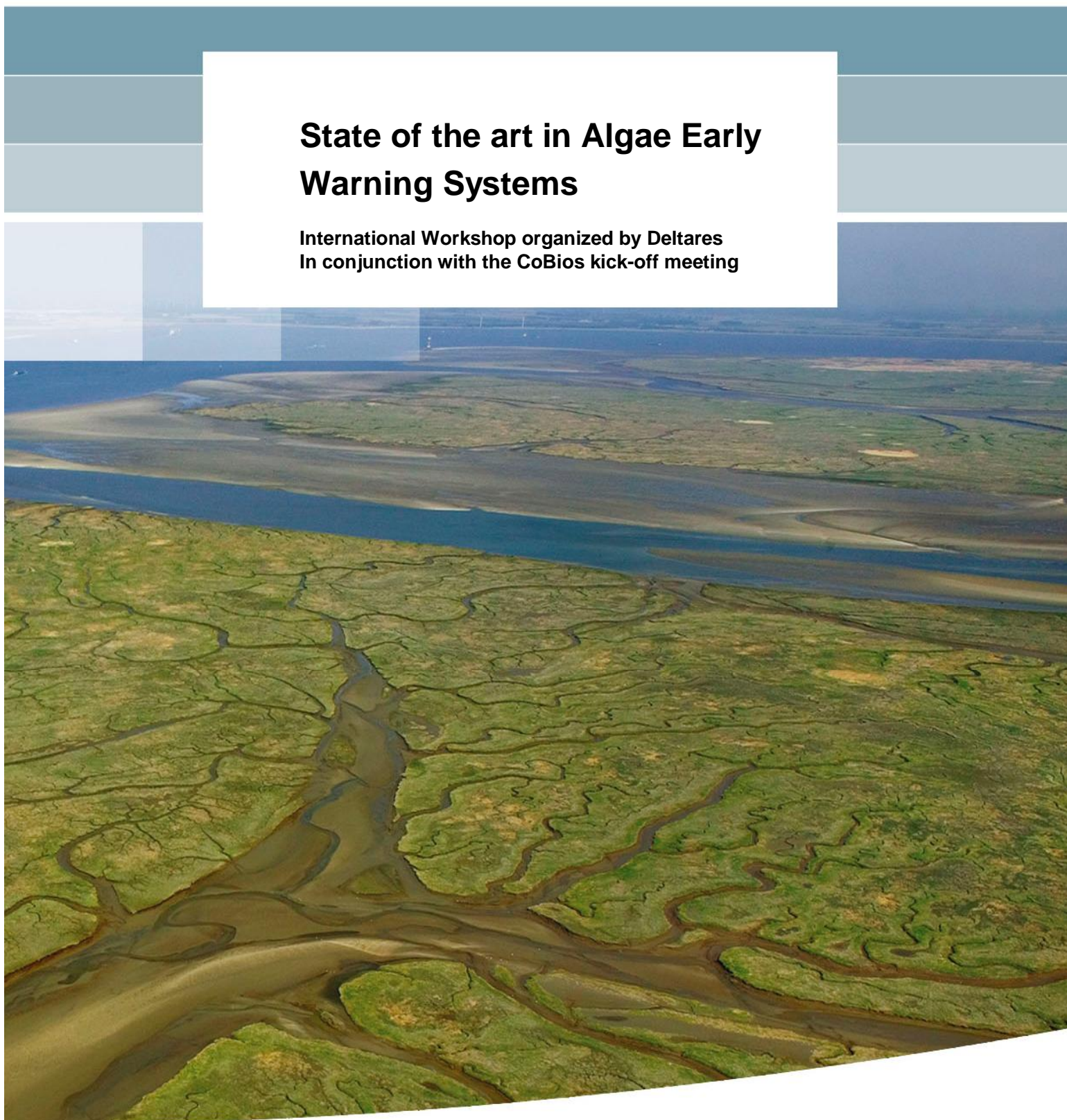


## **State of the art in Algae Early Warning Systems**

**International Workshop organized by Deltares  
In conjunction with the CoBios kick-off meeting**





## **State of the art in Algae Early Warning Systems**

**International Workshop organized by Deltares  
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1201763-000



## Title

State of the art in Algae Early Warning Systems

## Project

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## Keywords

Coastal algae blooms, monitoring systems, Earth Observation, forecasting, early warning systems




## Summary

On January 26, 2011 Deltares hosted an international workshop in Scheveningen, The Netherlands, on coastal Algae Early Warning Systems. The workshop was held in conjunction with the kick-off meeting of the EU FP7 CoBIOS project (Coastal Biomass Observatory Services).

The workshop focused on the current state of the art in Europe in monitoring and forecasting of (harmful) algal blooms in coastal regions. Such blooms can cause problems for ecological and public health and are of concern to coastal water managers as well the aquaculture industry and the tourism and recreation sectors. The existing algae warning systems in the European coastal countries were presented.

Additionally, a short introduction was given for two new EU FP7 research projects (COBIOS and ASIMUTH) that will further develop a European algae information system, providing real-time and forecast information on coastal algal blooms.

This report gives a short summary of each of the presentations, together with the contact information for the relevant institutes that are involved in each of the coastal warning systems.

Version	Date	Author	Initials	Review	Initials	Approval	Initials
1	February. 2011	N. Villars		dr. T.A. Troost		T. Schilperoort	
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## **Contents**

<b>1 Introduction</b>	<b>1</b>
<b>2 Denmark</b>	<b>3</b>
<b>3 Ireland</b>	<b>5</b>
<b>4 France</b>	<b>7</b>
<b>5 Netherlands</b>	<b>9</b>
<b>6 Finland</b>	<b>11</b>
<b>7 United Kingdom</b>	<b>13</b>
<b>8 Belgium</b>	<b>15</b>
<b>9 The DYMAPHY project</b>	<b>17</b>
<b>10 The ASIMUTH Project</b>	<b>19</b>
<b>11 The CoBios Project</b>	<b>21</b>
<b>12 Discussion summary</b>	<b>23</b>

## **Appendices**

<b>A Workshop Programme</b>	<b>A-1</b>
<b>B List of participants</b>	<b>B-1</b>
<b>C Relevant Links</b>	<b>C-1</b>





## 1 Introduction

On Wednesday January 26, 2011 Deltares hosted an international workshop on coastal Algae Early Warning systems. The workshop, at the pier in Scheveningen, The Netherlands, was held in conjunction with the kick-off meeting of the EU FP7 CoBIOS project (Coastal Biomass Observatory Services).

The workshop focused on the current state of the art in Europe in monitoring and forecasting of (harmful) algal blooms in coastal regions. Such blooms can cause problems for ecological and public health and are of concern to coastal water managers as well the aquaculture industry and the tourism and recreation sectors.

The existing algae warning systems in the European coastal countries were presented. A short summary from each country is given below, together with the contact information for the relevant institutes. The full presentations have also been made available<sup>1</sup>. The workshop programme and list of participants are given in Annex A and B, respectively.

In the coming three years, two EU FP7 research projects will further develop a European algae information system, providing real-time and forecast information on coastal algal blooms:

1) ASIMUTH (Dr. Julie Macguire, coordinator, Daithi O'Murchu Marine Research Station, Ireland)

2) CoBIOS (Dr. Steef Peters, coordinator, Vrij University / Institute for Environmental Studies, Netherlands)

Both projects are GMES-downstream services, using GMES Marine Core Service information products and creating region specific tailor made information. A brief summary of each project was given by the project coordinators. The CoBIOS kick-off meeting was held in the two days following the workshop (January 27-28).

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1. The full presentations are available per February 2011 on:  
<http://www.deltares.nl/en/event/980272/algae-early-warning-systems-workshop>



## 2 Denmark

### Early warning for marine aquaculture in Denmark, Hanne Kaas (DHI, Denmark)

The algal risk assessment system in Denmark is fully operational and is run by two private companies, DHI and Orbicon. The main objectives are to support the marine aquaculture sector by helping them plan operations (e.g. delaying the transfer of juvenile fish to the sites), to improve mitigation, and to optimize use of medication and life supporting agents. The system makes use of earth observation data (EO) as well as various monitoring data including in-situ data from online sensor. A set of dynamic models (MIKE3D) is used to make forecasts and a key component of the algal risk system. Data assimilation of Chlorophyll-a is made to improve the model forecasts. The combined information from the model and other sources is evaluated by an expert, who makes a risk assessment. All relevant data and information is shown on the website *havbrug.algevarsling.dk*, where the user can select different locations and or transects for the relevant information. Information on specific harmful algal species is available, including *Chattonella*, *Prymnesium* and *Chrysochromulina*.

The primary users are fish and mussel farmers, as well as the local environmental authorities. New methods of communication to the users are being developed and evaluated, such as SMS and smartphone applications. Additionally, ongoing developments and improvements in the system are focused on incorporating higher model resolution (local models), obtaining more precise timing of spring succession in phytoplankton, and improved modelling of the high risk algae *Chattonella*.

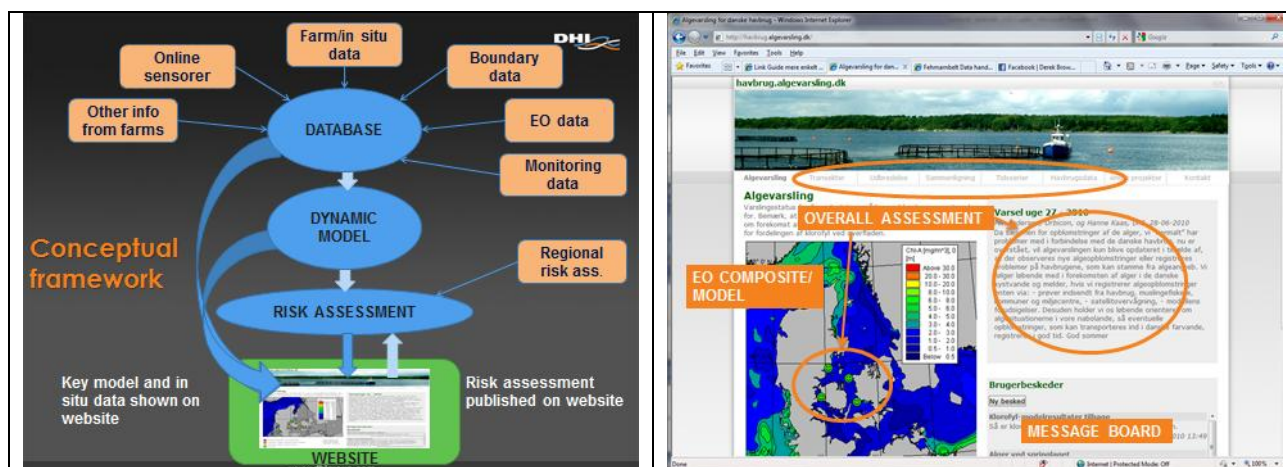


Figure 1 Conceptual framework for the algal early warning and risk assessment system in Denmark (left) and an example of the web-based information system (right).



### 3 Ireland

#### Algal early warning systems in Ireland, Joe Silke (Irish Marine Institute)

The Harmful Algal Bloom (HAB) tracking and forecasting system in Ireland is operated by the Irish Marine Institute. This system has been developed due to the importance of the shellfish and finfish industries in Ireland (primarily mussels and salmon). These industries are worth respectively, 59 and 58 Million Euros annually, but the aquaculture areas regularly need to be closed due to harmful algal blooms.

The marine environment around Ireland is a physically forced ecological and biogeochemical system. The circulation processes alone explain much of the observed pattern of the biogeochemical fields such as primary production, oxygen concentrations and nutrient distributions. Regional physical water characteristics determine the type of phytoplankton species (including HAB species) present. The forecasting system for Irish HABs is achieved through an integrated approach, including dynamic hydrodynamic and ecological models, earth observation, and various monitoring data (real-time as well as historic data). Different modelling approaches are used for different regions, depending on the critical factors determining blooms for a specific area.

Examples for predicting *Alexandrium* blooms in Cork Harbour as well as HAB blooms in SW Ireland using relatively simple, existing models were shown. More sophisticated modelling capabilities at the Marine Institute are being built up since the last 5 years. Open source models for coupled hydrodynamic and biogeochemical modelling are being used (ROMS & SWAN). The Irish Marine Institute will be participating in the EU FP7 ASIMUTH project (see also Chapter 10) as technical coordinator, and will work on developing a HAB Distributed Decision Support System.

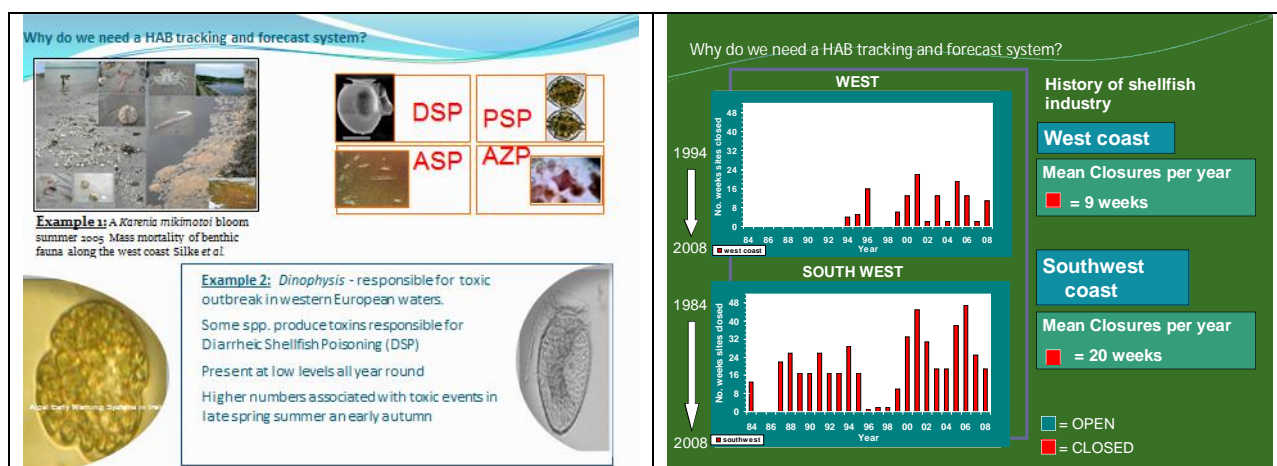


Figure 2 Problems caused by harmful algal blooms and related toxin are illustrated (left). These lead to closures of aquaculture areas, resulting in significant economic losses (right).



## 4 France

### **French Operational Warning System for Phytoplankton and Phycotoxins, Alain Mènesquen (Ifremer, France)**

There are different systems in France providing information on (harmful) algae and coastal phytoplankton conditions. The fully operational component is REPHY (National Monitoring Network for Phytoplankton and Phycotoxins). This was set up in 1984. The two main objectives of REPHY are:

- 1) environmental: knowledge of space and time distribution of the coastal marine phytoplankton species, with inventory of toxic, harmful or exceptional events, and
- 2) sanitary: detection of toxic species in water and quantification of toxins in shellfish

It is completely carried out by IFREMER with funding from the Ministry of Food, Agriculture and Fisheries and from five Water Agencies (2.5 M€/year). Ifremer has 12 coastal laboratories in charge of the monitoring network, which comprises (1) a routine sampling programme with 29 stations for all phytoplankton species and 103 stations for blooming and toxic species and (2) an emergency, episodic sampling programme at 108 stations for toxic species only.

In addition to REPHY, there are three additional informative tools related to phytoplankton:

- 1 - Phytoplankton picture automatic analysis using FlowCAM and Phytolmage software
- 2 - Satellite image browser (NAUSICAA): <http://www.ifremer.fr/nausicaa/marcoast/index.htm>
- 3 - Operational coastal model (PREVIMER): <http://www.previmer.org/>

NAUSICAA, partially supported by the MARCOAST project (ESA funded), is an operational on-line browser of satellite images of Sea Surface Chlorophyll and Suspended Particulate Matter (MERIS, MODIS). This satellite-based information can in some cases be used to give an advanced warning of an exceptional algal bloom. An example was given of a warning to Guernsey authorities in July 2010 for a bloom of *Karenia mikimotoi*, which induced local sampling and monitoring by the Environmental Health and Pollution Regulation Unit. Forecast information is based on an operational biogeochemical model which includes several different (harmful) phytoplankton species.

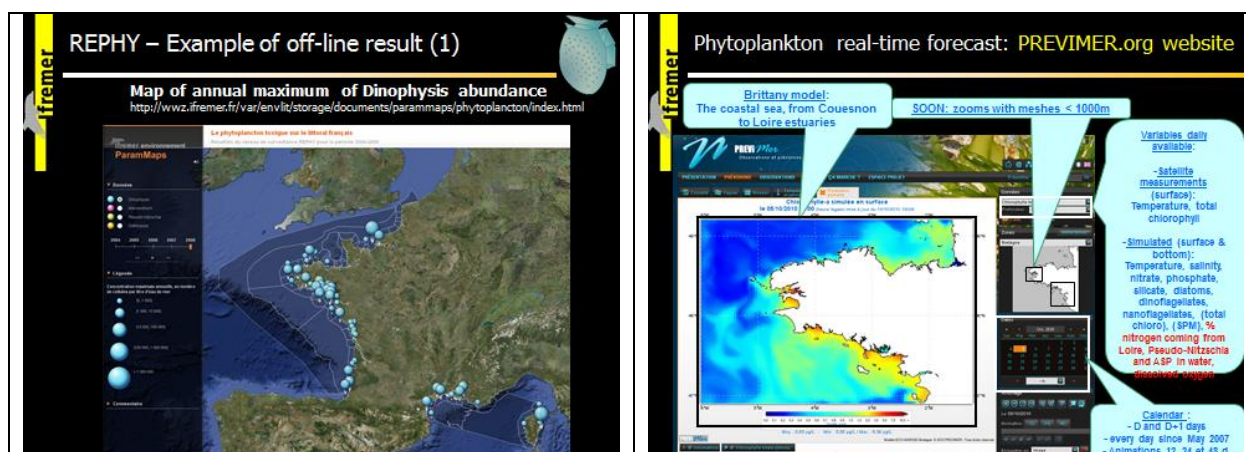


Figure 3 Results of the national monitoring programme REPHY (left) and the phytoplankton forecasting system PREVIMER (right) are available on internet.





## 5 Netherlands

### Operational forecasting of harmful algal blooms in the Netherlands

**Tineke Troost** (Deltares) & **Arjen Vrielink** (Water Insight)

The algae forecasting system in the Netherlands is mostly focused on *Phaeocystis*, which is considered more of a 'nuisance' species than a 'harmful' algae species. *Phaeocystis* primarily causes (smelly) foam on the beaches, which deters water recreation and beach tourism. However, in 2001 there was a bloom in the southwest Delta region of the Netherlands which caused significant mussel mortality and economic damage to the aquaculture sector. This led to the development of the algae warning service.

The current operational service is run by Deltares and Water Insight, but includes important real-time input from the Meteorological service (KNMI) as well as VU/IVM and Rijkswaterstaat. It makes use of a predictive hydrodynamic and ecological models (Delft3D-FLOW + Delft3D-BLOOM), the latter of which incorporates earth observation data to provide the real-time suspended sediment concentrations in the North Sea. Additionally, real-time data on nutrient loads from the Rhine River (Lobith) are included in the model. The data processing and data management for these predictive models is fully automated, using the Delft FEWS software platform.

The NRT processing of the earth observation data as well as the information dissemination is conducted by Water Insight. The results of the algae forecasting are supplemented with an 'expert judgment', and are incorporated into an algae bulletin, a *pdf* file which is sent to the National Water Authority twice per week during the algae season. Additionally, results are made available on internet. New methods for disseminating information are also being considered.

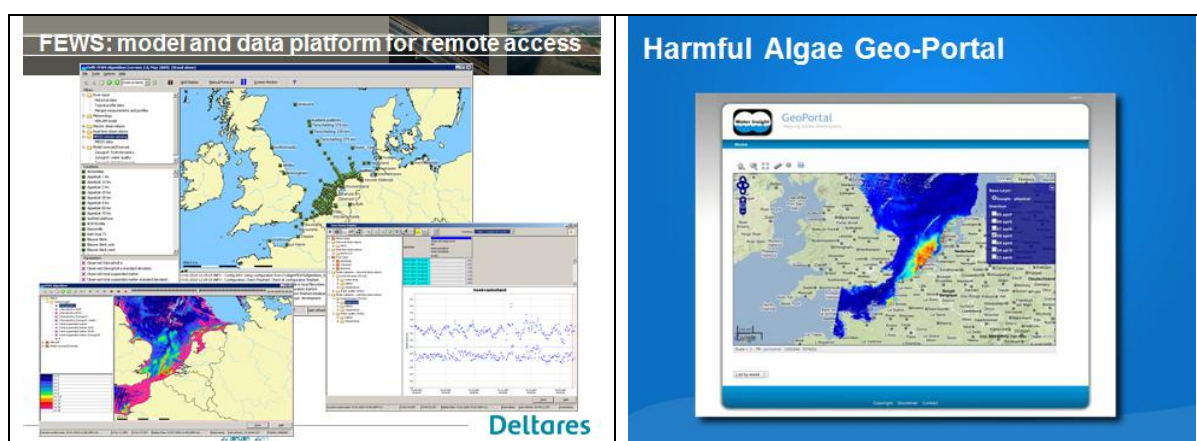


Figure 4 The operational forecasting of harmful algal blooms in the Netherlands uses the Delft-FEWS software (Deltares) to fully automate the modelling process (left). Earth Observation data and information dissemination by geo-portal is provided by Water Insight (right).



## 6 Finland

### Algal Monitoring and Ecosystem modelling in Finland, Stefan Simis (SYKE, Finland)

Algal blooms in the Baltic Sea are widespread and sometimes toxic. There is evidence that continued eutrophication of the Baltic Sea, combined with an ever thinner ozone layer, is favouring the toxic cyanobacterium *Nodularia spumigena*.

Two Finnish institutes are active in the monitoring and forecasting of the phytoplankton conditions: SYKE focuses on remote sensing of water quality, *In situ* monitoring, ecosystem modelling, new detection methods and photobiology of phytoplankton, while the Finnish Meteorological Institute, FMI is responsible for weather and climate monitoring and forecasting, including ice and waves as well as ecosystem modelling.

Earth observation includes daily analysis of Sea Surface Temperature (April/May-Sep), Turbidity (April/May-Sep), Chlorophyll a (April/May-Sep) and surface blooms of cyanobacteria (July-August). In situ observations are made during monitoring cruises, where measurements of phytoplankton, zooplankton (+ invasive aliens), nutrients, CTD, and benthic fauna are made as well as physical conditions such as wind, waves and currents. Automatic analysis is part of an extensive ferry box network covering the Baltic Sea (Alg@line). Additional analysis of the automatically collecting water samples comprises nutrients, taxonomy (microscopy, pigments) and biomass.

SYKE is also involved in bio-optical research in order to improve primary production monitoring, and to be able to combine remote sensing products with in situ observations of phytoplankton physiology. The algae forecasting conducted by FMI is based on a 3D-biogeochemical ocean model forced with 30 day ensemble weather forcing from ECMWF then analyzed and illustrated for end users. The above activities are not yet part of an operational information system providing regular bulletins or web-based information products to end users.

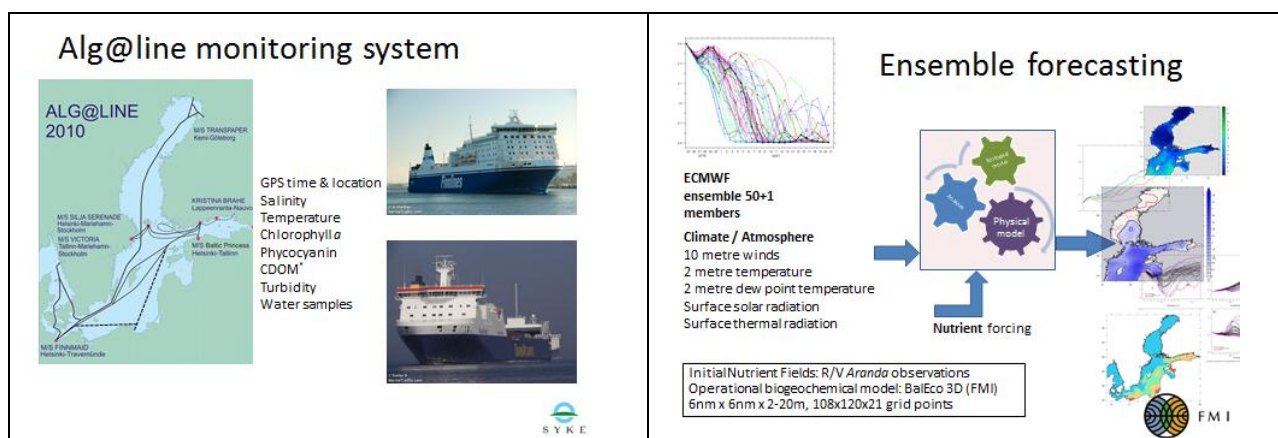


Figure 5 Information on algal blooms in the Baltic Sea is based on ferry box monitoring coordinated by SYKE (left), as well as model forecasting conducted by the Finnish Meteorological Institute FMI (right).



## 7 United Kingdom

### **AlgaRisk: UK bloom warning system using EO and ecosystem modelling, Peter Miller (Plymouth Marine Laboratory, UK)**

The AlgaRisk bloom warning system was developed jointly by Plymouth Marine Laboratory, The UK Met Office and the Environment Agency, to provide operational information on algae blooms, primarily for bathing water areas. The system relies on Earth Observation (satellites) to give a picture of bloom formation, numerical models to predict what will happen over the next few days and simple stochastic model to apply this to an individual coastal location.

Earth Observations products are prepared by Plymouth Marine Laboratory (PML). These include both MODIS and MERIS products, using the standard NASA algorithms as well as specific algorithms for Case 2 waters, developed in the MARCOAST project. Forecasts of the algae conditions are made by the UK Met Office with the MRCS (Medium Resolution Continental Shelf model) and ERSEM (European Regional Seas Ecosystem Model) models. The models are running in fully operational system (365/24/7), and produce 5-day forecasts of SST, salinity, stratification, currents (speed & direction), PAR, winds, cloud, chlorophyll, phytoplankton biomass (flagellates, diatoms, dinoflagellates, picoplankton) as well as nutrients and N:P ratio. This information is all made available on an AlgaRisk web portal and is updated automatically throughout the day. Comparisons of the EO and model results can be made using the portal (<http://www.npm.ac.uk/rsg/projects/algarisk/>).

PML is further developing EO classifiers to attempt to discriminate HABs from normal algae based on ocean colour; this is part of the FP7 AquaMar project on GMES downstream water quality services development.

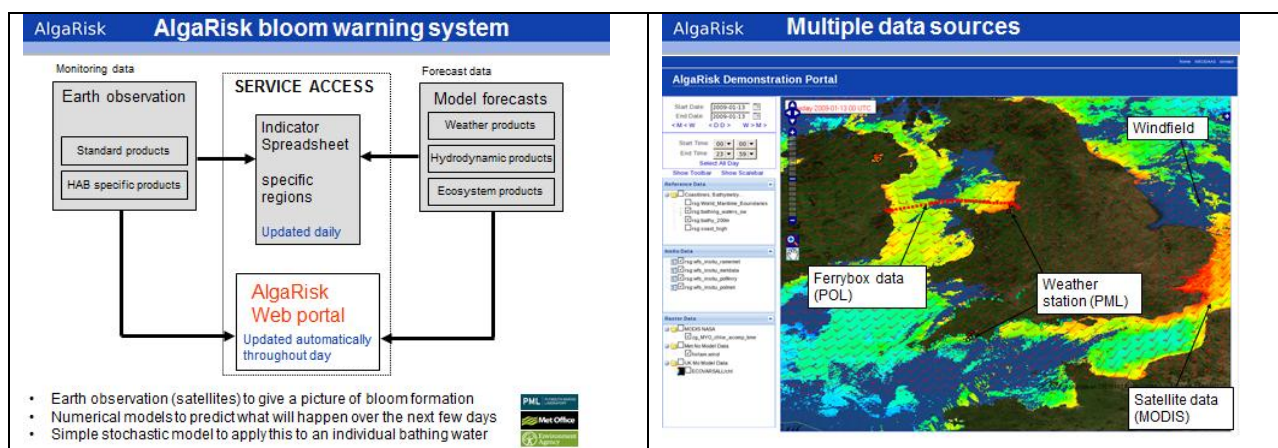


Figure 6 The AlgaRisk system includes information from monitoring data (EO) and model forecasts, which are also combined with expert judgment to provide indicators for specific regions (left). Multiple information sources are combined in a web-portal which is updated automatically (right).



## 8 Belgium

### Remote sensing tools to support near-real time estimate of phytoplankton biomass and bloom timing: Dimitry Van der Zande (MUMM, Belgium)

Remote Sensing tools for phytoplankton monitoring have been developed at MUMM, the Belgian federal research department for marine ecosystem management, responsible for monitoring, modelling and management of Belgian coastal waters. In the context of the GMES MarCoast project, water quality monitoring and algae Bloom detection and alert based on Earth Observation (MODIS and MERIS) have been developed.

An important aspect of the EO data analysis is 'binning' of the data, in order to make weekly, monthly, quarterly or seasonally averaged products (e.g. chlorophyll maps). Each product also provides information on the number of data values per pixels used to make the product. The spatial products of Chlorophyll-a in turn form the basis for detecting algae blooms. Pixels with Chlorophyll a concentration values higher than a certain threshold are considered algal bloom (AB) pixels. The threshold used is the Chlorophyll-a P90 value based on data from multiple years.

Ongoing development of the system is focusing on improved definition of the threshold values (P90) as well as identifying individual species or harmfulness of an algal bloom, not just biomass.

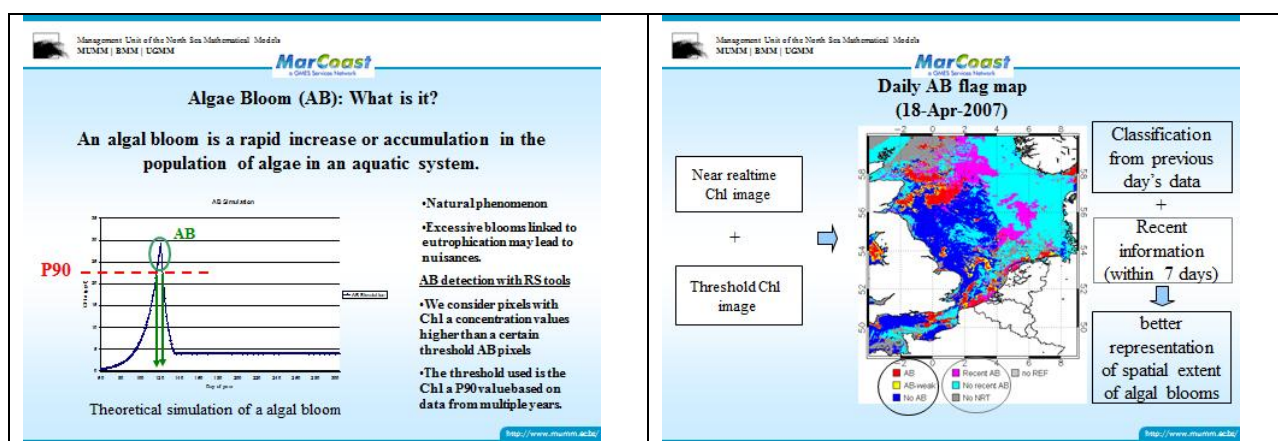


Figure 7 Information from historic EO data of chlorophyll a is used to calculate a threshold concentration (P90) for each pixel, which defines an 'algal bloom' for that pixel (left). NRT Chlorophyll images are combined with the 'threshold' maps for automatic identification of algal blooms (right).

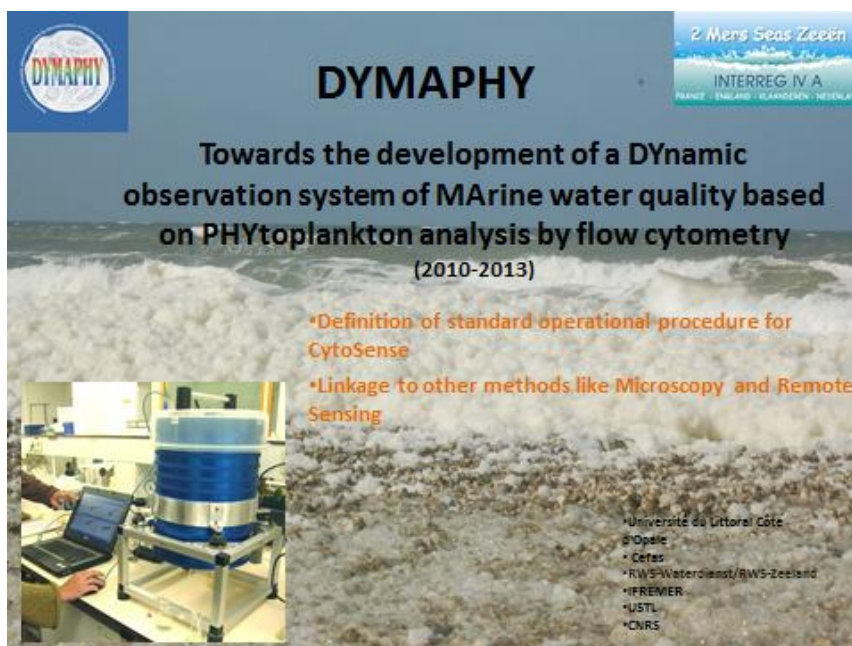




## 9 The DYMAPHY project

**Machteld Rijkeboer**, (*Rijkswaterstaat – National Water Center, The Netherlands*)

DYMAPHY is an Interreg IV project that started in 2010. It will focus on the development of a dynamic observation system of marine water quality based on phytoplankton analysis by flow cytometry. Project partners are Rijkswaterstaat, Ifremer, CEFAS, CNRS, Université Lille, and Université du Littoral Côte d'Opale (ULCO).



The poster for the DYMAPHY project features a background image of a turbulent sea. In the top left corner is the DYMAPHY logo. In the top right corner is a banner for '2 Mers Seas Zeeën' and 'INTERREG IV A' with flags for France, England, Flanders, and the Netherlands. The main title 'DYMAPHY' is in large, bold, black letters. Below it, the subtitle reads: 'Towards the development of a DYnamic observation system of MARine water quality based on PHYtoplankton analysis by flow cytometry (2010-2013)'. Two bullet points in orange text are listed: '•Definition of standard operational procedure for CytoSense' and '•Linkage to other methods like Microscopy and Remote Sensing'. On the left side, there is an inset photograph of a laboratory setup with a blue flow cytometer and a laptop. On the right side, a list of partners is provided: '•Université du Littoral Côte d'Opale', '•Cefas', '•RWS-Waterdienst/RWS-Zeeland', '•IFREMER', '•ULSTL', and '•CNRS'.

**DYMAPHY**

Towards the development of a DYnamic observation system of MARine water quality based on PHYtoplankton analysis by flow cytometry (2010-2013)

- Definition of standard operational procedure for CytoSense
- Linkage to other methods like Microscopy and Remote Sensing

•Université du Littoral Côte d'Opale  
•Cefas  
•RWS-Waterdienst/RWS-Zeeland  
•IFREMER  
•ULSTL  
•CNRS



## 10 The ASIMUTH Project

### Introduction to the ASIMUTH project, Julie Maguire (Daithi O'Murchu Marine Research Station, Ireland)

ASIMUTH is an EU FP7 GMES downstream project focusing on the development of forecasting capabilities to warn of impending harmful algal blooms. The steps to achieve this include a series of scientific and technical objectives which will enable the modelling of physical – biological interactions leading to the forecasting of toxin events, fish mortalities or ecological disruption from harmful algal blooms. The project started in December 2010 and has a duration of three years. Eleven consortium partners from Scotland, Ireland, France, Spain and Portugal are participating. The project has five main scientific objectives:

1. The identification of key past events which will be re-analysed and used for training the modelling system
2. Incorporation of the GMES Marine Core Services (MCS) with the above selected events will be used to develop model based hindcast products. These will be used to tune the system and move towards an operational model for forecasting events.
3. Design of regional model systems and delivery of nowcast for specific HABs and location information, transport pathways, remote sensed data.
4. Population of HAB-Distributed Decision Support system (HAB-DDSS) (effectively a HAB specific Thematic Assembly Centre) from relevant data streams (phytoplankton, biotoxin, satellite, in-situ, etc).
5. Provision of expert interpretation of the available data by way of the web-portal which will be carried out on a periodic basis depending on risk. This assessment will be then issued via a warning system to end users.

Test sites will be selected on the basis of locations where there are existing HAB events with defined impacts. The locations will also be decided upon on the basis of data availability

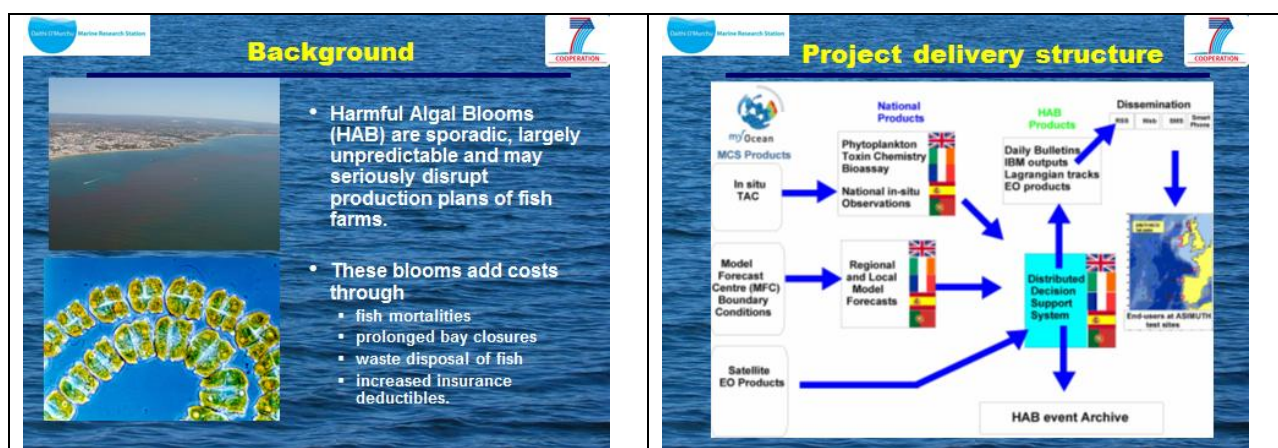


Figure 8 The ASIMUTH project focuses on development of forecasting capabilities to warn of impending harmful algal blooms (HABs). Results will be issued via a warning system to end users.



## 11 The CoBios Project

### Introduction to the COBIOS project, Steef Peters (VU/IVM, The Netherlands)

COBIOS is an EU FP7 GMES downstream project focusing on development of forecasting systems for high biomass algae blooms. The project starts in January 2011 and has a duration of three years. Nine consortium partners from The Netherlands, Germany, Belgium, Denmark and Finland are participating. The project has six main objectives:

1. To implement the improvements in models and EO-products in software and to test the enhanced output quality by running two series of trials.
2. To demonstrate the novel CoBiOS information system by operationally running the models and EO-products service chains during an extended Near Real Time demonstration phase.
3. To collect relevant in-situ validation data during the Near Real Time operational phase and to actively engage key-users of the CoBiOS services in the validation of the service performance.
4. To implement the improvements in models and EO-products in software and to test the enhanced output quality by running two series of trials.
5. To demonstrate the novel CoBiOS information system by operationally running the models and EO-products service chains during an extended Near Real Time demonstration phase.
6. To collect relevant in-situ validation data during the Near Real Time operational phase and to actively engage key-users of the CoBiOS services in the validation of the service performance.

Information dissemination, interaction with product users, and development of a sustainable service strategy will be important components of the project.

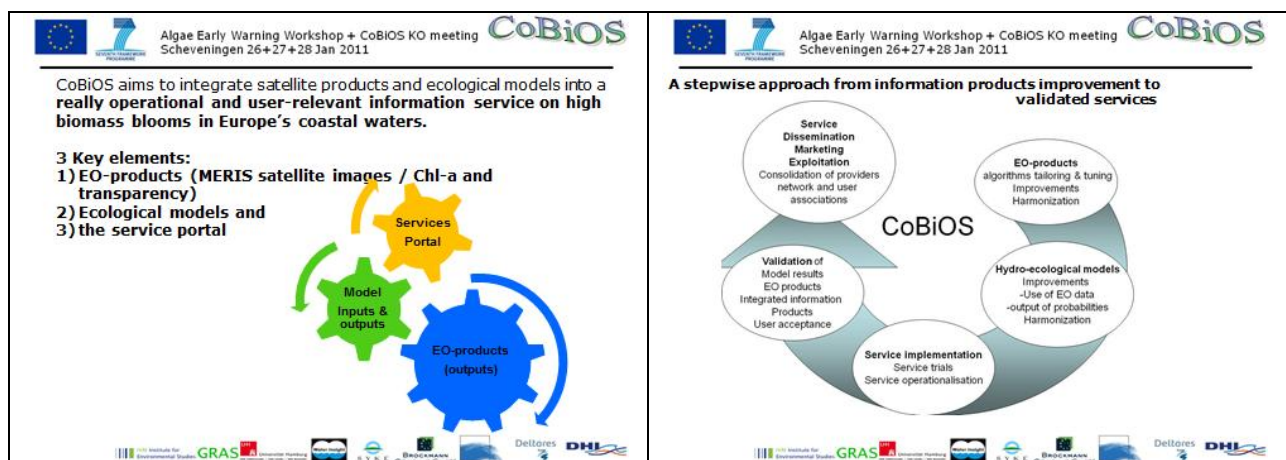


Figure 9 The COBIOS project focuses on development of forecasting systems for high biomass algae blooms. An information dissemination system will be developed and evaluated.



## 12 Discussion summary

A short group discussion was held after all the presentations. One of the main themes was that of information dissemination, and how best to 'reach' and communicate with the users of the information services. There was wide consensus that the scientific and research community is capable of producing a wide range of information on (harmful) algal blooms that can be of relevance to the user community. During the workshop, several examples of interactive web-portals were shown, in which the user can, for example, zoom into an area of interest, select relevant parameters, look at maps, data points (time series or transects) of forecasted or historical information. However, in practice, many current users seem to want only a simple message (per email or sms) if there is a problem expected in *their* area of interest. Identifying the specific and tailored information that different users want and providing this to them in an automated way will be a challenge to all the algae warning service providers.

A second topic discussed briefly was that of sustainability of services after the EU funding as finished. It is clear that a sustainable service also needs a sustainable source of income. This may be government and/or users. The user community is primarily the aquaculture industry, and water managers, and to some extent the tourism and recreation sector. All participants recognized this future challenge.

Finally, it was recognized that the two EU projects, ASIMUTH and COBIOS, have quite a bit in common and could both benefit from interaction over the coming years, perhaps with joint workshops or other means of exchanging information. The project leaders have agreed to stay in contact and see how this can best be arranged.





## A Workshop Programme

### Workshop on Operational Coastal Algae Early Warning Systems

In conjunction with EU FP7 CoBios project  
26th January 2011, The Hague, The Netherlands

9.30-10.00      Arrival and coffee  
10.00-10.10      Welcoming and introduction  
                     Hero Prins (R&D Management Team, Deltares, The Netherlands)

#### Part 1: AEWS current state of the art in Europe

10.10-10.40      Warning system for marine aquaculture in Denmark  
                     Hanne Kaas (DHI, Denmark)

10.40-11.10      Algal early warning systems in Ireland  
                     Joe Silke (Irish Marine Institute)

11.10-11.30      coffee break

11.30-12.00      Review of the French operational model for the coastal zone  
                     Alain Ménesguen (Ifremer, France)

12.00-12.30      Algae Warning Service for Rijkswaterstaat, The Netherlands  
                     Tineke Troost (Deltares) & Arjen Vrielink (Water Insight)

#### 12.30-13.45      Lunch break

13.45-14.15      Algal Monitoring and Ecosystem modelling in Finland  
                     Stefan Simis (SYKE, Finland)

14.15-14.45      AlgaRisk: UK bloom warning system using EO and ecosystem modelling  
                     Peter Miller (Plymouth Marine Laboratory, UK)

14.45-15.15      Remote sensing tools to support near-real time estimate of phytoplankton  
                     biomass and bloom timing  
                     Dimitry Van der Zande (MUMM, Belgium)

15.15-15.30      coffee break

## Part 2: What next? EU FP7 Research projects

- 15.30-15.50    Introduction to the ASIMUTH project  
Julie Maguire (*Daithi O'Murchu Marine Research Station, Ireland*)
- 15.50-16.15    Introduction to the COBIOS project  
Steef Peters (*VU/IVM, The Netherlands*)
- 16.15-16.45    Discussion
- 16.45            Closing words  
Nicki Villars (*Deltares, The Netherlands*)
- 19.00-...**     **Dinner offered by Deltares**

## B List of participants

### Workshop on Operational Coastal Algae Early Warning Systems

In conjunction with EU FP7 CoBios project  
26th January 2011, Scheveningen, The Netherlands

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## C Relevant Links

During the presentations there were many references to web-sites or portals with information relevant to algae forecasting and monitoring. An overview of these links, as taken from the presentations, is given below. This is not meant to be an exhaustive list of all available web sites / portals.

Please add relevant links in the table below:

Information	Web link
Danish algae information system	<a href="http://www.havbrug.algevarsling.dk">www.havbrug.algevarsling.dk</a>
Irish aquaculture	<a href="http://www.bim.ie">www.bim.ie</a>
Observations and model results for the Baltic Sea	<a href="http://www.balticseaportal.fi">www.balticseaportal.fi</a>
European Ferrybox community	<a href="http://www.ferrybox.org/">http://www.ferrybox.org/</a>
Dutch Algae Bulletins	<a href="http://www.fytoplankton.nl">www.fytoplankton.nl</a> and <a href="http://www.rws.nl/water/natuur_en_milieu/waterkwaliteit/fytoplankton/plaagalgenbulletins/">http://www.rws.nl/water/natuur_en_milieu/waterkwaliteit/fytoplankton/plaagalgenbulletins/</a>
Water InSight Geoportal for water quality	<a href="http://www.geoportal.waterqualitymap.eu">www.geoportal.waterqualitymap.eu</a>
France REPHY data	<a href="http://www.ifremer.fr/envlit/index.htm">http://www.ifremer.fr/envlit/index.htm</a> and <a href="http://envlit.ifremer.fr/var/envlit/storage/documents/parammaps/phytoplankton/index.html">http://envlit.ifremer.fr/var/envlit/storage/documents/parammaps/phytoplankton/index.html</a>
French browser for RS data (nuasicaa)	<a href="http://www.ifremer.fr/nausicaa/marcoast/index.htm">http://www.ifremer.fr/nausicaa/marcoast/index.htm</a>
French operational forecasts of coastal systems	<a href="http://www.previmer.org/">http://www.previmer.org/</a>
UK AlgaRisk site	<a href="http://www.npm.ac.uk/rsg/projects/algarisk/">http://www.npm.ac.uk/rsg/projects/algarisk/</a>
EC FP7 AquaMar project	<a href="http://www.aquamar-fp7.eu/">http://www.aquamar-fp7.eu/</a>
ESA MarCoast project:	<a href="http://www.gmes-marcoast.info/">http://www.gmes-marcoast.info/</a>
NOAA Harmful Algal Bloom Operational Forecast System (US)	<a href="http://tidesandcurrents.noaa.gov/hab/">http://tidesandcurrents.noaa.gov/hab/</a>