Exploiting UK Capacity for Marine and Coastal Environment Information Services

"MCEIS"

A project supported by the British National Space Centre, under the ESA Ministerial Preparatory Action

Final Report

31st March 2005

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MCEIS Partners:
Satellite Observing Systems (SOS)
Plymouth Marine Laboratory (PML)
Proudman Oceanographic Laboratory (POL)
Centre for Environment Fisheries and Aquaculture Science (CEFAS)
With
The Environment Agency (EA) and Fisheries Research Services (FRS)


MCEIS – Executive Summary

Introduction

The Marine and Coastal Environment Information Services (MCEIS) project was a 6 month project (October 2004 – March 2005) supported under the British National Space Centre (BNSC) European Ministerial Preparatory Action (EMPA) programme.

Following recent environmental policy initiatives and agreements, such as OSPAR and the EU Water Framework Directive, government agencies now have a legislative requirement to provide water quality monitoring services. MCEIS brought together key UK organisations to develop and deliver a pilot water quality monitoring service, based on a combination of satellite, model and in situ data. The UK user agencies (EA, CEFAS, FRS, SEPA, EHS) have reviewed these services and contributed to this final report which provides recommendations for operational implementation, as required to satisfy UK agencies' long-term requirements. Plans for implementation include participation in the MARCOAST proposal for marine environment monitoring services under the European Space Agency's GMES Service Element programme.

Project Achievements

MCEIS has

- Held a workshop with partners and users to provide an agreed specification for the pilot marine water quality services.
- From October 2004 delivered a pilot water quality service covering the entire coastline of Britain and Ireland, at http://www.npm.ac.uk/rsg/projects/mceis, providing:
  - *Near Real Time processed satellite data (updated daily, with weekly composites)*
    - Chlorophyll, water clarity and suspended particulates
    - Sea-surface temperature
  - *Near Real Time Model Fields*
    - Surface and bottom temperature and currents from the POL Irish Sea model (1.8km resolution).
  - *In Situ Data*
    - CEFAS SmartBuoy Data (fluorescence, PAR irradiance, salinity, temperature and turbidity)
  - *Functionality*
    - Individual images that can be viewed interactively.
    - Functions include zooming, interactive colour scale, selection of coastline overlays.
    - Equivalent processed images produced by different satellites can be compared side-by-side
    - A searchable online archive.
- Following user feedback these services were upgraded to include
  - Time series of EO and model derived water quality statistics at selected sites,
  - Archived output from UK Met Office Medium Resolution (6km) Continental Shelf coupled bio-geophysical model[1].
- Carried out a full service evaluation, developed recommendations for development & exploitation.
  Users have identified priorities are to provide statistics of EO and model derived water quality indicators aggregated either onto a regular grid, or mapped onto WFD or OSPAR assessment regions, and the development of a warning system to advise of potentially harmful events (e.g. Harmful Algal Blooms).
- Carried out a review of tools available to provide interactive data access, and explored the issues surrounding practical implementation of such tools
- Worked for the inclusion of MCEIS services within the MARCOAST proposal, submitted to ESA under GSE Phase 2 (project leaders ALCATEL Space, France).

End User Interest

All the UK agencies with responsibilities for water quality monitoring have cooperated with MCEIS. CEFAS, EA and FRS were engaged as full partners. All have identified that services developed from MCEIS could make a significant contribution to their operational activities, and have expressed a keen interest in finding ways to support continued development and delivery.

[1] The UK Met Office was not a funded MCEIS partner.

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Acknowledgements

We are grateful to John Siddorn, Martin Holt and Mike Bell of the UK Met Office for the provision of model data to the MCEIS web-site and many helpful contributions to discussions. The UK Met Office will be an important partner in any future developments.

We would like to acknowledge the contributions of scientists from the UK environmental agencies who accessed the MCEIS web site and provided assessments and recommendations, these included:
Tim Sawyer[2], Kyle Brown, Crispin Hambidge, and Andrew Wither from the Environment Agency,
Bill Turrell and Eileen Bresnan of the Fisheries Research Services,
Sue Brown and Anton Edwards of the Scottish Environment Protection Agency,
Mark Charlesworth of Environment and Heritage Service (Northern Ireland),
Shane O'Boyle of the Environment Protection Agency (Republic of Ireland),
Guy Westbrook of the Marine Institute (Republic of Ireland).

In addition we have received helpful contributions from Alison Houghton (HR Wallingford), Beth Greenaway (DEFRA), John McEvoy (North Atlantic Fisheries College), Gay Mitchelson-Jacob (University of Wales, Bangor), Caroline Cusack (National University of Ireland, Galway).

[2] Now no longer at the Environment Agency

1 Introduction

1.1 Overview

The Marine and Coastal Environment Information Services (MCEIS) project was a 6 month project (October 2004 – March 2005) supported under the British National Space Centre (BNSC) European Ministerial Preparatory Action (EMPA) programme.

Following recent environmental policy initiatives and agreements, such as OSPAR and the EU Water Framework Directive, government agencies now have a legislative requirement to provide water quality monitoring services. MCEIS brought together key UK organisations to develop and deliver a pilot water quality monitoring service, based on a combination of satellite, model and in situ data. The UK user agencies (EA, CEFAS, FRS, SEPA, EHS) have reviewed these services and contributed to this final report which provides recommendations for operational implementation, as required to satisfy UK agencies' long-term requirements. Plans for implementation include participation in the MARCOAST project team's proposal to provide marine environment monitoring services under the European Space Agency's (ESA) GMES Service Element programme (GSE).

1.2 Project Background

When the MCEIS proposal was submitted to BNSC, it was on the basis of ESA's stated plans to issue an ITT for the "Implementation Phase" of the GMES Service Element (GSE) programme. It was understood that ESA would invite proposals to provide (satellite based) environment monitoring services under 8 themes, one of which would be for monitoring water quality in the marine and coastal environment. Under the earlier phases of GSE these services were provided by the ROSES and COASTWATCH projects. It was also known that partners from these two projects were planning to merge into a single team in order to respond to this anticipated AO.

In the first phase of GSE, the ROSES project team had offered "Harmful Algal Bloom" (HAB) monitoring services covering the Norwegian Coastline, Eastern North Sea and the north and western French coastline. Recognising that EO data alone could not provide a complete service these initial services brought together satellite data, operational modelling, and near real time *in situ* data to provide a combined integrated service. Users responded favourably to the ROSES HAB service, though they identified requirements to build in interactive data access tools and extend coverage.

1.3 Initial Aims for Exploitation

The rationale behind this proposal to the BNSC EMPA AO was to demonstrate pilot ocean water quality services from UK providers. The proposed pilot services were planned to be entirely consistent with the existing ROSES services and in line with planned service expansion, but aimed to demonstrate enhanced capabilities and extra important geographical coverage. It was argued that a successful and timely demonstration would place the partners in a strong position to be invited as full service provision partners in any response to the ESA AO for the GSE Implementation phase.

Key issues were

- UK involvement in the service provision side of the GSE Phase 1 ROSES and COASTWATCH projects had been relatively low.
- There were important gaps in the geographical coverage of services offered by ROSES and COASTWATCH (specifically along the western coastline, including the Irish Sea, all of Scotland, northern England and the Republic of Ireland)– gaps that are important with regard

to UK and Irish users as they cover the main areas of interest to the aquaculture industry and regions of great importance in terms of monitoring water quality.

- From consultations with users we were aware that the present level of services was not sufficient to meet the needs of the targeted users in the UK (EA, SEPA, CEFAS, FRS). The range of parameters was too limited, and presented at too "basic" a level for them to be of real practical value. Thus there was scope to increase the range of water quality parameters being offered, and to improve the presentation and accessibility of these data through the application of interactive GIS and other data presentation software.

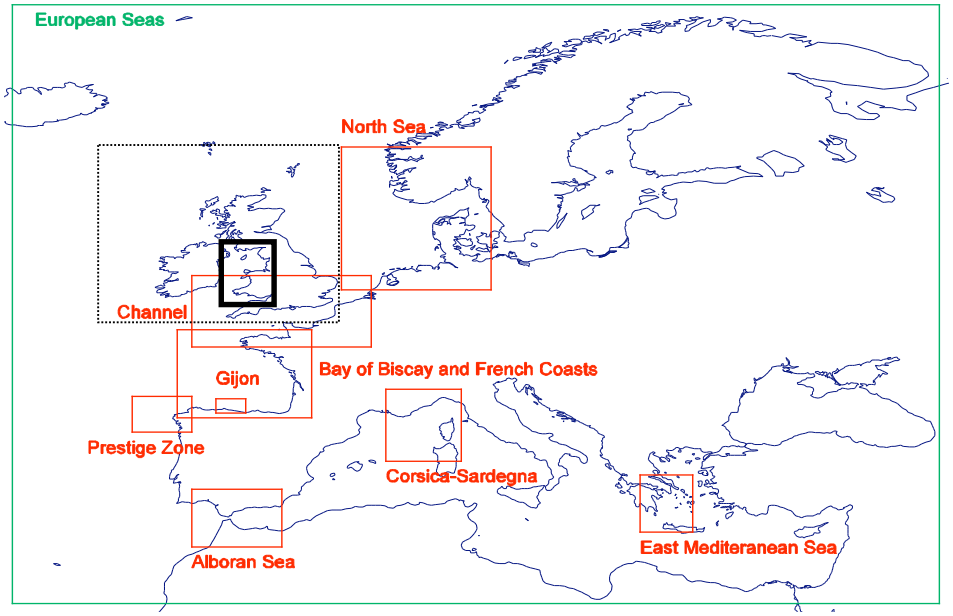

Figure 1: The red boxes identify regions supplied by ROSES services in 2004. The solid black box indicates the area presently covered by the POL Coastal Observatory, the dashed black box indicates the initially planned coverage of the pilot service to be offered by MCEIS

1.4 End User Involvement

All the UK and Republic of Ireland agencies with responsibilities for water quality monitoring have participated in MCEIS through accessing the MCEIS site and providing an evaluation of the service. CEFAS and the EA were full partners in MCEIS.

1.5 This Report

The layout of this report is as follows:

In Section 2 we describe the MCEIS pilot service provided during the project, from October 2004 onwards. In section 3 we introduce the users that were engaged and summarise their evaluation of MCEIS and their recommendations for future developments and implementation. Section 4 provides a review of tools that are available for interactive access to marine data sets, especially when they are available from separate and diverse sources. The following two sections describe activities and plans for future exploitation / implementation of MCEIS. Section 5 describes activities within the ESA GMES Service Element programme, and Section 6 proposes an implementation strategy for a UK monitoring service. Section 7 provides the conclusions, and the annex provides a summary administrative report for the whole project.

2 The MCEIS Pilot Service

2.1 Introduction

In this section we describe the development and operation of the Pilot MCEIS Service.

The MCEIS Pilot service has been available online since October 2004, it offers water quality and algal bloom information based on processed ocean colour and sea surface temperature satellite imagery, operational model predictions and near real time buoy data, as described below. Access is provided through the (password protected) MCEIS public web site at:

http://www.npm.ac.uk/rsg/projects/mceis.

Due to the compressed timescale of the project, operation of the web sites and development of new products, methods and data sources proceeded in parallel; hence, some functionality or data became available toward the end of the formal demonstration period.

2.2 Regions and Demonstrations

The initial plan of MCEIS was to undertake near-real time EO monitoring in two areas: the Irish Sea at high resolution and the whole of the United Kingdom and Republic of Ireland at a lower resolution. In the event both areas were supported with high resolution (1km) satellite data. In addition, because of the high levels of cloud cover, coupled with the low coverage of SeaWIFS and MODIS over northern European waters in winter, another region showing the western Mediterranean was added to demonstrate the near-real time value of ocean colour data. However, it should be stressed that the high levels of cloud cover during winter coincides with the minimum of phytoplankton growth and hence also a time of minimum concern for harmful algal blooms (HAB).

As a result of the user consultation at POL in October it was also decided to provide additional deliverables comprising archived examples of HAB in the western English Channel (of Karenia mikimotoi, a problem species in Scottish waters) and in the North Sea (with blooms of Chattonella spp.). The western English Channel demonstrator included a prototype HAB likelihood index applied retrospectively to an entire season of data for MCEIS. Figure 2 shows the MCEIS front page – offering these alternatives.

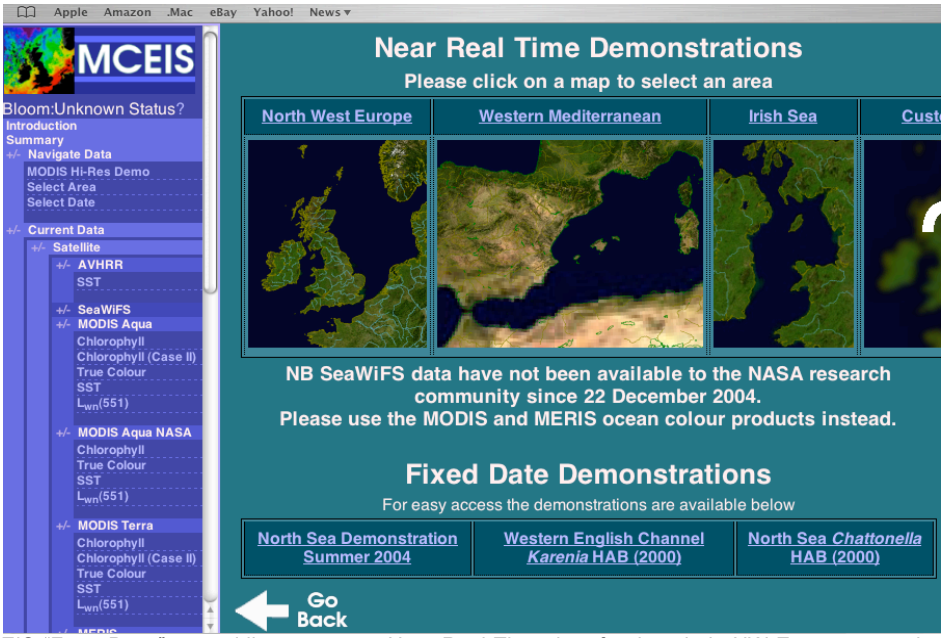

Figure 2: The MCEIS "Front Page" – providing access to Near Real Time data for the whole NW Europe coastal region, the western Mediterranean, the Irish Sea, and to some archived demonstration data sets

2.3 Products

2.3.1 Satellite Data

The MCEIS website shows the most recent available day's data, the previous six days and a composite image comprising all clear data from these seven days. The satellite data are updated daily; weekly composites of data are generated by integrating images from individual sensors. Parameters available are:

- Chlorophyll, water clarity (expressed as an attenuation of light in water), suspended particulates (a reflectance value)
  - daily at 1-km resolution from MERIS, MODIS (Aqua and Terra) and, until December 2004, SeaWIFS; weekly composites from each sensor;
- Sea-surface temperature (SST)
  - Daily updates and weekly composites from AVHRR and MODIS (Aqua and Terra);

Additional view options include comparisons of

- All products
- All composites
- Chlorophyll
- SST
- True colour

These enable intercomparison of the same data type (e.g. chlorophyll) from different satellites, or from different algorithms.

For the NW Europe and Irish Sea regions near-real time demonstrations daily data are produced from:

- SeaWIFS[3] chlorophyll, near-true colour, normalised water leaving radiance (a proxy for suspended particulates) and attenuation of light at 490nm (a measure of water clarity); composite images are produced for the first three parameters.

- AVHRR sea-surface temperature with 7-day composites. Data from both operational AVHRR instruments are produced and it is possible to view individual passes through choice on a drop down menu.

- MODIS Aqua and Terra (two satellites) chlorophyll (Case 1), chlorophyll (Case 2), water leaving radiance at 551nm, SST and true colour. Composites were developed for the chlorophyll products.

MODIS Aqua data are additionally received and processed from the NASA Ocean colour website to fill gaps in northern waters caused by the instrument being switched off during data downloads over Spitzbergen.

MERIS: through access to the ESA Envisat data by PML it is possible to make available MERIS products on chlorophyll. This deliverable was outside the scope of the original work plan.

For the Western Mediterranean data are processed for all of the satellites noted above but with a sub-set of products and composites.

[3] SeaWIFS data were not available after December 2004, as the public licence was terminated.

For the period up to 15 January 2005, the near-real time demonstrations total data produced specifically for MCEIS included

- SeaWIFS: 109 passes processed with 4 products for each of the 3 regions
- AVHRR: 1,390 passes processed with 1 product for each of the 3 regions
- MODIS: 801 passes processed with 5 products for each of the 3 regions

That is a total approx 5,900 x 3 = 17,700 products (plus daily composites of many of these products). In addition 85 MERIS passes were processed with a single product.

For the archive demonstrations the following data were processed: 298 MODIS, 581 SeaWIFS, 2716 AVHRR, totalling approx 6,500 products.

Hence, in total 24,000 individual products were computed from ~1.6 Terabytes of data! The nature, of course, of near-real time data processing is that a sizeable number of these data are of little use because of cloud cover; however, even partly clear scenes can contribute to the weekly composites.

Figures 3, 4 and 5 give examples of the NRT MERIS, MODIS and AVHRR data,

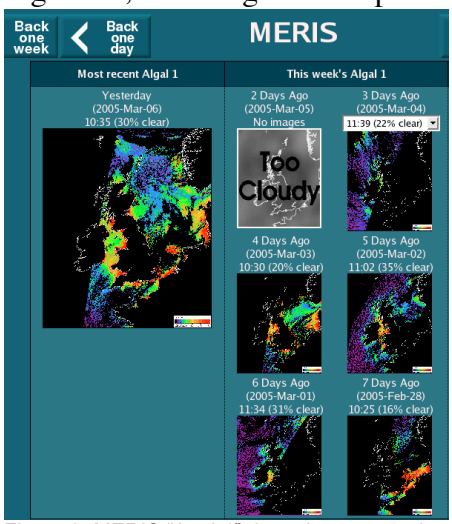

Figure 3. MERIS "Agal-1" data, the present day and previous 6 days

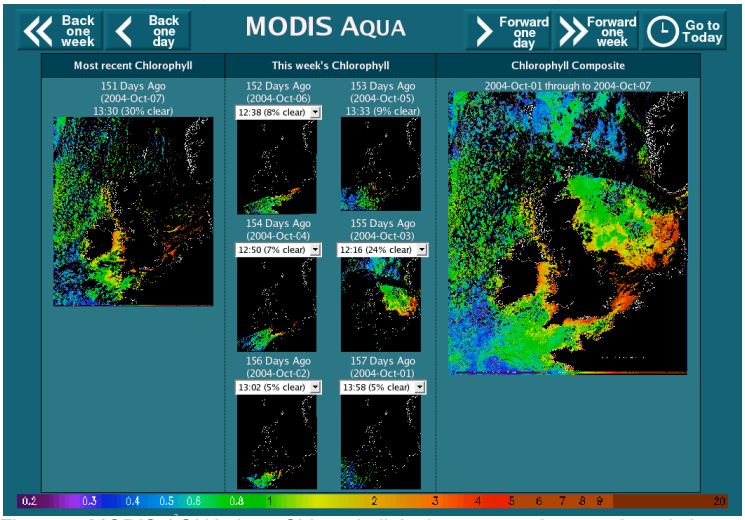

Figure 4. MODIS AQUA data, Chlorophyll-A, the present day, previous 6 days and weekly composite

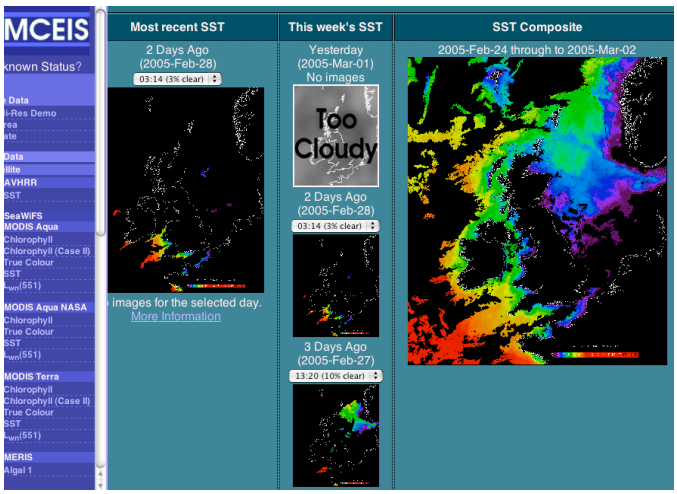

Figure 5. AVHRR Sea Surface Temperature. The present day, previous 6 days and weekly composite

2.3.2 In Situ and Model Data

In the first instance *in situ* data and model fields were obtained respectively from CEFAS and POL. At a later stage in the project the UK Met Office provided access to archived model data (see section 2.3.4).

The *in situ* data comprises SmartBuoy data (fluorescence, PAR, salinity, temperature and turbidity) for two buoys located in the Irish Sea and the Thames estuary. These data are e-mailed to PML and are automatically extracted and added to a database. This is linked to a simple graphical display tool specifically written for MCEIS that allows choice of start and end date for plotting.

The POL Irish Sea model fields comprise daily surface and bottom temperature and surface and bottom currents from the high resolution (1.8km) operational Irish Sea model. These can be viewed in the same format as the satellite images, or as overlays on the satellite images (currents only).

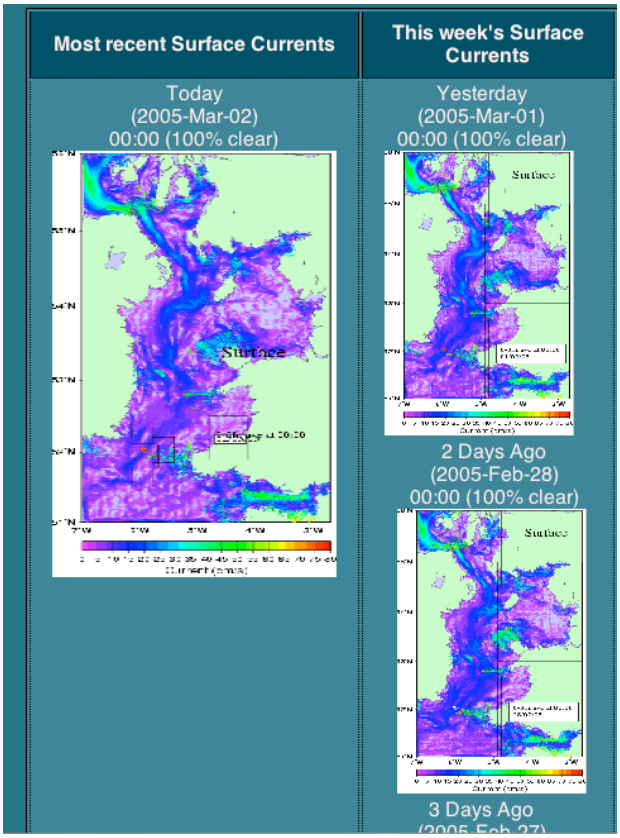

Figure 6 . Surface Currents from the operational Irish Sea circulation model (POL).

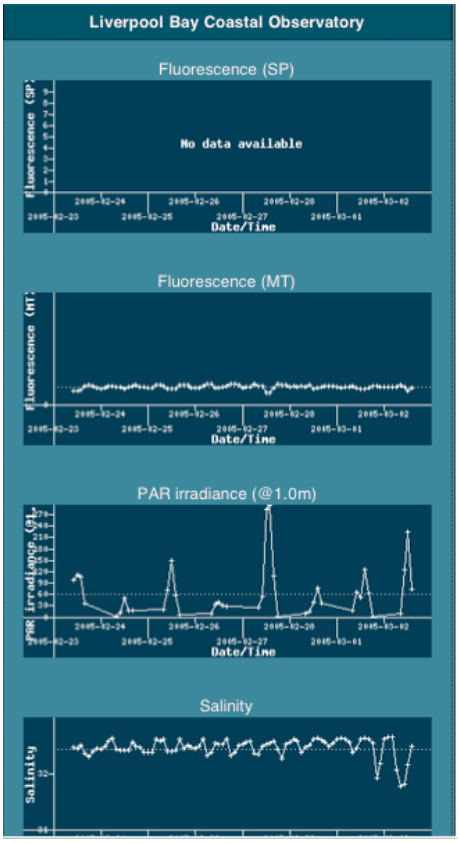

Figure 7. Time Series from the CEFAS SmartBuoy In Liverpool Bay

2.3.3 Interactive Tools

Software has been developed to allow images to be viewed interactively. The functions are accessed simply by clicking on any selected image, and include zooming and panning of the image, interactive stretching/compression of the colour scale. Coastline overlays or masks can be applied, as can grid overlays. Equivalent processed images produced by different satellites can be compared side-by-side. A searchable archive is also available online.
Figures 8, 9 and 10 demonstrate some of this capability.
The software uses java code that has to be downloaded onto the user's computer. The limitations of computer configurations (versions of browsers, access to java) available to some users meant that they could not all access these capabilities. Information on the required configurations is available through the "User Preferences" tab on the left hand side of the web pages. This limitation, and

dependency on user computer configurations, remains an issue for future implementation (see section 4).

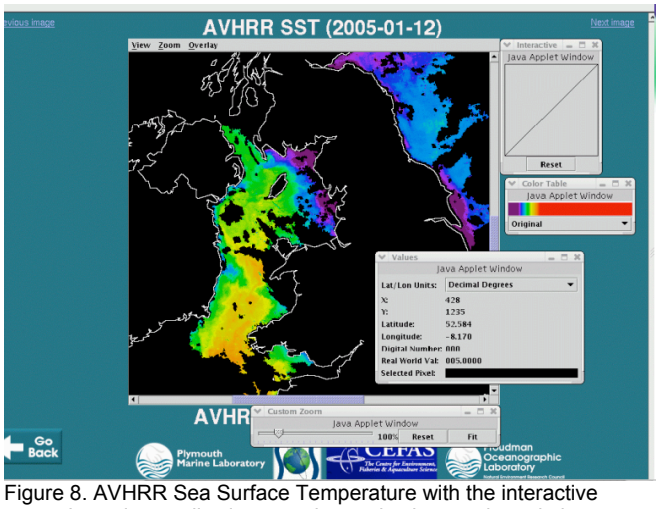

Figure 8. AVHRR Sea Surface Temperature with the interactive Java viewer allowing zooming and colour scale variation

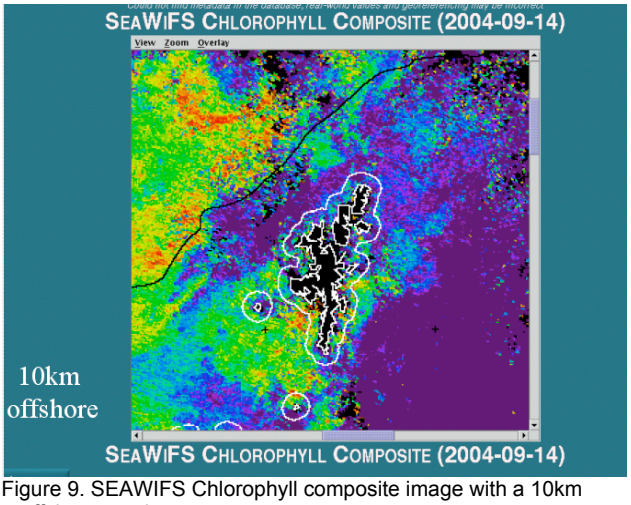

Figure 9. SEAWIFS Chlorophyll composite image with a 10km offshore overlay.

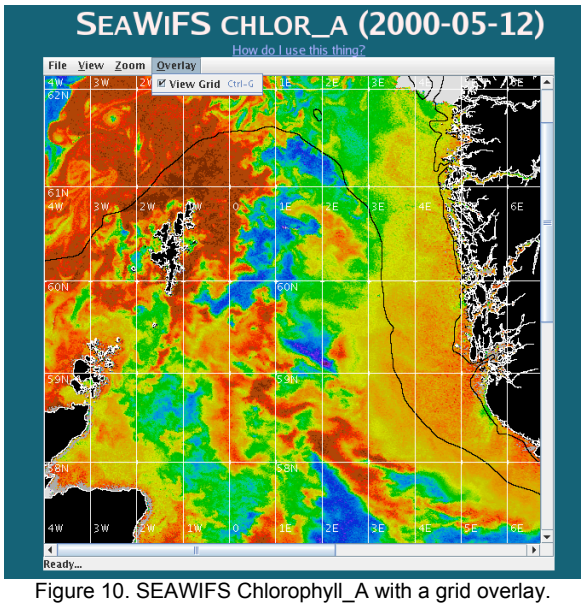

Figure 10. SEAWIFS Chlorophyll_A with a grid overlay.

2.3.4 Demonstration Data Sets

Archived Satellite Data

The winter season is not an ideal time to demonstrate a service based on satellite data which relies on a cloud free view of the ocean surface. In addition, many of the bio-geophysical phenomena of most interest to the user occur in spring and summer. Access to a number of archive data sets has been provided therefore to demonstrate representation of these important events, as follows

- North Sea Summer 2004: data from SeaWIFS, AVHRR and MODIS on Aqua and Terra
- North Sea Chattonella HAB, May 2000: data from SeaWIFS and AVHRR
- Western English Channel Karenia HAB, July 2000: data from SeaWIFS and AVHRR notably with composites of HAB likelihood index (See Figure 11)
- A test “bloom warning” indicator applied to Chlorophyll-A images (see Figure 12)

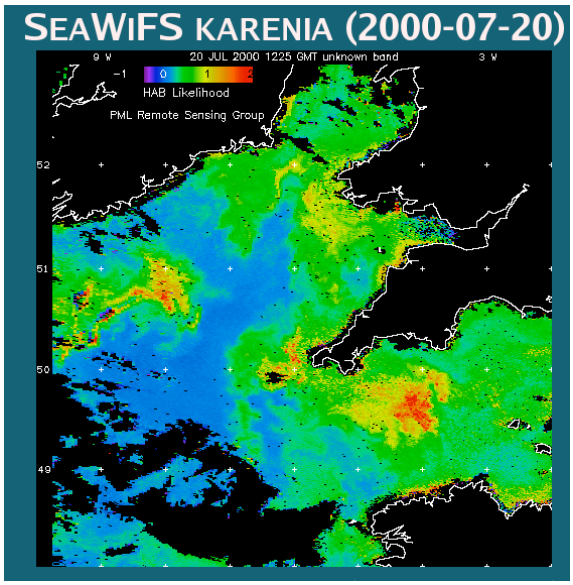

Figure 11. Sample HAB likelihood map for a *Karenia* bloom in the western English Channel

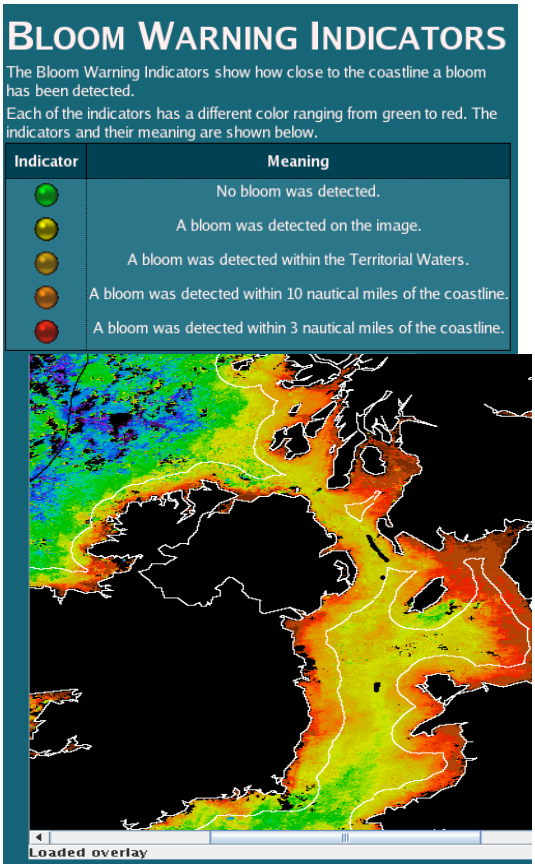

Figure 12. Automated "Traffic Light" warning of a high Chlorophyll_A bloom near the coast.

High Resolution Satellite Data

The web site provides demonstration of high resolution data from the MODIS satellite with 500m resolution chlorophyll data (Figure 13) and 250m resolution suspended particulate images.

Time Series / Water Quality Statistics

Following a request from the users for time series information, a demonstration capability has been provided by averaging satellite derived chlorophyll within a few selected regions (Figure 14). Longer term aims would be to provide statistics of EO and model derived water quality indicators aggregated either onto a regular grid, or mapped onto WFD or OSPAR assessment regions, and to include a capability to retrieve time series and so enable the user to assess present conditions against "normal" for the time of year.

Operational Near Real Time Bio-Geophysical model output.

Another aim is to incorporate Near Real Time output from operational bio-geophysical models. This would include both the POL Irish Sea model at 1.8 km resolution, and the UK Met Office Medium Resolution (6km) Continental Shelf model. Although unfunded by MCEIS, the UK Met Office has supplied archived model output for 2004 to the project (Figure 15). We would like to acknowledge their support to the project, and emphasise the importance of their involvement in any future developments.

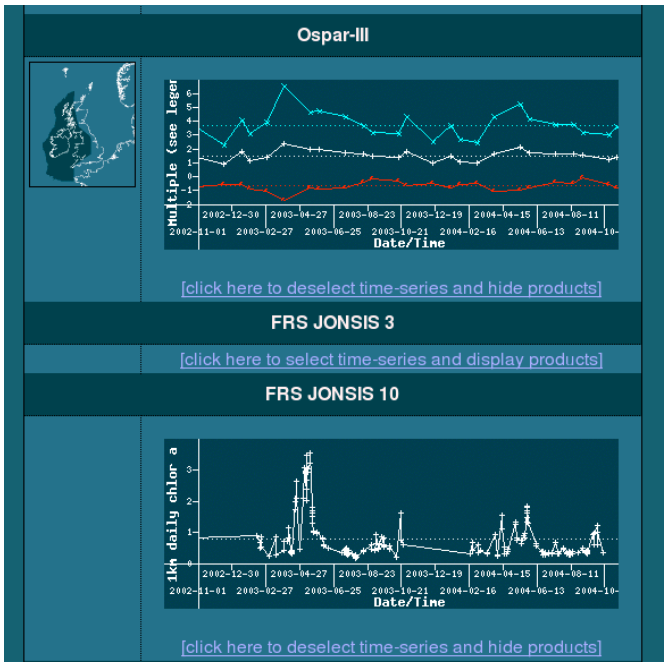

Figure 13. Time series of satellite derived chlorophyll averaged over user defined regions

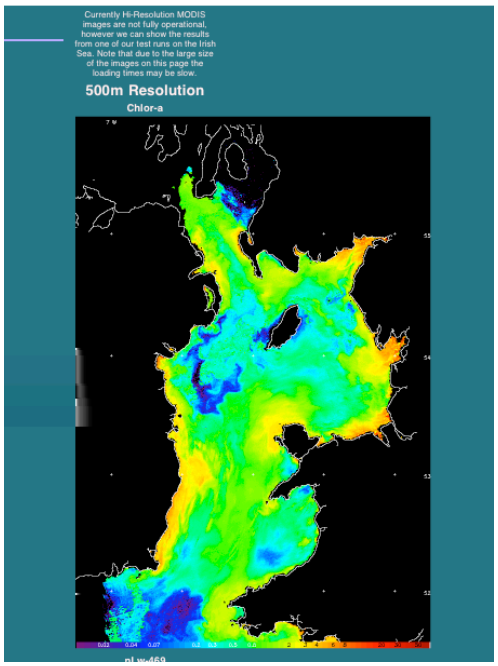

Figure 14. High resolution chlorophyll-A (500m) from MODIS

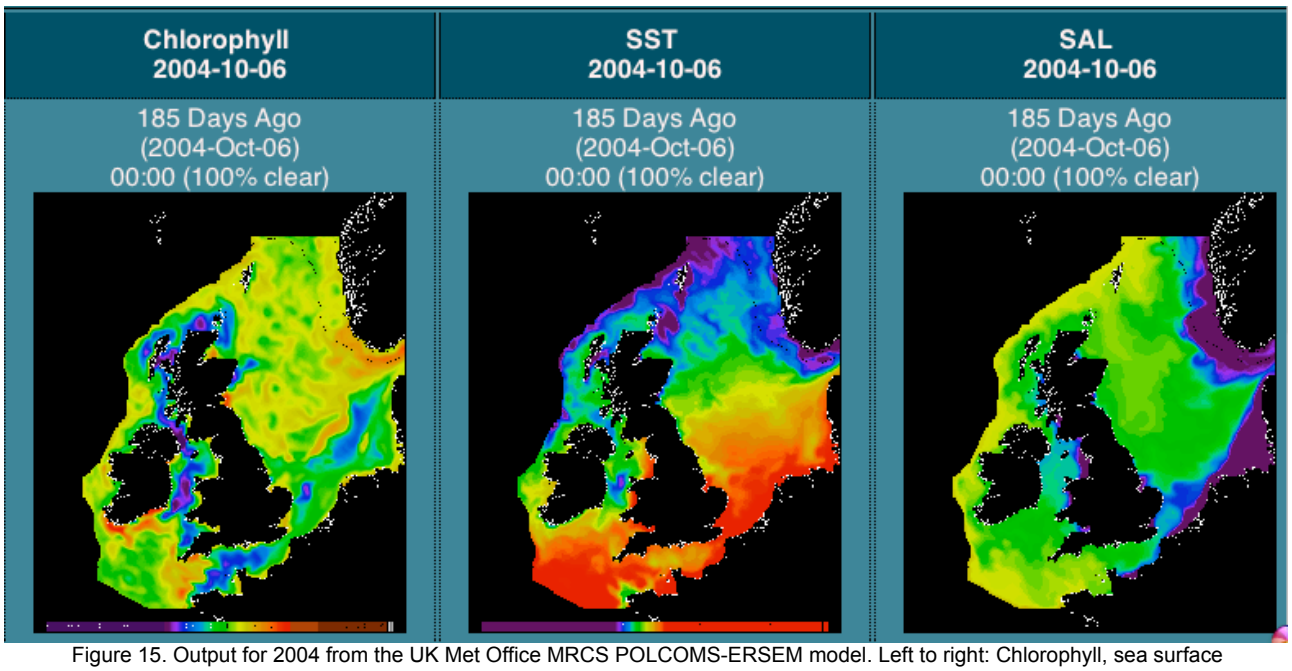

Figure 15. Output for 2004 from the UK Met Office MRCS POLCOMS-ERSEM model. Left to right: Chlorophyll, sea surface temperature, salinity

2.4 User Access

At the start of the demonstration a single MCEIS username and password was set up, however, this did not allow detailed tracking of user access and data downloads by individual user or partner group (e.g. POL, CEFAS or FRS, SEPA etc). Hence, unique log on username and password were supplied.

By 15/01/2005, the number of hits to the web page was 7,601 excluding PML who obviously were developing the site and 9,525 unknown IP addresses, which obviously could include bona fide researchers.

Entity	Hits
POL	1665
IFREMER	1105
FRS Mar Lab	906
UCC	430
Met Office	481
EA	1210
UHI	1247
NERSC	9
NI Executive	528
DEFRA	20
Total	**7601**

3 User Evaluation

3.1 Introduction

The close involvement of user agencies was an important factor in MCEIS. Without, it would not have been possible to satisfy the aim of developing services to help the user agencies fulfil their operational responsibilities in applying marine environment policies. Thus three user agencies were full MCEIS partners (the Environment Agency, the Centre for Environment, Fisheries and Aquaculture Science and Fisheries Research Services). These agencies plus a range of other interested parties (see Table A2 in the appendix) were invited to participate in the evaluation of MCEIS products, and to provide recommendations for future developments and implementation.

Activities included:

- A workshop early in the project (October 2004) to allow users to present their key requirements and provide an initial specification for the MCEIS pilot services.
- Email requests for further detail and observation.
- A service review workshop in January 2005, at the Environment Agency, to gain user comments on the initial service and further recommendations.
- Opportunity to contribute to and review this final report.

Minutes of the workshops and copies of the powerpoint presentations are available at http://www.satobsys.co.uk/Private/EMPA

3.2 User Agencies and Interests

Environment Agency (England and Wales)

The EA responsibility in coastal waters reaches to 3nm from the coastline. EA anticipate that the main application of EO based services would be to satisfy WFD requirements. They are developing a "toolkit" to carry out WFD assessments which includes, amongst other things, a database to monitor for occurrence of exceedance of monthly chlorophyll thresholds. Because the EA's remit applies to the near-shore, difficulties of supplying satisfactory coverage of this region at sufficiently high temporal and spatial resolution are seen to be major limitations on the direct application of satellite data. Nonetheless it is recognised that EO data could provide a potentially important contribution, for instance to allow the EA to interpolate between in-situ measurement sites.
For operational Algal Bloom warning/monitoring EA would like to see simplified "risk" maps providing present HAB status (e.g level of risk high, medium, low) – also it is important to provide an assessment of the risk of individual blooms being toxic (e.g. a HAB likelihood index).
To ensure take up, the use of monitoring services must not require a high level of technical expertise. Services must link to statutory requirements and show a cost benefit if EA is to adopt them over the long term. In most cases a cost saving must be demonstrated.
EA has a lot of *in situ* sampling data and airborne data, which could be used to assess and / or add value to the MCEIS services.

Centre for Environment, Fisheries and Aquaculture Science – (England and Wales)

CEFAS has a wide range of statutory monitoring requirements, including OSPAR, WFD, urban wastewater management, and shellfish hygiene. CEFAS' monitoring responsibilities require seasonal information (mean, maximum, etc) of key parameters for coastal regions - defined variously for the different directives. CEFAS also has an interest in Harmful Algal Bloom warnings, and would be interested in derived satellite products relating to water clarity e.g. estimates of the ratio of Case1 to Case 2 waters.
CEFAS has recently started a 5 year Eutrophication Thematic Programme for DEFRA– within this programme EO data could have a key application in a hindcast role to determine the "expected"

level of particular parameters, to provide a spatial context for in situ time series data and to validate models.

Fisheries Research Services (Scotland)

FRS has responsibilities with regard to water quality monitoring, algal bloom monitoring and fisheries management. In many ways they have an equivalent role to CEFAS, but for Scottish waters.

With regard to water quality and algal bloom monitoring, the main interest is for Near Real Time provision of specified physical and chemical parameters. It should be noted that aquaculture forms an important part of the economy in some Scottish regions, and some sites appear to be vulnerable to blooms that apparently develop offshore and are then advected into the coast. Recent HAB events in Orkney and Shetland have affected the shellfish and farmed fish industries.

Under the present methodology applied to fisheries management ("single stock assessment") a "water quality" monitoring service would have little relevance. However FRS anticipates a move towards an ecosystem based approach in the next few years, which would then represent a huge new potential and real need for EO and operational models to provide underlying data.

Scottish Environment Protection Agency

SEPA's remit covers the near coastal waters (similar to the EA responsibility for England and Wales). The long Scottish coastline is covered by a relatively small number of SEPA scientists, and SEPA does not have access to an airborne monitoring capability, so a satellite based "advanced warning" system to help target deployment of resources could be especially useful. As noted above, the aquaculture industry is important to the Scottish Executive, with 300-350 sites in Scotland (mostly concentrated on the north and west coasts).

Key water quality parameters are chlorophyll, SST, salinity, suspended sediments. Gridded seasonal values are of interest. SEPA has identified sites of particular interest, which they believe would be suited to satellite based monitoring.

Environment and Heritage Services (Northern Ireland)

The Environment and Heritage Service is the agency mainly responsible for statutory water quality monitoring in Northern Ireland and have responsibility for licencing under the Food and Environment Protection Act (e.g. for shoreline construction, dredging and dredge disposal).

The EHS has similar requirements as the EA and envisages that satellite information would also be useful for assessments under Urban Waste Water Treatment Directive and Nitrates Directive as well as OSPAR and WFD.

North Atlantic Fisheries College (Shetland, Scotland)

NAFC has been monitoring near surface variables at a fixed station on the west coast of Shetland as part of participation in the EUROGEL 5th Framework project. Variables including algal presence, temp, oxygen, salinity, etc are measured every few minutes with a CTD fluorimeter. Also plankton samples are sent to FRS on a routine basis.

NAFC is currently planning to extend coverage to about 15 sites around Shetland. One of the aims of this project is to monitor algal levels and predict (if not forecast) problem situations. The addition of satellite imagery coupled with appropriate hydrodynamic models to this in situ data gathering system could offer the potential to provide a forecast capability.

NAFC advise that the aquaculture industry would be very interested in any service that could monitor and predict Harmful Algal (and other relevant) blooms.

Scottish Association of Marine Science (Oban, Scotland)

SAMS is a research laboratory. Although it does not have a specific governmental responsibility to implement environmental policies, it operates a wide-ranging monitoring programme, though no

data are presently transmitted in near real time. SAMS are planning, with POL and FRS, a Scottish Marine Observatory.

University of Wales Bangor (Menai Bridge,Wales)

The School of Ocean Sciences at the University of Wales (Bangor) has an active research programme, specialising in shelf seas and shallow marginal marine environments. MCEIS fits well with 2 INTERREG projects led by UWB: Ferry measurements in the Irish Sea, and MATSIS – Methods of Assessment of Trophic Status of the Irish Sea.

Environment Protection Agency (Republic of Ireland)

EPA's main interest is the application of Water Framework Directive Monitoring requirements to Irish coastal waters. The areas best suited to satellite monitoring are the larger estuaries off the SW, W and NE Irish coastline.

Marine Institute (Republic of Ireland).

MI is developing in-house satellite analysis and modelling capabilities. They are most interested in monthly/seasonal climatologies.

National University of Ireland, Galway – NUIG (Ireland)

The main interest of NUIG in MCEIS is through the ongoing project "Biological Oceanography of Harmful Algal Blooms. NUIG would require surface concentrations of chlorophyll (including information on intensity and durations of events showing high intensities of chlorophyll) water transparency and sea surface temperature.

3.3 Priority Requirements

The user requirements summarised here have been compiled from contributions received direct from the above agencies. Readers are also referred to the recent "State of the Seas" report, available from http://www.defra.gov.uk/environment/water/marine/uk/stateofsea/. This report was prepared jointly by DEFRA, the Scottish Executive, the Welsh Assembly Government and the devolved administration in Northern Ireland on behalf of the United Kingdom Government.

Water Framework Directive

The WFD presently only applies to the near-shore (< 1nm in England and Wales, < 3nm offshore for Scotland). Nevertheless some large estuaries may be suited to satellite based monitoring.

General WFD requirements are:

- Monthly / seasonal composites of key parameters (chlorophyll, suspended particulate matter, sea surface temperature, water clarity) aggregated over areas to match WFD coastal regions,
- Assessment of phytoplankton diversity, composition, abundance,
- Monitoring the frequency and intensity of biomass blooms in transitional and coastal waters.

OSPAR

The 1992 OSPAR convention contains a general obligation to collaborate in regular monitoring and assessment of the state of the marine environment in the maritime area. Under this convention a wide range of commitments have been agreed including a requirement to classify all coastal waters.

Warnings of Algal Blooms and Other Events

Local real time water quality information is important to agencies, in most cases satellite or model derived data would be used to provide initial early warnings, and to give the agencies some extra time to take any necessary contingency action and set up systems to monitor a situation. In such cases the warnings would advise of (for instance) blooms building in a region and, ideally, provide

modelled predictions on likely developments. It was emphasised by agencies that key decisions (e.g. to close beaches to the public) would not be made on the basis of EO (or model) data alone, but that EO/model derived warnings would be used as a basis for initiating the deployment of agency resources.

Warnings could consist of text warnings issued during the HAB season (perhaps through email or text message to identified parties) based on expert analysis of imagery. Initial implementation would probably be best achieved, at least in the first instance, by communicating through a central contact, who had some knowledge of EO and model analyses, and who would then have the responsibility to contact local officers. Perhaps there is a case for an "office trial" using historical EO and archived in situ data – to test the system on cases when the outcome is known (for instance making use of EA records of blooms).

HAB Risk Maps

Some agencies have a requirement for HAB statistics and risk maps in addition to those necessary for WFD. For example the EA have identified a need for simplified "risk" maps providing present HAB status (e.g level of risk high, medium, low) and for an assessment of the risk of individual blooms being toxic (e.g. the HAB likelihood index that has been developed by PML and the EA). It would be important to cover offshore and coastal areas, so that the system can warn of blooms that pose a potential threat and early action can be taken.

3.4 Observations and Recommendations

General Observations

The MCEIS pilot service was universally received with enthusiasm – in fact the main concern expressed was that the service should continue without interruption.

To quote one user (EHS):
"MCEIS has greatly improved the use of earth observation data for monitoring and research purposes and demonstrated that it has the potential to fulfil many legislative requirements that had not been previously shown. In particular the greater resolution near coast, the improved determination of chlorophyll, the interpretation of time series and algae bloom forecasting has already demonstrated many potential uses and with some further refinement could become a very useful tool to meet legislative requirements for the identification of eutrophic events. MCEIS could therefore partly meet requirements such as OSPAR, WFD and sensitive and polluted areas under the UWWT and Nitrates Directive. I strongly recommend the development of MCEIS into a national resource with core funding. This would open up the use of earth observation to all the scientific community and also importantly to the public. Like MCEIS this resource/centre should be user driven and a large part should be aimed at research and development."

FRS further recommended that an operational (and sustainable) basic monitoring service (using EO data and model output) be established as soon as possible, so that it could be taken up by agencies as new monitoring systems are developed. They suggested that subsequent developments and refinements could be added in progressively. It was argued that the service should be free at the point of use, available through open access to all, and that long-term continuity was provided.

From the EA, key positive points were that the service offered:

- High quality data,
- Daily updated data,
- Easy access to current and older data,
- Data can be viewed at relatively high resolution.

Limitations

It is important to be candid and realistic about the limitations of satellite data. These limitations fall into three areas:

- Lack of availability close to the coast (and the related need for very high resolution data near the coast),
- Frequent and significant impact of cloud cover in UK waters,
- Limited accuracy available for some parameters in some water types.

Many of the water quality directives under discussion apply at (or very close to) the shoreline – it is important to recognise that EO data on its own may not be able to provide useful coverage or the spatial and temporal resolution to necessary to capture variability in the parameters of interest. It is also likely that EO data cannot provide a direct estimate of the parameter that is required. Hence EO data must be provided as part of an integrated system, which includes output from models, and data from in situ instrumentation and other local sources.

Some of the initial EO based water quality systems have expected too much expert knowledge on the part of the user. It was emphasised by almost all users that it is important not to assume a high level of user expertise. Thus "value" must be added to the information products, which should be presented in a simple fashion to allow inexpert users to interpret and apply the water quality monitoring services.

Specific Requirements

Key Enhancements

Two specific enhancements were requested by the users:

- Provision of statistical information (mean, max, min, variance, number of observations) for specified parameters, either on a regular grid (e.g. 6km x 9km, weekly), or aggregated over regions selected by users (e.g. OSPAR regions, WFD water bodies,….)
- An algal bloom early warning service.

Processing, Parameters

A number of requirements for further processing or parameters were identified. In particular the provision of calibration and confidence measures is important, indeed required under WFD. Thus error estimates and detection limits should be provided for all derived data. Specific requirements were:

- A reliable autonomous technique to separate the signals from suspended sediment and chlorophyll in satellite data.
- Map, record and display the temporal and spatial extents of blooms.
- Provide information of the spatial variability of in water optical properties, e.g.
    - ratio of Case 1 / Case 2 waters,
    - vertical attenuation coefficient.
- Include estimates of surface irradiance.
- Include summary data (means, errors, threshold exceedance) within water management areas.
- Highlight the 10 mgl^{-1} chlorophyll concentration contour.
- Absolute values of e.g. chlorophyll are not always required, but rather estimates of whether concentrations lie within predefined limits.

Extra Functionality
There is an interest in higher levels of functionality, in particular for improved interactive capabilities which would allow:

- Direct access to geospatial information (actual parameter values at selected locations).
- Facility to plot time series (at a point, along a line, or over a defined area).
- Overlay of management boundaries, coastlines, etc.
- Options to download data (not just images) for subsequent processing / applications.

Presentation
The present configuration of the MCEIS website perhaps reflects the developmental nature of the project, and the research background of the providers. Thus a lot of information is provided – sufficient in fact to confuse or even put off the inexpert user. Thus the site should be re-configured specifically to suit the targeted users. In general the user should be able to gain direct access to pages of specific interest to them. For instance these pages might present a limited number of simple maps or indicators with subsequent easy direct access to key data sets. Such a service would provide an indication of the level of risk, mapping of information to coastal waters, and an identification of potentially harmful blooms, linked to a pro-active warning service (text messages identified as preferable to email). Alternatively users with OSPAR or WFD responsibilities should be able to link directly to the latest status report for a specific WFD region.

As noted above a combination of a data browser and web GIS is required to provide better interactive capabilities. Some users are finding the existing interactive capabilities on selected scenes difficult to operate (possibly the present capability is too restrictive with regard to computer platforms and software configurations).

4 Interactive Data Access Tools

4.1 Introduction

Within MCEIS a specific task was to review the current tools and IT systems that provide interactive access to spatial data over the internet. This review was carried out by CEFAS.

There were two main areas of activity. Firstly, relevant information on the current suite of interactive data access tools was gathered as part of the review process. Second, CEFAS explored the issues surrounding the practical implementation of one of the data access tools within the current CEFAS web mapping server, iSEA (www.cefas.co.uk/isea). This process has provided the project team with a much clearer view of the key issues that will need to be addressed in any future system development. A separate report on WP3 gives full details, we provide a brief summary here.

4.2 Review of tools for interactive data access

Web-based GIS are on the increase within the public sector as more organisations realise the value of these systems for communicating with the public and providing access to key data holdings.

It is important to note the distinction between web-based spatial data portals and web-based GIS. Web-based data portals provide access to spatial data without the added functionality of data interactivity and overlay. GIS provides extra interactivity tools, such as panning, zooming, data overlay, distance measuring, selecting and extracting information.

In order to integrate spatial data from multiple organisations, datasets are typically assembled from different sources and uploaded onto local servers. An alternative is to use open standards and transfer protocols for transmitted spatial data over the internet. Then data from multiple organisations can be viewed through a single point of access, typically a web-GIS. Relevant standards for sharing geospatial data over the internet have been developed by the Open Geospatial Consortium (OGC), and are:

- Web Map Service (WMS). Produces a map as a raster image. Answers basic queries about the content of the map, and tells a client what maps it can produce and which of those can be queried further. Not intended to provide access to the original unprocessed data.
- Web Feature Service (WFS). A WFS server provides raw coordinate data that the client can manipulate to produce a map. Data manipulation operations include the ability to get or query features based on spatial and non-spatial constraints, create, delete or update a feature.
- Web Coverage Service (WCS). WCS provides access to unrendered, raw data such as imagery (e.g. GeoTIFF), and other types of gridded data. The WCS provides true data access. Returning the unrendered data, it enables the client to perform its own rendering or modelling.

WMS and WFS services, both client or server, are becoming available in proprietary web-GIS software, whereas WCS is a relatively new standard and has not yet been adopted by any of the major software providers. WCS server capabilities are built into the open source MapServer environment (http://mapserver.gis.umn.edu/), which was used to build DISPRO, a prototype of a web-based, distributed marine information system (http://dispro.ucc.ie/apps/dismar/europa.xml)

Another initiative of relevance is the concept of the Grid. In simple practical terms, the Grid would operate as follows:

- The user submits a request through a Graphic User Interface.

- The Grid finds and allocates suitable resources (computing systems, storage facilities etc) to satisfy the user's request, and subsequently monitors request processing.
- The Grid notifies the user when the results are available and eventually presents them

The user doesn't have to know which resources they are using or where they are. They simply receive computing power and storage space from the Grid through a standard interface.

The NERC DataGrid (NDG) is a UK-based e-Science project developing Grid middleware and metadata systems to support access to a range of environmental data across the UK. A prototype is currently being developed using BODC and BADC data archives. More information on NDG can be found at http://ndg.nerc.ac.uk/.

Grid systems are in their infancy and cannot be used to develop an operational web-enabled marine water quality information service similar to MCEIS. In time it is likely that Grid systems will provide huge benefits for advanced users (scientists and researchers) requiring access to large datasets, computationally intensive models and processing power. As we have found during the MCEIS project, the majority of users of marine environmental information want processed data and simple output statistics, and these can be delivered using more established technologies.

4.3 Practical implementation and testing

The present MCEIS web site at PML is provided through a MapServer OGC WMS server which holds a number of satellite images and modelled outputs of marine environmental parameters. CEFAS attempted to develop WMS client capabilities by developing a link between CEFAS's current web-mapping server, iSEA, and PML's WMS server. If successful, data held remotely at PML would have been accessible via the iSEA web mapping server. Unfortunately the link could not be established during the time available to this project.

The recently upgraded iSEA v2 will be released in mid-April 2005 and will demonstrate test WMS client capabilities but not unfortunately through a link with PML's WMS server due to a number of unresolved implementation issues. Instead CEFAS have uploaded a number of sample images (GeoTIFFs) from PML displaying chlorophyll *a* concentrations around the UK during September 2004 from the SeaStar sensor on SeaWIFS. They have also provided access to SmartBuoy data from the same time period and for the same parameters to allow direct comparison of the two datasets.

Figures 16-21 demonstrate iSEA v2 and access to the marine environmental information described above.

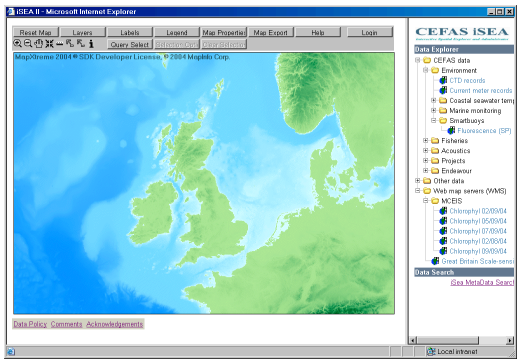

Figure 16. Main page of iSEA showing map view with GEBCO 1-minute raster bathymetry (held locally) and data browser on the right. A login facility provides access to MCEIS and SmartBuoy data.

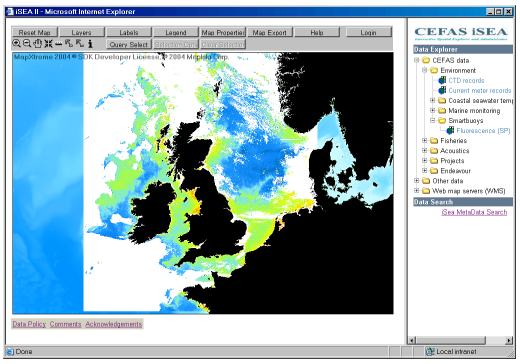

Figure 17. A chlorophyll *a* image is added to the map view by selecting it from the data browser.

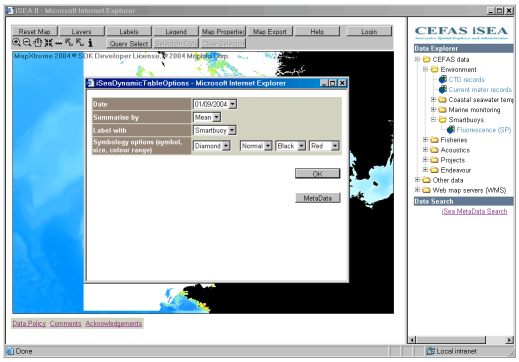

Figure 18. SmartBuoy data collected on the same day as the satellite image is added to the map through a query dialogue.

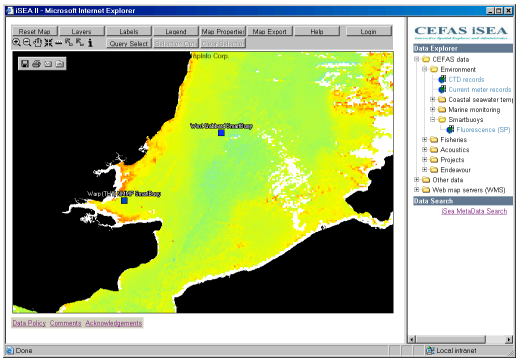

Figure 19. The SmartBuoy data has been added and the map view zoomed in to the southern North Sea to highlight the West Gabbard and Warp SmartBuoys.

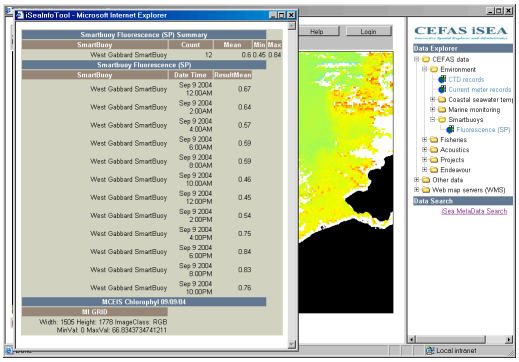

Figure 20. The information retrieval tool has been used to return attribute information for the West Gabbard SmartBuoy and associated data from the chlorophyll *a* image, allowing a direct comparison of the two datasets.

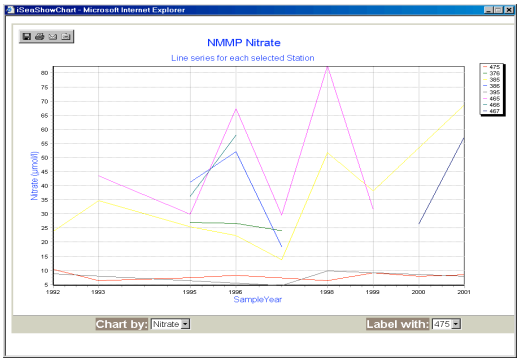

Figure 21. Time series plot of nitrate data from NMMP station to demonstrate the type of data presentation that could be possible if time series SmartBuoy data were accessible through iSEA.

4.4 Conclusions

Web-GIS technologies will undoubtedly form an essential component of any marine environmental information system, as spatial integration is critical to understanding ecosystem level processes. This review has provided a useful exercise in the practical implementation of systems and approaches for integrating spatial data over the web. Our experience is that proprietary web-GIS providers adopt newly emerging OGC standards to varying degrees and that support is more limited compare to that offered for the proprietary data sharing services (e.g. ESRI ArcIMS or ArcGIS server). Open source web map servers such as MapServer may be quicker to adopt new standards but support problems may hinder rapid development and deployment.

The current MCEIS service is not OGC compliant and we recommend that future initiatives aim to develop the necessary infrastructure to ensure that participating organisations can integrate their data using open standards, rather than rely on uploading data from remote servers to a central repository. Whilst the side-by-side browser style approach to data presentation adopted by MCEIS provides a quick and easy way of visualising multiple images, this should be complemented with a true spatial integration system whereby multiple images and other data can be overlaid and interrogated simultaneously. Functionality inherent to web-GIS should be more fully exploited rather than having to develop new routines in a non-GIS based system.

5 Exploitation (A) ESA GMES Service Element Phase 2 – The MARCOAST Proposal

5.1 Introduction

A specific aim of the BNSC EMPA programme was to support increased UK involvement in the European GMES programme. A key aim of the MCEIS project was to place UK organisations in a good position to respond to an anticipated ESA Invitation to Tender for Phase 2 of their GMES Service Element programme (GSE).

GSE Phase 2 is due to start in summer 2005, and follows GSE Phase1 which took place in 2003-2004. In GSE Phase1 two project teams, ROSES and COASTWATCH, provided services to monitor the marine and coastal environment.

ESA duly issued an ITT for GSE Phase 2 in January 2005 and, as anticipated, the ROSES and COASTWATCH teams combined to form the MARCOAST team, under the leadership of the French organisation ALCATEL Space. ESA called for proposals under 7 themes, one of which was monitoring of the marine environment. This theme incorporates oil spill and water quality/HAB monitoring. MCEIS is restricted to applications related to water quality / HAB monitoring. SOS coordinated the response of the MCEIS partners to this aspect of the call.

In this chapter we describe key aspects of the ESA ITT, and the subsequent contribution of the MCEIS team members to the MARCOAST proposal. Note that the UK Met Office, although not formally a member of the MCEIS team were closely involved in this activity, as the contribution of operational model data from the UK Met Office was recognised as being crucial to the credibility of the UK team's proposal.

5.2 The ESA GSE Phase 2 Proposal

General

The ITT was issued on the 25th January 2005, with a submission deadline of 29th March 2005, and an anticipated Kick-Off in June 2005. Projects were to last three years, proposals were to include "core" services (to address specific requirements identified by ESA in the ITT, mostly based on the services that were provided under GSE phase 1), which would be adopted as a whole, and a range of proposed "extension" services, from which ESA could choose a selection.

ESA have assigned a total budget of 40 M to GSE Phase 2, 27 M to support "core" services, 13M to support "Extension services". They will fund 3 European scale projects (marine, ice, land), and 4 regional projects (forest, urban subsidence, risk, food security)
The maximum budget for individual European Scale projects is 5M for "core" services, and 5M for "extension" services.

ESA issued a set of "Cardinal" requirements for proposals. They must:

- demonstrate long term sustainability,
- deliver services on larger scales,
- establish a durable open GMES service provision network,
- establish common standards and working procedures.

Other key issues that ESA highlighted were:

- Involvement of user agencies is crucial.

- Baseline service proposals should be supported by Service Level Agreements with user agencies.
- Extension services can include extension in coverage, additional new types of services, adding new users, providing more extensive validation, adding functionality,….
- Each extension service work package should require funding in the range 200-500k .
- Links to existing European / national projects add credibility (framework, interreg,…)

Budget

One of the main constraints is that a strict geo-return will be imposed on contributions from each participating country. National contributions to the 40M , the ESA budget for GSE Phase 2 were:

De:	11.25	Fr:	6.58
It:	6.00	**UK:**	**5.42**
Be:	5.33	Ch:	1.33
Sp:	1.25	Fi:	0.92
Gr:	0.42	Nl:	0.25
Aus:	0.17	No, Dk:	0

It is presumed that once the initial evaluation is complete, and proposals have been accepted in principle, ESA will look at all the accepted proposals and then address any requirement for budget reallocation.

5.3 The MARCOAST Proposal

General

The MARCOAST proposal evolved rapidly over time, in response to frequent tele-conferences, discussions and updated contributions. Here we provide an overview of the final proposal.

Budget

ALCATEL compiled an initial target budget for national contributions to MARCOAST:

	Realistic Marcoast Budget (Baseline)	**Realistic Marcoast Budget (Extension)**
Germany	900	1000
France	1500	2000
United Kingdom	**500**	**300**
Belgium	300	300
Italy	500	300
The Netherlands	200	100
Spain	400	500
Finland	100	200
Sweden	?	?
Greece	200	100
Norway	400	200
Denmark	?	?
	5000	5000

It can be seen immediately that France is planning to be the main contributor to this project. In addition to the MCEIS team (and the UK Met Office), it is known that UK organisations (specifically BMT) are planning to contribute to the oil spill services. Thus the 500k for UK contributions under baseline services, and the supplementary 300k for “options”, will have to be shared between WQ/HAB and oil spill service providers/users.

ESA Definition of Water Quality and HAB Services

ESA provided a definition of "required" water quality services in the ITT, as follows:

Baseline (Water Quality, HAB) Services

HAB and eutrophication statistics at "European Scale".
Water quality monitoring and HAB Alert for European Seas.
HAB evolution forecasting for the Norwegian Sea.
HAB statistics at basin and European Scale.

Priority Extension Services (Water Quality, HAB)

HAB and eutrophication statistics at "European Scale".
HAB evolution forecasting for European Waters.
HAB statistics at basin and European level.

Outline definitions were:
HAB and Eutrophication statistics – Pan European Services ("Water Quality Assessment", WP3500 in Fig 22)
Annual statistics at *Basin and European Level* for:

- HAB occurrence (bloom type, number of occurrences) at better than 10km resolution.
- Eutrophication conditions with sampling better than 10km x 10km, covering:
  - » Transparency,
  - » Phytoplankton concentration levels (algal blooms, toxic algae, chlorophyll-A.

WQ Monitoring and HAB Alert – National Services ("Water Quality Monitoring", WP3300 and "Algae Bloom" WP3400 in Fig 22)

- Routine monitoring of European Seas and measurement of:
  - » Chlorophyll concentration,
  - » HAB occurrence (identification of HAB, delineation of extent),
  - » Water clarity.
- Information to be provided twice weekly with daily updates during HAB events.
- Resolution at least 1 km.

HAB Evolution Forecasting – National Services (WP3300)

- Timesteps of 12 hrs up to T0 + 72 hours.
- 1km grid for coastal waters, 5k for open ocean.
- Valid for estuaries and inshore areas and open ocean.
- Forecast includes chlorophyll concentration and concentration of key contaminants.

HAB statistics – National Services (WP3500)

- HAB occurrence (bloom type, no of occurrences) at better than 5km resolution.
- Eutrophication conditions with sampling better than 5km x 5km.

MARCOAST Structure

Figure 22 shows the project structure; the work packages to which UK organisations are contributing are highlighted.

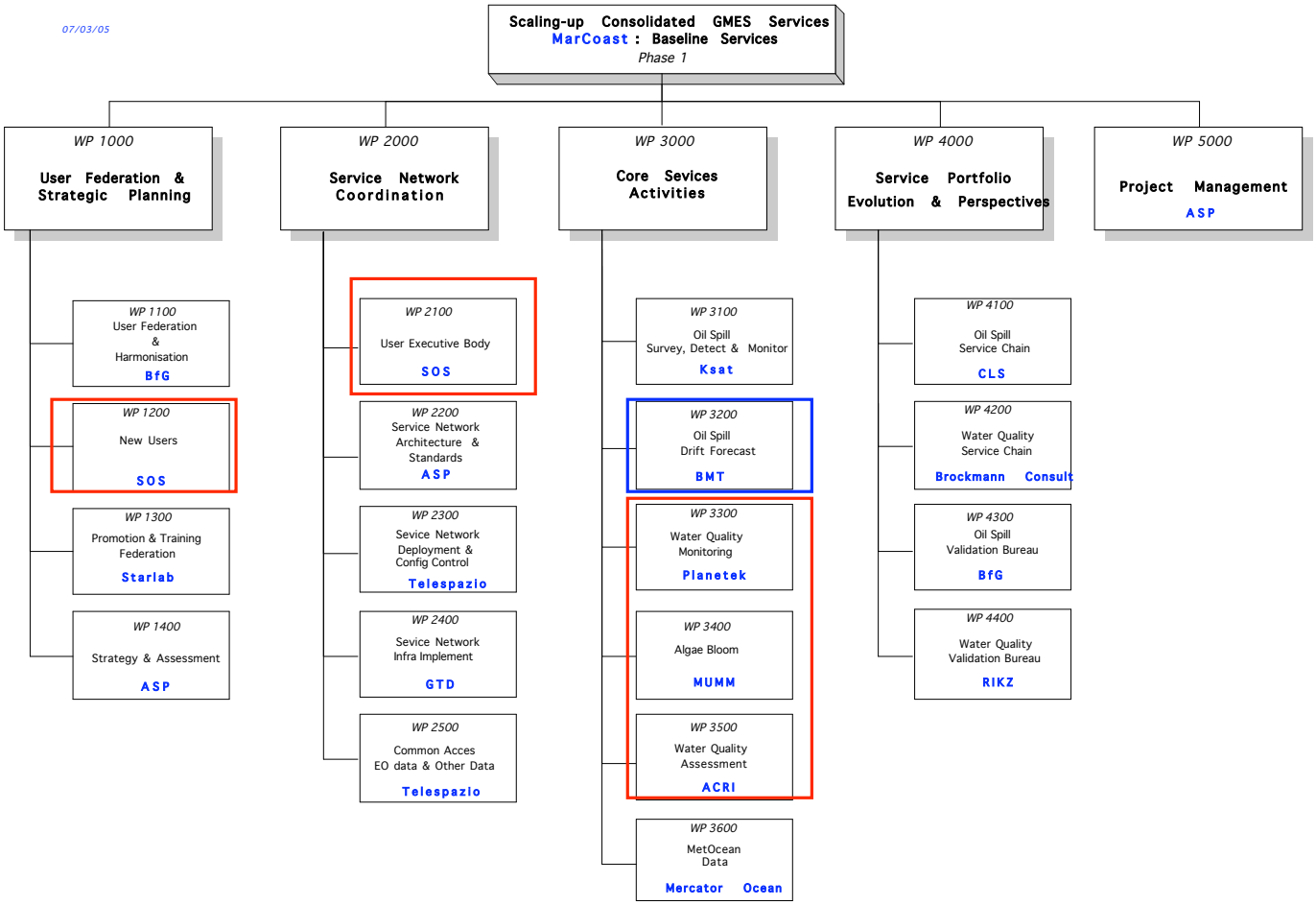

Figure 22: The Final Structure of the MARCOAST proposal. The work packages to which UK organisations are contributing are highlighted (in red MCEIS partners, in blue other UK organisations).

For provision of Water Quality services, the main Work Packages, and WP leaders, are:

WP 3300	Water Quality Monitoring	Planetek
WP 3400	Algae Bloom	Mumm
WP 3500	Water Quality Assessment	ACRI
WP 3600	Metocean Data	Mercator Ocean

5.4 MCEIS Team Contribution to MARCOAST

The MCEIS team[4] proposed a combined contribution, to WP 3300 (Water Quality Monitoring), WP3400 (Algae Bloom Alert and Forecasting), WP3500 (Water Quality Assessment), and WP3600 (Met Ocean Data). In addition SOS was selected by ALCATEL to lead WP 1200 (New Users) and WP2100 (User Executive Body).

Subsequently the MCEIS team were asked to provide detailed proposals for extension services under WP3300 and WP3400 (detailed below). They were not considered for significant contributions to services under WP3500 or WP3600.

WP 3300 Water Quality Monitoring Services – UK and Atlantic Extension

The MCEIS team have proposed with IFREMER, a UK and Atlantic Extension service to WP3300. The UK part of this service extension offered a "web-based service providing EO and model derived water quality monitoring service comprising maps of key parameters, through daily images, weekly and monthly composites,…..to cover the whole Great Britain and Ireland coastline."

[4] In this chapter we include UK Met Office under the MCEIS team.

PML are to be responsible for maintaining the Web Services, and will process, format and generate composites of EO data covering the NW European Continental Shelf.
The UK Met Office will provide products derived from their coupled ecosystem model.
POL will provide higher resolution information for the Irish Sea. This includes output from a 1.8km resolution coupled ecosystem model, plus *in situ* and other data.

Year 1-3 Services
Earth Observation Services (PML)
Daily maps, weekly (or 8 day), and monthly composites of: chl-A (Case 1 and Case 2), sea surface temperature, water clarity (K490) and suspended particulate matter proxy (Rrs551).
Sources: MERIS (level 1 and 2), MODIS Aqua and Terra, AVHRR.
Resolution: 1-km at nadir
*Coverage:*47°– 63°N; 15°W –10°E

Ecosystem model service (UK Met Office)
POLCOMS-ERSEM MRCS (Medium Resolution Continental Shelf) model output, 6km resolution. The initial service will comprise weekly composite maps of chlorophyll, plankton biomass (functional groups of diatoms, flagellates and dinoflagellates), SST, salinity, nutrients and currents. In years 2-3 POL will provide a high resolution (1.8km) model service in the Irish Sea.

In situ data (POL)
Time series measurements in Liverpool Bay (Coastal Observatory): Weather, SST, Turbidity. Other sources including Ferry box (Birkenhead – Belfast, Cuxhaven – Harwich).

Year 2 Service Developments
Web Service (PML) : From year 2 PML will phase in a Prototype Web Map Server (developed in DISMAR) to integrate EO and model raster with in situ model and baseline vector data.

MRCS Model Service (UK Met Office): Maps of eutrophication, either as oxygen or other indicator as determined by consultation with users, will be added to the MRCS model service

Irish Sea Model Service (POL): High resolution (1.8 km) biophysical model (POLCOMS-ERSEM) model data for the Irish Sea will be added. The model includes assimilation of SST and NRT river inputs. Nowcast + 72h forecast will be available.

In-Situ Data: Data from in-situ Irish Sea moorings will be included. In addition data from a second ferrybox route Heysham-Douglas (Isle of Man) is planned, with measured surface nutrients.

Year 3 Service Developments
MRCS Model Service (UK Met Office): Maps of sediment and light. Users will be consulted to determine whether depth averaging is required, and/or for which levels data are needed.

WP 3400 HAB Alert and Forecasting Services – UK and Baltic Extension

The MCEIS team, with the Finnish Institute of Marine Research (FIMR), have proposed an Algae Bloom alert and forecasting Extension service for UK and Baltic waters. The "UK Group" will offer EO and model derived HAB warning and advice, backed up by near real time *in situ* data from buoys and ferrybox routes. These services will cover the Great Britain and Ireland coastline.

Year 1 Service

EO Service (PML)

1) HAB likelihood indicators for *Karenia mikimotoi* and *Chattonella.* At least daily updates within 2 hours of acquisition of MODIS data. A multivariate classification approach is used, shown to be effective for discriminating these species from normal algal blooms.
2) Prototype bloom/hazard alert system that flags when chlorophyll is over a set threshold in region of interest. These regions to be specified in SLAs. The system is run at least daily, reporting warnings within 2 hours of acquisition of MODIS data.
3) Automated bloom anomaly detection. A rolling background average is subtracted from the latest chlorophyll and SPM data. Run at least daily, indicating new bloom anomalies within 2 hours of acquisition of MODIS data.

Near Real Time Bio-Geophysical Model based Services (UK Met Office, POL)

POLCOMS-ERSEM MRCS model (UK Met Office), 6km resolution: Daily averaged maps of chlorophyll indicating regions where threshold levels have been exceeded (indicating the potential presence of blooming HAB species). To support discrimination of HAB species, plankton biomass as functional groups of diatoms, flagellates and dinoflagellates will also be provided.

IRS (Irish Sea) POLCOMS-ERSEM model (POL), 1.8 km resolution: Daily surface maps of chl and plankton biomass. Rates of chl and biomass will be determined and where rates exceed accepted criteria a traffic light system will operate to indicate regions where there is HAB potential.

Year 2 Service Extensions

EO Service (PML) HAB likelihood indicators also applied to MERIS data – providing more frequent coverage and robustness against data drop out due to cloudiness. The additional spectral channels may allow further HAB species to be discriminated, and with greater accuracy.

Higher-resolution MODIS ocean colour products (500m chl-a and clarity, 250m SPM) to provide more effective near-real time algal bloom detection near to the coast and amongst islands, etc.

MRCS Model Service (UK Met Office) A near real time daily eutrophication indicator will be added as a proxy for HAB trigger events. Bottom oxygen is suggested as a potential indicator, but the supply of other parameters (such as N to P ratios) will be discussed with users.

Irish Sea Model Service (POL)

The Irish Sea model service will be extended by offering HAB indicators derived from POLCOMMS-ERSEM Nowcast and a forecast out to 72 hours. Maps of HAB likelihood derived from fuzzy logic indicators will be provided. In addition in situ Irish Sea mooring and ferrybox route data will be made available to support the service.

Year 3 Extension Services

UK Met Office Model Service The MRCS model service will be enhanced to include forecasts. Maps of HAB likelihood derived from fuzzy logic indicators will be provided.

5.5 Summary

Within MARCOAST, MCEIS partners have proposed "Extension" services as part of the Water Quality Monitoring and HAB Alert and Forecasting work packages, to the total value of 126k over three years[5].

If the MARCOAST proposal is accepted by ESA it is to be expected that there will be subsequent negotiation, (a) to determine which extensions services are selected, and (b) to balance the budget

[5] This includes the UK Met Office contribution.

according to geo-return. In all, 17 extension Services have been proposed within MARCOAST. To support the case for the selection of the services involving MCEIS partners, strong user backing is required, as evidenced by SLAs. To date, SOS has received signed SLAs from EPA, MI, EA, SEPA and EHS.

Note that whatever the outcome ESA will only provide funding for 3 years. The long-term aim is that the services will gain funding from the user agencies, and that ESA's role will revert to that of data supplier. Thus whatever level of funding the MCEIS partners receive through GSE, it will at best provide medium term support for some aspects of the existing capability. The team cannot therefore rely on GMES alone to provide for long-term implementation of the full service capability that is required by the user agencies. There is consequently a need to plan for implementation in a way that is complementary to but not dependant upon GMES – this need is addressed in the next section.

Finally, the MCEIS partners are concerned that the current planning within GSE has tended to exclude UK organisations from basic data provision (in MARCOAST this is mostly provided through WP3600 by French organisations). This is despite the existence of well-regarded facilities in the UK - specifically ground stations, satellite data processing and ocean modelling capabilities. It is not clear that the process of selecting basic service providers is based on objective criteria, necessary to ensure that the organisation best able to meet the service requirements is selected.

For example consider the MARCOAST algal bloom alert service. To be effective the near real-time delivery of information extracted from colour sensors should be made as fast as possible and certainly much less than 12 hours after acquisition. Under current plans within MARCOAST this requirement will not be met unless the capacity of the identified service provider is upgraded. Yet this capacity already exists in the UK as demonstrated through MCEIS over the winter of 2004/5.

6 Exploitation (B) Recommendations for a long-term UK MCEIS

6.1 Introduction

The UK user agencies have expressed an interest to maintain MCEIS as an operational service. They have highlighted the importance of EO and model based water quality monitoring services as essential components of systems they are developing to carry out their responsibilities under WFD, OSPAR, for monitoring Algal Blooms, and other directives.

This interest has been expressed through written contributions to MARCOAST reports, within presentations to MCEIS workshops, and also in the form of "Service Level Agreements" for MARCOAST/MCEIS signed by five of the potential agencies in the UK and the Republic of Ireland. These were required by the European Space Agency, as part of the MARCOAST proposal preparation, as proof of genuine user interest. They express commitments on behalf of the service providers and the users of the service.

With regard to MCEIS, a specific recommendation from FRS was that an operational (and sustainable) basic monitoring service (using EO data and model output) be established as soon as possible, with developments and refinements to be added in progressively.

We are hopeful that the ESA GSE programme (as discussed in the previous chapter) may provide some initial funding support, through the MARCOAST project, but it is clear that complementary activities are also necessary to ensure implementation of a practical operational service, tailored to the needs of UK agency users.

Thus, in this chapter we propose an implementation plan for a national EO and model based water quality monitoring service, building upon the existing MCEIS capability. This proposal is intended to be complementary to plans being developed within DEFRA, IACMST and elsewhere, providing a practical first step on the way to a possible wider national facility.

6.2 MCEIS Implementation Plan

The following steps to implementation are proposed:

1. **MCEIS "v2"** is implemented in **Summer 2005** (Table 1 provides an initial specification).
    - Essentially the same components as MCEISv1
    - Redesigned to provide simple direct access for users to key data sets.
    - Distinct operational user and research and development areas.
    - Consider inclusion of priority developments (see next section)

The funding basis is to be established (see model proposed below), the required level of support will be dependant upon the success of the MARCOAST proposal.

2. **Summer 2005. Trial of algal bloom warning system**, based on historical data, and validate against EA records.

3. **Autumn 2005**. **Review MCEISv2,** ideally through a workshop, to recommend service modifications, and establish agreed development plan. POL have indicated they would be willing to host this workshop.

4. **Winter/Spring 2005-2006**. **Upgrade MCEISv2** according to review recommendations and development plan.

Table 1 – Outline Specification for MCEISv2 for implementation in June 2005

	Description	Details	Coverage
Core Capability	Web site	Maintenance of operational web site with EO data, model data and in situ data. Includes image browse, search, analysis, comparison;	47°– 63° N; 15°W –10°E
	EO data sets	Parameters: chl-A Case 1 and Case 2 computed at PML, SST, clarity (K490) and SPM proxy ($R_{rs}551$). Sources: MERIS (level 1 and 2 assumed to be free from ESA), MODIS Aqua and Terra, AVHRR (SeaWiFS pending successful negotiations with Orbimage). Time: near-real time (<2 hours) daily; MERIS : 12-24 hours Resolution: 1-km at nadir	47°– 63° N; 15°W –10°E
	MRCS POLCOMS ERSEM output	Weekly composite maps of chlorophyll, plankton biomass (functional groups of diatoms, flagellates and dinoflagellates), SST, salinity, nutrients and currents at a resolution of 6km. Near-real time daily averaged maps	48^{o}N to 62^{o}N, 12^{o}W to 13^{o}E on shelf only. 2002 to present day.
	Irish Sea POLCOMS ERSEM and PROWAM output	Daily surface maps of chl and plankton biomass Irish Sea 1.8km model nowcast/48h forecast hydrodynamics and waves (prowam) (from Sept 2005)	Irish Sea
	In situ MetOcean data	Time series measurements Liverpool Bay (Coastal Observatory): Weather, SST, Turbidity. Ferry box SST, Turbidity, Fluorescence Liverpool - Belfast twice daily	Liverpool Bay
	Management	Overall management: coordination with users, govt agencies, links with related initiatives (national and European), exploring possible engagement of new users.	Not Applicable
Specific Services	Algae Bloom Alert Satellite Data [Image interpretation and higher level analysis]	Application of: 1) HAB likelihood indicators for Karenia mikimotoi (English Channel and also around Scotland); Chattonella (N. Sea); 2) Prototype bloom/hazard alert system that flags when chlorophyll is over a set threshold (e.g. as specified in an OSPAR region) in proximity to the coast, or a sampling site, or WFD "area of concern" or within a region of interest 3) Automated bloom anomaly detection.	47°– 63° N; 15°W –10°E Western Eng Channel and eastern North Sea
	Algae Bloom Alert Model data	Application of prototype bloom/hazard alert system that flags when chlorophyll, SPM or clarity is over a set threshold in proximity to the coast or within a region of interest.	Irish sea and MRCS
	Statistics/ Climatologies	EO and model based. Parameters and resolution to be determined On a regular grid and/or for specified locations regions/water bodies. e.g. Time: daily, weekly or 8-day, monthly composites Resolution: 1-9km as required	Whole domain, and/or specfied regions

6.3 Service Requirements

We propose that, in the first instance, MCEIS "v2" is targeted specifically at WFD, OSPAR monitoring requirements, and at the provision of Algal Bloom alert and forecasting services.
In addition to the existing MCEIS capabilities, as described in an earlier section of this report, the users have indicated the following priorities for development.

- Site layout to be redesigned to be more accessible to operational users
    - Possible division of service into "expert" and "operational" user pages.
- Provision of statistics / climatologies, on a regular grid and/or on user defined regions.
    - EO and model derived parameters (SST, Chlorophyll,…)
    - Time and space resolution to be determined (6km x 9km, weekly?)
- Provision of warnings of risk – HABs and exceedance of other thresholds
- Indications of errors, detection limits.
- Responsive modelling of algal blooms to forecast likely fate, to support risk assessments.

In addition some structural/technical issues to be addressed

- Improved integration of model (and in situ) data.
- Added GIS functionality to allow interactive queries (e.g. online mapping of areas to extract summary information).

These recommendations formed the basis of the MCEIS v2 specification (Table 1), and the service enhancements outlined in the following section.

6.4 Potential Service Enhancements

In addition to the specification proposed for MCEISv2 (Table 1), it will be possible to add extra capabilities in 2006 and 2007. Below we list the service enhancements that could be offered.

Enhancements available for 2006

Web site improvements

- Prototype Web Map Server to integrate EO and model raster with in situ, model and baseline vector data.

EO data processing / interpretation

- Application of HAB likelihood model to MERIS data.
- High resolution ocean colour products: 500m chl-A and clarity (K490) and 250m SPM proxy (Rrs551) from MODIS.
- Interpretation of higher resolution chl-A products for use in confined areas, e.g. coastal lochs, around islands, etc.
- Interpretation of higher resolution SPM products: notably in estuaries.

Model Data

Medium Resolution Coastal Shelf Model (UK Met Office)

- 12 km resolution hourly winds and 3 hourly incident light. 6 km daily averaged SST, surface chl and currents. Other depths can be supplied if required by the user.
- MRCS eutrophication maps.

Irish Sea 1.8km bio-geophysical model (POL),

- Assimilation of SST and with NRT river inputs.
- Nowcast + 72h forecast (assuming MO extended met data available).

Hindcast for Climatology (from POL)

- Outputs of 50 year run of ocean/shelf model (AMM) and shelf model (MRCS) - biophysical parameters for baseline statistics

In situ Data

- Additional *in situ* Irish Sea moorings.
- Heysham-Douglas (Isle of Man) ferrybox route
- Ferrybox surface nutrients.

HAB Warnings and Risk Analyses(Possible trial in summer 2005?)

- Expert knowledge: on Karenia blooms in the Eng Channel and the Chattonella through involvement in ESA Decide-HAB and EC-HABILE.
- Warning/advice service – text or email advisory notes. Supported by expert interpretation of data, links to specific pages with text info.
- Responsive modeling to predict fate of blooms observed offshore (to be confirmed)

Enhancements available for 2007

EO data processing / interpretation

- Combined ocean colour sensor statistics (MODIS Terra and Aqua, MERIS and SeaWiFS + other as available). 1-9 km resolution, daily, weekly, monthly.

Model Data

- Change from UK Mesoscale model to the extended domain North Atlantic European (NAE) model.
- MRCS maps of sediment and light. User consultation to determine whether depth averaging is required, and which and how many levels of data to be supplied.
- Extend MRCS model map supplies to include forecasts.
- Daily averaged MRCS sediment and light as detailed above. Forecast frequency and length to be determined in consultation with users.
- Maps of HAB likelihood derived from fuzzy logic indicators.

6.5 Costs

Below we give cost estimates for the service proposed above. The estimates given here have taken into account that some core facilities / capabilities required for MCEIS are supported by long-term funding from other sources. These costs are not included in the outline estimates provided below:

MCEIS v2 Operational Costs

For the operational provision of MCEIS v2, as defined in table 1, by the PML, POL, UK Met Office, SOS consortium, the estimated cost is ***£70k per annum***.
This estimate is pending a clarification from CEFAS of their participation.

There will be no initial set-up and testing costs, as these have effectively been covered by the existing programme.

Development Costs

A number of possible service enhancements have been suggested in the previous section. We have estimated that the annual total cost of supporting the development of all these enhancements would be **£35k per annum**.

Once the development and testing is complete, in the general case there will be no additional operational cost associated with these extra services. The expectation would therefore be that the

annual operational costs would remain at £70k per annum. The major exception would be the provision of daily expert interpretation of HAB information, as this would require a specific additional staff time commitment (operational cost estimated at £10k per annum).

6.6 Initial Funding Model

Seven user agencies have expressed a direct interest in the MCEIS water quality services (CEFAS, EA, SEPA, FRS, EHS, EPA, MI). If all agencies are able to contribute to supporting a long term implementation of MCEIS, then the ***effective long term cost per agency*** would be ***£10K per annum***, plus funding necessary to support desired service developments (up to £5k per annum per agency). Clearly, if there were fewer subscribers, the cost per subscriber would be higher.

Pending the results from the evaluation of the MARCOAST proposal, parts of MCEISv2 may be supported by ESA funding in the short term. Therefore a number of possible scenarios exist:

1. Best Case Scenario

The entire proposed UK contribution to the MARCOAST water quality monitoring services is supported by ESA for three years. Consequences are

- MCEISv2 water quality and HAB advice / alert services fully supported within MARCOAST
- MCEIS water quality / assessment statistics / climatology service not supported by MARCOAST.
- Most of the proposed service developments indicated would also be supported, exceptions are
    - HAB warnings and Risk Analysis service (2006)
    - Combined ocean colour sensor statistics (2007)
- All agencies who have signed Service Level Agreements will receive the MARCOAST services at no cost for 2005-08 – beyond the costs of providing evaluations, validation data etc., as agreed within the SLA[6].
- ***Costs for statistics and climatology (2005-08)*** - £5k One-off development costs
- ***Costs for developing additional services***
    - ***HAB warnings and risk analysis*** - £10k per annum operational costs
    - ***Combined ocean colour sensor statistics*** – This is a complex research problem, PML are seeking funding from SBRI and ESA in this area, which if successful could feed into MCEIS for no additional cost.
- ***Costs beyond 2008*** will remain at ***£70k per annum*** (plus up to £35k development costs).

2. Partial GMES funding

Only part of the proposed UK contribution to MARCOAST water quality monitoring services is supported. Consequences are

- Statistics / climatology service not supported by ESA, other aspects of MCEISv2 partially supported within MARCOAST
- All agencies who have signed Service Level Agreements will receive the MARCOAST services at no cost for 2005-08 – beyond the costs of providing evaluations, validation data etc., as agreed within the SLA.
- ***Costs for services not funded under MARCOAST (up to£ 10k / yr)***
- ***Costs for statistics and climatology*** - £5k One-off development costs.
- ***Costs for developing additional services***
    - ***HAB warnings and risk analysis***- £10k per annum operational costs

[6] Note that under a protocol being developed for MARCOAST, we expect that it will not be possible to provide MARCOAST services to agencies who have not agreed and signed SLAs.

  - ***Combined ocean colour sensor statistics*** (See above)
  - Those enhancements not funded under MARCOAST
- ***Costs beyond 2008*** will remain at ***£70k per annum*** plus £35k development costs.

3. Worst Case Scenario
None of the proposed UK contribution to MARCOAST water quality monitoring services is supported. Consequences are

- ***MCEIS services will need immediate funding support.***
- ***Costs are £70k per annum, plus development costs*** up to £35k per annum.

Additional Note
A further point of discussion is whether the absence of SeaWIFS data significantly limits the usefulness the service, and therefore if a possible purchase of a user licence should be considered.

Development Plan

It is suggested that, as part of the user review in Autumn 2005, the user agencies are asked to indicate which developments are required and then a development plan can be established, either as bi-lateral agreements between MCEIS and individual agencies or (preferably) on an across board basis, with an agreed package of service developments accessible to all.

6.7 Conclusions

MCEIS can be implemented as a fully operational long-term service, starting in June 2005. The annual operational running cost for the service (defined in Table 1) is £70k per annum. A number of service enhancements have been proposed, the ongoing development of these enhancements would cost a further £35k per annum. If 7 agencies subscribe, the effective cost per agency would be £10k per annum (+ £5k development costs

We are hopeful that aspects of this service can be supported through the ESA GSE programme, under the MARCOAST project, for three years starting in June 2005. If the UK aspects of this proposal are funded this would allow the initial cost of MCEIS to be significantly reduced.

This service proposal and funding model are put forward as a basis for discussion, and we welcome comments from all interested parties.

7 Conclusions

Since October 2004, the MCEIS project has provided a water quality monitoring service to the UK and Republic of Ireland agencies with responsibilities for the marine environment. This service has been well received by the user agencies, who have advised that it has the potential to make an important contribution to their statutory monitoring responsibilities under the EU Water Frameworks Directive, OSPAR and other directives. The users have also recommended that a basic monitoring service (using EO data and model output) be established as soon as possible, with developments and refinements to be added in progressively. The user agencies have also made some specific recommendations for priority developments to the service.

The MCEIS partners have contributed to the MARCOAST proposal which, under the management of ALCATEL Space (France), has been submitted to the European Space Agency in response to an ITT issued for the GMES Service Element programme (Phase 2). Specific proposals for water quality monitoring and harmful algal bloom alert and forecasting (provided by PML, POL and the UK Met Office) have been included in the MARCOAST proposal as "Extension" services. Projects selected by ESA are expected to start in June 2005. The team have expressed concern that UK EO capability may not be fully exploited within the ESA GMES programme as a whole.

The MCEIS team propose a parallel implementation of a national water quality monitoring service, which will be coordinated with any activity supported (for a limited period) under the ESA GSE programme. The aim will be to ensure that the UK user agencies continue to receive the services piloted under MCEIS.

The MCEIS team identified the importance, and relevance, of recent developments in web server and GIS capabilities. It is recommended that a future service makes use of recent GIS web server developments.

GLOSSARY

ALCATEL	French company, leaders of the MARCOAST proposal
AVHRR	Advanced Very High Resolution Radiometer. Main source of Sea surface temperature data. Instrument on board US NOAA polar orbiting satellites
BADC	British Atmospheric Data Centre
BNSC	British National Space Centre
BODC	British Oceanographic Data Centre
CEFAS	Centre for Environment Fisheries and Aquaculture Science
COASTWATCH	One of the 2 marine GSE projects supported by ESA
DARD	Department of Agriculture and Rural Development (N Ireland)
DEFRA	Department for Environment, Food and Rural Affairs
EA	Environment Agency
EHS	Environment and Heritage Services (Northern Ireland)
EMPA	ESA Ministerial Preparatory Action
EO	Earth Observation
EPA	Environment Protection Agency (Republic of Ireland)
ESA	European Space Agency
FEPA	Food and Environment Protection Act
FRS	Fisheries Research Services
GIS	Geographic Information Systems
GMES	Global Monitoring for Environment and Security
GSE	GMES Service Element
HAB	Harmful Algal Bloom
IFREMER	Institut francais de recherche pour l'exploitation de la mer
INTERREG	A European Community initiative aiming to stimulate interregional cooperation in the EU
iSEA	interactive Spatial Explorer and Administrator, CEFAS marine data website
MARCOAST	Proposal to ESA GSE Phase 2 – formed by ROSES and COASTWATCH project teams
MCEIS	Marine Coastal Environment Information Services (this project)
MERIS	Medium Resolution Imaging Spectrometer, ocean colour instrument on board the ESA ENVISAT Satellite
MI	Marine Institute (Republic of Ireland)
MODIS	Moderate Resolution Imaging Spectroradiometer, an instrument on the NASA Terra (AM) and Aqua (PM) EO satellites
NASA	National Aeronautics and Space Administration (US)
NDG	NERC Data Grid
NERC	Natural Environment Research Council
NERSC	Nansen Environmental & Remote Sensing Centre, Norway
NMMP	National Marine Monitoring Programme
NOAA	National Oceanic and Atmospheric Administration (US)
NUIG	National University of Ireland, Galway
NRT	Near Real Time
OGC	Open Geospatial Consortium
OSPAR	Oslo – Paris Convention, Commission for the protection of the marine environment of the North East Atlantic
PAR	Photosynthetically Available Radiation
PML	Plymouth Marine Laboratory
POL	Proudman Oceanographic Laboratory
POLCOMS-ERSEM	Coupled BioGeophysical Ocean model, developed at POL and PML, implemented at POL and the UK Met Office
ROSES	One of the 2 marine GSE projects supported by ESA
SeaWIFS	Sea-viewing Wide Field-of-view Sensor. Ocean colour sintrument on board the US Seastar satellite. Data access through Orbimage.
SEERAD	Scottish Executive Environment and Rural Affairs Department
SEPA	Scottish Environment Protection Agency
SLA	Service Level Agreement (agreement between service supplier and user – defining the commitments of each
SmartBuoy	CEFAS automated multi-parameter recording platform for marine environmental monitoring
SOS	Satellite Observing Systems
SST	Sea Surface Temperature
UWB	University of Wales, Bangor
WFD	Water Framework Directive (EU)
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Map Service

Annex 1 – Administrative Report

Introduction

This annex provides an administrative summary of activities carried out within the BNSC EMPA – MCEIS project.

Work Package Summaries

WP1 Workshop, Service Definition and Preparation
A draft "Service Specification" was issued and a "Service Specification Workshop" was held, with users, at Proudman Oceanographic Laboratory on 22/10/2004. The Workshop minutes are available through the MCEIS Internal Project web site:
http://www.satobsys.co.uk/Private/EMPA/

Following this consultation with users, PML, POL and CEFAS agreed data input requirements and the necessary data exchange mechanisms were put in place to allow the Pilot Service to be initiated.

WP2 Water Quality Pilot Service
Through the PML MCEIS service web site (http://www.npm.ac.uk/rsg/projects/mceis) PML, POL and CEFAS have provided a water quality monitoring service for the entire duration of the project, from October 2004 to March 2005. The original plan was to provide the service for a two month period only.

The pilot service provided access to parameters derived from satellite ocean colour measurements (Terra/MODIS, Aqua/MODIS, MERIS, and SEAWIFS), and sea surface temperatures (from NOAA AVHRR). Initially only individual images were available but during the project weekly composite images have been produced from both MODIS instruments and for water clarity (K490) and suspended particulates (nLw555). A search option has been constructed to search for data archive on the base of date, time or image clarity (cloud cover). In addition the site provides access to model output in graphical form from the POLCOMMS Irish Sea circulation model, and CEFAS smart buoy data with an option for plotting temporal sequences.

In December 2004, the service was updated to provide access to historical data sets with examples of Algal Bloom events, and to cover an additional geographic area (Western Mediterranean) which would allow a better chance of cloud free skies during the northern hemisphere winter.

A subsequent modification in January 2005 provided access to time series of chlorophyll (satellite derived) averaged over selected areas, and to data from the UK Met Office coupled bio-geophysical POLCOMS-ERSEM shelf seas model for 2004.

Despite not being funded by MCEIS the UK Met Office has cooperated fully with the project and provided access to historical model output. It is clear there are common interests between the UK Met Office and the MCEIS team.

The Service Specification document and Service Provision report provide more details.

WP3 Review of Tools for Interactive Data Access
CEFAS have provided a final work package – providing an overview of tools currently available and implemented on various sites, and an investigation of the issues surrounding the implementation of such tools on the CEFAS' own web-mapping server.

WP4 Evaluation and Exploitation within GSE
PML and SOS have been in contact with users to help them access the MCEIS Pilot services, receive their comments and to gain their general input on priorities and interests.
In addition to internal communications with members of the project team (including the EA and FRS), SOS and PML have been in contact with

- Susan Brown: Scottish Environment Protection Agency,
- Dr Gay Mitchelson-Jacob: University of Wales (Bangor),
- Dr Sean O'Boyle: Environment Protection Agency, Republic of Ireland.,
- Dr Toby Sherwin: Scottish Association of Marine Science,
- Dr Mark Charlesworth: Department of Environment (Northern Ireland),
- Dr Ned Dwyer: University College, Cork, Republic of Ireland,
- The ESA GSE ROSES project team,
- John McEvoy, North Atlantic Fisheries College, Scalloway, Shetland,
- Ben James, The Scottish Executive (Ecological Advisor),
- Dr Guy Westbrook, Marine Institute, Republic of Ireland.

Annex 2 provides a complete list of contacts

SOS attended the final "ROSES" project review meeting at which plans for the follow-on Phase 2 proposal were discussed. In addition SOS and CEFAS attended a Eurogoos Marine Services workshop in Brussels. These both took place in November 2004.

Regarding exploitation within the ESA GMES Service Element programme, SOS have been involved in frequent discussions with members of the MARCOAST team (see main text of the report, to negotiate the inclusion of MCIES services within the MARCOAST proposal)

WP5 Project Management
Minutes were issued after the Kick-Off meeting and Service Specification workshop, and a progress report issued in mid-November. A Collaboration Agreement has been signed by all funded partners. First and mid-term payments made according to the agreed payment plan and invoices received. Final payments will be arranged on acceptance of this final report, and receipt of invoices from partners.

General Comments
Progress has gone largely according to plan, except for the delay of the joint Mid-Term Review meeting and Service Review Workshop, from 6th January to 17th January. This delay was agreed to allow sufficient preparation time after the Christmas break. The Final MCEIS meeting was held on Monday March 21st at BNSC, London. Final reports were completed by March 31st 2005.

Project Participants

SOS: David Cotton, Tom Allan and Ellis Ash
PML: Steve Groom, Peter Miller, Daniel Sanders and Ben Wheatley
POL: Jason Holt, Roger Proctor, Duncan Stirling
CEFAS: Paul Eastwood, Marc Scriven, Colin Kirk, David Mills
FRS: Bill Turrell, Eileen Bresnan
EA: Tim Sawyer (now ex-EA), Kyle Brown, Crispin Hambidge.

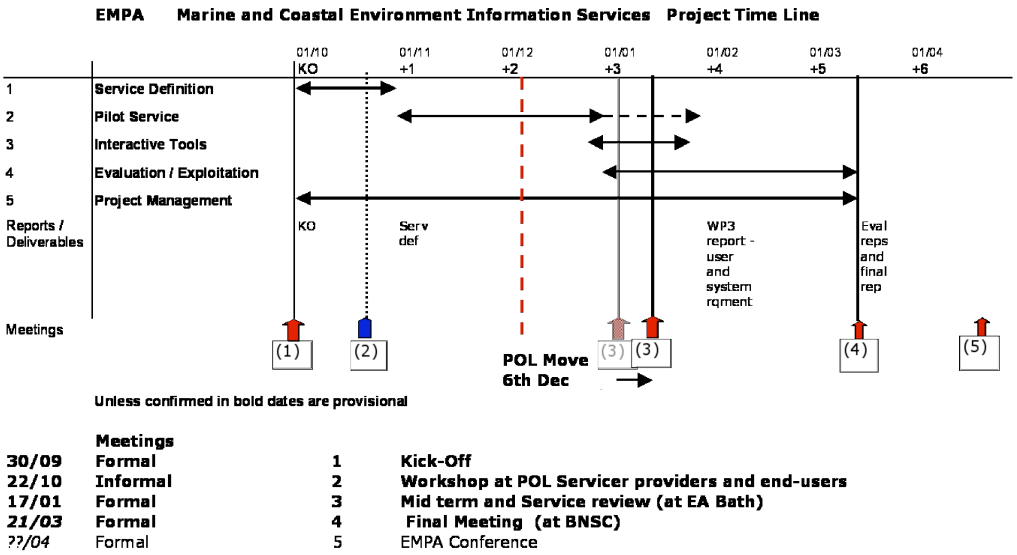

Figure A1 – MCEIS GANNT Chart

Deliverables

Table A1 details the deliverables.

Output	Description	Due Date	Status
Service specification	Report	31/10/2004	Draft issued 30/10/2005 Final version 11/01/2005
Pilot service	WWW site	Nov-Dec 2004	Service Provided 11/04-present Report Issued 17/01/2005
Mid Term Report	Report	January 2005	Report submitted 14/01/2005
Meeting minutes, monthly progress reports	Minutes, monthly progress reports, by email	As necessary	KO Minutes: 04/10/2005 Service Specification Workshop Minutes: 28/11/2005 1st progress report issued 17/11/04. Mid-Term Report issued 15/01/2005
Final report (including user evaluation and recommendations)	Report	31/03/2005	Completed 31/03/05

Table A1 – Status of MCEIS Deliverables

Documents Produced:

WP1 Final Report - ***MCEIS Pilot Service Specification***, PML, 11/01/2005
WP2 Report – ***MCEIS Pilot service***, PML, 17/01/2005
WP3 Report, ***Review of Tools for Interactive Data Access***, CEFAS, 31/03/2005
WP5 ***MCEIS Mid Term Report***, SOS, 15/01/2005
WP4,5 ***MCEIS Final Report***, SOS, 31/03/2005

All documents are available at http://www.satobsys.co.uk/Private/EMPA
In addition, presentations made at the MCEIS meetings are available.

Meetings

The following meetings and visits have taken place:

30/09/2004	Kick-Off meeting at BNSC (attended by SOS, PML, POL, CEFAS).
12/10/2004	BNSC ICP2 meeting D Cotton (SOS) presented a paper on UK experience on ESA Marine GMES Service element projects, and introduced the MCEIS project.
19/10/2004	D Cotton visited CEFAS to discuss users requirements.
22/10/2004	Service definition workshop at POL: (attended by POL, PML, SOS, CEFAS, EA, FRS, SEPA (Scottish Environment Protection Agency).
26/10/2004	D Cotton visited UK Met. Office to discuss possible UKMO involvement (operational provision of model output) in longer term implementation of MCEIS services.
8-9/11/2004	D Cotton and D Mills (CEFAS) attended Eurogoos GMES marine services workshop in Brussels.
16/11/2004	D Cotton visited University of Wales (Bangor - UWB), School of Ocean Sciences to discuss complementarity of EMPA-MCEIS with Irish Sea initiatives led by UWB.
24/11/2004	D Cotton attended the ESA GSE ROSES project final review meeting, held at ALCATEL Space, Toulouse. The meeting incorporated discussions of planning for GSE Phase 2 proposal.
17/01/2005	Mid Term Project Review and Service Review Workshop at EA Bath (attended by POL, PML, SOS, CEFAS, EA, FRS, UKMO, BNSC).
15/02/2005	D Cotton, P. Miller and I. Allan to the UK Met Office for discussions re possible inclusion of UK Met Office MRCS POLCOMS-ERSEM model output on MCEIS web pages.
21/03/2005	Final MCEIS project meeting at BNSC, London

Annex 2 MCEIS Contact Details Partners / Potential Service Providers/User Groups / Interested Organisations

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