OPerational ECology

Ecosystem forecast products to enhance marine GMES applications

DG SPACE

Collaborative Project - small or medium-scale focused research project

Project Number: 283291

Deliverable No: D7.5		Workpackage: 7	
Date:	December 2014	Contract delivery due date	31.12.04
Title:	Scientific dissemination activities		
Lead Partner for Deliverable	PML		
Author(s):	All partners		
Dissemination level (PU=public, RE=restricted, CO=confidential)			PU
Report Status (DR = Draft, FI = FINAL)			FI

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under Grant Agreement No. **283291** for the project **Operational Ecology**: ecosystem forecast products to enhance marine GMES applications (OPEC)

OPEC Overview

"OPEC provides an enhanced capability to predict indicators of good environmental status in European regional Seas"

The OPEC project (Operational Ecology) will help develop and evaluate ecosystem forecast tools to help assess and manage the risks posed by human activities on the marine environment, thus improving the ability to predict the "health" of European marine ecosystems. The programme will focus on four European regional seas (North-East Atlantic, Baltic, Mediterranean and Black Seas) and plans to implement a prototype ecological Marine Forecast System, which will include hydrodynamics, lower and higher trophic levels (plankton to fish) and biological data assimilation.

Products and services generated by OPEC will provide tools and information for environmental managers, policymakers and other related industries, laying the foundations for the next generation of operational ecological products and identification of knowledge / data gaps.

OPEC will use the EU's Global Monitoring for Environment and Security Marine Service as a framework and feed directly into the research and development of innovative global monitoring products or applications. This in turn will advise policies such as the European Marine Strategy Framework Directive and Common Fisheries Policy, as well as the continued monitoring of climate change and assessments of mitigation and adaptation strategies.

www.marineopec.eu

OPEC Publications

1. **Christensen A, Butenschon M, Gurkan Z, Allen JI (2013). Towards an integrated forecasting system for fisheries on habitat-bound stocks. Ocean Science 9: 261-279. doi:10.5194/os-9-261-2013**

   Abstract. First results of a coupled modelling and forecasting system for fisheries on habitat-bound stocks are being presented. The system consists currently of three mathematically, fundamentally different model subsystems coupled offline: POLCOMS providing the physical environment implemented in the domain of the north-west European shelf, the SPAM model which describes sandeel stocks in the North Sea, and the third component, the SLAM model, which connects POLCOMS and SPAM by computing the physical–biological interaction. Our major experience by the coupling model subsystems is that well-defined and generic model interfaces are very important for a successful and extendable coupled model framework. The integrated approach, simulating ecosystem dynamics from physics to fish, allows for analysis of the pathways in the ecosystem to investigate the propagation of changes in the ocean climate and to quantify the impacts on the higher trophic level, in this case the sandeel population, demonstrated here on the basis of hindcast data. The coupled forecasting system is tested for some typical scientific questions appearing in spatial fish stock management and marine spatial planning, including determination of local and basin-scale maximum sustainable yield, stock connectivity and source/sink structure. Our presented simulations indicate that sandeel stocks are currently exploited close to the maximum sustainable yield, even though periodic overfishing seems to have occurred, but large uncertainty is associated with determining stock maximum sustainable yield due to stock inherent dynamics and climatic variability. Our statistical ensemble simulations indicates that the predictive horizon set by climate interannual variability is 2–6 yr, after which only an asymptotic probability distribution of stock properties, like biomass, are predictable.

2. **Ciavatta S, Torres R, Martinez-Vicente V, Smyth T, Dall'Olmo G , Allen J (2014). Assimilation of remotely sensed optical properties in a marine ecosystem model. Progress in Oceanography. Volume 127, 74-95 doi:10.1016/j.pocean.2014.06.002**

   Abstract: In this paper we evaluate whether the assimilation of remotely-sensed optical data into a marine ecosystem model improves the simulation of biogeochemistry in a shelf sea. A localized Ensemble Kalman filter was used to assimilate weekly diffuse light attenuation coefficient data, Kd(443) from SeaWiFs, into an ecosystem model of the western English Channel. The spatial distributions of (unassimilated) surface chlorophyll from satellite, and a multivariate time series of eighteen biogeochemical and optical variables measured in situ at one long-term monitoring site were used to evaluate the system performance for the year 2006. Assimilation reduced the root mean square error and improved the correlation with the assimilated Kd(443) observations, for both the analysis and, to a lesser extent, the forecast estimates, when compared to the reference model simulation. Improvements in the simulation of (unassimilated) ocean colour chlorophyll were less evident, and in some parts of the Channel the simulation of this data deteriorated. The estimation errors for the (unassimilated) in situ data were reduced for most variables with some exceptions, e.g. dissolved nitrogen. Importantly, the assimilation adjusted the balance of ecosystem processes by shifting the simulated food web towards the microbial loop, thus improving the estimation of some properties, e.g. total particulate carbon. Assimilation of Kd(443) outperformed a comparative

chlorophyll assimilation experiment, in both the estimation of ocean colour data and in the simulation of independent in situ data. These results are related to relatively low error in Kd(443) data, and because it is a bulk optical property of marine ecosystems. Assimilation of remotely-sensed optical properties is a promising approach to improve the simulation of biogeochemical and optical variables that are relevant for ecosystem functioning and climate change studies.

3. **Cossarini G., Lazzari P., and C. Solidoro, 2014. Space-time variability of alkalinity in the Mediterranean Sea. Biogeosciences Discuss., 11, 12871-12893. doi:10.5194/bgd-11-12871-2014**

Abstract: The paper provides a basin assessment of the spatial distribution of ocean alkalinity in the Mediterranean Sea. The assessment is made using a 3-D transport-biogeochemical-carbonate model to integrate the available experimental findings, which also constrains model output. The results indicate that the Mediterranean Sea shows alkalinity values that are much higher than those observed in the Atlantic Ocean on a basin-wide scale. A marked west-to-east surface gradient of alkalinity is reproduced as a response to the terrestrial discharges, the mixing effect with the Atlantic water entering from the Gibraltar Strait and the Black Sea water from Dardanelles, and the surface flux of evaporation minus precipitation. Dense water production in marginal seas (Adriatic and Aegean Seas), where alkaline inputs are relevant, and the Mediterranean thermohaline circulation sustains the west-to-east gradient along the entire water column. In the surface layers, alkalinity has a relevant seasonal cycle (up to 40 µmol kg^{-1}) that is driven both by physical and biological processes. A comparison of alkalinity vs. salinity indicates that different regions present different relationships. In regions of freshwater influence, the two measures are negatively correlated due to riverine alkalinity input, whereas they are positively correlated in open seas. Alkalinity always is much higher than in the Atlantic waters, which might indicate a higher than usual buffering capacity towards ocean acidification, even at high concentrations of dissolved inorganic carbon.

4. **Politikos D, Somarakis S, Tsiaras K, Giannoulaki M, Petihakis G, Machias A, Triantafyllou G (2014). Simulating anchovy's full life cycle in the Northern Aegean Sea (eastern Mediterranean): a coupled hydro-biogeochemical-IBM model, Progress in Oceanography. Available online. doi:10.1016/j.pocean.2014.09.002**

Abstract: A 3-D full life cycle population model for the North Aegean Sea (NAS) anchovy stock is presented. The model is two-way coupled with a hydrodynamic–biogeochemical model (POM–ERSEM). The anchovy life span is divided into seven life stages/age classes. Embryos and early larvae are passive particles, but subsequent stages exhibit active horizontal movements based on specific rules. A bioenergetics model simulates the growth in both the larval and juvenile/adult stages, while the microzooplankton and mesozooplankton fields of the biogeochemical model provide the food for fish consumption. The super-individual approach is adopted for the representation of the anchovy population. A dynamic egg production module, with an energy allocation algorithm, is embedded in the bioenergetics equation and produces eggs based on a new conceptual model for anchovy vitellogenesis. A model simulation for the period 2003–2006 with realistic initial conditions reproduced well the magnitude of population biomass and daily egg production estimated from acoustic and daily egg production method

(DEPM) surveys, carried out in the NAS during June 2003–2006. Model simulated adult and egg habitats were also in good agreement with observed spatial distributions of acoustic biomass and egg abundance in June. Sensitivity simulations were performed to investigate the effect of different formulations adopted for key processes, such as reproduction and movement. The effect of the anchovy population on plankton dynamics was also investigated, by comparing simulations adopting a two-way or a one-way coupling of the fish with the biogeochemical model.

5. **Teruzzi A, Dobrici S, Solidoro C, Cossarini G (2013). A 3-D variational assimilation scheme in coupled transport-biogeochemical models: Forecast of Mediterranean biogeochemical properties. Journal of Geophysical Research: Oceans, DOI 10.1002/2013JC009277**

Abstract: Increasing attention is dedicated to the implementation of suitable marine forecast systems for the estimate of the state of the ocean. Within the framework of the European MyOcean infrastructure, the pre-existing short-term Mediterranean Sea biogeochemistry operational forecast system has been upgraded by assimilating remotely sensed ocean color data in the coupled transport-biogeochemical model OPATM-BFM using a 3-D variational data assimilation (3D-VAR) procedure. In the present work, the 3D-VAR scheme is used to correct the four phytoplankton functional groups included in the OPATM-BFM in the period July 2007 to September 2008. The 3D-VAR scheme decomposes the error covariance matrix using a sequence of different operators that account separately for vertical covariance, horizontal covariance, and covariance among biogeochemical variables. The assimilation solution is found in a reduced dimensional space, and the innovation for the biogeochemical variables is obtained by the sequential application of the covariance operators. Results show a general improvement in the forecast skill, providing a correction of the basin-scale bias of surface chlorophyll concentration and of the local-scale spatial and temporal dynamics of typical bloom events. Further, analysis of the assimilation skill provides insights into the functioning of the model. The computational costs of the assimilation scheme adopted are low compared to other assimilation techniques, and its modular structure facilitates further developments. The 3D-VAR scheme results especially suitable for implementation within a biogeochemistry operational forecast system.

6. **Tzanatos E, Raitsos DE, Triantafyllou G, Somarakis S, Tsonis AA (2014). Indications of a climate effect on Mediterranean fisheries. Climatic Change. DOI 10.1007/s10584-013-0972-4**

Abstract: Using the Food and Agriculture Organization's (FAO) Mediterranean capture fisheries production dataset in conjunction with global and Mediterranean sea surface temperatures, we investigated trends in fisheries landings and landings per unit of effort of commercially important marine organisms, in relation to temperature oscillations. In addition to the overall warming trend, a temperature shift was detected in the Mediterranean Sea in the late 1990s. Fisheries landings fluctuations were examined for the most abundant commercial species (59 species) and showed significant year-to-year correlations with temperature for nearly 60 % of the cases. From these, the majority (~70 %) were negatively related and showed a reduction of 44 % on average. Increasing trends were found, mainly in the landings of species with short life spans, which seem to have benefited from the increase in water temperature. The effect of oceanic warming is apparent in most species or groups of species sharing ecological (e.g. small and medium pelagic, demersal fish) or taxonomic (e.g. cephalopods, crustaceans) traits. A landings-per-unit-of-effort (LPUE) proxy, using data from the seven Mediterranean European Union member states, also showed significant correlation with temperature fluctuations for six out of the eight species examined, indicating the persistence of temperature influence on landings when the fishing effect is accounted for. The speed of response of marine landings to

the warming of the Mediterranean Sea possibly shows both the sensitivity and the vulnerable state of the fish stocks and indicates that climate should be examined together with fisheries as a factor shaping stock fluctuations.

7. **Wan Z, Bi H, She J (2013). Comparison of Two Light Attenuation Parameterization Focusing on Timing of Spring Bloom and Primary Production in the Baltic Sea. Ecological Modelling, Volume 259, 40-49. doi.org/10.1016/j.ecolmodel.2013.03.010**

Abstract: The physical–biogeochemical coupled model HMB–ERGOM is used to investigate the effects of light attenuation on the timing of spring bloom (TSB) in the Baltic Sea. When light attenuation was not included, the predicted TSB was earlier than observed values in shallow areas (<50 m) and the predicted primary production tended to be lower, especially in the open-sea areas. Tuning the value of related parameters could not resolve these two discrepancies simultaneously. In the present study, a new light attenuation parameter was introduced to incorporate the effects of inorganic suspended particulate matter (SPM) using bathymetry depth and vertical turbulent diffusivity. A variable optimal photosynthesis irradiance in ERGOM was replaced with a constant value. The new parameterization led to improvement in three aspects of modeled results: nutrients and chlorophyll concentrations, TSB, and primary production. However, insufficient light utilization and under-estimation of primary production in some coastal regions remain problematic. The present study demonstrates the possibility of examining the potential impacts of inorganic SPM without explicitly coupling a complicated SPM model and highlights the importance of inorganic SPM modulating TSB in shallow areas. The new parameterization could be used to examine spatial variation of TSB in the Baltic Sea.

8. **Zhenwen Wan, Hongsheng Bi (2014). Comparing model scenarios of variable plankton N/P ratio versus the constant one for the application in the Baltic Sea. Ecological Modelling 272, 28-39. DOI: 10.1016/j.ecolmodel.2013.09.018**

Abstract: Observation data on surface dissolved inorganic nutrients in 2000–2009 at 15 stations in the Baltic Sea were used to analyze the ratio of nitrogen change to phosphorus change (N/P) before and after spring blooms. The ratios of nutrient N/P before and after spring blooms vary from 6.6:1 to 41.5:1. To estimate the spatially varied plankton N/P ratios, the observed nutrient N/P ratios as proxies for plankton N/P ratios are used to extrapolate a spatial pattern, and then the spatial pattern is adjusted by comparing observations and model results and the best fit spatial pattern is selected to discern the horizontal variability of plankton N/P, i.e., low in the center of the Baltic, relatively high away from the center. To examine the potential impact of spatially varied N/P ratios on phytoplankton and nutrients, a three dimensional physical–biogeochemical coupled model is used to compare two scenarios: spatially varied plankton N/P ratios versus a constant N/P ratio. When comparing model results to observation data, model results with spatially varied N/P ratios showed consistent improvements over model results with a constant N/P ratio, specifically in dissolved inorganic nitrogen, dissolved inorganic phosphorus, chlorophyll. Therefore, we concluded that the spatially varied N/P ratios can feature the horizontal distribution of plankton N/P in the Baltic Sea. Furthermore, the impacts of the variable plankton N/P ratio on primary production and nitrogen fixation are also investigated using the 3D ecosystem model. The estimated primary production and nitrogen fixation using

the constant N/P ratio of 16:1 are 38% and 317% higher, respectively, than those estimates using the variable N/P ratio.

Submitted and in preparation

Akoglu E, Libralato S, Salihoglu B, Oguz T, Solidoro C (2015). EwE-F 1.0: An implementation of Ecopath with Ecosim in Fortran 95/2003 for coupling (submitted to Environmental Modelling & Software).

Ciavatta S, Kay S, Butenschon M, Allen I. Decadal reanalysis and seasonal assessment of key ecosystem indicators in the North-West European Shelf, in preparation

Kalaroni S, Tsiaras K, Petihakis G, Economou-Amilli A, Triantafyllou G. Data assimilation of satellite Chl-a distribution into the water column taking into account of the light attenuation, in preparation.

Oguz T, Arkin S, Fach B, Akoglu E, Salihoglu B. Modeling the intrinsic controls of the carbonate system in the Black Sea. Submitted to Marine Ecology Progress Series.

Sathyendranath S, Moore T, Jackson T, Brewin R, Brockmann C, Brotas V, Chuprin A, Dowell M, Franz B, Grant M, Groom S, Horseman A, Martinez Vicente V, Platt T, Regner P, Roy S, Steinmetz F, Swinton J, Thompson A, Ciavatta S, Werdell J. Creating an ocean-colour time series for use in climate studies: the experience of the ocean-colour climate change initiative, in preparation

Torres R, Artioli Y, Kitidis V, Ciavatta S, Villareal M, Shutler J, Polimene L, Martinez V, Widdicombe C, Woodward EMS, Smyth T, Fishwick J, Tilstone G and Knappett D. Sensitivity of modelled CO2 air-sea flux in a coastal environment using a complex ecosystem model, in preparation.

Tsiaras K, Triantafyllou G, Petihakis G, Kalaroni S, Hoteit I. A hybrid Ensemble-OI Kalman filter for efficient data assimilation into a 3-D ecosystem model, in preparation.

Tsiaras K, Triantafyllou G, Hoteit I, Petihakis G. Assessing the impact of atmospheric forcing uncertainties on seasonal ecosystem predictability in the Mediterranean, in preparation.

Other reports

Ciavatta S, Kay S, Saux-Picart S, Butenschon M, Torres R, Allen 1. (2014). Multi-annual reanalysis of the North East Atlantic biogeochemistry and carbon fluxes through ocean colour data assimilation, NCEO Research Highlights 2014, page 28