalaj et al. 2021). This model was calibrated against data from 1986 to 2017 and driven with fishing effort and Sea surface temperature (SST) to assess the impacts of fishing and the increase in SST on the marine ecosystem. Ecosim's time dynamic model revealed that trophic interactions, fishing, and increasing temperatures were the primary drivers of ecosystem dynamics (Szalaj et al. 2021). Moreover, future predictions highlighted the considerable effects of increasing temperature on marine ecosystem (Szalaj et al. 2022). Currently, the Ecospace model is under development to assess whether the impacts of climate change on the future distribution of marine species can be mitigated by management actions such as Marine Protected Areas (MPAs) and reductions in fishing effort. To achieve this, an Ecospace model (Szalaj et al. in prep) was parametrised and coupled with environmental dataset produced by the marine ecosystem model ERSEM coupled to the regional ocean circulation model POLCOMS. Climate scenarios (CMIP RCP4.5 and RCP8.5), combined with scenarios implementing a 30% reduction in fishing effort and implementing MPAs covering 30% of the Portuguese shelf were assessed.

Results from Ecospace, the spatial-temporal dynamic model, displayed variable responses of ecosystem components to changing climate conditions (Szalaj et al. in prep). Some species/groups exhibited positive responses to climate change, while others did not. Particularly noteworthy was the substantial decline projected for sardine populations, especially in the southern region, across both climate scenarios. Significant differences were observed between the RCP scenarios, with more adverse effects under RCP8.5. Additionally, species projected to increase in the RCP8.5 scenario showed a northward migration trend, implying climate-induced shifts in species distribution. The results underscored that the implementation of MPAs and reduced fishing efforts could mitigate the adverse impacts of future climate changes. Eight groups benefited from both measures, while five benefited solely from effort reduction, suggesting that effort reduction was more effective in these simulations.

Both climate scenarios indicated declines in most catch-related indices, with RCP8.5 showing more pronounced effects. Comparing the scenarios, biomass-related indices declined more significantly in RCP8.5, while trophic-based indices, marine mammals, bird biomass, predatory biomass diversity indices, and MTI increased in both scenarios. Notably, Ecological Network Analysis (ENA) indicators depicted more severe effects in the RCP8.5 scenario, suggesting an ecosystem becoming more efficient yet less stable and resilient, with diminished recovery capabilities from perturbations. Importantly, the application of management actions did not exhibit any discernible effect on the overall ecosystem indicators.

The day closed with a short general discussion session on best practices to be adopted to 1) implement a regional NEA model, 2) to make models standardized and operational, and 3) funding to pursue the construction/implementation of NEA regional model.

4 Wednesday morning. Policy Scenario testing preparation

C. Piroddi presented specific examples of past applications of the Blue2MF in support of EU policies (Piroddi et al. 2021). She introduced the new Commission policy needs, which aim to use the models scenarios in support of the impact assessment and review process of the MSFD. Indications were given to the participants on their potential contribution in assisting the Commission, e.g., further building and/or refining the MEME models for policy support. She presented the general scenarios testing, specifying the time scale, the descriptors and criteria to be analysed and the specific scenarios (e.g., nutrients reduction, fishing reduction, MPAs under climate change 4.5).

The rest of the morning was given to scenarios testing set up, which included preparation of hydrodynamic-biogeochemical models data to be used for EwE models, draft of an excel file with needed HTL-LTL data. The JRC agreed on providing a version of the spatial temporal module of EwE to allow the MEME modellers to perform the necessary scenarios in space and time.

Next tasks and timeline for the scenarios:

- LTL-JRC data and a spatial-temporal module of EwE will be sent to the MEME experts to run the scenarios (September 2024);
- Scenarios runs (mid 2025);
- Analysis and assessments of the scenarios by JRC/experts (end of February 2026);
- Final report with results/analysis (end of March 2026).

5 Conclusions

In a conclusive part, the role of modelling in policy development has been highlighted. The day concluded with the JRC modelling team thanking the attendees for the enthusiastic participation and for the willingness to support the Commission with the policy scenarios testing.

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List of abbreviations and definitions

Abbreviations	Definitions
AA	Administrative Arrangement
Blue2MF	Blue 2 Modelling Framework
EBFM	Ecosystem-Based Fisheries Management
ENA	Ecological Network Analysis
ERSEM	European Regional Seas Ecosystem
EwE	Ecopath with Ecosim
Feco	Ecosystem-based fishing mortality reference point
GES	Good Environmental Status
HTL	High Trophic level
ICES	International Council for the Exploration of the Sea
LTL	Lower Trophic level
MPA	Marine Protected Area
MEME	Network of Experts for ReDeveloping Models of the European Marine Environment framework
MTI	Mixed Trophic Impact
MSFD	Marine Strategy Framework Directive
NEA	North East Atlantic
NWES	North Western European Sea
SWES	South Western European Sea
PP	Primary production

Abbreviations	Definitions
POLCOMS	Proudman Oceanographic Laboratory Coastal Ocean Modelling System
PML	Plymouth Marine Laboratory
SBT	Sea bottom temperature
SST	Sea surface temperature
SWES	South Western European Seas
WGSAM	Working Group on Multispecies Assessment Methods

Annexes

Annex 1. List of participants

#	Name	Institute
1	Jacob Bentley	Natural England, UK
2	Chris Lynam	Cefas, UK
3	Ching-Maria Vilanueva	Ifremer, France
4	Didier Gascuel	Agrocampus Ouest, France
5	Clive Fox	SAMS, Scotland
6	Sheila Heymans	European Marine Board
7	Xavier Corrales	AZTI, Spain
8	Eider Andonegi	AZTI, Spain
9	Dorota Szalaj	ICM-CSIC, Spain

Annex 2. Agenda

Day 1 –Tuesday 6 June	
10:00	Workshop opening and welcome address by JRC Round table introductions ALL Background (Blue2 and MEME) and review of scope and desired outcomes JRC
10:30	**Session I - NEA Models**
11:30	*Coffee Break*
11:45 **Session II - NEA Models**	
13:00	Lunch Break
14:30	**Session III – NEA Models**
15:30	Coffee break
16:00	**Round Table - modelling the NEA MSFD region**
17:00	Discussion day 1
18:00	***CLOSURE OF DAY 1***
19:30 Social Dinner	
Day 2 –Wednesday 7 June	
09:30	**Session IV – Blue 2.2/2.3 exercise**
11:00	Coffee break
11:15	**Round Table – preparing the scene for the Blue2.3 exercise**
12:15	***Conclusions and next steps***
13.00	***END OF THE WORKSHOP***

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