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Towards a European Marine Ecosystem Observatory (EMECO)

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Abstract

There are a number of current initiatives to establish collaboration between European national and multi-national agencies to maximise benefits from operational monitoring programmes (e.g. EuroGOOS, ECOOP GMES). As pressure upon national resources mount and growing awareness of environmental problems with a transboundary nature continues, for example at a catchment level in the Water Framework Directive and for a prospective European marine directive, the need for (international) collaborative regional initiatives have begun to be realised. As the first step towards establishing a wider regional initiative a European Marine Ecosystem Observatory (EMECO) has been established within the North Sea.

To develop EMECO (www.cefas.co.uk/emeco) a bottom – up approach has been adopted based upon collaboration between agencies with statutory responsibilities for a range of environmental pressures from monitoring and assessment of nutrients and hazardous substances, wave monitoring to fish stock assessments. The monitoring programmes associated with such activities are by nature long-term and these programmes form key components of EMECO. However, there are a range of other programmes with either a relevant North Sea component (EU Ferry Box programme, International CPR programme, Smart-Buoy programme) or are part of wider initiatives (e.g. satellite remote sensing) that will also contribute to the observatory. It will also embrace initiatives to protect and conserve renewable and sustainable resources such as Marine Protected Areas and closed area for fisheries such as the Dutch Cod Box. The observatory will provide an opportunity to integrate research with monitoring and assessment programmes and to undertake reviews at a regional level to identify gaps in information and develop strategies to address shortcomings.

Within the ecosystem approach, ICES is increasingly aware of the need to include ecosystem considerations in its fisheries assessment models in order to enhance their predictive properties. Moreover, ICES' preparedness to carry out integrated assessments could be greatly enhanced by the scientific framework embedded in EMECO.

This paper will describe the approach taken so far with EMECO, will explore the relationships and chances for collaboration with other initiatives (ECOOP GMES, EuroGOOS) and will examine how EMECO might contribute to ICES' needs for environmental information in fisheries and ecosystem advice.

Keywords: ecosystem observatory, monitoring, Ferry Box, Smart-Buoy, remote sensing

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INTRODUCTION

In order to detect environmental change and to identify its causes we require data spanning an extraordinary range of spatial and temporal scales that cannot be obtained without a long-term *in-situ* presence in the oceans. EMECO aims to provide the infrastructure to support and make sustained measurements over decades at coastal and regional scales to quantify temporal variability in physical, chemical and biological properties in the ocean.

EMECO time-series will complement other components of an environmental change observing system including satellite missions and ship-of-opportunity observing programmes (e.g. Ferry-Box) together with long-term observations of sensitive indicators of environmental change (e.g. Continuous Plankton Recorder). The observatory will contribute towards improved understanding of coastal ocean dynamics where the greatest threats to ecosystem integrity arise through fishing, pollution and eutrophication. Advancing understanding of coastal processes and setting them into a regional perspective in order to manage resources better, mitigate risks and explore new phenomena is challenging. The environmental control processes occur over a wide range of space and time and cannot be simultaneously studied with ship-based platforms alone. This initiative will build on several long-term (>5 y) *in situ* observing networks (SmartBuoy, Wavenet, Ferry Box) and build on new initiatives. It will promote synergy between current and future observing and modelling programmes in order to gain maximum benefit for all stakeholder.

Examples of the key components of EMECO will be described followed by examples of case studies to illustrate the potential outcomes in terms of detecting environmental change and also in terms of the opportunities for synergy between programmes leading to improved understanding of North Sea system function.

COMPONENTS OF EMECO

The location of a selection of North Sea monitoring and operational programmes is shown in Figure 1 to illustrate the potential building blocks of EMECO. These include repeated observations ranging from those undertaken as part of national marine monitoring programmes, long-term monitoring undertaken by the CPR survey, FerryBox routes and fixed point observations recorded from an array of buoys. Measurements include a range of physical, chemical and biological variables. The examples shown in the figure are not a complete picture of all North Sea monitoring but serve to illustrate the comprehensive spatial coverage of a selected range of *in situ* observations. Some specific examples of these components are described in more detail below.

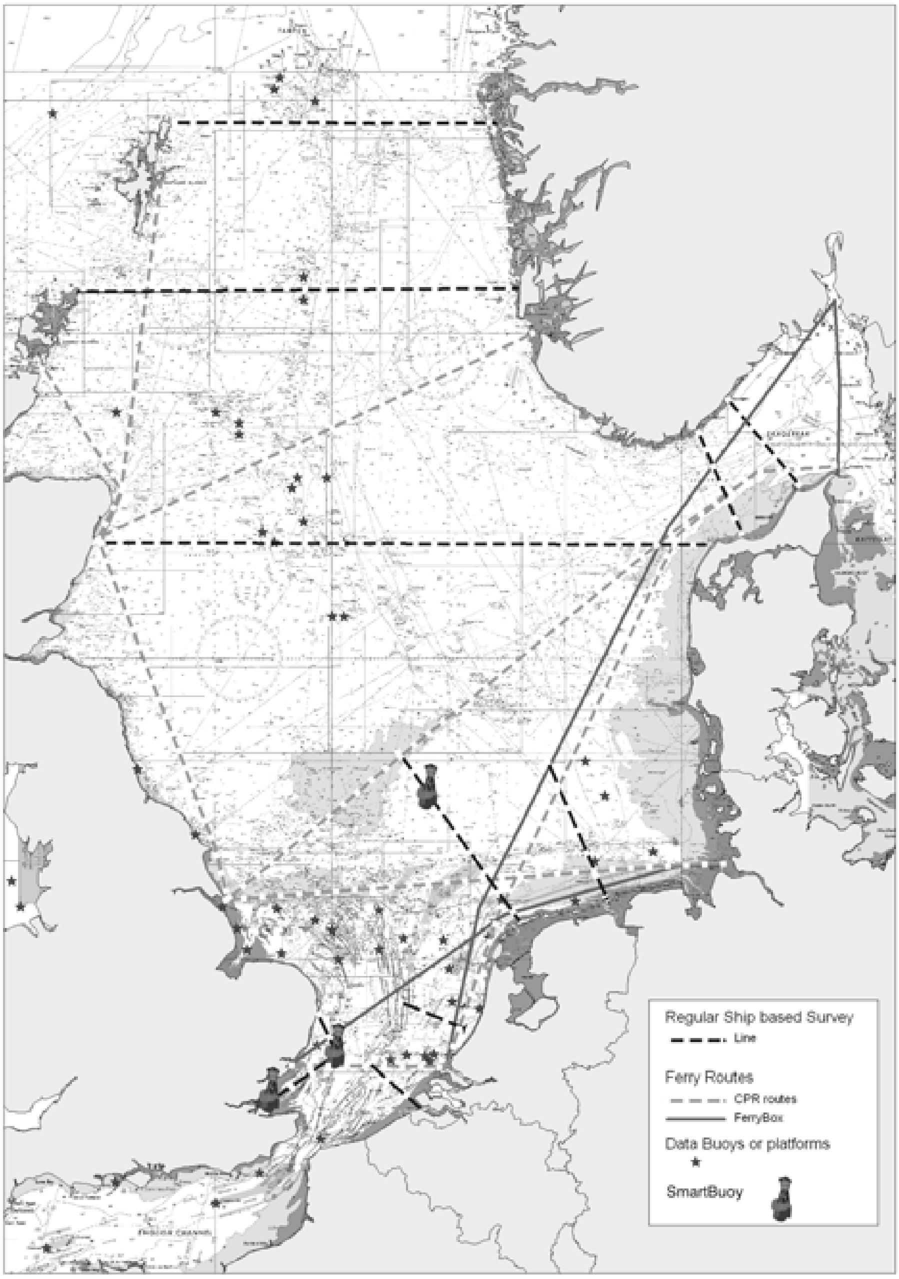

Fig 1 Map showing a selection of locations where repeated observations are carried out either from ships, including the CPR survey routes and from fixed points. The latter includes data buoys as well as fixed platforms including oil and gas rigs See text for further details.

Fixed point (time-series) observations

CEFAS currently operates an integrated network of buoys in the southern North Sea primarily designed to provide information on ecosystem health and information for coastal defence, especially flooding. At one offshore location a buoy is maintained jointly by CEFAS and RIKZ as part of a UK-Netherlands bilateral collaboration. For ecosystem monitoring high frequency (minutes to hours) sub-surface measurements are made of environmental control variables (e.g. temperature, salinity, turbidity, irradiance, nutrients) and key ecosystem variables (e.g. phytoplankton biomass and species composition, oxygen concentration, SPM) (Figure 2; Mills et al., 2002). For coastal defence purposes surface measurements of significant wave height, speed and direction are made. Data is returned in real-time for wave data or near (2-6 hours) real time for ecosystem data and published to the web (www.cefas.co.uk/monitoring; www.cefas.co.uk/wavenet).

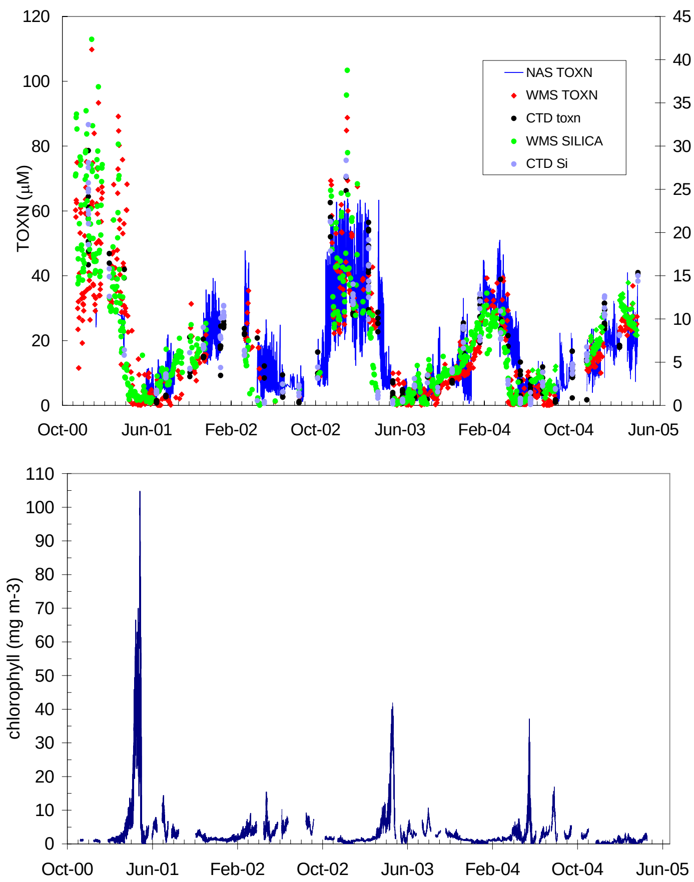

Fig 2 Time series of SmartBuoy (2000-2005) measurements from southern North Sea (Warp Anchorage - Thames estuary) showing (upper panel) near surface TOxN (nitrate + nitrite) measured at high frequency using a NAS *in situ* nutrient analyser. TOxN is also presented from lower frequency (approx. 2/week) measured on discrete water samples collected by an automated water sampler (AquaMonitor - WMS) together with silicate concentration. Ship based measurements from water bottle casts are also shown. The lower panel shows near surface chlorophyll concentration derived from fluorescence measured every 30 minutes. Strong interannual variability is seen in the data set with over-winter nutrient and chlorophyll concentrations varying by almost an order of magnitude during the time-series. Note the apparent absence of a spring bloom in 2005.

Spatial measurements

Plankton sampling by the CPR survey

The Continuous Plankton Recorder programme has been making repeated measurements of the abundance and distribution of phytoplankton and zooplankton in the North Atlantic for more than 50 years (Figure 3). On some routes of the network monthly sampling is unbroken since 1946. Measurements of plankton are taken from Ships of Opportunity (SOOP's) using a towed body. Water passes through a silk mesh that moves past an aperture at the front of the CPR and the plankton retained on the silk are analysed in the laboratory. Identification of up to 500 different phytoplankton and zooplankton taxa is possible together with an estimate of phytoplankton biomass based upon discoloration of the silk (phytoplankton colour index). Direct comparisons between the phytoplankton colour index and other phytoplankton chlorophyll estimates including SeaWiFS satellite derived estimates show strong positive correlations (Batten et al., 2003).

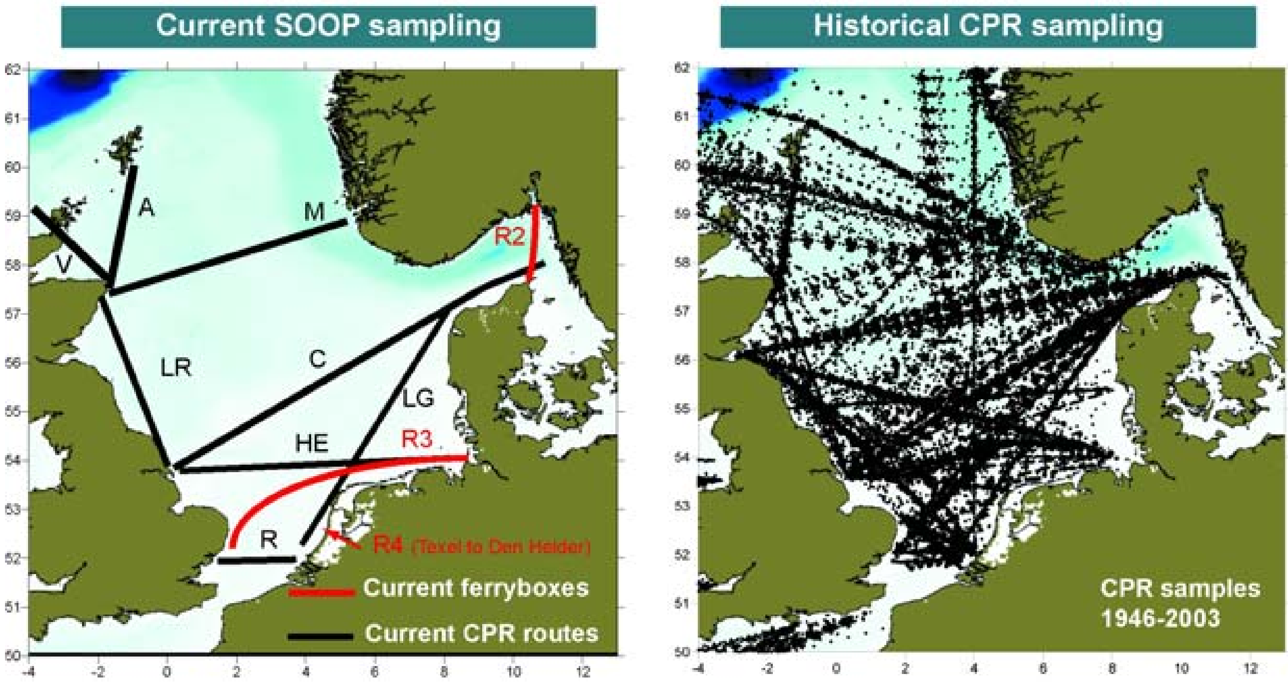

Fig 3 Location of current CPR survey routes and also FerryBox routes and a composite figure showing the historic range of CPR samples in the North Sea

FerryBox

FerryBox provide a practical approach to the establishment of cost effective monitoring systems using the principle established by the CPR of employing SOOP's to carry sets of scientific instruments (Boxes). There are a number of operational routes in the North Sea including (Figure 3), for example, GKSS Harwich to Cuxhaven (Petersen et al., 2003) and the NIOZ Den Helder to Texel (Ridderinkhof et al, 2002). Payloads vary depending on the primary purpose of the specific programme. The GKSS FerryBox is an automatic system comprised of instruments that measure variables including temperature, salinity, oxygen, nutrients (nitrogen, phosphate, silicate), chlorophyll fluorescence and turbidity. All sensors are installed in a continuous flow system. Water from the sea is pumped through this system during sailing of the ferry from a depth of 5 m. The ferry follows a route from Cuxhaven – Harwich (UK) collecting a dense data set each day that resolves short-term events that are unlikely to be sampled using traditional shipboard measurements from research vessels. The NIOZ FerryBox programme includes measurements of surface salinity, temperature and turbidity together with a downwards facing ADCP recording the current field below the ferry. The ferry crosses the transect across the Marsdiep tidal inlet each 30 minutes daily from 06.00 to 22.00 hrs, permitting resolution of tidal variability. The Cuxhaven – Harwich and Den Helder-Texel routes are part of an European project (www.ferrybox.org), which is coordinated by GKSS, with the goals to develop and establish a network of Ferry-Boxes in Europe for operational monitoring.

National marine monitoring programmes

The map of the North Sea (Figure 1) also shows routes followed by survey vessels undertaking routine monitoring. Observations along these routes include surface mapping and CTD stations that resolve vertical structure. Examples of locations for these observations are shown for national marine monitoring programmes of Norway, The Netherlands and the UK. Such repeated observations are made to meet the national requirements of international and European policy drivers and provide data for detection of environmental change and assessment of environmental status.

Case studies

Regime shifts in the North Sea

The long-term records of the plankton have shown changes major changes in the spatial and temporal abundance of phytoplankton functional groups The standardised anomaly plots, Figure 1 show the long-term monthly variability of phytoplankton colour (biomass) from 1948 to 2002, dinoflagellate cell counts (1958-2002), diatom cell counts (1958-2002) and SST (1948-2002) in the central North Sea. The warming of the North Sea sustained from the late 1980's till presents is reflected in shifts in the relative abundance of diatoms and dinoflagellates. In general diatoms have declined during the period observed although winter levels appeared to have increased during recent years. Dinoflagellates have increased in abundance during the last 15 years of the record. The environmental change in the during the 1980's appears to extend beyond the phytoplankton and has had effects upon zooplankton, benthos and fisheries (Reid and Edwards 2001; Beaugrand and Reid 2003). The causes of these changes, termed a regime shift, are not certain but they have been associated with changes in the North Sea Atlantic Oscillation, long term circulation patterns and trends in the Northern Hemisphere Temperature regime (Beaugrand 2004). The association of 'regime shifts' with indicators of climatic change is important as it is critical in order to establish robust relationships between cause and effect (Hsieh et al., 2005). The role of EMECO should be to provide rapid access to complimentary data and information particularly on external forcing and its consequences in the marine ecosystem and also to provide access to appropriate physical and ecosystem model results.

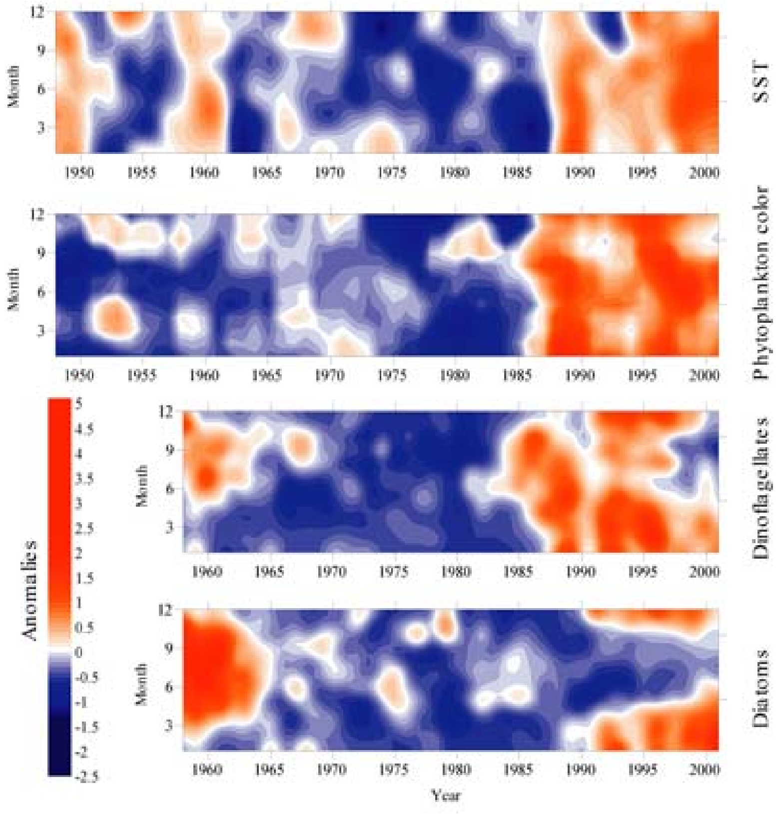

Fig 4 Monthly standardised anomaly plots for (a) Sea Surface Temperature (1948-2002). (b) Phytoplankton colour (1948-2002). (c) Dinoflagellate cell counts (1958-2002), (d) Diatom cell counts (1958-2002). Darker shades signify values above the long-term mean and lighter shades are values below the long-term mean. Zero mean values are in white. Data averaged for the central North Sea. See text and Edwards et al (in press) for further details.

Detecting transboundary environmental pressures and consequences

The environmental pressures faced by the North Sea system are oblivious to national boundaries. Impacts from over-fishing and transport of contaminants provide good examples of pressures with transboundary causes and consequences. In order to mount effective monitoring and assessment there is a need to move beyond the nationally focussed monitoring toward integrated and coherent multinational initiatives.

SmartBuoy measurements in the North Sea provide high frequency fixed point observations of a range of physical, chemical and biological variables. They are providing long-term observations critical to the assessment of eutrophication as currently required by OSPAR and various EU Directives. They also provide measurements that can be combined with similar data from other sources such as spatial data from FerryBox to give greater confidence in environmental assessments. A comparison between SmartBuoy and FerryBox observations was carried by Wehde et al (submitted) together (Figure 3) with an application of a hydrodynamic model. Without the application of the hydrodynamic model the comparison between the observations show a poor relationship. However, whenwater masses measured with the FerryBox were introduced as Lagrangian Tracers in to a General Circulation Model (GCM) their spatial displacement was predicted. The spatial shift in the simulated parameters resulted in a much improved agreement between buoy and FerryBox data. This counts for quasi conservative parameters like salinity. For non conservative parameters like chlorophyll the results remain still unsatisfactory (Figure 5). Therefore a biological module was implemented to estimate the changes in phytoplankton chlorophyll concentration within the time span the water mass is transported from the SmartBuoy to the ferry route. This results in much improved agreement between the two data sets (Figure 6). This study illustrates one method for simulation and quantification of the transport of contaminants contained within water masses.

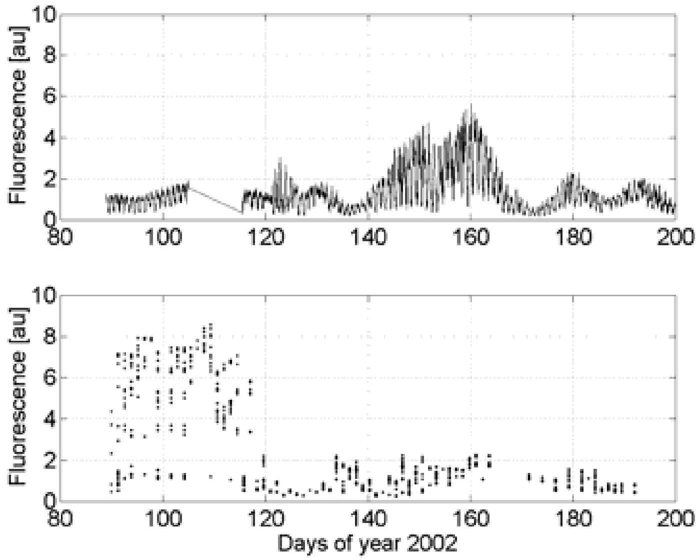

Fig 5 Chlorophyll fluorescence observed at Cefas Gabbard buoy (upper panel) and chlorophyll fluorescence of water passively transported within the GCM (lower panel)

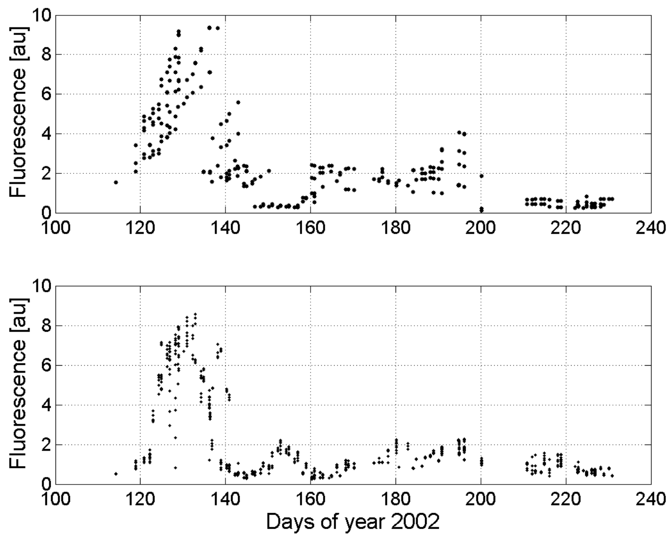

Fig 6. Comparison between observed FerryBox Chl Fluorescence (lower panel) and estimated chlorophyll for tracers starting from the Gabbard and drifting to the FerryBox route (upper panel)

Questions concerning the extent of transboundary transport of nutrients have arisen as a result of European member states citing the cause of eutrophication in their own maritime waters as due to anthropogenic nutrient enrichment sourced from another state. The answers to such questions require the combined use of data and models to provide estimates of fluxes. Collaborative efforts between member states to gather and provide data as well as agreement on choice and method for application of appropriate models are more likely to lead to more widely acceptable answers.

Synergy between sampling strategies

While the FerryBox approach can provide good temporal resolution along a defined route spatial extrapolation of such observations needs to be carried out with caution. One approach to enhance the information derived from FerryBox measurements is to combine with information derived from other platforms. For example, the spatial restriction of a FerryBox to the transect can be overcome for certain parameters such as chlorophyll and suspended matter by combining with results from remote sensing. Figure 7 shows, as an example, the spatial distribution of chlorophyll-a concentration derived from ENVISAT-MERIS (algal-2 for case-2 water) for the North Sea in May 2005 and the chlorophyll fluorescence, dissolved oxygen (DO) and pH along the track measured by the FerryBox on the same day that the satellite image was recorded. From the image the spatial extent of the algal bloom in the English Channel region (3.3°E – 4.2°E) can be clearly seen. The bloom along the Dutch coast (4.8°E – 6.5°E) began in April and was already diminishing in May as evidenced by the increased patchiness. The activity of the algal bloom is also reflected by DO concentration along the track. High over-saturation of oxygen indicates photosynthetically active blooms in the English Channeland in the Elbe estuary (8°E – 8.7°E). In contrast, along the Dutch coast the oxygen levels are lower possibly due to oxygen consumption (DO 90 – 100%) and indicative of a collapse of the bloom in this region.

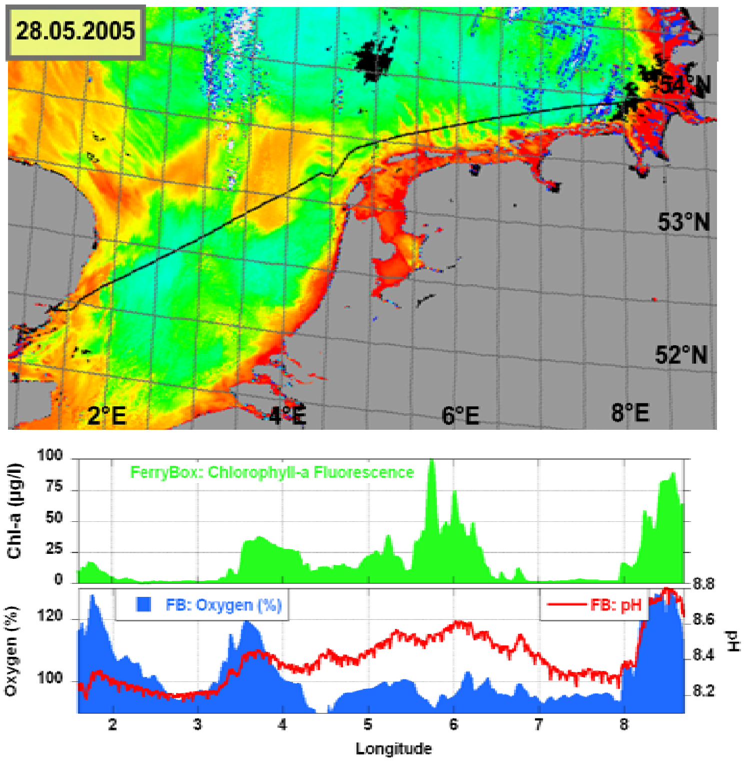

Fig 7 Chlorophyll-a concentration derived from ENVISAT-MERIS (algal-2 for case-2 water) for the North Sea and comparison with chlorophyll-a fluorescence, oxygen saturation index and pH along the track of the ferry (black line) on 28th of May 2005.

In this example we demonstrate the way in which combining data from different platforms, with different spatial and temporal characteristics, enables us to improve the overall picture of environmental state. Clearly, there are times when observations are not available from one platform, for example, when clouds interfere with ocean colour measurements. A further example of the synergy to be derived from multi-platform observations is the potential for using *in situ* observations for ground-truth purposes. These examples demonstrate that effective monitoring requires a range of observational strategies. EMECO will provide a mechanism to identify opportunities for synergy between programmes operated around the North Sea by a range of different organisations and countries.

A further example of the synergy that may be achieved between, in this case, remote sensing, *in situ* observations and model predictions from several sources is illustrated from multi-national work focussed on the German Bight. Phytoplankton biomass is shown for the German Bight at midday 8 November 2005 (Figure 8). A MERIS image processed by NERSC shows chlorophyll concentration (increasing from lighter to darker). Overlaid are contour lines of phytoplankton concentration and surface current (black arrows) from the operational met.no/IMR (Norwegian Meteorological Office /Institute of Marine Research [Bergen]) coupled ecosystem model (shown are 25-hour mean fields). Also shown are tide gauge observations of sea level anomaly, provided by BSH (Germany) and DMI (Denmark). All data are collated in near-real-time at met.no and displayed in the visualization tool DIANA. NERSC provides MERIS images daily for the previous day. The Norwegian Meteorological Office runs the ecosystem forecast model daily, with physical lateral boundary conditions provided by the UK Met Office (FOAM N. Atlantic) and by SMHI (in the Kattegat). Near-real-time tide gauge data are also provided for UK, Norwegian, Swedish and Dutch stations. Data exchange has been facilitated through the EuroGOOS NOOS (North West Shelf Operational Oceanographic System) projects, MERSEA (EU project) and MONCOZE (Norwegian national project). Monitoring products for the northern North Sea are updated regularly for viewing at http://moncoze.met.no.

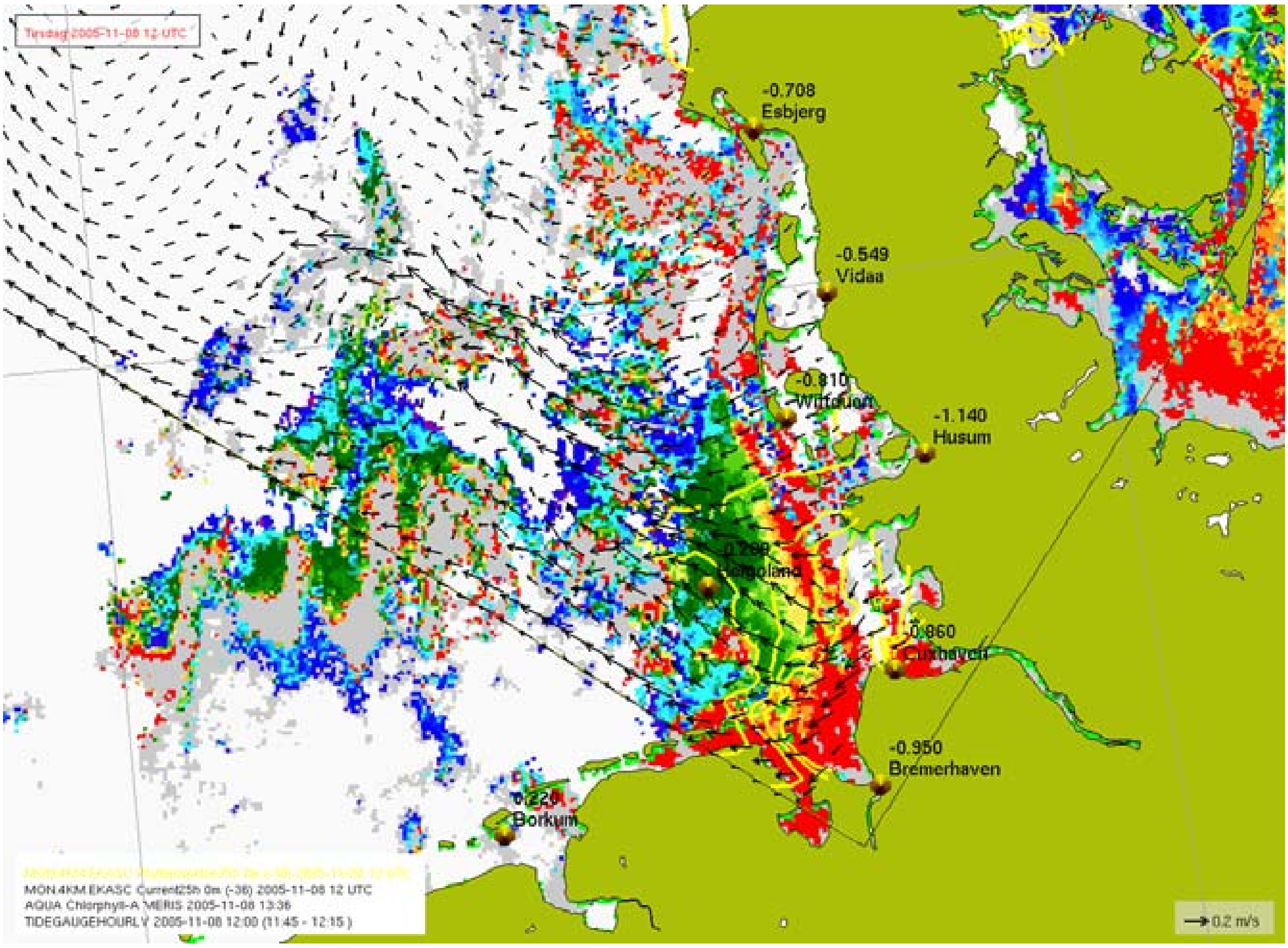

Fig 8 A composite image showing MERIS derived chlorophyll-A in November 2005, increasing in concentration from **blue to green to yellow to red together with hourly tide gauge data. See text for full details.**

DISCUSSION

The review of components available to build EMECO is not exhaustive. Nevertheless, the examples illustrate a range of monitoring programmes in place in the North Sea and identifies examples of synergy between these programmes. These examples should provide confidence in the potential of EMECO for to promote greater harmony between monitoring, modelling and process orientated research programmes in the future.

There are many other benefits that should accrue from such initiatives. Harmonised cross-sector data sets will provide important contributions to new assessments required for Strategic Environmental Assessments (SEA) and Regional Environmental Assessments. An associated public outreach programme will promote wider societal awareness of and engagement with marine environmental issues. Through encouragement of wider European collaboration, at a range of levels, there is also potential for reducing conflict in international policy fora, for example in addressing concerns over transboundary transport of contaminants as illustrated in the case studies.

EMECO has the potential to create a whole that is greater than the sum of its parts. By building from the 'bottom up' on current and largely policy driven monitoring programmes it has a long-term future, that it is sustainable and not reliant on additional short-term funding.

The benefit of an EMECO should also be considered in the context of the Global Monitoring for Environment and Security (GMES) initiative from the European Commission Research DG and the European Space Agency (ESA). From this perspective it represents a regional contribution to the pan-European marine monitoring capacity, and can play an important role in contributing towards fulfillment of national GMES obligations.

REFERENCES

Batten, S.D., A.W. Walne, M. Edwards, and S.B. Groom. 2003. Phytoplankton biomass from continuous plankton recorder data: an assessment of the phytoplankton colour index. *J. Plankton. Res*. 25: 697–702

Beaugrand, G., F. Ibanez, and P.C. Reid. 2000. Long–term and seasonal fluctuations of plankton in relation to hydroclimatic features in the English Channel, Celtic Sea and Bay of Biscay. *Mar. Ecol. Prog. Ser*. 200: 93–102.

Beaugrand, G. 2004. The North Sea regime shift: evidence, causes, mechanisms and consequences. *Prog. Oceanogr*. 60: 245–262.

Edwards, M., Johns, D.G., Leterme, S.C., Svendesen, E. & Richardson, A.J. (in press). Regional climate change and harmful algal blooms in the north-east Atlantic. Limnology and Oceanography.

Hsieh, Chih-hao, Glaser, Sarah M., Lucas, Andrew J., Sugihara, George (2005) Distinguishing random environemntal fluctuations from ecological catastrophes for the North Pacific Ocean. Nature, 435, 336-340

Mills D. K., Laane R. W. P. M., Rees J. M., Rutgers, M., van der Loeff, Suylen J. M., Pearce D. J., Sivyer D. B., Heins C., Platt K. and Rawlinson, M., 2003. SmartBuoy: A marine environmental monitoring buoy with a difference. In: Building the European capacity in Operational Oceanography. Proceedings of the 3rd International Conference on EuroGOOS conference, 3 - 6th December 2002, Athens, Elsevier Oceanography Series, 19, Amsterdam, Netherlands, 311-317

Petersen, W., Petschatnikov, M., Schroeder, F., Colijn, F., 2003. FerryBox Systems for Monitoring Coastal Waters. in: Dahlin, H.; Flemming, N.C.; Nittis. K.; Petersson, S.E.: Building the European Capacity in Operational Oceanography, Proc. Third International Conference on EuroGOOS, Elsevier Oceanography Series 19, Amsterdam, Netherlands, 325-333.Reid, P.C. and M. Edwards. 2001. Long–term changes in the pelagos, benthos and fisheries of the North Sea. In: Kröncke, I. and Türkay, M. and Sündermann, J. (eds), Burning issues of North Sea Ecology, Proceedings of the 14th International Senckenberg Conference North Sea 2000. Senckenb. Marit. 31: 107–115.

Reid, P.C. & Edwards, M. 2001. Long-term changes in the pelagos, benthos and fisheries of the North Sea. Senckenbergiana Maritima, 31: 107-115.

Ridderinkhof, H., van Haren, H., Eijgenraam, F., Hillebrand, T., 2002. Ferry observations on temperature, salinity and currents in the Marsdiep tidal inlet between the North Sea and Wadden Sea. In. Flemming, N.C., S. Vallerga, N. Pinardi, H.W.A. Behrens, G. Manzella, D. Prandle, J.H. Stel, Operational Oceanography: implementation at the European and regional seas. Proc. Second International Conference on EuroGOOS, Elsevier Oceanography Series 17, Amsterdam, Netherlands, pp. 139-147.Wehde, H., F. Schroeder, F. Colijn, U. Callies, S. Reinke, W. Petersen, C. Schrum, A. Plüß, D. Mills, (Submitted) FerryBox observations in the Southern North Sea – Application of numerical models for improving the significance of the FerryBox data for the Southern North Sea region.

Authors' biographies

David Mills has a doctorate in marine sciences from Heriot-Watt University in Edinburgh in 1985. He worked at the School of Ocean Sciences in Anglesey on biological oceanography from 1982 to 1991. Currently at CEFAS he has particular interests in improving ocean observations though development of instrumented buoy networks and linking *in situ* observations to ecosystem models. Research interests include physical controls of marine production, development of indicators of ecosystem health and improving understanding of the causes and the consequences of eutrophication in shelf-seas.

Jon Rees has degrees from Warwick, Southampton and University of East Anglia and has over twenty years experience of research in physical oceanography specialising in deep sea / coastal dispersion and sediment erosion, transport and deposition. He provides expert advice to the Government, as part of the UK Government Review process, on coastal processes issues and also undertakes research into the impacts of wind farms on the marine environment and on changes to sedimentological and biological environments around marine aggregate extraction sites. He is a project manager for research and consultancy contracts for a variety of customers ranging from Oil multi-nationals, industry consortia, other national government and commercial clients.

Stephen Malcom has a Ph.D. in biogeochemistry from the University of Edinburgh. Twenty-five years experience of biogeochemical research, specialising in marine eutrophication and the biogeochemical consequences of disturbance of the estuarine, coastal and marine ecosystem. Key policy advisor on marine eutrophication and ecosystem assessment and monitoring programmes to the UK government.

Clive Fox conducts research in the sea and laboratory on the distribution of egg and larval stage of fishes in relation to hydrographic features and on the effects of the environment including climate change on the growth and survival of early life history stages.

Martin Edwards has been research scientist and, more recently, Assistant Director (research) at the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) since 1995. His research interests are spatial and temporal ecology, community ecology, phytoplankton blooms, climate change, biodiversity, non-indigenous species and North Sea ecosystem changes. As part of his responsibilities for co-ordinating research undertaken at SAHFOS he has been heavily involved with the deployment of continuous plankton recorders (CPRs) in the Atlantic and the acquisition, interpretation and publication of CPR data.

Remi Laane studied organic chemistry and did the research for his Ph.D. on the chemical characteristics of organic matter at the Netherlands Institute of sea Research. He is now head of environmental chemistry at he RIKZ and a part-time professor in marine biogeochemistry at the University of Amsterdam.

Pieter Bot was educated at the University of Amsterdam (MSc) and University of Groningen (PhD). He currently works at Nationale Institute for Coastal and Marine Management (RIKZ) and has twelve years experience in monitoring and assessment of marine waters. He is responsible for the biological, chemical and physical monitoring programs in the Dutch marine waters.

Herman Ridderinkhof completed undergraduate studies at the Technical University in Delft 1984. He received his Ph.D. in 1990 on “Residual currents and mixing in the Wadden Sea’ (Utrecht University, 1990). Between 1990 and 1996 he participated in a variety of multidisciplinary oceanographic programs. Since 1996 he chairs the department of Physical Oceanography at the Netherlands Institute of Sea Research. In 1998 he initiated a long-term observational program using a ship-of-opportunity to study the exchange of materials between the Wadden Sea and the North Sea.

Franciscus Colijn has a doctorate from the University of Groningen, he has research interests that have ranged from estuarine and marine ecology, though to marine ecosystem indicators, monitoring and assessment of environmental health. He currently is the Director for the Institute for Coastal Research, GKSS/HGF, in Germany.

Wilhelm Petersen graduated in chemistry in 1979, Ph.D. in analytical chemistry in 1983. Fields of activity are trace element analysis, studies of biogeochemical processes in sediment and water, statistical analysis of time series of water quality data, developing automatic, remote-controlled systems for investigation of water quality. Recently involved in projects developing FerryBoxes on SoO’s.

Friedhelm Schroeder is heading the In situ Instruments group at GKSS Institute for Coastal Research. His main experiences are in the assessment and quantification of ecological processes. He specialized in the development of analytical methods and instruments for the detection of aquatic substances, and in the development and application of whole automatic and remote-controlled systems for the determination of environmental parameters and contaminants in coastal waters.

Henning Wehde graduated in oceanography in 1996 and received his Ph.D. in 2001 at the University of Hamburg. His primary focus of his research in oceanography is on the impact of physical environment on the ecosystem functioning as well with the help of field experiments as developing and applying numerical models.

Johnny André Johannessen is a Research Director in Ocean Remote Sensing, Nansen Environmental and Remote Sensing Center, Bergen, Norway. He also holds a Professor 2 position at Geophysical Institute, University of Bergen. Johannessen has 25 years experience in satellite oceanography and sea ice research. He has authored/co-authored 57 papers published in International Review Journals.

Einar Svendsen has 25 years experience in research on physical oceanography, remote sensing and marine ecology. Of special interest is the development and use of NORWECOM (the Norwegian Ecological Model system, operational from 1994) for studying links between physics (climate) and lower trophic level biology and fish recruitment prediction. Has published about 50 scientific review articles and taken part in 17 larger expeditions (several as chief scientist) in the Arctic, Antarctic and the Northern Seas.

Bruce Hackett obtained a graduate degree in physical oceanography from the University of Bergen in 1979. He has since worked in basic and applied oceanographic research in academia, private industry and public research institutes. From 1995 he is Senior Scientist at the Norwegian Meteorological Institute, R&D Dept., with responsibility for marine environmental research.