OPEC WP2 Workshop Athens

24-25 April 2012

Contents

Executive Summary....2
General meeting summary....2
Status of related deliverables....2
Regional Model Status....5
Baltic Sea HBM-ERGOM....5
North East Atlantic POLCOMS-ERSEM....6
Mediterranean Sea POM-ERSEM....6
Mediterranean Sea OPATM-BFM-EwE....7
Black Sea POM-BIMS....8
Data Assimilation Implementation (MS9)....10
Higher Trophic Level Data Capture and Model Assessment....12
Actions....14
Participant List....15
Agenda and Presentations....15

Executive Summary

The second meeting of the Operational Ecology (OPEC) project was held in Athens on 24th-25th April 2012 and was hosted by the Hellenic Centre for Marine research (HCMR). The goal of the meeting was (1) to establish a suite of metrics that will be used to assess the skill of each regional model in forecasting the selected target variables and (2) to discuss contemporary data assimilation schemes and plans of each partner with respect to implementation. Also discussions focused on (3) the current status of all the regional models and resolving any issues that might hinder the OPEC agenda and (4) establishing a suite of target variables which will be used to assess the current and the future state of the European marine ecosystems and on which the model outputs will be mapped.

The meeting was successful with respect to achieving all of the goals above, with the majority of discussion focused on the main goals (1) and (2).

General meeting summary

The discussion centred around four topics, namely, “Regional model status”, “Common metrics on model skill assessment”, “Data assimilation” and “Higher trophic level data capture and model assessment”. For a discussion on “Common metrics on model skill assessment”, the reader should refer to the section “Status of related deliverables”.

Status of related deliverables

D2.3 Target variables and benchmarking metrics

Target Variables

The following target variables were agreed on upon considering their relevance for management purposes and the availability of data for model skill assessment:

- Winter Nutrients, DIN,DIP,DIS (J-M)
- NO3+NH4/PO4, NO3/Si
- Maximum Chl (monthly mean based)
- Oxygen Minimum
- Primary Production
- Maximum Bloom Timing
- Bloom Days Per Year
- pCO2
- + anomaly (seasonal)

- Salinity + Temperature Anomaly (seasonal)
- Transport
- Water Column Stability (MLD, PEA)
- Euphotic Depth (90%)
- Zooplankton

See "General meeting summary" for a discussion on target variables related to higher trophic levels.

Common metrics on model skill assessment

Skill assessment period will be 1990-2009 considering the ecological data scarcity in most regions and the fact that DMI downscaled forcing covers this period. Data assimilation will be repeated for 2000-2009. Assessment will be made for the whole domain considering assessment boxes and during the period where data is available. Rolling forecasts will be discussed in the December meeting.

Each region has access to in-situ or remote sensing benchmarking data for the following variables:

- Temparature
- Salinity
- DIN
- DIP
- Surface Chl-a
- Dissolved Oxygen

A common set of metrics was agreed upon for the comparison of model output and benchmarking data. These include bias, RMSD, unbiased RMSD and correlation, which are to be summarised in a target diagram (Joliff et al., JMS 2009). Model data comparison is to be done on unaggregated in-situ data, each measurement is to be compared against the closest model output in space and time.

For comparisons against satellite, chlorophyll-a data should be transformed (k^2 or omega transformations), then correlation will be computed.
Same metrics will be used in adequate assessment areas for each region.

For skill on seasonal time scales, from data and model the annual mean for each year shall be subtracted, then correlations and amplitude mismatch (std fraction) will be computed over the data time series.

For skill on interannual time scales, correlations and amplitude mismatch on annual time series will be computed (where statistically meaningful), data might require detrending, where an obvious trend would lead to spurious ("overoptimistic") correlations.

Advanced metrics are highly recommended to obtain and provide additional information not included in basic metrics. These include:

- Wavelet analysis (Saux-Picart et al., GMD 2012) for resolving model skill spatially.
- Spatial principal component analysis for the representation of dominant modes in the annual cycle.
- Multi-variate principle component analysis (Allen and Somerfield, JMS 2009) for functional relationships between variables.
- Self-organising maps for the classification of ??????

In addition to the above metrics, the following metrics will be used for certain indicators:

- Thresholds and discrimination analysis (see MEECE report on metrics)
- Bloom timing: determine bloom condition from satellite chl data through bloom threshold, e.g. median+5% of median (Racault et al., Ecological Indicators 2012).

- Bloom Maximum: interannual time series, intarannual variability + spatial variability max chl for each month, highest monthly mean among 12 means for interannual

The assessment boxes for the regional seas will be region specific and are already determined (eg: ICES areas). The separation is done generally based on hydrographical differences and/or ICES statistics, bioprovinces. Subdivisions can be made based on annual cycles. The time scales for the assessment will be seasonal and interannual.

D2.4 Description of the coupled model for each region

D2.5 Report listing meta data for validation data for regional system

Regional Model Status

Baltic Sea HBM-ERGOM

Ecosystem model compartments

Trophic level-0
- N - nitrate
- A – ammonium
- P-phosphate
- D - Labile pelagic detritus
- DO-desolved oxygen

Trophic level-1
- Diatom
- Flagellate
- Cyanobacteria

Trophic level-2
- one bulk zooplankton module
- multiple species and stage-resolved zooplankton module

Data availability for the Baltic Sea

In-situ observations for DIN, DIP, Chlorophyll a, DO are from ICES database from 1960-2009.

Forcing data: atmospheric data from DMI-HIRLAM reanalysis products and river loadings from SMHI-HBV model outputs

Operational products are available 2009-today

Hindcast data 2001-2009 are available and hindcast data 1980-1999 will be available through MEECE soon.

Forecast data 2080-2099 will also be available through MEECE.

North East Atlantic POLCOMS-ERSEM

Modelling system for the NE-Atlantic:

- Ocean Physics: POLCOMS
- LTL Ecosystem component: ERSEM
- HTL Ecosystem component: EwE
- DA: Ensemble KF applying ocean colour product

The physical component POLCOMS is preferred for all work within OPEC including the hindcast and rolling hindcast over the NEMO shelf implementation for coherence. The data assimilation and HTL coupling implementation are based on this system; additionally the NEMO shelf implementation continues to exhibit reliability problems.

Model resolution is 12km, atmospheric forcing for new hindcast experiment 1990-2010 is delivered through DMI, while river forcing, atmospheric nutrient input and SPM relaxation is based on a climatology delivered through the MEECE project. Hindcast data 1960-2004 for this system and end of century scenarios are available through MEECE.

Other current work focuses on direct validation of policy relevant indicators provided through model output with particular focus on the dealing with thresholds. Validation data is mostly based on remote sensing products and nutrient, chlorophyll-a, oxygen, temperature and salinity data available through the ICES database.

Mediterranean Sea POM-ERSEM

Modelling system

- Hydrodynamics: POM
- LTL Ecosystem component: ERSEM
- HTL Ecosystem component: anchovy IBM
- DA: Singular Evolutive Extended Kalman (SEEK) and Ensemble Kalman Filter (SEIK) assimilating satellite ocean colour

Model horizontal resolution is ~10Km, while 25 sigma-levels are resolved in the vertical.

Hindcast simulations have been performed using ERA40 (1985-1995) and Poseidon (2000-2008) atm. forcing. The new hindcast simulation experiment (1990-2009) will use DMI atm. forcing that is currently tested. River forcing is obtained from SESAME project.

Different Kalman filter variants (SEEK, SEIK, SFEK) and their localized versions are currently tested.

Validation data are mostly based on remote sensing products and some in situ data for nutrients, chlorophyll-a, pH (Medatlas 2002). Additional sources of validation data (e.g SeaDataNet) extending to the simulation period (1990-2009) will be examined.

Mediterranean Sea OPATM-BFM-EwE

The modelling system for the Mediterranean Sea at OGS consists of:
- Transport model OPATM forced by the physical forcing fields provided by Myocean;
- LTL Ecosystem component: BFM;
- HTL Ecosystem component: EwE;
- DA: 3DVAR for the assimilation of satellite surface chlorophyll.

Horizontal resolution for the Mediterranean Sea LTL model is 1/8° and the vertical discretization consists of 72 levels. The HTL model consists of one single location (the Adriatic Sea).

Current work focuses on the implementation of the carbonate module of the BFM model, the definition of initial condition and boundary conditions for carbonate system variables (Alkalinity and DIC at Gibraltar strait, rivers and Dardanelle strait) and testing a spinup run. Improvement of the 3DVAR scheme (already under testing within MyOcen) is also in progress.

Validation data is mostly based on remote sensing products available through MyOcean catalogue and eventually available in situ data for the Adriatic Sea.

Black Sea POM-BIMS

Technical details of the ecosystem model

BIMS_ECO, BIMS_CIR (Oguz et al, 2001)

- Pelagic food web model
- Nutrient cycling
- Vertical grid extends to 150 m (23 z-levels with 2 m resolution near the surface and 20 m near the lower boundary).
- Horizontal grid (0.1° x 0.0625°).

Ecosystem model compartments

Tropic level-0

- N - nitrate
- A – ammonium

  DON- Dissolved inorganic nitrogen
- D - Labile pelagic detritus

Tropic level-1

- Ps - small (<10 µm) phytoplankton
- Pl – large (> 10 µm) phytoplankton

Tropic level-2

- Zs – microzooplankton
- Zl – mesozooplankton
- Zn - opportunistic heterotrophic dinoflagellate
- *Noctiluca scintillans*
- Za - gelatinous carnivore *Aurelia aurita*
- Zm- gelatinous carnivore *Mnemiopsis leidyi*
-

Regional simulations that are available

- Ecosystem hindcasts completed.

1980 – 1999 (IPSL-CM4-V2), (ERA40), (ERA40 + assimilation of physical ocean variables)

- Ecosystem forecasts completed

2080 – 2099 (IPCC scenario A1B)

Data availability for the Black Sea

Time frame 1980-1996 (Source: Black Sea Data Base)

DIN, DIP, Chlorophyll a:

Data available from cruises etc. across the entire Black Sea. (ca. > 2000 stations per parameter).

DO: data from one cruise in open Black Sea 1993 available (19 stations) .

Time frame after 1996 (Source: SeaDataNet)

DIN, DIP: after 1996 total of 217 stations in coastal areas off Georgia available (1999, 2000, 2006,2008-2010).

DO: 98 stations available (2007-2010)

Model upgrade is progressing in 3 stages

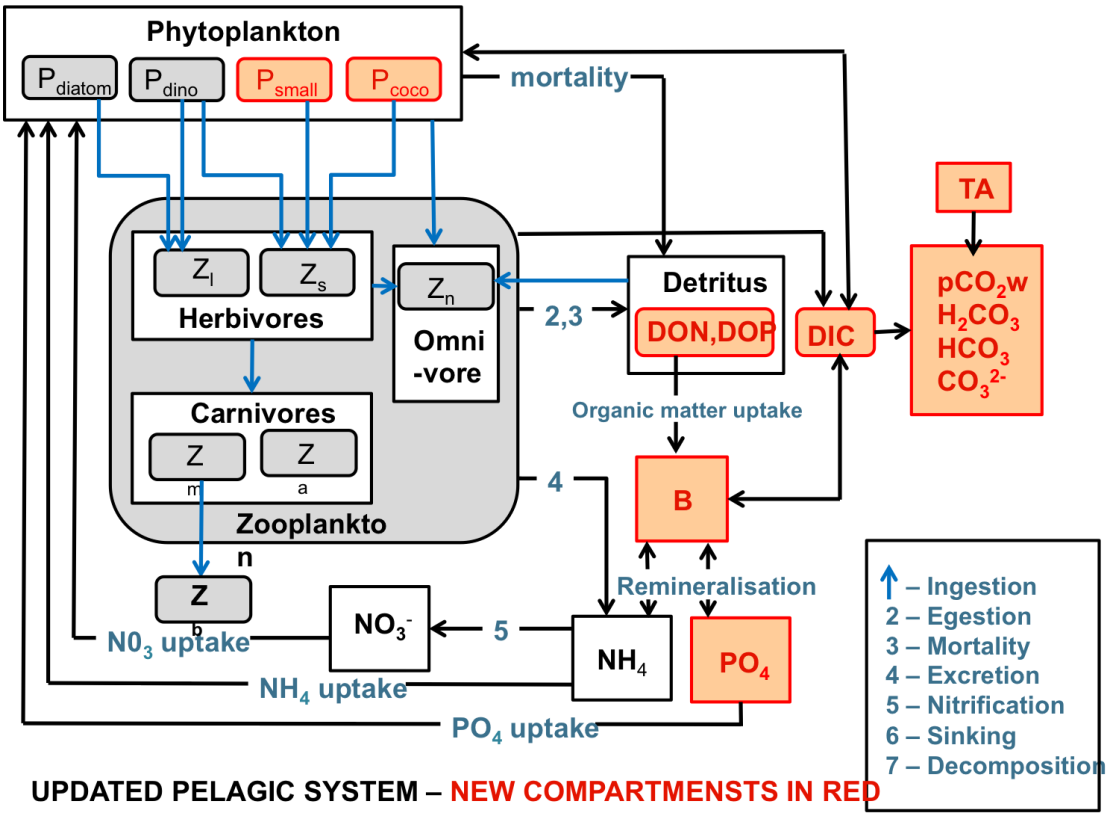
1) Additional chemical compartments

- DON
- Phosphate
- Bacteria
- Oxygen
- Carbonate chemistry

2) Additional plankton functional types

- Diatoms
- Dinoflagelates
- Small phytoplankton
- Cocolithophores

3) Oxidation-reduction at suboxic interface



Data Assimilation Implementation (MS9)

Within WP2, we are developing the data assimilation (DA) systems (Task 2.5, months 1-28) that will be used to run reanalysis simulations for each regional ecosystem (Task 2.6, months 12-18).

The main features of the DA systems and reanalysis simulations are summarized in Table 1 for each Task and Region.

The DA systems are region-specific, to better cope with the different features of the ecosystems and to exploit systems and expertise already developed by the project partners.

The assimilated data and reanalysis years in Table 1 should be considered as a preliminary indication, which will be refined at the start of Task 2.6. However, in all the regions, we will assimilate remotely sensed chlorophyll (regional products) to

run the reanalysis simulations. The length of the simulation period will be consistent with the availability of boundary conditions and forcing function in the different areas. In any case, the reanalysis will be run within a 10-year time window from 2000 to 2009.

We will apply the benchmarking metrics defined in Task 2.2.2 to assess the skill of the DA simulation and evaluate the reanalysis products. The DA skill assessment will use the same data used in the 20-year hindcasts evaluation (i.e. simulations without DA, Task 2.6). This will guarantee the comparability of the DA performance with respect to the performance of the hindcast outputs, for those years when the two simulations overlap.

However, chlorophyll data will be considered differently in the hindcast and DA assessment. Since satellite chlorophyll will be the assimilated variable, the DA skill assessment for chlorophyll, and related indicators, will be carried out using primarily independent, *in situ* chlorophyll data.

Table 1. Main features of the DA schemes and reanalysis simulations

Task (partner, contact)	**Region**	**Physical-Ecosystem model**	**DA scheme***	**Assimilated data (assimilation frequency)**	**Reanalysis years**
T 2.5.1 (DMI, Zhenwen)	Baltic Sea	HRM-ERGOM	EnOI	satellite chlorophyll (monthly assimilation)	2000-2009
T 2.5.2 (PML, Ciavatta)	NE Atlantic	POLCOMS-ERSEM	EnKF (simplified)	satellite chlorophyll (monthly assimilation)	2000-2009

T 2.5.3a (HCMR, Triantafyllou)	Mediterranean Sea	POM-ERSEM	SEEK SFEK/ ensemble (SEIK	satellite chlorophyll (8 day)	2000-2009
T 2.5.3b (OGS, Cossarini)	Mediterranean Sea	OPATM-BFM	3DVar	satellite chlorophyll (weekly assimilation)	2000-2009
T 2.5.4 (METU, Arkin)	Black Sea	POM-BIMS	SFEK/EnKF	satellite chlorophyll (monthly assimilation)	2000-2009

* EnOI : Ensemble Optimal Interpolation; EnKF: Ensemble Kalman Filter; SEEK: Singular Evolutive Extended Kalman filter; 3DVar: three-dimensional variational assimilation; SFEK: Singular Fixed Extended Kalman filter

Higher Trophic Level Data Capture and Model Assessment

Higher trophic level models will be developed for the four areas:

Baltic Cod model: DTU

Ecosystem based (Ecosim / Ecospace) model and Individual based model of Anchovy populations in the Black Sea: METU

Ecosim / Ecospace model of North East Atlantic community focussing on the North Sea: CEFAS

Individual based model of Anchovy populations in the Aegean: HCMR

Ecosystem based (Ecosim / Ecospace) model of Adriatic shelf seas: OGS

The indicators for these models are being drawn up in an Excel spreadsheet and are classified according to the Good Ecological Status (GES) classifications developed for earlier projects.

These indicators and their classifications, together with agreed resolution and time and spatial dimensions have been entered into a spreadsheet to be placed on the OPEC website. It was noted that the emphasis should be on indicators which show high sensitivity to short term changes, e.g. short lived species and productivity measures.

Species and data under consideration should fall into three categories.

- Common data which will be available via OPEC products and for which comparable data exists in all areas – population and recruitment for a small pelagic and population, population and recruitment for predator species.
- Important species which have well characterized data and model outputs and will be available in OPEC products, but for which data would not be available for all locations, for example invasive *Mnemiopsis* in the Black Sea area, and seabirds in the North Sea Area.
- Additional species which are available as model outputs in several of the models, possibly with good comparison data but will not make up an OPEC product and does not need to be presented. For example there are a total of over 40 functional groups in the Adriatic model and over 60 in the North Sea model, but some species may be regarded as of minor importance or not perceived as being well modelled e.g. Whales.

The primary data will be in terms of population, productivity (recruitment) and where appropriate (i.e. for 2D and / or size structured models) information on changes in distribution and size / age distribution. It is expected that data for population and productivity will single annual data points. Distributional data is likely to be available at the resolution of the ICES rectangle (30 nautical miles by 30 nautical miles square at 60 degrees North). The largest models, therefore, correspond only to a few hundred cells and this combined with the low temporal frequency means that there are no serious issues with the amount of data processing needed.

For productivity and population for the short lived species, particularly anchovy, a single year point to point comparison can be used in skill assessment. For longer lived species, including Herring and predator species such as Cod, skill assessment should take into account lags and may need to include some measure of temporal cross-correlation. For spatial data appropriate measures of distribution would need to be developed, taking into account, for example, that individual based models may predict spatial limits to the entire population, but density based models such as Ecospace will not since the entire area modelled will have non-zero population density. Therefore the specific area occupancy metrics will be worked out by individual groups and communicated to other practitioners.

It was agreed that those involved in HTL modelling would be in contact by correspondence or Skype to share information, methodologies etc.

Actions

T2.3 Collation of validation data M3-M12
NE Atlantic (PML, Cefas) Baltic (DMI, DTU) Mediterranean & Aegean (OGS, HCMR) Black Sea (METU)

T2.4 Implementation of the model system M1-M12 METU T2.4.1 Baltic Sea, Zhenwen Wan (DMI) Asbjorn Christensen (DTU) T2.4.2 NE Atlantic Momme Butenschon (PML) Jonathan Beecham (Cefas) T2.4.3 Mediterranean HCMR Kostas/George, OGS Jpiero/Simone D. T2.4.4 Black Sea Heather Cannaby and Bettina Fach (METU)

T2.5 Data Assimilation M1-M18 HCMR T2.5.1 Baltic Sea M1-M12 Weiwei Fu (DMI) T2.5.2 NE Atlantic M1-M12 Stefano Ciavatta (PML) T2.5.3 Mediterranean Sea M1-M18 George Triantafyllou (HCMR), Gianpiero Cossarini (OGS) T2.5.4 Black Sea M1-M18 Sinan Arkin (METU)

T2.6 Hindcast the ecosystem of each region and benchmark the target variables M1-M18 HCMR T2.6.1 Baltic Sea M1-M18 DMI T2.6.2 NE Atlantic M12-M18 PML WP2.6.3 Mediterranean Sea M12-M18 OGS, HCMR

WP2.6.4 Black Sea M12-M18 METU

Participant List

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Stefano Ciavatta, PML
Zhenwen Wan, DMI

Agenda and Presentations

Day 1
Morning Session:

09:30 Common metrics on model skill assessment by Momme Butenschon

10:00 Brief updates on the implementation of the model systems by each group

Afternoon Session:

13:30 Roundtable discussions on target variables lead by Baris Salihoglu and Momme Butenschon

14:30 Formation of documentation on common metrics lead by Baris Salihoglu and Momme Butenschon

16:00 Data assimilation algorithms and approaches by George Triantafyllou
16:30 Data assimilation algorithms and approaches by Stefano Ciavatta

16:50 Data assimilation algorithms and approaches by Gianpiero Cossarini

Day 2
9:00-11:30 Roundtable discussions on data assimilation and preparation of a report on the way forward lead by George Triantafyllou and Stefano Ciavatta