JRC CONFERENCE AND WORKSHOP REPORT

Report on the fourth workshop of the Network of Experts for ReDeveloping Models of the European Marine Environment

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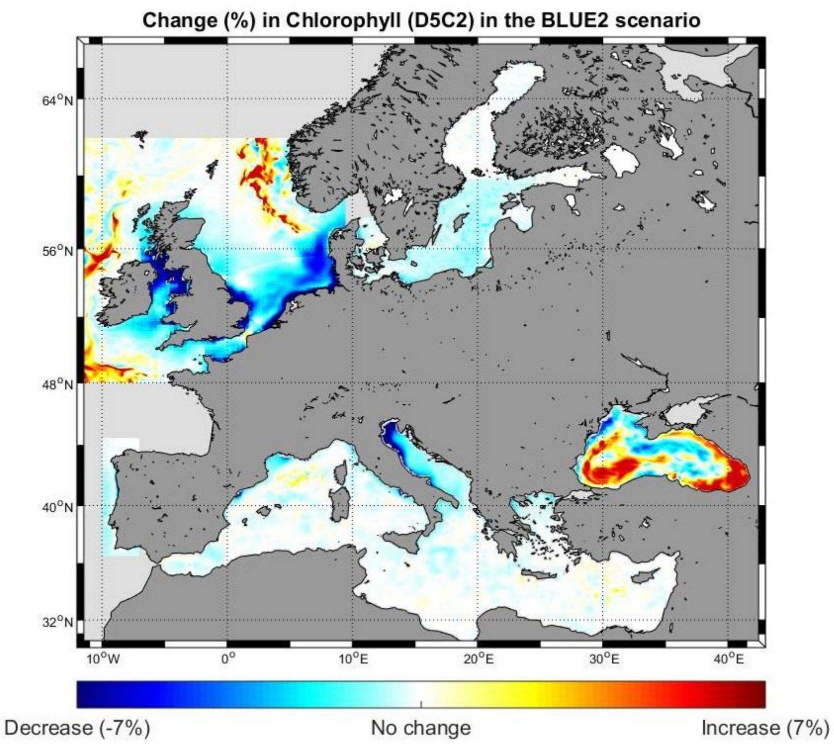

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Foreword

The fourth workshop of the 'Network of Experts for ReDeveloping Models of the European Marine Environment' was held on 19-20 November 2019 in Ispra, Italy, jointly organized by DG Environment and DG JRC (Water and Marine Resources Unit) within the framework of the Marine Strategy Framework Directive (MFSD). The aim of this workshop was to continue the information exchange between the Commission and marine modelling experts with a particular focus this year on the links between land-based management options and their impact on different aspects of the marine ecosystems downstream. A multi-model ensemble approach was followed in which different marine models for the diverse EU basins were fed with common rivers' load scenarios based on a set of pre-defined pressures at continental level. Both low-trophic level models and high-trophic level models were involved in the exercise to increase confidence in the results and to assess the uncertainty associated to model structure and deficiencies. In total 19 research groups from different MS institutions provided 13 low-trophic levels models and 9 high-trophic levels models to the ENSEMBLE. General and basin-specific conclusions on the impacts of the freshwater scenarios on descriptors associated to the MSFD were drawn from the different simulations. This report summarizes the workshop and provides further detail on the presentations, discussion and conclusions.

1 Introduction

Marine and coastal waters find themselves at the end of a pipeline as they are impacted by management options realized far away from them (e.g., agriculture measures and waste water management plans). In order to understand how policy options could influence the status of marine ecosystems and their provided services, a holistic, integral approach to the land-sea continuum is necessary. The main aim of the major EU Marine Directive (the Marine Strategy Framework Directive, MSFD) is to achieve the "Good Environmental Status" (GES) in EU jurisdictional waters through the implementation of measures to be decided by each individual member state (MS). Many of these measures are land-based, as the main allochthonous source of inorganic nutrients to coastal and marine ecosystems are river outflows. Hence, it is necessary to create and apply tools that can resolve the complex connection between agriculture, manure management and urban waste water treatment with the ecological status of the marine ecosystems receiving those impacts.

The EU Commission, and in particular its science DG, the Joint Research Centre (JRC), has been working on building robust and reliable 'earth system models' which incorporate all the elements necessary to simulate the different compartments that influence the dynamics of marine ecosystems. These models (the 'Marine Modelling Framework', MMF) have been used to test the impacts of diverse management options on the status and services of marine ecosystems at different EU basins (e.g., Macias et al., 2018; 2019; Miladinova et al., 2017; 2018).

A common approach to increase the reliability of model predictions and decrease their uncertainty is to use an ENSEMBLE of different models to study the same process. In fact, by imposing the same management scenarios to different modelling tools, it is possible to determine consistent reactions to the forcings and identify those aspects where models diverge in their predictions. With this approach in mind, the marine modelling team of JRC unit D02 launched a call to marine modelling experts from outside the Commission in order to participate, for the first time, a Pan-European multi-model comparison of the impacts from freshwater management plans on coastal and marine ecosystems.

19 research groups responded to the JRC call, providing 14 low-trophic level (LTL) models (involving hydrodynamic models and biogeochemical models) and 9 high-trophic (HTL) level models (describing the food-web structure of marine ecosystems) to the exercise. All LTL models were provided with two scenarios regarding freshwater quality and quantity. Both river scenarios were developed by the hydrological modelling team at JRC D02 based on the actual state of pressure on freshwater resources (REF (reference) scenario) and on a list of potential measures to be taken on both water usage, point-source nutrient pollution and diffusive-source nutrient pollution (BLUE2 scenario).

The impacts of these river scenarios (REF and BLUE2) on marine ecosystems have been evaluated by the different LTL models for all EU basins through the use of indicators as provided in MSFD descriptor 5, Eutrophication. Those changes (e.g., increase/decrease in nutrients and/or primary production), then, have been fed into the HTL models to assess how the perturbation propagates up the food web. As for LTL models, MSFD indicators, particularly D1, biological diversity; D3, commercially exploited species; D4, marine food webs were used to evaluate the impact.

The workshop of modelling experts group (MEME) was hold to present and discuss the outputs of the ENSEMBLE with the experts. It was the fourth MEME workshop and organized as a 2 days meeting with 4 sessions to represent the main EU marine basins: 1. Mediterranean, 2: Southern Seas (which included the Black and Iberian Seas); 3. Baltic Sea and 4. North West European Seas (which included the North, Irish and Celtic Seas). The results from the LTL and HTL models for each basin were presented by JRC scientists and discussed with the whole community.

This fourth workshop of the modelling experts group was initiated to strengthen the collaboration and awareness within the network and provide a first scientific assessment of the impacts of pan-European land-based measures regarding freshwater quality on marine and coastal EU ecosystems.

2 Tuesday morning

The workshop was opened by **J. del Salle** (DG ENV), who presented aims and objectives of the EU Commission regarding the development of modelling tools. Jacques mentioned the need and importance of an 'integrated policy assessment capacity' in the freshwater and marine environment fields to evaluate the effectiveness of EU policies and measures. In this context, an integrated, holistic approach including freshwater quality & quantity models with the marine modelling framework (MMF) has been developed within the BLUE2 project to assess a full range of EU policies. The new EU GREEN DEAL is the backbone of the future work of DG ENV and, even if marine waters are not part of single headlines (boxes), they are included in several ones, e.g. addressed by the Clean Air and Water Action Plans. For the near future, the work within BLUE2 and its follow up will focus on four basic priorities:

- Understanding & modelling of the baseline situation and most important socio-economic drivers until 2030 (if possible even until 2050)
- Suitable policy scenarios of the freshwater – marine continuum will be developed, including Programme of Measures (PoM) of MSFD, WFD, GES thresholds (where possible) and an updated database of measures
- Using and applying the developed modelling capabilities, with focus on 5 key pressures: water abstraction, nutrients, fishing pressure, contaminants and litter
- Networking with the wider scientific community with the aim of obtaining robust model results directly transferable into management strategies

A. Stips (JRC), followed with a welcome to the meeting in which he explained the BLUE2 initiative and how this work has allowed to link hydrological and marine (LTL-HTL) models in a common framework within the JRC. He also explained the potentials of using an ENSEMBLE approach, especially in the context of providing sound support to decision making. By using independent and diverse modelling tools to assess e.g., the impacts of different freshwater scenarios it is possible to reduce the uncertainty in the predictions and, hence, improve the confidence in the models by stakeholders.

B. Grizzetti (JRC) provided the next presentation, by explaining the freshwater modelling tools and the different scenarios considered. The GREEN model is a statistical model that largely builds up on Geo-databases of the sub-catchments (up to 7km^2 resolution). Using a European-wide dataset of nutrient concentrations in freshwater systems covering the period 2008-2012, GREEN has been validated and proved to be suitable for scenario simulations. Within the context of the BLUE2 initiative, several scenarios regarding the implementation of measures affecting freshwater amount and nutrient concentrations were developed, assuming different intensities of measures' implementation. In the context of the ENSEMBLE exercise, two freshwater scenarios were considered: REF and BLUE2. REF (reference) is based on the actual state of pressures at EU level, it's a representation of the present day conditions in EU rivers. The BLUE2 scenario (high technical feasible reduction) included the upgrade of wastewater treatment plants to the highest possible standard and an optimal fertilization, meaning that the fertilizer surplus is kept minimal (10% of the spread fertilizers remain unused and enter the freshwater). At Pan-European scale, the BLUE2 scenario resulted in a reduction of nutrients ending up at sea of 14% for Nitrogen (N) and 20% for Phosphorus (P). The reduction of N (P) loads originated from agriculture was 70% (16%) and from point sources 30% (84%). The GREEN output produced within the BLUE2 framework covers only the years 2005-2012 (as the updated Geo-databases are covering only this time span), but longer time series (1980-2005) were produced with previous versions of GREEN and could be made available. The BLUE2 scenario means a strong reduction of P loads from point sources and is thereby the end of the line of P load reduction from non-agricultural sectors.

The discussion following Bruna's presentation included questions related to the application of possible phosphate reductions beyond what was considered in the BLUE2. The answer was that different reductions could be considered/applied however they need to be evaluated together with policy makers to make sure they are in line with expectations from different legislations. Potentially larger nitrate reductions seem possible, especially in relation to agriculture. There was also a discussion about the potential effects of climate change (precipitation/evaporation changes) on river modelling simulations. It was indicated that this is already planned for the next phase of the JRC work. There was also a request to obtain GREEN model results for a longer time-series in order to allow marine models to get a stable response. Bruna indicated that the bottleneck for their modelling tools is data availability (being a statistical model) and that is difficult to get reliable data for the past.

K. Fennel (Dalhousie Univ.) gave a keynote presentation on a global synthesis of control mechanisms for coastal hypoxia (published recently, Fennel & Testa, 2019, https://doi.org/10.1146/annurev-marine-010318-095138). The authors divided the hypoxia areas into 3 groups (upwelling shelves, river dominated shelves and estuaries, retentive systems) and compared the time scales of hypoxia occurrence with the residence times (e.g., if residence time is high, large-scale hypoxia can occur). For the river-dominated systems the authors found a surprisingly significant linear relationship of N and P loads, resulting in N:P ratios highly above Redfield ratio leading to hypoxia. Further, 3 examples of 3D-LTL-models (Baltic Sea, Gulf of Mexico and East China Sea) were presented, which were enhanced by an element- and age-tracing technique (as part of the post-processing), which allowed to quantify the importance of local nutrient loads compared to external nutrient supply. The results for the different systems led to the conclusion that the nutrient reduction needs are very specific in every region and that this peculiarities (also with respect to the N:P ratios of the loads) have to be considered for suitable management scenarios. Also, for some basins such the Baltic, inorganic nutrients (phosphate) residence time could exceed 35 years indicating the need to test long-term scenarios in order to obtain meaningful effects.

The first ENSEMBLE presentation was delivered by **D. Macias** (JRC) showing the results of this exercise using LTL models for the Mediterranean Sea. In particular, four different LTL models were included in the ENSEMBLE, with different configurations, diverse horizontal and spatial resolutions and biogeochemical model structures. All models were provided with the same rivers' conditions coming from the GREEN simulations for the REF and BLUE2 scenarios (2005 – 2012). The main results for this basin highlight a general improvement of D5 related indicators such as nutrient concentrations (D5C1), chlorophyll-a (D5C2) and bottom oxygen (D5C5) concentrations in the BLUE2 scenario compared with the REF. All models show a high level of agreement, indicating improvement of the different descriptors for the same areas of the basin. The largest effects are found for all models within the Adriatic Sea while impacts are less evident in the Ionian and Eastern Mediterranean. The only indicator that increases in the BLUE2 scenario is the free inorganic nitrogen in surface waters. Model results are less coherent for this indicator but most of them show regions where surface nitrate concentration increases with the BLUE2 scenario. Nitrate is the 'non-limiting' nutrient in many regions of the Mediterranean Sea, so when phosphate inputs (the limiting nutrient) is reduced relatively more that nitrate in the BLUE2 scenario, this provokes an increasing amount of unused nitrate to remain free in the marine waters. Per se this increase of free nitrate in the Mediterranean Sea might not be deleterious for D5 indicators (it can't provoke phytoplankton grow as long as there is no phosphate available) but it can be conductive of unforeseen problems not considered by the applied models.

In the follow-up discussion one question concerned the load reduction (i.e., if it was only applied to inorganic loads or also organic loads, or if organic loads were considered at all). This, in fact, might have an effect on nutrients spreading and on local oxygen conditions (which showed a high variability between the models). Also, it was proposed to calculate the relative changes only over the shelf areas (up to 100/ 200m depth) instead of open sea areas, which could be a suitable extension for the calculated rates of change of the MSFD regions. Other questions related to the way the different models dealt with sediment biogeochemistry and if there were changes between the scenarios; the relation between nutrient loads from EU28 for the overall region (e.g., African Mediterranean countries); the spatial difference of areas with N- or P-limitation and possible explanations. JRC pointed out that a comparison of nutrient loads provided by GREEN with observations for the large rivers was done, showing a good agreement, but due to the simplified (using climatologic monthly water loads) transfer of the annual loads to monthly values some differences are additionally caused.

C. Piroddi (JRC) delivered the next presentation of the morning by showing the results of the HTL modelling for the Mediterranean Sea. Three models were taking part in this ENSEMBLE exercise, all of them based on the Ecopath with Ecosim (EwE) tool, but applied to different regions/areas of the Mediterranean Sea (only the JRC model covered the entire basin). All HTL models were fed with primary production/phytoplankton biomass simulated by the JRC LTL model for the two scenarios and the relative differences in five indicators were assessed (D1.C2 Forage fish biomass; D3.C1 Forage fish catch; D3.C3 Mean trophic level of the catch; D4.C1

Species diversity index and D4.C3 Mean trophic level of the community). In general all models simulate a decrease of forage fish biomass and catches for the BLUE2 scenario, while mean trophic levels and species diversity remain mostly unchanged (or with non-significant changes). Only for the Adriatic Sea division, the JRC EwE model shows an increase of biomass and catches of forage fish under the BLUE2 scenario. The reasons for this are not yet clear but it seems related with a change in the top-down (predators) control of the system and needs to be investigated further.

In the discussion, one comment was related to the need of applying a cost-benefit analysis of nutrient load reduction measures to the HTL models to assess the economic impact of these measures on e.g. fishery sectors. Also, the suitability of the presented MSFD indicators was questioned, as they might not fully reflect the energy flux passing through the food web, suggesting other ecosystem based indicators e.g. the total system throughput to be more appropriate. Further, it was pointed out that between the 2 nutrient load scenarios only the primary production should differ, while climate forcing or fishing effort assumptions should be the same. On the other hand, it was questioned if the BLUE2 scenario may get enhanced in the future by a suitable (sustainable) fishery scenario, or if it is more suitable to switch on/off single drivers to distinguish the effects and uncertainties. Finally, it was proposed not to analyse the results for the full food web and concentrate instead on the most interesting species. Future developments should focus on 2-way coupling of the LTL and HTL models, so that changes in the HTL part are reflected consistently also in the LTL.

The next talk was provided by **S. Miladinova** (JRC) on LTL modelling results for the Black Sea. Only two LTL models were available for this marine basin although they were very different in nature. For several D5 indicators, both models showed a reduction in the BLUE2 scenario being consistent in the sign of change for 50-90% of the basin (depending on the considered indicator). In this basin, both models indicate that under the BLUE2 scenario there could be a potential increase of free, unused phosphate in the marine ecosystem. The reasons behind this pattern are similar to those leading to free unused nitrate in the Mediterranean Sea. However in the Black Sea, nitrate is the limiting nutrient, so a reduction of this nutrient will lead to more 'non-limiting' nutrient remain unused. Having excess phosphate in the marine ecosystem is a potentially dangerous situation, as it could lead to the proliferation of certain species, which can fix atmospheric nitrate (e.g., cyanobacteria). Again, the results of this modelling exercise point to the need for careful consideration of nutrient reduction plans. At least monthly nutrient loads have to be provided as forcing conditions for the scenario analysis, so the models can better evaluate the seasonal effects on nitrate and phosphate pattern in the sea.

In the discussion, it was questioned if the hypoxic area may be used as additional indicator. Further, it was questioned, if the Black Sea has to be divided into several regions to analyse the temporal development in more detail.

The presentation on Black Sea HTL was delivered by **E. Akoglu** (Middle East Technical Univ.) as he was the developer of the only EwE model for this basin. This food web model used the nutrients concentrations computed by the JRC LTL model as forcing, and phytoplankton was thus consider as 'consumer' in this food web structure. As observed for the Mediterranean HTL models, also here a decrease in forage fish biomass and catches was simulated for the BLUE2 scenario while mean trophic levels and species diversity remain mostly unchanged (or with non-significant changes).

In the discussion, it was questioned whether using phytoplankton as 'consumer' could not be the best approach for this type of exercise. The answer was that different model structures exist for the Black Sea which consider phytoplankton as producer and difference in the different methodologies could be tested. In addition, it was proposed to compare the simulated phytoplankton coming from LTL and HTL to check for consistency/accuracy.

The next presentation dealt with the Iberian façade LTL modelling. There was just one model available for this region, developed by the University of Aveiro and it was presented by **D. Macias** (JRC). This model considered only nitrogen as limiting resource, showing the strongest reaction near to the coastlines. Due to prevailing hydrodynamics, the fluctuations within the single years were quite high. Therefore a seasonal analysis of the differences between REF and BLUE2 should be more adequate for this region. At the moment, no HTL model of the area is available, but a follow up HTL model is planned.

Indeed, in a companion presentation by **E. Andonegi** (AZTI) different HTL developed for and applied in the Bay of Biscay region were shown. Both EwE models and Atlantis model have been used in the region coupled (off line) with data from the Copernicus Marine Service. The area covered by these HTL models did not include the western Iberian region but potential future collaborations could help JRC efforts to cover these regions of the EU jurisdictional waters.

3 Tuesday afternoon

O. Parn (JRC) presented the ENSEMBLE results for the Baltic Sea LTL models. In this exercise, five different models contributed to the ENSEMBLE, all with different hydrodynamic and biogeochemical structures and configurations. As for the other basins, all LTL models were provided with riverine conditions for the period 2005 – 2012 corresponding to the REF and BLUE2 scenarios and the changes in marine ecosystems indicators were evaluated. Most models agree (~77%) in their predicted sign of change for the selected indicators. However the absolute change is rather limited for most of the considered descriptors/criteria. One main conclusion that could be drawn from this experiment is that longer-time series are needed in order to see a substantial change in the Baltic Sea environment conditions.

In the following discussion it was pointed out that major changes were concentrated around the boundary of the models (Skagerrak region), which indicated a critical influence of the boundary conditions (that must be equivalent for all models). Also, it was questioned why one ensemble member was behaving so strongly different than the others. It turned out that Tallinn Technical University (Marine Systems Institute, MSI) has chosen a different way to apply the annual loads provided by GREEN. JRC promised to provide downscaled nutrient loads on monthly levels, which are supposed to represent the annual climatology better, with which MSI will repeat their Baltic Sea simulation. Additionally the local importance of inorganic and organic nutrient loads was discussed, as the dissolved organic matter makes a substantial part of the overall loads, but not being reduced at BLUE2 scenario. Over the whole ENSEMBLE, it turned out that the simulation period of 8 years was not sufficient to see coherent responses of the LTL, as nutrient turnover rates are several decades. Hence, it is not possible to testify if the load reduction measures are sufficient to reduce nutrient or Chl-a concentrations significantly.

M. Tomczak (Stockholm University, Baltic Sea Centre) showed the impacts of changing the LTL conditions on their EwE model. This HTL uses inputs from BALTSEM (LTL model) including nutrient concentrations, net primary production and the cod reproductive volume (CRV). Although, the BALTSEM LTL results were showing only small fluctuations, the HTL variables have a strong variability, which was questioned strongly in the discussion. JRC proposed to use the output of more LTL ensemble members as input for the HTL model, as long as they can provide all needed variables.

In the final discussion of the day, S. Heyman (European Marine Board) raised the question about the suitability of the selected indicators for food web changes. It seems that the selected indicators are not the most adequate to analyse the bottom-up controls of food webs included in the present exercise. It was agreed that scientifically it would be better to use other metrics, but we are bound to the legislation (MSFD descriptors) when choosing the indicators.

4 Wednesday morning

The second day of the workshop started with a plenary talk by **K. de Mutsert** (George Mason Univ.) about using ecosystem modelling to assess the impacts of nutrient and hypoxia reductions on living marine resources in the northern Gulf of Mexico. This particular coastal area is very rich on fish/fisheries and receives the loads (water and nutrients) from the Mississippi River. A LTL model was used to evaluate effects of nutrient reductions on the extent of hypoxic zones, which was further linked to a full ecosystem model to study the effects on the food web. As the extent of hypoxic zones is potentially affecting the fish ecosystem and the fisheries sector, a hypoxia task force was established (including a variety of agencies) and a target was set to reduce the hypoxic area to 5,000 km2 (recently it is approx. 15,000 km2) by 2035. Given the strong influence of riverine loads on the marine conditions in the area, the target was set to reduce the loads by 20% until 2025 (for both N and P) and to a further 45% by 2035.

To estimate the effects of different load reduction intensities, a variety of scenarios was developed and applied to the LTL model, covering a total of 35 years. Modelled Chl-a (monthly median of surface values), water temperature, salinity and dissolved oxygen concentrations (monthly median of near-bottom values) were, then, provided to the developed HTL model. This was spatially explicit (based on ECOSPACE, grid cells are approx. 5 km2) and consisted of 62 groups, which were partly further split into different life stages. The model results have been validated using trawl data, showing a good agreement. Using the observed biomasses and environmental drivers, specific response curves were established and applied to estimate the habitat capacity per grid cell. While in the LTL model, the load reductions resulted in a decrease of Chl-a and of the hypoxic area, the effects on most fish species were weak and mostly showing a slight decrease. Additionally, for the HTL simulation the changes of hypoxic zones and Chl-a were divided to distinguish the effects of single drivers. Thereby it could be shown that the decrease of the hypoxic zone had a positive effect on fish biomass (increasing), but it was less strong than the Chl-a reduction (negative) effect, so that the cumulative net effect of both caused a small decrease of fish biomass.

In the discussion, the question was raised how to include the effect of low dissolved oxygen (DO) concentrations also on the survival/ fitness of fish eggs or larvae, which are less able to migrate. New species could also appear in the wake of hypoxia extension changes, something the current model is not able to replicate. The modelled fishing efforts were following the improved DO concentrations, which might not fit with reality, as fishermen try to keep the travelled distance minimal (to reduce costs). Finally, it was questioned, if it was possible to compare the present situation with a pristine one (around 1940), before nutrient loads increased drastically to estimate the feasibility of the hypoxic zone and nutrient input targets.

The following presentation dealt with the LTL models results for the North Sea, Irish and Celtic Sea and was provided by **R. Friedland** (JRC). Four different research groups provided LTL models for this basin, differing with respect to their hydrodynamic models, structuring of the biogeochemistry and the spatial coverage. Each group did two twin model runs, one with the rivers conditions from the REF simulation and another with the BLUE2 scenario (2005 – 2012). For the BLUE2 scenario, all models show similar decreasing concentrations of nitrate and phosphate. Those reductions are stronger within the North Sea than at the Celtic Sea. There is, however, a higher discrepancy among models regarding phytoplankton biomass, two show an increase while other two show a decrease.

In the discussion, the different load reduction intensities of the surrounding countries were questioned. A more detailed in depth analysis of model results should be performed, as 2 of 4 ensemble members have a variable stoichiometry (and a more sophisticated phytoplankton growth model). This might explain the differing Chl-a reductions in the different models (compared to the quite comparable changes of nutrient concentrations). Further, it was suggested to enlarge the list of MSFD indicators by an analysis of the changed N:P ratios, as well as having a look at the seasonal (monthly) rates of change instead of the annual ones.

The final regional presentation of the workshop dealt with the HTL models of the North and Celtic Seas and was delivered by **C. Piroddi** (JRC). Four different models participated in this comparison, two EwE, one OSMOSE and one Atlantis, with diverse spatial coverage and overall structure. All these models used the outputs (primary production) coming from the JRC LTL model and the results show that 2 out of 4 models highlight a decreasing trend in biomass and catch of the forage fish group, while trophic levels of the catch and of the community show a variable change depending on the model/area.

In the discussion, it was underlined that the stochastic model (OSMOSE) showed no significant changes to the reduced loads/ net PP. Further, it became evident that only short living species (like sprat) reacted to the load reductions, underlining the need of longer simulation times. Further, it was pointed out that ECOSPACE results were strongly differing, whether vertically averaged or integrated NPP was used as input. Hence, it was concluded to assess both NPPs (averaged or integrated) as HTL input to better analyse the uncertainties induced by the differing ways of forcing the HTL model, as well as the need to standardize the way LTL outputs are provided to HTL models. Further, it was raised that HTL models of the region are heavily struggling to include migratory fish in a more sophisticated way, as they are quite important for the area.

5 Discussion session and Conclusions

A. Stips (JRC) gave a summary of the presented (preliminary) results (see preliminary executive summary) and opened the roundtable discussion. It was mentioned that a common protocol to perform model runs (especially for LTL) should be established and followed by all members of the ENSEMBLE.

J. del Salles (DG ENV) made several remarks from the policy-making point of view, including:

- We should not focus too much on the results (numbers) of this multi-model exercise, but rather on the exercise itself
- It is a very valuable initiative and we should stress the lesson learned (e.g., the need to consider the N:P ratio in nutrient reductions) and think how to best present our results to policy-makers
- It is essential to explain in lay-man terms how the different models work and how they 'communicate' to each other
- He also encouraged participating scientists to think about how their model could help with the MSFD evaluation through their home country institutions

So, for the nutrient load scenario stronger reductions seem possible and also nutrient loads for a longer period are needed (either to get more appropriate hindcast simulations and/ or to understand the long-term impact of the load reductions until some sort of steady state is achieved). S. Heymans (EU Marine Board) strongly suggested that we should be honest with ourselves when using our modelling tools, regarding what we have achieved in reality, what need to be done and on how to make our models useful (fit for purpose).

It was also suggested to enlarge the set of simulations by using each time only 1 year of loads and repeating it for the whole simulation period. This might allow to understand/ quantify the reaction of the single ensemble models to the reduced loads in a more sophisticated way, aiming to estimate the single model uncertainties better.

Also, it was mentioned that the ensemble results should be analysed more in depth, e.g. by:

I. looking also into the seasonal/ monthly rates of changes
II. finding more suitable areas than only the MSFD regions/subregions (e.g. shelf areas)
III. looking on changes of the N:P ratios .

If possible, a comparison with GES thresholds of the regional sea conventions (at least HELCOM & OSPAR) should be done. Further, as far as possible, it would be wishful to provide the input of more LTL models to the HTL models. It is planned to provide a first draft of scientific paper(s) on the Pan-European ensemble approach in March, the writing is led by the JRC MMF team but inputs from all experts are needed.

6 Preliminary executive summary of the MEME workshop

- Several nutrient reduction scenarios covering the EU28 were developed. They resulted in overall nutrient load reductions into the European Seas of on average 2%, 6% and 14% for nitrogen and 3%, 8%, and 20% for phosphorus, respectively in the BAU, NUTR and BLUE2 scenarios compared to the reference loads. The reductions differ strongly between the regions.

- The BLUE2 scenario was selected for the simulation in the ensemble modelling exercise, because of the largest expected effect resulting from the available 8 years period.

- In general implementing the BLUE2 scenario would lead to a small overall improvement of several eutrophication indicators (especially nutrient concentrations) in the different regional seas. Potentially the largest load reductions within the BLUE2 scenario could be achieved in the UK, affecting especially the UK coastal waters and the North Sea region.

- However the regional response to these load reductions is depending on the limiting nutrient in that marine region/basin. In the Mediterranean Sea, phosphate is the limiting nutrient and therefore the assumed strong phosphate reductions lead to more remaining (unused) nitrate and consequently to a worsening of that indicator. In the Black Sea, nitrate is the limiting nutrient and therefore the assumed strong nitrate reductions in the Danube river basin lead to more remaining (unused) phosphate and to a worsening of that indicator.

- From the precautionary principle it follows that the implementation of the envisaged land-based measures should take into account the nutrient situation in the receiving marine basin.

- The BLUE2 scenario leads potentially for the majority of the European regional seas and sub-regions/areas to an overall decline of biomass and catch of the forage fish group, whereas species diversity and trophic level indicator do not provide a consistent picture. The selected MSFD indicators might not be the most appropriate to demonstrate food web changes/impacts.

- The long residence/retention times of the semi-enclosed European seas are limiting the effect from these load reductions and lead only to a small improvement of the eutrophication indicators. It is therefore required to apply much longer nutrient load time series of at least 20-30 years duration.

- These conclusions are supported by the rather high degree of agreement among the ensemble members, even if models' structure and construction are very different.

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List of abbreviations and definitions

ATLANTIS: end-to-end model of marine ecosystems

BLUE2: reduction scenario for nitrate and phosphate in freshwater

CRV: cod reproductive volume

DG ENV: Directorate General Environment

DG JRC: Directorate General Joint Research Centre

EC: European Commission

EU: European Union

EwE: Ecopath with Ecosim

GES: Good Environmental Status

GREEN: Statistical hydrological model

HELCOM: Helsinki Commission

HTL: High Trophic Levels model

LTL: Low Trophic Levels model

MEME: Network of Experts for ReDeveloping Models of the European Marine Environment

MMF: Marine Modelling Framework

MS: Member State

MSFD: Marine Strategy Framework Directive

N: nitrogen

OSMOSE: high trophic level model

OSPAR: north-east Atlantic commission

P: phosphorous

PoM: Program of measures

REF: Reference scenario for freshwater conditions

WFD: Water Framework Directive

Annexes

Annex 1. List of participants

Fennel Katja

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Parn Ove

Friedland René

Garcia-Gorriz Elisa

Paris Vasilakopoulos

Stips Adolf

Annex 2. Workshop agenda

Day 1 –Tuesday 19 November	
08:15-08:30	Pickup from hotels by bus
09:00	Meeting Building 27B, Room 008
09:15	Workshop opening and welcome address by COM Round table introductions ALL Background and review of scope and desired outcomes ENV The MSFD scenario modelling exercise JRC (B. Grizzetti)
10:00	Keynote – Katja Fennel
10:30	Coffee Break
10:45	Session I – LTL ecosystem modelling Mediterranean
11:45	Session II – HTL ecosystem modelling Mediterranean
13:00	Buffet Lunch
14:00	Session III – LTL ecosystem modelling Southern Seas
15:00	Session IV – HTL ecosystem modelling Southern Seas
16:00	Coffee break
16:15	Session V– LTL ecosystem modelling Baltic Sea
17:15	Session VI – HTL ecosystem modelling Baltic Sea
18:15	CLOSURE OF DAY 1 (bus to hotels)
20:00	Dinner – Melograno (Angera, Via Cavour 13)
08:15-08:30	Pickup from hotels by bus
09:00	Day 2 –Wednesday 20 November
09:00	MEME-BLUE2 with the JRC (J. Martinsohn)
9:05	Keynote – Kim De Mutsert
9:30	Session VII – LTL ecosystem modelling NWES
10:30	Coffee break
10:45	Session VIII - HTL ecosystem modelling NWES
12:00	Buffet Lunch
13:00	Session IX – Preliminary European wide comparative analysis
14:00	Round table: Lessons for future EU level modelling
15:30	Conclusions and next steps
16:00	END OF THE WORKSHOP

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