



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: D6.1		Workpackage: WP6	
Date:	21-Dec-2012	Contract delivery due date	31-Dec-2012
Title:	Report on Downstream user requirements		
Lead Partner for Deliverable	BC		
Author(s):	Kerstin Stelzer, Carole Lebreton (BC)		
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

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Executive Summary

The purpose of this document is to present and list potential users and their requirements for a **Downstream Service** built on the OPEC core products. These requirements have been collected from different users and different sources. This document summarizes the variables that are provided by OPEC on the one hand and the parameters that are requested by the users on the other hand. Further, the technical requirements on the products and services are described. Finally, requirements on the Water Quality Service System (WAQSS) online tool are listed.

Relevance to Policy

A common set of descriptors with associated indicators for assessing the Good Ecological Status (GES) for within the Marine Strategy Framework Directive (MSFD) and Essential Climate Variables (ECVs) will be defined across the four regions (Atlantic, Baltic Sea, Mediterranean Sea and Black Sea). These are the OPEC target variables. OPEC emphasises the assessment of predictability of these key indicators. The downstream service is dedicated to tailor the core OPEC products to the user requirements so that the products can be easily picked up by the users and integrated into their running systems.

Introduction

Downstream Services

The GMES Marine Core Service (MCS) is intentionally serving large institutional users and intermediate users (i.e. service providers) only. The service to regional, national and local monitoring agencies, industry and other market segments, as well as the public with their very specific user requirements is performed within the GMES Downstream Services, which are currently developed and consolidated in a number of EU and ESA/GSE funded initiatives. One of them is the MARCOAST Network of Marine Service Providers (<http://gmes-marcoast.com>) which delivers satellite-based services in the field of marine and coastal applications. Furthermore, in different FP7 Downstream projects, dedicated services for e.g. inland waters (Freshmon; <http://www.freshmon.eu/>), for high biomass algal blooms predictions (CoBiOS; <http://www.cobios.eu/>), or the development of forecasting capabilities to warn of impending harmful algal blooms (HABs) (Asimuth, www.asimuth.eu) are developed. The WAQSS System developed within the MARCOAST framework by Brockmann Consult will be used as an example case for the OPEC services to provide the OPEC products as tailored Downstream Service products to the users. OPEC is adding new services and products based on the developed indicators from models, and will amend the WAQSS system with processing and distribution capabilities.

How this User Requirement study has been conducted

The requirements of the users that are already receiving downstream service provided by BC were compiled. This information is based on previous discussions with users, user training and past experience. In addition, selected users have been interviewed to ascertain their requirements. A third source of information were the

user requirement studies that have been conducted within other FP7 downstream projects CoBiOS, Freshmon and Aquamar as well as the German GMES project DeMarine.

Characterisation of Users

Categorisation of Users

Users of services providing environmental products derived from Earth Observation, models, in-situ data or combination of them, can be divided into 3 different types.

High level users and user federations (e.g. HELCOM, EEA, BOOS), with access and contributions from several institutions with extensive resources and practical interests arising from legislative mandates and obligations. These users are mainly users of the Core Services. However, special requests could also require a dedicate tailoring performed by a downstream service provider.

Institutional well-equipped users and developers (e.g. BSH, SYKE) are interested in the technology behind the product, and capable of using technique development and performing scientific analysis of the acquired data. Typically these institutions have national obligations of service provision or such services are an important part of their operations. Thus, these users are often themselves service providers; the products they request have therefore to fit in to their running services and systems in order to ensure interoperation. These users are both Core Service as well as Downstream Service Users.

Baseline end users are rather more interested in using the systems and services than developing them. Typically the baseline end users could integrate the service products to their operations. This means that the users require very specific products dedicated to their running systems. Product integration and use is only possible if the products fulfil their requirements and serve the requested interfaces. These Users are typically Downstream Service Users. These are mainly Scientists, individual users.

Involved Users

Today, users of water quality parameters are foremost the European and national monitoring agencies. Industries operating in coastal waters, such as aquaculture or oil industry, are also concerned by water quality and some are regular users of water quality information.

- **BSH** (Bundesamt für Seeschifffahrt und Hydrographie, Germany, eng.: Federal Maritime and Hydrography Agency): long term user of water quality services within Marcoast and Aquamar
- **BAW** (Bundesanstalt für Wasserbau, Germany, eng: Federal Waterways Engineering and Research Institute): user of water quality products within Marcoast
- **CORPI**: user of water quality products within Marcoast

- **BG** (Brockmann Geomatics, Sweden)/ Swedish Agencies: long term user of water quality and indicator products within Marcoast, Aquamar and Freshmon
- **LLUR** (Landesamt für Landwirtschaft, Umwelt und ländliche Räume Schleswig Holstein, Germany, eng: State Agency for Agriculture, Environment and Rural Areas): user of intertidal flat products, direct interview performed
- **UHAM** (University Hamburg, Germany): modeller and service provider for model output, interviewed in the name of OSPAR

User Requirements

Parameters

OPEC Variables

The following parameters are the core output parameters of the models running within OPEC project (see D2.3 for further details).

Variables

- Low Trophic Level
 - DIN, DIP
 - Chl_a and Chl_a maximum values
 - Bloom timing and bloom durations
 - Net Primary Production
 - Phytoplankton Biomass
 - Dissolved oxygen concentrations in anoxic areas
 - pCO₂
 - Phosphate
 - Nitrate
- High Trophic Level
 - fish stock biomass
 - fish mortalities
 - fish stock yield
 - interspecies predation preferences

Resolution & Spatial coverage

7-12 km, covering the different Basins

- NE Atlantic
- Mediterranean
- Baltic
- Black Sea

Formats

- NetCDF formats
- ASCII (Time Series)

Target Variables

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

- Winter Nutrients, DIN,DIP,DIS (J-M)
- $\text{NO}_3+\text{NH}_4/\text{PO}_4$, NO_3/SiO_4
- Maximum Chlorophyll (monthly mean based)
- Oxygen Minimum
- Primary Production
- Maximum Bloom Timing
- Bloom Days Per Year
- pCO_2
- pCO_2 anomaly (seasonal)
- Salinity + Temperature Anomaly (seasonal)
- Transport
- Water Column Stability (Mixed Layer Depth MLD, Potential Energy Anomaly PEA)
- Euphotic Depth (90%)
- Zooplankton

Required variables by Users

The users we work with in our downstream services are interested mainly in the following variables derived from remote sensing data:

- Chlorophyll concentration,
- Total suspended matter,
- Transparency / Euphotic Depth (90%)
- CDOM,
- Temperature

Special products (mainly for coastal zones and inland waters):

- Frontal zones
- Submerged vegetation (small scale)
- Floating emerged macrophytes,
- Bathymetry and bottom type (small scale)
- Indicators for algal blooms (starting point, extent, maximum, end), plus information on peak values of blooms
- Prediction of high biomass algal blooms

These requirements have been collected during the work performed within Marcoast, Aquamar, Freshmon and CoBios.

Parameters that are not derived from remote sensing which are of high relevance are:

- Nutrients: also TN and TP which are getting increasingly important within the MSFD.
- Salinity
- Primary Production, also with Net Ecosystem Production (closely related to CO_2 exchange with atmosphere).
- Oxygen Minimum: timing and extension of low oxygen, plus sedimentation of organic matter to catch the O_2 dynamic.

- Maximum Bloom Timing with information on peak values of bloom
- Bloom days per year: need to precise threshold used
- Transport: please add **physical transport information on sections** e.g. NOOS sections so that the transport information can be used to make budgets e.g. for C, N or P, and as extra deliverable **heat and salinity transport** would be a valuable information
- Water Column Stability, please add **volume below thermocline** as valuable information for the oxygen budget calculation on AOU (Apparent Oxygen Utilization)

Zooplankton: In order to close the food web in an ecosystem model for higher trophic levels the information on **zooplankton mortality** would be good to have – could be related to higher trophic level.

During the Annual Review Meeting in Dartington Hall (10th-12th December 2012), the proposed list was accepted by the modelling partners who also agreed to provide the required extended variables when needed.

There are for now no variable for Higher Trophic Levels. The information provided there is still too sparse (e.g. 1 value per year per region), and needs further work and inputs in order to be relevant for the users who are currently engaged in the project.

Required added value

Based on the aforementioned parameters, the users have special requirements on spatial and temporal aggregation of the data, a certain way of mapping and extraction of data for certain areas.

Examples are monthly averages for a region (North Sea, Baltic Sea) or the **statistical extraction for WFD (Water Framework Directive) water bodies** for a defined time frame, e.g. P90 of the Chl concentration over the growing season. P90 is the 90th percentile which specifies the value of the respective parameter from which 90 % of values are lower and 10% higher.

Other required products are **time series** for dedicated stations that show the evolution of Chl or TSM over one or several years. Ideally this will be presented in conjunction with the in-situ data acquired by the users.

Information about the **timing of algal blooms** is important for the users; the starting time of blooms and the duration, maximum extent and maximum chlorophyll concentration are good indicators for the characterisation of blooms. This is relevant especially for the Aquaculture industry, but in this case a high spatial resolution is required. This requires a dedicated processing of the tailored products which will be realised in the WAQSS Downstream services chains.

Required Reliability of the Services

The users will only use services and products if they are reliable and are coming with known quality.

The three key aspects of reliability from a user perspective are

- Availability of products
- Continuity of product generation
- Quality of the products

In addition the users would like to retrieve information about the quality of the data. Here, the quality itself is not always the most important factor as long as the uncertainty of the quality is provided with the data.

Technical Requirements

The following sections list the requirements of the users for technical characteristics of the products they receive such as formats, projection or documentation. These technical requirements are valid for real data products that are delivered to the users and they are often individual and need to be adjusted for the different users. This leads to the requirement that a user specific processing can be triggered by the system to be built. The description of these requirements is done for each task and a priority from 1 to 3 is put to each requirement. In the end, a list of user requirements (UR) and their priority (PRIO) is available.

The requirements on visualization via an internet tool are described in section 4.5.

Formats

Raster data sets:

- netCDF,
- geoTIFF,
- ascii
- BEAM DIMAP
- ERDAS IMAGINE

UR - 1	The output format for raster data needs to be specified for each production line.	PRIO 1
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Images:

- png,
- jpg
- TIFF

UR - 2	The output format for images needs to be specified for each production line.	PRIO 1
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Extracted spatial data (e.g. WFD relevant information):

- ESRI Shapefiles

UR - 3	The output format for vector data sets shall be ESRI shapefiles.	PRIO 1
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Time series:

- plots (png, Excel),
- tabulated data (Excel, csv, ASCII)

UR - 4	Time series extracted from the data sets shall be provided as plots and tabulated data.	PRIO 1
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Metadata:

- xml
- simple readme files

UR - 5	Meta data provision is required. Meta data shall be propagated during the processing steps and finally extracted. The format of metadata shall be xml AND simple readme files.	PRIO 1
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Projections / Grids

The users work with different projections/geographical grids.

General:

- Geographic lat/lon
- UTM

National Grids (some examples):

- Gauß-Krüger in Germany, currently changing to ETRS89(-System) based on the GRS80-Ellipsoid.
- Finnish national coordinate system (YKJ)
- GCS_KKJ
- Swedish National RT90
- GCS_Estonia_1997 (GRS_1980)
- RD (Rijks-Driehoek) system

UR - 6	Geographic projections will be user dependent and shall be specified for each processing line. They will include generic projections as well as national grid projections.	PRIO 1
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Delivery

In most cases, products are provided via ftp for operationally running services, but also via e-mail for smaller products and individual services.

UR - 7	The dissemination shall be able via ftp and openDAP server. The user will define the way of dissemination.	PRIO 2
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Documentation

The users need adequate documentation of the services and products delivered. The can be in form of fact sheets, link to related literature. Metadata providing information about the processing steps, processing time and responsible persons are mandatory.

UR - 8	Documentation about the products shall be available in form of fact sheets containing references to further publications if available.	PRIO 1
UR - 9	Meta data shall be available as XML and for the user as simple readme text file. The simple readme files shall contain user readable information about: Parameter Name, Units, Area, Date of data, Processing steps, Date of processing, contact person, credits	PRIO 2

Software used by the Users

The technical requirements of the users are driven by the software the users have in place and therefore have to be served by appropriate formats and interfaces. ArcGIS is the most often used software for processing the spatial data, but also a number of other software tools and script languages are used for analysing, processing and visualise the data such as BEAM, R!, SAS, Matlab, MapInfo or ENVI. Own software is also in place.

Requirements on a Web Service

Users that do not want to receive data products prefer on working with data for visualisation via a web service. For the visualisation of model output, users want to ask for mapping a certain time frame and area displayed as a movie/sequence for respective days (derived from daily or weekly products). Further, the display of time series for different areas / points would be of interest.

Users would like to include own region of interest by drawing geometries on the maps or importing vector files in order to display their region of interest to the model results.

Users would also like to include the service via a WMS into their own applications.

Queries shall be possible on:

- time range,
- area,
- parameter

Display shall be possible.

- Model output
 - single days
 - movie for several days
 - hindcast and forecast
- Time Series plot

UR - 10	The model output shall be displayed as daily map on the webpage.	PRIO 1
UR - 11	The values are visible for the ocean. Over land, a map showing countries, rivers, cities shall be available.	PRIO 2
UR - 12	The map shall be zoomable and panable.	PRIO 1

UR - 13	The user shall be able to specify the time frame for the data to be visualized	PRIO 1
UR - 14	The user shall be able to specify the parameters to be visualized	PRIO 1
UR - 15	The user shall be able to switch between different parameters	PRIO 2
UR - 16	The visualization of data shall be available also as movie (images over time) (user to specify time frame and parameter)	PRIO 2
UR - 17	Time series extraction shall be possible online. The user wants to click a point or a region and get a graph with a time series plot for a specified time frame.	PRIO 1
UR - 18	The images of data shall be available via a WMS to be requested by an external client.	PRIO 3

Derived requirements for an upgraded WAQSS delivery system

The GMES Marine Service is intentionally serving large institutional users and intermediate users (i.e. service providers) only. Consequently there is a gap between MSC and regional, national and local monitoring agencies, industry and other market segments, as well as the public. Today, users of water quality parameters are foremost the European and national monitoring agencies. Industries operating in coastal waters, such as aquaculture or oil industry, are also concerned by water quality and some are regular users of water quality information. Brockmann Consult is member of the MARCOAST network and is offering its services through WAQSS, the Water Quality Service System [www.waqss.de]. To date, no model data are part of the service portfolio.

OPEC will add new services and products based on the developed indicators from models, and will amend the WAQSS system with processing and distribution capabilities. The user requirements described above show which processing and distribution capabilities are needed. The provided service and products shall be tailored for seamless integration into user's geospatial data infrastructure through widely used formats of products (NetCDF, GeoTIFF) and OGC/ISO compliant interfaces for the services. The uptake of the products and integration into WAQSS will ensure compliancy with INSPIRE compatible metadata and compliancy with national data structures.