International Innovation

Disseminating science, research and technology

Delving Deeper

A new era for marine collaboration

JAMES BUTLER
NOAA

LUIS VALDÉS
Intergovernmental Oceanographic Commission

KOSTAS NITTIS
European Marine Board

Other highlights:

JEAN-PASCAL VAN YPERSELE
IPCC

SANDY ANDELMAN
Conservation International

RESEARCH SPOTLIGHT
JPI Oceans • United Nations Environment Programme
Global Climate Observing System • Partnership for European Environmental Research

Welcome
to *International Innovation*

FUNDAMENTAL SCIENCE HOLDS the name for a reason, but we are now living in an age where the environmental sciences no longer simply reveal the marvels around us as they did in antiquity; science must actively inform the way in which we live. From individual choices on how best to source food and recycle waste responsibly, to national energy schemes and international decision making, the environmental sciences must help support vast infrastructures. In order to do so, the sciences themselves require effective frameworks in order that projects can effectively be directed and funded, and the best possible value derived from the knowledge they generate.

The marine sciences are presently undergoing huge changes in order to optimise work at the fundamental level so that data feeds into broader observation systems on global climate change and biodiversity loss. In this issue we are thrilled to include interviews with a broad range of interrelated institutions and programmes dedicated to 'joining the dots' of marine research. Intergovernmental Oceanographic Commission – Ocean Science section Head Luis Valdés explains how the unit is brokering cooperation between stakeholders to maintain the health of our oceans. European Marine Board Chair Kostas Nittis outlines work to meet future challenges and opportunities for marine science and society, while Giuseppe Alati, Italian member of the JPI Oceans Management Board, highlights the importance of pooling resources and an increased focus on knowledge transfer.

Moving beyond the marine focus, we speak with James Butler, Director of NOAA's Global Monitoring Division, about their efforts to improve understanding of manmade impacts upon climate change, ozone depletion and air quality. Finally, Sandy Andelman, Vice President of Conservation International, reveals how the Vital Signs Africa initiative puts key information in the hands of local stakeholders to ensure that necessary agricultural growth results in positive development on the continent.

At *International Innovation*, we are working hard to build a dynamic community, bringing together a diverse range of researchers, funders, policy makers and commercial partners, to showcase the very best from across the research spectrum. Please don't hesitate to get in touch to suggest further improvements, to enquire about a subscription, or to put forward your latest research development for consideration in our next publication.

Enjoy the issue.

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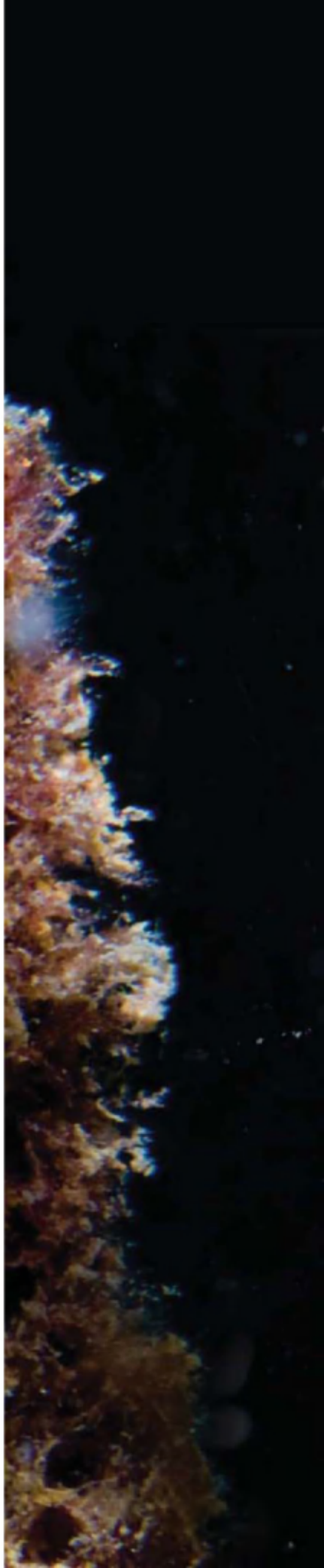

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ACUMEN

Insight into some of the most cutting-edge developments from the world of research

Fungal frogs

Study warns that climate change could place frogs at greater risk of contracting fungal disease

Evidence from researchers at the Oakland University of Michigan has shown that dramatic fluctuations in daily and monthly temperature recording could reduce frogs' resistance to a disease known as chytridiomycosis, which is caused by the fungus *Batrachochytrium dendrobatidis*.

One third of amphibians are vulnerable to extinction, and although this is mainly due to the loss of their natural habitat, frogs are also threatened by the fungal disease in question. The research has now been published in *Nature Climate Change*.

The team is led by Thomas Raffell, who has addressed the link between the impacts of climate change and the increase of disease incidence in frogs. Using Latin America to conduct their experiment, the team investigated Cuban tree frogs' reaction to different temperature settings when exposed to the fungus. The first group was analysed under constant temperatures, the second was placed in regular temperature changes that imitated the frogs' natural day-night cycle, and the final group were subjected to randomised temperature changes. Results showed that the frogs in the third group were those most susceptible to the fungal disease, acquiring the highest levels of the disease.

Colony communication

Researchers at the University of York are fitting hairy wood ants with tiny radios in order to monitor the way they communicate and move between nests

Plans are underway to investigate the way ants communicate, and to map their movement between different nests. 1,000 hairy wood ants located at the National Trust site Longshaw Estate in Derbyshire, UK have been fitted with tiny radio receivers in order to further study the processes behind how a colony works, and the ways in which ants perform socially.

The three-year project is being conducted by a team based at the University of York. Carefully attaching the receivers to the ants, which are 1 mm in size, allows the researchers to study their communication with other colonies. The receivers do not affect the ants and can be administered in a few seconds.

The results will be obtained by the National Trust as a means of identifying the location of the ants. This should help to enable contractors on the site to pinpoint the traces made by the ants so as to avoid destroying the tracks and paths they have created.

One member of the project, biologist Samuel Ellis commented: "The way the ants use this network has important implications for how they interact with their environment. And the way information is passed through the network may even have implications for our information and telecommunications networks". The tagging is set to begin in the summer of 2013.

World Water Week

World Water Week 2012 explores today's major threats to our global food and water supply

This year's World Water Week commenced on 26 August in Stockholm, Sweden, with the intent of addressing the world's most urgent water-related problems. More than 2,000 people attended, including politicians, CEOs, scientists, researchers and figureheads of leading international organisations to focus on issues relating to 'Water and Food Security'.

Figures today show that over 900 million people are suffering from hunger, and 2 billion more face severe health problems from lack of food; however, it is also the case that 1.5 billion people overeat and over one third of all food produced is wasted by some means.

Food and water security demands continue to climb the public health agenda, and food and fibre needs are expected to increase by 70 per cent by 2050, simultaneously with an increase in global population to 9 billion. World Water Week hopes to encourage a reduction in pressure on the planet's water resources, particularly in regions where food and water supplies are threatened. The event's participants are approaching members of the public and private sectors for investment to reduce food loss, improve management of water resources and prevent food waste.

New horizon for hydrogen

A team at the University of Cambridge has invented a way of producing hydrogen with water as the only by-product

The researchers, led by Dr Erwin Reisner, an Engineering and Physical Sciences (EPSRC) Research Fellow and Head of the Christian Doppler Laboratory at Cambridge University, are currently in the early stages of producing hydrogen from water.

Reisner comments: "Until now, no inexpensive molecular catalyst was known to evolve H2 efficiently in water and under aerobic conditions. However, such conditions are essential for use in developing green hydrogen as a future energy source under industrially relevant conditions".

The benefits of using hydrogen are vast and plentiful; it has three times more energy per unit of weight than petrol and, more significantly, the only by-product of the process is the water. Furthermore, it is a cost-effective alternative, saving the consumer approximately half the price of petrol costs. The team is testing cobalt; an inexpensive material could be the key to replacing costly materials such as platinum catalysts. Researchers at Cambridge are also looking to develop a solar water-splitting device, where a fuel-based H2 and the by-product 02 are produced concurrently.

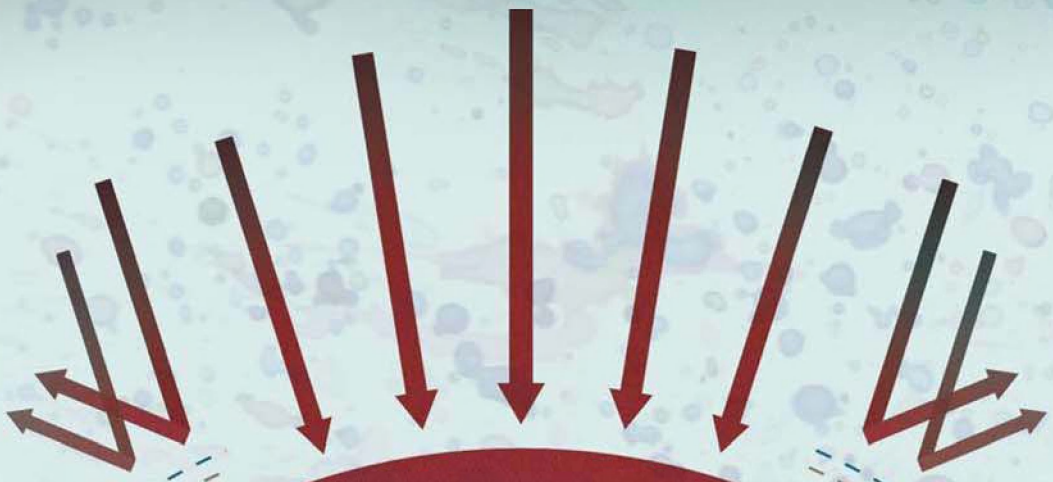
Salt marsh management

Better understanding of salt marshes is needed in order to carry out effective restoration activities

A study has been published in the *Estuarine, Coastal and Shelf Science* journal which seeks to enhance our understanding of and experience with restoration, recovery and human-induced impacts on salt marsh landscapes. According to this investigation, more knowledge is needed of the impact of previous land use and the connection between physical, biogeochemical and ecological functions.

Coastal salt marshes aid a number of wide-ranging ecosystem services and nearly 50 per cent of the salt marshes around the globe have been damaged or disturbed by human activity. Attempts have been made to restore this land, eg. many Europe and US schemes involved in salt marsh restoration have used Managed Realignment (MR) – a relatively new technique which includes the removal of artificial flood defences and the restoration and recovery of saltmarshes. Unfortunately, it has been noted that recent MR activities usually tend to focus on ecological concerns such as animal population and vegetation, as opposed to biogeochemical features.

In order to tackle issues such as poor vegetation development, insufficient drainage and limited oxygen in the root zone, restoration methods are required to migrate towards a more holistic strategy. Alterations to sediment structure and surface are also a concern for tidal flow and drainage, as well as biological and chemical processes. Further research would offer a deeper understanding of the requirements for salt marsh restoration as well as their contribution to ecosystem services, and more successful provision of information on the management and maintenance of these areas.



JAMES BUTLER
Director of Global Monitoring Division, The National Oceanic and Atmospheric Administration

UNDERSTANDING THE ATMOSPHERE

Few people remain unaware of manmade impacts upon climate change, ozone depletion and air quality, but the processes themselves remain highly complex and environmental researchers constantly strive to better understand this complexity. Against this context, *International Innovation* delves deeper into the work of NOAA's Global Monitoring Division which has been conducting stellar research in this field under various guises for over 40 years

Can you begin by explaining how the Global Monitoring Division (GMD) first emerged?

Around the time NOAA was created by Executive order from President Nixon (1970), the predecessor to GMD – known at that time as Geophysical Monitoring for Climate Change (GMCC) – was formed from components of the National Weather Bureau and the Earth System Science Agency (ESSA). At that point, GMCC captured or initiated measurements of what were to become multi-decadal observation records of CO_2, stratospheric and tropospheric ozone, ozone-depleting gases, surface radiation and solar transmission, aerosols, and various substances related to air quality.

In the late 1980s, GMCC served as the model for the World Meteorological Organization (WMO) to set up its Global Atmospheric Watch Programme (WMO/GAW), expanding the number of international partners in the business of monitoring global distributions and trends of atmospheric composition. Today, GMD still provides the framework for that global network through its provision of world calibration scales and quality control activities, and the sheer number of contributing observation sites. In the early 1990s, GMD became the Climate Monitoring and Diagnostics Laboratory (CMDL), a moniker that lasted until 2005, when NOAA combined six laboratories in Boulder into four Divisions of the Earth System Research Laboratory (NOAA/ESRL).

What are the principal objectives of GMD?

We seek to provide the best possible information on atmospheric constituents that drive climate change, stratospheric ozone depletion, and background air quality. In a more general sense, we seek to understand the role that atmospheric composition plays in maintaining Earth's climate. We do this by acquiring, evaluating, and making available accurate, long-term records of atmospheric gases, aerosol particles and solar radiation in a manner that allows the causes of change to be understood. We engage many national and international partners in all aspects of this endeavour.

Why is a Global Cooperative Air Sampling Network important?

Earth's climate depends substantially upon atmospheric composition. Long-term trends in atmospheric composition can have significant impacts on the environment and social systems that support us. The trends, distributions and fluxes of greenhouse gases, ozone and ozone-depleting gases, stratospheric water vapour, aerosols and surface radiation need to be studied and reported upon if society is to make any adjustments in its activities and know why it is doing so. These responses by society can take the form of adjusting behaviour that leads to emissions or adapting to the anticipated changes.

How do you isolate constituents to ensure they are of anthropogenic origin?

That is a good question. It is difficult when a substance such as CO_2 or methane (CH_4) derives from both natural and human sources. One way is to look at records in ice cores which reach back hundreds of thousands of years, or firn air (air trapped into consolidated snow) which goes back around 100 years, and observe what the levels and variability of these compounds were before humans had significant influence upon them. Then one can look at today's records and deduce the human influence. Another way to do this is to look at isotopes of key elements in the gases. The best example of this is radioactive carbon (C-14), which is created in the upper atmosphere and cycled naturally throughout the Earth system. However, because C-14 decays with a half-life of ~5700 years, long burial times and subsequent isolation from the Earth System means that fossil fuels have no C-14 left in them. So, when they are burned, the CO_2 emitted is devoid of C-14. This dilutes the amount of C-14 in atmospheric CO_2. We can follow this trend globally over time, which provides a measure of the increase in CO_2 derived from human activities, but we can also observe and evaluate specific regions. With a little more research, we will soon be able to use any number of trace gases not only to evaluate human vs anthropogenic influences, but also help identify the relative contributions of different sectors in our economies that are contributing more or less with time.

Why is the Mauna Loa Observatory of significant importance to climate research? Why is this location ideally suited to its purpose and how are other monitoring stations contributing?

Mauna Loa is the gold standard of global observatories for monitoring changes in atmospheric composition for several reasons. First, situated in the middle of our largest ocean, it is located remotely from any major sources of gases and thus able to report reliable, global scale trends. Second, the observing site is located at sufficient altitude as to be sampling what we call the 'free troposphere', which is further isolated from local influences. Third, it is in the Northern Hemisphere, which is where most of the human population and vegetation on the planet reside, and is thus able to capture overall trends due to changes and variability of sources and sinks of substances. If the world were to have only one observatory for monitoring changes in atmospheric composition, it would need to be Mauna Loa. It was a great foresight by those in the National Weather Bureau to establish this site in the mid-1950s in association with the upcoming International Geophysical Year, and, in those early days, was the first location to reliably report on the global trends of atmospheric CO_2 or to detect the springtime transport of dust across the Pacific Ocean.

What is the significance of Perfluorocarbons? How do you hope to improve detection and monitoring techniques?

Perfluorocarbons are a growing class of compounds used by industry for a variety of purposes, ranging from smelting of aluminium to novel approaches in manufacturing required by today's economy. They are extremely resilient compounds, having atmospheric lifetimes of thousands of years. Once these are in the atmosphere, they stay there for significant periods and, while unlike the chlorofluorocarbons, they do not deplete stratospheric ozone, they happen to be extremely strong greenhouse gases. They pose no major threat at the moment, but as their atmospheric concentrations increase, they could be an insurmountable problem in the future.

To measure these adequately, an air sample has to be concentrated and cooled to nearly the freezing point of nitrogen, which is a

surmountable problem and has been accomplished by some laboratories. There are subsequent analytical issues in their separation, but those too are manageable.

Can you explain the actions proposed to reduce uncertainty in observations?

For almost everything we measure, the issue is not the adequacy of an individual measurement. For the most part, we achieve the guidelines we have established with the international community to answer pressing scientific questions – both current and anticipated (an individual measurement of CO_2 is often good to within 1 part in 8,000). In terms of maintaining global networks, the issue likewise is not having adequate calibration scales. It is pretty clear that global calibration procedures also meet essential criteria, although maintaining accurate and relevant calibration scales requires continued vigilance and coordination with our partners to keep the scales and measurements on target. And it's not really a matter of having an international community that works closely together. We have that too, through any number of national and international organisations, but most notably through WMO/GAW.

The big problem in reducing uncertainty has to do with compatibility of measurements made independently at different sites. Two observing sites can be using similar instruments and be on the same calibration scales and inevitably they will have differences in the amounts reported for a given gas or substance. This is often very small, but for us or others to derive accurate, regional scale information from global scale models, it is critical that we know the bias introduced by each site. For some compounds, a small bias at a single site can lead to significant differences in the estimated or modelled the fluxes of that gas from various locations on the planet. We address this challenge by coming up with numerous ways to compare measurements from different sites and maintain those comparisons continuously. It's an added burden to what we do, but absolutely necessary.

How are technological developments helping to further our understanding of complex atmospheric concentrations?

Technologies are improving in several ways. In terms of sampling, Pieter Tans, head of the carbon cycle and greenhouse gases group at GMD, recently came up with a novel approach to take vertical 'cores' of the atmosphere and analyse them back in the lab. This sounds impossible. but it is analogous to sampling sediments in the ocean or an ice core in Antarctica. Even better, this sampler, known as AirCore, has no moving parts, which makes it essentially maintenance-free and inexpensive. The device is composed of a ~50m coil of narrow tubing that can be deployed to very high altitudes and brought down to Earth by balloons, aircraft or even unmanned aerial vehicles (UAVs).

An approach to improving analysis has been taken by several private companies to improve stability of field instruments through what is known as cavity-ring-down lasers. When well-engineered, these instruments are capable of obtaining high quality measurements with substantially improved stability and linearity over the current spectrometric or gas chromatographic approaches. These will ultimately allow the deployment of larger networks, providing better resolution for reanalysis models that derive fluxes from the inversion of atmospheric measurements.

These inversions and other types of reanalyses, supported by sufficiently dense, high-quality observing networks, will provide the kind of information society will need to make adequate decisions on climate change.

Finally, we must not forget satellites. Satellites do a great job of picking up land imagery, sea-surface temperatures, cloud coverage, surface winds, and the like, which are important for the inversion models, but they do an overall poorer job of measuring low concentration gases in the atmosphere. Measurements of stratospheric ozone today are done quite well by satellite, as is stratospheric water vapor, radiation, and some aerosol properties, but they all need continuous validation from surface-based and in situ measurements. We continue to work with our partners in the space agencies to develop and improve the much more difficult greenhouse gas retrievals.

In your opinion, what has been the greatest success of the GMD to date?

Identifying one success amongst many is difficult. We have produced a number of 'game-changing' publications and many of our scientists are leaders in their fields. A number of us contribute to the IPCC Climate Assessments and the WMO/UNEP Ozone Assessments and we're very active in WMO's Global Atmospheric Watch programme. But I think I have to say that our greatest success is having produced and maintained these high-quality, long-term data records at over 100 sites around the world for up to five decades in some cases and for the most part, uninterrupted. That is not trivial and requires skilled scientists, technicians, and communicators to make it work and continue to work. Collectively, that is a unique contribution to understanding the composition of Earth's atmosphere and its influence on the Earth system as a whole.

Virtually all sites help to improve understanding of what is causing climate change. Many contribute to the stratospheric ozone issue, and many also contribute to a better understanding of background air quality. These records are fundamental to the success of the IPCC assessments, the Scientific Assessments of Ozone Depletion that inform the Montreal Protocol, as well as national and regional assessments. Based entirely or in large part on data we produce, thousands of papers have been published in the refereed literature, not only by our scientists, but by the global community as well, to whom we make all of our data available.

www.noaa.gov

Towards a European ocean monitoring service

Pierre Bahurel describes the European ocean monitoring service that provides, at a pre-operational level, free access to worldwide oceanographic information and products to support many applications, from ocean management and environmental conservation to weather forecasting

In introduction to this work, can you outline the core principles of MyOcean?

The MyOcean project was driven by the desire of the European Commission and EU Member States to pool the resources of the various European ocean forecasting centres to create a pan-European ocean monitoring service. In three years, MyOcean established a unique European capability: 46 separate systems were integrated into a single system with common standards. MyOcean is a free and open service that now serves up to more than 1,400 users – European and national agencies, operational centres, institutes, laboratories and private companies. Through the MyOcean web portal, users can access a catalogue of more than 250 regularly-updated oceanography products. These can be downloaded at will and cover seven regions of the planet (the Arctic, Baltic, Mediterranean, Black Sea, Atlantic European North-West Shelves, Atlantic Iberic-Biscay-Irish area and the global Ocean).

What is the ultimate goal for MyOcean2?

MyOcean2 took over in April 2012 to transition MyOcean to long-term operational service. MyOcean2 will evolve the service through greater coordination, removing duplication, creating large economies of scale and offering a more comprehensive and responsive service to a greater number of users. In response to the need for sustainability, by the end of 2014 the European Centre for Ocean Monitoring and Forecasting (ECOMF) will be operating MyOcean as the European Global Monitoring for Environment and Security (GMES) Ocean Monitoring & Forecasting service (GMS/OMF).

Could you outline the role of GMES in monitoring Earth system processes? To what extent will MyOcean enhance its operation?

Like GALILEO, GMES is an EU flagship programme, which aims to secure the EU's independence and its position as a global leader in space technology. GMES will implement operational Earth monitoring information services. The objective is to keep close watch on our planet, its ocean, atmosphere and land.The GMES Service information is mainly derived from Earth observation data (satellites) and *in situ* data and should in particular support Earth environment management and security issues. MyOcean is the European project dedicated to the implementation of the main component of the GMES Marine Service – GMS/OMF – in four areas of benefit: Marine Resources, Maritime Safety, Marine and Coastal Environment and Weather/Seasonal Forecasting and Climate.

What benefits do these newly developed services bring? What current issues do they address?

Current issues illustrate how far ocean and maritime topics are omnipresent and affect all of us every day, such as the radioactive pollution in the sea near Fukushima, current record melt of Arctic sea ice, harmful algal or jellyfish blooms along the coasts or forecasting hurricanes, to name just few examples. Answering questions raised by all of these challenges requires a continuous stream of reliable data – observations, analyses and forecasts. MyOcean supplies these for all seas and oceans, including temperature, currents, salinity, sea surface height, sea ice drift and thickness, ocean colour, primary production and chlorophyll and nutrient concentrations.

Can you briefly outline who the MyOcean's services are aimed at?

MyOcean mainly serves 'intermediate users' working with national authorities, with their own capabilities and services, such as national oceanographic agencies, fisheries organisations, marine research institutes, weather forecasting centres, maritime safety agencies, coastguards and so on. Many of them are members of a MyOcean key partner, EUROGOOS, the European Association of National governmental agencies and research organisations committed to European-scale operational oceanography. They use MyOcean data as inputs for their own analysis and forecast models, such as predicting regional oil spill drifts, planning for environmental risks, protecting coastal marine environments or integrated with weather prediction. MyOcean also serves European agencies like the European Maritime Safety Agency (EMSA), the European Environment Agency (EEA), the European Centre for Medium-Range Weather Forecasts (ECMWF) and also intergovernmental organisations and Regional Conventions. Currently, nearly a quarter of MyOcean users come from the private sector. On average, MyOcean welcomes 15-20 new users each week.

MyOcean supports users through a manned Service Desk, able to solve problems and to connect users and experts. What ultimately matters to us is the production of high quality marine information for all users, with a human dimension.

Finally, how would you quantify the success of MyOcean2 to date?

The 59 MyOcean2 partners have built a European Maritime community with great internationally-recognised scientific expertise. This credibility, together with the tremendous ongoing work on product assessment and quality, explains why 'Research and Science' describes half of the MyOcean's users and why MyOcean's services are already delivered in 65 countries worldwide.

Valuable and viable **marine services**

The **MyOcean2** project is transitioning the highly successful MyOcean service into full scale operational deployment. With a growing user base and an excellent track record for quality, the service offers information, data and tools for everyone interested in the sustainability of the world's seas and oceans

EUROPEAN MARITIME POLICIES seek to support the competitiveness of the maritime economic sector while sustaining the marine environment and its safety and security. For such policies, consistent, long-term observations are required: they can be used for modelling the effects of future events, exploring the impacts of past events or guiding present-day decisions in a variety of contexts, from shipping and fisheries management to strategies for protecting coral reefs or mitigating the effects of extreme weather events and planning responses to anticipated emergencies. The project was funded under the EU's Seventh Framework Programme with the aim of creating a knowledge base of research and information concerning the maritime environment. Though it is based in Europe, the scope of the MyOcean service extends to cover the whole globe.

The original project started in 2009 and over the course of three years built a credible and viable European ocean monitoring service – MyOcean – integrating existing national and regional observing and forecasting systems, unifying diverse data sources and streamlining access by providing a single point of entry via a web portal to a sole catalogue of products. An interactive catalogue facilitates product queries and MyOcean products can be downloaded for free after registering online.

The consortium responsible for MyOcean is now refining the service to prepare it for operational deployment in the form of the European Global Monitoring for Environment and Security (GMES) Ocean Monitoring and Forecasting (GMS/OMF) service in 2014.

This will make the GMS/OMF service ready for 'business as usual'. Meanwhile, MyOcean products and services will remain available via the web.

USER-DRIVEN SERVICE PROVISION

The initial project was developed through structured interaction with users, so the service design was effectively validated throughout its construction. MyOcean2 follows the same model, with users being part of the consortium and deeply involved in governance via two important advisory bodies: the MyOcean Advisory Committee and the Core User Group.

As Bahurel explains, being a core service, MyOcean2 prioritises the requirements of 'intermediate reference users', who are service providers in their own right and contribute to the development of GMES marine downstream services: "MyOcean has been designed to work closely with and for these users. They are typically large national public agencies and members of EuroGOOS and GOOS regional alliances committed to European-scale operational oceanography". In general terms, the service was built with continuous reference to the requirements and feedback of all the many different types of target users and their feedback is now being used to improve the service during the MyOcean2 phase.

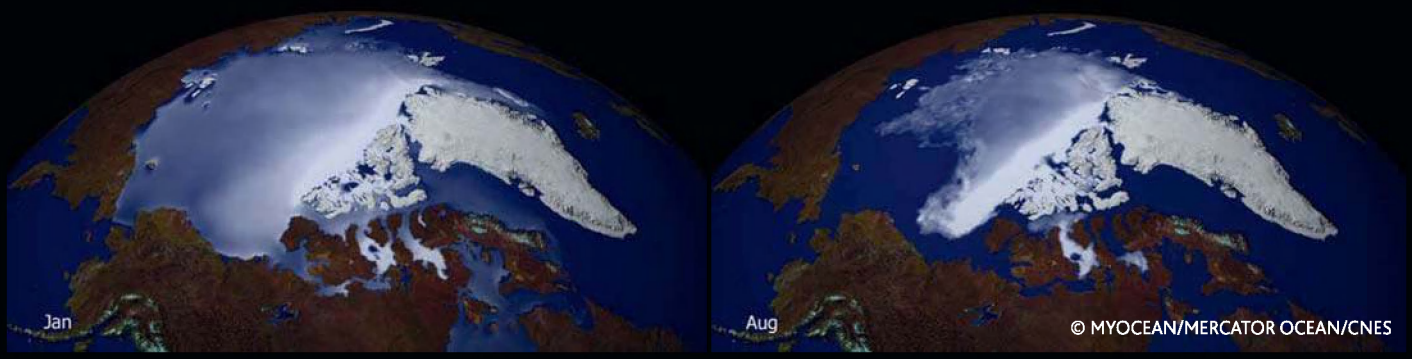
WIDE AREAS OF BENEFITS

MyOcean products and services are meant to serve all marine applications: Marine resources, Maritime safety, Coastal Environment, Seasonal Forecast & Climate. Many everyday applications for MyOcean datasets exist, from data on sea ice for shipping in the Baltic or in the Arctic Seas to information for climate change modelling and 'what-if' analyses designed to discover how different factors

might have an impact on the seas and their resources. It is also in emergency situations, that MyOcean's added value is demonstrated.

MyOcean currents forecast can be used in models which determine how far and fast oil spillages will drift after a shipping incident such as oil tanker accidents and the highly publicised Costa Concordia wreck in the Mediterranean in January 2012. When the *Costa Concordia* (see image above, courtesy of Italian Coast Guard) foundered near a coastal nature reserve,

IMAGES OF RECORD LEVELS OF ARCTIC SEA ICE MELT BASED ON A MYOCEAN PRODUCT



MyOcean2 prioritises the requirements of 'intermediate reference users', who are service providers in their own right and contribute to the development of GMES marine downstream services

THE MYOCEAN2 CONSORTIUM

MyOcean provided daily information to the Italian Coast Guard about the currents in the vicinity, allowing them to model the likely spread of the 2,300 tonnes of fuel on board if the ship were to break up.

Backtracking oil spills is also possible by using MyOcean currents data to detect where ocean and coastal pollution originally emanated; this was tested after an event in the Black Sea in May 2011, where an oil spill contaminated long stretches of the coast near Odessa. The authorities were able to identify those responsible and mount a prosecution.

Following on from the tsunami in March 2011 that damaged the Fukushima nuclear power plant, the International Agency for Atomic Energy asked for support with real-time coastal monitoring and drift modelling to establish how far contamination from radioactive particles in the sea off northeastern Japan was likely to extend. A French national research team supplied a real-time coastal monitoring and drift modelling suite based on MyOcean forecasts of currents.

A VALUABLE CONTRIBUTION

The principles of a science- and user-driven development and continuous improvement that the MyOcean2 project is applying will ensure the long-term sustainability of the service itself. Bahurel's vision is that MyOcean will become indispensable to its users: "My hope is that the service will inspire user loyalty, by contributing to European and National operational services, sustaining decision-making processes in public institutions at all levels and adding value to help European industries and services to compete," Bahurel asserts. While strengthening marine scientific research, the work has also contributed to increasing awareness among the general public about the numerous maritime challenges.

Four important events to come

- EuroGOOS, national maritime centres and MyOcean2 representatives will convene at a plenary meeting on 10 October in Nicosia, Cyprus, organised and hosted by the Oceanography Centre of the University of Cyprus, a member of the project's consortium. The objective of the meeting is to develop a long-term Strategic Partnership between National Agencies and Institutes and the European Ocean Monitoring and Forecasting service as embodied by MyOcean and EuroGOOS Regional Alliances
- MyOcean will contribute (speakers and booth) to the '20 Years of Progress in Radar Altimetry' symposium co-organised by ESA and CNES 24-29 September in Venice, Italy
- A second series of MyOcean Science Days between 19-21 November, 2012 at the premises of Helmholtz-Zentrum (a MyOcean2 partner), near Hamburg in Germany. The Science Days are for the whole scientific community concerned with research and development and operational matters in ocean observing and forecasting systems
- Following on from the success of the first MyOcean User Workshop in 2011, there will be a second workshop early in 2013

Access and download the free MyOcean iPhone App (right)

INTELLIGENCE

MYOCEAN2

OBJECTIVES

To deliver and operate a rigorous, robust and sustainable Ocean Monitoring and Forecasting system of the GMES Marine Service (OMF/GMS) to users for all marine applications: maritime safety, marine resources, marine and coastal environment and climate, seasonal and weather forecasting.

PARTNERS

RBINS/MUMM, BE • **IOBAS**, BG • **OC-UCY**, CY • **AARHUS UNIVERSITY; DMI: DTU**, DK • **MSI**. EE • **FMI; SYKE**, FI • **ACRI-ST; CLS; CNRS; Ifremer; Mercator Ocean; METEO-FRANCE**, FR • **BROCKMANN CONSULT; BSH; HZG**, DE • **HCMR; UNIVERSITY OF ATHENS**, GR • **MARINE INSTITUTE**, IE • **IOLR**, IL • **CMCC; CNR; ENEA; INGV; ISPRA; OGS; USAM**, IT • **Latvia University; EPA**, LV • **UMT-IOI-POU; INRH**, MA • **KNMI**, NL • **IMR; MET NO; NERSC, NIVA**, NO • **MIG**, PL • **EDISOFT; IST**, PT • **INCDM**, RO • **NIERSC**, RU • **NIB**, SI • **ALTAMIRA; CSIC; IEO; PUERTOS; STARLAB; SMHI**, ES • **IMS – METU**, TR • **MHI**, UA • **CEFAS; ECMWF; MET OFFICE; NERC; PML; UNIVERSITY OF PLYMOUTH; UNIVERSITY OF READING**, UK

FUNDING

EU Seventh Framework Programme (FP7)

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Connecting European coasts

Patrick Farcy and **Ingrid Puillat** outline work to create a consolidated network of coastal observation systems and services to support research into climate change and improve on current monitoring facilities

Can you begin by explaining the main objectives of your current research?

One of the main challenges of environmental research is to evaluate how the climate is changing and what are the consequences for mankind. Of course, the global changes have a huge impact on the marine ecosystem health and thereby on human health. Coastal oceanography enables forecasting the evolutions of the coastal seas and assessing the consequences of global change on biodiversity, phytoplankton, fish and marine mammals.

Why is there a need for a central networked infrastructure of coastal observatories?

There is a need for a more coordinated infrastructure network, ie., infrastructures which are acquiring fundamental coastal parameters through harmonised methodology, from sensors to data quality assessment. This will guarantee that best quality datasets are produced from coastal monitoring (mainly through digital models) by scientists and users across Europe. There is also a need to optimise the network; to measure parameters in more sensitive areas. The more data we have, the more precise the results.

What do existing observatories measure and what technologies are currently deployed to procure this knowledge?

The Joint European Research Infrastructure Network for Coastal Observatories (JERICO) priority parameters include standard temperature and salinity, and also dissolved oxygen, carbon dioxide, pH, turbidity and chlorophyll-a. A complementary set of important environmental parameters includes nutrients (nitrate, phosphate, and silicate), sea level and plankton species information.

Existing coastal observatories in European waters are composed of platforms such as moored buoys, piles, profiling systems, gliders, shore-based High Frequency radars, 'ferryboxes' and automated systems on board fishing boats. The sensors themselves are commercial products, such as physical sensors of temperature and currents and chemical sensors; and, in some cases, optical sensors.

How will data be translated for modelling the coastal regions around Europe?

The first step is to choose reliable sensors and calibrate them following approved methodology. It is important to assess how and when bio-fouling will impact sensor measurements. The datasets are transmitted to a data centre, for quality control and validation. Following this step, the data become available for assimilation into oceanographic models or validation.

Will an integrated approach help in our understanding of existing coastal resources and emerging trends in marine stocks?

Naturally, JERICO is only one link in the chain. For modelling fish stocks, Ifremer has developed the RECOPESCA system (this will be integrated in JERICO) which measures the fishing effort, and physical parameters in the water column, on volunteer fishing ships. All the information – depth of the net, weight of the fish and physical parameters – is concatenated with the GPS position and sent to the data centre. These datasets are used in national databases and also in the European databases for the Common Fishing Policy.

Sensing coastal changes

A programme integrating and updating observation data, technologies and sites for a **Joint European Research Infrastructure Network for Coastal Observatories** will provide coherent high quality Europe-wide coastal monitoring data and enable transnational research

How will JERICO contribute to Global Monitoring for Environment and Security (GMES)?

GMES is an EU programme that promotes the use of satellite and *in situ* data to monitor the ocean environment on a global scale. In situ data can and will feed GMES databases by contributing to the MyOcean Marine Core Service. In addition, validation of satellites continuously requires new in situ data – although it is not trivial to validate satellites near the coasts. In that way, the JERICO network will provide data to GMES downstream services.

Can you explain your contribution to the European Global Ocean Observing System (EuroGOOS)?

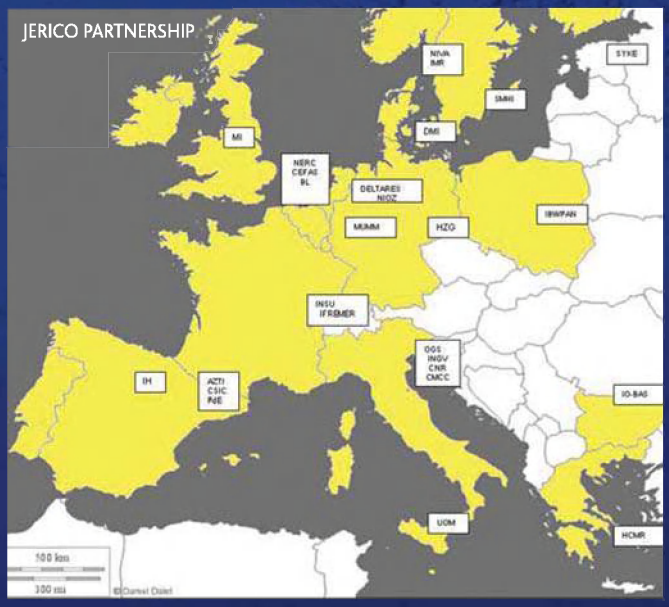
The six Regional Ocean Observing Systems in EuroGOOS are part of the JERICO network. Their involvement is managed in a dedicated work package on trans-regional exchanges. Effectively, the JERICO network is the coastal part of the EuroGOOS programme.

What framework is required in order to guarantee the project's future sustainability?

The maintenance of a coastal observatories network induces high costs because regular site visits are required to maintain the observing systems.

In JERICO, we shall consider the development of some cheaper, more compact, autonomous systems. One future trend is to integrate the citizen science into the network by developing small systems which can be housed in professional fishing boats or private sailing boats; with comparatively low investment and lower operating costs, we could then have a really significant and interesting set of information.

SINCE THE INCEPTION of the Global Environment Observing System of Systems (GEOSS), worldwide efforts to integrate, consolidate and make information about conditions in the Earth's atmosphere, oceans and land universally available have been energetically undertaken. These activities have been directed towards global sustainability and coordinated responses to threats to human health and safety. In parallel, a number of international programmes now contribute to decision support. The European component of GEOSS is the Global Monitoring for Environment and Security (GMES) programme, which seeks to standardise observations of land, oceans and atmosphere, to harmonise emergency responses and to inform policies on global security and climate change.



In terms of the European marine environment, the programme that supports GEOSS is the European Global Ocean Observing System (EuroGOOS). EuroGOOS comprises a number of Regional Ocean Observing Systems (ROOS) and a new programme, Joint European Research Infrastructure Network for Coastal Observatories (JERICO), has been conceived to integrate all regional coastline observing elements into a network of European operational coastal observatories (OCO).

JERICO is being funded within the European Union's Seventh Framework Programme (FP7) and supports the European Strategy Forum on Research Infrastructures; in this capacity, JERICO is a strategic move towards strengthening and integrating European scientific research on evolution of the marine environment and climate change. The Programme's main objectives aim to ensure that a wide variety of datasets, collected from increasing sources of observations and information systems, are standardised and made easily available in order to meet the ever-increasing demands of coastal oceanographic management and research. The work is also expected to contribute to climate research and marine ecosystem planning.

JERICO is being developed by a consortium of 27 partners from 17 European countries under the management of the Institut français de recherche pour l'exploitation de la mer (Ifremer), the French national research centre in charge of sustainable management of the sea. The programme started on the 1 May 2011 and is due for completion by the end of April 2015. Patrick Farcy, the coordinator of JERICO, is a Senior Engineer responsible for oceanographic research management at Ifremer and is also leading the Service Access work package.

Within the programme, coastal observing methodologies are being harmonised according to common technical standards and coastal sensor calibration will be standardised. The work offers a significant opportunity to modernise obsolete technologies and methods, improve the range of information collected and explore the implementation of emerging technologies.

COASTAL OBSERVATIONS

Coastal monitoring systems have links to meteorological services and environmental

JERICO

JOINT EUROPEAN RESEARCH INFRASTRUCTURE NETWORK FOR COASTAL OBSERVATORIES

OBJECTIVES

JERICO proposes a Pan European approach for a European coastal marine observatory network, integrating infrastructure and technologies To increase the coherence and the sustainability of these dispersed infrastructures.

PARTNERS

Ifremer, France • **SYKE**, Finland • **IBWPAN**, Poland • **DMI**, Denmark • **NIVA**, Norway • **IMR**, Norway • **DELTARES**, The Netherlands • **OGS**, Italy • **CNR**, Italy • **UOM**, Malta • **HCMR**, Greece • **NERC**, UK • **INGV**, Italy • **HZG**, Germany • **MUMM**, Belgium • **CEFAS**, UK • **SMHI**, Sweden • **CSIC**, Spain • **NIOZ**, The Netherlands • **MI**, Ireland • **BL**, UK •**TECNALIA-AZTI**, Spain • **INSU/CNRS**, France • **IH**, Portugal • **Institute of Oceanology/Bulgarian Academy of Sciences**, Bulgaria • **Puertos del Estado**, Spain • **The Euro-Mediterranean Center on Climate Change**, Italy

FUNDING

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INGRID PUILLAT has a PhD in Oceanography and is current Deputy Coordinator of JERICO and also former Deputy Coordinator of the FP6 Network of Excellence ESONET. She has experience in project management and research.

agencies, providing data for climate research weather forecasting and oceanic modelling. It is also required for assisting with responses to disasters such as hazardous material spills. Coastal and shelf sea observations in particular, are important for predicting coastal flooding, managing shipping safety and marine resources, and monitoring potential threats from river discharges and agricultural runoffs that may degrade water quality or lead to excessive algal blooms.

Coastal observatories measure a wide range of parameters collected from sensors that are housed on fixed platforms (such as buoys, platforms, piles, gliders and fishing boats), 'ferryboxes' on ocean liners and cargo ships, and from devices carried by 'ships of opportunity' (commercial and private boats, and yachts that volunteer to participate in collecting measurements). High Frequency radars on shore measure the speed and direction of ocean surface currents – they can measure large marine areas, many kilometres off shore. All of these measurements, methods and technologies will be joined up in the new network, as Farcy explains: "We need to combine high-resolution models and precise observations of both physical, chemical and biological parameters".

DEVELOPING JERICO SERVICES

JERICO is producing a networked infrastructure based on the end-to-end coastal monitoring process from data acquisition to dissemination. The work is structured in 10 Work Packages (WPs), the first two taking the initial baseline of current technology and methods and setting a common vision and strategy for the future. Given the goals of the project, a key consideration is to ensure terminology is being standardised. A technical harmonisation WP1 addresses the various observing systems – an example of such a system is RECOPESCA, which is installed on volunteer fishing vessels and collects information about catches and environmental factors to inform coastal management and research activities on fish stocks. "There is also a need to optimise the network, to measure parameters in more sensitive areas. The more data we have, the more precise the results will be," Farcy highlights. This optimisation process is the focus of another work stream.

Ultimately, the programme is developing a strong cluster of services. Best practice guidelines and quality-control standards are being produced and means of improving OCO service components through technological upgrades and innovation.

The researchers are assessing management of distributed data, which is currently held in systems such as MyOcean and SeaDataNet (see pages 9 and 27 respectively), including data requirements for ocean modelling systems. Interfaces between the different ROOS are being developed through a dissemination web portal, OceanBoard. This will provide information about the programme and its progress, to professional and academic users and policy makers. It will also support raising public awareness about the programme. As a key requirement is for the OCO to be cost-effective, operational and maintenance methods and costs will be addressed – this includes sensor fouling, calibration and quality control.

One important component of JERICO is trans-national access (TNA) to infrastructure. TNA is designed to share research infrastructures beyond national boundaries and promote knowledge by providing access to data and resources to researchers from countries lacking the necessary infrastructure. Examples of products include databases, prototypes, instruments, algorithms, protocols and standards. A major objective of TNA is fostering joint research initiatives across national boundaries. This aspect of TNA is piloted in a number of twinning experiments: "The expectation is that this will strengthen collaboration between twinned partners around common inter-calibration procedures hence providing better quality data for better quality results," explains Farcy.

FUTURE PROOFING

"One of the main challenges for environmental research is to evaluate climate change and its present and longer term consequences for human beings. We need to gather the longest possible time-series for understanding and predicting global change and to sustain scientific activities. Therefore it is crucial to guarantee a long lifetime for the JERICO network," Farcy reflects. The latter requirement, together with the cost and time that would be necessary to develop and implement new technology, led JERICO to seek technological sustainability of the OCO. The consortium therefore endeavours to incorporate emerging profiling technologies for coastal seas, to develop new technologies such as new biochemical and DNA/RNA physico-chemical sensors and to enhance interoperability between existing sensors and systems; the intention is to harness mobile technology and software for monitoring key biological compartments and processes; and to increase coastal oceanographic measurement.

One of the main challenges for environmental research is to evaluate climate change and its present and longer term consequences for human beings

Mending the Med

Understanding marine ecosystem responses to climate change and manmade stresses is a vital part of broader climate change studies. Here, **Dr Patrick Raimbault** explains the efforts of a project which is improving this knowledge base, by focusing on the long-term changes in the Mediterranean Sea

Why is the assessment of impact of climate change and anthropogenic pressure on the marine ecosystem over long periods so important?

The MOOSE project aims to observe the long-term evolution of the northwest Mediterranean Sea, in the context of climate change and anthropogenic pressure. We hope to identify environmental trends and anomalies of the marine ecosystem. The collection of long time-series will allow us to capture episodic processes that could not be previously observed. Sustained observations will also allow more rigorous and accurate assessments of significant changes and temporal trends, which are necessary for accurate climate change studies.

Does the timescale over which these effects occur prove a challenge with regards to producing reliable results?

In order to build a homogeneous and efficient observation network, it is crucial to better structure the relation between the coastal system (which is ideal to observe anthropogenic impact), and the open ocean system (a perfect area for climate change issues due to the space and timescales of processes studies). Our approach aims to be more innovative than the last decade of programmes which focused more on biogeochemistry and natural variability than on ecosystem, biodiversity and anthropogenic change. Thus the impact of continental inputs, related to climate change, requires us to handle the marine system as a continuum from coastal area to open ocean including several processes both physical and biological.

Have you faced any significant challenges so far, or are there any obstacles that you anticipate arising over the course of the project?

The major issue is to develop an *in situ* observing system, capable of capturing all scales of variability, while avoiding any aliasing effects caused by sub-sampling. This is a very challenging goal, as *in situ* observing systems have different components complementing information on continental-atmosphere-sea interactions and the whole water column. Additionally, sustained year-round surveys can only be accomplished by combining land observations from automatic sampling stations on rivers and for atmospheric deposition, and at sea with ship surveys, moorings and Lagrangian profiling floats, in both coastal and open sea regions. A boost to our efforts has been provided by the continuing development of gliders, a new technology based on unmanned autonomous vehicles (UAVs) for profiling to great depths, along sections across basins.

After two years of 'start-up', I am confident the involved strategy will rapidly bring new and original results.

How are you working with partner institutions in order to conduct your research?

The MOOSE project is coordinated in line with the Barcelona Convention of 1976. It also complies with the recommendations of the Aberdeen Declaration and the Green Paper – an initiative which identifies the observation of the sea as one of the priorities of European policy in marine. MOOSE aims to strengthen cooperation between the EU and southern Mediterranean countries in the field of marine environment – this project is called 'International-MOOSE'.

Additionally, within the framework of the French initiative for a large Mediterranean multidisciplinary programme (MISTRALS), led by the Institut National des Sciences de l'Univers (INSU), several research programmes have recently been initiated to study the Mediterranean Sea in collaboration with MeteoFrance and Ifremer. Three projects which focus on the climate forcing on the Mediterranean marine ecosystem have a special interest and interfaces with MOOSE:

- Hydrological cycle in the Mediterranean Experiment (HYMEX)
- Marine Ecosystems Response in the Mediterranean Experiment (MERMEX)
- Chemistry Aerosol Mediterranean Experiment (CHARMEX)

This collaboration shows that MOOSE can be considered as a transverse project. The MOOSE initiative is also appreciated by the operational oceanography community for its role in promoting the acquisition of real-time data in the northwestern Mediterranean Sea.

How would you rate the success of your achievements on the project to date?

Overall, the MOOSE programme is creating a solid and transparent organisation, which can provide operational service for the timely, continuous and sustainable delivery of high quality environmental data and information products, related to the northwestern Mediterranean environment. It promotes joint research initiatives and standardisation, giving a lift to the oceanic instrumentation. Through the MOOSE project, the French Mediterranean community is able to provide a permanent monitoring system of ocean dynamics, covering the coastal and open ocean areas. These are the only datasets that evidence climatic trends. MOOSE also provides a large flux of real-time data to facilitate validation of operational oceanographic models.

Marine science in the Mediterranean

The Mediterranean Sea is under threat both environmentally and ecologically. In response to this, comprehensive research regarding the effects of humans and climate change is being conducted by **MOOSE**, with the long-term objective of improving observation technology and potentially the Mediterranean as a whole

THE MEDITERRANEAN SEA is a mosaic of hugely diverse geographical, physical and ecological domains. The Mediterranean basin, including its seas and the bordering continental surfaces, has long been subject to increasing anthropogenic impacts. As a result, it is now enduring considerable stress, both in terms of its ecological balance and exploitable resources and water systems. Slow and irreversible changes are occurring in Mediterranean waters – including the warming of deep waters, an increase in anthropogenic carbon dioxide and acidification. Such factors are inducing changes in both deep waters and marine habitats as a whole.

More specifically, the northwestern Mediterranean area is a region of highly important biological activity, such as phytoplankton bloom. The measured values of winter surface nutrients, spring chlorophyll concentration, annual primary production and carbon export are all higher than in the rest of the basin. Subsequently, the northwestern Mediterranean Sea acts as a major sink of atmospheric CO_2, in comparison with the whole Mediterranean. With all these issues in mind, the Mediterranean can be seen as a localised means by which to observe the marine environment's response to both climate change and anthropogenic factors.

Surprisingly, while intensive research efforts have been undertaken in the Mediterranean Sea for more than a century, an integrated view and understanding of its evolution is still lacking. There is a pressing need for this knowledge-gap to be filled, in order to accrue information on changes to climate and causal anthropogenic pressure. Fortunately, the Mediterranean Ocean Observing System on Environment (MOOSE) project, coordinated by Dr Patrick Raimbault, has been set up as an interactive and integrated observatory system of the northwestern Mediterranean Sea, in order to meet this demand. This system has been primarily set up to detect and identify long-term environmental anomalies in the Mediterranean basin.

WORK AT SEA. LAUNCHING OF A SEDIMENT TRAP IN THE LIGURIAN SEA DURING THE 2012 CRUISE ON THE R/V *LE SUROÎT*

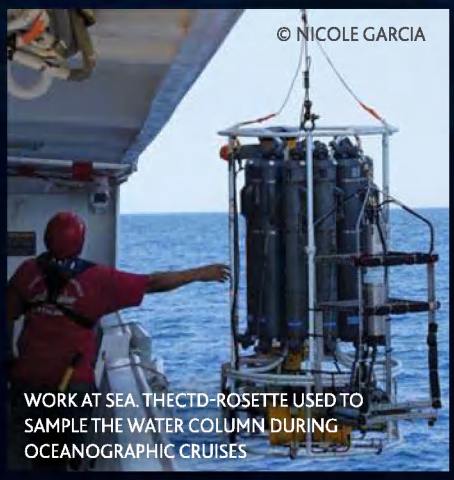
JOINING THE DOTS

MOOSE primarily aims to observe the long-term evolution of the northwestern Mediterranean Sea, specifically focusing upon climate change and anthropogenic effects. As part of this project, the team hopes to build efficient indicators of the health of this region in the Mediterranean basin. In physical and geographical terms, MOOSE is built as an interactive, distributed and integrated observatory of the French Mediterranean Sea, based on a multisite network of continental, shelf, shelf-break and deep-sea permanent stations. The project combines Eulerian observatories and autonomous mobile platforms, which are able to enlarge and enhance observation of the Mediterranean. Additionally, MOOSE has adopted Lagrangian platform networks, which can be used to observe the spatio-temporal variability of processes which interact between the coastal-open ocean and the ocean-atmosphere components.

Overall, the MOOSE observatory system implementation serves to coordinate and integrate observation initiatives into a network based on existing and new stations and facilities, taking into account the scientific specificity of each station. Ultimately, MOOSE aims to provide integrated and multi-scale observation networks, which include both long-term monitoring and near real-time measurements capabilities concerning river inputs, atmospheric deposition and *in situ* marine measurements. The system will be able to detect and monitor seasonal or inter-annual variability, as well as the impact of extreme events that control fluxes and budgets in the marine environment. In light of these innovative measures, Raimbault believes that MOOSE is fundamental to future studies of the Mediterranean: "It will enable next-generation studies of the complex and interlinked physical, chemical, biological and biogeochemical processes operating in the Mediterranean Sea," he stipulates.

IMPRESSIVE RESULTS

One of the most important features of the MOOSE project is that it was built as a long-term programme – to be completed over the course of approximately 10 years. Presently, only two years in, MOOSE has already been successful in large-scale data collection efforts, with new scientific findings already presenting themselves. So far, results have been obtained concerning the quantification and composition of dissolved and particulate matter, which has been brought by the Rhone River to the Sea during flood events. Findings on water mass distribution and deep water formation during winter have been made using both the glider endurance lines and eulerian moorings.



WORK AT SEA. THECTD-ROSETTE USED TO SAMPLE THE WATER COLUMN DURING OCEANOGRAPHIC CRUISES

MOOSE's inception was partly based on discussions and recommendations, which were established by scientists during several workshops in order to address the key scientific and environmental issues relevant for operational oceanography and climate change in the northwest Mediterranean basin. The success of this collaborative approach has led to MOOSE's greatest success to date: the creation of a real multidisciplinary network of many associated French laboratories along the northwestern Mediterranean coast and the technical oceanographic centre of INSU-CNRS, all of which are working towards the same objective. Furthermore, MOOSE has received official recognition, with regard to its successes so far, recently obtaining a national label from the French Agency for Environment (ALLENVI).

A SHARED INTEREST

In tandem with MOOSE's initiative, the National Institute of Science (INSU) has also decided to set up a national prospective for a

new generation of observation systems, with multiple and integrated sites. This thought process is intended to enlarge the scope of the long-term observation panel, which promises to enlarge the long-term results and success of each project. Additionally, to heighten the level of cooperation, both MOOSE and the INSU's projects work within the framework of the national Mediterranean programme Mediterranean Integrated Studies at Regional and Local Scales (MISTRALS). Such a unified, national strategic plan serves to reinforce the mutually beneficial relationships between the three Mediterranean Observatories (Banyuls, Marseille and Villefranche) and the marine research labs that are located along the Mediterranean coastline. MOOSE also collaborates closely to European and international programmes inlcuding EUROSITES, JERICO (see p12), PERSEUS (see p18), EMSO, and OceanSITES.

Raimbault is keen for MOOSE to remain at the forefront of marine observation, whilst retaining the multitude of organisations researching the Mediterranean Sea: "One key objective is to contribute to the sharing of resources as well as better coordination of the efforts involved by favouring the definition and development of a joint technical oceanographic centre," he explains.

HOPES FOR THE FUTURE

With many years of research lying ahead for the MOOSE project, it is expected that the system will have an impact on marine science and policy in both the short- and long-term. In terms of marine observation, it is likely that the team's delivery of products, such as measures or indicators of change and impact, will be widely used for policy decisions. These could potentially range from energy and pollution control, to fisheries quota determinations. Such indicators depend strongly on calibrated and validated data provided by the ocean observing systems.

The projected impacts will be nebulous and benefit a number of individuals and sectors. For example, researchers will be able to deepen their scientific knowledge of the Mediterranean Sea in terms of anthropogenic global change issues; this in turn could affect education, regarding coastal ocean functioning and its associated processes.

Beyond the realms of the scientific community, governments will be better able to support assessments of marine environment in order to decide upon the effectiveness of policy or technical measures to limit its degradation. Furthermore, the fishing industry could begin to achieve truly sustainable sea exploitation based on new knowledge generated from MOOSE's data. Moreover, the ability to better anticipate the consequences of the climate change on their sector will also help the future-proofing for the entire industry. Ultimately then, Mediterranean society as a whole will benefit from MOOSE's wide-ranging and successful research capabilities.

MOOSE STRATEGY: THE 2010-13 IMPLEMENTATION PLAN

INTELLIGENCE

MOOSE

MEDITERRANEAN OCEAN OBSERVING SYSTEM ON ENVIRONMENT

OBJECTIVES

MOOSE is a multidisciplinary observing network based on fixed observatories and mobile autonomous platforms on land as well as in coastal and open ocean regions. It aims to observe the spatio-temporal variability of processes interacting between the coastal-open ocean and the ocean-atmosphere components.

PARTNERS

CNRS/INSU

Météo-France

Ifremer

IRSN

FUNDING

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PATRICK RAIMBAULT is a senior scientist at the French Marine Institute of Oceanography (MIO) in Marseille. His research focuses on the carbon and nitrogen cycles in marine environment and especially in the upper layer of the ocean, so-called euphotic layer, by using chemical and isotopic-tracers procedures. He is currently leading activities in long-term observations of the northwestern Mediterranean Sea with primary interest in understanding impacts of river an input and atmospheric deposition.

Fostering collaboration in the Southern European Seas

PERSEUS

PERSEUS Project Coordinator **Dr Vangelis Papathanassiou** reflects on how the early stages of this important marine-based project is seeing many policy research boundaries effectively bridged

Firstly, what are your main responsibilities as Coordinator of the Policy-orientated marine Environment Research in the Southern European Seas (PERSEUS) Scientific Steering Committee (SSC)?

The SSC coordinates the scientific progress of the project, keeping it focused and working towards its scientific goals. Additionally, it takes all the important decisions within the programme; these are subsequently validated through the General Assembly. SSC also assures integration within and across the various Work Packages, the geographical areas and the cross-cutting themes. It is a crucial management body for the efficient running of the project.

Nevertheless, the Project Coordinator has the overall responsibility and ultimate decision-making capacity on all issues, with help from the PERSEUS Management Office. The Coordinator, together with the Management Office, also communicates with partners, monitors their activities, identifies problems

Unifying Europe's marine research and governance

With an integrated approach to building a deeper understanding of both human and natural pressures in European waters, **PERSEUS** is enabling the rapid improvement of marine governance and decision-making processes

INCREASING PRESSURES ON Europe's marine areas, particularly around the Mediterranean and Black Sea, is highlighting the need for these areas need to become more resilient to activities and change. There is a large scientific research effort already underway to identify some of the environmental baselines, but the challenge now lies in transferring that knowledge into innovative and effective governance. The EU-funded 'Policy-orientated marine Environmental Research in the Southern European Seas' (PERSEUS) project is attempting to resolve this. By using Europe's Marine Strategy Framework Directive (MSFD) as a foundation, PERSEUS is developing and initiating a marine research governance framework that effectively unites scientific research with policy development. The PERSEUS team hopes that, by offering a collaborative framework which supports scientists, policy makers and the wider public, the shared knowledge will promote collective decision making. This not only relates to the MSFD, but is also inherently relevant to other common commissions and policies such as the Integrated Maritime Policy, the UNEP/ Mediterranean Action Plan and the Common Fisheries Policy.

Dr Vangelis Papathanassiou from the Hellenic Centre for Marine Research at Greece's Institute of Oceanography is PERSEUS' Project Coordinator. He explains that their overriding goal is to support the Mediterranean and Black Sea countries to reach the 'Clean Seas by 2020' target and achieve the Good Environment Status (GES). This will be realised through the development of a number of adaptive policies, policy recommendations and management programmes which is set to support successful governance of this marine area. One of

and resolves them. The Steering Committee, chaired by the Project Coordinator, helps to deal with impromptu issues as and when they arise. Therefore, as Coordinator, it is important to be flexible and solution-orientated in all aspects and lay foundations for the efficient and successful activity of the SSC.

What do you consider to be the greatest threat to the successful implementation of this programme?

I do not think that there is a significant danger regarding the implementation of European Marine Strategy Framework Directive (MSFD). This will be achieved by the EU countries; it is an iteration process with a cycle of six years and I am really confident that this will be completed and eventually prove a great help regarding the management options in the Southern European Seas countries.

As far as PERSEUS is concerned, the mandatory remark of the project is that the sea has no frontiers: whatever happens in one country will reflect on the ecosystem of another country.

Therefore, the greatest threat is the reception of the activities and the project results – as well as the involvement of the stakeholders of these countries in the process – by non-EU countries.

Many marine scientists believe 'marine parks' to be an appropriate way of protecting the health of our seas. What is your personal view?

Marine parks, or rather, the Marine Protected Areas (MPAs) can help significantly in protecting the marine environment. However, we must bear in mind that protecting a system implies that we know the system well. Knowledge of the functioning of the marine environment in areas, such as the Mediterranean or the Black Sea, must be completed and this knowledge has to be shared and followed by protection measures and policies to see matters improve. If we understand this major issue, protection through MPAs is much easier to achieve. Many marine scientists offered their expertise free of charge to gain the knowledge and protect the environment, so I believe that the political will should be increased and give the opportunity to achieve these protection targets. These will eventually increase and sustain the development and economies of the various counties under discussion.

What events have you organised to support the project's aims?

One of the most important project events is the Umbrella Workshop, which will take place at the end of the first year to highlight knowledge gaps and dictate the sampling strategies to be followed. The Workshop will present and prioritise the identified knowledge gaps in the respective work packages of the project. Based on these results the sampling strategies will be refined in accordance with other projects' requirements and the relevant interconnections will be established, thereby finalising the environmental issues of socioeconomic importance to be treated within PERSEUS.

Finally, can you highlight the broader challenges associated with this work?

PERSEUS is not just an EU scientific research project. The complexity of the work requires achieving a great deal scientifically with the aim of translating the results into policy options and adaptive policies. The project has therefore been designed using interconnected clusters, which makes it easier to organise the work, but it is challenging in terms of addressing the policy issues related to the marine environment, even beyond the MSFD.

the approaches that PERSEUS has chosen is fostering strong linkages between both the natural and the socioeconomic sciences to achieve integration across disciplines and activities, as Papathanassiou highlights: "Through this approach, PERSEUS aims to help predict the long-term effects of pressures on marine ecosystems. But also by assessing good environmental status in a coherent and holistic manner, it will support the ecosystem-based approach to management".

DESIGNING FEASIBLE MARINE MANAGEMENT SCHEMES

This project has been driven by the ever-mounting evidence that the current environmental state of the Southern European Seas is undergoing rapid change because of both natural processes and anthropogenic activities. Physical dynamics and hydrological structures are being affected by greenhouse gas emissions, warming surface ocean temperatures are changing habitats and migration patterns and modifications to ecosystems are impacting on the region's socioeconomic state. "In the coastal Mediterranean," Papathanassiou points out, "nearly 150 different threats have been identified, including pollution related to urbanisation and industrial activities, overexploitation of fisheries and invasion of exotic species." Many of the changes that are taking place, or losses of coastal ecosystems and species, are now considered to be practically irreversible. This means that changes must take place in the way humans manage activities that impact on the marine environment and to achieve this policy and governance must be directed by robust evidence-based science.

One of the greatest weaknesses in current knowledge is how human and natural pressures interact. To resolve this, PERSEUS is divided into four key clusters: policy, knowledge, tools and users. The intention is that the knowledge and tools clusters feed innovative new data and methods, as well as interpreted information, into the policy cluster where it is then developed into what is known as a new Adaptive Policy Framework ready to be shared through the users cluster. This will collectively form the basis of effective management and governance recommendations: "In turn, all of the work under PERSEUS will enhance the capacity for science-based policy making both internally and externally to the PERSEUS consortium and we will communicate the results to the wider stakeholders' community," Papathanassiou explains.

THETIS SUBMERSIBLE (HCMR REMOTELY OPERATED VEHICLE)

PERSEUS

POLICY-ORIENTATED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

OBJECTIVES

To identify the interacting patterns of natural and human-derived pressures on the Mediterranean and Black Seas, assess their impact on marine ecosystems and (using the objectives and principles of the Marine Strategy Framework Directive as a vehicle) design an effective and innovative research governance framework based on sound scientific knowledge.

PARTNERS

53 partners from 21 countries.
See website below for further details.

FUNDING

EU Seventh Framework Programme (FP7) – contract no. 287600

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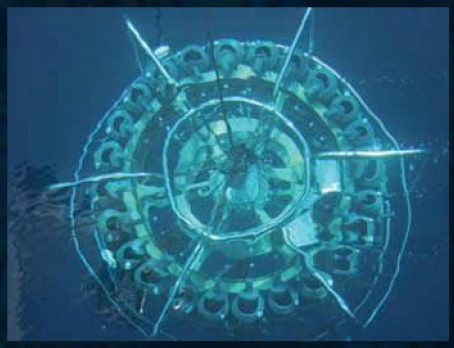
DR VANGELIS PAPATHANASSIOU has held the position of Director of the Institute of Oceanography at HCMR and has over 30 years of experience in National and EU projects in the field of ecotoxicology, marine ecology and management studies. He was Coordinator for the marine and coastal programme of the European Environment Agency from 1996-99. He was responsible for the organisation of the Inter-regional Forum with all major European Sea Conventions and has worked as evaluator in several DG Research Programmes, as well as being the Coordinator of the EU IASON project. In 2006 he became the Coordinator of SESAME, one of the largest European projects on ecosystem and subsequent climate changes in the Mediterranean and the Black Seas, while his latest endeavour is the PERSEUS project.



ROSETTE SAMPLER INSTRUMENT USED TO COLLECT WATER SAMPLES

COLLABORATING WITH OTHER EU-WIDE INITIATIVES

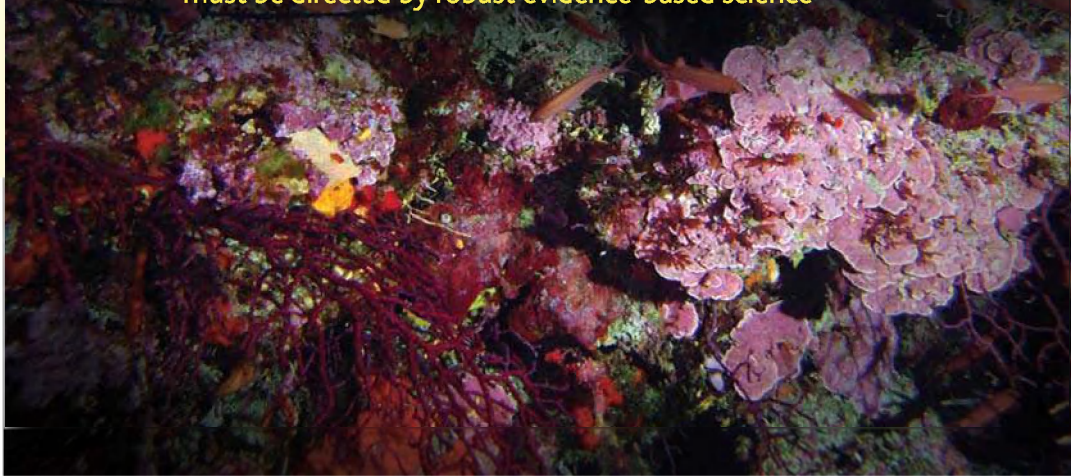
There are many historic and existing EU initiatives and programmes dedicated to protecting the marine environment, there are also a great deal more which impact on coastal and ocean areas. Many of these projects include observations, modelling and data management which will be drawn on to support the PERSEUS outcomes. Several of the Principal Investigators, Work Package Leaders and coordinators of these other initiatives are set to become actively involved in the PERSEUS project to avoid duplication of efforts and maximise the impact that can be achieved from the array of endeavours. One such example that has the same geographical area is COCONET, which is attempting to set up Marine Protected Areas (MPAs).

COCONET and PERSEUS have many common goals and partners which means they should both directly benefit from the development of a solid dataset across the Southern European Seas. Experts from both projects will be working collaboratively, with stakeholders developing collective schemes and policies, and policy makers creating a policy framework that focuses on the goals and objectives of both projects. The links between COCONET and PERSEUS are being formalised through joint partner and stakeholder meetings and joint summer schools.

Emphasis will be given to aligning with research projects that are studying the ecosystems of the Southern European Seas, such as CIRCE, MESMA, HERMES, MedSeA and HYPOX. The SESAME project will receive particular attention because of the scientific networking opportunities that are presented from all of the modelling tools, policy alternatives and scenarios it developed. The objective behind PERSEUS is to directly utilise and build upon many of the exiting national monitoring programmes and large networking activities, in particular the GMES, MOON, MedGOOS and Black Sea GOOS networks. "PERSEUS will propose a monitoring strategy to combine all these activities to a more coherent and integrated tool. This can then be used for the implementation of the ecosystem approach to marine environmental management, which is the core of the MSFD," Papathanassiou states.

Having successfully completed the first training activity on the MSFD principles earlier this year, PERSEUS is now aiming to help improve consistency in marine issues and research throughout the Black Sea countries. This is primarily related to the MSFD principles, including assessment, monitoring capacities and strategy and ecological modelling. Whilst training is focused on postgraduate students, they have also developed educational activities for stakeholders and visits for scientists and technicians from a number of selected academic institutions. This work anticipates strengthening scientific networking, expanding the existing Southern European Seas scientific tools, projects and networks and aligning with scientists from both EU and non-EU countries that border this area. As Papathanassiou explains, the project will offer cooperation and networking between scientists through several different avenues, including training activities, personnel exchange schemes and workshops: "The opportunities we are fostering will create a platform for strengthening human capacity-building in interdisciplinary science and science-based management to create a two way process".

Changes in the way humans manage activities that impact on the marine environment must take place and to achieve this policy and governance must be directed by robust evidence-based science



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JPI Oceans Management Board

Giuseppe Alati, Italian member of the JPI Oceans Management Board, outlines the vital importance of maximising the efficiency of national ocean research budgets through the pooling of resources and an increased focus on knowledge transfer

To begin, what is your position within the JPI Oceans Management Board and what are your key responsibilities?

I am one of the Italian representatives. The main task of the Management Board will be to decide on the establishment of the common Strategic Research and Innovation Agenda (SRIA) and participate in cross-border actions.

A proposal for the SRIA will be prepared within the framework of a support action funded by the European Commission. This proposal will be presented to the Management Board, who will then be charged with responsibility for final approval of the agenda. The next stage will be to decide which actions are to be undertaken. These will then be taken up in the Implementation Plan of the JPI.

The initiative aims to coordinate a wide range of research projects on oceans and coastal areas in order to streamline the process. How do you effectively manage this process?

In Italy, we already coordinate research activities in the maritime sector through the National Maritime Technology Platform, in which both public and private research organisations participate. This Platform also contributes to the planning initiatives surrounding the Research and Innovation activities and contained within the Italian National Strategy for Biodiversity.

In addition, Italy has just launched RITMARE, the Italian Research Programme for the Sea, which is our main coordinating initiative for marine and maritime research and has a budget of €250 million for the period 2012-16. One of the main deliverables of the project will be a new research vessel for worldwide open ocean research missions that will strengthen the Italian oceanographic fleet. The main goals of the programme are the reduction of fragmentation, a focus on technology development and transfer, and support to excellence.

These same goals are shared by JPI Oceans, and the lessons learned in RITMARE will be transferred to the JPI, which will aim to achieve them by increasing knowledge transfer to the industrial community and at the policy level, as well as expanding the pooling of resources and infrastructure base. In this way the members of the JPI can benefit from complementarities between the resources of the different countries, which will hopefully form the basis of long-term cooperation. In addition, we hope that the JPI will fund common programmes and actions.

The committee is made up of a number of member countries, with an aim of streamlining research, distributing resources and sharing findings. How do you navigate this? Are there ever conflicting views that make this a difficult process?

At the moment the JPI is still in its first phase, during which the structure of the governance of the JPI will be developed. Summer 2012 will herald the establishment of the Strategic Advisory Board, elected among over 70 nominees from science, industry and civil society. In addition, the first strategic discussions on the use of structural funds have been held. A study commissioned by the European Commission showed that structural funds have been used in many countries to finance marine research infrastructures and during the meeting of our Board it became clear that there are still untapped opportunities to finance such infrastructures.

As discussed earlier, we are in the preliminary phase of the establishment of the SRIA. As yet, this has not led to many conflicting views, and when the agenda is developed, the JPI governance structure will allow all countries to undertake actions on a variable geometry. This means that all countries can – but do not have to – participate in strategic actions in which they can see an added value.

What are the main concerns and priorities of your own country, and how do these fit in when approaching the topics from a pan-European level?

Italy is currently the only 'pure' Mediterranean country participating in JPI Oceans – that is, the only one with a direct and sole impact in the Mediterranean Sea. Moreover, the southern Mediterranean countries are not part of the EU and this could make the implementation of many actions more difficult due to additional negotiations, complexity of rules, and different funding instruments which could give rise to delays and decreased efficiency. So for Italy, the international dimension of JPI Oceans is a very important issue that needs to be discussed.

How does the long-term approach of JPI Oceans benefit this area of research? Is this particularly important in light of the changing climate and increasing environmental pressure on the world's oceans?

The marine environment, coupled with human activities, is a complex system. Therefore it is difficult to assess the impact/benefits of independent and fragmented policy decisions and/or actions. It is important to establish a long-term process of defining common priorities and coordinating efforts. This will increase the impact and the efficiency of a strategic implementation of policy decisions and actions, especially in dealing with climate change and environmental pressures.

What are the principal challenges faced by JPI Oceans with regard to the process of scientific research?

Human and natural pressures on the marine environment will put it at risk from uncontrollable changes and necessitate a knowledge-based strategy in marine spatial planning. Mainly, we will focus on the sustainability of human activities and use technologies and the potential of the seas to create growth and jobs.

How are you aiming to integrate marine sciences and technologies into Horizon 2020? What are the main areas that you are focusing on in this respect?

Horizon 2020 has many references to marine sciences and technologies. The identification of marine and maritime research as a societal challenge within the wider challenge of 'Food security, sustainable agriculture, marine and maritime research, and the bioeconomy' is very much welcomed. However, we believe that seas and oceans, being a transversal challenge, are also crucial in other areas such as energy, transport, new resources and health, climate and biotechnologies – a factor which needs to be better reflected throughout Horizon 2020. The interdisciplinary and cross-sectoral aspects of most of the challenges involved in oceans research call for strategic planning and better coordination between the European Commission and Member States. This is especially true given the variable geometry on which JPI Oceans will act: where members can select the actions they consider the most relevant, the balance between different European regions can be upset.

What strategies are in place to ensure that initiatives such as JPI Oceans respond effectively to science, policy and societal needs?

The involvement of representatives from science, industry and public authorities in the Strategic Advisory Board of JPI Oceans is a fundamental step forward to the integrated approach the JPI would like to pursue. In doing so, the societal needs and possible solutions will be effectively taken into account, given that representatives from science, industry, civil society and public authorities are elected. Such dialogue and integration between all the stakeholders (collectively helping to define common goals and priorities before launching actions), is the most effective procedure in order to make an impact in the long term, and will hopefully lead to a well-balanced agenda and implementation plan in the next phase of the JPI.

How do you see policy makers and industry engaging with these broader initiatives as opposed to smaller individual research projects?

These broader initiatives will bring added value and will not interfere with smaller individual research projects. Horizon 2020 will still provide an opportunity for excellent researchers to be funded. Nevertheless, there is a need for a more strategic approach of the coordination of national investments in a global context.

The JPI will bring a clear added value in the landscape, providing a platform for the effective coordination of research programmes and priorities and helping to avoid some of the fragmentation we currently experience. At the moment we have 17 different members in the JPI, all with their own priorities and projects. Consequently, there is a need to further streamline the current activities taking place on a national level. In addition, for national policy makers, the JPI will identify clear gaps and opportunities in the European research landscape, thereby facilitating their work.

If the JPI can do just a little bit to address the current fragmentation in our 17 member countries and succeed in providing a real European SRIA, the initiative will be judged a success.

www.jpi-oceans.eu

Piecing together the atmosphere

Professor Spyros Pandis is the scientific coordinator of an exciting new pan-European project to provide a comprehensive picture of the atmosphere over the continent. Here, he provides an outline of their novel approach

What are the main aims and objectives of the PEGASOS project?

The objective of PEGASOS is to identify mitigation strategies and policies to improve European air quality while limiting climate change. To achieve this we need to improve our understanding of the interactions between atmospheric chemistry and a changing climate. The project will affect the design and implementation of European policies by: providing better characterisation of air pollution over Europe using field measurements; providing better estimates of the impacts of European air pollution on climate and vice versa; assessing the effectiveness of past and current policies in improving air quality; and identifying mitigation strategies and policies.

PEGASOS will map the changes in atmospheric composition over a time-scale of 50 years. To your knowledge, are there any similar projects in existence? How does yours differ from past efforts?

A number of efforts have been undertaken to predict how our atmosphere over Europe will look 50 years from today for different scenarios of development. However, some of them have focused on greenhouse gases, assuming that air pollution and the various ecosystems

Science in the skies

Scientists are taking to the air over Europe for **PEGASOS** – a collaborative project that aims to improve understanding of the interactions between air pollutants and climate change, and advance mitigation strategies

ONE OF THE most urgent challenges for environmental policy makers is to address both air pollution and climate change in a common policy framework. Many substances present in our atmosphere as a result of human activities play a dual role as drivers of climate change and air pollutants, but climate change and air quality problems have traditionally been treated separately by both the scientific and policy communities.

Highly complex interactions of emissions from human activities with atmospheric chemical reactions, biosphere-atmosphere exchanges and pollutant transport make predictions of how this complex system will respond to changes in anthropogenic sources very difficult. A change of a single component can lead to significant and non-linear changes in the atmosphere and the resulting feedbacks are critical to the behaviour of the system as a whole.

QUANTIFYING FEEDBACKS

The Pan-European Gas-Aerosol-Climate Interaction Study (PEGASOS) project brings together leading European research groups to quantify the magnitude of regional to global feedbacks between atmospheric chemistry and a changing climate. Professor Spyros Pandis, from the University of Patras and the Foundation for Research and Technology Hellas (FORTH), Greece, is the scientific coordinator of the project: "The philosophy of PEGASOS is to treat air quality and climate change problems together, focusing on air pollution over Europe in a changing climate," he explains. The researchers' ultimate aim is to identify mitigation strategies and policies to improve air quality, while limiting the impact on climate change.

The project bridges the spatial and temporal scales that connect local surface to air pollutant exchanges, air quality and weather with global atmospheric chemistry and climate. More broadly, it is addressing the question of how climate change will affect the accumulation of pollutants and the resulting air quality and its regulation in Europe, on both regional and urban scales. The investigators focus on how emissions respond to a changing climate, shifts in biomes

will not change. The rest have focused on the air pollutants, but assumed that climate will remain constant. Our ambition is to put all of these pieces together, quantify their interactions, and look at the complete picture for the first time.

How do you successfully monitor interactions that are normally complicated by feedbacks and tropospheric influences?

This is indeed a challenging problem. We will initially study the individual pieces of the puzzle in the laboratory and with our field measurements. However, it is impossible to put all the pieces together using just observation. For this reason we are developing state-of-the-art modelling tools simulating air pollution and climate together. We will evaluate these tools with our measurements, improve them further if needed and then use them to quantify these feedbacks.

Which pollutants have had the biggest impact? How has this landscape changed?

The answer varies for different parts of Europe and between the seasons. For example, high ozone levels are a problem in the summer in Southern Europe. High ammonium nitrate levels are a big problem in areas such as The Netherlands and Belgium. High sulphate levels are still a problem in Eastern Europe and the Balkans. Organic particles from wood burning become a problem in the winter. Agricultural waste open burning is a major problem in parts of Europe where this practice is used extensively.

Major improvements have been made in parts of Europe where sulphur dioxide emissions have been reduced and industrial sources have been controlled. However, old problems persist in other parts of Europe and new challenges are rising in addition to existing concerns.

How do you create policy on air quality when it is not spatially or temporally restrictive? How would you overcome disputes on jurisdiction?

The old paradigm was that air pollution was viewed as a problem in urban areas with heavy industry, which could be solved by controlling the local sources. This was probably the case in London in the 1950s but it is not true anymore in most areas in Europe. Pollutants are not aware of political boundaries or jurisdictions and travel between countries.

The solution is relatively straightforward: we should look at the problem at the European level with each country or city taking care of their contribution. I think that this is a great area for true pan-European collaboration towards a common objective: cleaner air for all of us.

Can you briefly outline the most significant forthcoming activities for the project?

The two Zeppelin missions will be the most visible parts of the project. They have been designed to cover a significant portion of Europe with different climates and anthropogenic and biogenic emissions. The southern mission during the summer of 2012 focused on polluted areas of Southern and Central Europe. The Northern mission during the summer of 2013 will investigate the interactions of anthropogenic pollutants with the biogenic emissions dominating atmospheric chemical composition in Northern Europe.

The dataset collected will be unique both because of the complete coverage of the lower atmosphere, but also because of the use of state-of-art techniques for measurements of the concentration of trace pollutants.

and land use, and the effect of these changes on European air quality and climate.

ZEPPELIN

PEGASOS combines development of new climate-sensitive biogenic and anthropogenic emission models with laboratory studies in some of the premier European smog chamber facilities and field measurements using a Zeppelin combined with mobile and fixed ground platforms.

The project is using a Zeppelin to take measurements across Europe for a total of 20 weeks, split into two missions covering different areas of the continent. During the five-week mission which began in June from Germany, the airship took the east route around the Alps to Italy. It then spent five weeks flying over the polluted Po Valley and the Adriatic. In April 2013, the researchers will head towards Northern Europe on a two-month mission to investigate the interactions between air quality and climate change over the boreal forest.

PEGASOS ZEPPELIN

The team of scientists accompanying the Zeppelin are using three different sets of equipment to measure various atmospheric pollutants. They are specifically interested on free radicals like the hydroxyl radical (OH) which has an important role in atmospheric cleansing, and atmospheric nano-particles. Data on the formation of these particles, and their contribution to climatic processes, are expected to provide researchers with new insights about the effect of human activities on climate.

Using the Zeppelin means the researchers can now observe these processes in the planetary boundary layer at an altitude of up to about 2,000 m – a layer of decisive importance. It is in this chemically very reactive, but as yet little investigated region that the fate of

PEGASOS

PAN-EUROPEAN GAS-AEROSOL-CLIMATE INTERACTION STUDY

OBJECTIVES

To quantify the magnitude of regional to global feedbacks between atmospheric chemistry and a changing climate, and to reduce the corresponding uncertainty of the major ones. The study also aims to identify mitigation strategies and policies to improve air quality while limiting their impact on climate change.

PARTNERS

Foundation for Research and Technology, Greece • **Research Centre Jülich**, Germany • **University of Helsinki**, Finland • **University of Leicester**, UK • **The French National Center for Scientific Research**, France • **Institute of Atmospheric Sciences and Climate**, Italy • **Swiss Federal Institute of Technology**, Switzerland • **University of Lund**, Sweden • **Wageningen University and Research Centre**, The Netherlands • **National University of Ireland**, Ireland • **University of Copenhagen**, Denmark • **Weizmann Institute**, Israel • **Norwegian Meteorological Institute**, Norway • **Joint Research Center of the EU Commission** • **Max Planck Institute**, Germany • **Finnish Meteorological Institute**, Finland • **Natural Environment Research Council**, UK • **Paul Scherrer Institute**, Switzerland • **Stockholm University**, Sweden • **University of Leeds**, UK • **Institute for Tropospheric Research**, Germany • **Climate Service Center**, Germany • **AirEI**, Estonia • **International Institute for Applied Systems Analysis**, Austria • **The Netherlands Environmental Assessment Agency**, The Netherlands • **University Joseph Fourier Grenoble**, France

FUNDING

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SPYROS PANDIS is a Professor in the Chemical Engineering Department of the University of Patras in Greece and Deputy Director of the Institute of Chemical Engineering Sciences. His research includes theoretical and experimental studies of atmospheric chemistry as it relates to urban and regional pollution and global climate change.

most of the pollutants emitted on the Earth's surface is decided. Information about this region is therefore necessary to understand the atmospheric processes in detail and verify computational air quality models.

NEW FINDINGS

The first year of the project has focused on the basic science and improvement of the team's understanding of the processes linking atmospheric pollution and climate change. There have been some significant findings already. The Max Planck Institute for Chemistry group has shown that agricultural activities and land-use changes may strongly influence the oxidising capacity of the atmosphere by releasing nitrous acid (HONO) which is then photolysed to produce hydroxyl radicals (OH).

A new pathway for the growth of atmospheric particles has been discovered by the University of Lyon (France), Weizmann Institute (Israel), and Leibniz Institute for Tropospheric Research (Germany). Major gaps exist in the understanding of the physicochemical pathways that lead to aerosol growth in the atmosphere and to changes in their properties while in the atmosphere. This study presents experimental evidence of a new photo-induced pathway for particle growth. "The researchers have demonstrated that heterogeneous reactions activated by light can lead to fast uptake of non-condensable volatile organic compounds at the surface of particles when only traces of a photosensitiser are present in the seed aerosol," Pandis elucidates.

FROM MEASUREMENTS TO POLICY

The data from the Zeppelin will provide the group with information which should help them to evaluate and improve models which aim to describe future air quality climate feedbacks. The researchers are using a number of different computer models, each having their own strengths: "Depending on the feedback or interaction we will use the models that have the most detailed description of the corresponding atmospheric processes," Pandis explains. "We can make the necessary changes – for example eliminate a process or keep something artificially constant – that allows us to quantify the interaction."

Evaluating these models will lead the scientists towards policy recommendations. They aim to understand how past air quality policy and regulations have inadvertently affected present day climate and, the corollary, how climate change over the last decades has had an impact on Europe's ability to meet its air quality targets for ozone and particulate matter. They will then review which policy-relevant metrics should be used to facilitate the formulation of international treaties dealing with compound regulations relevant to the climate, and the assessment of the interactions between air quality and climate policies.

> Using the Zeppelin means the researchers can now observe these processes in the planetary boundary layer at an altitude of up to about 2,000 m – a layer of decisive importance

WIDESPREAD IMPACT

The ultimate goal of PEGASOS is to shape policy; directly through public outreach and by providing relevant results to policy makers, and indirectly by delivering relevant scientific studies to international assessments and organisations that in turn are important in international and European policy making. Through the long-standing involvement of its partners in the International Panel on Climate Change reports and other international assessments, PEGASOS ensures that results will be relevant outside of Europe, which is essential in the climate policy arena given the often repeated sentiment that climate change is not an issue that stops at borders.

In addition, Pandis hopes that the project has an impact beyond the scientific and policy community. Although most major air pollution sources have been, or are in the process of being controlled, smaller sources of pollution still present a problem: "Each one of us controls a few of these small sources," he concludes. "Realising this and trying to change our behaviour is a major step forward in our effort to improve air quality. We hope that the presence of the Zeppelin and the other outreach activities of PEGASOS will allow us to reach parts of the population that we have not been able to reach in the past."

Interconnected and interoperable

Dick Schaap, technical coordinator of the SeaDataNet marine environment data management project, updates us on recent progress, the remaining challenges and the exciting potential for future expansion

Could you begin by recapping the context from which the SeaDataNet network emerged?

SeaDataNet is the leading network in Europe, actively operating and developing a pan-European infrastructure for managing, indexing and providing access to ocean and marine datasets and data products acquired from research cruises and monitoring activities in European marine waters and global oceans.

The SeaDataNet II project has been underway for almost a year now and was preceded by SeaDataNet (2006-11) and Sea-Search (2002-05). These made great progress in establishing an infrastructure of 68 connected data centres from 29 countries around European seas, giving access to more than 1 million datasets, a range of pan-European metadata services and SeaDataNet standards that have been widely adopted across the EU.

What is the specific goal of the current SeaDataNet II project?

The overall objective of is to move towards an operationally robust and state-of-the-art Pan-European infrastructure. This includes: seeking full INSPIRE compliance, expanding the number of connected data centres; achieving an improved capacity for handling marine biological data, establishing machine-to-machine interfacing in addition to the present client user interface for serving specific user communities, such as the Marine Strategy Framework Directive; and achieving both delayed-mode and real-time data provision capacities for operational oceanography.

Can you highlight the greatest challenge in the effort to achieve standardised data capture?

Common standards and protocols for data management, including quality control, formatting, naming, and giving data access, are key issues for establishing a coherent infrastructure engaging major actors in ocean and marine data acquisition and management. SeaDataNet has focused on establishing common standards and on applying those standards to interconnect a large group of major data centres in Europe with great success. Moreover, by initiating and collaborating with other EU projects, such as Geo-Seas (see p30) for geological and geophysical data, JERICO (see p12) for operational oceanography, and European Marine Observation and Data Network (EMODNet), its standards are adopted and adapted to provide a richer set of standards fit for handling a wider scope of data types.

How important is cooperation between the US, EU and Australia and how are your activities helping to strengthen ties?

Europe, the US, Australia and IOC-IODE are making significant progress in facilitating the discovery and access of marine data through data management infrastructures such as SeaDataNet, Geo-Seas, IOOS, the Australian Ocean Portal and the IODE Ocean Data Portal. All contribute to the implementation of standards for the formats of metadata, data, data products, quality control methods and flags and common vocabularies. They also provide services for data discovery, viewing and downloading, and software tools for editing, conversions, communication, analysis and presentation, all of which are increasingly being adopted and used by national and regional marine communities.

There is also a general trend towards the use of the basic ISO and OGC standards; however, these allow the use of different profiles and vocabularies. As a result there are differences in the standards used in the different regions which hinder their direct exchange and use at an international and global scale, and as a result act as a barrier to the realisation of global portals such as the IODE Ocean Data Portal and GEOSS. It is therefore necessary to develop common standards, where possible, and otherwise establish interoperability solutions between these leading infrastructures for Europe, US, and Australia, and global portals. This will be subject of the new Ocean Data Interoperability Platform (ODIP) project that was recently awarded to an EU partnership, selected from SeaDataNet and Geo-Seas, together with IOC-IODE and key US and Australian partners.

Moving forward, what are your hopes for Horizon2020 in supporting your continued efforts?

SeaDataNet is a major contributor to the development of the overarching European Marine Observation and Data Network (EMODNet) that is initiated in the framework of the MSFD. EMODNet encourages more data providers to come forward for data sharing and participating in the process of making complete overviews and homogeneous data products. This will give wider visibility at the policy and management levels both at EU and Member States that should seek integration of EMODNet output and services in management and policy processes and that will decide upon its future sustained funding.

In parallel, further RTD work, such as that taking place in SeaDataNet II, will and must continue on standards and protocols that can be applied as basis for the expanding EMODNet portals. For this purpose Horizon 2020 will provide a fertile ground for SeaDataNet III and Geo-Seas II projects that will refine and expand the data management standards as well as their services.

Masters of marine data delivery

SeaDataNet II is the next step in the progression of European infrastructure for marine data management. Building on its current success, the team is aiming to expand the scope of the network, setting their sights on global collaboration

BETWEEN 2006 AND 2011, SeaDataNet emerged as an impressive pan-European infrastructure for marine data management, coordinating vast quantities of information from hundreds of disparate sources in 35 different countries. Now, data about the geographical and environmental makeup of the European seas is accessible in a way that was previously impossible. This innovative approach has facilitated work in a variety of fields, from scientific research to European-level political policy. By standardising data formats, quality control procedures, and vocabularies, and creating common protocols of communication, the SeaDataNet group was able to ensure the interoperability of the many data centres involved.

In order to maintain the high quality access to up-to-date data achieved so far a new phase, SeaDataNet II, has been underway since October 2011. Coordinated by Michele Fichaut of Ifremer and technically coordinated by Dick Schaap of MARIS, the second stage of the process aims to build on the achievements of the first. In particular, SeaDataNet II wants to increase the efficiency of the data management infrastructure and its capacity to cope with the huge diversity and volume of data available. This work will provide users from a wide range of backgrounds with access to reliable observations of seas and oceans and facilitate their research into marine environments which may have important social, economic and environmental consequences.

PAN-EUROPEAN COOPERATION

SeaDataNet II will rely on the continued cooperation and support of its various partners. Without collaboration from research institutes and oceanographic data centres from all over Europe, the project would never see fruition. Among the many members of the SeaDataNet consortium are the IEO Data Centre of Spain, the British Oceanographic Data Centre, SMHI of Sweden, and the Institute of Meteorology and Water Management of Poland, to name but a few.

Maintaining effective communication and good relationships between all of the involved parties is a considerable achievement and fundamental to the success of the SeaDataNet infrastructure. Schaap does not underestimate the value of all contributors and recognises the exciting potential it holds for expansion beyond European borders: "These networks and contacts contribute to the further positioning and development of the SeaDataNet infrastructure at operational and strategic levels. The consortium also includes IOC-IODE, ICES and two World Data Centres, RIHMI-WDC and PANGAEA-MARUM that will contribute to further strengthening the tuning of standards on a global scale".

BIGGER AND BETTER

Despite the enormity of the challenge to standardise cross-disciplinary databases in over 35 different countries, SeaDataNet II has very clear targets for improving the existing infrastructure and aims to become an operationally robust and state-of-the-art Pan-European infrastructure. This includes among others: seeking full INSPIRE compliance; achieving an improved capability for handling also marine biological data; establishing machine-to-machine interfacing in addition to the present client user interface for serving specific user communities such as MSFD, and achieving both delayed-mode and real-time data provision capacities for operational oceanography.

True to the project's core value of maintaining and facilitating effective communication, SeaDataNet II will see enhancements to its range of software tools and services for data analysis and prepare entries for the infrastructure, making them easier to use and providing improved functions and features. Alongside these developments, the project has introduced science literacy and training courses to share knowledge and give guidance about the SeaDataNet standards, services and various tools and how these can be gainfully adopted and applied. The first of these courses was held in Ostend, Belgium in July 2012 and received very positive feedback from participants who are now better equipped not only to make the most of SeaDataNet's services, but also to communicate that information to their colleagues and contribute their data sets to the overall infrastructure.

Many other activities are in the pipeline, if not already underway, for SeaDataNet II, working in close collaboration with its partners. These activities include; increasing the number of connected data centres and the volume and types of data accessible through SeaDataNet services, the expansion of its role as a key component in European Marine Observations and Data Network (EMODNet), and working with other marine infrastructure projects such as Eurofleets and MyOcean to optimise the flow of data between systems.

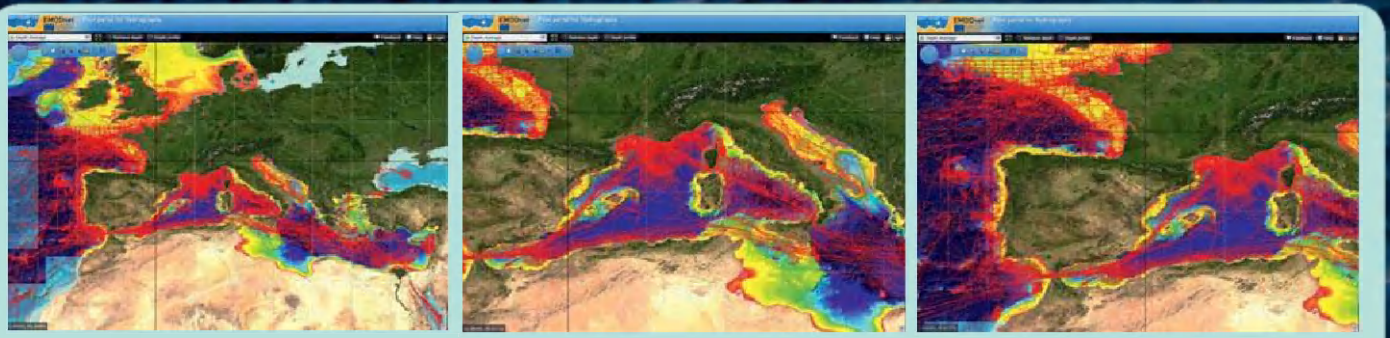

FIGURE 1. Higher resolution Digital Bathymetry for European seas as developed in EMODNet Hydrography with SeaDataNet giving overview and access to the underlying bathymetric survey datasets.

EVIDENTLY EFFECTIVE

For one specific example of the benefits of the SeaDataNet infrastructure, Schaap directs us towards the case of the EMODNet Physics Portal project. This was initiated early in 2011 as a cooperative effort between SeaDataNet, MyOcean, and EuroGOOS. The goal of the project is to provide a broad and useful dataset of in situ observations, both near real-time and long historical time series, from operational oceanography programmes and monitoring systems to serve a wide variety of user communities. Schaap emphasises the positive effect of this type of project: "The EMODnet Physics portal will also encourage other physical data providers outside the present communities to come forward, contribute and become engaged".

The portal provides users with direct access to comprehensive charts and tables of time series for a sliding window of the last 60 days and facilitates requests for the downloading of historical time series of selected stations and parameters. It is a flexible, user-friendly portal which makes use of the SeaDataNet infrastructure in combination with the EuroGOOS and MyOcean infrastructures, as it was intended, to facilitate scientific research, management and economic user applications, by giving access to data from a wide area and various sources through one portal.

BEYOND EUROPE

Given the success of the pan-European data management infrastructure, including its offspring Geo-Seas for marine geology and geophysics data, the project is also undertaking activities in a new, more global, direction. Currently, efforts to create an Ocean Data Interoperability Platform (ODIP) for Europe, the US and Australia are underway.

ODIP will bring together leading marine data management initiatives from three continents with the goal of exploring common standards and interoperability solutions that will facilitate common access to the wide scope of underlying data centres and their databases. This will also pave the way for contributing to the global Ocean Data Portal of IOC-IODE and GEOSS. Partners involved from the US include parties from research and governmental sectors of oceanography such as Marine Metadata Initiative and Rolling Deck to Repository, as well as the National Oceanic and Atmospheric Organisation (see p6). Participation is also anticipated from various Australian organisations working towards the realisation of an Australian ocean and marine data infrastructure, for example the Australian Ocean Data Network and the Integrated Marine Observing System. The success of collaboration on this global scale would provide the first step towards a transformation in the way data is shared across national borders, scientific fields and organisations of all shapes and sizes.

SeaDataNet Portal homepage at www.seadatanet.org.

In practice, ODIP will organise international workshops to foster the development of common standards and develop prototypes to evaluate and test selected potential standards and interoperability solutions. Schaap is enthusiastic about what ODIP can achieve thanks to the vast experience afforded by the SeaDataNet and Geo-Seas projects: "The ODIP partnership will provide a forum to harmonise the diverse regional systems, while advancing the European contribution to the global system".

The strong ethos of collaboration – which has driven many aspects of SeaDataNet's work so far – has evidently been central to its success in achieving greater interoperability. Bringing together such an impressive array of organisations from all over Europe to create a data management network which serves the common interests of researchers worldwide has served to demonstrate how much can be achieved from working collaboratively. With a strong track record of success, ever more exciting services and developments are expected from the next phase of the project and its rapidly expanding horizons.

> This work will provide users from a wide range of backgrounds with access to reliable observations of seas and oceans and facilitate their research into marine environments

INTELLIGENCE

SeaDataNet II

A PAN-EUROPEAN INFRASTRUCTURE FOR OCEAN AND MARINE DATA MANAGEMENT

OBJECTIVES

To network the existing professional data centres of 35 countries, active in data collection, and provide integrated databases of quality online standards.

PARTNERS

Ifremer, France • **MARIS BV**, The Netherlands • **NERC**, UK • **BSH**, Germany • **RIHMI**, Russia • **ENEA**, Italy • **INGV**, Italy • **METU**, Turkey • **CLS**, France • **AWI**, Germany • **Université de Liège**, Belgium • **IMR**, Norway • **NERI**, Denmark • **ICES – CIEM** • **European Commission** • **Marine Institute**, Ireland • **Instituto Hidrogràfico de Portugal**, Portugal • **NODC**, The Netherlands • **MUMM**, Belgium • **VLIZ**, Belgium • **MRI**, Iceland • **FMI**, Finland • **Institute of Meteorology and Water Management**, Poland • **TTU**, Estonia • **Latvian Institute of Aquatic Ecology**, Latvia • **EPA**, Lithuania • **SIO-RAS**, Russia • **National Academy of Science of Ukraine**, Ukraine • **IO-BAS**, Bulgaria • **NIMRD**, Romania • **Tbilisi State University**, Georgia • **IOF**, Croatia • **NIB**, Solvenia • **University of Malta**, Malta • **University of Cyprus**, Cyprus • **IOLR**, Israel • **CNR**, Italy • **IBSS**, Ukraine • **UniHB**, Germany • **TUBITAK-MAM**, Turkey

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DICK M A SCHAAP received an MSc in coastal engineering in 1980. At present he is Technical Coordinator for the FP7 SeaDataNet II and FP7 Geo-Seas projects and Technical Harmoniser for EMODNet.

Building a pan-European e-infrastructure

Project Coordinator **Helen Glaves** returns to *International Innovation* to discuss the latest developments in the Geo-Seas project, which aims to harmonise Europe's marine geoscience data

To begin, can you briefly sum up the objectives of the project and highlight the progress that has been made since we last spoke to you?

The Geo-Seas project is building a pan-European e-infrastructure for the management and delivery of harmonised marine geological and geophysical data. The main aims of the project have been to improve the ability of communities to locate and access a wide range of marine geoscience data types, and provide direct access to this data in standardised formats via the Geo-Seas portal.

Geo-Seas has achieved these objectives by creating a network of 26 data centres across 17 European countries and implementing an online data discovery and access service (www.geo-seas.eu). The Geo-Seas 'portal' is currently providing access to more than 78,000 federated marine geoscience datasets and this number continues to rise as each designated data centre adds to the information pool.

To assist the user with the process of data selection, Geo-Seas is also developing a suite of visualisation tools and services, which will shortly be available via the portal and allows users to preview seismic data, 3D digital terrain models and borehole log data.

How does Geo-Seas work with other organisations to garner data on the many aspects of the marine world?

Geo-Seas includes 28 partner organisations from around Europe who have responsibility for the acquisition and/or archiving of marine geoscience information. These data centres are delivering a range of marine geological and geophysical data for their own country and many are also involved with other initiatives for the delivery of other types of marine information both on a national and regional scale. For example, many Geo-Seas partners are also involved with SeaDataNet (see p27) which is delivering oceanographic data.

In addition to SeaDataNet, the Geo-Seas project also works closely with a number of other EU-funded initiatives involved with the management of marine data, with a view to furthering the development of multidisciplinary marine science at a time when there is an increasing need to take a more ecosystem-level approach to the marine environment. Geo-Seas is also underpinning the geology component of the multidisciplinary European Marine Observation Data Network (EMODNET) and, as a result, users can access marine geoscience data in combination with other marine data types.

The EU Ocean Data Interoperability Platform (ODIP) was recently granted funding. Could you outline its purpose and core values?

The aim of ODIP is to establish a Europe-US-Australia coordination platform with the objective of developing interoperability between the various marine data management infrastructures currently in use in these regions. The ultimate goal of the project is to further the development of a common approach to marine data management which allows the sharing of marine data across scientific domains, organisations and national boundaries. This will be achieved through the development of a consensus between European, US and Australian partners on a coordinated approach to the harmonisation of marine data management infrastructures which can be implemented and adopted globally.

Can you expand upon how SeaDataNet is presently assisting Geo-Seas in their long-term goals?

The Geo-Seas e-infrastructure has been developed by adopting and adapting the architecture and technologies that were originally developed by the SeaDataNet project for the management of oceanographic data. This approach has resulted in the development of a joint infrastructure for the management of both marine geoscience and oceanographic data which makes a wide range of harmonised marine data types available to users. This has also led to increased interoperability of marine data and furthered the development of multidisciplinary marine research.

What advancements in technology are propelling Geo-Seas to explore new areas of the marine environment?

Geo-Seas is focused on the management and delivery of marine geoscience data for Europe. We are seeking to include additional partners in future plans for the project, which will extend the coverage of the data that is available. But this is generally not currently driven by the development of new technologies. However, as new technologies are built, Geo-Seas will seek to include the data from these systems in the data discovery and access service, and make it available to the end-user.

Multidisciplinary marine research

After three years, the **Geo-Seas** project is now reaching the final stages of its efforts to create a multidisciplinary, transnational data network for geological and geophysical marine research

IN EUROPE, A large proportion of marine geological and geophysical observations are gathered and analysed by research institutions and national geological surveys. Therefore, a European-wide data infrastructure is crucial for achieving transnational online access to standardised data and data products. Located in 17 European maritime countries and 26 marine geological and geophysical data centres, Geo-Seas is coming to the end of its three-year project which aims to develop and implement a successful data management infrastructure.

SeaDataNet is the leading initiative in the field of marine observation and data collection. The consortium has been expanding the SeaDataNet marine and ocean data management infrastructure to include marine geological and geophysical data, data products and services. Some of the primary datasets and data products the group aims to deliver to user communities are bathymetric data and digital terrain models, sediment grain-size data, lithological data and geotechnical data. To deliver these datasets the researchers have built an ICT-based infrastructure system to underpin the development of e-infrastructures.

HARMONISING DATASETS

Geo-Seas has been expanding the SeaDataNet infrastructure through the inclusion of multinational surveys and data collections of selected geological research institutes. It is intended that this collected knowledge be published and maintained in common catalogues. Facilitating and promoting access of this data to the different user communities – government, research and industry being three central examples – via the Internet has also played a key role in their objectives, along with harmonising the formats of information for transnational relations and consistency. A subsequent value of the project is that, via the data portal, users will be able to search transnational metadata, specifically harmonised marine geological and geophysical datasets.

The strengthening of the data infrastructure developed by SeaDataNet will lead to wider use across Europe by both the marine geoscience and oceanographic communities. New geological and geophysical data products and services will be developed on a transnational level to fulfil the needs of the different end-user communities, achieving greater cooperation between data centres and greater coherency of data management services. This should lead to an international exchange between user communities as well as to the development of new, global data products.

ECOSYSTEM-BASED APPROACH

Increasingly, an ecosystem-based approach is taken to marine research in Europe. This strategy requires that large amounts of quality marine data be made available to various users for a variety of purposes, such as marine planning and management, scientific research and policy making. "Facilitating this ecosystem-based approach also requires interoperability of marine data types from different disciplines and between organisations around the world," Project Coordinator Helen Glaves states. The development of this interoperability requires collaboration between the organisations currently involved with the management of marine data. "These collaborative relationships are essential for knowledge exchange and the development of a common unified approach to marine data management which can be adopted on a global scale," Glaves explains.

Through a transnational e-infrastructure, which incorporates network data centres and key organisations, the Geo-Seas project has been developing a unified approach to marine geoscience data management. The researchers are now seeking to develop connections with marine data management organisations in Australia and the US, with the understanding that collaborative exchange of knowledge will benefit marine data worldwide.

Geo-Seas is contributing to global framework initiatives such as the Global Earth observation System of Systems (GEOSS). Connecting the providers of decision-support systems and the data producers with end users, GEOSS aims to enhance the relevance of Earth Observations to universal issues and the Global Monitoring for Environment and Security (GMES) initiative. In this way, the Geo-Seas team is drawing together data from many different sources in order to provide a cohesive picture of the global environment to which marine conditions are obviously of great importance. Geo-Seas hopes that an increase in the quantity and quality of marine knowledge will benefit such initiatives.

NEARING COMPLETION

Set up on 1 May 2009, the Geo-Seas project concludes in October 2012. The final meeting is set for 9-10 October 2012 at University College, Cork in Ireland. As a platform for a topical poster session and presentations from other related projects, this will be an opportunity for Geo-Seas to present the overall results, including tools and services developed for use by the community. Exciting research looks set to continue after this, with funding being granted for the Ocean Data Interoperability Platform, an EU-US-Australia initiative bringing together experts to develop a common approach to marine data management.

INTELLIGENCE

GEO-SEAS

PAN-EUROPEAN INFRASTRUCTURE FOR MANAGEMENT OF MARINE AND OCEAN GEOLOGICAL AND GEOPHYSICAL DATA

OBJECTIVES

To implement an e-infrastructure for the management and delivery of marine geoscience data by creating a network of data centres including national geological surveys and selected geological research institutes, and to publish and maintain common catalogues of available data, data products and services. Geo-Seas will also harmonise quality standards, and exchange formats, to facilitate access to and delivery of data to the various user communities.

PARTNERS

BRGM/Office of Geological and Mining Resources, France • **British Geological Survey**; **British Oceanographic Data Centre**; **Centre for Environment, Fisheries and Aquaculture Science**; **National Oceanography Centre**; **CIRIA**, UK • **University of Barcelona**; **IGME/ Marine Geology Service**, Spain • **CDG/CNRS - Université de Strasbourg**; **Ifremer/IDM/ SISMER**; **SHOM** France • **Bulgarian National Oceanographic Data Centre**, Bulgaria • **University College**, Cork, Ireland • **EU-CONSULT**; **TNO**; **Marine Information Service**, The Netherlands • **University of Latvia**, Latvia • **BGR**; **NODC**, Germany • **GEUS**, Denmark • **Geological Survey of Estonia**, Estonia • **Geological Survey of Ireland**, Ireland • **NGU**, Norway • **Institute of Geology and Geography, Nature Research Centre**, Lithuania • **National Observatory of Athens/IGME**, Greece • **LNEG**, Portugal • **Royal Belgian Institute of Science**, Belgium • **OGS**, Italy • **Polish Geological Institute – BMG**, Poland

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Reform and react

The EU's Common Fisheries Policy often comes under attack for doing too little to protect the environment and engender a sense of accountability from the fishing industry for its long-term success, but these criticisms should soon be a thing of the past thanks to sweeping reforms built upon the best available information. The work is being driven by the leadership of European Commissioner for Maritime Affairs and Fisheries, Maria Daminaki

SEAS AND OCEANS, and the services they provide for us, are integral to human life and wellbeing. It is vital that we ensure they are protected, maintained and preserved both now and in the future. A plethora of challenges now face the world's oceans and seas – and this list is growing rapidly – but Europe is presently focused on the biggest issue: the fishing industry.

As one of the largest industries in the world – producing over 6.4 million tonnes of fish a year and employing around 350,000 people – Europe must ensure the future of the fisheries industry is secure. European marine industries are among the most advanced worldwide, using cutting-edge technologies and scientific expertise capable of harnessing the ocean's great potential. Nevertheless, there are still major concerns with the level of unsustainable, economically-unviable activities in the fisheries sector.

COMMON FISHERIES POLICY

The EU's Common Fisheries Policy (CFP) was established in 1983 as a sustainable and progressive common resource for Member States to follow, outlining acceptable fishing activities and practices. Unfortunately, many of those who are affected by the CFP are unhappy with the policy, criticising the support and legislative guidance it offers for numerous reasons. Issues raised include:

- Discard – an alarming rate of fish is thrown away by fishermen. These fish are returned to the sea due to their being the incorrect size or gender, poisonous or a lack of space on board to name a few reasons. Fish that are not retained on board usually die soon after returning to the water
- Vessel utilisation – money used to scrap boats has not been used to its full potential. Too many fishing boats in Europe outweigh the small number of fish being caught.
- Lack of management – European Commissioner for Maritime Affairs and Fisheries, Maria Daminaki would like to give control back to regions, Member States and those working for the fishing industry. She suggests that little intervention from the EU would be required, and instead they "would be the lighthouse, showing the way." However, she is keen to maintain that Member States, regions and industry would still be "steering the ship"
- 'Back to basics'– the need to return to more traditional methods of fishing, using national waters. Fishermen can then look after their own stocks, render them sustainable, and hand the stocks (as well as knowledge) down through generations
- Smaller fishing boats – due to the hundreds of small boats in the fishing business, many are facing financial ruin. This is according to campaigners who are calling for radical reform of European fishing rules
- A lack of information offered to potential consumers and buyers about the quality of fish stock and sustainable fishing methods

SPEAKING SENSE

During an introductory presentation given at last year's World Oceans Day celebration at GLOBE, Commissioner Daminaki outlined the enormity of the European fisheries policy's impact: "This reform concerns everybody: fishermen, coastal populations, retailers, consumers and taxpayers. It concerns us all and yet the US, Australia, New Zealand and Norway are already way ahead of us in adopting modern, sustainable policies that deliver good results for both the industry and the oceans".

The general consensus is that this two-decade-old policy needs replenishment; a more contemporary outlook on fishing practices, and a closer focus on sustainability and economically-friendly fishery management. The CFP is set to undergo a major reform over the coming years, where common policies will be reviewed and the challenges of managing modern fisheries analysed and evaluated.

MAXIMUM SUSTAINABLE YIELD

Overfishing is one concern which needs to be addressed throughout fishing practices across Europe. Data collected for the reform of the CPF has found that around 75 per cent of EU fish stocks are overfished, whereas only 25 per cent accounts for the average worldwide figures. Overfishing not only damages fish supplies, but also enhances Europe's risk of coming up against financial difficulties. Many have commented that the dwindling stocks of fish are due to 'too many boats catching too many fish'; a phrase used commonly among those who stand against the current CFP, and who are unconvinced by its actions. Instead of the CFP initiating change for the better, overfishing is now more of an issue than ever before. The older, more mature fish are dying out due to overfishing, and we are eating younger fish in their place, which are not given the opportunity to fully develop or reproduce. This exhausts fish stocks dramatically and edges the industry closer to financial ruin.

Maximum Sustainable Yield (MSY) takes into consideration the largest possible catch that can be acquired from fish over an indefinite period of time, without harming the species, and in the most sustainable way. The EC hope to reach MSY in all European oceans and sea by 2015, and are working towards ensuring this will become a legal obligation. "I want a capital of healthier fish stocks giving rich interests, in the form of landings, to our fishing industry. I want to maximise the economic return to fishing communities," remarks Daminaki.

TIME FOR CHANGE

If Europe continues to exhaust its fish stocks, the future for fishing industries will remain uncertain. By placing the marine ecosystem under such stress, Europe is significantly damaging a great source of high-protien, low-fat food. A range of health benefits are linked with eating fish: they produce 'good' fats for the body; maintain cardiovascular health through regulating blood flow and reducing clotting; essential for prenatal and afterbirth neurological development; and alleviate inflammation and symptoms of rheumatoid arthritis, to name a few. "Brain and heart-related diseases are blowing up our healthcare budgets and in the long run, fish consumption can contribute to reduce the pressure," Daminaki elaborates.

> As one of the largest industries in the world, Europe must ensure the fisheries industry is conserved and that its future is secure

A new funding framework for the EU's maritime and fisheries policies has been proposed and will be offered over 2014-20. It is hoped that this will bring about some exciting changes to the CFP reform. As Europe moves towards the future, a legal framework for marine preservation, policy must become more robust and accurate. Communication between Member States, regions, industry and the European Commission will require strengthening, and decision making between them will need to be made more clear and precise. With the greater picture in mind, Daminaki sums up the importance of the fisheries industry: "We are talking about monumental change in one of our most ancient and most essential sectors – foodstuff".

An important step in delivering effective change is the analysis of sustainable growth scenarios and the measures required to bring these to fruition. The complexity of the task requires cooperation from all stakeholders in the EU. Beyond this, an industrial policy for coastal regions and maritime sectors must provide strong direction. Under Daminaki's leadership, the EU will move towards smart and green fisheries. Innovation must be responsible for contributing to the objectives of the new CFP to ensure competitive EU fisheries, the promotion of sustainable fishing and adding value to fishing and fishing-related activities. Market failures clearly exist, but by identifying these, a platform for public intervention can be forged, offering a brighter future for EU citizens, industry and the environment across the board.

Helping marine science reach new depths

The development of underwater and wave gliders has provided two new and flexible platforms for marine observation. **Dr Laurent Mortier** discusses current EU efforts to create a supportive infrastructure for these platforms to ensure they effectively feed into marine observation objectives at global level

Could you begin with an overview of Gliders for Research, Ocean Observations and Management (GROOM)? What led to its establishment?

The main objective of GROOM is to design a European Research Infrastructure that uses underwater gliders for the benefit of research and industry. Gliders are new marine platforms requiring highly-skilled personnel and a strong network of organisation. The even newer wave glider – a surface vehicle with promising capabilities – has similar characteristics and is being included in the GROOM activity. An EU Seventh Framework Programme (FP7) project was the perfect tool to establish the right infrastructure for that and above all to overcome the challenge of avoiding fragmentation in the establishment of such an infrastructure at national and international level.

How do you foresee the integration of this work developing? What challenges are associated with this?

Gliders represent a very attractive platform for research in a wide range of marine sciences. This first led to the EGO initiative, yet issues of sufficient finance for effective research and organisation of hardware remained. GROOM allows for the integration of national initiatives started in labs to ensure good science and observations are made and they reach governmental level so finance is made available. What makes glider research different from other marine platforms is the extent to which the infrastructure is distributed between many countries with gliders ports where gliders are serviced, controlled and data stored. This requires a very strong network of workshops, computers and personnel. The logistical challenges are therefore huge.

Can you outline the purpose of the Global Ocean Observation System (GOOS) and how GROOM will become integrated into its objectives?

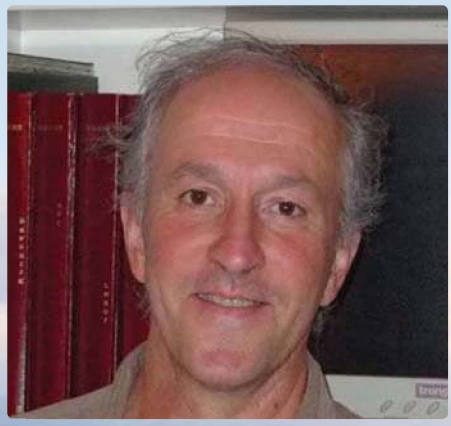
GOOS is a permanent global system for observations, modelling and analysis of marine and ocean variables to support operational ocean services worldwide. The main GOOS infrastructure at present relies upon the ~3,000 ARGO profilers which are freely drifting devices scattered in the global ocean. As ARGO profilers cannot be directed towards specific locations with higher interest, there is a need for a versatile platform that can be steered. Against this context, the goal of GROOM is to fill the gaps left by other devices including profilers, moorings and boats. As gliders can remain in the sea for a long time, move over large distances and be sent to specific regions of interest, they are now the best candidates.

What biogeochemical and bio-optical properties do gliders try to analyse? What scientific innovations are driving this understanding forward?

Gliders have versatile payloads and can be used to collect a large number of types of data. This includes basic ocean variables such as temperature and salinity, but also biogeochemical data including oxygen, nitrates measured by optical sensors. In the near future, they will be able to collect additional optical proxies and even images, suitable for biological data and species recognition. This new capability will offer researchers high-density information on the plankton ecosystems being observed. In addition, acoustic sensors can provide useful information for higher trophic level by listening to the noises made by these larger animals.

What role does industry play in driving innovation and how does GROOM facilitate industry in trying to successfully utilise oceanic resources sustainably?

Gliders were initially developed by US labs, including the Webb Research Corporation, which is a company tightly linked to the Woods Hole Oceanographic Institute and the Massachusetts Institute of Technology. These partnerships allow for the effective exploitation of technological breakthroughs. This collaboration between oceanographers, engineers and industry has underpinned the success of the gliders. Gliders cannot be developed without industry as they are very complex systems. Companies are interested in them because gliders are multipurpose and can also be used for industrial applications, in particular by the oil and gas sector. Moreover, the wave glider is a pure industry driven project



THE SLOCUM GLIDER 'CRATE' AND THE WAVE GLIDER 'HERMES' BEING DEPLOYED FOR THE TOSCA EXPERIMENT IN THE NORTH WESTERN MEDITERRANEAN, NOV 2011.

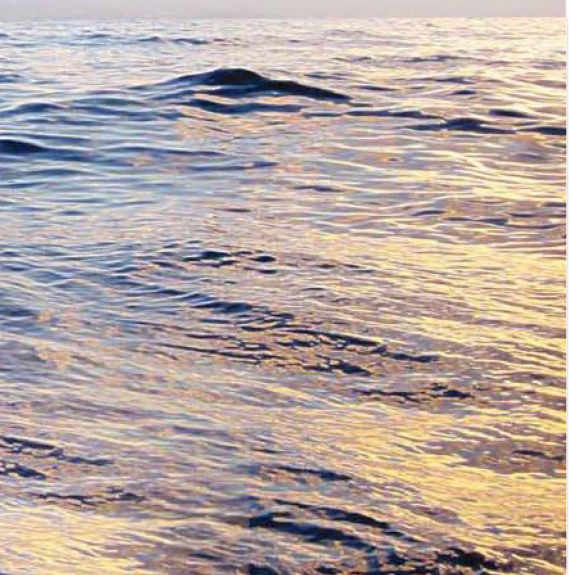
of an US company with environmental and business motivations.

In Europe we are not as advanced in such partnerships. This is now a priority for the EC in particular for building marine instrumentation. To this end, GROOM promotes the integration of innovative optical sensors developed by European companies and labs which can provide interesting data on hydrocarbons for pollution monitoring. Acoustic sensors that can measure wind and rain at the surface will also be integrated on gliders. Field measurements are planned in GROOM to demonstrate the interest of such sensors.

Finally, can you outline the perceived benefits to society as a result of remote platforms?

The benefits such platforms can bring should be compared with meteorological services which rely on a global network of daily measurements. The same services must now be delivered for the ocean. This is being spearheaded by MyOcean (see p9) which delivers products such as tailored datasets for specific goals. For this, a large amount of data is required, and so MyOcean aggregates datasets from a broad array of platforms, including gliders. This benefits research of course, but it also benefits society. A good example is the monitoring of heat contained in the Ocean which is vital for addressing climate change and here gliders can bring invaluable information where profilers cannot operate. The situation is the same for ecosystems and biodiversity where other platforms are useless or prohibitively expensive.

At a more local scale, there are pollution problems around coastal areas near cities or due to accidental oil spills. Gliders are able to deliver accurate information in these areas. There is also a need to ensure industry does not cause excessive destruction to the marine environment, which again provides societal benefits. All these aspects fulfil the aims of the EU's Marine Framework Directive. To help deliver this, efficient marine platforms and infrastructures such as GROOM are necessary.



Into the depths

Nearly a year has passed since the GROOM project was initiated, and it is now making significant headway with creating and evaluating a new European glider infrastructure, using both underwater and wave gliders for monitoring and sampling oceanographic data

MARINE OBSERVATION is not a new field. Since the time of Elizabeth I and Napoleon III, collaborative efforts have been made ensure safe shipping conditions and this gave birth to the World Meterological Organization (WMO). More recently, a large cooperative effort with oceanographic vessels has supported the World Ocean Circulation Experiment conducted by the global ocean community, mapping for the first time the global thermohaline circulation. However, despite the many advantages to these vessels, including voluntary observing ships and free drifting profilers, significant gaps remain in ocean monitoring and sampling activities. In the late 1990s, underwater gliders equipped with miniaturised sensors were developed to address these knowledge gaps. These gliders are controlled remotely and have the ability to move over vast distances, making extensive and complex studies of the ocean more viable and accessible.

Underwater gliders are a novel type of autonomous underwater vehicle (AUV). They can control their own buoyancy and thus move vertically. Thanks to their wings they can change these vertical motions to forward movement. This saw-tooth trajectory from surface down into the depths of the ocean can be done with minimal power consumption and long-term missions can therefore be organised. At present, several types of underwater gliders are being used in the ocean (Oceanographic labs for research, by national Navies, monitoring during the Blue Horizon disaster, etc.) because of their flexibility, durability and longevity. These novel devices are capable performing ocean sampling missions lasting weeks or even months, covering thousands of kilometres of range. Furthermore, the recently developed wave glider can remain at surface and propel itself forward by harvesting wave energy. It also carries several sensors and can travel almost indefinitely as it recharges its battery with solar panels.

Underwater gliders are used to take measurements from surface to depth such as temperature, salinity, currents, turbidity, fluorescence, dissolved oxygen and other optical and acoustic measurements. The wave glider performs similar measurements at the surface and can also record atmospheric parameters.

The potential of underwater gliders and wave gliders is vast, including their ability to detect hazardous or toxic substances in the ocean, as well as biological, chemical and radioactive threats. They also allow researchers to track water masses for their physical and biogeochemical properties and collect thorough information on the health of marine ecosystems (eg. ecosystems shifts, eutrophication events, etc.).

THE GROOM PROJECT

The capability of gliders as observation platforms is clear, but at present, there is a pressing need to create an infrastructure upon which data can be effectively acquired, utilised and translated into useful services for global level research, industry and societal benefit. The Gliders for Research, Ocean Observation and Management (GROOM) project is a design study for a European glider Research Infrastructure (RI). The project is part of the EU Seventh Framework Programme (FP7) and coordinated by the Université Pierre et Marie Curie. The consortium comprises 19 European partners from different countries (France, Germany, Finland, Greece, Italy, Spain, the UK, Norway and Cyprus), which

GROOM

GLIDERS FOR RESEARCH, OCEAN OBSERVATION AND MANAGEMENT

OBJECTIVES

To design a new European research infrastructure to use underwater gliders for the benefit of European citizens, researcher, and industry. GROOM will define the scientific, technological and organisational/ legal levels, of a European glider capacity for research and sustained observations of the oceans, in line with the other European and international initiatives for marine *in situ* observations.

PARTNERS

UPMC, France • **UCY**, Cyprus • **IFM-GEOMAR**, Germany • **HZG**, Germany • **AWI**, Germany • **UT**, Germany • **FMI**, Finland • **CNRS**, France • **Ifremer**, France • **HCMR**, Greece • **NURC**, Italy • **OGS**, Italy • **UIB**, Norway • **NERSC**, Norway • **CSIC**, Spain • **PLOCAN**, Spain • **SAMS**, UK • **UEA**, UK • **NERC-NOC**, UK

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LAURENT MORTIER is Professor of physical oceanography at ENSTA-ParisTech. Since 2003, he has played a major role to develop the French glider national facility and the European coordination for gliders. He is now PI of the French Mediterranean Ocean Observing System (MOOSE).

The capability of gliders as observation platforms is clear, but at present, there is a pressing need to create an infrastructure upon which data can be effectively utilised

strengthens the importance of their research efforts.

Since its inception in October 2011 – and with an overall duration of three years – GROOM has set out to demonstrate a number of objectives, including:

- The creation and distribution of 'gliderports,' not only in Europe, but also overseas
- Keeping costs to a minimum and providing effective cooperation and coordination whilst operating glider fleets simultaneously with other traditional observing systems
- Maintaining a suitable glider infrastructure for continuous effective monitoring and research activities
- Offering a world-class service to those associated with research and environmental monitoring

The group hopes to assess and evaluate the use of a roadmap – for adhering to a number of short- and long-term goals – and tools for the implementation of a sustained and coordinated glider component that meets the standards and expectations of a European Network of Marine Observations, eg. contributing to the Global Ocean Observation System (GOOS). The focus is on delivering a safe approach to operating large fleets of gliders, as well as individual vehicles, much like air traffic control at an international airport. This should ensure that multitudinous observations can be made effectively in a safe way.

The potential impact of GROOM has recently been analysed in a vision statement, created by the European Science Foundation's Marine Board (see p40). This statement stressed the paramount requirement for stability and integration in the marine observatories arena, 'installed and operated through multinational cooperation and support, providing consistent *in situ* data from the seas and oceans in support of the EU Integrated Maritime Policy and as a driver for smart, sustainable and inclusive growth in Europe'.

Given the number of teams addressing similar issues, this management project aims to reduce duplicate research efforts. GROOM has the ambition to become the 'glue' between the members of the ocean community that performs marine work to harbour creative investigations and provide useful applications, whilst avoiding 'copycat' work.

TASK MANAGEMENT

By following five Work Packages (WPs), GROOM is able to distribute time and labour effectively among each important area of the project. The WPs consist of:

- WP1: Scientific coordination – the first task for the project is to coordinate the partners' scientific and technological activities, so that they are in line with the other WPs and all the specific objectives. GROOM coordinators are hopeful that conforming to this WP will enable better communication, timing and evaluation of scientific work that has been and will be accomplished
- WP2: Integration in GOOS – three introductory actions regarding the creation and maintenance of a sustainable glider component in GOOS will be assessed. Here, in addition to the design of the glider component in the GOOS, monetary and legislative guidelines will be analysed, as well as a legal framework required by EU standards
- WP3: Scientific innovation – split into three tasks (developing sensors and sensor combinations, designing a glider data portal and providing innovative communication training), WP3 aims to improve Europe's research and development infrastructure
- WP4: Targeted experiments – existing glider data and metadata, eg. data flows, sensors, mission design, software and logistical aspects, is taken into consideration. During this WP, new techniques and methods will be tested at sea for a better assessment.
- WP5: Observatory infrastructure – GROOM will define all architecture of the single glider port as well as the network of glider ports and data centres which need a dedicated IT infrastructure. Here all the operating costs will be analysed.

FUTURE PLANS

The programme is in the process of creating the roadmap for the implementation of the infrastructure, these include: 'glider ports' for effective glider operations; free and accessible data exchange; soft and hardware services; rules for sensors; and organised steering of glider fleets. They will also be helping to integrate wave gliders, another exciting development in this developing field. A legal entity may be built to better support these activities.

Optimal configuration of the RI that GROOM proposes will clearly be successful if it can conform to both marine research and operational oceanography requirements – performing both intense and innovative research studies and continuous monitoring, but keeping costs low. For this reason, underwater gliders and wave gliders show tremendous promise and could revolutionise future ocean observations while improving Europe's position in the global competitive research infrastructure.

Supporting oceanographic **exploration**

A new observing and forecasting system in the Baleraric Islands is setting a new paradigm in ocean research. **Dr Joaquín Tintoré** offers some thoughts on why this project is so important

To begin, what is the Balearic Islands Coastal Observing and Forecasting System (SOCIB) and what are the key objectives of the project?

SOCIB is an Ocean Observing and Forecasting System located in the Balearic Islands in the Mediterranean. It is a new facility which is a multiplatform distributed and integrated system that provides streams of oceanographic data and modelling services to support operational oceanography in a European and international framework. SOCIB therefore also contributes to the needs of marine and coastal research in a global change context.

In line with the European Global Ocean Observing System (EuroGOOS), this project helps operational oceanography to be understood in a wider sense, which includes the systematic long-term measurements of the seas and their interpretation and dissemination, and also the sustained supply of multidisciplinary data to cover the needs of a wide range of scientific research and societal priorities. This work will allow a quantitative increase to help answer a range of key questions on oceans and climate change, coastal ocean processes, ecosystem variability, sea level rise, etc. It will also help to drive us towards a more science-based coastal and ocean management.

Where does SOCIB fit in to the European policy realm?

SOCIB, as a part of the Large Scale Infrastructures Programme from the Spanish Ministry of Economy and Competitiveness, is already an ongoing example of the new Marine Research Infrastructures that are being established internationally. This type of new marine infrastructures should be enhanced in the 2014-20 perspectives to support the European Integrated Maritime Policy and as an example the sound implementation of the Marine Strategy Framework Directive. It is also fully in line with the objectives of the new European Commission Framework Programme Horizon2020.

Could you explain why an observing and forecasting system around the Balearic Islands is needed?

The Mediterranean is a semi-enclosed sea, essentially a small-scale ocean laboratory characterised by significant changes in the circulation of currents and related ecosystem response and with a key socioeconomic impact for European citizens. The Balearic Islands are located at an important place in the western Mediterranean, the Ibiza channel being at a hotspot of biodiversity related to the interaction between Atlantic and Mediterranean waters. The main ocean processes can be studied and monitored in the ocean waters around the Balearic Islands and the findings are of global interest. At the same time, the socioeconomic importance of the Balearic Islands and tourism in the Mediterranean cannot be overlooked and accordingly, sound science and knowledge-based coastal and ocean management is requested by both residents and tourists. These society driven interests must also be addressed, related mostly to improving water quality, sound beach management, etc., for both residents' welfare and the satisfaction of tourists.

Are you employing any unique or interesting techniques and technologies in order to collect your research data?

The key phrase is really 'multiplatform integration'. Gliders are one of the new technologies implemented at SOCIB, monitoring the channels between the islands and also contributing better understanding of ocean variability through process orientated research projects. Gliders allow high resolution sampling, profiling from the surface to a depth of 1,000 m at kilometre intervals for up to three months, and have shown the existence of new features, such as sub-mesoscale eddies that are characterised by strong horizontal gradients and intense vertical motions. These structures interact with the underlying mean flow and topography and can block the general circulation or give rise to intensified upper ocean biogeochemical exchanges. These are just two examples of scientific topics of worldwide relevance in a climate change context that have been specifically addressed at SOCIB in collaboration with the Mediterranean Institute for Advanced Studies, a research centre jointly governed by the National Research Council and the University of the Balearic Islands.

To conclude, can you highlight your proudest moments working on this project so far?

We are particularly proud that SOCIB is unique among the new observing and forecasting systems in that its mission and objectives are science, technology and society driven. Multiplatform integration and data availability are the two key elements of SOCIB which we have worked hard to achieve. One particularly special component of this project is the new 24 m coastal catamaran which is providing spacious laboratory space and accommodation for up to 15 people that is also fast and cost-efficient. This mobile laboratory will be a crucial monitoring component of SOCIB.

A solid foundation for multi-platform oceanic research

Experts at the **Balearic Islands Coastal Observing and Monitoring System** are revolutionising our understanding of key questions on ocean processes, climatic change and ecosystem variability

IN 2008 THE International Union for Conservation of Nature recognised the Mediterranean as one of the global biodiversity hotspots under threat. There is no doubt that the diverse array of marine species and ecosystems in this area are facing major changes as a result of changing environments and climates. A significant level of research effort is being directed at understanding what species and ecosystems are present in the Mediterranean, as well as how climate change is likely to impact on this biodiversity. A unique observing and forecasting system has been set up in the Baleraric Islands with science-, technology- and society-driven objectives to support marine research in a novel way. The Balearic Islands Coastal Observing and Forecasting System (SOCIB) is part of a new group of marine research infrastructures which are currently establishing innovative methods of encouraging international cooperation in oceanography. Dr Joaquín Tintoré, Permanent Research Professor at the Spanish Council for Scientific Research and Director of SOCIB, is enthusiastic about their prospects: "This work will lead to major scientific breakthroughs, innovations in oceanographic instrumentation and create new pathways down which science-based coastal and ocean management can develop".

BUILDING ON TECHNOLOGICAL ADVANCES

Historically, developing an understanding of the oceans and coasts was based on data gathered from single observation platforms (ships). Today, a whole host of platforms are available to researchers, including satellites, gliders and buoys. The advent of advanced computer technologies has meant that marine observation systems have very rapidly become multiplatform and integrated. SOCIB takes full advantage of all available observation techniques to deliver cutting-edge marine information. Recently, only small teams of researchers were able to access observation data, however this information is now directly available to a wide range of global stakeholders in near real-time. As Tintoré explains: "Today, the data is quality controlled and made available in quasi real-time, which means all scientists and other stakeholders can have direct access to this information. This significantly increased accessibility is having a major impact upon the ocean observing community". The real benefit that comes with the development of these new tools is that far more effective knowledge-based decision support is provided for oceans and coastal management.

> This work will lead to major scientific breakthroughs, innovations in oceanographic instrumentation and create new pathways down which science-based coastal and ocean management can develop

AN ARRAY OF TECHNICAL SUPPORT AND FACILITIES

The SOCIB team has developed a number of observing facilities to support delivery of their monitoring programme. Seven major new Observing Facilities are now operational from the open ocean waters to the Balearic beaches, including open ocean moorings, a technologically advanced catamaran, a long-range high-frequency radar system in the Ibiza channel, gliders, coastal moorings, Argo profilers, surface drifters and nearshore monitoring system of beaches. These facilities

24 METRES LOA RESEARCH VESSEL SOCIB

GLIDER DEPLOYMENT

deliver a variety of data, such as surface currents, biogeochemical measurements, water temperature, freshwater storage and transport, hydrodynamics and sediment transport. Backup for all the systems is provided by a highly skilled Engineering and Technology Development Division, who provide the technical 'backbone' for all the application, development and testing of both existing technologies and those future systems currently in planning.

The SOCIB Modelling and Forecasting facility offer a range of modelling to help advance the understanding of the processes that are taking place within the western Mediterranean. This includes circulation models, ecosystem models, wave models and satellite data to support the development of coastal models. The research group is improving knowledge on the evolution or adaption of the oceanic and coastal processes under a range of scenarios, including the latest scenarios provided by the Intergovernmental Panel on Climate Change. The Modelling subsystem is presently running an operational model for ocean currents, which is nested to the wider MOON/MFS system. They have also set up a wave operational system, established together with Puertos del Estado, for the southern coast of Mallorca and the Palma harbour entrance. In addition, a pre-operational meteo-tsunami system is in operation to support the Balearic harbours authority when strong sea level oscillations occur, mostly at Ciutadella harbour in Menorca.

The Data Center is at the very core of SOCIB; work developing and implementing a general data management system to guarantee international standards, quality assurance and interoperability are core outputs. This Center is performing specific developments and tools for the different facilities when required, as Tintoré highlights: "Its main functions and capabilities range from data reception to its distribution and visualisation, via web services and THREDDS/ OPeNDAP protocols, passing through processing, quality control, documentation, standardisation, archiving and data discovery". The facility is responsible for all cataloguing and distribution of the data generated by SOCIB observations and forecasting. Strict quality procedures are applied to all data and across the whole data lifecycle. This is a complex undertaking and requires that a wide-range of international data initiatives, standards and protocols are adhered to. The Data Center develops a number of its own tools to handle such a large amount of scientific data which is being accessed by a wide range of end-users. The SOCIB Design phased spanned from 2009-10 and has been followed by the Construction phase that ends in 2012. Simultaneously, the different facilities have started to provide operational data and modelling services that are available through the SOCIB THREDDS catalogue in NetCDF format.

CONTRIBUTING TO A WIDER OBSERVATION COMMUNITY

From Tintoré's perspective their role is to support the best research and management decisions possible by delivering high-quality data. They reach out to stakeholders in a number of ways. A website has been developed which offers visitors access to a range of material as well as information on the latest news and communications from SOCIB contributors. Workshops are regularly organised to help share in new tools and processes being developed at SOCIB. One of the latest was held on marine data interoperability, sensor web enablement services and the implementation of Open Geospatial Consortium standards. Participants attended from a number of research institutions and marine observatories in Spain and the US. Seminars are also held to discuss some of the most current research and the latest developments in oceanography, as well as new technologies that are becoming available. The SOCIB consortium participates annually in several international meetings where the progress in expertise and tools are presented and shared with other researchers, scientists and stakeholders. Clearly, the range of work this group is undertaking places them in a very strong position to support the future of global oceanographic research.

1,000 M DEPTH PRESSURE CHAMBER TESTING

INTELLIGENCE

SOCIB

BALEARIC ISLANDS COASTAL OBSERVING AND FORECASTING SYSTEM

OBJECTIVES

A multiplatform distributed and integrated system that provides streams of oceanographic data and modelling services to support operational oceanography in a European and international framework, therefore also contributing to the needs of marine and coastal research in a global change context.

PARTNERS

MINECO • CSIC • IEO • Balearic Islands Government

FUNDING

Balearic Islands Government

Spanish Ministry of Economy and Competitiveness

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SOCIB Balearic Islands Coastal Observing and Forecasting System

GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

Govern de les Illes Balears

European Marine Board

The European Marine Board provides a pan-European platform for its member organisations to develop common priorities, advance marine research and bridge the gap between science and policy. **Kostas Nittis**, Marine Board Chair, outlines how their work aims to meet future challenges and opportunities for marine science and society

In what ways does the Marine Board engage with researchers and policy makers? How do you aim to bridge the gap between science and policy in doing so?

Bridging the gap between marine science and policy is central to the mission of the Marine Board. Over the years the Board and its Secretariat have developed a range of tools to realise this objective. Marine Board working groups are one of the core instruments we use to inform policy makers and advisors as well as science programme developers and managers about key research priorities and needs. Working Groups consist of about eight to 15 nominated experts who engage in an 18 month (on average) foresight exercise facilitated by the Marine Board Secretariat. Their conclusions and recommendations are published in position papers subject to external peer-review and approval by all of the Board's 34 Member Organisations from 20 European countries.

But working groups are not the only instruments at our disposal: for issues that are more pressing or which require a higher level perspective, we may set-up short term vision groups which produce brief, highly visual documents in a much shorter time frame (about six months). Our Vision Document on Marine Renewable Energy is a good example of such a publication (www.marineboard.eu/publications). We also release even shorter statements and science policy briefings which feed into key policy processes such as the current development of Horizon 2020 which allows us to react within days to weeks. The range of these tools offers the necessary flexibility to our operation at the science policy interface.

Publications are just one way of reaching our target audience; engaging directly with them is sometimes more useful and productive. Therefore we regularly organise science-policy meetings and conferences, alone or with other partners, including the European Commission. The Marine Board Open Fora and the EurOCEAN series of conferences, for example, provide a forum for scientists, policy makers and various other stakeholders to meet, discuss and seek solutions to some of the most burning issues related to marine science and the marine environment. The last EurOCEAN Conference was held in 2010 in Ostend, Belgium, under the Belgian EU presidency and attracted more than 400 participants. The conference highlighted some of the key societal challenges which must be addressed by marine research including climate change, sustainable supply of food from the seas and environmental and human health. The Ostend Declaration, agreed by the conference delegates, highlighted that the Oceans represent in fact one of the grand societal challenges of the 21st Century.

Finally, the Marine Board Secretariat, Executive Committee and the Delegates themselves participate in a wide range of externally organised or funded science policy events, advisory bodies and strategic coordination projects to promote marine research and improve its coordination in Europe. For example, the Marine Board Secretariat is responsible for strategic analysis activities of SEAS-ERA, a Seventh Framework Programme (FP7) marine science ERA-NET bringing together 20 major European Marine Research Funding Organisations from 20 countries in the basin regions of the Atlantic, the Mediterranean and the Black Sea. One of the main goals of SEAS-ERA is to contribute to the establishment of a European Marine and Maritime Research Agenda and to develop a stable European overarching operational structure for its implementation. (see also www.marineboard.eu/external-projects/seas-era).

What does the Marine Board regard as the key concerns and challenges that face the marine environment over the coming years?

The oceans and seas are of major strategic importance to Europe, both economically and socially. European marine and coastal waters provide an enormous range of services and goods for our society including transport routes for shipping, extractable sand and gravel, access to subsea oil and gas, food for human consumption and a backdrop for recreation and tourism.

Unfortunately, the increasing human activities and demands for marine space and resources place tremendous pressures on the marine environment. Hence there are many challenges and concerns including the impacts of climate change, invasive alien species, biodiversity and habitat loss, ocean acidification, depletion of fish stocks, to name just a few. These challenges cannot be addressed by one country alone, nor tackled from a sectoral perspective, but require an international collaborative and integrated approach. We are still struggling to address these issues in a holistic and integrated way, which is one of our biggest challenges as a scientific community.

We must also look at specific problems and research areas to tackle some of the key issues related to the marine environment. In our recent paper we focus on the problem of chemical pollutants and the appropriate means to adequately monitor them in European waters. According to a recent poll carried out as part of the EU Project CLAMER (www.clamer.eu), pollution of our seas and oceans is the main concern of the European public when considering negative impacts on the marine environment and this is not unjustified. From a scientific perspective, marine chemical pollution raises particular issues related to sampling and analytical techniques, risk assessment approaches and regulatory frameworks to better monitor the marine environment. The need to extend and better coordinate existing and new marine research infrastructures, that are key contributors to long-term environmental monitoring in Europe, is another key challenge that requires a lot of our attention.

How do offshore gas and oil activities affect marine ecosystems and the marine environment as a whole? Do you have recommendations for wider monitoring and regulation to limit the damage caused by such industries?

Due to various oil spills in recent years (such as the disasters with the Prestige in Spain and Deepwater Horizon in the Gulf of Mexico), most people are familiar with the risks of pollution resulting from the release of oil itself from oil extraction activities at sea, or from its oil transport over sea. There has been a lot of attention to this kind of pollution and while much can still be done to improve the situation, the problems and risks are relatively well understood. From a scientific viewpoint, much less is known about other impacts resulting from oil and gas extraction activities at sea, particularly during drilling and extraction.

Firstly, during the drilling phase, effects are mostly expected on the seabed or sub-seabed and monitoring has traditionally focused on this benthic compartment. Because of changes in drilling practices, however, the impacts on benthos during drilling have reduced considerably and there is now less need for benthic monitoring. Secondly, during the production phase, there is an impact from the wide range of chemicals that are released in the produced water. While the composition, the potential toxicity and effects of produced water is poorly understood, evidence suggests that the potential adverse effects from the resulting water-related compounds are a cause for concern. These compounds are neither well known, nor well monitored, and information is critically lacking, which prevents a science-based risk assessment of the current situation. Hence, there is a need for more extensive water monitoring and assessment, and guidelines on how this should be achieved. More research is needed to overcome a number of complicating factors such as high dilution of the produced water and the changes in plume direction.

Another complication is that efforts and applied practices to monitor the release and effects of chemicals from off-shore oil and gas industry in Europe vary from country to country as there is no uniform Pan-European legal framework or regulation which covers chemicals from oil and gas industry activities at sea. Some guidelines exist, but not all countries are following them rigorously. There is therefore a need to develop a consistent Pan-European or regional (legal) framework/regulation which covers the oil and gas industry activities at sea. At the same time, there is a need for more information and research on the release and the effects of chemicals arising from offshore oil and gas activities.

Can you highlight the latest outputs from the Marine Board?

We are pleased to announce the release of our most recent paper: 'Marine Board Position Paper 17 on Marine Microbial Diversity and its role in Ecosystem Functioning and Global Change'. This paper has been produced by a multidisciplinary working group which has been working since 2010 to assess the state of the art in marine microbial research and to identify research priorities and recommendations to advance this important area of research in the next decade. This paper was formally launched at the European Maritime Day in Gothenburg on 22 May 2012 with representatives of the European Commission and the Joint Programming Initiative on Healthy and Productive Seas and Oceans.

We are also publishing in the coming weeks a 'Future Science Brief on Marine Biodiversity'. This short paper will examine the major achievements and progress of the past 10 years in the field of marine biodiversity research. It will also emphasise the significant remaining gaps in our knowledge and the critical importance of addressing those gaps to meet both societal and policy goals. The paper will provide priority research recommendations and a roadmap of key enabling actions to guide the research agenda in Europe and beyond in the coming decade.

Finally, as an organisation, how do you intend to respond to future change?

Every three to four years, the Board engages in a very broad and intensive consultation with its members and external experts and stakeholders with the goal of producing an overview of the main challenges and opportunities for marine research in the coming decade. These challenges are to a large degree linked to the societal challenges and environmental concerns associated with the marine environment. The result is a series of comprehensive position papers called 'Navigating the Future'. The papers provide a very good overview of what is, and what will become even more important in the coming years and which European marine research priorities require urgent attention. The paper also looks at wider issues such as how marine science is structured in Europe and what marine research infrastructures are available or should be in place to address the key societal and scientific questions. While some elements remain of relevance over time, each paper addresses new aspects as we gather new knowledge and both the science, policy and societal landscape changes over time and new emerging issues surface. We have finalised the 'Navigating the Future IV' paper which was published in early 2012.

MARINE BOARD

www.marineboard.eu

Into the blue

Professor Michael St John discusses the EURO-BASIN project, which aims to bring North Atlantic environmental institutes together, elucidate the inner workings of the Ocean's ecosystems and reveal how these are affected by climate change and increased human intervention

To begin, could you explain the core objectives of the EURO-BASIN project?

The multidisciplinary EURO-BASIN team's core objectives are resolving the impacts of climate and fisheries on the structure of North Atlantic marine ecosystems. Changes in ecosystem structure can lead to important consequences for the sequestration of greenhouse gases in the deep ocean, the production of fish stocks and ultimately feedback to global climate. The North Atlantic is one of the key areas influencing global climate and our understanding of its importance for climate is still in its infancy. The project's activities will contribute to this understanding.

What are the key challenges faced in understanding the dynamics of North Atlantic ecosystems and how does the EURO-BASIN project aim to respond to such challenges?

There are many challenges facing us but probably the biggest is the vastness of the region, the complexity of the interactions and, with the spatial limitations of existing sampling techniques, our ability to examine only a small area at any one time. Think of it as the story of the blind men and the elephant. As they touch different parts of the elephant these men come to different conclusions about the animal. Similarly, we are looking at a vast area through a keyhole and trying to understand how the whole system is functioning. Add to that the fact that the whole system is in motion, while the biological and biogeochemical components in it are evolving in space and time.

How do you intend to use modelling techniques to further our understanding of climate variability on marine ecosystems and the feedbacks to the Earth system?

Coupled climate-physical oceanographic, single species and ecosystem models serve as the glue for developing our understanding of how these ecosystems will evolve as well as helping us overcome our problem of scale. For example, models use relationships derived from experiments and observations on the effects of temperature and food availability on an organism's feeding and growth. The models allow us to extrapolate process mechanisms so we can better understand how our key species control the flow of carbon through an ecosystem and ultimately influence the storage of carbon in the deep ocean. They also allow us to simulate how ecosystems and their key species will fare under different future scenarios. Models serve as the state of our predictive art; without them, our understanding of the evolution of the system and its feedbacks to climate would be little more than a guess.

Can you highlight how the project aims to develop understanding and strategies that will improve and advance ocean management?

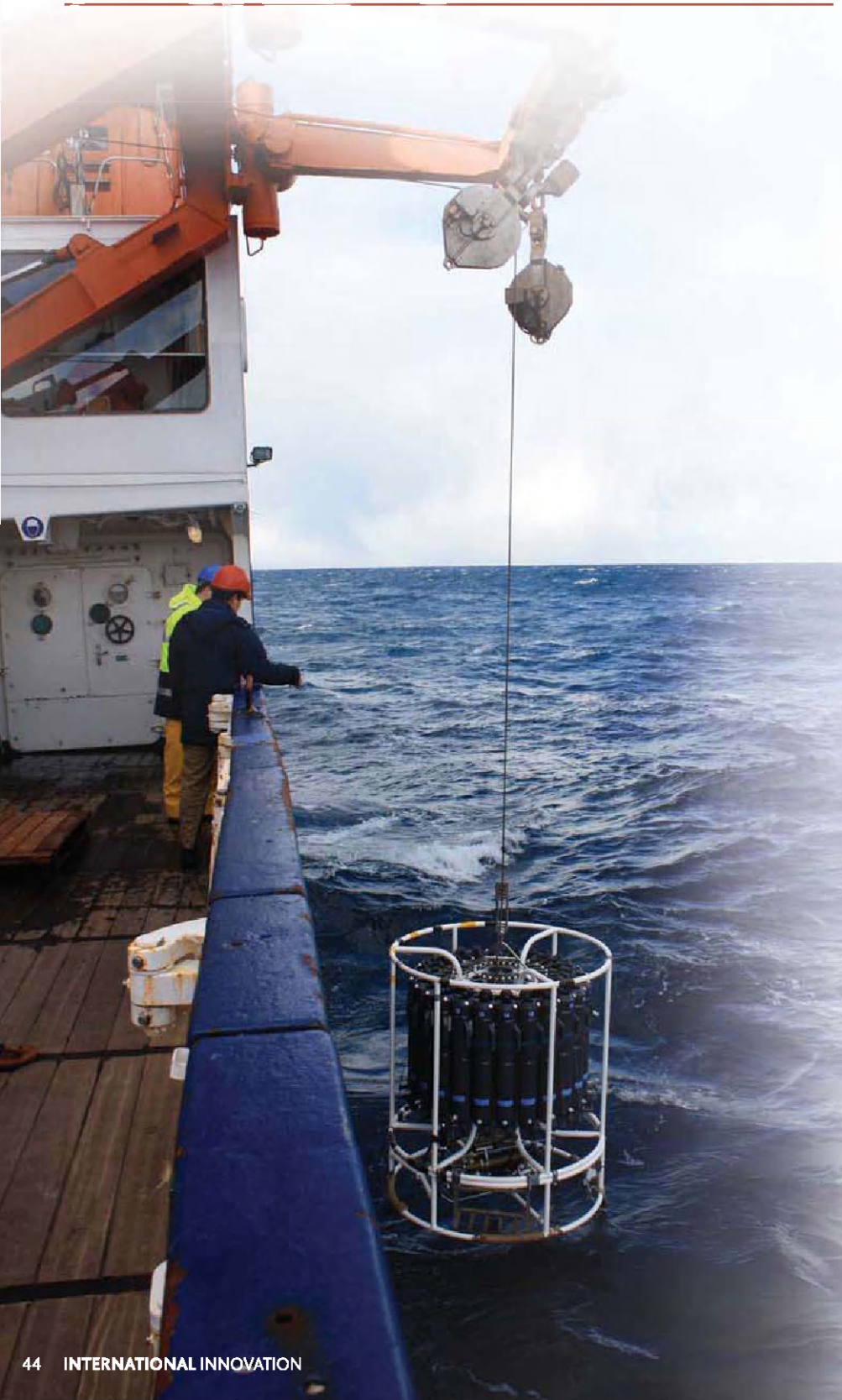
To manage our oceans we must understand how populations of key species, some of which we harvest, will change as their habitats evolve due to climate. Our laboratory and field activities define the habitats critical for their survival, while our coupled climate-physical oceanography-ecosystem models allow us to simulate the occurrence of these habitats and, as a result, the success of these species in the future. This information will empower managers to modify harvesting practices to preserve these key species and the services they provide. Furthermore, by identifying these key habitats, fish spawning grounds, for instance, we can provide environmentally-based advice for shipping and the placement of offshore energy facilities, as well as understanding the consequences of mineral extraction. Finally, our understanding of the effects of marine ecosystem structure on greenhouse gas storage is rather rudimentary. The project supplements and extends our knowledge in this area with the potential to better understand the role of marine ecosystems in climate regulation, thereby developing better management strategies to enhance the role of marine ecosystems in climate.

How is the EURO-BASIN project linked with other similar projects internationally?

EURO-BASIN was originally planned to form part of a transatlantic collaboration with the US and Canada. In fact, scientists from both sides of the Atlantic collaborated to develop an international science plan to help focus a joint programme. Unfortunately, funds were not forthcoming for the North Americans to link with the European initiative. At the moment, EURO-BASIN is the only major funded ecosystem-based project in the North Atlantic but this does not stop international collaboration. The research activities performed by EURO-BASIN allow North American scientists to link their activities to research cruises and project meetings, providing a skeleton upon which other smaller projects developed by North American scientists can fill research gaps in the EURO-BASIN programme.

A new approach to North Atlantic research

The North Atlantic Ocean holds key information on the effects of global climate change and human impacts on marine ecosystems, yet much is still to be learnt about its underlying mechanisms. **EURO-BASIN** is developing novel tools for unifying ecosystem research activities



ONCE CENTRAL TO the migration of Western settlers moving to the Americas, the North Atlantic Ocean continues to provide a home for a wealth of fish species and complex marine ecosystems. Integral to the societal and economic survival of its many surrounding nations in Europe and North America, a vast proportion of the Ocean's deep and shelf sea regions helps to support fisheries and sequester our planet's greenhouse gas emissions.

The North Atlantic ecosystems are a major player in the global carbon cycle, responsible for 5-18 per cent of the annual atmospheric carbon sequestered by the oceans. These ecosystems, the key species responsible for carbon flow, and their habitats, are constantly changing, under the influence of both large-scale fishing and climate change. Their evolving capacity to sequester carbon and provide services to society, should current climate and fishing trends continue, still warrants further investigation. However, the current gaps in knowledge have left environmental institutes unable to arrive at an agreed technique for marine system management.

Actively researching the connections between ecosystem dynamics and oceanographic processes, Professor Michael St John coordinated the launch of the project 'European Union Basin-scale Analysis, Synthesis and Integration' (EURO-BASIN). Initially set up to assess the potential impact of climate change and fisheries on the North Atlantic, EURO-BASIN aims to: uncover the major processes that influence the North Atlantic basin's various ecosystems; achieve better methods for forecasting changes in species distribution due to climate change; and successfully integrate positive strategies that will improve and advance management of the basin's ever-evolving ecosystems.

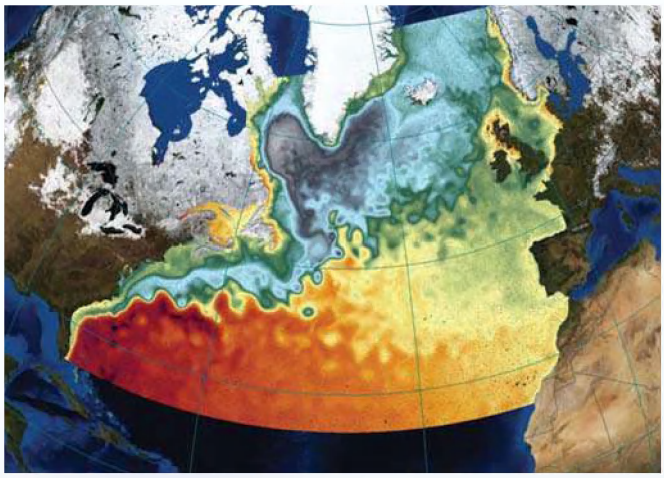
PAST AND PRESENT METHODS

Split across eight work packages of various disciplines, the project utilises existing data and current best practices while conducting its own laboratory investigations, field research and applying shared modelling techniques. These range from simple ecosystem models to fully coupled end-to-end (lower and higher trophic level) models.

EURO-BASIN is conducting several mesocosm experiments, which give researchers the advantage of being able to study minor sects of the natural environment under controlled conditions. Between mid-July and late August 2012, an experiment will be conducted at the Sletvik Field Station, Bay of Hopavågen. Run by the Norwegian University of Science and Technology (NTNU) and associated with the HYDRALAB IV network of European institutes for hydrological research, the station will host the investigation of 18 'core' mesocosms with different food webs to establish the variances in biomass production and flow of materials due to bacteria, phytoplankton and organisms involved in the basin's food structure.

In addition, major cruise campaigns are planned for 2012 and 2013. A series of localised cruises in 2012 is being conducted in parallel with the mesocosm experiments. A joint venture for 2013

between research vessels from Germany, Norway, Canada and the UK will survey the seasonal change in key species in the ecosystem and their natural habitats. Set to begin in March and end in August, the study will perform three sequential return transects of the North Atlantic, making it the first coordinated seasonal survey of its kind.



RESOLVING MORE AT A BASIN-SCALE. A HIGH-RESOLUTION MODEL OF OCEAN PHYSICS IN WHICH BETTER ECOSYSTEM KNOWLEDGE WILL BE EMBEDDED
© J HARLE, NOC

A COMMON GOAL

The researchers believe that a common approach to ocean management is long overdue, especially for the North Atlantic basin, which represents a key element to global climate change. St John enlisted the assistance of experts from institutes around the North Atlantic with the hope of bringing together a wide range of knowledge and resources. The participation of these countries holds particular significance as they are all historically responsible for the anthropogenic pressures exerted on the region.

EURO-BASIN is in its early stages, but has already made considerable leaps in progress. The 'Deep Convection' ocean expedition onboard the research vessel FS METEOR between the Faroe Islands, Iceland and Norway for instance, has discovered several key aspects regarding the processes involved in the local ecosystem during winter and early spring. The project is also engaging researchers from Canada and the US at a joint strategy meeting (6-8 November 2013 in Lisbon), which intends to develop a long-term regional research programme focused on the North Atlantic.

LEADING THE FIELD

Funded by the EC's DG Research under the Seventh Framework Programme (FP7), the project receives further support from its partner institutes, who offer contributions of equipment, vessel time and manpower. The institutes themselves also receive funding from their respective national governments, nearly tripling support for the research area as a whole.

Despite its success, the project has met numerous challenges, ranging from logistical issues linked to the North Atlantic basin's extent, to formulating the best approach to integrative knowledge management. With so many contributors scattered across Europe working toward the same goal, research data needs to be accessible and available. To ensure this, the project will archive all newly generated datasets at the World Data Centre for Marine Environmental Sciences (WDC-MARE) and later disseminate as peer-reviewed data publications in the open access journal *Earth System Science Data* (www.earth-system-science-data.net).

St John feels that the sharing of research data is essential if we ever wish to manage our environment effectively: "Research data is the currency of knowledge and our understanding of the environment". The project plans also include publication of recommendations for ocean management and the potential outcomes from continuing certain practices on North Atlantic ecosystems. In addition, EURO-BASIN will make all its research results and publications freely available to developing countries and the public at large via the OpenAIRE open access repository for research publications (www.openaire.eu).

SHARED ASPIRATIONS

The tools and connections established by EURO-BASIN will allow for more accurate means of surveying species and help to address major political objectives, including the European Common Fisheries Policy, part of which aims to achieve an ecosystem-based approach to the management of the North Atlantic basin, the Marine Strategy Framework Directive and the Maximum Sustainable Yield concept first agreed on by the World Summit on Sustainable Development.

Ecosystem interactions account for everything from fish production to carbon storage and cannot be predicted solely through classic reductionist scientific means. Following this, the EURO-BASIN team is now working on a hybrid modelling tool, which has the potential to alleviate any previous constraints and allow scientists to better predict how ecosystems and their species and processes might be changing, giving a clearer picture and stronger knowledge base. Besides providing the information necessary for current and future institutes to draw up strategies that will advance ocean management, predict the environmental effects of mineral extraction and offshore energy facilities, St John highlights that the tool could also be utilised in other, more diverse areas: "If the tool is successful in marine ecosystems, the most complex of these adaptive systems, it will prove useful for prediction in other systems such as economics and earthquake prediction, to name but a few".

EURO-BASIN

EUROPEAN BASIN-SCALE ANALYSIS, SYNTHESIS & INTEGRATION

OBJECTIVES

To advance understanding on the variability, potential impacts, and feedbacks of global change and anthropogenic forcing on the structure, function and dynamics of the North Atlantic and associated shelf sea ecosystems as well as the key species influencing carbon sequestering and ecosystem functioning.

PARTNERS

DTU-Aqua, Technical University of Denmark, Denmark • **Aarhus University**, Denmark • **Collecte Localisation Satellites**, France • **Centre National de la Recherche Scientifique**, France • **Institut français de recherche pour l'exploitation de la mer**, France • **Institut de Recherche pour le Développement**, France • **Université Pierre et Marie Curie**, France • **MARUM**, Germany • **University of Bremen**, Germany • **IHF, University of Hamburg**, Germany • **HAFRO**, Iceland • **Marine Research Institute**, Iceland • **University of Nordland**, Norway • **Institute of Marine Research**, Norway • **Uni Research**, Norway • **National Marine Fisheries Research Institute**, Poland • **Fundación AZTI**, Spain • **Instituto Español de Oceanografía**, Spain • **Institute of Marine Sciences**, Turkey • **Middle East Technical University**, Turkey • **CEFAS**, UK • **NERC National Oceanography Center**, UK • **Plymouth Marine Laboratory**, UK • **SAHFOS**, UK • **University of Swansea**, UK • **University of East Anglia**, UK • **University of Strathclyde**, UK

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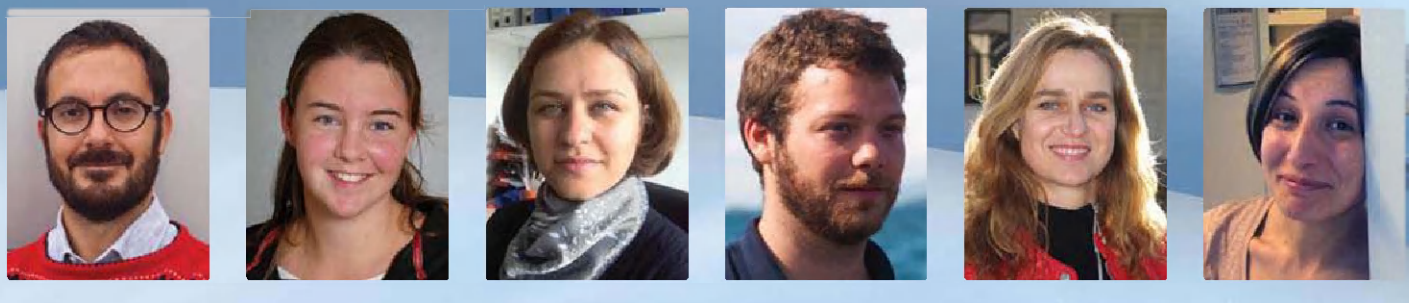
PROFESSOR MICHAEL ST JOHN has served on the German Science Foundation's (DFG) Oceanography commission. He has been active in both the IGBP programmes IMBER and GLOBEC as the co-chair of the Ecosystems End-to-End group. His primary research focus has been that of coupling variations in species dynamics to physical oceanographic phenomena.



From left to right: Dr Paolo Simonelli, Dr Elin Lindehoff, Dr Jamileh Javidpour, Dr Romain Pete, Dr Stella Berger and Dr Tatiana Tsagaraki.

Expert web

By placing a component of the marine environment under controlled conditions, mesocosms provide important links between field studies and laboratory experiments. Project Leader **Dr Paolo Simonelli** and scientific site coordinators **Drs Elin Lindehoff, Jamileh Javidpour, Romain Pete, Stella Berger** and **Tatiana Tsagaraki** explain how they are opening up access to these unique resources for European scientists

To begin, could you briefly outline the present state of research into aquatic ecosystems?

RP: Aquatic ecosystems are vast and understanding them is a slow process. We now face challenges in many fields. One is regarding the use of aquatic resources, such as fishing, aquaculture and the shellfish industry, as well as recreational use. Prioritising research in the field of aquatic ecosystems would address these concerns. Mesocosms are the tool of choice, as manipulation of large volumes allows significant representation of the ecosystem under study.

EL: Our mesocosm facility aids ongoing investigation of human impacts on the Baltic Sea – an ecosystem already heavily strained by eutrophication, intensive fishing and pollution. New challenges are arising from increased temperatures due to climate change. Increased river inputs are expected, and thus increased dissolved organic matter, nutrients and pollutants. These factors could change the base of the Baltic food web with repercussions up the web chains, thus affecting fish populations. Understanding these processes has great ecological and socioeconomic value.

SB: Interactions of organisms within pelagic food webs and/or coupling to benthic food webs and transfer to higher tropic levels are important ecosystem functions that need to be studied outside lab monocultures. With the support of MESOAQUA, several mesocosm experiments manipulated factors such as CO_2, eutrophication, temperature and changes in light availability or food web compositions to assess the impact on planktonic food webs in different oceanic environments.

TT: We were able to answer lots of questions which – as is often the case in science – raised new ones. We aim to study the effects of acidification and temperature change in our marine community though an experiment planned for 2013. We also plan to work on the interactions induced by Saharan Dust on ecosystems and improve and expand our modelling tools.

How has MESOAQUA progressed since we last featured the project?

RP: The MESOAQUA project has two main objectives. The first is to give transnational access (TA) to mesocosm facilities to aquatic researchers addressing original scientific questions. The MESOAQUA consortium has met the planned access target, offering over 4,000 days of access to around 20 projects and 150 scientists spread over the seven facilities in the project. This clearly demonstrates the need and interest of the scientific community in such an aquatic research tool.

The second objective of MESOAQUA is to develop mesocosms as a way of investigating different ecosystems in contrasting regions of the world. The Kiel Off-Shore Mesocosms for future Ocean Simulations (KOSMOS) and the new Lagrangian Mesocosms Platform (LAMP) were implemented and tested during the course of the project. They are now both operational and will surely be the next generation of mesocosm facilities for aquatic research.

PS: This final test of LAMP, constructed at CNRS – Ecosym Montpellier/Medimeer Sète, was performed in September 2011 in Crete and consisted of a joint experiment which involved all MESOAQUA partners.

Further to this, at the beginning of September 2011, MESOAQUA organised a workshop in Kiel, attracting graduate and postgraduate students from 17 countries, on the challenges and potential of using mesocosms in aquatic ecology.

Through TA, MESOAQUA has supported a number of experiments ranging from the effects of CO_2-induced seawater acidification on plankton communities to the impact that Saharan dust deposition has on the biogeochemistry of the Eastern Mediterranean Sea.

EL: One of the greatest achievements of MESOAQUA is a significant growing network through TA activities and joint projects. Introducing and making mesocosm facilities available to international researches and graduate students is a top priority.

SB: This year, two mesocosm experiments were performed in Bergen and one in each of

PHYTOSTRESS EXPERIMENT AT THE NORWEGIAN NATIONAL MESOCOSM CENTRE, UNIVERSITY OF BERGEN, NORWAY © STELLA BERGER

the other facilities, in Crete, Montpellier, Umeå and Kiel. Another important goal met is the Virtual Transnational Pelagic Mesocosm Centre (VTPMC), our information hub providing TA information and web-based TA applications. The VTPMC (www.mesoaqua.eu) provides information about and contacts for mesocosm facilities, a bibliography of mesocosm publications, a picture gallery of people working at the different mesocosm structures and locations and news about all other activities such as workshops, meetings and symposia within and outside the MESOAQUA network.

How has the MESOAQUA network grown since its inception?

SB: The MESOAQUA mailing list contains about 800 members and is still increasing. Presentations of mesocosm experiments supported by MESOAQUA at international conferences contribute to increase the network. Through blogs during experiments we also get more people wanting to join the MESOAQUA network. Our personal contacts with scientists all over the world make the network a fruitful tool for future mesocosmic science.

Have you set any new priorities for the network as a whole?

PS: The impact that human activities and climate change have on aquatic food webs and the role that oceans play in the functioning of our planet are most urgent issues if we want to ensure the future of our species. Unfortunately, this is the last year of MESOAQUA, but the consortium of facilities and scientists will continue to exist and run new experiments to answer these questions.

Our next priority is to organise and publish the knowledge of mesocosm-based science acquired during these last four years in scientific journals and through other fora such as open workshops.

RP: The MESOAQUA steering body will seek to perpetuate the consortium and enlarge the network. The web portals (http://mesoaqua.eu and http://mesocosm.eu) will continue to be run and updated with information and literature on research and news, projects and calls in this area.

The network covers research into aquatic ecosystems from the Arctic to the Mediterranean. What are the challenges in studying and communicating research findings across such a wide geographical area?

PS: The wide geographical area covered by our consortium is rather an advantage. Thus it provides a unique opportunity for scientists to test their hypothesis under completely different ecosystems and compare them. Moreover, the need to collectively plan a mesocosm experiment, provide high-quality data within given deadlines, collectively publish the result, and not least the social pleasure of doing this as a member of a multidisciplinary team, tends to smooth any kind of cultural differences creating networks and working relationships that last far beyond the period of any single project.

RP: Often, these regions are considered delimited, one being warm, dry and sunny, the other very cold, icy, and receiving light half of the year. Indeed, the regions represent a continuum of ecosystems throughout the latitudinal gradient. Since the tools used in experiments are similar, the main challenge is the way relationships and comparisons can be set between contrasting ecosystems.

SB: Although climate change and eutrophication occurs worldwide the oceanic environment is very different at distinct geographical locations and so is the composition of the plankton organisms. This can lead to completely different responses and that is what makes our work so interesting. For example, an increase in temperature might have a more pronounced or a completely different effect on cold-adapted Arctic plankton organisms than on temperate or warm adapted Mediterranean species.

Finally, can you highlight some of the ways in which you plan to continue the work of this exemplary network in the future?

TT: This coming October, the Hellenic Centre for Marine Research will be hosting an international symposium in Crete. It will be the first symposium dedicated to mesocosm research, drawing together scientists funded by MESOAQUA and others working in the field from all backgrounds. It will be an excellent opportunity to share knowledge with other experts in the field and start future collaborations.

PS: Although the project will conclude by the end of 2012, the consortium of scientists and infrastructures will continue to exist. Mesocosms are precious tools which can uniquely answer important scientific questions. The success of MESOAQUA demonstrates that there is a real need for access to mesocosm facilities within the European aquatic ecologist community.

Sustainable mesocosmic cooperation

MESOAQUA has united more than the European marine mesocosm facilities; scientists from across Europe now work collaboratively to evaluate and compare the effects of climate change and ecological challenges on aquatic environments using mesocosms as central research tools

INCREASING ACIDIFICATION AND temperature rises in the oceans are a concern not only for the viability of coral reefs and other marine ecosystems, but also for the food security of many millions of people. Thus, these changes may negatively affect the microbial food web upon which all the other higher trophic compartments up to commercial importance depend. Understanding the functioning of the microbial food web and its response to pollution and climate change effects is therefore vital.

This cannot be achieved only inside the laboratory but scientists need tools allowing experimental approach to near-natural pelagic systems. This is the premise of a coordination effort in MESOAQUA, a European Union Seventh Framework (FP7) project that started in 2009 and is due to conclude later in 2012.

MESOAQUA has established a network of mesocosms facilities to provide European and non-European scientists with experimentation access for the study of future aquatic ecosystems from the Arctic to the Mediterranean. Moreover, MESOAQUA facilitates the exchange of mesocosms technical innovations and promotes interdisciplinary collaboration and training for young scientists.

Mesocosms are reservoirs that enclose a volume of water which can be manipulated to modify its biological physical and chemical characteristics. They therefore allow study of the effects that increased temperature, increased acidity, pollutants and invasive species, exerts on the aquatic microorganisms. Some are designed to be portable and deployable in different waters. "The mesocosm-based research field is relatively young and unknown. The usefulness of this experimental approach and the possibilities the network offers in terms of access to facilities and training for young scientists deserve wide attention," asserts Dr Paolo Simonelli from the Department of Biology of the University of Bergen, the present coordinator of MESOAQUA.

THE EUROPEAN MESOCOSMS

There are seven mesocosms facilities throughout Europe that represent very different marine environments: the CRETACOSMOS mesocosms at the Hellenic Centre for Marine Research near Heraklion, Greece; the MEDIMEER mesocosms platforms of the University of Montpellier sited on the Mediterranean coast on the Thau lagoon near Sète, France; an indoor facility at the Helmholtz Centre for Ocean Research at Kiel (GEOMAR) in Germany from which depends also the mobile mesocosm called Kiel Off-Shore Mesocosms for future Ocean Simulation (KOSMOS) that have been deployed in the Arctic in a Norwegian fjord and recently in the Baltic Sea; the Norwegian National Mesocosm Centre mesocosm of the University of Bergen (UiB), near Bergen, Norway; the Umeå Marine Sciences Centre mesocosm of Umeå University, Sweden; and the mesocosms at the Kings Bay Marine Laboratory, the northernmost marine laboratory in the world, at Ny-Ålesund in Norway.

Each mesocosm supports whole ecosystem studies to provide further insights into the complexity of aquatic ecosystems. All the European mesocosms are augmented with sophisticated environment monitoring, water sampling and analysis technologies, and during MESOAQUA, a number of technological improvements and upgrades to components and systems have been conducted: "Mesocosms are research tools under continuous development. All the partners are continually testing and developing increasingly optimal, state-of-the-art solutions. This allows exchange of good practice and technologies for the benefit of both local users and visiting scientists," states Simonelli.

STRENGTH IN BREADTH

MESOAQUA has provided 4,200 days of access to the European mesocosms facilities. These were taken up by a many European and non-European scientists who staged or participated in experiments and Joint Research Activities, some while completing doctorate degrees, obtaining samples and data for a variety of studies, as Dr Stella Berger, the Scientific Coordinator for the Norwegian National Mesocosm Centre at Espegrend, highlights: "MESOAQUA has supported cooperation between many scientists from research institutes all over the world from various fields of expertise, enabling them to gather information on several levels in large-scale experiments and very effectively expand their scienctific network strongly benefiting the development of global future marine science".

A good example of the novel work the network supports is that of the Montpellier University/ Sète team, who developed the Lagrangian Aquatic Mesocosm Platform (LAMP). LAMP is equipped with several sensors monitoring automatically physiochemical and biological parameters of the experimented natural water masses in the mesocosms, and transmits the data in real-time.

SCUBA DIVER DEPLOYING LAMP MESOCOSMS ©PIERRE HENNEQUIN-UNIVERSITY OF MONT-PELLIER 2-FRANCE

LAMP has been transported to Crete for a study of the effects of the limitation of phosphorus on the food chain in the Cretan Sea: "It was exciting to build an off-shore mesocosm platform from scratch, deploy it for a 10 day experiment and then repack it. Every day there was a new problem to solve, a new challenge," reflects Dr Romain Pete, the Scientific Coordinator for MEDIMEER. KOSMOS is another next-generation large scale free floating mesocosm that was deployed after transportation to the Baltic Sea.

Four research projects this year alone addressed the effects of seawater acidification on plankton in different ecosystems. Other projects have used mesocosms to investigate such subjects as the effects of eutrophication, trace metal depletion on microalgae composition and the effects of increasing UV light, due to climate change on aquatic species, food chain and ecosystems dynamic. "Mesocosm studies are important for understanding how processes such as climate change and eutrophication affect different marine environments and the effects of any countermeasures, which is key to restoration of marine habitats and protecting the production of marine resources, from fisheries to aquaculture," explains Dr Elin Lindehoff, the scientific site coordinator for the Umeå Marine Sciences Centre mesocosm.

In addition, the importance of sharing knowledge and educating early stage researchers has been reflected in the coordination of a number of workshops and symposia. This year, Dr Jamileh Javid staged a workshop at the Helmholtz Centre for Ocean Research at Kiel (GEOMAR) that focused on jellyfish as the model organism and attracted 26 students from 24 universities in 15 countries and 13 guest speakers. She is keen to empahsise how successful the workshop proved: "We provided a series of lectures given by experienced scientists like Jennifer Purcell, Mark Martindale and Kylie Pitt from different fields of jellyfish-related aquatic science to discuss the advantages and limitations of mesocosms in current research on gelatinous zooplankton. We also presented current ocean acidification, stress ecology and trophic ecology mesocosm studies".

AN EVOLVING LEGACY

The funding for MESOAQUA ends this year, but the scientists involved already envision future collaborative studies: "The final symposium will be in October: it will summarise the project and also trigger the next steps for mesocosm research in aquatic science," declares Simonelli.

The consortium plan to release sets of guidelines for mesocosm-based research which will include the many lessons learned in mescocosm design, setup and deployment during MESOAQUA. The team are delighted that the MESOAQUA web portals will be maintained, providing updated links and information on new literature, meetings, funding opportunities and press releases related to mesocosm-based aquatic ecosystem science in Europe and worldwide. They also anticipate extending to freshwater mesocosms in future.

To Simonelli, the greatest legacy of the project is the rapid exchange of knowledge and nurturing of a network of young scientists that it has fostered and enabled: "The MESOAQUA young scientists form a natural cooperative group, building transnational scientific cooperation that will persist, expand and spark new projects long after the termination of MESOAQUA".

The group will continue to collaborate to build a future project to include more mesocosm facilities in marine and freshwater ecosystems. The perpetuation of the VTPMC (www.mesoaqua.eu and www.mesocosm.eu) after the completion of the project reflects this vision.

INTELLIGENCE

MESOAQUA

OBJECTIVES

To offer European researchers access to a range of mesocosm facilities; develop and test new technologies; improve the services of the facilities by exchange of technology and experience; facilitate cross-disciplinary fertilisation and better coordination; and promote the training of young scientists in the use of experimental ecosystem research.

FUNDING

EU Seventh Framework Programme (FP7) – contract no. 228224

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PAOLO SIMONELLI is a researcher at the University of Bergen, Norway, and Project Coordinator of MESOAQUA. His research focuses on the role of mesozooplankton in the marine trophic webs.

ELIN LINDEHOFF is the scientific site coordinator for the Umeå facility. Her research is aimed at metabolic strategies of phytoplankton and interactions within the microbial community.

JAMILEH JAVIDPOUR is a researcher at the Helmholtz Centre for Ocean Research (GEOMAR), Kiel. Her focus lies in trophic ecology and invasion ecology of jellyfish.

ROMAIN PETE is a postdoctoral researcher and scientific site coordinator of Medimeer at the University of Montpellier 2. His research is focused on marine trophic food web dynamics and composition under climate changes.

STELLA BERGER is a researcher and scientific site coordinator of the Bergen facility. She uses mesocosms to study environmental effects on planktonic food webs in freshwater and marine ecosystems.

TANYA TSAGARAKI is the scientific site coordinator at the Cretacosmos facility in Crete, Greece. She is interested in microzooplankton trophic interactions and water column stoichimetry.

the Insider

In the first of a new series, one of our featured contributors highlights the burning issues in their field. **Helen Glaves** from the EU-funded Geo-Seas project expands on some of the major structural challenges facing the marine sciences

What do you see as the key challenges facing the drive to develop a coordinated approach to marine and ocean monitoring and research infrastructure?

A number of well-established regional infrastructures for the management of marine data already exist and developing a more coordinated approach to marine data management will require some level of harmonisation and integration of these systems. To some extent, this integration can be achieved by the creation of interoperability solutions. However, achieving a fully integrated approach will require changes being made to some if not all of these infrastructures.

Currently, there is a range of different technologies, standards, vocabularies, coordinate systems and best practice in use throughout the marine and ocean data management domain. The use of these various systems presents a significant barrier to the harmonisation of the various infrastructures. In order to remove these barriers there is a need to develop a common approach to marine data management which is adopted by the entire marine monitoring and research community.

A lack of resources to implement the necessary changes as well as organisational, national and regional level policies may also represent significant challenges to the development of a coordinated approach to marine research infrastructures.

In what ways are you working within your project to create relationships and partnerships with other networks?

Geo-Seas (see p30) already has close collaborative relationships with a number of other European projects and initiatives including SeaDataNet (see p27). The two programmes share a common architecture for the discovery and access of marine data which has led to the development of a joint e-Infrastructure for the management of marine geoscience and oceanographic data.

Geo-Seas is also underpinning the activities of the geology component of the European Commission's European Marine Observation and Data Network (EMODNET). The EMODNET-Geology project is one of six preparatory action projects that, in addition to marine geology, have brought together information on marine chemistry, marine biology, hydrography, seabed habitats and physical properties of the marine environment.

Furthermore, Geo-Seas is seeking to develop collaborative relationships with other communities within Europe, for example, we are currently exploring the possibility of including archaeological data in the Geo-Seas data discovery and access service. This is being achieved through the development of a collaborative relationship with the Submerged Prehistoric Landscapes and Archaeology of the Continental Shelf (SPLASHCOS) initiative (an EU-funded COST action).

What lessons can Europe learn from cooperation taking place in other regions? How are links being forged with these regions to ensure best practice is shared?

Within the marine domain there is a recognition that in Europe as well as other regions there is a need for the development of a common approach to marine data management. This common approach is needed because the use of different standards, formats, coordinate systems, etc. not only inhibits the sharing of data but, also the development of products which make use of data from multiple sources. This is becoming increasingly important since the need to take a more ecosystem-based approach to marine research – which relies on large amounts of good quality marine data being available – has become a priority in recent years.

To further this development of a common approach to marine data management, Geo-Seas has been seeking to develop collaborative relationships with similar initiatives outside Europe. This has included projects such as the Rolling Deck to Repository (R2R) project in the US which is developing an infrastructure for the management of marine underway data, as well as other data management infrastructures elsewhere in the world with the objective of developing interoperability between these various marine data management infrastructures.

The need for the development of this interoperability has also been recognised by the funding agencies in Europe, the US and Australia. As a result, a new initiative, the Ocean Data Interoperability Platform (ODIP) has recently been funded. The prime objective of this platform is the development of a common approach to marine data management including the development of a number of interoperability prototypes to demonstrate how this common approach can be implemented within real systems. ODIP will also seek to disseminate these common approaches to the wider user community with the aim of encouraging other regions to also adopt these developments.

The huge volumes of data created by monitoring platforms create enormous challenges in terms of how data is shared, analysed and stored. Can you highlight the fundamental issues that must be addressed to ensure Europe is deriving maximum value from this data and delivering this value to stakeholders?

The key to ensuring that Europe is deriving maximum benefit from marine data by improving the user's ability to discover and access this data and also by removing the barriers to its re-use. The main challenge to this re-use is the use of different formats, standards, and coordinate systems, not only between countries or regions but also between different organisations in the same country!

By removing these barriers, users are able to locate, assess and access data which is fit for a wide range of applications.

In addition, there are the issues of data access policies and licensing which also inhibit the reuse of marine data by stakeholders. Currently, data varies from being freely available to having a significant cost attached to it according to who is responsible for its acquisition, management and archiving. There is now a move towards data that is collected and held by public organisations becoming freely available to the end-user. However, other companies still seek to restrict access to their data and often imposing terms and conditions and a significant cost for its use.

The fact that the size of datasets are also increasing exponentially with the development of new sensors, etc. also presents another significant challenge to the re-use of some datasets and this requires a different approach to how they are made available to the end-user. The key issue should be to ensure that the existence of available data is made known to potential users. This can be achieved through the use of discovery services such as those made available by the Geo-Seas and SeaDatNet portals, which give open access to discovery level metadata as well as providing a suite of visualisation tools that allow the user to view large datasets without having to download them. These tools and services therefore allow the user to assess whether a dataset is fit for their purpose before they request what may be a large and costly investment.

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CALENDAR

8-12 October **Brest, France**
International Marine Science and Technology Week

8-10 October **Bled, Slovenia**
5th International Symposium on Transboundary Waters Management

12 October **Geneva, Switzerland**
9th Meeting of the Bureau of the Protocol on Water and Health of the UNECE Watercourses Convention

17-19 October **Dublin, Ireland**
4th International Conference on Ocean Energy 2012

31 October **London, UK**
2nd Annual Shipping and Offshore CSR (Corporate Social Responsibility) Forum

6-14, November **Geneva, Switzerland**
14th Session of the WMO Commission for Hydrology (CHy-14)

21 November **Worldwide**
World Fisheries Day

27-29 November **Limassol, Cyprus**
8th Meeting of the Water and Marine Directors

28-30 November **Rome, Italy**
6th Session of the Meeting of the Parties to the Water Convention

FUNDING CALLS

Long Endurance Marine Unmanned Surface Vehicles Proposals

The Natural Environment Research Council (NERC) and the Defence Science and Technology Laboratory (Dstl), with the Technology Strategy Board are currently hosting an initiative to develop novel marine strategies to develop sustainable marine robotics.

Themes: Technology, Environment, Energy Efficiency

Deadline: 5 November 2012

www.innovateuk.org

'The Ocean of Tomorrow 2013' Call

Applicants should focus on the development of competitive and innovative marine technologies, in cooperation with technology providers for a variety of applications. Proposals should consider a broad range of scientific and economical sectors.

Themes: Food, Agriculture and Fisheries, Biotechnology; Nanosciences, Nanotechnologies, Materials and new Production Technologies - NMP; Energy; Environment; Transport

Deadline: 7 February 2013

http://ec.europa.eu

Offshore Wind Manufacturing

Off shore wind manufacturers will be able to submit an application for support for major investments, from around the UK. Those interested will be able to produce a single project or through joint application with other manufacturers.

Themes: Renewable Energy, Environment

Deadline: March 2015

www.decc.gov.uk

Water-Inno-Demo Call

The EU's Seventh Framework Programme encourages researchers and scientists to produce innovative demonstration projects towards the improvement of current water resource efficiency.

Themes: Environment, Climate Change

Deadline: 4 April 2013

http://ec.europa.eu

As climate change and manmade drivers continue to place stress on marine ecosystem dynamics, understanding the complexity of responses will help manage future change. **Professor Icarus Allen** and **Jessica Heard** describe efforts to provide knowledge and tools to support the implementation of effective strategies to ensure the sustainability of the European seas

Future-proofing marine ecosystems

Firstly, can you offer a brief outline of the main aims of the MEECE project?

The implementation of the Marine Strategy Framework Directive (MSFD) requires Member States to develop strategies to achieve a healthy marine environment and make ecosystems more resilient to climate change in all European marine waters by 2020 at the latest.

The specific goals of MEECE are to improve the knowledge base of marine ecosystems and their response to climate and anthropogenic driving forces, and develop innovative predictive tools and strategies to resolve their dynamic interactions.

What key drivers of change are you taking into account when analysing marine ecosystem evolution?

MEECE addresses both climatic drivers of change (such as temperature, circulation, stratification and acidification) and direct anthropogenic drivers (such as eutrophication, pollution and fishing).

MEECE has adopted a regional approach to eight European regional seas (North West Shelf, Barents, North, Baltic, Biscay, Adriatic, Aegean and Black) along with the Benguela Upwelling, from a global perspective. Scenario definition and validation are crucial to model design in MEECE – we have defined a common suite of climate-forced and anthropogenic driver scenarios. In addition, we evaluated the performance of global climate models for each region and as a consequence defined a range of methodologies for downscaling climate model outputs regionally. We have also defined core model metrics (outputs and validation methods) for the MEECE scenarios; the choice of core outputs being informed by mapping model outputs onto MSFD key descriptors.

How do you assess model accuracy to enable confident application of your simulations to science and policy?

As a matter of policy, MEECE rigorously evaluates core model outputs to test that they are fit for purpose. We also need to understand model uncertainty, which is a combination of the uncertainty in our understanding of natural variability, and model structural and forcing uncertainty. Ideally, we would run an ensemble of simulations to explore uncertainty, but the computing resources do not exist for this. Therefore we run targeted scenarios which bound the ranges of likely forcing and perturbations.

What decision-making tools are you developing to support the EC Marine Strategy and the Maritime and Common Fisheries Policies?

Some of the modelling tools can be applied to management strategy evaluation by running targeted scenarios that explore management options. At this stage, the models are in research mode and require experts to run them. Further refinement in close collaboration with users is required to convert candidate models to operational tools. In addition, we have developed expert systems for invasive species and pollution which synthesise environmental and biological data into indicators of environmental status.

How do you translate your findings from specific regions into a more universal outlook for marine management?

While all regions are in practice subjected to all drivers, in reality some are more sensitive to certain drivers than others. For example, enclosed basins like the Baltic or Black Seas are more sensitive to eutrophication impacts than climate, unlike seas with a direct ocean connection.

We have to take a comparative approach – comparing the same outputs between regions to understand the differences. We must also investigate the issues specific to each region. A report summarising our findings is in preparation. The MEECE Model Atlas will allow visualisation of the results.

How does knowledge transfer form a key part of MEECE?

The MEECE knowledge transfer team intend to facilitate the dissemination of research-based knowledge, expertise and skills between the project partners and wider users. Effective knowledge transfer requires communication between MEECE scientists and global users (policy makers, advisory bodies, research managers, conservation and user groups, and management bodies), and results in the production, dissemination and use of research-based knowledge in decision making and enterprise. The key MEECE target groups include decision makers in science and policy areas, small and medium enterprises interested in the application of knowledge and the interested public.

Lastly, can you offer some thoughts on what ultimate impact you hope MEECE will have?

The expected impacts are twofold: firstly, to improve the knowledgebase on marine ecosystems and the way they are impacted by the many driving forces, either anthropogenic or natural; and, secondly, to provide input to governmental and non-governmental actors in the development of innovative tools and strategies for the rebuilding of degraded marine ecosystems, protection and sustainable use of the sea and its resources, through the perspective of the ecosystem approach.

Saving the seas

Furthering knowledge of marine ecosystem processes is vital to improving marine management. To address this, the EU-funded **MEECE** project has garnered expert studies and tools to support understanding of the current state, and likely future evolution, of these ecosystems in European seas and inform policies for their protection

CLIMATE CHANGE IS placing significant stress on the world's seas and their ecosystems. In addition, fishing has heavily reduced fish stocks in parts of the oceans, while pollution from human marine activities such as shipping, and land-based activities such as farming, exacerbate the situation further for the delicate ecosystems and marine food webs that support marine life. In Europe, there is a real danger that some marine species will be irretrievably lost.

The EU Marine Strategy Framework Directive (MSFD) aims to ensure that Member States develop action plans that will efficiently protect the European marine environment, in cooperation with other EU states and countries outside the Union. In support of this, the Member States are required to provide an assessment of their marine environments and set out what a 'Good Environmental Status' (GES) means for them, along with strategic targets and measures by which the States will monitor their future evolution.

The drivers of change for planktonic and benthic ecosystems are the focus of these assessments:. These are: ocean temperature, circulation, stratification and acidification, pollution, overfishing, invasive species and eutrophication. Compliance with the MSFD depends on the ability of Member States to accurately interpret the vulnerabilities of marine ecosystems and the ways in which they might adapt to environmental factors and human activities. Accordingly, the European Union Seventh Framework Programme for Research and Technological Development (FP7) has sponsored the Marine Ecosystem Evolution in a Changing Environment (MEECE) project as a means to support Member States in achieving their obligations.

MEECE OBJECTIVES

The primary goal of MEECE is to provide input to the development of innovative tools for assessing GES and to facilitate understanding of the implications, so as to expedite implementation of the MSFD by informing strategies for dealing with the effects of change. "Underpinning the delivery of the MSFD is the scientific challenge of investigating and understanding the sensitivities and potential responses of marine ecosystems to both climatic change and the direct effects of human activity," explains Jessica Heard, the Project Manager of MEECE. "Without understanding how an ecosystem might respond to these multiple drivers, we shall find it very difficult to manage marine ecosystems." MEECE has therefore applied a combination of data collection, computer-aided simulations, expert systems and targeted research to acquire and share the comprehensive knowledgebase and predictive tools required to support decision making about marine ecosystems.

The MSFD is regionally focused; as a result, the MEECE project focuses on key marine regions of the EU: the Adriatic, Barent, Baltic, Black and North Aegean Seas, the North East Atlantic including the North Sea, the Bay of Biscay and the Benguela Upwelling. Users of the MEECE knowledge base and toolkits include a global spread of policy makers, advisory bodies, research institutes, consultancies, conservation groups, NGOs, industry and coastal and maritime management bodies. There are 21 European partners and one African partner involved in the project. Because of the large variety of stakeholders and potential users, a User Advisory Group represents the interests of different types of users – and society at large – acting as a focal point for the project to obtain input about the specific needs of each. The project maintains a Stakeholders' Contact Database which allows rapid and targeted dissemination of MEECE products and facilitates searches of stakeholder information. The User Advisory Group consists of a set of stakeholders representing different sectors, supplying information that ensures the project offerings are relevant. The Group also aids MEECE's efforts by informing the consortium of user priorities.

MODELS AND THE MEECE MODEL ATLAS

Modelling is a central part of the group's work: "This allows us to describe the state of a system and how it may evolve, representing the dynamics of the pressure-state relationship so we can assess the risk of negative indicator events," Scientific Coordinator Professor Icarus Allen details. The project evaluated a number of modelling systems, selecting 11 for further development during the MEECE project. Allen explains: "If we are to use models either for science or policy, then we need to be able to understand and articulate their quality. We therefore needed to assess model applicability to understand how well the model fits the data in space and time".

The model systems selected may be used on their own or integrated with the others to produce end-to-end ecosystem simulations. The full suite of models developed during the project have been collated to form a Model Library, complete with user guides available at www.meece.eu/Library.aspx.

Using the MEECE models it is possible to obtain information regarding up to eight of the 11 GES descriptors for a particular regional sea: biodiversity, non-indigenous species, fish, shellfish, food webs, eutrophication, sea floor and contaminants. The project has improved the means by which the systems might be joined for end-to-end use by providing various coupling tools. They now support, for example, scenarios concerning the abundance and distribution of particular commercial marine species and scenarios for assessing biomass and the productivity of key species in marine ecosystems. Distribution and dispersal of nutrients and contaminants from the Aegean to the North Sea can also be modelled for the purpose of assessing the impacts of eutrophication on habitat condition.

"A key legacy of the project will be the MEECE Model Atlas," asserts Heard. The Model Atlas has

been developed in collaboration with the MEECE User Advisory Group and provides access to the many simulations that have been obtained over the last four years, for different seas according to different drivers and indicators, via a web portal. The web-based Atlas will give non-modelling experts access to model outputs in a user-friendly manner, it can be interrogated by region across a range of variables displaying decision support outputs for present and future scenarios.

MEECE KNOWLEDGE BASE AND KNOWLEDGE TRANSFER

MEECE seeks to ensure that project outputs are presented in a way that is relevant and meaningful and has placed a strong emphasis on knowledge transfer to society, through the dissemination of research-based knowledge, expertise and skills: "Since the project started in 2008, MEECE scientists have published 58 papers, with a further 22 submitted, and they have delivered more than 180 presentations of project work," highlights Heard. MEECE has also produced a library of fact sheets that highlight key project findings and outputs, which include both scientific reports and reports about aspects of the project itself.

In addition to knowledge transfer via its products, MEECE has sought to train a new generation of ecosystem modellers to ensure that expertise is developed for future generations. Last year, more than 35 students were trained in a dedicated week-long summer school. The summer school was designed to expand the students' knowledge of the state of the art of marine ecosystem simulation and share methodologies for interpreting the outputs.

The MEECE project will be presented to the EU Joint Research Centre biodiversity workshop on biodiversity descriptors in Brussels in November; with the launch of the Model Atlas also planned for this event.

In addition to knowledge transfer via its products, MEECE has sought to train a new generation of ecosystem modellers to ensure that expertise is developed for future generations

MEECE

MARINE ECOSYSTEM EVOLUTION IN A CHANGING ENVIRONMENT

OBJECTIVES

To use a combination of data synthesis, numerical simulation and targeted experimentation to further understand how marine ecosystems will respond to multiple climate change and anthropogenic drivers.

PARTNERS

Plymouth Marine Laboratory, UK (Coordinator) • **Bolding & Burchard Hydrodynamics**; **Danish Institute for Fisheries Research, Technical University of Denmark**; **Syddansk Universitet**, Denmark • **Institut de Recherche pour le Développement**; **Centre National de la Recherche Scientifique**; **Commissariat à l'énergie atomique**, France • **University Hamburg**, Germany • **Hellenic Centre for Marine Research**, Greece • **Università di Bologna**; **Università del Piemonte Orientale**, Italy • **Klaipeda University Corpi**, Lithuania • **Universitetet i Bergen**, Norway • **University of Cape Town**, South Africa • **Fundación AZTI-AZTI Fundazioa**; **Instituto Español de Oceanografía**, Spain • **Wageningen IMARES BV**, The Netherlands • **Institute of Marine Sciences, Middle East Technical University**, Turkey • **Centre for Environment, Fisheries and Aquaculture Science**; **Natural Environment Research Council**; **Sir Alister Hardy Foundation for Ocean Science**, UK

FUNDING

EU Seventh Framework Programme (FP7) – contract no. 212085

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JESSICA HEARD has an MSc in Marine Policy. She has extensive experience of EU projects working in a dual capacity as Project Manager and science communicator over several framework programmes.

PROFESSOR ICARUS ALLEN specialises in the development of complex marine system models for hypothesis testing and forecast, model skill assessment and ecotoxicology. He has been involved in over 35 national and EC scientific projects.

A new wave of marine biotech

Dr Steinar Bergseth explains the work of a Europe-wide project that seeks to enable easier and more effective collaboration and funding for marine biotechnology research in Europe

How does CSA MarineBiotech define marine biotechnology and in what ways can these technologies help to meet the Grand Challenges for the 21st Century?

Biotechnology, as defined by the Organisation for Economic Co-operation and Development (OECD), is the application of biological knowledge and techniques to develop products, knowledge and other benefits. MarineBiotech takes this definition and applies it to the marine environment. Marine organisms contain molecules not seen in the terrestrial environment that may lead to the development of new drugs and disease treatments. The same is true for enzymes with unique properties that can be used in industrial processes to make them cleaner and more energy efficient, and for processes that will benefit both the environment and climate. In addition, a focus on marine biology and marine biotechnology will increase the possibilities for sustainable production of food and energy from the seas.

What is the importance of effective coordination of marine biotechnology research in Europe and what is required to achieve this?

The development of technology and applications using marine biotechnology will be greatly improved when it is coordinated and developed in close synergy between European partners. It is a big challenge to penetrate the understanding of biology and uncover how this can be best utilised technologically. This requires the efficient use of human, infrastructure and monetary resources which can be facilitated by coordination and innovative thinking. To achieve this, networks between policy makers and scientists must be active and open, effective communication channels must be operative and a political understanding of the importance must be manifested in budgets enabling developments and innovations.

Can you sum up the specific aims and objectives of this project?

CSA MarineBiotech's main objective during its 18-month duration is to establish a trans-European consortium of funding agencies and other stakeholders, who together will facilitate developments in marine biotechnology. This is most likely through a Seventh Framework Programme (FP7)-financed European Research Area Network (ERA-NET) aimed to start in late 2013 that will work in close collaboration with other European and international activities relevant for this field.

Who are the CSA MarineBiotech's target audience and how are you looking to effectively distribute your findings and results?

The main audience is the European funding agencies who actively want to create the consortium to fund collaborative research and developments in marine biotechnology. In addition we need support and advice from a range of stakeholders, including industry and science organisations, to define the best possible research priorities and knowledge gaps. Findings and results are being distributed through two workshops, newsletters, our website and a final conference in the spring of 2013.

What future activities have been proposed by the MarineBiotech consortium?

The CSA MarineBiotech consortium will discuss these in detail as they will provide the basis for the European cooperation areas, but a coordinated working group leading up to this project completed an initial mapping of fields where common interests exist. These were molecular aquaculture, biodiscovery/bioprospecting, biomass production and utilisation for energy, fine chemicals and nutraceuticals, and tools and infrastructure developments tailored for the marine field. These and probably others will be further developed in the ERA-NET consortium established through the project.

What are the major strengths of the project? Have you faced any significant obstacles in achieving the project's objectives to date?

The strengths are the dedication from the consortium and the increased awareness marine biotechnology is attracting from many different angles. Significant obstacles have not emerged so far, but building a common understanding of the importance of marine biotechnology, and assembling the right and strong consortium to advance marine biotechnology in Europe will certainly be a big challenge. An emerging obstacle, though we are not yet sure how big it might be, is the economic situation in some of the countries that should be central players in this area. Also, other initiatives might divert interest and focus from a Marine Biotech ERA-NET participation for some.

Would you like to discuss any other aspects of CSA MarineBiotech?

CSA MarineBiotech is the first action that the EU has supported to bring together funding agencies in a deliberate way, to plan for a future in which marine biology and biotechnology have a strong role to play in the bioeconomy. This is an important time to 'get it right' in this area, in terms of sustainability and collaboration, so it is very exciting for us to see how the next years will progress.

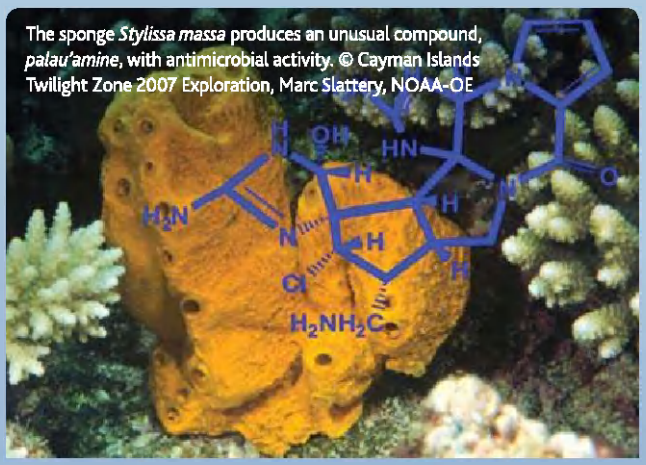
Scientific synergy

CSA MarineBiotech, an ERA-NET Preparatory Action in Marine Biotechnology, is engaging with European partners in order to facilitate effective cooperation and research collaborations

THE CHANGES FACING marine environments due to human-driven factors mean that we are currently in the midst of a critical period for preservation of these ecosystems. Yet concurrently, the seas represent one of the most abundant sources of food and energy production on the planet, as well as containing the potential for countless innovations in drug production, industrial process development, ecosystem management and other related fields. Consequently, research into marine environments is incredibly important, both in discovering critical products and processes, and avoiding over-exploitation either for food production, aquaculture or any other uses.

Investigations into these environments must be carefully coordinated but, at present, research activities across Europe are fragmented. Biotechnology challenges must be better defined and coordinated so that high quality research is more effectively utilised. This can be achieved through a number of carefully considered measures including common research and innovation agendas, better use of infrastructure, improved stakeholder participation and the identification of existing gaps and barriers to cooperation.

In order to address this, the CSA MarineBiotech programme, led by Dr Steinar Bergseth, of the Research Council of Norway, was launched in October 2011 for an 18-month period. It seeks to create a synergy between 11 partners involved in marine biotechnology research (members of funding agencies, research institutes and consultancies) across nine countries. CSA MarineBiotech will thus prepare the foundations for a European Research Area Network (ERA-NET) which will subsequently help prevent unnecessary repetition of work and maintain the sustainability of investigations.



The sponge *Stylissa massa* produces an unusual compound, *palau'amine*, with antimicrobial activity. © Cayman Islands Twilight Zone 2007 Exploration, Marc Slattery, NOAA-OE

GOOD TO TALK

There are a number of ways in which CSA MarineBiotech is helping to create an effective environment for biotechnology innovation across Europe. Two significant components are the MarineBiotech Strategic Forum, and the MarineBiotech Stakeholder Group. Bergseth explains the thought process behind the creation of these two branches of their work: "CSA MarineBiotech is a coordination effort to improve interest in and create the networks for the next stage which will promote science and development in academia and innovations in the industries". Within this aim, the Strategic Forum brings together all funding agencies interested in supporting research and development across Europe. Similarly, the Stakeholder Group provides advice on the areas which require investigation, helping to identify the priorities and paths for developing marine biotechnology across Europe.

The CSA MarineBiotech consortium is laying the foundations for an ERA-NET that will develop a biotechnology toolbox of advanced methods and analyses tailored to the challenges of making use of marine bioresources. This will then accelerate innovative marine biotechnology developments in sectors ranging from environmental and human health, to the sustainable supply of food, energy and biomaterials. By developing technological solutions, new knowledge within marine biology can be applied to other disciplines and problems which encompass a number of related fields.

CSA MARINEBIOTECH

OBJECTIVES

The main goal of the CSA is to prepare the foundation for an ERA-NET in the area of marine biotechnology.

PARTNERS

VLIZ – Flanders Marine Institute, Belgium

EMB-ESF – European Science Foundation Marine Board

DTU – Technical University of Denmark

CNRS – Centre National de la Recherche Scientifique – Station Biologique Roscoff, France

IFREMER – French Research Institute for Exploration of the Sea, France

Norgenta North German Life Science Agency, Germany

CNR – National Research Council of Italy

RCN – Research Council of Norway

FCT – Ministry of Education and Science, Portugal

TÜBITAK – The Scientific and Technological Research Council of Turkey

BioBridge Ltd, UK

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DR STEINAR BERGSETH is special advisor on biotechnology in The Research Council of Norway and has seven years' experience of building and running Norway's largest biotechnology effort, FUGE. He is instrumental in much of the strategic biotech work in Norway, chairs the international Salmon genome sequencing effort and is active in OECD's work on marine biotechnology.

MarineBiotech

MICROALGAL STRAINS WITH POTENTIAL FOR BIOFUELS © IFREMER/OLIVIER DUGORNAY

ASSISTING STRATEGIES

One area of special note is the contribution of marine biotechnology to the Europe 2020 strategy. This initiative is focused on boosting growth and employability across a 10-year perspective and aims at intelligent, sustainable and inclusive growth. Bergseth is quick to explain how the consortium is working within these parameters: "CSA MarineBiotech will pave the ground for contributions to these goals by generating new innovations, leading to employment possibilities in new areas, utilising biological resources in a smart and sustainable way". The programme partners are also hoping that their work will contribute to climate and energy efforts by facilitating collaborations and innovations in these fields, helping researchers to investigate the power and potential contained within the marine environment more effectively.

SAFE, SECURE SEAFOOD

A area in which biotechnology innovations can impact consumers and the general public is safe seafood production. This comprises a number of elements, as Bergseth explains: "One major aspect of seafood safety is traceability, the facility of following the product from the sea to the shelf in order to confirm its identity". With DNA-based methods providing excellent tools for this aspect of the work, developing and improving these tools is a central focus for many biotechnology researchers. Biotechnology will also help in selecting seafood lines that are inherently more resistant to disease, or have enhanced nutritional profiles. Similarly, researchers are at pains to find inexpensive and high throughput ways of assessing the microbial and toxicological safety of the food. Biotech labs are working through continuous developmental processes in order to address these issues in ways that are both efficient and secure. Innovations in this field can also include the analysis of marine environments for substances which may affect food production in negative ways. The team are hoping that their work will facilitate improved methodologies for both traceability and safety within seafood – technologies which could have an impact across Europe and the world.

DEVELOPING NOVEL DRUGS

Another major field within which marine biotechnology can contribute is drug development. In fact, new molecules are continuously being discovered within the marine context, including a large number related to the cancer field such as *cytarabine*, *eribulin (Halaven®)* *trabectin (Yondelis®)* and *salinosporamide A*. A notable drug recently developed from marine biotechnology is *Prialt®* (*ziconotide*), an analgesic which has been produced from the cone snail *Conus magus*. Used to manage severe chronic pain, the drug has proven extremely effective.

MARINE BIOTECH AND THE BIOECONOMY

Such discoveries are examples of the many and varied outputs that research and development in marine biotechnology can produce. CSA MarineBiotech hopes that by defining the current state of the art and laying the foundations for strong collaborative activities, it will be able to assist future discoveries and new technologies. It is through the success of these future projects that the value of marine research can be realised – creating both technology at the cutting-edge of science and useful outputs that are sustainably produced.

Many of the aims of the Copenhagen Declaration, which was issued at the end of the 'Bioeconomy in Action' event in 2012, have helped to promote the need for biotech solutions. Focusing on the European Commission's Strategy 'A Bioeconomy for Europe: Innovating for Sustainable Growth', which was submitted during the Danish Presidency of the EU, the declaration presents a number of key findings that suggest an ERA-NET along the lines envisaged by CSA MarineBiotech would be beneficial to European scientists, industries and society at large. In the European context, marine biotechnology can and should make an important contribution towards meeting the 'Grand Challenges' for the 21st Century and the development of greener, smarter economies, central components of the Europe 2020 Strategy.

With key initiatives including knowledge and innovation communities, CSA MarineBiotech's efforts to aid collaboration amongst researchers will assist in achieving the targets of the declaration. The partners are hoping that their own work in committing funding agencies to become part of an ERA-NET will provide a strong statement on the power of working synergistically in the pursuit of biotechnology outcomes.

Tackling the secrets of marine genomics

Dr Frank Oliver Glöckner, Coordinator of the large Ocean of Tomorrow project Micro B3 on marine microbial biodiversity, bioinformatics and biotechnology, outlines the research efforts on an integrated information system including new tools for 'Omics analysis, to be used by researchers worldwide

To begin, can you outline the context from which the Micro B3 project emerged?

With technological advances in the fields of sequencing technology, oceanography and lab automation, marine scientists are now starting projects they only dreamed of 10 years ago. However, the deluge of data produced is beyond the skill set of many marine scientists and very little data management infrastructure exists at the moment. Our project aims to facilitate the whole process from sampling and data acquisition to analysis, leading to better understanding of marine ecosystems and biotechnological applications.

What are the specific objectives of the project?

The overarching objective is to cross borders by creating a new inter- and multidisciplinary culture in marine RTD. We aim to achieve this by providing access to, and by integrating genomic, oceanographic and Earth observation databases into, one Micro B3 Information System (MB3-IS), based on global standards for sampling and data processing.

We are building capacity across Europe including training on intellectual property rights, knowledge and technology transfer. Our Ocean Sampling Day planned for 2014, will be a major dissemination event to measure marine microbial diversity and test our bioinformatic and environmental MB3-IS in practice.

What is the role of bioinformatics in bridging the current gaps in microbial data analysis? How do you plan to integrate and visualise this data?

Novel techniques and infrastructures for Environmental Bioinformatics are urgently needed to turn data into sensible and useful information and finally into biological knowledge. The marine bioinformaticians' work ranges from data and quality management (cleaning, standardisation) of the raw data to processing and annotating via data-mining and large-scale georeferenced data integration – and statistics and ecosystem modelling tasks.

How is Micro B3 integrating global marine data with research on microbial biodiversity and function? What partner institutions are making this possible?

Our main partners are the Centre National de la Recherche Scientifique (CNRS) and Consejo Superior de Investigaciones Científicas (CSIC) for the TaraOceans and Malaspina cruises. Other partners are several European long-term ecological research sites (LTER) from the UK, France, Greece and Germany, the owners of datasets from coastal stations, and finally a five-partner SeaDataNet team (see p46) for linking us to the oceanographic community.

By what means does Micro B3 analyse the genetic makeup of marine microbiology? Have your efforts uncovered any novel characteristics that may be of benefit to commercial applications?

With Marine Genomics we mine data, not resources. Using next-generation sequencing technologies this can be achieved quickly and efficiently. Strong arguments for using marine resources are the high bio- and chemical diversity in the sea, where many bio-active substances are in use in the fight for survival. However, sufficient quantities are difficult to obtain, expensive to extract, and any long-term harvesting of commercially useful amounts is neither sustainable nor guaranteed over time. Mining of genomic data is therefore an efficient and environmentally friendly alternative.

Could you explain what Ocean Sampling Day is and how preparations for this are progressing?

The Ocean Sampling Day (OSD) is a highly concerted effort that will be conducted in parallel on the summer solstice (21 June) in 2014 at numerous marine stations. It will use best practices developed, discussed within Micro B3 and tested during pilot OSDs in 2012 and 2013, and further refined during a summer school shortly before. It will be based on ongoing efforts of the Genomic Standards Consortium and thus ensure a high level of consistency across sites and maximum usefulness for stakeholders.

Intense regional and Europe-wide PR work will accompany this event. An open call to select the best additional sites is envisaged in 2013/14.

How have European frameworks evolved over the years to consider the importance of marine microbes? In order to fully integrate Micro B3, what additional policy is needed?

Several small and large projects have been funded by the European Commission on national and international levels. Micro B3 is in many respects a pilot project to build appropriate capacities in bioinformatics, but also in data mining for biotechnology and modelling, as well as Intellectual Property Management (IPR). To address the latter, a group of international experts and biotech companies such as PharmaMar are integrated in Micro B3.

To conclude, can you briefly highlight your hopes for the future success of Micro B3?

In cooperation with ESF and European research infrastructure initiatives we are achieving a better understanding of the needs and wishes across disciplines. I am convinced that success of future environmental and life sciences will strongly depend on the abilities of individual researchers to work across disciplines, ranging from classical marine knowledge to bioinformatics, oceanography, biotechnology and intellectual property management. Micro B3 will develop a mutual understanding between field and computer scientists, lawyers, industrial researchers and product developers.

Understanding the world from a marine microbial perspective

The emergence of new marine knowledge based on the genomic revolution is leading to a better understanding of the biggest ecosystem on Earth. There is massive potential for biotechnological innovation without overharvesting the marine environment. The **Micro B3** project aims to bring about major developments in the field of environmental bioinformatics to support these novel technologies

BIOTECHNOLOGY BASED ON genomic, proteomic and metabolomic information (collectively called 'Omics), from marine organisms has wide-ranging applications, most significantly in agriculture, the food industry, medicine and pharmaceuticals. In spite of this, 'blue biotechnology' is new territory for most companies. Globally, only 1 per cent of all biotechnology companies make use of marine ecosystem knowledge.

By improving the infrastructure for the huge amount of data on marine ecosystems, the ability of researchers to take a holistic approach to data can be improved, especially through combining 'Omics with environmental, biological and biochemical knowledge. A new research discipline called Environmental Bioinformatics is emerging, with Micro B3's task to ensure this is developed and implemented internationally.

The €9 million Ocean of Tomorrow Project Micro B3 is led by Dr Frank Oliver Glöckner, Professor of Bioinformatics at Jacobs University in Bremen. It forms teams of experts in bioinformatics, computer science, biology, ecology, oceanography, bioprospecting, biotechnology, ethics and law. The group includes a large number of partners who own considerable amounts of data on marine microbial diversity and the marine environment.

Micro B3 builds on output from two earlier developments in related fields: Since 2005 the megx.net system has been providing scientists with access to integrated environmental and meta-genomic data to be used in marine microbial ecology. It is used to generate hypotheses to discover new functional genes by integrating meta-genomic and ribosomal data with curated metadata and primary environmental data. Megx.net was supplemented through the EU NEST Metafunctions project which ran from 2005-08 and achieved final proof-of-concept as well as providing further data mining tools.

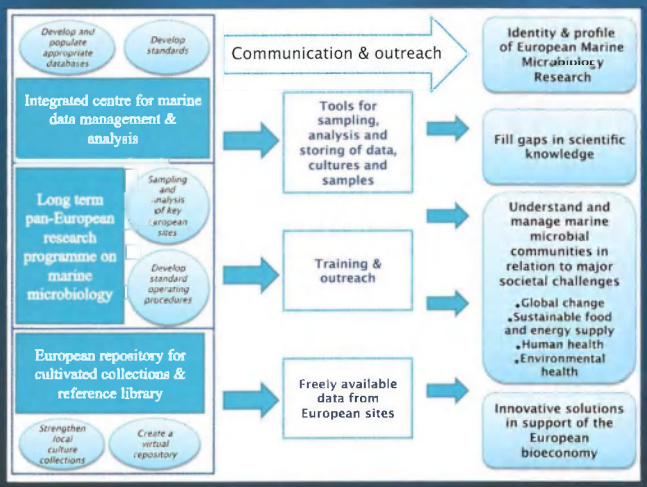

FIGURE 1. Schematic overview of main recommendations and their expected impacts in relation to addressing the key societal and scientific challenges (ESF Position Paper 17: *Marine Microbial Diversity and its Role in Ecosystem Function and Environmental Change*, May 2012).

Starting in 2004, main drivers for large-scale collaboration across Europe were two Networks of Excellence: 'Marine Genomics Europe' and 'Marine Biodiversity and Ecosystems Functioning'. Micro B3 builds on all these projects, its research and training is conducted in close contact with two large research infrastructure initiatives: the European Marine Biological Resource Centre (EMBRC) and the European Life Sciences Infrastructure For Biological Information (ELIXIR).

Micro B3 will provide researchers with new analytical approaches to marine ecological genomics, which will be integrated, standardised and extended to other applications within the project. The consortium's main aims are to bring together the existing bodies of expertise in ecosystems biology, the processing and interpretation of data, modelling and prediction and the development of intellectual property agreements to facilitate the exploration of potential commercial applications.

"Micro B3 aims to develop an innovative, transparent and user friendly, open-access system, which will allow for seamless processing, integration, visualisation and accessibility of the huge amount of data collected in ongoing sample campaigns and long-term observations," states Glöckner. "We also plan to offer analytical and feedback tools on our platform. This is unique in terms

of integrating genetic and ecological information and will generate collective knowledge. This will in turn offer new perspectives for the modelling and exploration of marine microbial communities."

OCEAN SAMPLING DAY

A key boost to the work will be provided by the Ocean Sampling Day (OSD), scheduled to take place on 21 June 2014. This will involve all partners in the project and will be open to any other interested labs across Europe and beyond. It will bring together a large group of marine researchers to undertake a detailed snapshot of microbes across the world's oceans on a single day.

OSD will take place at various sites, with pilots conducted 2012-13 to establish standardised sampling techniques. All analyses will adhere to the Minimum information checklists (MIxS) standard for describing molecular samples as outlined by the Genomic Standards Consortium.

The event is a key element of Micro B3 as it will generate a massive amount of useful marine microbial data to be included in the project's integrated MB3-Information System, providing other members of the team with information to generate hypotheses for more cost- and time-efficient biotechnological testing and applications.

INTELLECTUAL PROPERTY – WHO OWNS MARINE MICROBES?

One of Micro B3's main tasks will be to develop an innovative set of model arrangements that foster facilitated access to pre-competitive research materials, software, data and published research results, as Glöckner highlights: "We promote appropriate IP management and open access strategies for downstream applications".

Since Micro B3 is likely to bring about the discovery of new biotechnological applications for marine microbial data, there are complex issues of intellectual property involved, particularly given that much of the data gathered originates in exclusive economic zones or areas of ocean completely beyond any national jurisdiction. Micro B3 has a strong focus on open access and on involving all interested stakeholders in a non-exclusive way, with a view to future applications of marine diversity research.

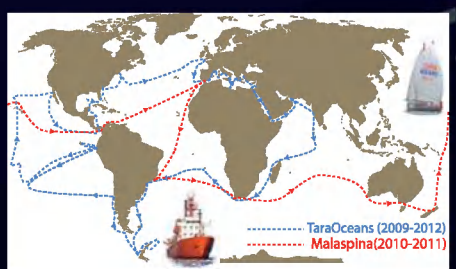

FIGURE 2. Overview of the Tara Oceans and Malaspina circumnavigation cruises © by B Garriz, E Broglio and JM Gasol.

THE MAJOR OBJECTIVE of the Micro B3 project is to cross borders by creating a new inter- and multidisciplinary culture in marine RTD. Detailed goals include:

- Providing access to state-of-the-art facilities and expertise to high quality sequence- and environmental data for a broad range of marine environments, combined with
  - **i.** Oceanographic databases, earth observation and monitoring data
  - **ii.** Data management, development of standards for describing all sampling, and data processing elements
- Bringing together expertise in
  - **i.** The development of innovative bioinformatics approaches for data processing, analysis and integration
  - **ii.** Ecosystems biology for better interpretation of data and to empower modelling approaches enhancing predictive capacities for the marine ecosystem
  - **iii.** Discovering enzymatic functions and bioactive compounds for biotransformation and biocatalysis
  - **iv.** Developing IP agreements for pre-competitive microbial research materials, for data and for the exploitation of high potential commercial applications
- Providing training and outreach activities to support knowledge and technology transfer as well as capacity building around Europe

The approach taken by Micro B3 is based on the Nagoya Protocol, which recognises that biological diversity is a 'common concern of humankind' and links to the broader goals of conservation and sustainable use of resources. The team aims to produce model contracts and good practice standards specifically tailored to the marine field.

Training for young scientists, including a summer school for the OSD as well as a range of workshops in biodiversity, bioinformatics and biotechnology, are planned together with highly accessible outreach activities (web portal, films, media materials) by Dr Johanna Wesnigk from the company EMPA. Related IP issues will be delivered by Dr Tom Dedeurwaerdere, Research Director of the Biodiversity Governance Unit of the Centre for the Philosophy of Law and his team.

Micro B3 is a hugely ambitious project sure to have implications on an international scale as it develops over the next four years. Glöckner and his partners are set to revolutionise Europe's capacity for bioinformatics and marine microbial data integration, to the benefit of a variety of disciplines in bioscience, technology, computing and law.

INTELLIGENCE

MICRO B3

MICROBIAL BIODIVERSITY, BIOINFORMATICS, BIOTECHNOLOGY

OBJECTIVES

To develop new bioinformatic approaches to analyse, integrate and visualise marine molecular and environmental data jointly. From the outset, this will be done in close collaboration with field scientists providing ecosystems expertise as well as their small and large-scale datasets.

PARTNERS

MPIMM, Germany • **UOXF**, UK • **HCMR**, Greece • **AWI**, Germany • **CNRS**, France • **IMS**, Portugal • **SZN**, Italy • **MBA**, UK • **VIB**, Belgium • **TUBITAK**, Turkey • **MARIS**, the Netherlands • **ICES**, Denmark • **VLIZ**, Belgium • **IFREMER**, France • **EMBL-EBI**, UK • **CEA - Genoscope**, France • **UniHB**, Germany • **UGRO**, The Netherlands • **BIOMERIT**, Ireland • **BANGOR**, UK • **IAMC**, Italy • **UCL**, Belgium • **CIESM**, Monaco • **IUCN**, Switzerland • **EMPA**, Germany • **MATIS**, Iceland • **BIO-ILIBERIS**, Spain • **INTERWORKS**, FYROM • **RIBOCON**, Germany • **Bio-Prodict**, The Netherlands • **PharmaMar**, Spain

FUNDING

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FRANK OLIVER GLÖCKNER is Head of Microbial Genomics and Bioinformatics Research Group at the Max Planck Institute for Marine Microbiology in Bremen, Germany and Professor of Bioinformatics at Jacobs University Bremen. His group develops enabling technologies to transform the wealth of sequence- and metadata from the environment into biological knowledge. Techniques are whole genome and metagenome analysis, sequence classification, phylogenetic inference as well as software and database development for integrated data analysis.

Ocean-going research

Drs Stéphane Blain and **Bernard Quéguiner** lead a project using the Kerguelen Island in the Indian Ocean as a natural laboratory to study the impact of iron fertilisation on the biological pump of CO_2

Firstly, what has encouraged your investigation into oceanic and plateau surface water interactions?

SB: In 1993, I was a postdoc at the Moss Landing Marine laboratory. At this time the group was working on the preparation of the first artificial iron fertilisation experiment, IRONEX1. I realised how exciting, but also complex and controversial, this kind of experiment to manipulate a small area of the ocean could be. I found that observing natural systems could also provide new insights into the role of iron in controlling the biological pump of CO_2. Kerguelen Island, a French archipelago in the Indian Southern Ocean was a perfect place to conduct such studies. My first cruise in this region occurred in 1995, providing me the opportunity to test the concept. This was the starting point for the construction of the more ambitious KEOPS project relying on two major oceanographic cruises in 2005 and 2011.

Could you outline the main aims and objectives of the KEOPS project?

SB & BQ: KEOPS aims to study the impact of iron fertilisation on the biological pump of CO_2 in the Southern Ocean. The first objective of KEOPS was to demonstrate that the bloom of phytoplankton occurring yearly around Kerguelen was promoted by natural iron fertilisation. Then, this natural laboratory was used to investigate the impact of the fertilisation on the functioning of the ecosystem and the biogeochemical cycles. Special attention was paid to quantify the role of iron on the carbon sequestration in the ocean.

What methods are being deployed to obtain reliable data? How are you able to reduce uncertainty?

SB & BQ: The general strategy of KEOPS was to conduct a pluridisciplinary study in a complex natural system. The circulation and dynamics of water masses was carefully described combining satellite observations and *in situ* data collected during the cruises or with instrumented moorings. Geochemical tracers and biogeochemical measurements were combined to quantify the stock and fluxes of the different chemical elements with a special focus on carbon. The structure of the ecosystems and its functioning was described, ranging from viruses to zooplankton using the most recent technologies for imaging and sequencing.

Can you explain the Argo project and how your work contributes to its development?

SB & BQ: Six Argo floats were deployed during the KEOPS2 cruise. The main advantage for us was that once the cruise was completed, they continued to provide salinity and temperature profiles in the region we are interested in. On the other side, we have contributed to the global effort of deployment of Argo floats in a region which is difficult to access. We have also deployed two bio-Argo floats in collaboration with the University of Tasmania, Australia, which in addition to salinity and temperature, also measured fluorescence and oxygen – two important parameters describing the dynamics of phytoplankton.

Now half way through your four-year project, what has been the most significant discovery to date?

SB & BQ: The KEOPS project has two major phases. KEOPS1 (2004-09) demonstrated that natural iron fertilisation of the Southern Ocean is a very efficient process for carbon sequestration. The efficiency was much higher than observed in previous artificial iron fertilisation experiments. Our results point out that the mode and nature of iron addition is a key factor in controlling the efficiency. KEOPS2 (2011-14) is the second phase and the cruise was successfully completed in November 2011.

What is the greatest challenge facing oceanic research at present? How can this be improved?

SB & BQ: Oceanic research, as with many other scientific fields, has entered the era of 'big data'. Satellite, numerical models and high-throughput sequencing technologies are among the tools providing copious amounts of data. It is a real challenge for oceanographers to deal with this unprecedented flow of data. However it is also important to realise that conceptual frameworks and basic understanding of the processes are critical to the proper interpretation of big data. In this context, field studies, considered a 'low throughput' technology, should remain a cornerstone of oceanographic research in the future.

Finally, as the second phase of the project progresses, what are the next events on the horizon for the project?

SB & BQ: We are currently processing the data and looking at the first results of KEOPS2. The first findings will be presented in early 2013 at international conferences, followed by publications in scientific journals. The KEOPS2 website will allow a broad audience to track the life of the project.

Water works

An international team of researchers working on the KEOPS project is investigating natural iron fertilisation in the Southern Ocean and its impact on marine ecosystem and biochemical cycles

THE SOUTHERN OCEAN is a key region in the global carbon cycle because it represents an important CO_2 sink. However, the magnitude of this sink is still highly debated. Theory and model studies show that atmospheric CO_2 is sensitive to changes in Southern Ocean biology, which are related to nutrient utilisation in the surface waters; this in turn is related to the availability of iron. It is well recognised that phytoplankton – a key player for sequestering carbon in the ocean – is limited by iron supply in this region. Iron thus plays an important role in the carbon cycle, and changes in its supply to the surface waters therefore have a significant effect on atmospheric CO_2 concentrations.

Artificial iron fertilisation experiments have succeeded in demonstrating that iron addition enhanced photosynthesis, but enhanced transport of carbon in the deep ocean has not been observed. Furthermore, except for a few locations where natural iron fertilisation was prominent, the source of iron supporting higher productivity in the Southern Ocean is a matter of debate.

NATURAL LABORATORY

The KEOPS project is an international, multidisciplinary collaboration between researchers in France, Belgium, Australia, Chile, South Korea, the UK and US, which is taking a new approach to tackling this unsolved issue. Using the Kerguelen Island plateau in the Indian Southern Ocean as a natural laboratory, the project team is studying the impact of natural iron fertilisation on ecosystem and biochemical cycles. Led by Dr Stéphane Blain, the project is now in its second phase. The first phase – KEOPS1 – took place from 2004-09 and the results of this study demonstrated that the efficiency of natural iron fertilisation, defined as the excess carbon exported versus the iron added, was 10-100 times higher than the efficiency of previous artificial iron fertilisation experiments. KEOPS1 also demonstrated that the concept of a natural laboratory is a powerful tool in marine biogeochemistry, allowing further investigation of the responses of ecosystem functioning and biogeochemical cycling to natural iron fertilisation.

The results from phase one of the KEOPS project raised new and important questions for Blain's group which have formed the focus of KEOPS2. The researchers now wish to identity which processes supply and retain bio-available iron in surface waters, and on what time scales they occur. Other efforts aim to assess the degree of coupling and decoupling between the iron, carbon, nitrogen, phosphorus and silicon cycles in the fertilised region. Further questions include how biological diversity is affected by natural iron fertilisation and whether the seasonal and interannual variability of the bloom can be better understood.

UNIQUE DATASET

Central to KEOPS has been two major oceanographic cruises. The KEOPS2 cruise was completed in 2011 and comprised 359 deck operations performed during 36 occupations of observation stations located mainly east of Kerguelen Island. Real-time satellite images in combination with trajectories of 50 drifters released during the first part of the cruise were used to carefully decide the positions of the stations. Samples were collected from the water column and from the superficial sediment.

KEOPS2 also includes a GEOTRACES process study. For this study, dissolved and particulate samples were collected during 30 deployments of a trace metal clean rosette, 15 deployments of *in situ* pumps and seven deployments of a multicorer, and these samples will inform the determination of trace element concentrations and isotopic composition analysis. Blain explains that this unique dataset will allow the description

KEOPS

KERGUELEN: OCEAN AND PLATEAU COMPARED STUDY

OBJECTIVES

An international (France, Belgium, Australia, Chile, South Korea, the UK and US) and multidisciplinary project that studies the impact of natural iron fertilisation on ecosystem and biochemical cycles in the Southern Ocean.

PARTNERS

Centre national de la recherche scientifique-Institut national des sciences de l'univers; Universities of Paris 06, Brest, Bordeaux, Lille, Toulouse, Marseille 2 France; Institut Paul Emile Victor; Collecte Localisation Satellites, France • **The Antarctic Climate and Ecosystems Cooperative Research Centre, Macquarie University Sydney**, Australia • **Vrije Universitat Brussels**, Belgium • **University de Concepcion**, Chile • **National Oceanographic Center Southampton**, UK • **Duke University; Boston University**, USA • **Korean Research and Development Institut**, South Korea

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Agence National de la Recherche

Institut Paul Emile Victor

Centre National d'Etudes Spatiales

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BERNARD QUÉGUINER is a Professor of marine biogeochemistry at Aix-Marseille University (France) in the Mediterranean Institute of Oceanography.

Iron plays an important role in the carbon cycle, and changes in its supply to the surface waters therefore have a significant effect on atmospheric CO_2 concentrations

of the vertical and horizontal distributions of trace elements in this region of the ocean, as well as the identification of the different sources of iron. The team is also investigating the nature and the time scales of the processes that are supplying or removing iron. The GEOTRACES study combined with other physics, biogeochemistry, and biology approaches conducted during KEOPS2 will contribute to improving the understanding of the functioning of the biological pump of CO_2 in the Southern Ocean and its response to iron fertilisation.

COLLABORATING ON INTERNATIONAL OBSERVATIONS

Alongside its own research objectives, KEOPS is also contributing to the work of the umbrella group Oceanic Autonomous Observations, whose aim is to develop autonomous oceanographic instruments, as well as to accommodate a multidisciplinary team of scientists who drive their use. These instruments include Argo floats – a global array of 3,000 temperature and salinity profiling floats for data collection. In the Southern Ocean, the coverage by Argo floats is lower than in other oceans, due to the reduced number of opportunities for deployment and to the sea ice cover. To combat this, autonomous sensors have been deployed on elephant seals which provide in situ data for salinity, temperature, fluorescence and oxygen. Blain highlights that the KEOPS2 cruise was an excellent opportunity to compare elephant seal data with data provided by the conventional methods used during the oceanographic cruise: "This comparison reinforces the quality of the dataset, especially for biological parameters".

Blain firmly believes that international collaboration will be required to avert oceanic disturbance in the future. There is substantial evidence to demonstrate that climate change is affecting marine life and the health of the oceans, but the capacity to predict their responses and the effect on the climate or on other oceanic basins is largely hampered by the lack of in situ observations. "The pursuit of international efforts is required to conduct both new oceanographic pluridisciplinary cruises dedicated to the understanding of the processes, and to deploy a network of autonomous instrumented platforms monitoring changes in space and time of key parameters," Blain notes.

UNDERSTANDING THE OCEAN, MITIGATING CLIMATE CHANGE

The artificial enhancement of the biological pump of CO_2 by large scale iron fertilisation of the ocean has been proposed as a geo-engineering tool to mitigate climate change. Neither the efficiency nor the side effects of such large-scale manipulation of the ocean have been fully examined. Results generated so far in KEOPS demonstrate that natural iron fertilisation in the Southern Ocean results in dramatic changes in the functioning of the ecosystem and has large impacts on biogeochemical cycles. The researchers have also learned from both projects that responses can differ greatly from one site to another. In this context, the observations made in the KEOPS project in naturally iron fertilised regions are a powerful approach to understanding the impact of iron addition on the response of the biological pump of carbon and on the Southern Ocean ecosystem.

Monitoring the climate

The Global Climate Observing System has been steadily improving observation networks for climate in regions of need throughout the world. Here, GCOS Director **Carolin Richter** and Implementation Project Manager **Richard K Thigpen** present the 20-year history behind the system's efforts to provide atmospheric, ocean and terrestrial climate data with true value

THE GLOBAL CLIMATE Observing System (GCOS), which is hosted by the World Meteorological Organisation (WMO) and co-sponsored by the Intergovernmental Oceanographic Commission (IOC) of UNESCO, the United Nations Environment Program (UNEP), and the International Council for Science (ICSU), is now 20 years old. Spanning the atmospheric, oceanic and terrestrial domains, its goal is to provide comprehensive information on the total climate system, involving a multidisciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrological, cryospheric and terrestrial processes.

Much has changed over the course of its 20-year history. Back in 1992, the Atmospheric Observation Panel for Climate (AOPC) defined two important networks: the GCOS Surface Network (GSN) and the GCOS Upper Air Network (GUAN). Around 1,000 stations within the GSN and about 150 stations in the GUAN were chosen from the existing Regional Basic Climatological Network (RBCN) stations operated by members of the WMO. Expected to provide good global coverage, the stations were selected because of their long operating histories. Importantly, they form baseline calibration networks which researchers can use as references when using other sources of climate data.

CLIMAT REPORTS

The AOPC advises that a monthly CLIMAT report containing at least maximum and minimum temperatures, and total precipitation for the month is needed in order to observe global trends. Moreover, daily maximum and minimum temperatures, and precipitation data are needed to analyse extremes. For the GUAN there should be at least 25 soundings per month up to at least 30 hPa (approximately 22 km), and the current widely used WMO report format is the TEMP report. These datasets are then distributed worldwide over the Global Telecommunications Network. The 'official' GUAN and GSN archive is kept in the National Climatic Data Center (NCDC) in Asheville, North Carolina in the US.

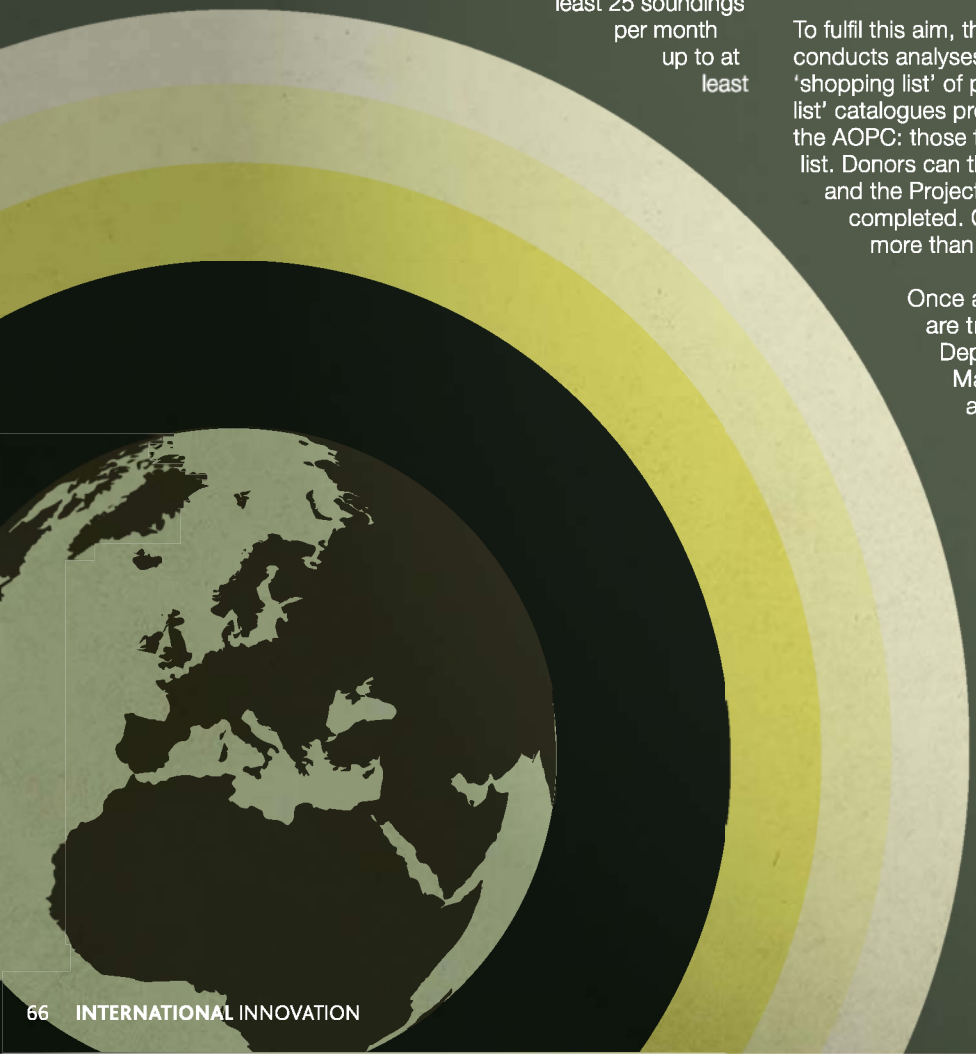
Almost as soon as the two GCOS and GUAN networks were defined, performance reports for each station were developed. Unfortunately, these reports showed that not all stations were working as well as expected. Many CLIMAT reports were not received, especially in developing areas. As a result, both Japan and Germany agreed to monitor stations for the GSN, while the European Centre for Medium-Range Weather Forecast (ECMWF) and NCDC agreed to supervise centres for the GUAN. Initial analyses indicated that many stations had become inoperative. For example, less than 70 per cent of the expected CLIMAT reports were actually received at the monitoring centres. For this reason, the GCOS Cooperation Mechanism (GCM) was founded in 2004 to address the issue.

GCOS COOPERATION MECHANISM

The aim of GCM is to identify and make the most effective use of resources available for improving climate observing systems in developing countries. In recent years, several countries have provided funds and participated on the Donor Board. The GCOS Sponsors (WMO, IOC, UNEP, ICSU) are seeking additional countries and organisations to help address the considerable and growing demands for improved climate observing networks in developing countries.

To fulfil this aim, the GCOS Implementation Project Manager conducts analyses of problems at stations and maintains a 'shopping list' of projects that need funding. This 'shopping list' catalogues projects according to scientific priority set by the AOPC: those that are more important are higher up on the list. Donors can then choose which projects they wish to fund, and the Project Manager works for them until the project is completed. GCM donors meet once each year, and, thus far, more than 50 projects have been completed.

Once a project is agreed, the funds from the donor are transferred into the GCM trust fund at WMO. Depending on the specific project, the Project Manager prepares the technical specifications and initiates a requisition through the WMO procurement system, which is modelled on the UN system and is fully competitive. All known potential suppliers are invited to bid and the lowest cost, technically responsive bid is the winner.



REVITALISING THE GUAN NETWORK

Initially, the AOPC set a higher priority for rejuvenating the GUAN network and increasing the number of stations to improve global coverage. At that time, nearly 20 of the 150 stations in the GUAN were not reporting (ie. silent). The problems for upper air stations are usually associated with the

relatively high cost of the radiosondes (the small instrument package used to measure temperature, humidity and winds in the atmosphere) and balloons, as well as the cost of the balloon inflation gas. Many developed countries use helium to inflate the balloons and, although it is safer, it is far more expensive than hydrogen and is often not available in the developing world. So hydrogen generators are used.

In the 1960s and 70s, many hydrogen generators were installed around the world when the upper air network was first developed, but these units no longer operate and replacement parts are not available. Thus a typical renovation of a GUAN requires a new hydrogen generator, including storage tanks and a supply of radiosondes and balloons. If the country has not operated a station for many years then retraining is also required.

Two of the first GCM projects were the implementation of new GUAN stations at Gan, in the Maldives, and at Dar es Salaam, Tanzania, as these were considered a top priority. The UK Met Office agreed to manage the project at Gan as they had been involved in the original activation of the station, and have extensive experience in overseeing such projects.

Several existing GUAN stations were then revamped through the provision of radiosondes and balloons, and many hydrogen generators have been replaced. Currently, all of the stations in the GUAN are capable of operating, although supplies sometimes run out or equipment breaks down. There are several areas where additional GUAN stations are needed, such as Luanda in Angola, and of course stations are added and closed by members over time. However, the number of GUAN stations has grown to 171.

REVIVING THE GSN STATIONS

The problems associated with GSN stations are slightly different; often instruments have become old and worn out, telecommunications between the remote observing stations and the main office fail to work, or simply the required reports such as CLIMAT and SYNOP are not prepared or distributed by the host country. Substantial analysis is often needed to determine exactly what must be done before the exact nature of the problem can be defined. Therefore, revitalisation of the GSN stations often requires provision of new instruments, telecommunications capabilities and staff training. In some cases actual repair of the facility has been needed, as was the case of Mount Bjelasnica, near Sarejevo in Bosnia and Herzegovina, and Aragats, Armenia. These projects presented real challenges as the WMO procurement unit in Geneva awarded local contracts for the work. In such cases the Implementation Manager arranged to meet with potential contractors during site survey missions.

The observing networks for ocean or on coastlines, as well as for the hydrological water cycle or for the cryosphere, also need to be improved. But it is not often easy to find the right partners for those projects, as the ocean and terrestrial observing community is more heterogeneously organised than that of the meteorological, atmosphere-observing community.

TACKLING PROBLEMS WORLDWIDE

In the easier cases new instruments are simply provided, but in more complex cases, such as in Madagascar, the UK Met Office is again assisting by managing the project to renovate 11 GSN stations. In Angola, a GCOS technical subcontractor based in Africa provides actual onsite assistance for the renovation of the eight GSN stations there.

The GCM has tackled the easier problems first and now some of the renovations that are needed include a complete revamp of the telecommunications capability in Zambia; a new telecommunications capability, including lightning protection, between the headquarters in Kinshasa, Democratic Republic of Congo, and WMO`s Global Telecommunication System (GTS) hub in Brazzaville, Congo; and the replacement of instruments at four stations in Cuba.

The Implementation Project Manager is also working to define similar projects in Central African Republic with the hope of establishing additional GSN stations there.

TRAINING FOR THE FUTURE

Station renovations are not the only means that have been employed to improve the operation of the GSN and GUAN networks. Training sessions have been organised. For example, all GUAN station operators in Africa received training in correct upper air observing techniques at a workshop organised in Windhoek, Namibia, and several workshops to teach the preparation of the monthly CLIMAT message have been conducted.

Technical Support Projects have also been used to provide specific assistance to stations within the region covered by the contract. Such a project has existed in the Pacific region for several years, which is funded by the US GCOS Program office and operated by the New Zealand Met Service. Similar projects have been used in South and Central America and the GCM has tried to establish such a contract in Africa but so far has found no capable suppliers. These contracts permit direct assistance to countries including repairing equipment, site inspections and training.

In addition, a network of Lead Centers for GCOS has been established so that the GCM has a more local presence around the world. Lead Centers are responsible for the stations within their respective region, which bridges many language and cultural differences. The Centers convene at a coordination meeting/ workshop every two years, the last of which took place in Hamburg, Germany, in October 2011.

Ultimately, these efforts have resulted in much better operating networks. For the GSN, the current reception rate is above 90 per cent, and all of the GUAN stations are now capable of operating. The GCM currently comprises representatives from the US, the UK, Switzerland, The Netherlands, Canada, Spain, Germany, and Japan. And, thanks to their generous donations to the GCM over the years, these improvements have been made possible.

www.gcos.wmo.int

GCOS
GLOBAL CLIMATE OBSERVING SYSTEM

Supporting ocean safety

Vice-Director of the Cyprus Oceanography Center **Dr George Zodiatis** outlines the role observing and forecasting systems play in improving oceanographic research and management in the Mediterranean

The Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) has been in use since 2002. What progression and growth has been made by the system over the past decade?

CYCOFOS consists of both Marine Core Service and Marine Downstream Services, and is the first operational coastal forecasting system used in the Mediterranean. CYCOFOS is improved, validated and consolidated constantly following the methodologies developed and implemented within several EU projects, including the Mediterranean Forecasting System Towards Environmental Predictions (MFSTEP), Marine Environment and Security in the European Areas (MERSEA-strand 1 and MERSEA-IP), European coastal-shelf sea operational observing and forecasting system (ECOOP), MyOcean and MyOcean2 (see p9).

Today, CYCOFOS provides high spatial (1 km), and temporal (three-hourly), resolution operational daily forecasts not only for the coastal and Exclusive Economic Zone (EEZ) of Cyprus but also in the entire Levantine Basin for sea currents, temperature salinity and sea level assimilating *in situ* data obtained by our gliders and from other observing platforms in the area. Moreover, CYCOFOS provides predictions of the wave and tide parameters both in the Mediterranean and the Black Sea, while recently also providing wave energy predictions in the Levantine. CYCOFOS delivers *in situ* observation from our gliders, the CYCOFOS OCB buoy and our mooring profiler, a network of coastal monitoring platforms, as well as satellite remote sensing SST data from our new ground HRPT receiving station, and satellite data from other platforms.

What was the purpose and inspiration behind the creation of the MEDSLIK oil spill model?

The response to an oil spill or a search and rescue incident requires a range of measures and equipment. The success of such a response depends on the prediction of the movement and weathering of the oil spill or moving of the floating object. Such predictions may be obtained through the application of the MEDSLIK oil spill and floating objects models to forecast where the spill or floating object will move, how soon it will get there, which resources are threatened and what it will look like when it arrives. MEDSLIK is a well-established operational system for oil spill and floating objects predictions in European seas, such as the Mediterranean, the Black and Baltic.

The motivation for the development of the MEDSLIK model was the 'Sub-regional Contingency Plan for preparedness and response to major marine pollution incidents in the Mediterranean', an EU Life project in 1998, due to the permanent high risk of an incident in the Mediterranean, which is greatly associated with the heavy traffic of maritime transport and with the coastal and offshore installations related to the oil industry.

Pioneering ocean monitoring

The management of the Mediterranean's marine environment represents a huge challenge to stakeholders. The **CYCOFOS** and **MEDSLIK** observing and modelling tools have been developed by the Cyprus Oceanography Center to significantly advance efforts in this field

THE MEDITERRANEAN IS well known as an area where climatic signals are magnified due to its enclosed basin physiography. Changes in biodiversity within this area are taking place at a rapid pace. To address many of the challenges related to this, the Cyprus Oceanography Center, based at the University of Cyprus, is gathering data including both physical and biological parameters, which are essential for helping to predict the changes that will likely take place in the near future.

In its first decade of existence, the Center has delivered some of the most cutting-edge ocean forecasting and observing technologies in the global oceanography arena, earning it international respect. One of these technologies is the Cyprus Coastal Ocean Forecasting and Observing System (CYCOFOS) which delivers daily near real-time datasets about the Mediterranean Sea that have been sourced from both observations from gliders and computer models. Operational since early 2002, the information gathered and produced by CYCOFOS is essential for improving understanding, monitoring and managing of the

How successful has this model proved to date?

At present, MEDSLIK is in use operationally by several ocean forecasting systems via the ERO –Emergency Response Office established between MONGOOS (formally MOON) and REMPEC/IMO in cases of real oil spills incidents or during exercise of the response agencies. Moreover, MEDSLIK is being used by several centres in Malta, Spain, Italy, Israel, Algeria and Russia. MEDSLIK has been used in the frame of several EU projects such as MFSTEP, ECOOP, MERSEA- strand1, MERSEA-IP, MyOCEAN, MEDESS4MS, PREMARPOL and many others.

In what ways does MyOcean provide support for maritime safety at sea?

The Maritime Safety area encompasses marine operations, oil spill combat, ship routing, weather forecasting, defence, and search and rescue actions. Real-time data on meteorological, sea-state conditions are essential for safety and efficient operations at sea. The success of oil spill and search and rescue response also depends on the prediction of the movement of the oil or drift objects. In combination with meteorological data, MyOcean forecasts enhance the response time and efficiency at a regional scale. At sub-regional and local scales the downscaling of MyOcean products is required to provide more detailed and higher spatial and temporal resolution marine information, in order to assist the response agencies in maritime incidents.

How do the CYCOFOS and MEDSLIK projects use MyOcean data to monitor and forecast ocean activity?

MyOcean provides marine information which is of primary importance for the downstream applications, such as maritime safety response. CYCOFOS uses the MyOcean products to provide higher resolution ocean forecasts in the Cyprus EEZ and the Levantine Basin, Eastern Mediterranean. CYCOFOS and MEDSLIK are two of the first downscaled and downstream systems in Europe, with products including oil spill and floating object trajectory predictions. Moreover, the MEDSLIK system has been adapted for use directly with the ocean products from MyOcean regional forecasting systems focused on the Mediterranean, Black and Baltic Seas.

The Cyprus Oceanography Center operates a fleet of two gliders in the Levantine basin since 2009 collecting data from surface down to 1,000 m. The datasets are transmitted via satellite and used for assimilation to improve the CYCOFOS ocean forecasts in the region.

Mediterranean's marine environment, from both a natural resource perspective and for marine safety administration.

FORECASTING AND OBSERVING

CYCOFOS has been developed as one of the core components of the Mediterranean Oceanography Network for the Global Ocean Observing System (MONGOOS), which functions to deliver a consolidated monitoring and forecasting system across the Mediterranean marine area and then integrate that into the European oceanography capacity (EuroGOOS). It also represents the contribution that Cyprus makes to the Global Monitoring of Environment and Security in Europe (GMES). Dr George Zodiatis, Vice-Director of the Cyprus Oceanography Center, explains that the major functions of CYCOFOS include the use of numerical models and monitoring platforms to obtain hydro-dynamical data in the Levantine Basin, data that helps predict the fate of pollution or oil spills, providing sea state forecasts and other biochemical parameters and fostering the education of scientists from Cyprus and abroad on the use of instruments, data and models. This observing and forecasting system offers a range of marine core and downstream services that support European agencies which deal with oil spill and pollution incidents as well as search and rescue operations throughout the Mediterranean Sea.

The team responsible for delivering the CYCOFOS technology has also been developing MEDSLIK, an advanced 3D oil spill model. The idea behind this model was to enable the prediction of oil spills in the Mediterranean Sea, including subsurface oil spills, how the oil would move, in what ways it would weather where and when it would finally end up. Coupling this with the CYCOFOS, as well as MONGOOS and MyOCEAN (see p9) forecasting data, and satellite SAR data detecting possible oil spills has enabled the MEDSLIK to deliver precise predictions in near real-time information. The physical parameters of over 200 hydrocarbons held in the Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea's database were added into the model to ensure wide coverage of all possible oil types spilt. This model has proven to be particularly useful for improving oil spill preparedness in the entire Mediterranean Sea, and beyond.

TECHNOLOGY SUPPORTING MANAGEMENT DECISIONS

The modelling technology is important to support marine safety and oil spill response teams to more effectively manage and control significant oil pollution incidents. The efforts by the Center and its partners mean that operational oil spill predictions using satellite SAR data in the Mediterranean Sea can be quickly delivered during an emergency situation. MEDSLIK has already proven itself to be invaluable during real oil spill incidents, including the 2007 spills in the strait of Gibraltar and the 2008 Adriatic Sea oil pollution events. "The successful MEDSLIK implementation during the Lebanon oil pollution crisis in the summer of 2006 demonstrates the benefit of having an operational forecasting system in place," observes Zodiatis. "The predictions from

CYCOFOS

OCEAN MONITORING PLATFORM

OBJECTIVES

To promote the operational oceanographic forecast and monitoring on local and sub-regional scales in the eastern Mediterranean Levantine Basin.

PARTNERS

INGV, Italy • **University of Athens**, Greece • **IOLR**, Israel • **IFREMER**, France • **HCMR**, Greece • **OGS**, Italy • **ENEA**, Italy • **MERCATOR**, France • **DFMR**, Cyprus • **DMS**, Cyprus • **EuroGOOS – European Global Ocean Observing System** • **MONGOOS – Mediterranean Oceanography Network for the Global Ocean Observing System** • **IOC – Intergovernmental Oceanographic Commission** • **IODE – International Oceanographic Data and Information Exchange** • **IOI-UM**, Malta • **CNR**, Italy • **ENEA**, Italy • **MERCATOR**, France • **IFREMER**, France • **CSNET**, International, USA • **PUERTOS Estados**, Spain

FUNDING

EU projects including: MFSTEP, MERSEA Strand 1, ECOOP, MERSEA-IP, MyOCEAN, GROOM, MyOCEAN2, MEDESS 4MS, PREMARPOL

National projects including: E-Wave, YPOKINOUMODA, IParallel

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DR GEORGE ZODIATIS has over 25 years of experience in oceanography of the Mediterranean. In the last decade he has been involved in the development of operational oceanography in the region, related to downscaled and downstream numerical forecasting and observing systems which led to CYCOFOS.

this model using the MONGOOS/CYCOFOS products made it possible to give ground truth to the greatest oil spill pollution ever seen in the Eastern Mediterranean."

PRESERVING MEDITERRANEAN MARINE SAFETY

Along with a range of partners, the Cyprus Oceanography Center is participating in the development of an innovative system intended to support the prevention of maritime risks, improve safety at sea and protect the natural environment in the Mediterranean area. Known as Mediterranean Decision Support System for Marine Safety, or MEDESS-4MS, which is co-financed by the European Regional Development Fund under MED programme, this novel service is designed as an integrated real-time multi-model oil spill prediction system. Zodiatis describes how the implementation of MEDSLIK implementation

> All forecasting systems and models that are run operationally on a daily basis are pieces of the puzzle that scientists compose to gain a broad image of the state of the Mediterranean

during the EU MERSEA-1, MERSEA-IP, ECOOP and MyOCEAN projects allowed the Levantine Decision support system – LEV DESS system 4 MS to be developed. "The latter has initiated the efforts to establish the MEDESS-4MS system jointly with other regional partners, aiming to assist the response agencies in the implementation of the EU Directive 2005/35 regarding the identification of polluters".

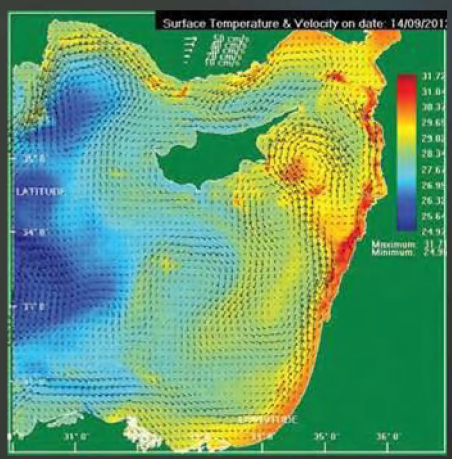
The vision behind the MEDESS-4MS service is the integration of the existing national ocean forecasting systems with the MyOCEAN GMES Marine Core Service. This will provide an interconnected network for data archiving from forecasting systems and monitoring platforms and facilitate access to this data, by harmonising the well established oil spill models the region. A unique web portal will offer a range of service scenarios, multi-model data access and interactive capabilities to suite the needs of REMPEC, EMSA and generic users. MEDESS-4MS will essentially support the marine emergency agencies to improve their response plans and help reduce marine pollution and its impact in the Mediterranean.

PREDICTING ENVIRONMENTAL CHANGE

The technologies created by the consortium have been indispensable for providing a more realistic estimate of the marine environment and what is happening in near real-time at a high resolution. All forecasting systems and models that are run operationally on a daily basis are pieces of the puzzle that scientists compose to gain a broad image of the state of the Mediterranean, and, of particular concern to the Cyprus Oceanography Center, the Levantine Basin," states Zodiatis.

One of the most successful consequences of this group's work is that they can now provide high spatial and temporal resolution forecasts and near real-time observations in the Exclusive Economic Zone of Cyprus and the Levantine Basin on a daily basis. These have proven essential for enabling effective management decisions to be made, as Zodiatis highlights: "We have collected more than 3,000 deep profiles of water properties using our ocean gliders in the last three years. This data is giving us a very detailed picture of some of the features in our seas, compared to the ship-based observations". Having a fully operational marine core oceanographic forecasting system in place is essential if Europe is to be in a strong position to respond in a fast and effective manner to major maritime incidents like oil spills. Finally, it is also critical to ensure that EU agencies have access to the most up-to-date oceanographic and marine information to support robust policy development.

FIGURE 1. The CYCOFOS provide three-hourly daily predictions for the next four to 10 days on a daily basis, using MyOcean regional forecast for its high resolution downscaling predictions. The CYCOFOS predictions are used for the MEDSLIK oil Spillane floating object predictions.



Balancing global climate research

Despite its role as the Southern Hemisphere equivalent of the Gulf Stream, the Agulhas Current has received little international attention until recently. **Professor Rainer Zahn** discusses research into the phenomenon

Over the last 10 years, the greater Agulhas system around southern Africa has stirred curiosity in many researchers. What knowledge has been gained about the transportation of heat and salt from this area?

The Agulhas Current carries warm and salty tropical waters from the equatorial Indian Ocean to the tip of Africa. This occurs at a rate similar to the water transported by the Gulf Stream in the North Atlantic, and the associated heat and saltwater transports have implications for the local climate and the world ocean circulation. Reconstructions of the Agulhas Current show that over the past several hundred thousand years the water transport from the Indian Ocean to the Atlantic, the so-called Agulhas leakage, strengthened substantially during periods of global climate changes. These observations underscore the sensitivity of the Agulhas Current and suggest a key role of the Agulhas leakage in global climate developments.

Who comprises the GATEWAYS consortium, and what skill sets are brought to the table by your interdisciplinary group?

The GATEWAYS consortium consists of scientists from Spain, Germany, Israel, The Netherlands, the UK and South Africa and forms an interdisciplinary partnership of physical oceanography, ocean and atmospheric numerical modelling, and paleoceanography and paleoclimatology. Analytical skills encompass laboratory-based methodologies, high-resolution climate modelling, and advanced numerical data processing techniques.

How are members of the project redefining ocean reconstructions and climate models? Is the team using any particularly unique or interesting methods for collecting data?

The project is innovative because it combines new and established analytical methodologies not normally available in single research projects; it links modern ocean and climatic processes with the analysis of materials collected from water column sampling and sediment traps in order to verify the degree to which the collected materials represent ocean processes. The research work applies coherent analytical protocols on a wide range of materials and links marine with terrestrial palaeoclimatic expertise to perform the often postulated, while rarely conducted, land-ocean palaeoclimatic linking.

Finally, the project combines these procedures with state-of-the-art numerical modelling that employs palaeoclimatic data fields to cutting-edge high-resolution modelling. Model runs of this quality require supercomputing facilities, and modellers do not normally feel encouraged to apply these models in palaeoclimatic research. Hence GATEWAYS establishes an interdisciplinary collaboration of a dimension seldom taken up in climate research.

What will your research mean for current Intergovernmental Panel on Climate Change (IPCC) models used to predict the next 100 years of climate change?

IPCC activities so far have focused largely (but not exclusively) on the ocean and climate regimes of the North Atlantic region because these are considered particularly sensitive and therefore a prime region to monitor the effects of ongoing global warming. The Southern Hemisphere regime, however, has long been ignored. GATEWAYS research focuses on the major ocean current system in the Southern Hemisphere and its role in and impact on ocean circulation and climate.

The Agulhas water transports and leakage cause a positive density anomaly in the South Atlantic that is approximately an order of magnitude larger than the negative density anomaly currently observed in the subpolar North Atlantic. Assessing the dynamics of the Agulhas system therefore provides important constraints on the sensitivity of the Atlantic meridonial overturning circulation (AMOC). Credible forecasts of Atlantic overturning changes and associated climate change can no longer ignore Southern Hemisphere processes.

Finally, what more can be done to promote awareness about the residual effects of the Agulhas Current on climate change?

Global climate change has outstanding visibility in the media owing to its immediate societal, economic and political significance. But the processes involved with global change are complex and proceed on multiple levels, making it difficult to convey the details to a wider non-specialist audience. The general public deserves a realistic description, in simple yet scientifically adequate words, of the processes involved in climate change. The Agulhas system is one such regime that exemplifies the climatic relevance of ocean circulation and its dynamic linking with global climate.

Modelling the southern hemisphere climate

The Agulhas Current has a profound effect on both the regional climate in southern Africa and the global ocean circulation. **GATEWAYS** is using cutting-edge modelling techniques to generate important insight on the system

THE AGULHAS CURRENT is the major western boundary current of the Southern Hemisphere, carrying water from the tropical Indian Ocean along the east coast of southern Africa. The Current impacts eastern and southern African climates and forms a key component of the global ocean 'conveyor' circulation. It controls warm water return flow to the Atlantic Ocean that compensates for the renewal of deep water in the subpolar North Atlantic and its export to the rest of the world Ocean. As such, it is increasingly recognised as a key player in ocean thermohaline circulation, feeding into the upper arm of the Atlantic meridional overturning circulation (AMOC) through the leakage of warm, saline waters from the Indian Ocean to the Atlantic.

Unusual dynamics pervade the motion of this warm-water current: as it moves west around the southern tip of Africa, it is retroflected back east by its own inertia (so-called vorticity) and the westerly winds offshore the tip of South Africa. Not all waters are captured by this sudden diversion of course – parts of the Agulhas Current leak away into the South Atlantic Ocean. Meanders, triggered by anticyclonic eddies deriving from the Mozambique Channel, propagate downstream with the current. On reaching the area of retroflection, eddies called Agulhas rings spin off into the South Atlantic.

COMPUTER MODELLING IS A BACKBONE OF THE GATEWAYS PROJECT

This leakage of Agulhas water at the southern tip of Africa causes a salt anomaly in the South Atlantic that influences the AMOC, including the strength of the Gulf Stream, thus affecting the climate in the Northern Hemisphere.

Modern observations and direct measurements show that Agulhas leakage is increasing under anthropogenic climate change. Computer simulations predict an increase by 25 per cent over the next 100 years, which could stabilise the AMOC at a time when global warming and accelerated melting of polar sea ice is predicted to weaken it. Model simulations suggest that a persistent change in leakage could impact the thermohaline properties of the Atlantic, changing its stratification and its potential for deep convection, thus altering the AMOC to a new stable state over a period of several hundred years, with direct implications for climate.

MODELLING AND RECONSTRUCTIONS

Despite increasing recognition of their significance, the dynamics and sensitivity of these mechanisms are not well understood. Numerical modelling combined with palaeo- and modern observations provide the insight to identify the controls that define the Agulhas system behaviour in a warming climate. Professor Rainer Zahn, from the Autonomous University of Barcelona in Spain, is leading an international initiative called Multi-Level Assessment of Ocean-Climate Dynamics: A Gateway to Interdisciplinary Training and Analysis (GATEWAYS). The project is funded by the EC FP7 Marie Curie ITN scheme and uses modern observations, ocean reconstructions and climate modelling to examine the dynamics of the Agulhas Current and its relationships with climate.

GATEWAYS tests the sensitivity of the Agulhas Current to changing climates of the past, the Current's influence on southern African climates, buoyancy transfer to the Atlantic

CORING OPERATIONS WITH THE FRENCH RV *MARION DUFRESNE* AT THE AGULHAS PLATEAU OFF THE TIP OF SOUTH AFRICA (APPR. 41°S)

by Agulhas leakage around southern Africa and modulation of the Atlantic circulation by the leakage. "These processes cannot be detected in oceanographic datasets from direct measurements, owing to the high degree of variability of the AMOC that makes it difficult to confidently isolate the various factors that drive the Atlantic circulation," Zahn explains. "This puts the onus on numerical modelling and reconstructions of Agulhas leakage and associated changes of the Atlantic circulation in the past." Embedding high-resolution Agulhas modules into global models, in conjunction with atmosphere-ocean simulations, allows for the assessment of impacts of the Agulhas regime on global oceanic and atmospheric circulation.

THREE KEY QUESTIONS

There are three key questions related to Agulhas Current dynamics and sensitivity. Firstly, how does the Agulhas Current react to shifts in wind fields and regional ocean fronts? Answering this enables understanding of the primary force driving the Agulhas Current along the eastern shores of southern Africa and the impacts that the ocean climatology south of Africa exerts on the Current. The next question is how such changes affect the Agulhas leakage into the Atlantic. This is connected with the role that the

LABORATORY ANALYTICAL WORK PROVIDES THE DATABASE FOR THE GATEWAYS PROJECT

mid-latitude westerly winds and the cold-water belt around Antarctica and its border with the warm water sphere of the subtropical South Indian and Atlantic Oceans play in controlling the Indian-Atlantic water transport. The final question is whether the leakage does indeed perturb the AMOC. This addresses the central hypothesis that the water transport from the Indian Ocean to the Atlantic generates a density perturbation and sub-surface ocean waves that ultimately impact the strength of deep water formation in the subpolar North Atlantic, with far-reaching consequences for a range of oceanographic and climatic processes.

DATA-MODEL INTEGRATION

GATEWAYS is structured into five Work Packages (WPs). In WP1, researchers are determining long-term variations of ocean climatology off Southeast Africa and sensitivity to regional and far-field forcing. WP2 is assessing Indian-Atlantic gateway dynamics, inter-ocean buoyancy transports and AMOC sensitivity. WP3 concentrates on terrestrial palaeoclimatology, evaluating connectivity between marine variability and southern African climates. WP4 is combining modern ocean observations with proxy formation and dynamics. Tasks include determining ocean variability and the impact on water column properties and proxy formation and integrating *in situ* instrumental observations of surface-ocean, thermocline and bottom water climatology with time series of particle settling fluxes. Finally, WP5 arranges the GATEWAYS project coordination and WP6 is dedicated to project synthesis and dissemination of results.

The research employs a range of numerical and laboratory-based analytical techniques that are centred on ocean climatology and sensitivity. Laboratory protocols involve stable and radiogenic isotope analysis, quantitative micropaleontology, molecular biomarker analysis and sediment component analysis. Long-term observations from ocean moorings provide the basis for data versus water column calibration. Advanced statistical data processing establishes modes of variability and co-variation between the different components of the Agulhas system, and with global climatic drivers. Data-model integration provides the framework for the dynamical evaluation of the project database.

TRAINING AND STRENGTHENING PARTNERSHIPS

GATEWAYS is offering training to 15 Early-Stage (ESR) and three Experienced Researchers (ER) in paleoceanographic reconstructions and ocean and atmosphere modelling. It provides extensive multi-level scientific and complementary skills training. "The impact of the project lies with its methodological innovation in combining established and new complementary laboratory and data analysis with cutting-edge high-resolution modelling," Zahn enthuses. "The skills resulting from the project training and research provide a firm foundation for the trainees' onward development."

Training encompasses novel laboratory-based methodologies; high-end equipment such as isotope-ratio and multi-sector inductively coupled plasma mass spectrometers; and high-resolution climate modelling, accessing supercomputing facilities at high-performance computing centres. Combined with the diverse scientific expertise converging on a common scientific theme, this provides the ESR and ER with outstanding research training opportunities. Trainees are also developing transferable skills in networking, languages and inter-institutional cooperation, and project management. Beyond the direct benefits of its training and research programme, the GATEWAYS project strengthens partnerships between the research teams, placing their expertise into a common logistical framework and embedding them into formalised partnerships.

INTELLIGENCE

GATEWAYS

OBJECTIVES

To conduct interdisciplinary climate change research on an ocean regime of regional and global significance: the Agulhas Current off southern Africa. It provides 15 early-stage and three experienced researchers with extensive multi-level scientific and complementary skills training in a number of processes relevant to climatic developments and projections.

PARTNERS

Royal Netherlands Institute for Sea Research (NIOZ), The Netherlands • **Cardiff University**, UK • **Helmholtz-Zentrum für Ozeanforschung Kiel (GEOMAR)**, Germany • **Vrije Universiteit Amsterdam**, The Netherlands • **Christian-Albrechts-Universitaet zu Kiel**, Germany • **University of Cape Town**, Republic of South Africa • **Geological Survey of Israel**, Israel • **Climate Risk Analysis – Manfred Mudelsee**, Germany • **Alfred Wegener Institute for Polar and Marine Research**, Germany • **University of Bremen (MARUM)**, Germany • **Hebrew University of Jerusalem**, Israel • **L-UP Project Management and Training**, France • **Simultec Environmental Consulting Zurich**, Switzerland • **EMDESK GmbH Website and Project Management**, Germany

FUNDING

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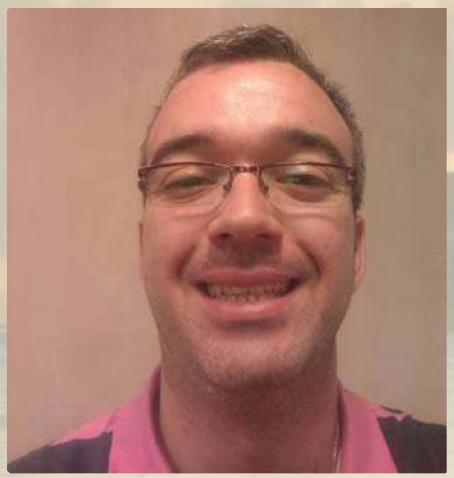
DR RAINER ZAHN is Professor at the Institució Catalana de Recerca i Estudis Avançats and holds affiliations with the Institute of Environmental Science and Technology and Department of Physics at the Universitat Autònoma de Barcelona. He has over 30 years of experience in marine climatology.

A beacon for maritime surveillance

Our seas have never been busier, with transport and trade requiring huge surveillance efforts. **Dr Gerard Margarit Martín** is coordinator of the NEREIDS consortium, which aims to produce a novel intergrated vision of maritime surveillance to benefit the wide range of domains affected



First, could you outline the context from which the New Service Capabilities for Integrated and Advance Maritime Surveillance project (NEREIDS) has emerged?

NEREIDS was conceived to provide solutions to a set of technological challenges that have yet to be overcome. It follows on from a set of projects promoted at the beginning of the last decade that aimed to enhance the capabilities of reported-based maritime surveillance systems. Before this, Earth Observation (EO), Synthetic Aperture Radars (SAR) and optic sensors boarded on satellites were the preferred options due to the large coverage and scene independence they offer.

How do you plan to provide an integrated vision of maritime policy and surveillance to benefit the different domains involved?

Classical monitoring systems based on reporting sensors have not exploited the information that EO technologies can provide. NEREIDS aims to change this situation by permitting the joint usage of report-based streams with EO-derived imagery. The result will provide an integrated picture containing sufficient information for tackling the different maritime domains. Transparency plays a vital role as users must use the available information independently from the origin of the data.

What challenges have you faced while coordinating NEREIDS?

NEREIDS accounts for a diversified consortium that covers large firms, Small and Medium Enterprises (SMEs), universities, scientific agencies, users and European agencies. The goals, as well as the outcomes, of all of them are very different.

For example, large firms need to gain a competitive position to be involved in the implementation of maritime surveillance systems; SMEs want visibility to achieve continuity in this type of European project. In parallel, universities want to keep their research lines alive so that they can justify their activities at local level.

How do you strike a balance between these diverse sectors?

The needs are focused to assure that the research activities provide a practical outcome that can be exploited in real scenarios. Merging these visions is not straightforward and a balance should always be pursued. The main goal is to make the partners understand that they need to relax their requirements and needs so that NEREIDS can satisfy the expectations of all the actors involved in maritime surveillance.

At what stage is the project at present?

We are currently at the conclusion of the theory stage: publishing a set of reports that tackle user requirement engineering and consolidation; the review of the state of the art; the description of the theoretical algorithms to be used; the design of system architecture, interfaces and standards; and the execution of management and dissemination activities.

How is the project funded? Has support been merely financial or have you benefited in other ways?

The project is funded under the 2010 Space Seventh Framework Programme (FP7) call issued by the European Commission in July 2009. The financial scheme is co-financed so that the consortium assumes part of the budget and the Commission, the remaining part. According to the type of entity (SME, large firm, public authorities, etc.) the co-financing scheme varies. Therefore, the development of these projects needs significant R&D investment from all entities in the consortium.

Are plans in place to ensure NEREIDS has a legacy that lasts beyond the current funding period?

NEREIDS is conceived to enable the transition from theoretical concepts to practical and operational services by developing the bases of the system. It is an essential element of the implementation of a complete, fully-operational and advanced maritime surveillance system working at European level. An effectively functioning system would permit authorities to have an invaluable tool with which to apply the mandates they are responsible for. Most of them are related to law verification so that security threats would be avoided, ensuring a comfortable quality of life for all citizen. The impact at European level is therefore enormous and the consortium is doing its best to fulfil the main goals which NEREIDS has been granted for.

How can industry and academia work in greater harmony to drive innovation with real societal benefits?

'Technology transfer' is the key phrase here. Academia has to assume that product development, publishing and dissemination should be a in duty of industry, while industry has to assume that academia needs the enough funds to conduct the different research lines.

Decoding maritime surveillance

Maritime surveillance is a subject of interest for all nations. **NEREIDS** aims to provide an integrated vision of maritime policy and surveillance to tackle the scientific challenges that the industry is currently facing

THE MARITIME DOMAIN supports an estimated 90 per cent of world trade and is therefore a crucial element of the global economy. With such vast levels of traffic on our seas, surveillance is necessary to ensure the movement of people and goods is safe and complies with international and national laws. Some of the challenges maritime surveillance is currently facing include illegal trafficking, illegal immigration, fisheries control, border surveillance and traffic monitoring. Addressing the needs of these different domains is the New Service Capabilities for Integrated and Advanced Maritime Surveillance project (NEREIDS). The project has been developed to provide an integrated vision of maritime policy and surveillance, so that innovative space and non space capabilities, techniques and methodologies can support the various maritime domains.

From a technological standpoint, this means enhancing integrated, automatic and unsupervised ship monitoring service capabilities for maritime situational awareness and, in turn, supporting advanced and efficient decision-making tools. This will be tackled by integrating advanced solutions based on Earth Observation, transponder-based tracking and *in situ* monitoring.

NEREIDS is currently addressing pre-operational services in the following areas: detection of small targets with low reflectivity; detection with adverse meteorological conditions; robust target categorisation; advanced data fusion with added-value features; and anomaly detection and analysis. One of the key challenges is to ensure diverse theoretical algorithms are effectively translated into something operational. In doing so, the project's activities will directly contribute to the aims of the European border surveillance system (EUROSUR), and the goal it sets out for achieving effective maritime awareness: "Detecting anomalies that may signal illegal acts and generating intelligence that enables law enforcement authorities to stop unlawful entry into the EU area".

SERVICING A BROAD FIELD

Dr Gerard Margarit Martín, Project Coordinator for NEREIDS, believes the main beneficiaries of the project will be national authorities, police corps, navies and European agencies and explains how the challenges differ for each group: "National authorities are mainly interested on monitoring illicit activities, such as illegal immigration or custom dealing, whereas European agencies require a more global vision of the scenario and they are normally orientated to traffic monitoring of medium/large targets in extended temporal and spatial ranges".

Today, the picture of maritime surveillance and monitoring is becoming less complex due to the strategy of a joint exploitation of the available resources combined with the deployment of interoperable nets. The design of a maritime surveillance system will be linked to an engineering analysis of user requirements. While some users are covering intensive surveillance campaigns focused on short durations of time, others with continuous monitoring mandates will require uninterruptible control activities.

SERVICE-ORIENTATED ARCHITECTURE

The NEREIDS working group has conceived an architecture based on the Service-Orientated Architecture (SOA) paradigm, which permits managing distributed capabilities that may be under the control of different ownership domains and implemented using various technology stacks.

The SOA-based solution appears to be efficient for working with geographically distributed and heterogeneous resources – a necessity given the nature of maritime surveillance where data providers require their own systems that can develop basic data pre-processing and can arrange the opportunity and acquisition plan of the different EO resources.

In addition, different entities can collaborate with NEREIDS participants to develop specific applications and features. With SOA architectures, the integration of such external

NEREIDS

NEW SERVICE CAPABILITIES FOR INTEGRATED AND ADVANCED MARITIME SURVEILLANCE

OBJECTIVES

To provide an integrated vision of maritime policy and maritime surveillance so that the different elements of the service become useful to the different maritime domains (Illegal trafficking, illegal immigration, fisheries control etc.) The project seeks to develop a system of systems that permits a complete and meaningful maritime picture and permits solving the most challenging technological drawbacks that current services have to face.

PARTNERS

GMV-AD, Spain • **eOsphere Limited**, UK • **Aratos Technologies S.A.**, Greece • **Joint Research Centre**, EU • **Universitat Politecnica de Catalunya**, Spain • **Research Centre of the Slovenian Academy of Arts and Sciences (ZRC SAZU)**, Slovenia • **GMVIS-SKYSOFT**, Portugal • **TNO**, The Netherlands • **NATO Undersea Research Centre (NURC)**, IO • **Thales Communications and Security S.A**, France • **Fraunhofer Institute for Communication, Information Processing and Ergonomics (FKIE)**, Germany • **European Union Satellite Centre**, EU • **Advanced Computer Systems S.P.A**, Italy • **Guardia Civil**, Spain • **Active Space Tech**, Germany • **Aerospace Innovation**, Germany

FUNDING

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GERARD MARGARIT MARTÍN received his PhD in the field of Communication and Information Technologies in 2007 from UPC, Barcelona. Since 2008, he has been enrolled at the Payload Data Processing and Applications (PDPA) business unit of the private Spanish firm GMV Aerospace and Defense. His current research interests are in the fields of radar image processing techniques, SAR simulation in multiple scenarios, wind and ocean current mapping and SAR applications in forestry and agriculture.

plug-ins is straightforward and only needs the adoption of specific libraries to reach the resources managed by the system.

ADVANCED IMAGE PROCESSING

One of the key elements of the NEREIDS system will be the algorithms tackling image processing. State-of-the-art imagery shows mature procedures that can detect most of the metallic targets at high seas, but issues appear when the targets of interest are small, wooden and sailing close to the coast. Atmospheric influence also plays a vital role for the case of optical imagery.

NEREIDS has experience tackling the main limitations in ship detection. It has developed algorithms based on wavelet processing, polarimetric and/or interferometric analysis, super-resolution techniques and image segmentation. The first three are suited to work with SAR images while the latter with optical ones. Wavelet processing works with the concept of scene texture. The information texture for ships, sea and land in SAR images differs after which a proper mathematical manipulation permits a clear isolation of the targets in the scene.

> The collaborators have vast experience in data fusion from both practical and theoretical perspectives

These practices will be put into effect as early as autumn 2012 in West Africa: "The maritime domains under study will be border surveillance for taking a pre-frontier picture of illegal immigration and custom dealing, traffic monitoring for monitoring illegal fishing and piracy," Margarit explains. "If a pre-frontier alert is provided to authorities, they would have adequate responsiveness time to deploy the proper resources in order to follow up the activities."

ADDED VALUE PROCESSING

Eosphere has developed a new detection methodology that makes novel use of the polarimetric representation of targets. In its current form the algorithm can be considered as a negative filter focused on the sea. Another recently-presented alternative proposes the usage of spectral estimators to locate punctual complex targets in SAR images. The idea consists of applying azimuth defocusing to refocus the image based on the spectral estimation theory.

The processing applied to images can be complemented with added-value capabilities. Examples are data fusion with collaborative sensors, track delineation and reckoning (estimation) based on ancillary information, anomaly detection and decision-making support.

The collaborators have vast experience in data fusion from both practical and theoretical perspectives. One of the most relevant results is the implication of GMV in the development of the Data Fusion Module that EMSA will use into its MarSurv system. Its main features are independence from the scenario conditions, track delineation and reckoning features, correlation features and data filtering, and a consistency checker.

First tests have now been conducted with FRONTEX and EUNAVFOR with positive feedback. Regarding anomaly detection, TNO has detailed some studies aimed at evaluating the behaviour of vessels in specific areas of interest. The output are maps of most probable corridors in which the vessels can cruise. This would be the base for introducing intelligence into data fusion and decision-making systems. This information would permit more accurate track estimations as well as more accurate tactical and strategic operations conducted on the sea.

CHALLENGING BUT ACHIEVABLE GOALS

The NEREIDS consortium has the competitive knowledge and experience not only to meet but also to exceed the main goals of the project. Theoretical studies conducted in the past assure success in developing the scientific challenges that maritime surveillance constantly faces. The goals that are fixed in NEREIDS are challenging, but they are needed in order to make an important step forward in the usage of Earth Observation means within maritime surveillance. This would have further repercussions in mission exploitation, their social impact, and finally and in the proposal of new missions with more advanced capabilities.

Intergovernmental Oceanographic Commission – Ocean Science section

A green future on Earth must also be a blue one. Section Head **Luis Valdés** explains how the IOC's Ocean Science section is brokering cooperation between stakeholders to maintain the health of our oceans

What are the key objectives and responsibilities of the IOC Ocean Science section? How do these objectives fit into the wider goals of UNESCO?

The IOC Ocean Science section has a key role to play as a global knowledge broker. This involves the promotion of science innovation; nurturing programmes; and transferring, disseminating and sharing information, data and knowledge, best practices, assessment and scientific services related to oceanography. All of these are done in an inclusive manner with the scientific community and in cooperation with other international institutions.

To ensure programme coherence, the ocean science activities are formulated around four IOC High-Level Objectives, which contribute to the UNESCO medium-term strategy. For the current medium-term strategy (2008-13) the high-level objectives are to:

- Prevent and reduce the impacts of natural hazards
- Mitigate the impacts and adaptation to climate change and variability
- Safeguard the health of ocean ecosystems
- Develop management procedures and policies leading to the sustainability of coastal and ocean environment and resources

A biennial work plan then details the actions to be taken in order to accomplish the goals and objectives laid out in the associated strategy.

Do you believe that coordinated international initiatives are becoming the most effective model for marine research?

International bodies and organisations are essential in developing marine projects and programmes that require international legitimacy and coordination. Clear examples to illustrate this are the research projects on biodiversity in marine areas beyond national jurisdiction, or the polemic experiments on ocean fertilisation carried out in international waters. It is important that the recent growth in international collaboration in ocean science maintains its momentum. This growth has only become possible because barriers that once prevented collaboration are being removed and appreciation for the global connectedness of the oceans is increasing.

However, there is scope for more collaboration. IOC should continue to lead at facilitating a global view of ocean science and mobilise existing global networks. We should help to strengthen existing platforms and ensure that they serve as a space for science, policy, business and society to interact in active and productive ways.

IOC Ocean science activities also contribute to enhancing scientific capabilities in developing nations, especially in Africa. Why are developing nations of primary concern with regards to scientific development and increased understanding of the effects of climate change?

We know that the lack of human and institutional capacity in ocean sciences, monitoring and management is a real barrier to developing nations, particularly for least developed countries in their efforts to achieve sustainable growth. This area has been highlighted in the Rio+20 outcome document and could lead to the development of a global strategy for building national and regional capacity in ocean management.

The IOC Ocean Science section is mainly involved in activities related with coastal erosion and adaptation to climate change. At a higher level, we conduct leadership development courses, skills development in fundraising, and decision support tools. We can positively report that the quality of

leadership, marine science and processes to inform decision makers, have all improved wherever IOC is present.

In a recent press release the IOC stated that 'the green future must be blue. To mitigate the rapid degradation of our ocean, Rio+20 must lay out a new vision for the governance of our ocean'. Why is ocean science so central to sustainability?

There is a clear link between poverty eradication, sustainable development, and better protection and restoration of our marine habitat and biodiversity. No science means no sustainability. A green economy must benefit coastal communities in developing states who depend on a healthy ocean for their survival. Indeed, healthy oceans are essential for sustainable development for millions of people. States can derive optimal economic and social benefits from a healthy ocean whilst protecting the environment in the long term. Therefore, the concept of a green economy must be extended to blue.

Has the Rio+20 conference achieved this goal of a new vision for the sustainable governance of the world's oceans?

At the Rio+20 Earth Summit it was clearer than ever that we must all play our part to protect our oceans and the planet. Although it has produced a non-binding declaration, committing the world's politicians to modest goals, it was extremely important that it addressed and encouraged efforts to expand marine research.

The final agreement features some important issues. The Rio outcomes document, 'The Future We Want', specifically mentions the need for marine scientific research and the monitoring and observation of ocean acidification, which is excellent news for the Ocean Acidification science community. The agreement also includes a commitment to take action to reduce marine pollution from land-based sources, especially plastics, as well as persistent organic pollutants, heavy metals, and nitrogen-based compounds. By singling out plastic as one of the most problematic forms of marine debris, we will now be better able to focus on the right solutions. The agreement also included a commitment to take action on fishing subsidies and overfishing. If all these actions are implemented, it will help to reverse the decline of our oceans.

Experts discussed topics that had been nominated by hundreds of thousands of people from around the world. In the pre-voting, actions to 'avoid ocean pollution by plastics' was the number one choice amongst ocean issues, and ranked fifth among all matters. Then, in the official dialogues, hundreds of experts voted that protecting the high seas and creating an international network of marine protected areas were among the most important actions needed for our oceans. However, it was a pity that no decision was reached to negotiate a new agreement for the conservation and management of biodiversity beyond national jurisdiction.

Can you detail some of your recent achievements? Is there anything that you are particularly encouraged by?

Among our achievements we can mention the following examples:

- The implementation of a global sampling programme, such as the Global Ocean Observing System (GOOS), is very promising and allows the scientific community to offer new services in terms of climate and knowledge
- In terms of the implementation of the ecosystem-based management approach, it is encouraging that many countries from different regions in the world have adopted the Integrated Coastal Area Management (ICAM) and marine spatial planning (MSP) guidelines as a standard to follow
- The Census of Marine Life (COML) and its databank, the Ocean Biogeographic Information System (OBIS), have been instrumental in the acquisition of new knowledge and science

On the policy side we have to mention the approval by the UN General Assembly of a new reporting process for the Ocean: the UN Regular Process of reviewing the state of the marine environment, including socioeconomic aspects, which will integrate existing data and information from various disciplines at various geographic scales through a variety of habitats and climatic regions. This regular process will help us keep the world's ocean and seas under continuous review, and improve the responses from national governments and the international community to the unprecedented environmental changes we face.

IOC governs the execution of many essential activities related with the promotion and coordination of best marine science and oceanographic research. What are your main priorities for the next two years?

We have several important challenges in our portfolio. First is the successful completion of the first assessment report of the Regular Process (which will be renamed the World Ocean Assessment). Rio+20 has produced a matrix of commitments including the establishment of an Ocean Acidification observation network, which is going to be set up taking advantage of existing observation networks (such as GOOS). This is a huge and promising step forward in terms of ocean science. We have recently created a cluster of activities to study the different ocean carbon sources and sinks (these include our activities in the International Ocean Carbon Coordination Project – IOCCP). We are also taking actions to coordinate science on plastics, this is a pollutant of particular concern and we have good support from the US, the EU and associations of producers.

Lastly, how is IOC involved in outreach activities as part of the implementation of the IOC and UNESCO mid-term strategy?

IOC produces outreach materials to increase public awareness of its programmes, projects and activities. These materials include brochures, fact sheets, open public exhibitions and partnerships with other organisations, such as aquariums, museums and science centres grouped in the World Ocean Network.

Every year IOC celebrates World Ocean Day (8 June) with exhibitions on ocean instruments, observations, science and services. The most recent included a joint exhibition with the European Space Agency, the Total foundation and the World Ocean Network. We also have signed a Memorandum of Understanding with the Multi One Attitude Foundation (MOAF) to use their ocean sailing races to develop outreach activities on key ocean issues such as plastics, and recently we have also signed a MoU with the Confédération Mondiale des Activités Subaquatiques (CMAS), who will work with us in the preparation of future exhibitions on marine biodiversity.

http://ioc-unesco.org

An ERA of change

Over a decade has passed since the inception of the European Research Area, and the European Commission has recently written a detailed Communication which discusses Europe's need for further growth and development within its research infrastructure. The report hopes to achieve the objectives of the European Research Area and address the major challenges affecting today's society

THE EUROPEAN RESEARCH AREA (ERA) – a venture intended to address major challenges of the present day and promote the EU as a location of thriving scientific and technological R&D – was initially endorsed during the Lisbon European Council, 2000. The main objectives of the ERA were to: instigate a system of scientific research programmes that encompassed the EU's scientific resources in a more inclusive and multi-national approach; improve mobility of knowledge workers; and generate growth, competition and cooperation in the European research arena, as well as its industry.

The general consensus was that research carried out in countries within the EU was less competitive and failed to successfully embrace and organise the 'coming together' of all regions at European level than such areas and countries as North America and Japan. Europe must, then, turn out a research investment and improve efficiency and efficacy of its public research infrastructure. In order to achieve this, cooperation among European experts is needed to address society's Grand Challenges (eg. the ageing population, energy consumption and environmental issues). Competition is also a matter of urgency, which should enable the brightest researchers to access funding and enable Europe to become a stable competitor in the global research landscape.

European Commissioners have proposed an increase in the EU's research, development and innovation budget for Horizon 2020 €80 billion Member States are also supporting EU goals by agreeing to invest approximately 3 per cent of EU GDP into research by 2020. However, the European Council anticipates that the ERA project will need to be achieved by 2014 in the hopes of maximising the return on this research, development and innovation investment. Europe will need to advance and ameliorate the current structure of its public research system, ensuring scientific excellence and effective research collaboration are the end results.

COMMUNICATION INITIATION

The European Commission outlines its plans for finalising the ERA in a detailed Communication to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Entitled 'A Reinforced European Research Area Partnership for Excellence and Growth' and published on the 17 July 2012, the reform agenda sets out to address the key issues within the EU's research infrastructure – increasing its access, communication and connection. The effectiveness of European knowledge circulation and transfer, and improving growth and job creation, were also listed concerns on the Communication.

During the launch of the paper, five key stakeholder organisations (the European University Association, the European Association of Research and Technology Organisations, the League of European Research Universities, Nordforsk, and Science Europe) signed a Memorandum of Understanding with the European Commission. Each organisation will contribute towards achieving the ERA and optimising Europe's return investment of research and innovation. The European Commission has also outlined concrete steps for Member States to follow in order to establish and maintain the Internal Market for researchers and innovators in Europe.

According to the EC's Communication, 'knowledge is the currency of the new economy'. Given the financial state of Europe, new and improved research and innovation ideas and solutions are needed, as well as the advocacy of scientific excellence among European regions. Therefore, world-class research and innovation initiatives, which bring together researchers and resources, are paramount to stabilising and securing Europe's economy, and allowing the EU a position in the emerging global order.

THE KEY PRIORITIES

The Communication focuses on five major points:

More effective national research systems

The EC has recognised that national-level competition amongst research institutions and universities is limited in Europe, leading to poor scientific quality. The requirement to maximise value from public funding invested in research is critical, and improved practices from Member States are needed. The Communication cites that a balance between the following two approaches will enable better research performance across the EU and Member States:

- Analysing research-orientated organisations and assessing the quality of research they produce. This includes formulating peer reviews as a means of operating organisational change where applicable
- Distributing funding via open calls for proposals, in the hope that researchers will be more inclined to perform internationally. This will be evaluated by a panel of leading independent experts, both domestic and non-domestic

Optimal transnational cooperation and competition

Attempts to break down current barriers of pan-European cooperation and competition continue to restrict interoperability and partnership among national and international organisations. The level of collaboration is too low, and therefore unable to successfully resolve societal and environmental challenges. The Commission has established that conditions need to change, so that Member States can develop more robust cross-border cooperation and competition. This involves:

- Adhering to alignment projects such as the Joint Programming Initiatives agenda – jointly tackling grand challenges through synchronised calls between Member States. Not only would this ensure pan-European competition, but would also emphasise the EU's strengths and weaknesses
- Review of national funding rules for the development of public-public Partnerships in Horizon 2020
- The Commission requested that Member States implement the European Strategy forum on Research Infrastructures (ESFRI) roadmap, which outlines the development and creation of better European research infrastructures
- European Member States were also persuaded to allow cross-border and performance-related access to their infrastructure – removing legal and other barriers between borders to allow for more open reserach infrastructure/ roadmap utilisation

An open labour market for researchers

The European Commission calls for an assessment of the European research labour market, suggesting that it faces several issues, an important one being 'the lack of transparent, open and merit-based recruitment, which makes research careers less attractive and hampers mobility, gender equality and research performance,' as outlined in the EC's report. Another hindrance relates to insufficient human resources policies. These are often detrimental to the quality of career prospects for young researchers; they fail to recognise gender equality practices, social security needs, and offer little recognition for qualifications and inadequate transfer from academia to business (one in six researchers in academia has private-sector experience).

As a way of including more positive approaches to the European labour market for researchers, the EC has stated that researchers outside of Europe should also be given access to national grants and ensure cross-border portability. This should increase mobility in the labour force. Legal and administrative barriers are an important consideration regarding non-national and non-residential researchers, which is another point to be addressed by the EC. Using initiatives such as 'Money Follows Researcher' can help to resolve barrier issues and provide guidance for Member States on organising access and portability of national grants.

Gender equality and gender mainstreaming in research

Despite efforts to introduce strategies that focus on gender equality, not all Member States or stakeholder organisations have utilised policies which allow them to benefit from expert female scientists and researchers. According to the Communication, 'European research still suffers from a considerable loss and inefficient use of highly skilled women,' who remain underrepresented in a number of science, technology, mathematics and engineering (STEM) workplaces, while 'integration of a gender dimension into the design, evaluation and implementation of research is also still too limited'. Addressing this gender imbalance is a key priority of the EC.

The lack of women in leadership and decision-making positions is also a cause for concern, and data shows that in 2009 only 13 per cent of heads of higher education institutions were women, and the Commission is committed to ensuring this changes through:

- Creating legal and administrative policies and incentives to help women progress as researchers
- Working alongside partnerships, with funding agencies, research organisations and educational environments to change current gender representation

Optimal circulation and transfer of scientific knowledge

The dissemination, sharing and exploitation of scientific knowledge is crucial to generating the best research and innovation strategies from scientists, research institutions, companies and the public. Ensuring access to and transfer of existing knowledge as well as future developments or activities could improve Europe's research infrastructure; however, open access is not an equally shared ideology amongst Member States.

There are a number of obstacles preventing the smooth progression towards electronic research services, including policies which state differing 'usage' guides for publicly funded research e-Infrastructures. In comparison to the US, European knowledge transfer is still inadequate – the links between public and private sectors remain poor, and so the quality of knowledge produced and transferred among them is usually unsatisfactory. The implementation of 'open access' – providing free internet use to and from publicly-funded scientific data, publications, etc. – is high on the EC's agenda. 'We need to foster Open Innovation, links between research, business and education (the knowledge triangle) as via European Institute of Innovation and Technology and, in particular, knowledge transfer between public research institutions and the private sector while respecting intellectual property rights,' the report elaborates.

In an attempt to resolve the issues regarding open access implementation, the EC has outlined a number of appropriate changes:

- Member States will be required to organise and detail policies on open access to scientific knowledge
- Acquiring national strategies for successful implementation of electronic (e-Infrastructure) research and knowledge systems – providing transnational access to digital services
- EC will use Horizon 2020 to establish open access projects, and offer funding to projects related to open access

THE NEXT STEPS

With support from Member States, research stakeholders and transparent monitoring, the EC is hoping to develop Europe's research excellence and world-class resources. To achieve the goals of the ERA and maximise its research investment, Europe must reassess and revaluate its public research facilities, allow transnational collaboration between expert researchers and innovators, and step up as a competitive and cooperative Union. These are the key solutions to improving and developing Europe as a global research landscape.

The assessment will be reviewed in 2013, when the Commission will determine whether improvements have been made. This will be closely checked and regularly updated in order to monitor the progress of the ERA, and allow the European economy to thrive.

Decision-making in Africa

Dr Sandy Andelman
Vice President, Conservation International

Launched with a grant from the Bill & Melinda Gates Foundation, the Vital Signs Africa initiative is putting key information in the hands of local stakeholders to ensure that necessary agricultural development on the continent is not to the detriment of natural systems and the services they provide

To begin, can you outline your role as Executive Director of the Vital Signs Africa initiative? How does this fit into your wider work at Conservation International?

I am responsible for leading the design, development and implementation of the global monitoring system and ensuring its success. In short, I am creating a dynamic global network of the world's top scientists and key policy makers, all of whom are collaborating with one another to figure out how to produce enough food to feed the world's growing population without destroying the environment. The network will transcend organisational and national boundaries. The initiative fits into the wider work of Conservation International in that it supports our mission of using science to protect nature for the benefit of people.

The project has been established in an attempt to increase food security and decrease environmental degradation. What key aspects of these broad issues does the monitoring system aim to tackle?

Right now, the success of agricultural development activities is typically measured by metrics such as changes in crop yield or income, but these measures do not tell us anything about the consequences for critical environmental services, such as water availability, soil health or availability of pollinators.

What are the main priorities of the programme and by what criteria were they selected?

The system will deliver three key objectives:

- The creation of a global public good that will help to prevent unintended consequences of agricultural development and ensure it does not degrade natural systems and the services they provide
- Access to scientifically credible information to measure both the sustainability of agricultural systems, as well as its performance against human wellbeing commitments and metrics
- Access to credible, reliable and consistent data to inform wise policy and planning decisions

You stated in a recent interview that "we can no longer afford to have siloed policy and decision making, with separate decisions for agriculture, poverty alleviation or nature conservation". How does the initiative offer a streamlined alternative?

Integrated information on agriculture, ecosystem services and human wellbeing is a key ingredient in policy making, but is lacking somewhat at present. There are places where agricultural practices and outcomes are monitored, or where biodiversity and ecosystem services are tracked, or where metrics associated with human wellbeing are monitored. However, there are virtually no instances in which all three of these are measured quantitatively, in the same place and in a coordinated way. Vital Signs is providing this missing element.

Conservation International strives to promote sustainable livelihoods where agricultural production and resource conservation positively reinforce one another. Which models do you believe will help ensure that these two issues can enjoy a symbiotic relationship?

To quote the recent Stiglitz report on the Measurement of Economic Performance and Social Progress: 'What we measure affects what we do; and if our measurements are flawed, decisions may be distorted'. Those individuals and institutions taking decisions about how to increase food production are like pilots trying to steer a course without a working dashboard. The report continues: 'The decisions they [as well as individual farmers] make depend

on what we measure, how good our measurements are and how well our measures are understood. We are almost blind when the metrics on which action is based are ill-designed or when they are not well understood'. Thus better metrics – the sort that Vital Signs is providing – are key.

What key methods are you using in order to monitor these areas of land use? How will these then be evaluated?

Our aim is to build the capacity of countries worldwide to provide integrated monitoring and decision support for sustainable agricultural development. We are starting this work in Africa. Our approach is to make grants to local organisations – initially in five countries in Africa – to implement Vital Signs Africa, subject to the scientific design standards for the system. We will also provide capacity building to the extent that it is needed. The system has three layers:

- The measurements layer consists of primary observations, obtained by a smart combination of fieldworkers, automated sensors, cell phones and airborne or satellite remote sensing
- The analytical output layer integrates these measurements with those from other existing systems, by way of models and analyses, into variables that are sensitive, meaningful and continuous with respect to detecting change in important system attributes
- The decisions layer contains a much-reduced number of highly integrated 'diagnostic' indicators of system state or performance which, in conjunction with tools for trade-off analysis, can guide policy makers in their decisions on agriculture, land use and the environment

Do you believe that there is a conflict between traditional means of agriculture and modern practices? What can be learnt from traditional land use (eg. peasant agriculture), as well as from new food production technologies, in order to ensure that agricultural expansion is sustainable?

They are both unsustainable, but for different reasons. High intensity agriculture, with high nutrient inputs and grain yields greater than 10 tons per hectare, has successfully increased food production and income. But this has come at the cost, unintentionally, of diminished biodiversity and essential ecosystem services such as water supply, nutrient cycling, erosion control and flood protection, and has increased greenhouse gas emissions. Low input/yield agricultural systems, such as those in Africa, are also unsustainable, not because of excessive nutrient inputs, but because they degrade ecosystems and the essential services they provide. For instance, by depleting soil nutrients, increasing soil erosion and contributing to loss of forests through slash and burn agriculture.

Pressure to increase agricultural production has never been greater, with 1 billion people currently undernourished and demand for food production expected to increase 70 per cent by 2050. Agricultural intensification is critical to meeting the growing demand for food production. However, to prevent unintended environmental consequences of increased agricultural production – particularly in the context of climate – change is needed in the way agricultural development decisions are made and agricultural systems managed. Systems-level decision making and management require systems-level understanding. To measure and monitor the success of agricultural development activities from a systems perspective, the set of metrics needs to expand from a narrow, sector-specific set (eg. crop yield and income) to an integrative set of metrics that reflects the interconnectedness of food security, water security, climate security, ecosystem health and human wellbeing.

Smallholder farming is a key process to support when looking towards the future demands on food production. Can you outline key environmental concerns in terms of resource scarcity?

A major factor that is especially relevant for agriculture is climate change, especially the seasonal distribution of rainfall. For example, in some parts of East Africa, where farmers are accustomed to having two rainy seasons each year in which to grow crops, the so-called 'short rains' are disappearing, which means that in the future they may only have one growing season instead of two. This affects which crops they can optimally grow, when they need to plant, and how they are going to ensure that their families have enough to eat throughout the year.

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Similarly, there is a need to produce more with less. So we need to be not only asking about the yield of a given crop, such as rice, but what the yield is relative to each drop of water used in producing it.

What do you envisage as the outcomes of the project? Likewise, what do you see as the key challenges in making the initiative a success?

Our aim is to change the way agricultural decisions are made, from a narrow, sector-specific approach to an holistic one that conserves critical resources such as water, pollinators and soil health. The key outcome we envision is that agricultural development becomes more environmentally sustainable and increased yields do not come at the expense of scarce resources. Ultimately, we want to ensure that improving food production supports resilient livelihoods and enhanced quality of life for smallholder farmers, while also supporting healthy natural systems.

The biggest challenge to our success is getting key stakeholders, such as governments, large donors and the private sector, to use the system. We have to make the information and the decision tools relevant for our stakeholders if we are going to succeed.

Are there any other projects or initiatives that Conservation International is working on that you would like to highlight?

Last May, His Excellency President Ian Khama of Botswana, who is also a member of Conservation International, convened the first Summit for Sustainability in Africa. Some 10 African governments – Botswana, Gabon, Ghana, Kenya, Liberia, Mozambique, Namibia, Rwanda, South Africa and Tanzania – participated and signed the Gaborone Declaration. This is a commitment to ensure that the contributions of natural capital to sustainable economic growth, maintenance and improvement of social capital and human wellbeing are quantified and integrated into development and business practice. At Rio+20, 49 more countries and 80 private sector corporations signed up to these commitments. Vital Signs can provide the data that these governments and companies need in order to meet this commitment.

In Rwanda, the Government is creating a National Climate and Environment Fund (FONERWA) to ensure sustainable financing is accessible to support environmental sustainability, resilience to climate change and green growth. Conservation International, in collaboration with the Rwanda Environment Management Authority (REMA) and the Wildlife Conservation Society, is using data from Vital Signs to inform the design of how the fund will provide conservation incentives for small holder farmers and Vital Signs will provide the data to evaluate the effectiveness of those incentives.

Lastly, how do you see the initiative shaping up in the future?

This is only the first phase of a 10-15 year plan. Our intention is to attract other donors to expand to Asia and South America and become a global monitoring system because the challenge we have ahead of us is a global one. To feed the 9 or 10 billion citizens of this planet in the next few decades without destroying nature, we urgently need to be able to offer consistent, transparent, integrated information that decision makers and individual farmers can access easily so that they can see the big picture: the sum of many parts. I describe it as an ability to take the Earth's pulse and gauge how its support systems are holding up. It is only with this view that policy makers, farmers and investors alike can make smart decisions that are positive for agriculture, nature and people.

www.conservation.org/vitalsigns
www.teamnetwork.org

CONSERVATION INTERNATIONAL

Averting disasters in Sub-Saharan Africa

A new research project is providing groundbreaking research on climate-induced risks within a range of five African cities. Here, **Professor Guy Weets** discusses the team's novel approach, the challenges it faces and potential strategies to mitigate climate change-induced risks in an urban context

FLOODED INFRASTRUCTURE AFTER HEAVY RAIN FALL IN OUAGADOUGOU © NATHALIE JEAN-BAPTISTE, UFZ

To begin, what are the key objectives of your research into Climate Change and Urban Vulnerability in Africa (CLUVA)?

The main objective of CLUVA is to develop methods easily applicable to African cities, manage climate risks, identify and reduce vulnerabilities, and improve resilience and coping capacity. The unique feature of CLUVA is its holistic approach. The methods under development address multiple risks such as flood, drought, desertification and coastal erosion due respectively to new rain patterns, heat waves and sea level rise in a consistent way, as well as considering the interaction between different types of risks. However, CLUVA also tries to place these risks in the correct local context, taking into consideration factors such as rapid urbanisation, poverty and governance. This approach embeds climate risk management into the more general issue of development. We aim to provide foresight that helps policy makers develop better science-based policies. Finally, to ensure that the project will not just be a one-off exercise, considerable resources have been allocated to improve the research capacity of our African partners in this field.

Why are you focusing on climate adaptation in urban areas of Africa and which cities have you chosen to focus on?

The climate-induced risks in urban areas are far less well understood than those in the countryside, and the complexity is probably an order of magnitude higher.

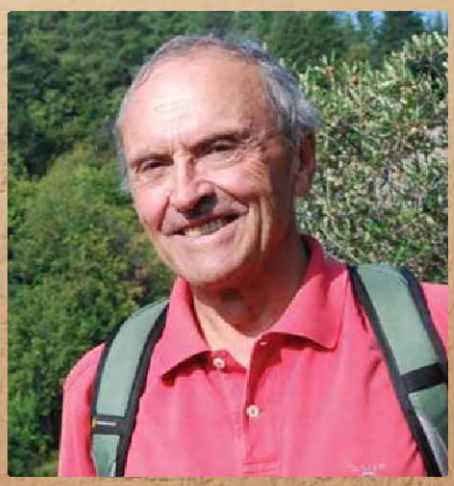
The selection of the cities was based on three criteria: the five cities must represent the most typical climates of sub-Saharan Africa; face significant climate-related risks; and have a local university with the capacity and willingness to effectively contribute to the research. The five selected cities are Dar es Salaam and Addis Ababa in East Africa, and St Louis (in Senegal), Ouagadougou and Douala (in Cameroon) in West Africa.

How are you bringing together experienced practitioners in the EU with their African counterparts in order to form an effective integrated research effort?

It was not an easy task, as research does not play an important role in African universities; teaching is the main focus, so research methodology is not very well understood. Initially we planned to rely on Internet communication to manage teams distributed over two continents from Norway to South Africa. Unfortunately, although improving, this approach is still far from satisfactory. The university network is often down, and many PhD students do not have email addresses. This has led the management to organise more workshops than initially foreseen. The best functioning teams were those formed mainly with fulltime PhD students; the process was more challenging with part-time staff members due to conflict of priorities.

Part of the project involves not only assessing the risks but also recommending adaptation strategies to cope with potential hazards. How are you approaching this task?

Our engineers and scientists are working on four fronts: the built infrastructure; ecosystems services; urban planning; and governance. These are all taken into account to evaluate the total risk. Effective adaptation strategy is based on rigorous assessment of the risks. The first part of the project has focused on assessment methodologies adapted to an African environment; the second part will concentrate on adaptation strategies.



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Directing development decisions

Many cities in Sub-Saharan Africa are vulnerable to flood, drought, desertification and coastal erosion. Amid this complex landscape of interconnected environmental and societal challenges, **CLUVA** strives to provide the knowledge and technology to combat sizable challenges

One of the key barriers to effective adaptation in areas of the global south is a lack of resources and funds. How do you expect your recommendations to be implemented with this in mind? Is funding available to put strategies into action?

Firstly, we are focusing on adaptation measures that do not require many resources; secondly we expected that funding from developed countries will become available, as promised at the International Panel on Climate Change summit in Copenhagen. Better understanding of the climate change impact was needed to submit sensible proposals. Unfortunately this funding has failed to materialise so far. However, the new partnerships established in CLUVA between researchers in the north and south, and the city stakeholders has provided a good basis for new project constellations and proposals to other funding agencies. KU, together with ARU and Addis, have submitted proposals to the Danish Development Agency's research fund under the title 'Water Resilient Green Cities'. The general lack of resources has led our researchers to work on cost-effective algorithms and methods that can be implemented and maintained in the case study cities.

DEVELOPING COUNTRIES, PARTICULARLY those located in Sub-Saharan Africa, are facing a multitude of socioeconomic, political and environmental issues. Climate-induced risks are a particularly pressing area of concern. Many of the countries in this region are struggling to implement effective risk reduction strategies. This is, of course, understandable given the difficulty of allocating scarce resources in areas where food security is not guaranteed. Another dimension to this dilemma is the fact that, not only can these countries ill-afford to fund preventative measures (the return period is 20-50 years), but they also lack the adequate economic, developmental and institutional capacities to adapt to the impacts of climate change.

One major concern is the lack of preventative or risk-reducing measures taken in Sub-Saharan Africa given that the impacts of climate change will negatively affect the developing countries in this region due to a heavy reliance upon climate-sensitive sectors such as agriculture. In addition to high-risk agricultural areas, it is the region's cities that are being pinpointed as areas of inherent vulnerability to the impacts of climate change. It is a sad fact that many of the urban areas in Sub-Saharan Africa facing the highest risks of climate change-induced dangers are those that contribute fewest greenhouse gases to the atmosphere.

With such risks continuously emerging, it is imperative that the existing risks posed by climate change and variability are addressed. It is necessary to anticipate the projected climate risks and implement means of adaptation to these within urban systems. While this might well prove a costly activity, the cost of inaction is much higher. Failure to act now could further increase the cost of the ongoing urban developmental processes in the most vulnerable sub-Saharan cities, leaving them even more vulnerable.

To address the issue, the Climate Change and Urban Vulnerability in Africa (CLUVA) project was conceived. The initiative, an EU co-funded collaborative venture between European and African research institutions, provides research and guidance on how to best adapt to the impacts of climate change in urban areas within Sub-Saharan Africa. By making use of case studies on adaptation practices in five African cities, the project hopes to inspire planners and policy makers in other cities to make wiser development decisions in response to changing climate.

IMPROVING RESILIENCE

Despite the reported issues surrounding the vulnerable urban areas of Sub-Saharan Africa, the true impact of climate change, particularly on a local scale, is yet to be fully understood. Current theories on potential effects of climate change within the Sub-Saharan region have all been based on 'Global Circulation models'. While it is almost certain that climate change in

CLUVA

CLIMATE CHANGE AND URBAN VULNERABILITY IN AFRICA

OBJECTIVES

To develop methods and knowledge to be applied to African cities to manage climate risks, to reduce vulnerabilities and to improve their coping capacity and resilience towards climate changes.

PARTNERS

Addis Ababa University, Ethiopia • **AMRA Scarl** (Coordinator), Italy • **Ardhi University**, Tanzania • **Centro Euro-Mediterraneo per i Cambiamenti Climatici Scarl**, Italy • **Council for Scientific and Industrial Research**, South Africa • **Helmholtz-Zentrum für Umweltforschung UFZ**, Germany • **Københavns Universitet**, Denmark • **Norsk Institutt for By- Og Regionforskning**, Norway • **Technische Universität München**, Germany • **Université de Ouagadougou**, Burkina Faso • **Université de Yaoundé I**, Cameroon • **Université Gaston Berger de Saint Louis**, Senegal • **The University of Manchester**, UK

FUNDING

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this area will be significantly prompted by the El Niño Oscillation – as well as land cover change – projections and theoretical models cannot hope to accurately represent the true future impacts. Such a task of speculating upon future climate change in Africa is more complex still, as there is a lack of accurate baseline data on both current climate and intricate climate variations. CLUVA seeks to fill this knowledge gap and use such findings to improve urban resilience towards climate change.

The project's primary aim is to develop methods which can be applied by African cities, to help them manage climate risks and reduce their vulnerability to the impacts of climate change. The researchers hope to explore these issues within the selected five urban case study areas and promote improvement in the capacity of local bodies, such as scientific institutions and local councils, to cope with climate change and the risks it poses. This will be achieved through integrated research between both EU and African experts in the knowledge-specific areas of climate, risk management and urban planning who will use this expertise to assess the environmental, social and economic impacts of climate change. In terms of the key risks that CLUVA has been focusing on, flooding appears to be the most devastating, as it is a risk shared by all cities. Other hazards include erosion, heat waves, drought and long-term risks, such as desertification.

While the research activities are ongoing, some trends have already emerged: "Addis Ababa and Dar es Salaam will face more frequent flooding; Ouagadougou might experience much hotter summers (up to 7 °C more by the end of the Century); Saint-Louis might have to plan a relocation of the city inland, due to accelerated coastal erosion and sea level rise and Dar Es Salaam is expected to see significant increase in rainfall," explains Weets.

OVERCOMING CHALLENGES

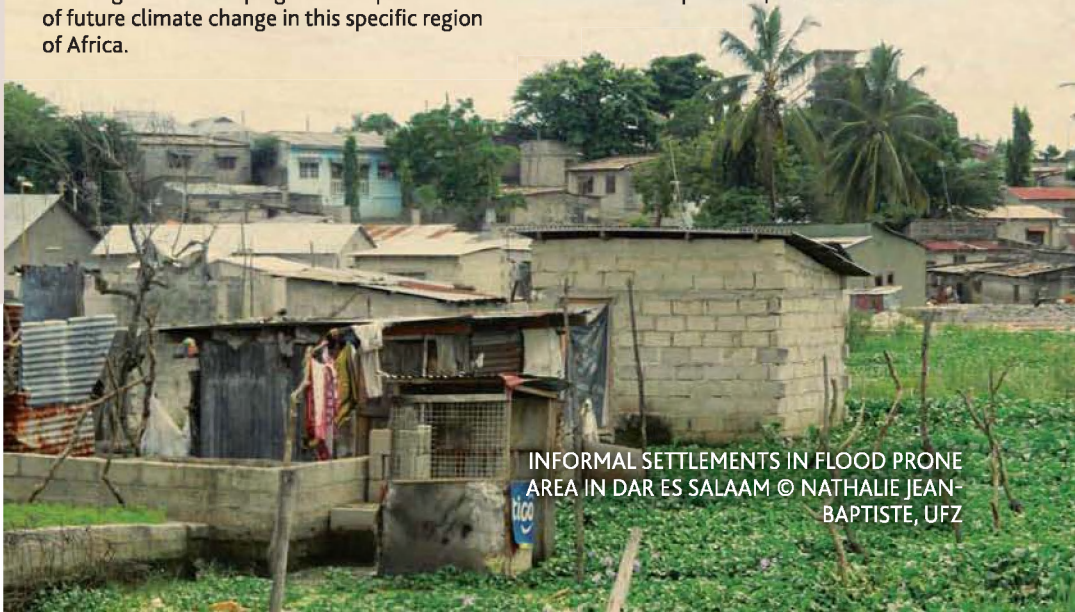
By developing appropriate climate change risk adaptation strategies and promoting their implementation in the cities of Sub-Saharan African, the negative effects of future climate-change induced hazards could be dramatically reduced. However, the group face a number of challenges in developing reliable predictions of future climate change in this specific region of Africa.

Firstly, it is extremely difficult to predict climate change; thus the scientists must develop plausible descriptions of how the future may develop, based on coherent and internally consistent sets of assumptions. With this in mind, part of CLUVA's work can be understood as sets of interrelated, plausible climate change and urban development scenarios. Scenarios are validated by applying them to the past; if the calculated values match the observation, only then can one be confident in the 'forecasting capability' of the scenario provided. In this region there is both a lack of accurate historical data, and a remarkably quick pace of change – including population growth and urbanisation. As such, these factors may limit the validity of today's scenarios.

> Failure to act now could further increase the cost of the ongoing urban developmental processes in the most vulnerable Sub-Saharan cities, leaving them even more vulnerable to climate change induced risks and hazards

LOOKING FORWARD

Despite the myriad challenges, the consortium continues to provide relevant and insightful research. Indeed, CLUVA intends to communicate their findings and recommendations to a wider field of policy makers and government officials within the Sub-Saharan African region. The final report on the five city test cases will be widely distributed: "We expect these publications, or at least parts of them, to be included in the UN-Habitat 'Cities for Climate Change' series," Weets reveals. Additionally, the final CLUVA conference will be held in Addis Ababa, with representatives of the African Union expected to attend. Finally, first results of CLUVA have been demonstrated and discussed at the World Urban Forum organised by UN-Habitat in Naples in September 2012.



INFORMAL SETTLEMENTS IN FLOOD PRONE AREA IN DAR ES SALAAM © NATHALIE JEAN-BAPTISTE, UFZ

Simplifying solutions for sanitation and water supply

Addressing the challenges faced by those most in need of improved sanitation and water supplies requires a shift away from centralised treatment. Here, **Günter Langergraber** and collaborators on the CLARA project outline their efforts to provide an effective planning tool for local stakeholders

With contributions from Teshale Dalecha (TD), Arba Minch University, Ethiopia; Valerie Naidoo (VN), Water Research Commission, South Africa; Benedict Mutua (BM), Egerton University, Kenya; Ali Dissa (AD), Water and Sanitation for Africa, Burkina Faso; and Mokhtar Jaait (MJ) ONEP, Morocco.

First, could you outline your work to help implement and operate integrated water supply and sanitation for small communities in rural and peri-urban areas?

GL: CLARA has two main objectives: we aim to develop a simplified planning tool for water supply and sanitation planning under African conditions, and encourage technological and non-technological improvements of low-cost water supply and sanitation systems.

The CLARA simplified planning tool is not a new participatory planning approach but shall assist local planners and consultants to compare different solutions of water supply and sanitation systems based on real costs. After developing a draft version of the planning tool, it is tested in the case study sites in five African countries – Ethiopia, Kenya, Morocco, Burkina Faso and South Africa.

Field research on technological and non-technological improvements is carried out in Arba Minch, Ethiopia. Three main topics are investigated: i) operation and maintenance, and financing mechanisms – strengthening the incorporation of businesses in the sanitation service chain; ii) faecal sludge treatment and urine conditioning methods; and iii) solutions for multi-storey condominium houses.

How severe are problems with water supply and sanitation at the case study sites?

TD: In Arba Minch, water supply is already scarce but the population increase is rampant, posing further challenge for sanitation. The water supply scheme design period expired more than 10 years ago, and therefore decentralised water supplies for non-potable water uses would be highly beneficial for Arba Minch.

VN: Schools in South Africa fall under the Department of Education whose core business is provision of education. They do not have the necessary expertise to implement water and sanitation services. These services are therefore undertaken through public works, private companies or partnerships with service providers and the correct questions may not be asked as to how an integrated water and waste and sanitation solution can be achieved.

BM: The selected case study for Kenya is the Njoro Township, which is divided into eight locations. Most of the areas within the study site have no water and sanitation systems in place. The worst affected areas are the peri-urban locations. Most of these depend on water from the River Njoro and others buy water from the few boreholes and use pit latrines.

While developing your planning tool, CLARA engages with community stakeholders in a case study. Can you highlight the work carried out at the case study sites?

VN: The first step was to develop a broad understanding with a partner. Once an agreement was reached with a partner municipality and stakeholders from the pilot site, a memorandum of understanding was signed. Thereafter, an enabling environment was created by having several meetings with the school stakeholders, community stakeholders, political representatives, municipality representatives, NGOs and university researchers. This is an ongoing process which ensures all partners have information as the project develops.

GL: Within this process, the CLARA simplified planning tool is tested for comparing different possible system solutions. After the planning of the integrated water supply and sanitation systems, application documents will be prepared that allow the pilot communities to ask for donor money.

Can you identify the biggest challenge faced in conducting this work to date?

MJ: The biggest challenges have been convincing all partners to participate in this project; collecting information and data for the planning tool and its implementation; and applying the results of the tool with the support of our local and international partners.

AD: I think the main challenge has been the involvement of the different stakeholders in developing a simple, sustainable and innovative tool in order to provide to the local government the best way to manage efficiently their low financial resources.

BM: Achieving a mentality shift on integrated water supply and sanitation has been difficult. Because of the poverty levels, most people do not regard water and sanitation as a major issue.

What has been the project's biggest success to date?

VN: The biggest success has been the strengthening of ties and fostering networking amongst project partners in the broader context of water and sanitation in Africa.

BM: For me, being able to develop the workable plans for the case study communities and get the baseline information for each has been a great achievement. The communities are slowly paying attention to water and sanitation challenges and supporting the CLARA project's objective in the development of a Planning Tool for integrated water supply and sanitation.

Practical planning

Rising to meet UN Millennium Development Goals, the **CLARA** project is creating a simple planning tool to support a resources-based, decentralised approach to water supply and sanitation solutions in Africa's rural areas

WATER AND WASTE are two of the most essential considerations of life today. The impact of these necessities is huge: it is no revelation that lack of adequate sanitation systems and use of unsafe water leads to numerous diseases and pollution of the natural environment. Yet compared to other social sectors, financial prioritisation of sanitation and drinking water is low, with precedence often given to health and education.

According to the joint monitoring programme of the World Health Organization and UNICEF, over 2.5 billion people are living without sufficient sanitation facilities. A large proportion of this number reside in Sub-Saharan Africa, where small rural towns and peri-urban areas are worst affected. Increasing rates of climate change affects water availability in many areas, which in turn has a direct impact on the agricultural livelihood of millions across the continent. The unavoidable escalation of these changes in the near future makes the issue of water supply and sanitation all the more pressing.

Set by the United Nations in the Summit 2000, Millennium Development Goal (MDG) Number Seven is to halve the proportion of people without sustainable access to safe drinking water and basic sanitation by 2015. The 'Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas' (CLARA) study is a collaborative project within the EU Seventh Framework Programme (FP7) aiming to make a significant contribution to achieving that goal through the creation of a 'simplified planning tool'.

IDENTIFYING THE KEY CONCERNS

Project partner Mokhtar Jaait, from ONEP in Morocco, outlines the problem areas in the sector: "The collection and treatment of wastewater; planning and sustainable management of water resources; solid waste management; capacity building; community sensitisation in terms of hygiene and safety; and the development of guidelines and manuals for the management systems of water supply and sanitation are all issues which must be addressed," he explains. It is worth noting that high rates of urbanisation are often not accompanied with improvements to water and sanitation services; every year huge amounts of sludge and industrial waste are ejected into the natural environment and the negative effects on both land and people are extensive.

Treating water at centralised systems and distributing it to households in sufficient quantities could be seen as the ideal solution for minimising health risks. Yet to reach the MDG target for safe water and sanitation using such methods would demand an investment of billions of euros per year: an impractically high cost. The attempted implementation of this system can lead to rural areas being subjected to an irregular water supply and the re-storage of water which can then become contaminated, even if the primary source of the water is safe.

A RESOURCES-BASED APPROACH

Coordinator of the project Günter Langergraber outlines a more effective strategy proposed by CLARA: "Resource-orientated solutions for water supply and sanitation are assumed to be better applicable and have a higher uptake potential in African countries". Indeed, the practical research of ROSA and NETSSAF has already demonstrated the potential of resource-orientated and decentralised systems of sanitation in Africa. Working closely from the discoveries of these projects, CLARA is integrating a consideration of water supply into sanitation planning, including multiple uses of water for a viable and economical approach to resource assessment.

By fostering an integrated 'closed-loop' approach, CLARA cultivates the growing perspective that waste should be a treated as a resource. The technological developments in waste and water management have been rapidly advancing in recent years. However, the technologies included in assessment must be adaptable to African conditions, as must the planning tool itself. The aim is to provide a scope of low-cost and technically simple, decentralised technologies that can be successfully adapted by a developing community.

Rather than the basic options outlined by Steve Esrey of 'drop and store' or 'flush and forget' (2001) that are still dominant in developing countries, a resources-orientated approach to

sanitation uses the nutrients in human excreta and urine to improve agricultural production, as well as protect the natural environment and local fresh water resources.

WASTE NOT, WANT NOT

In resources-based thinking, an important distinction is made between different water and waste types. For example, the soluble nutrients of nitrogen and phosphorus found in urine – known as 'yellow water' – make it beneficial as a fertiliser after appropriate storage. The concept of re-using 'grey water' from kitchens and washing use for the watering of crops has been spreading across the continent in recent years. Benedict Mutua from Egerton University, Kenya iterates the broader benefit of this prudence: "The reuse of treated wastewater, especially the grey water stream in irrigation, will enhance food security".

> This resources-orientated type of sanitation and water supply invariably leads to greater resilience in communities to react to climate change scenarios

Composting or drying faeces successfully eliminates the hazardous pathogens and can potentially also be utilised as an agricultural aid. CLARA battles cultural taboos against using dry faeces as fertiliser (soil conditioner) by demonstrating the benefits of its use in agriculture through facilitating examples. One of the main objectives of the project is to ensure the highest degree of safety for all methods of re-use and employment of waste.

With thorough knowledge of decentralised and low-cost technologies, CLARA will work with local stakeholders and partners to create a planning tool that will enable local municipalities to assess their own water and sanitation needs and capabilities; make short-term, mid-term and long-term plans for improvement; and apply for funding accordingly. CLARA envisages enabling local capacity for forming adequate integrated systems of water supply and sanitation. Long-term sustainability is central to the objectives of the project, on both environmental and economical levels.

COMBATING CLIMATE CHANGE

Valerie Naidoo of the South African Water Research Commission (WRC) reaffirms the benefit of a localised approach to sanitation and wastewater: "This resources-orientated type of sanitation and water supply invariably leads to greater resilience in communities to react to climate change scenarios," she stresses. Having a decentralised system in place allows for communities to react quickly to resetting systems after natural events such as storms, and the adaptability of the systems to local climate change is a central focus of the organisation. "Resource-orientated types of sanitation and water supply generally require a closer working interface between the user and the water and sanitation system," Naidoo adds. This closer interface is integral to the creation of locally controlled, closed-loop sustainable systems CLARA hopes to enable.

EXCITING WORK IN PROGRESS

CLARA is currently working at five African case study sites where, building on the practical experience of ROSA and NETSAAF, they are carrying out the research needed to create an integrated planning tool that accounts for different economic, cultural and social boundary conditions across the continent. With 15 partners altogether, eight partners are from ROSA or NETSTSAF, ensuring the utilisation of the results from these two projects. Having finalised its first year in March 2011, the CLARA project hopes to have the draft version of this simplified planning tool completed in Autumn this year and is aiming to carry out the testing of the tool in early 2013.

CLARA

CAPACITY-LINKED WATER SUPPLY AND SANITATION IMPROVEMENT FOR AFRICA'S PERI-URBAN AND RURAL AREAS

OBJECTIVES

To develop a simplified planning tool for integrated water supply and sanitation systems for small communities and peri-urban areas, and assess and adapt existing (low cost) technologies for decentralifed systems and African conditions.

PARTNERS

Universität für Bodenkultur (BOKU), Austria (Coordinator) • **University of Natural Resources and Life Sciences**, Vienna, Austria • **ttz Bremerhaven**, Germany • **EcoSan Club Consulting KG**, Austria • **BIOAZUL S L**, Spain • **Centre of Biotechnology of Sfax**, Tunisia • **Egerton University**, Kenya • **Water Research Commission**, South Africa • **Water and Sanitation for Africa**, Burkina Faso • **Office National de l'Eau Potable**, Morocco • **Arba Minch University**, Ethiopia • **Arba Minch Water Supply and Sewerage Enterprise**, Ethiopia • **Arba Minch Town Municipality**, Ethiopia • **'Engan New Mayet' Compost Production Youth Association**, Ethiopia • **'Wubet le Arba Minch' Solid Waste Collectors Association**, Ethiopia • **Arba Minch Health Center**, Ethiopia

FUNDING

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clara
Capacity-Linked water and sanitation for Africa's peri-urban and Rural Areas

United Nations Environment Programme: Division on Environmental Policy Implementation

UNEP is built upon a cornerstone of dedication to saving lives and protecting biodiversity around the world. In this candid interview, **Keith Alverson**, Head of the Climate Change Adaptation and Terrestrial Ecosystems Branch, details the many challenges involved in ecosystem management and their focus on supporting climate change adaptation measures in developing countries

Could you begin with an overview of the aims and objectives of the UNEP Division of Environmental Policy Implementation (DEPI)?

DEPI is the operational project delivery arm of UNEP. Based on scientific research and environmental assessment – and in the context of the regional cooperation, multilateral agreements and conventions that broadly comprise UNEP's normative work – DEPI implements projects at the local, national and regional level which protect the environment, enable sustainable development, and support human wellbeing. Of UNEP's six priority focus areas (climate change, disasters and conflicts, ecosystem management, environmental governance, harmful substances and resource efficiency) DEPI takes the lead in ecosystem management, disasters and conflicts, and the adaptation and REDD+ related aspects of climate change. In this broader context, our climate change adaptation strategy is focused on four areas:

- Supporting coordinated, international research in vulnerability, impacts and adaptation through the ProVIA programme
- Demonstrating the effectiveness of ecosystem-based adaptation through implementing on-the-ground projects
- Managing the Global Adaptation Network as a platform for interaction amongst regional and thematic networks
- Facilitating national access to multilateral and bilateral sources of adaptation funding

How might ecosystems be harnessed to reduce human vulnerability to climate change? Do such strategies necessarily vary between regions?

Global climate change impacts upon ecosystems as well as human livelihoods and wellbeing. The extent of these impacts is influenced by the regional expression of climatic forcing and the degree of vulnerability of natural and human systems. Unlike climate change mitigation efforts, which are predominantly multilateral and focused on global targets such

as average temperature and greenhouse gas concentrations, adaptation measures are inherently local and respond to regional patterns, including flooding, drought, sea level rise and extreme events. Furthermore, unlike average global temperature, which is well outside the natural envelope of variability for the past millennium, regional hydrological variability over this same period has included rapid, large and sustained changes on a par with, or greater than, those projected by climate models for future decades. For this reason, ecosystems and traditional societies have developed an inherent resilience to climate variability.

UNEP's ecosystem-based adaptation approach is grounded in management of ecosystems and the services they provide, in partnership with the local communities that depend on them, in order to reduce future vulnerability to anthropogenic climate change. The concept of harnessing ecosystem resilience as part of an integrated adaptation strategy is robust, and UNEP is applying it around the globe in ecosystems ranging from high mountains, to drylands, river basins, coastal zones, agriculturally-dominated and even urban areas. However, the specific method of implementation must differ regionally: by ecosystem type, according to the specific adaptation challenge addressed and depending on local community priorities. Mangroves and corals, for example, can provide natural resilience to sea level rise in the tropics, but not in the Arctic. There are also differences between areas in the cost-effectiveness of ecosystem-based approaches. For example, it makes far more sense for Tanzania to build a seawall around its major port in Dar es Salaam rather than plant mangroves there, but protecting the rest of its long and valuable coastline with a wall would be ridiculous.

In terms of capacity building, where are you focusing your efforts? Is it the case that those countries likely to be most greatly affected by climate change are least equipped to deal with it?

We focus all of our efforts on developing countries, not because they are the most vulnerable, but because they are the countries that request assistance and engagement from UNEP in developing and implementing plans to adapt to climate change. The oft-repeated mantra that 'least developed countries are most vulnerable to climate change' is simplistic at best. Physical and ecosystem impacts of climate change vary spatially of course, but there is no reason to expect there to be a correlation between this variability and national boundaries. For example, Bangkok, an urban centre of great wealth in a relatively rich country, showed itself to be quite vulnerable to flooding last year, when it sustained 815 deaths, massive displacements of population and US $45 billion in economic damage, including lasting damage to its automobile and electronics supply chains. Moreover, the landfall of Hurricane Katrina in New Orleans in 2005 caused 1,836 deaths and $81 billion in damage.

It is certainly true that development can ameliorate some aspects of climate change vulnerability, but as these events show, we surely should not be fooled into thinking development is the entire solution to the climate change adaptation challenge. At the very least, developing countries can find, and are finding, new development pathways that avoid some of the maladaptation that has already occurred in the developed world. Developing and developed countries alike can benefit from ecosystem management and services as an integral part of policies to help reduce vulnerability and increase resilience in the face of climate change.

The Division is supporting a Global Adaptation Network (GAN) to share best practice. What examples of maladaption could you offer that might have been avoided as a result of this proactive approach?

The UNEP-facilitated GAN provides an opportunity to both share best practices, and avoid some of the worst examples. One of the unfortunate Achilles' heels in adaptation work is that it is often rather difficult to identify the difference between these two extremes. Considerable funds have been spent for 'quick win' adaptation projects – a favourite target of many funding agencies with 'fast track' funds to spend – but not much attention has been paid to the longer-term problem of monitoring and evaluation. There are many examples of perceived success, based on short-term effects that can become less attractive, and even increase vulnerability, over a longer timescale. For example, the accumulated effects of repeated successful short-term adaptation measures, much like successful fishing expeditions, can sometimes lead to greater vulnerability in the long term, when the fishery collapses. Other interventions may reduce vulnerability for a favoured subset of a population disproportionately, or perhaps even at the expense of others.

Considering how much we know about where the impacts of climate change will be most keenly felt, what are the mitigating factors? For example, what are the limits of decadal predictability, and are they significant enough to throw climate models into doubt?

Anyone with a working knowledge of climate models should have doubts about their accuracy. It is a great pity that as soon as one makes a perfectly reasonable, but slightly sceptical statement regarding climate models – such as asking what the uncertainty bars are on downscaled regional precipitation forecasts for the horn of Africa in 2050 – somebody inevitably makes the completely ridiculous conclusion that you must be a 'climate change denier', twists your statements out of context, or embroils you in a nonsensical debate about the existence of anthropogenic climate change.

Nevertheless, the questions as to where the impacts are greatest, and where they are most keenly felt are very different indeed. The latter is not dominated by climate change patterns, but is mostly about patterns of vulnerability underpinned by social and economic variables. Regrettably, mapping decadal projections of vulnerability is, if anything, an even less accurate science than climate modelling. The bottom line is that uncertainty will remain in both climate forecasts and socioeconomic development projections, so there is little point putting lots of effort

into improving the accuracy of downscaled forecasts and trying to tailor adaptation projects to specific projected regional impacts or vulnerabilities.

We know that modelling studies in the IPCC fourth assessment show the Horn of Africa enjoying major increases in long-term projections of seasonal and annual mean rainfall. It is fortunate we are not designing adaptation interventions based on this particular projection, as it contrasts rather starkly with conditions just last year, when the region experienced a horrific La Niña-related drought, resulting in tens of thousands of deaths, massive displacements of populations and, needless to say, numerous high profile statements in the media regarding drier conditions in sub-Saharan Africa associated with climate change reducing the resilience of local populations. Such statements were not based on robust model projections, but on the observed conditions last year in comparison to the instrumental record.

The answer to this apparent conundrum is that adaptation interventions need to be based on a range of plausible hydrological variability, and a range of technological, social and ecosystem-based measures for adaptive management, to decrease vulnerability and enhance resilience in the face of this variability.

The Amsterdam Open Science Conference stated the urgent need for 'an ethical framework for global stewardship and strategies for Earth System management'. In a complex environment where one issue is often addressed at the expense of another, how are climate adaptation research priorities, and their applications, addressed?

Much has been made of various 'planetary boundaries', some related to climate change and others not directly so, which might define a 'safe operating space' for the planet. In a very limited set of cases, such as reducing the loss of stratospheric ozone by banning chlorofluorocarbons, multilateral global agreements appear to be working in this way.

However, for most human impacts on the global environment, including climate change, there is no sign of effective global stewardship or Earth System management at present. I am concerned that the idea that humanity might seek to 'operate' the planet, like one does a car, steering around little potholes such as global warming, is more likely to reflect mankind's hubris rather than our actual collective abilities. Geoengineering is a particularly troubling example of such hubris that does not merit further taxpayer funding. In any case, it is precisely because there has been so little progress in mitigating climate change globally, despite the urgent need identified in Amsterdam more than a decade ago, that local adaptation is now so critical.

Yet, I do not agree that addressing such adaptation needs must be at the expense of either mitigation or any other priority. The fundamental idea behind the ecosystem-based approach that UNEP advocates and implements is that it delivers multiple benefits beyond climate resilience, including a wide range of ecosystem services, such as clean air, water, human health and biodiversity, and can even serve to increase the lifetime, and thereby reduce the costs, of engineering adaptation measures such as dams and seawalls, when applied in concert with them. Thus, one of the main ways that climate adaptation priorities can be met is by incorporating adaptation goals within ordinary, ongoing development and environment-orientated strategies and projects.

Could you offer your personal perspective on the recent accord reached at the Durban climate conference? Did political leaders go far enough in stimulating greater action on climate change?

There were some commendable political victories in Durban, but it is also true that the participant nations, the host country and the UN are all desperately trying to spin the meeting as a success. Perhaps this will be helpful in that success, even if only perceived, might breed success. However, another unfortunate fact is that these political victories, unlike burning fossil fuel, have had no impact on our atmosphere, so no matter how many times one may assert that great achievements are being made, atmospheric greenhouse gas concentrations are still going up. I remain optimistic that some combination of global negotiations, regional, national, municipal and individual actions will eventually turn this tide, but in the meantime adaptation should be on everyone's priority list.

What is your vision for the next decade in terms of the UNEP's environmental policy work? Are you optimistic that you can lead the way in dealing with the impact of a changing climate, or is it incumbent upon humanity to take a more proactive approach when it comes to our energy consumption, and try to slow the trend of global warming?

I am a strong supporter of reducing energy consumption for all kinds of reasons, including mitigating global warming. However, I am not optimistic regarding slowing the trend of higher global average temperatures and related regional and local climate impacts. 2011 saw record high atmospheric greenhouse gas levels achieved at a record increase in rate. It is unequivocal both that significant anthropogenic warming has occurred and that it will continue to occur for decades simply due to past emissions that have not yet been realised as atmospheric temperature rise, let alone future emissions.

Anthropogenic global warming will continue to occur for decades, regional climate variability will remain substantial and adaptation will be required. Thus, over the next decade countries will have no choice but to increasingly focus efforts on adapting to this variability and change, and UNEP stands ready to assist them in doing so. I am confident and optimistic that we will save lives, protect property and steward our global environment by locally implementing ecosystem-based climate change adaptation approaches as an integral part of developmental and environmental work.

GLOBAL ADAPTATION NETWORK

www.unep.org/depi

Seeking sustainability

Professor Maria del Mar Delgado is coordinating an exciting network which could transform the way governments, scientists and local communities interact with one another to tackle climate change

To begin, what are the main objectives of the project on COmmunity-based Management of EnvironmenTal challenges in Latin America (COMET-LA)?

Over the last few decades, Earth has faced dramatic environmental changes. The effects of these changes can be local or global but are most keenly felt on a local level, in particular by communities that base their livelihood on the exploitation of natural resources. However, the solutions can also originate locally. Better knowledge and context-specific decisions on managing these environmental challenges is urgently needed. The objective of COMET-LA is to identify sustainable community-based governance models for the management of natural resources that could be used in different social-ecological systems in the context of climate change and increasing competition for resources.

Why are community-based, participatory models an important method of managing natural resources?

In many areas of the world, local communities have traditionally developed community-based management of natural resources, which has created sustainable models. However, these models are facing increasing pressure from the current model of economic development. A better understanding of local knowledge and traditions, and the amalgamation of local and scientific knowledge, could answer the needs of local communities facing problems with resource management and help to identify sustainable local solutions that contribute to global sustainability.

The project works with three case studies in Mexico, Argentina and Colombia. What procedures are in place to ensure effective collaboration between the partners involved?

COMET-LA will create a participatory 'learning arena' involving not only Civil Society Organisations (CSOs) and research organisations, but also policy makers and other stakeholders in the analysis and discussion of community-based management of natural resources, and identification of practices and lessons of interest. The overall objective is not to generate new knowledge, but to use the existing knowledge (scientific information, practical experiences, and organisational patterns) to adapt community-based management of natural resources to the challenges of climate change. Bottom-up and participatory approaches are crucial, because they permit the use of local knowledge and foster ownership of the strategies by their beneficiaries.

How do you hope to adapt the outcomes of your research to local, national and global scales?

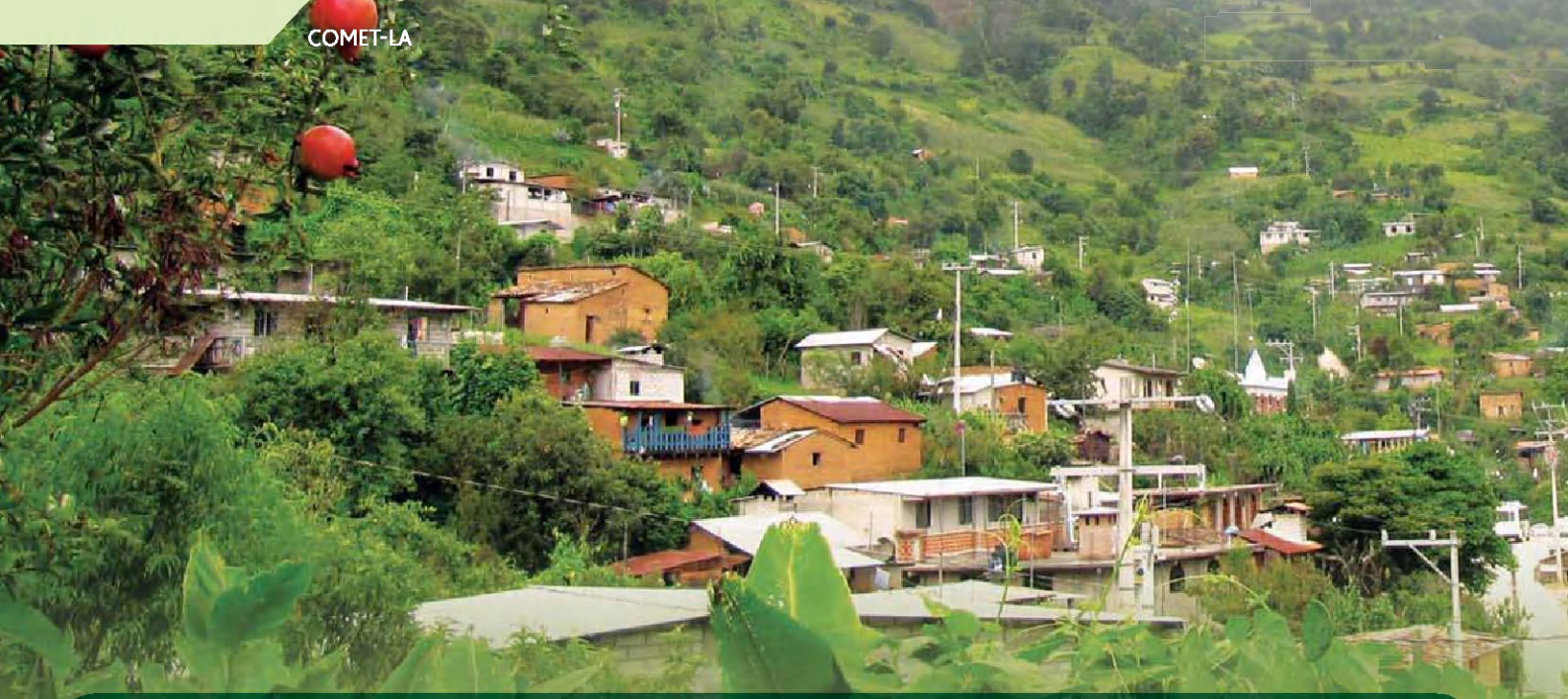
The results of the analysis and research developed in the case studies will be synthesised to provide information on issues related to sustainable management and governance of natural resources. The synthesis and integration of these results will allow the sustainable management and governance models to be applied beyond their specific social-ecological systems. Once these models are available, two other case studies will be established where we can test the suitability of the proposed methods and models.

How are local communities, and the natural resources that they rely on, threatened by commercial interests and an increasing global demand for resources?

The problems of each case study are different, but all share pressures such as overexploitation of natural resources or conflicts over access. More specifically, in the Colombian case, there are conflicts over illegal timber extraction, mining and hunting, illicit crops, overexploitation of forest and fisheries, infrastructure development and its impact on ecosystems and local communities, and access to and use of water. In the Mexican case, after many years of government ownership and use of Oaxaca's forests, local communities managed to regain control and tenure of their land and forests. The current tasks are to enhance community welfare without losing equity and to increase value-added economic activities without creating a division between the industrial sector and the primary sector. In the Argentinian case, less artisanal fishing has affected the livelihoods of the families in the area. Alternative activities such as aquaculture or tourism should be explored.

Who are your key collaborators on the project? How are you maintaining close contact with the communities in the areas that you are researching in?

In each case study a Civil Society Organisation is a full partner in the project. Their role is to organise interaction with the local people, to identify the relevant stakeholders and to organise the different participatory workshops. In short, they will link local and scientific knowledge and guarantee close contact between researchers and local communities. The Spanish Committee of the International Union for Conservation of Nature will integrate and upscale the results. The main benefit of these partnerships is the creation of a space for interaction between researchers, local communities and policy makers. All too often, governance problems derive from a lack of such arenas.



Lessons from Latin America

Climate change is affecting the day-to-day lives of many people around the world. COMET-LA is an innovative knowledge-sharing platform which aims to consolidate global and local issues and facilitate sustainable responses to this environmental crisis, with collaboration and communication at its core

THE IMPACT OF climate change is increasingly difficult to ignore and communities worldwide are struggling to conceive and implement sustainable resource management strategies. The challenge is greatest for those who depend on natural resources for their livelihoods so, although climate change is a global phenomenon, the most innovative responses to it are often local initiatives. The COMET-LA project will examine the responses of three Latin American communities to climate change and, in collaboration with local and international organisations, use their findings to develop models of sustainable practise for other communities worldwide.

A KNOWLEDGE NETWORK

Unlike most research, the main objective of COMET-LA is not to acquire brand new knowledge. The principal goal is to facilitate the circulation and use of existing knowledge, whether it refers to local traditions or scientific information. The main challenge facing the collaborators is to bring together the knowledge of a variety of interested parties; from national and international governing bodies, to NGOs and CSOs, to citizens from a diverse range of societies and cultures. Project Coordinator Professor María del Mar Delgado stresses the fact that there is an emphasis on a two-way flow of information: "Scientists can support management by targeting their research and providing local communities with understandable and useful information. Morevover sustainable community-based models and local perceptions can be integrated in the management of environmental and climate changes".

The team hopes to achieve this goal of efficient and intelligent use of existing knowledge by creating a pioneering learning arena. The network will allow all parties to access a wide range of knowledge and enable better decision making for sustainable resource management.

COMMUNICATION AND COLLABORATION

At this early stage, Delgado and her collaborators are working to ensure that all components of their network will be able to communicate effectively with one another. Three sites have been chosen in Latin America for careful study of their resource management practices. Building close relations with the communities involved is crucial to success of the project, so the studies will focus on three regions which are already working with CSOs keen to benefit from scientific research into how they might better tackle problems caused by climate change. Coordinating and managing all parties in the learning arena will be no mean feat, but Delgado believes the results make this worthwhile: "The coordination and management of such partnerships can be a challenge, but on the other hand it can represent a unique richness and opportunity to share problems, views, approaches, and understanding".

Indeed, when the challenges these communities must confront are considered, it seems clear that COMET-LA could become a vital scheme in the quest for truly global sustainability. In order to gain knowledge that will serve as many other communities as possible, the team will study a range of environmental concerns. The collaborators established that water and biodiversity management, forest and land use, and marine and coastal management are currently the most pressing environmental issues, and chose their case studies accordingly.

LEARNING FROM THE LOCALS

The first case study addresses biodiversity and water management in Colombia. Water is, of course, crucial to all life but rising sea levels and unusual rainfall means that it is also one of the most troublesome aspects of climate change. Biodiversity creates a fine balance between all living species, but this becomes strained by the destructive use of the Earth's resources. Colombia is one of the world's most biodiverse countries and many socio-ecological systems have developed along its territory. With an increasing number of species threatened with extinction in Colombia, the need to improve water and biodiversity management is evident.

The Alto y Medio Dagua and the Cuenca Baja del Río Calima communities, with populations of 1,254 and 4,000 respectively, have been selected as the focus of COMET-LA in Colombia. These communities share a long tradition of close interaction with nature, and depend on resources such as biodiversity, fisheries, timber and soil for

survival. This dependence has become the social axis of these communities and create a strong sense of belonging to the land. The pressures of a changing environment coupled with land ownership conflicts and the presence of illegal armed groups make tackling climate change a sensitive issue in this region. COMET-LA aims to empower these communities by providing the necessary tools to deal with these problems.

The second case study is situated in Mexico and focuses on forest and land use. The role of forests in carbon absorption and balancing the climate, as well as a habitat for innumerable species of flora and fauna, is common knowledge. However, deforestation and poor management remain the most significant threats to forests worldwide. Mexico is home to vast areas of forest but the annual rate of deforestation is estimated at 4-6 million ha. Although the Government has attempted to mitigate this, forestry is still one of the biggest employers in the country.

COMET-LA is focusing its attention on the community of Santiago Comaltepec, situated in the state of Oaxaca with a population of around 2,000 people. This forest community manages the forest sustainably but its exploitation is not enough to provide livelihood to all its inhabitants and they are forced to migrate. The community's notion of environmental sustainability could provide valuable lessons in responsible resource management. In exchange, COMET-LA can help with research into other economic and social welfare problems which the community is currently facing.

The third and final case study is based in Argentina. Coastal and marine areas are among some of the most affected by anthropogenic climate change; many of the world's largest cities are found on or near coastal areas, and fishing provides a vital source of food and employment worldwide. With so much depending on marine ecosystems, any disruptions to them are widely and swiftly felt by many different populations. With one of the biggest expanses of coast in Latin America, and a coastal capital, many communities in Argentina are trying to combat the effects of climate change.

The international team from COMET-LA will study the Bahia Blanca Estuary and the many fisheries it sustains. Poor management and decision making has led to overfishing and other problems in the area. Although some local organisations from both the public and private sector are trying to develop better coastal management strategies, more must be done to protect the short- and long-term interests of local people. Here the project intends to work with families from the area to examine different options for increasing the sustainability of the fisheries. Of particular interest is the question of how they can adapt to the effects of climate change.

THINK GLOBAL, ACT LOCAL

All three of these studies will incorporate matters concerning gender and resource management. Another goal of the project is to empower and engage with women from all aspects of the learning arena and to ensure that all programmes developed for sustainability and conservation are sensitive to gender issues.

With promising lessons to be learnt from the local communities and valuable scientific support available, the COMET-LA learning arena will no doubt be a vital component in the fight to mitigate and adapt to climate change. Truly the epitome of the motto 'Think global, act local', this project will join the dots between responsible resource management at a local level and sustainability on a global scale.

RESEARCHERS FROM ALL THE PARTNERS AND LOCAL COMMUNITIES IN COLOMBIA

INTELLIGENCE

COMET-LA

COMMUNITY-BASED MANAGEMENT OF ENVIRONMENTAL CHALLENGES IN LATIN AMERICA

OBJECTIVES

To identify sustainable community-based governance for the management of natural resources that could be used in different social-ecological systems in a context of climate change and increasing competition in the use of these ones.

PARTNERS

Alice Newton, Norsk Institutt for Luftforskning, Norway • **Kirsty Blackstock**, James Hutton Institute, UK • **John Icely**, Sagremarisco-Viveiros de Marisco Lda., Portugal • **Mª Adelaida Farah**, Pontificia Universidad Javeriana, Colombia • **Roberto Escalante**, Universidad Nacional Autónoma de México, Mexico • **Gerardo Perillo**, Instituto Argentino de Oceanografía, Argentina • **Pablo Bordino**, Fundación Aquamarina Cecim, Argentina • **Sebastián Moreno**, Consejo Comunitario de la Comunidad Negra de la Cuenca Baja del Río Calima, Colombia • **Yolanda Lara**, Estudios Rurales y Asesoría Campesina, AC, Mexico • **Tania de la Fuente**, Comité Español de la IUCN, Spain

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MARIA DEL MAR DELGADO is an agricultural engineer specialised in problems and policies affecting rural areas. She works as a Professor at the University of Cordoba and is the Director of the Doctorate Unit. Her main research interests are related to the intergation of social and environmental aspects and to link science with society needs and effective policy-making.

JEAN-PASCAL VAN YPERSELE

Vice-chair, Intergovernmental Panel on Climate Change

When it comes to the environment, policy decisions must be informed by hard, unbiased scientific evidence. Jean-Pascal van Ypersele discusses the IPCC's role in assessing and analysing existing research to provide a firm basis for effective policy making

To begin, can you outline your role as Vice-chair of the Intergovernmental Panel on Climate Change (IPCC)?

My main objective is to help the IPCC continuously improve the manner in which it provides policy-relevant (but not policy-prescriptive) information to policy makers and other stakeholders, so that they can better understand and manage the challenge that climate change represents for humanity and ecosystems.

A key role of the Vice-chairs (three in total) is to support the best possible links between Working Groups (WGs). We aim to help build bridges across the WGs in a cross-cutting manner. Our knowledge of the IPCC 'across the board' can often help the Chair to find consensus or compromises where there are diverging views, or advise Co-chairs on issues related to the overall coherence of the IPCC or difficulties they meet in their WGs. Vice-chairs can also represent the IPCC at international meetings, and answer some of the requests made to the IPCC or its Chair. Additionally, we sit on the Science board of the IPCC Scholarship Programme, where we help to select the applications which will benefit from a grant (with funding derived initially from the Nobel Peace Prize the IPCC received in 2007).

How do you tread the fine line of making your information policy-relevant and yet never policy-prescriptive? Does this prove challenging at times?

We always have to take into account a cross-section of scientific views and the range of possible hypotheses behind the scenarios (related to emissions, development pathways, population growth, economic activities, resource potential and evolution of technology, etc.). We then present to the policy makers the range of options, with their positive and negative sides. This is fundamentally different to pleading for a particular temperature target or technology or policy.

Is it challenging? Yes, sometimes, because all scientists are citizens and they have opinions too. But the IPCC process is very robust, and its key conclusions are based on a careful and balanced review of the literature, and not on the opinion of individuals. We need to present options to policy makers and let them choose, without attempting to pre-empt their role.

What is the IPCC's current focus in light of recent events such as Rio+20?

The work of the IPCC underpins the climate negotiations at the UNFCCC and provides a context for all international meetings on sustainable development. Even if climate change was not a separate topic at Rio+20, it ran through all discussions and there were many references to the IPCC's assessments. Our current focus is the Fifth Assessment Report, which will appear in 2013 and 2014. Countries meeting at the UN Climate Change Conference in Durban at the end of last year (COP17/CMP7) agreed to increase their ambition to act. This is being led by the climate science in the IPCC's Fifth Assessment Report and the global Review which takes place 2013-15. This fits exactly with the IPCC's role of bringing science to policy makers. Policy making in complex areas such as this requires a firm foundation of science, and the IPCC has reviewed its internal procedures over the last two years to make its assessments even more robust.

Can you expand on your recent side-events at Rio+20, which explored the links between science and policy? What conclusions were drawn from these events?

Last year the IPCC produced two extremely relevant reports in this context: the IPCC Special Reports on 'Renewable Energy Sources and Climate Change Mitigation' (SRREN), and on 'Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation'

(SREX). In addition to highlighting those reports, these side-events also represented an opportunity to remind policy makers about the content of the last IPCC overall assessment report, published in 2007.

At Rio we held two side events, one at the UN Conference on Sustainable Development itself, and the other at the Forum on Science, Technology and Innovation for Sustainable Development. At both events we examined the science-policy interface, taking IPCC assessments and the recent special reports as examples of how scientific work could feed into the policy process.

What were the key findings of the SREX report?

SREX assesses the state of knowledge about the observed increase in the length or number of warm spells or heat waves in many regions, the likely increase in frequency of heavy precipitation events, or the projected increase in duration and intensity of droughts in some regions. It also shows that, while some extreme weather and climate events lead to disasters, others do not. Policies to avoid, prepare for, respond to and recover from the risks of disaster can reduce the impact of these events and increase the resilience of people exposed to extreme events. I am confident this report will help to improve preparation for effective response to extreme climate events and disasters, enhance recovery, and help to find synergies between effective adaptation to climate change and sustainable development.

The IPCC aims to provide the world with a clear scientific view on the current state of knowledge in climate change, its potential environmental and socioeconomic impacts, and the solutions at hand to reduce emissions or adapt to climate change. How is this scientific view informed by existing research on climate issues?

As the IPCC does not produce original research itself (at least in the classical sense), it must rely on scientific literature to base its assessments. The author teams review and assess this scientific basis, and reflect in their chapters the quality of evidence and the level of scientific agreement in that literature. The IPCC reports are actually so heavily based on the literature, which it assesses in the most comprehensive and objective manner possible, that the number of pages devoted to bibliographical references is now becoming an issue.

What are the benefits of creating scientific reports of climate change that take an international approach? Are there any limitations of not creating country specific reports on climate change?

There are physical but also human reasons to justify a global approach. We all share the same planet, even if regional climates differ. The climate system can be seen as a series of interconnecting processes occurring far apart: Sea level in Pacific islands is influenced by ice melting in Greenland; El Niño events west of Peru can affect rainfall in Australia or East Africa. You cannot understand local or regional climate change and variability without looking at the global picture. But the human reasons are pretty important too; for example, local food prices are influenced by world markets. The next IPCC report will contain more regional information than previous ones, but in a global context.

Can you identify the main challenges that the IPCC faces in communicating scientific research on climate change?

Communicating science is a particular challenge for the IPCC, be it with our prime audience of governments or with other stakeholders. This is because the rigorous reviews behind an IPCC report culminate in a dialogue between scientists and government representatives in which the texts are accepted or approved (with scientists having the last word). As a result, it is not possible for the IPCC itself to later simplify or paraphrase the content to make it easier to understand for a lay audience without threatening the agreed text or its scientific accuracy.

How does your role as Vice-chair complement your wider work in the field of climate change modelling and anthropogenic effects of climate change?

Let me offer an example: I have been chairing the Energy and Climate Working Group of the Belgian Federal (advisory) Council for Sustainable Development since 1998. This has allowed me to practise consensus-building in a group with stakeholders of very diverse interests and opinions (including electricity producers, employers, trade unions, environment and development NGOs).

My research has broadened over the years. It includes: detailed modelling of ocean and sea ice interactions in the Southern Ocean; modelling climate variations at the century and paleoclimate timescales; regional climate modelling in polar regions, Europe, and Africa; and interdisciplinary work with adaptation scientists on key vulnerabilities, with demographers on the role of population growth in carbon emissions, and with economists on the stability of international climate agreements using a game-theoretical approach. I have peer-reviewed publications in each of these areas. This is one of the reasons I enjoy having a cross-cutting role as Vice-chair: I like building bridges across disciplines and people, to serve the common good.

Jean-Pascal van Ypersele currently holds the position of Professor at the Université catholique de Louvain.

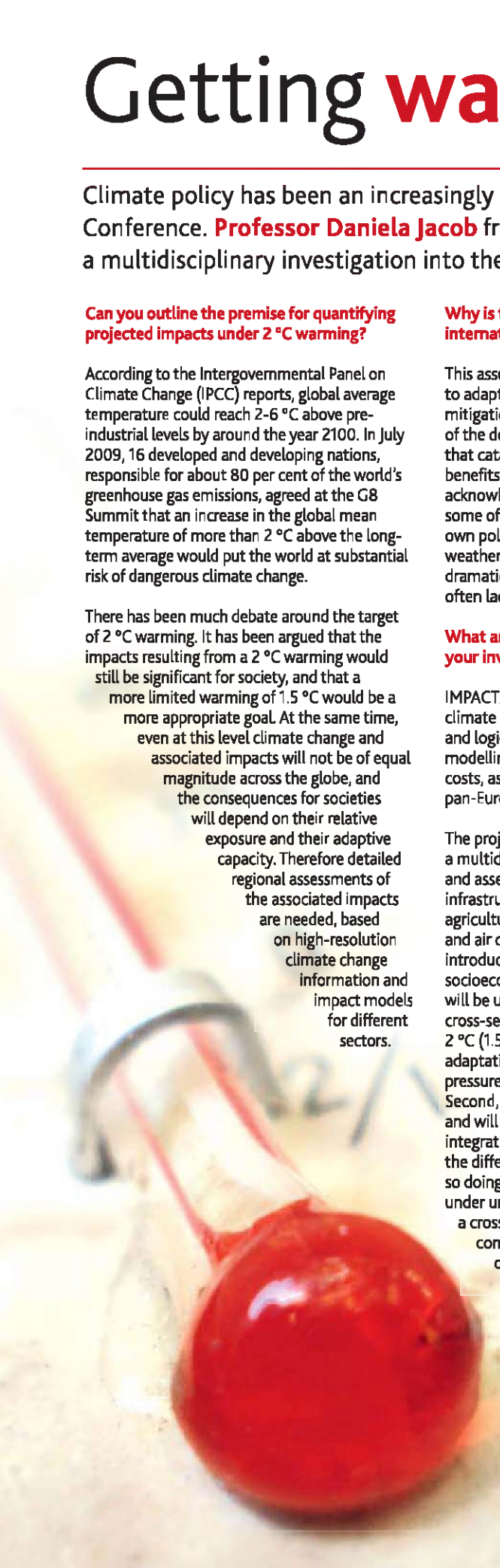
Getting warmer

Climate policy has been an increasingly common topic of debate in the lead up to the recent Rio+20 Conference. **Professor Daniela Jacob** from Hamburg's Climate Service Center offers insight on a multidisciplinary investigation into the impacts of climate change policy across Europe

Can you outline the premise for quantifying projected impacts under 2 °C warming?

According to the Intergovernmental Panel on Climate Change (IPCC) reports, global average temperature could reach 2-6 °C above pre-industrial levels by around the year 2100. In July 2009, 16 developed and developing nations, responsible for about 80 per cent of the world's greenhouse gas emissions, agreed at the G8 Summit that an increase in the global mean temperature of more than 2 °C above the long-term average would put the world at substantial risk of dangerous climate change.

There has been much debate around the target of 2 °C warming. It has been argued that the impacts resulting from a 2 °C warming would still be significant for society, and that a more limited warming of 1.5 °C would be a more appropriate goal. At the same time, even at this level climate change and associated impacts will not be of equal magnitude across the globe, and the consequences for societies will depend on their relative exposure and their adaptive capacity. Therefore detailed regional assessments of the associated impacts are needed, based on high-resolution climate change information and impact models for different sectors.



Why is the accurate assessment of international climate policy so important?

This assessment will help to prepare Europe to adapt to climatic changes, in addition to its mitigation efforts. It must include an analysis of the development of means and extremes, so that catastrophe can be mitigated and possible benefits exploited. In this context Europe acknowledges its responsibility to also support some of the most vulnerable regions outside its own political sphere. In these regions extreme weather situations can have a much more dramatic impact. In addition, these regions often lack adaptive capacity.

What are the main aims and objectives of your investigation?

IMPACT2C enhances knowledge, quantifies climate change impacts, and adopts a clear and logical structure, with climate and impacts modelling, vulnerabilities, risks and economic costs, as well as potential responses, within a pan-European sector based analysis.

The project utilises a range of models within a multidisciplinary international expert team and assesses the effects on water, energy, infrastructure, coasts, tourism, forestry, agriculture, ecosystems services, and health and air quality-climate interactions. IMPACT2C introduces key innovations. First, harmonised socioeconomic assumptions and scenarios will be used to ensure that both individual and cross-sector assessments are aligned to the 2 °C (1.5 °C) scenario for both impacts and adaptation; for example, in relation to land use pressures between agriculture and forestry. Second, it has a core theme of uncertainty, and will develop a methodological framework integrating the uncertainties within and across the different sectors, in a consistent way. In so doing, analysis of adaptation responses under uncertainty will be enhanced. Finally, a cross-sectorial perspective is adopted to complement the sector analysis. A number of case studies will be developed for particularly vulnerable areas subject to multiple impacts, for example, the Mediterranean, and cross-sectorial interactions – such as land use competition and cross-cutting themes – as found in cities.

The project also assesses climate change impacts in some of the world's most vulnerable regions: Bangladesh, the Nile and Niger basins in Africa and the Maldives.

You use a variety of scenarios in your assessment. From where do you draw your data?

The provision of relevant climate data, tailored (ie. bias corrected) to the needs of the impact studies, is a key aspect of IMPACT2C. A multi-model ensemble will be constructed from existing IPCC 4th Assessment Report scenarios. In addition, data from the new climate change scenarios prepared for the IPCC 5th Assessment Report, following the concept of Representative Concentration Pathways (RCP) will be is used in IMPACT2C. These RCP scenarios include stabilisation scenarios that will allow impact studies for climate change at the level of a global increase in mean temperatures by 2 °C. The global scenarios will be downscaled to high resolution over Europe and the non-European regions, since it is well known that spatial resolution is a crucial parameter in climate modelling.

Why are you quantifying the impacts on Europe and vulnerable regions in particular? Why is this not being conducted on a global scale?

The EU is very interested in the 2°C target and associated challenges. Therefore Europe took the lead by establishing IMPACT2C in order to quantify the impacts in Europe, and the most vulnerable regions worldwide. Europe has been chosen because of the political interest, but also because of the long tradition in cooperation between the scientists of different Member States. In addition, the data availability is very good so that the modelling results can be verified against observations before they are used for studies of future climates in Europe and elsewhere.

The real impacts of 2 °C warming

A groundbreaking four-year investigation into the effects of climate change across Europe is currently underway. **IMPACT2C** aims to inform future EU policy on adapting to the impacts of 2 °C global warming

AT THE 2009 G8 Summit, world leaders came to the agreement that in order to prevent disastrous climate change, global temperatures should not be allowed to rise more than 2°C above preindustrial levels. However, exactly how this can and should be achieved remains an unresolved issue at the heart of the heated debate over global warming. In addition it is still unclear how a 2 °C warming will change the regional climate and impact society. In order to take the most efficient and effective action, politicians must rely on scientific expertise, and so the EU is funding the IMPACT2C project. This research will examine the effects of a temperature increase of 2 °C above pre-industrial levels on a wide range of sectors across the EU and beyond. It will be invaluable to the EU policy makers who must decide Europe's role in this global environmental challenge.

Coordinated by Professor Daniela Jacob of the Climate Service Center (CSC) in Hamburg, the four-year project brings together the expertise of 29 different organisations from 17 different countries. Jacob is confident that the team is well-positioned to tackle the task of managing the research: "The newly established CSC in Germany is particularly suited to coordinate such an interdisciplinary activity, which is fully in line with CSC key objectives," she states. "These include networking between disciplines and linking climate information with the demands of the impact, vulnerability and adaptation communities, as well as with stakeholders from public and private sectors."

INTERNATIONAL COOPERATION

The research has brought together experts from the top of a wide range of fields in order to achieve the most detailed projection of the effects of 2 °C warming. This complex process will therefore benefit from the collaboration of many different institutions; from universities such as the Technical University of Crete and the University of Graz in Austria, to national meteorological centres including the UK's Met Office and Meteo France, and international bodies like the World Health Organization.

Due to the wide range of possible future situations, accounting for uncertainties is integral to decision making for adaptation to climate change

As the scope of the project goes beyond the borders of the EU to assess the adaptability of some of the world's most vulnerable countries to climate change, there are also experts from the Ministry of Housing and Environment in the Maldives, water management institutions from Bangladesh and Sri Lanka, and application for development in Niger and Nile River basins.

With such a broad range of expertise available, IMPACT2C aims to assess the impact of 2 °C warming on water and air quality, industries such as tourism, agriculture and forestry, and on health and infrastructure. To do this, the team will first need to paint the most accurate possible picture of Europe's climate under 2 °C warming. This requires careful analysis of regional climate change patterns in the past, provision of high-resolution models and scenarios of atmospheric changes and downscaling of global climate change scenarios so that the impact of climate change can be accurately assessed.

DEALING WITH UNCERTAINTY

An important consideration in any scientific research is the amount of uncertainty involved. For IMPACT2C, which aims to make predictions for a wide range of sectors, the question of uncertainty is of the utmost importance. Jacob explains that, due to the wide range of possible future situations, accounting for uncertainties is integral to decision making for adaptation to climate change, and this is in the centre of the project: "This leads to a focus on robustness, flexibility and adaptive management; for example, the use of a phased approach to cope with uncertainty, including monitoring and re-evaluation".

Once equipped with models for climate change and the framework for integrating uncertainty, the scientists will be able to assess the impact of 2 °C warming on environmental, social and economic factors. With this accomplished, researchers will go on to estimate the costs involved with adapting to the change for each of the sectors implicated. All of the interrelating factors and how they connect will be taken into account when calculating the levels of risk and cost.

To achieve this, the team plans to use a combination of models. There are three key areas to be investigated with regards to the impacts and costs of a global mean temperature increase of 2 °C. The focus in particular for Europe is on water resource management and flooding and a multi-model approach will be implemented to analyse freshwater, energy and tourism in this domain. Secondly, forestry, agriculture and ecosystems services will be examined. The research will take results from biophysical models to input into economic models and determine which options would lead to the most effective adaptation to climate change for this sector. Finally, for air pollution and health, the objective is to use data from the last 20 years to predict how the composition of Europe's atmosphere would be affected by a 2 °C temperature rise and the costs involved.

BEYOND THE EU

Little research in this area has matched the scope of the current effort. IMPACT2C represents the most comprehensive study so far into the real impacts we are likely to see across Europe due to climate change. To ensure the projections are reliable, all results will be synthesised across the various sectors so that a clear picture can emerge of how they interact and what the overall consequences, both environmental and economic, are likely to be. But the researchers are well aware that not all regions in the world will be affected to the same degree, and many countries do not necessarily have the resources to adapt effectively to climate change. IMPACT2C thus aims to build up case studies of some of the world's most vulnerable regions to support their efforts to adapt.

In Africa, the team will focus on the Nile and Niger River basins to evaluate how 2 °C climate change would impact water flow and the vegetation and agriculture it sustains. This information would be used to assess the vulnerability of these regions. The research aims to provide information that can inform the emergency decision-making processes, water management and food production so areas can be better equipped to adapt to the effects of climate change. Two more case studies will examine the Maldives and coastal regions of Bangladesh. With the same objectives as the African case study, this work will enable these vulnerable regions to better prepare themselves for a 2 °C rise.

SPREADING THE WORD

With such valuable research underway, Jacob is keen to emphasise one more crucial consideration of their work: "The project develops an awareness-raising programme and dissemination activities to present the findings and key messages to politicians, decision makers, policy makers, the media and climate information users in general". This research has the potential to shape the future of European economic, climate and environmental policy and, as such, it must be presented and communicated to many different people. This is why the objectives of the consortium include synthesising the findings so they are accessible to a wide audience. Not only does IMPACT2C seek to inform policy, it also aims to raise awareness of the issues at stake.

As part of the awareness raising programme Jacob and her collaborators are organising summer schools for young scientists. Clearly, this is a project with a long-term vision. Passing on the most up-to-date knowledge is vital to meeting the 2°C target and to solving a problem which will potentially impact many generations to come.

INTELLIGENCE

IMPACT2C

QUANTIFYING PROJECTED IMPACTS UNDER 2 °C WARMING

OBJECTIVES

To enhance knowledge, quantify climate change impacts, and adopt a clear and logical structure, with climate and impacts modelling, vulnerabilities, risks and economic costs, as well as potential responses, within a pan-European sector based analysis.

PARTNERS

HZG, Germany • **PIK**, Germany • **UniRes**, Norway • **MET.NO**, Norway • **SMHI**, Sweden • **EU JRC**, Belgium • **ENEA**, Italy • **CNRS-IPSL**, France • **MeteoF**, France • **UniGraz**, Austria • **JR**, Austria • **IIASA**, Austria • **DMI**, Denmark • **KNMI**, The Netherlands • **WU**, Netherlands • **TUC**, Greece • **PW**, United Kingdom • **UNIL**, Switzerland • **SOTON**, UK • **SEI-Oxford**, UK • **MetOffice**, UK • **MHE**, Maldives • **BCAS**, Bangladesh • **IWMI**, Sri Lanka • **WI**, The Netherlands • **WHO**, Europe • **IWM**, Bangladesh • **ACMAD**, Niger • **GCF**, Germany

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PROFESSOR DANIELA JACOB is Associate Director at the Climate Service Center, Helmholtz-Zentrum Geesthacht, Germany. Being Head of the Climate System Department, she is gathering information about climate change and is supporting partners from science, industry and administration in interpreting the data. Since 2009 Jacob has been Professor at the University of Bergen, Norway. She is also contributing to the 5th Assessment Report of the IPCC as one of the lead authors.

SEVENTH FRAMEWORK PROGRAMME

Preventing pollution in the Med

Gloria Rodríguez, **Víctor Vázquez** and **Eva Pérez** explain how they are supporting the dissemination of Best Available Techniques to encourage the prevention and control of industrial pollution in North Africa and the Middle East

To begin, can you outline the key objectives of the BAT4MED programme?

Industrial pollution processes account for a considerable share of the overall pollution in the Mediterranean. The principal objective of the project is to ensure a higher level of environmental protection of the Mediterranean region, minimising the negative impacts associated with activities, products and services from key industrial sectors in Mediterranean Partner Countries (MPC).

The possibilities for and impact of diffusion of the EU Integrated Pollution Prevention and Control (IPPC) approach to the MPCs will be assessed and the implementation of Best Available Techniques (BAT) in the national environmental programmes will be promoted and supported.

Could you explain BAT in the context of this project?

The European IPPC Directive introduced a regulatory system that uses an integrated approach to environmental protection by controlling emissions to air, water and land from those industrial activities falling within the scope of the Directive. In essence, the policy

A better path to cleaning up the Mediterranean

The Andalusian Institute of Technology is leading the **BAT4MED** project to disseminate pollution prevention and control schemes from EU Member States to other countries in the Mediterranean region

THE MEDITERRANEAN AREA is one of the most environmentally vulnerable regions in the world. According to the United Nations Environment Programme around 60 per cent of the world's 'water-poor' population is concentrated in the 22 countries that encircle Europe's largest sea. Because it is ostensibly landlocked, the Mediterranean's waters have a very low renewal rate of 80 to 90 years, and this makes the sea particularly sensitive to pollution from land-based industrial activity.

Since 1996, the EU's Directive of Integrated Pollution Prevention and Control (IPPC) has required EU Member States in the Mediterranean region to limit the negative impacts of their polluting industries, and in 2010 the IPPC was integrated into the Industrial Emissions Directive along with six other European directives regulating large industrial sites. The IPPC obligates operators of polluting industries to obtain a permit in order to continue their activity, with the condition that they comply with certain standards regarding large-scale pollution, waste disposal, energy efficiency and the use of the Best Available Techniques (BAT) in all of these areas.

The IPPC has helped to limit pollution from industrial activity among EU Member States; however, only six of the countries bordering the Mediterranean are Members of the EU, meaning the majority of countries in the region are not subject to the IPPC directive. Due to the intensification of the industrial activities there has been an increase in the discharge of industrial liquid waste into the Mediterranean Sea in recent years, both in terms of the quantity and types of waste. The Boosting Best

requires polluting industrial operators to obtain environmental permits to run their facilities.

Such permits are based on the application of BAT to prevent and control emissions to all environmental media. BAT is defined by the IPPC Directive as 'the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for Emission Limit Values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole'.

Why are you focusing on Egypt, Tunisia and Morocco in your assessments?

Egypt, Tunisia and Morocco are among the Mediterranean countries where the European Environment Agency identified industrial effluents as major environmental problems. Moreover, the participating organisations from these countries showed significant interest in the project. The need for representation at the policy making and public authorities level in these countries – as well as their experience and involvement in previous and current programmes for the protection of the environment – presented a unique opportunity to collaborate and develop the BAT4MED project.

What are the key challenges presented in the research?

From a scientific perspective, one of the key challenges is to tailor the concept of BAT to the industrial system and the territorial context in which the production is carried out. This is fundamental to guarantee that the IPPC-like approach in the MPCs would lead to a feasible and replicable adoption process that is simultaneously able to yield significant improvements on the environmental performance.

In this spirit, coordinated efforts are being undertaken to involve and bring together stakeholders mainly from industries, public authorities, universities and agencies operating in the target sectors of the three participating MPCs to provide support and assist in tailoring the BAT concept and reports in such countries.

It would be impossible for one country to gather and analyse all the information needed to define common environmental strategies in the Mediterranean Area. All partner inputs will contribute to both research-related activities and policy making, helping provide important information for the development of common environmental plans.

How has the project been funded? What wider schemes or EU initiatives does it fit into?

The BAT4MED project is a Coordinating Action co-funded by the European Commission in the Environment Theme of the Seventh Framework Programme (FP7).

There are several wider schemes or EU initiatives that BAT4MED fits into, such as the Eco-Innovation Action Plan and Horizon 2020. The project can help strengthen Eco-AP Action 5 (International Cooperation) by supporting the transfer and uptake of environmental technologies in the MPCs.

Additionally, by coordinating high-level research in the field of pollution prevention and control in the Mediterranean region and disseminating the results of the research to the wider EU and Mediterranean community, BAT4MED will contribute to strengthen the implementation of the Horizon 2020 initiative, particularly to its research component.

Available Techniques in the Mediterranean Partner Countries (BAT4MED) project is thus attempting to extend the environmental protection afforded by the IPPC to the EU's Mediterranean Partner Countries (MPCs) in order to bridge the gap on pollution prevention and control.

AREAS FOR IMPROVEMENT

BAT4MED, which is being co-financed by the European Commission as part of the Seventh Framework Programme (FP7) for Research and Technological Development, is coordinated by the Andalusian Institute of Technology (IAT) in collaboration with seven partners from six countries in Europe and North Africa.

The central aim of the project is to assess the potential for extending the principles of the IPPC, in particular the concept of 'Best Available Techniques' (BAT), throughout the Mediterranean region. BAT is one of the key features of the IPPC and refers to the most advanced and effective methods of limiting pollution which are at the same time accessible and economically viable. Eva Pérez, the project coordinator at IAT, explains this objective: "BAT4MED has arisen from the need to promote technological cooperation and know-how transfer regarding the technical, environmental and economical characteristics of BAT in industrial sectors".

To date, research has focused on using a deep industrial analysis in order to identify the industrial sectors in the MPCs which have the most significant negative impacts on human health and the environment, and would therefore benefit the most from the application of BAT. In the three participating countries – Egypt, Tunisia and Morocco – the dairy and textiles industries were selected for closer analysis based on two main criteria: they should be shared industries which have a high Environmental Benefit Potential and they should also permit the transferability of results to neighbouring countries.

Following the selection of these sectors, technical audits were carried out in a number of industrial installations spanning the two industries and three participating countries in order to ascertain the current technologies being used and the associated emission and consumption levels. This information will be written up into BAT sector reports which will assess the potential for improvements based on environmentally friendly techniques for pollution prevention and control.

The research has also focused on developing a methodology for determining which techniques constitute the 'best available' for a given industry: "This methodology involves the evaluation of all potential environmentally friendly techniques, or so-called candidate BATs, with respect to their technical feasibility, environmental benefit and economic feasibility in MPCs," the project's senior environmental advisor, Víctor Vázquez, outlines. The results of this evaluation will also be included in the BAT sector reports for each MPC, which will constitute one of the key outcomes of the project.

The team hopes that these sector reports will encourage MPCs to improve their techniques in the field of pollution prevention and control: "The information on BAT will demonstrate the environmental, but also the economic, benefits arising from their application, in order to motivate industrial managers for their implementation".

BAT4MED

BOOSTING THE BEST AVAILABLE TECHNIQUES IN THE MEDITERRANEAN PARTNER COUNTRIES

OBJECTIVES

To ensure a higher level of environmental protection of the Mediterranean region, minimising the negative impacts associated to the activity key industrial sectors. To that aim, the possibilities for and impact of diffusion of the EU Integrated Pollution Prevention and Control approach to the Mediterranean Partner Countries (MPC) will be assessed and the implementation of Best Available Techniques in the national environmental programmes will be promoted and supported.

PARTNERS

Centre for Environment and Development for the Arab Region and Europe, Egypt • **Scuola Superiore di Studi Universitari e di Perfezionamento Sant'anna**, Italy • **Vlaamse Instelling voor Technologisch Onderzoek Nv**, Belgium • **Egyptian Environmental Affairs Agency**, Egypt • **Association du Centre Marocain de Production Propre**, Morocco • **Agencia de Residus de Catalunya**, Spain • **Centre International des Technologies de L'environnement De Tunis**, Tunisia

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The central aim of the project is to assess the potential for extending the principles of the IPPC, in particular the concept of 'Best Available Techniques'

BUILDING NETWORKS IN THE REGION

The consortium is also working to ensure that the benefits of the project are not confined to the three countries under detailed study by networking with other organisations in the Middle East. Among others, the Lebanese Cleaner Production Centre and the Jordanian Royal Scientific Society – EcoTech Park have already confirmed their interest in disseminating the project's results at a national level: "This will enhance networking with all MPCs and allow them to benefit from project results, ensuring thus a higher impact of project results all over the Mediterranean," Pérez states. This aim is also being furthered through the participation of CEDARE, an international environmental NGO which intends to spread the project results to the other countries in the Mediterranean region which are not directly involved in the programme.

The project coordinators believe that by engaging with a wide range of decision makers they will be able to produce concrete policy recommendations to limit pollution in the MPCs. So far, there has been direct participation from policy makers and advisors from the three participating MPCs, and local expert groups comprising industry representatives and national authorities have also been formed in each of the three countries. These Technical Working Groups will ensure that the policy recommendations are suited to the specific conditions in each country, as Gloria Rodríguez, IAT's Scientific Manager, explains: "One of the key challenges is to tailor the concept of BAT to the industrial system and to the territorial context in which the production is carried out".

BEYOND BAT

Aside from the development of BAT sector reports, a longer-term goal of the work is to assess the potential for an IPPC-approach permitting process in the MPCs. To this end, the study will analyse the potential efficacy of a system of integrated permits and its operational validity in the context of the MPCs. The researchers intend to propose institutional innovations that could facilitate the implementation of a BAT-based permitting system, whilst working to build consensus among a range of stakeholders on the introduction of a tougher regulatory system.

An important element of this analysis will be to assess the impact an IPPC-based scheme would have on the economic development of the developing countries in the Mediterranean region. Pérez suggests that, rather than hindering development, greater environmental regulation would likely increase the competitiveness of the MPCs: "The pattern of economic growth of the MPCs is increasingly relying on the ability of their industrial activities to face up to the competitive challenges of the EU markets, by complying with increasingly high-quality standards and performance requirements". However, ensuring that a new permit-based system would not affect the economic development of the MPCs will be an important consideration for the researchers.

EUROMED2012

The 4th International Euro-Mediterranean Conference brings together stakeholders from approximately 60 countries: researchers, professionals, practitioners and those with a passion for all major scientific areas related to cultural heritage. Held from 29 October to 3 November, the event will take place in Lemesos, Cyprus – a Mediterranean island steeped in rich archaeological history

GLOBAL CHANGE HAS created significant challenges for mankind, ranging from the pressing need to lower rates of biodiversity loss to trying to adapt to extreme weather events and ecosystem disruptions which might place our own species in direct danger. One often overlooked impact is the threat posed to our cultural heritage; those very objects and artefacts that represent the unique beauty of our personal and collective existence.

Protection of cultural heritage in the face of global change is becoming a major concern for decision makers, stakeholders and citizens in Europe. Research into strategies, methodologies and tools is needed to safeguard cultural heritage against continuous decay. Before irreversible damage is done, concerted actions, based on sound science, are needed to protect, strengthen and adapt Europe's unique cultural patrimony.

Scientific projects in the area of cultural heritage have received national, European Union or UNESCO funding for more than 30 years. Through this financial support and cooperation, major results have been achieved and published in peer-reviewed journals and conference proceedings with the support of professionals from many countries. This work will be carried forward by initiatives such as the European Commission's JPI on Cultural Heritage and Global Change. The European Conferences on cultural heritage research and development – and in particular the biannual EuroMed Conference – have become regular milestones on the never-ending journey of discovery in the search for new knowledge of our common history and its protection and preservation for the generations to come. They also provide a unique opportunity to present and review results, and draw new inspiration.

The agenda of this unique conference will include hundreds of excellent oral and poster presentations, as well as workshops and demonstrations from academia and industry, reflecting the wide scope of our work in the area of cultural heritage. Policy makers, professionals, students and delegates from more than 60 countries are expected to attend this special Euro-Mediterranean conference which is dedicated to the protection, preservation and e-documentation of cultural heritage.

The ultimate aim of the 4th EuroMed conference is to bring together as many stakeholders as possible from different backgrounds in order to achieve a high level of mutual understanding of the needs, the requirements and the technical means of meeting them. Therefore, the common goal is to focus on interdisciplinary and multi-disciplinary research on tangible and intangible cultural heritage, the use of cutting-edge technologies for the protection, preservation, conservation, massive digitalisation and visualisation/presentation of cultural heritage content (archaeological sites, artefacts, monuments, libraries, archives, museums, etc). Simultaneously, the event is intended to cover topics of research ready for exploitation, demonstrating the acceptability of new sustainable approaches and new technologies by the user community, SMEs, owners, managers and conservators of cultural patrimony.

It is important that policy makers and a wide public are involved in management of the cultural heritage, and it is useful to inform European citizens about recent developments and scientific achievements in this area. The entire exhibition as well as special satellite conference sessions will be dedicated to raising public awareness in the whole field of cultural heritage.

INTERNATIONAL CONFERENCE ON CULTURAL HERITAGE
Oct 29th - Nov 3rd 2012
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Research Roundtable: Nature's Capital

Humans benefit from a variety of resources and processes that are readily supplied by natural ecosystems, known collectively as ecosystem services. Here, *International Innovation* seeks the opinions of a number of economic and scientific experts on the effects of placing economical value on the world's natural resources, to find out whether this is beneficial or detrimental to the environment and society

Does attaching monetary value to ecosystem services necessarily damage efforts to improve environmental protection, or could a move away from this recent trend inadvertently strengthen the position of those whose only interest is financial gain?

Dr Nancy Johnson (Czech University of Life Sciences):

In my opinion, this criticism is political hyperbole. Although monetary value is a poor proxy for the multifaceted values of natural ecosystems, I still believe that attaching an economic value to ecosystem services is useful in some situations. Money helps set priorities in capitalist societies. Converting the intangible values of nature into the currency of commerce should be one of many strategies for protecting the environment.

Carlos Manuel Rodriguez (Conservation International):

Environmental services that are essential for livelihoods and economic growth are too often unrecognised or undervalued by market prices and national accounting. Without understanding the value of ecosystem services – or what it would cost to replace the services that nature provides for free – we have been steadily drawing down our natural capital. Decision makers with access to information on the value of ecosystem

services are better placed to make more efficient, cost-effective choices as they understand not only the economic value of nature, but also the higher costs of damaging it.

My country, Costa Rica, pioneered this concept 20 years ago to fight deforestation. After studies showed the economic benefits of natural ecosystems (especially tourism) the Government created a national policy for payments for environmental services. This gave people an incentive to protect their forest as opposed to chopping it down for income from agriculture and cattle ranching. Today around 700,000 hectares of forest are protected by the programme, benefiting more than 7,000 private land owners in rural areas.

Comparing the benefits associated with conservation of natural areas with the benefits from conversion of land for other uses can aid priority-setting in a variety of contexts, such as development decisions in rural landscapes and conservation planning at the national scale. Attaching monetary value to ecosystem services always strengthens efforts to improve environmental protection.

Keith Alverson (UNEP):

The concept of valuation of nature in the context of climate change derives primarily from the need to balance costs associated with the impact of climate change against investments required to adapt. While climate change is a global problem, both its impacts and adaptive responses are local. Elinor Ostrom received the Nobel Prize in Economics in 2009 for her work cautioning against global governance solutions to environmental destruction in favour of management decisions made locally by the most engaged and knowledgeable stakeholders.

Following this logic, economic valuation is quintessentially a local management tool that can assist in balancing tradeoffs, conflicting choices and alternate courses of action given limited financial resources. Valuation is less useful at the national or global level. Figures in the trillions meant to reflect the value of global ecosystems, or some broad subset thereof such as 'coastal' or 'forest', are not useful except perhaps for creating rudimentary awareness. Indeed such large-scale bean-counting can even backfire when the obvious counterpoint is made that it is patently ridiculous to put a price tag on something as valuable as to defy such trivial reductionism. State-dependent, context and stakeholder-specific valuation of malign and benign impacts are nonetheless useful for tangible decision making at the local level. For example, if a road or dam is being planned it makes sense to estimate plausible resulting economic losses, which are often local, and balance these against the proposed gains, which are often more dispersed. In conclusion, I would suggest that economic valuation is a useful tool with potential to clarify decision making at the local level and arrive at socially desirable outcomes.

Dr Günter Langergraber (University of Natural Resources and Life Sciences (BOKU), Vienna):

At the start of the development of the CLARA simplified planning tool – designed to assist local planners and consultants to compare different solutions of water supply and sanitation systems based on real costs – we also aimed to include economic valuations of environmental and health aspects. However, we excluded those aspects from our tool because: 1) only solutions that are within the legal framework shall be considered; and 2) the economic valuation of these aspects is not a standardised procedure yet and we want to have a simplified tool that can be used by local people. Within point one, it is assumed that solutions falling within the legal framework also benefit the environment and human health.

Leon C Braat (Alterra, Wageningen University & Research):

The costs biodiversity loss and the benefits of conserving non-market ecosystem services have long been ignored by politicians around the globe (Braat & Ten Brink, 2008). The concept of ecosystem services and the so-called utilitarian approach to biodiversity, where the value is assigned via ecosystem services, of which biodiversity presumably is an essential part, has become at least as important in arguments for conservation and sustainable use, eg. in the European Biodiversity Strategy.

In The Economics of Ecosystems and Biodiversity (TEEB) Foundation's (2010), valuation is depicted as a form of 'regulatory adaptation to provide feedback in an economic system'. Valuation of changes in biodiversity, natural capital and ecosystem services then becomes a logical and necessary element of the sustainable development policy cycle.

'To value is to monetise' in the eyes of many, some of which state this with enthusiasm, others with horror. The limitations of monetary valuation are many, if only that the currencies employed may be instable, the market-based methods suffer from the same flaws as the markets themselves, and when ecosystems are near critical thresholds and change is irreversible, money values do not help as a regulatory mechanism (Braat & De Groot, 2012). Robert Constanza observed recently that the concept of 'economic value' is too often unnecessarily and incorrectly equated and simplified to the term 'market value' and that the act of 'expressing economic value of ecosystem services in monetary terms' is similarly and wrongly equated to 'privatisation and commodification of biodiversity and ecosystem services" (5th Annual meeting of ESP, Portland, 2012).

There is clear evidence for a central role of biodiversity in the delivery of ecosystem services. Most of the current measures and indicators of biodiversity and ecosystems were however developed for purposes other than economic assessment. They are therefore not always able to show clear relationships between components of biodiversity and the services or benefits they provide to people. Through establishing the relative contribution of both ecosystems and man, a sound basis for monetary valuation of ecosystem services can be established (see also: http://ec.europa.eu/environment/nature/biodiversity/economics/index_en.htm).

Paolo Simonelli (University of Bergen):

Although I believe, that the concept of 'ecosystem services' was born with the intention of stimulating social responsibility toward the vulnerability of planet ecosystems, I do agree with George Monbiot's concerns about the increasing ecosystems privatisation. Originally, the economic valuation of nature was aimed to inform decision makers about the potential cost for the replacement of services freely provided by nature. This was thought to drive them towards more responsible choices in terms of ecosystem protection. Today this concept is shifting to an 'ecosystems market' where seas, rain and forests become 'natural capitals'. This arises, in my opinion, from the erroneous assumption that everything which has an economical value is automatically buyable, sellable and exchangeable. Moreover, how is it possible to define the value of something that we do not entirely understand the function of and who should define the beneficiaries of such value?

There are so many difficulties related to the economic valuation of nature that I wonder whether we really need it. Would it not be better to raise decision makers' awareness about ecosystems conservation through a more organic cooperation between them and the scientific community? It might be in vain but is at least, less dangerous.

Positioning biochar for a solid future

Dr Franco Miglietta has been developing biochar to sustainably sequester atmospheric carbon dioxide. He talks about the potential for its adoption through opening access to voluntary carbon credit mechanisms

What stage is EuroChar at in its assessment of biochar as a means to effectively sequester carbon while simultaneously improving agricultural soils? What have you discovered to date?

We are discovering many new things all the time. For instance, we have been able to estimate the fraction of carbon which is rapidly attacked by soil microbes in the field by using Cavity ring-down spectroscopy of the natural abundances of ^{13}C and ^{12}C in soil-respired carbon dioxide. We were able to gather this new data by using the peculiar isotopic signature of biochar produced from plants with C^4 metabolism – basically corn residues – which have been used by Advanced Gasification Technology and Carbon Solutions to produce biochar. We are also discovering that charcoal is favourably modifying soil properties over centennial time scales. For this, EuroChar is undertaking unprecedented research in alpine charcoal pits that were operated until the end of the 18th Century. Using molecular approaches in a model plant, we have also investigated detailed plant responses to the addition of biochar to the soil. This was carried out to elucidate a series of mechanisms leading to substantial positive effects of biochar on early plant growth.

Can you briefly outline the benefits of biochar?

Biochar has only been recently proposed as one of the most promising strategies to sustainably sequester atmospheric CO_2 in agricultural soils. Mitigation potentials of biochar were estimated to be as high as 12 per cent of current anthropogenic carbon dioxide emissions by Woolf and colleagues in 2010. This is something that might possibly be achieved under a win-win framework leading to a substantial enhancement of soil fertility, increased crop yields and renewable energy production. The long-term stability of the carbon contained in biochar was demonstrated to be greater compared to non-pyrolysed organic matter that was incorporated into soils with the same environmental conditions by a number of scientists from 2002-08. Biochar has an approximate mean residence time in the soil more than 1,000 years and this long-

term stability is a fundamental prerequisite to consider biochar as a suitable method for carbon sequestration. However, such an optimistic scenario requires more detailed and reliable assessment of direct biochar effects on crops and the environment, as well as an evaluation of socioeconomic implications. Most of the agronomic studies on biochar application were made in tropical and sub-tropical climates. In the meantime there is a significant lack of studies at mid-latitudes and in temperate climates.

By what means is biochar produced? How can approaches to its production differ?

Biochar is a carbonaceous residue of thermochemical transformation of biomass which occurs in the absence of oxygen. EuroChar considers two main types of biochar produced from gasification and hydrothermal conversion. Gasification is a thermochemical conversion process in which biomass is partially oxidised by heating at high temperatures to greater than 1,000 °C leading to the production of a gas mixture and a solid carbonaceous sub-product: charcoal. The primary product that results from this method is a gas produced during biomass gasification; this is conventionally called syngas and is a mixture of carbon monoxide and dioxide, hydrogen, methane and nitrogen. Gasification can be applied to a large range of products that have useful energy content.

Many different designs of gasifiers have been described in a range of literature, generally classified according to the characteristics of the bed of fuel and the way air or oxygen is introduced into it. Fixed bed gasifiers are distinguished in three main types: updraft, downdraft and crossdraft. In an updraft gasifier, air passes through the biomass from the bottom and the combustible gases are expelled from the top. The fuel essentially moves in counter current to the gas flow. In downdraft gasifiers, the air passes instead through the biomass in the downdraft direction and the combustible gases come out from the bottom. Here the fuel and air move in the same direction, with the main advantage being the production of gas with low tar content but high amounts of ash and dust particles in the gas. Crossdraft gasifiers are produced when the reactor operates at very high temperatures – around 1,500 °C and higher – with minimal tar-converting capability.

In a different process altogether, fluidised bed gasifiers are produced which instead are designed for large-scale applications, using smaller particle feedstock size and a bed of inert particulate material (sand) to form a turbulent mixture of gas and solid. Antal and Grønli found in 2003 that the production of charcoal may be substantial, especially in downdraft gasifiers. The resulting sub-product is normally a fine-grained, highly porous material that may significantly vary in its chemical and physical properties depending on the process parameters.

What aspects of the agricultural system are you analysing and by what means are you achieving this?

One of the key areas that we are working on is the testing of biochar effects on soils and crops with a particular focus on any resulting safety issues. EuroChar intends to answer three basic questions. Firstly, we are concerned with whether the production and field application of biochar is dangerous at all or if it can result in potential harm to human and animal health as well as ecosystems. Secondly, we are looking at how effective the carbon sequestration obtained using biochar is. In this case we are particularly keen to understand what the fraction of carbon contained in biochar is which actually remains in the soil over the long term. Finally, our consortium is interested in understanding more about the significant applications of biochar with regards to soil and whether this creates any problems or negatively affects the productivity of crops, grasses or tree plantations. To answer these questions we have prepared a specific work package which is devoted to biochar Life Cycle Assessment, where we hope that we can better assess the overall mitigation potential of biochar.

Is the production of biochar a carbon neutral process? Do you believe the costs outweigh the benefits?

The biochar option can be normally defined as 'carbon negative'. The carbon contained in biochar was previously contained in the atmosphere and when biochar is buried into the soil, a fraction of carbon dioxide is removed from the atmosphere. The Life Cycle Assessment studies that we are working on under EuroChar confirm that the production and agricultural utilisation of biochar have a large carbon-sequestration potential. We have a joint paper undergoing peer review that provides novel data on the whole gasification-energy production-biochar application chain specifically for rice.

What is the general opinion on biochar from the farming community and industry?

Very few farmers are aware of the possibility of using biochar as an alternative in their fields. Their interest could dramatically increase if biochar addition will finally open their access to voluntary carbon credit mechanisms. A farmer producing large amounts of useless crop residues may well be attracted by the idea of using gasification technologies or hydrothermal carbonisation (HTC) to transform biomass into recalcitrant carbon forms and then sell the carbon credits. The CarboMark platform, which is a voluntary Carbon Credit system that is now operating in Italy, has already introduced biochar in its schemes and we are looking forward to a rapid growth of biochar use. Several firms are already producing biochar in Europe, more frequently as a byproduct of energy production from biomass. They all see a potential for the biochar market and are anxious to see and evaluate EuroChar results, to create a market for their byproduct. Overall, the industrial and agricultural systems are ready to adopt biochar as a real solution. But more scientific data is required before progressing to implementation. Any regulatory policy, which is required for real-scale implementation, must be based on robust experimentation and solid evidence.

In your opinion, what are the next steps for advancing biochar's acceptance and adoption?

Factual interactions between the scientists and the media have been very positive so far. There is the need to communicate the results of scientific investigations to a much wider audience including policy makers. The media offers great potential in this area, provided that a proper bilateral and careful information exchange occurs between scientists and journalists. This is the next stage upon which to focus our efforts.

The power of collaboration

The **EuroChar** alliance is helping to develop biochar technologies in preparation for long-term carbon sequestration. The secret to their success lies in fostering effective teamwork and partnerships across Europe

AS INCREASING CARBON levels in the Earth's atmosphere begin to affect our lives, research efforts around the world are focusing on ways to transfer this carbon into valuable carbon deposits. These efforts are searching for effective strategies to reduce the impacts of greenhouse gas emissions by sequestering carbon in biomass or non-atmospheric carbon pools. One area receiving particular attention is the use of sequestered carbon to create beneficial products; for example, through the reforestation and afforestation of forest areas. A solution that seems increasingly likely to deliver a simple and effective answer to this problem is to enrich agricultural soils with carbon. However, there are some potentially negative effects that result from this, including the potential it has to increase other greenhouse gas emissions, the need for effective agricultural management practices to support carbon collection in the soil and the generally poor capacity of soil to actually store carbon.

An EU Commission-Funded Seventh Framework (FP7) Project is currently looking at ways to overcome these obstacles by investigating the potential of biochar – a carbonaceous residue of the thermochemical transformation of biomass – as a carbon accumulator which can be added to soil. The EuroChar project is looking at the two main types of biochar which are produced from gasification and hydrothermal conversion. Aerobic digestion leads to residues which are poor in carbon, whereas biochar is a carbon-rich product. This means that biochar differs significantly from the biomass which is produced through anaerobic digestion and is therefore believed to be highly effective at improving soil quality and carbon sequestration. The vision behind the EuroChar project is to form a multidisciplinary alliance that draws on the expertise of a number of European academic institutions, research centres and two Small and Medium Enterprises (SMEs) who are all involved in the thermochemical and hydrothermal transformation of biomass to help draw out the potential of biochar.

BUILDING RESEARCH LINKS

One of the key people in charge of this project is Dr Franco Miglietta, who is based at the Consiglio Nazionale delle Ricerche, Istituto di Biometeorologia in Italy. Miglietta is working alongside colleagues from a number of different countries including Italy, France, Germany and the UK. The two SMEs who are part of the EuroChar alliance – Advanced Gasification Technology and Carbon Solutions – specialise in both biomass gasification technologies which produce renewable energy and in biomass waste processing using a proprietary hydrothermal conversion reactor design. This means they can bring significant industry expertise to the project as well as provide opportunities for the research institutes to test their results on real-life scenarios. There are many benefits to be gained from working so collaboratively, including that a wide range of pressing problems can be responded to and investigated. "This kind of EU-funded research is highly relevant and very important, especially in areas where new knowledge is needed to urgently develop, and subsequently implement, new policies to help respond to rapidly evolving critical issues," highlights Miglietta.

Dissemination of results is an important part of the EuroChar project. The team is targeting both European and international groups, including policy makers, private companies, stakeholders and the research arena, as well as the general public. Press conferences, writing summaries for policy makers, presentations at major international scientific meetings and a dedicated webpage are all important methods used for

communicating the findings. The collaboration has also been active in publishing papers on the outcomes of their work. In 2011 they published conclusions to some investigations into biochar as a strategy to sequester carbon and increase yield in durum wheat in the prestigious *European Journal of Agronomy*. This work highlighted that the application of biochar has positive effects on biomass production and yield, with no consequential differences observed in grain nitrogen content. In early 2012, a paper looking at the surface albedo variations on agricultural lands following biochar application was published in *Environmental Research Letters*. Their work showed that plots treated with biochar showed a significant decrease in surface albedo.

> The vision behind the EuroChar project is to draw on the expertise of all involved in the thermochemical and hydrothermal transformation of biomass to help draw out the of potential biochar

REAL-WORLD APPLICATIONS FOR BIOCHAR

A project of this scale and complexity is not without its challenges. One that is of concern to the EuroChar team presently is the effect biochar has on toxicity levels and its potential polycyclic aromatic hydrocarbons (PAH) content. Miglietta explains that biochar does contain PAH as does humus, peat and many other substrates. To address these concerns the team is now working on assessing the fraction of PAH that are contained in different thermochemical biochar production (TC) and hydrothermal biochar production (HTC) systems and to investigate just how strongly they are included in the biochar matrix. They have already managed to gain some positive results through this work, as Miglietta observes: "New data has now been obtained using sophisticated measurement technologies, such as mass spectrometry used for studying high-molecular weight compounds and a proton-rate mass spectrometer which supports the analysis of volatile compounds".

There is potential for the use of biochar at both the industrial and agricultural scale, and use it as a replacement for domestic compost as compost is thought to most likely amplify the modifying properties of biochar. Mixtures of the two materials that make up biochar and compost are also currently being scrutinised for potential large-scale applications within the agriculture sector. The infrastructure that is required for mass adoption of biochar does not currently exist – there are no large biochar production plants in place yet in Europe. However, according to Miglietta, the TC and HTC systems both have great potential to be further developed and reach large industrial scales: "Several stakeholders are considering these two technologies as promising avenues for large investments. Some resources have now been invested in pilot systems throughout Europe in order to progress this".

The current European agricultural policy does not yet assess the use of biochar in its attempt to reduce carbon emissions; however some individual countries are giving serious consideration to biochar as a viable option. Miglietta points out that the EU Commission is currently funding new research and a coordination action to explore standardisation aspects needed to support the incorporation of biochar into agricultural policy. There is every possibility that this product will become just a normal part of agricultural business in the future, and at the same time help to improve the sequestration of atmospheric carbon.

EUROCHAR

BIOCHAR FOR CARBON SEQUESTRATION AND LARGE-SCALE REMOVAL OF GREENHOUSE GASES (GHG) FROM THE ATMOSPHERE

OBJECTIVES

To investigate carbon sequestration potentials that can be achieved by transforming plant biomass into charcoal (or biochar) and add that to agricultural soils. Biochar production will be demonstrated using thermochemical or hydrothermal carbonisation processes that can produce energy and store 15-20 per cent of the carbon originally contained in the biomass.

PARTNERS

Universitè Pierre et Marie Curie – Paris 6 and **CNRS**, France • **Imperial College of Science, Technology and Medicine**, UK • **Martin-Luther-Universitaet Halle-Wittenberg**, Germany • **University of Southampton**, UK • **CS Carbon Solutions Deutschland GMBH**, Germany • **Libera Università di Bolzano**, Italy • **Advanced Gasification Technology**, Italy

FUNDING

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DR FRANCO MIGLIETTA has a background in agronomy and terrestrial ecology. He developed innovative approaches in elevated-CO_2 research, in terrestrial carbon-cycle science and in climate change mitigation strategies. Since 2010 he has held the role of Scientific Director of FoxLab, a joint research collaboration between CNR and the Fondazione E Mach in San Michele all' Adige, Italy.

eurochar

Renewing the carbon debate

Sequestering carbon and improving soil quality are major challenges facing Europe. **Professor Bruno Glaser** discusses strategies for utilising biochar – a highly porous charcoal that enables soils to retain nutrients and water while helping reduce emissions from material that would otherwise degrade to greenhouse gases

PROFESSOR BRUNO GLASER

First, can you give an overview of the Biochar COST Action and its key research objectives?

This European COST Action connects national biochar research across Europe to enable the quick implementation of sustainable management of natural resources, especially to maintain or improve soil quality while efficiently sequestering carbon (CO_2) in the long term. Innovative biochar strategies can help the EU mitigate greenhouse gases, while industries and farmers benefit from new markets, opportunities and use of improved soils that can be used for biofuel production without endangering food supply. However, a risk assessment is necessary to protect the food web and human health. For this purpose, four working groups will focus on biochar production and characterisation, land use implementation, economic analysis (including life cycle assessment) and environmental impact assessment.

Can you expand on the *terra preta* phenomenon? How is ancient activity informing contemporary methods of carbon sequestration and agriculture?

An impressive example that the biochar concept can be applied successfully already exists. Found in central Amazonia, anthropogenic dark earths, or *terra preta de Índio*, are 2,000-year-old manmade soils that exhibit high nutrient and soil organic matter stocks, allowing sustainable agriculture even today. These soils were made by huge inputs of organic waste materials, such as kitchen leftovers, excrements, biomass waste, and charred residues of charcoal or biochar, cultivated by indigenous soil organisms. In recent years, *terra preta* has gained increasing interest because it could act as a model for promoting sustainable agriculture while storing large amounts of CO_2 from the atmosphere in the ground with additional positive benefits.

How does biochar compare to other climate mitigation tools and how does it surpass them in terms of its carbon sequestration?

Conventional techniques for climate change mitigation such as biofuels and carbon capture and storage (CCS) are 'closed loop,' which means they only sequester emitted CO_2. Therefore, these techniques cannot reduce actual or future CO_2 levels in the atmosphere. In addition, as they are not 100 per cent efficient, both of them will further increase atmospheric CO_2 levels. Capturing CO_2 in stable solid forms, as biochar, and using it for the improvement of ecosystem services or in construction materials can actively lower atmospheric CO_2 concentrations while generating added economic value.

What areas and industries do you expect your results to have an impact on? How do you intend to maximise the uptake and action on your findings?

From a technological point of view, several companies, such as PYREG and 3R Technologies, already have well-developed pyrolysis systems to produce biochar. These systems are capable of handling a range of biomass types including organic waste materials. Furthermore, there are large volumes of readily-available biomass to feed the process. The main obstacle is a

An ancient solution for modern day problems

A team at **Martin-Luther University**, Germany, is using the study of biochar-rich dark earths in the Amazon to propose coordinated strategies for alleviating atmospheric carbon in Europe

lack of political will to drive the widespread implementation of this ready-to-use technology.

To achieve wide public acceptance of biochar technology and use, it is necessary to address different key audiences; researchers working in the field, industry, including small and medium enterprises, stakeholders and policy makers, regional planners and the general public. Then, we must identify and analyse their concerns and provide them with due information improving their understanding of optimised material flow systems based on biochar technologies.

How important do you think the uptake of biochar technologies could be in the future of climate mitigation strategies?

If implemented on a global scale, biochar could have a much larger impact than CCS and go a very long way to slowing or possibly reversing the increase of atmospheric CO_2. Since biochar is a 'ready to go' tool it should be added to the climate change toolkit of renewables, energy saving techniques and CCS. Furthermore, given that the issue of rising CO_2 levels is an immediate problem, we believe that it is imperative to deploy all the available carbon capturing tools at our disposal in as prompt and large-scale a fashion as possible.

EMISSIONS OF HUMAN-INDUCED greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), have risen to such dizzying heights that they can no longer be ignored. Indeed, environmental institutes continue to pour their efforts into finding a practical solution. Wind, hydroelectric, solar and other renewable energies form viable energy options, but their implementation is often expensive and not always available. Nuclear power, meanwhile, remains inherently controversial; despite its potential to power entire nations, plant disasters and vast amounts of hazardous waste make it a wholly unfavourable energy route.

In light of these concerns, many nations are turning to CO_2 mitigation techniques, from biofuels to carbon capture and storage (CCS), to reduce the effects of greenhouse gases. Still, while steadily becoming regular practice through their ability to sequester atmospheric CO_2 emissions, these methods are not entirely effective and are unable to reduce present or future levels.

An ecological alternative to carbon capture, 'biochar' was first discovered in the tropical rainforests of central Amazonia in 2,000-year-old manmade soil patches known as anthropogenic dark earth, or *terra preta de Índio* (*terra preta*). Due to high rates of rainfall and high temperature throughout the year, rainforest soil is generally eroded and deficient in nutrients. However, these manmade soil patches have the ability to store large amounts of atmospheric CO_2 in solid form, and are remarkably fertile even today.

Scientific evidence shows that *terra preta* was created by pre-Columbian inhabitants between 4,000 BCE and 1492 CE through the natural breakdown of excrement, leftover food, biomass waste and various other organic materials. This collection of matter remained in the soil with charred residues that were likely created by slowly burning fires used for cooking or spiritual purposes and, over time, developed into *terra preta*. More than 2,000 years later, the rich soil continues to provide farmers the means for sustainable agriculture.

A COMBINATION OF POSITIVES

Containing extremely high amounts of organic matter, *terra preta* commonly exhibits more than 200 mg kg-1 of plant-available phosphorous as opposed to the average 5 mg kg-1 found in surrounding soils. This allows for impressive levels of fertility in a region previously known for its weathered and barely cultivable soils. In bean and cereal crops, for instance, *terra preta* soils achieve around twice the yield of their synthetically fertilised counterparts.

Following their discovery in central Amazonia, *terra preta* sites have since been found in the Upper Xingu region of Brazil, Amazon parts of Peru, Colombia and in the Guianas of southern Venezuela. Approximations consider the total extension of *terra preta* to reach around 10 per cent of Amazonia, though surveys in south eastern Amazonia and north eastern Rondonia indicate this figure to be a lot higher.

21ST CENTURY TRADITION

In today's practices, biochar is produced through pyrolysis, the thermal decomposition of complex molecules. This process creates stable, aromatic rings (char) that can be stored in soil over long periods of time, a liquid bio-oil for energy generation and a gas used for the synthesis of organic molecules (syngas). Resistant to biochemical degradation, biochar has the potential to store carbon over centuries to millennia and enable carbon neutral farming by capturing nutrients that might otherwise have run off the land.

Environmental bodies in Amazonia and around the world have now begun to accept biochar as a feasible action against climate change with many biochar stoves being set up for use in developing countries as a means of supporting positive expansion. However, current biochar research is often fragmented across institutes and departments, with many studies being unnecessarily repeated and inadequately publicised as a result.

In response to this lack of knowledge exchange, Dr Bruno Glaser, a professor at the Institute of

BIOCHAR AS OPTION FOR SUSTAINABLE RESOURCE MANAGEMENT – COST ACTION TD1107

OBJECTIVES

To produce innovative Biochar strategies that help the EU mitigate greenhouse gases, while industries and farmers benefit from new markets, opportunities and use of improved soils, eg. for biofuel production without endangering food supply.

PARTNERS

Participating Countries:

Austria • Belgium • Denmark • Estonia Finland • France • Germany • Greece Hungary • Iceland • Ireland • Israel • Italy Latvia • The Netherlands • Norway Poland • Portugal • Romania • Slovakia Spain • Switzerland • UK

FUNDING

COST (Cooperation in Science and Technology) is a European funding scheme for networking activities, allowing the coordination of nationally-funded research on a European level.

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PROFESSOR BRUNO GLASER is Head of Soil Biogeochemistry at MLU Halle-Wittenberg, Germany. He has conducted world-leading research in two major areas: investigations on biogeochemical processes under Global Change conditions (eg. extreme climatic events, increasing land use pressure); and on the potential of soils as sources and sinks for CO_2.

Agricultural and Nutritional Sciences, Martin-Luther University, together with Dr Jürgen Kern at ATB Potsdam and Dr Claudia Kammann at the University of Giessen (all in Germany), established the European COST Coordination Action 'Biochar an option for sustainable resource management' to push biochar to the forefront of the climate change debate. Glaser's work focuses primarily on connecting European biochar research and bringing field experts and stakeholders together in an attempt to better investigate the concept's benefits.

For Glaser, biochar offers the next logical step for organised environmental efforts: "Biochar is a fascinating topic combining basic research with the real option to make our non-sustainable world renewable," he states.

CARBON COUNTING

While adopting biochar on a global scale can help support sustainable agriculture and store large amounts of atmospheric carbon, it would also compensate considerably for the effects caused by deforestation, burning non-renewable fossil fuels, conversion of grassland to agricultural fields and other negative procedures. In Europe alone, the residue from cereal crops, forestry, viticulture, household and commercial garden waste totals up to 500 million tonnes. Coupling this figure with currently available technologies, Europe could have an annual production of 140 Megatonnes (Mt) of biochar, comfortably offsetting 10 per cent of the continent's emissions. In view of the fact that Europe intends to reduce its carbon emissions by 14 per cent by 2020, biochar could make a significant contribution.

Employing the project's web of biochar stakeholders and available expertise, Glaser has been able to solicit new, related studies on the material's numerous advantages. This work breaks down into several key foci, including classification of biochar's material properties, measurement of greenhouse gas emissions, land use implementation, life cycle assessment and comparison of different biochars and ecosystems.

As part of the land use implementation branch of the project, researchers have begun investigating the potential use of *terra preta* in arid desert regions around Africa, where it could be utilised to cultivate jatropha, an energy-producing plant. Interest has also come from several companies, including PYREG and German Charcoal GmbH, who have set up industrial processes with which to create biochar for construction purposes.

THE POLITICS OF CHANGE

While Glaser has already achieved substantial success, he has been faced with his fair share of challenges, one of which is the search for an agreed definition of what biochar actually is. Since biochar production in the EU is still under development, no protocol or standard yet exists. Consequently, the project is currently working on the rapid implementation of a European biochar safety certification that will help the process gain acceptance on a more public scale. In addition, Glaser aims to identify and redirect the current allocation of natural materials, with biomass of particular importance for biochar application, and proposes to make socioeconomic solutions a higher priority in comparison to the continual focus placed on economic and political issues.

Glaser now wishes to study the environmental behaviour of biochar through its chemical composition and test the material under further field conditions. In order to bring attention to this and other work, he plans to disseminate the project's findings through as many channels as possible, starting with the COST Action's website. This will soon be followed by participation in organisation workshops, open days, conferences, short-term missions, seminars and trade shows.

From providing cleaner fuel and improved soil quality to the development of robust building materials and workable benefits for sustainable agriculture and industry, Glaser believes biochar could hold the key to tackling the global increase of atmospheric carbon dioxide.

> Biochar is a fascinating topic combining basic research with the real option to make our non-sustainable world renewable

PYREG REACTOR WORKING AT ECOREGION KAINDORF, AUSTRIA

Symbiosis in the Serengeti

Dr Nancy Collins Johnson is presently conducting research into the role of arbuscular mycorrhizal symbioses in Tanzania's Serengeti National Park, the world's largest intact grazing ecosystem. Here, she outlines her work and the relevance it could have on agriculture

To begin with, what are the aims and objectives of this study?

One objective is to gain basic ecological information about the abundance, diversity and species composition of arbuscular mycorrhizal (AM) fungi (*phylum Glomeromycota*) in an intact natural grazing ecosystem.

A second objective is to look for relationships between soil properties, precipitation, grazing, and AM fungi so that we can test hypotheses about the factors that structure *Glomeromycotan* communities and control their mutualistic function.

Could you explain the role of mycorrhizas in the uptake of nitrogen and phosphorus?

Mycorrhizal symbioses increase the surface area through which plants can acquire minerals from the soil because thin fungal hyphae can explore much smaller pores in the soil than roots, or even root hairs. This property of mycorrhizal fungi is important for accessing immobile minerals, particularly phosphorus. Unlike nitrate and potassium that dissolve in water, immobile minerals are held tightly to soil particles and do not move with water in the soil. This means that these minerals are not transported to roots with water that is pulled into roots through the flow generated by transpiration. Instead, immobile nutrients must contact a root, root hair, or fungal hyphae and be actively transported across the cell membrane.

What features of the Serengeti ecosystem afford it a unique position for investigation?

The Serengeti provides a natural laboratory to study how complex interactions among climate, soils, microorganisms, plants and animals can generate a stable ecosystem. Rainfall varies tremendously from year to year, yet the system is resilient to this variation.

Over millennia, interactions among living and non-living components of the Serengeti have generated a complex system of checks and balances. The tight coupling between producers, grazers and scavengers in the Serengeti is remarkable, and differs from anywhere else in the world. For example, despite the millions of grazing animals roaming the Serengeti plains there is surprisingly little dung on the ground because within a few hours dung beetles and other scavengers carry it away and incorporate it into the soil.

How will you investigate the climatic interactions that influence this fauna-plant-fungi relationship?

We are using two approaches. First, we constructed and tested a structural equation model using data collected from a series of grazed and ungrazed (fenced) sites that were selected to create natural gradients of soil fertility and precipitation. This analysis showed that even when all other factors are taken into account, drier sites have a greater abundance of AM hyphae than the wet sites. Now we are conducting controlled experiments to determine if this pattern is caused by slower hyphal decomposition or greater production of new hyphae in dry sites compared to wet sites.

What molecular methods have you developed to address the gaps in existing knowledge?

I am currently collaborating with a group of researchers in Estonia who are extracting DNA from the roots of grasses that we collected from the soil fertility and precipitation gradients in the Serengeti and using high-throughput sequencing methods and bioinformatics to analyse the AM fungi inhabiting the dominant grasses.

These new molecular analyses complement our microscopy-based analysis of fungal spore communities. One method shows the fungi that are inside the roots while the other shows the reproductive effort of the fungus. Both are important for understanding the ecology of AM fungi.

Lastly, could you highlight the most significant discoveries you have made in ecosystem dynamics during your career in environmental science?

My colleagues and I have explored the reasons why mycorrhizal symbioses' function varies from mutualism (+/+) to commensalism (+/0) and even parasitism (+/-). A series of studies have helped us elucidate the factors that control whether AM symbioses will help or hinder plant growth. We have discovered that the interaction of soil phosphorous and nitrogen availability often controls mycorrhizal function. Plants grown in soil that is phosphorous-limited, but has ample nitrogen, tend to benefit the most from AMs, while those grown in soils rich in both phosphorus and nitrogen benefit the least from the symbioses.

We believe that fertilisation reduces mycorrhizal benefits because it causes plants to allocate less carbon belowground to roots and mycorrhizas and more aboveground to shoots, leaves, and seeds.

Our most important discovery is that in undisturbed grassland ecosystems, plants and AM fungi adapt to their local environment and each other so that the symbioses that they form maximise mutualistic benefits in phosphorus-limited soils and minimise parasitism in phosphorus-rich soil.

PHOTOS COURTESY OF RICK JOHNSON

Fungal fundamentals

The Serengeti grasslands provide an ideal site to study the ecology of mycorrhizal fungal communities which form nutritional symbioses with plants and comprise a large proportion of the living biomass of soils

ARBUSCULAR MYCORRHIZAL (AM) FUNGI are essential in aiding plant uptake of essential nutrients such as phosphorus. These fungi live symbiotically with plants and form large underground networks of hyphae that are able to acquire immobile minerals from the soil that otherwise would not be accessible to roots or root hairs. Greater knowledge of the processes underlying these exchanges could help to reduce human reliance on inorganic fertilisers, particularly in tropical ecosystems. However, little is currently understood about the effective management of mycorrhizal fungi and how external variables such as climate, soil fertility and herbivore activity affect them.

Dr Nancy Collins Johnson – an expert in soil ecology at Northern Arizona University – is attempting to advance our understanding of these fungal communities, working in collaboration with a team from Syracuse University who are focusing on symbiotic bacteria in legume roots and nitrogen-fixing bacteria on the surfaces of native grasses. Johnson explains the aims of this collaborative project: "We plan to combine our data to test the hypothesis that plants satisfy their nutritional requirements by cultivating complex microbial communities in and around their roots in the same way that animals support communities of gut microorganisms to digest their food".

These communities can best be observed in undisturbed ecosystems, and Johnson's team has had the good fortune of conducting fieldwork in Tanzania's Serengeti National Park, the world's largest intact grazing ecosystem. Prior work on mycorrhizas has generally concentrated on grasslands in temperate regions, particularly in North America, but very little work has been done in tropical grasslands where mycorrhizal symbioses are believed to play key roles in nutrient cycling and plant nutrition. The Serengeti is also an ideal location to study complex interactions among grazing animals, the plants they consume and underground fungal communities.

REFINING EXISTING MODELS

The researchers are using natural gradients in precipitation, soil texture, soil nutrients and organic matter within the Serengeti to measure the impacts these have on the abundance and community composition of AM fungi at eight different sites. Replicated plots at each site were fenced off in order to create a long-term grazer removal treatment so the influence of herbivorous animals can be measured. In addition, Johnson and her colleagues are studying mycorrhizal responses to watering and phosphorus fertilisation treatments in field plots in the Serengeti. Combining insights from studies of natural gradients with the findings from the manipulative experiments will help uncouple the complex interactions among factors controlling mycorrhizal symbioses in the Serengeti.

This research draws on a number of existing models that predict the structure and function of AM fungal communities. The functional equilibrium model suggests that plants will benefit most from mycorrhizas and support more AM fungi when soil resources such as phosphorus are scarcer than photosynthate. This is because the symbiotic relationship supplies carbon to the fungi in the form of sugars in return for the immobile minerals accessed by the hyphae on behalf of the plant. The model predicts that the abundance of AM fungi should be inversely related to the availability of essential soil resources.

To a large extent, this expectation has been borne out by Johnson's earlier research; however, the Serengeti studies have revealed important interactions with precipitation and soil type, and also differences among fungal families. During the most recent fieldwork, Johnson discovered that certain families of AM fungi survive better in coarse textured sandy soil, whereas others prefer fine-textured clay soil.

A further significant finding from the study, derived from the long-term grazing removal experiment, is that grazing has surprisingly little effect on the biomass of roots and AM fungi. However, analysis of communities of AM fungal spores suggests that removal of grazing may cause a shift in the community composition of AM fungi. Ongoing studies of fungal DNA inside roots will help determine the extent of divergence of fungal communities in grazed and un-grazed vegetation. Combining these analyses with structural equation modelling represents an important advance in understanding fauna-plant-fungi relationships at an ecosystem scale.

Previous studies in North American grasslands by Johnson and her colleagues supports the co-

adaptation model, which posits that in natural ecosystems plants and indigenous fungal communities adapt to their surroundings and to each other in order to maximise mutualism and minimise parasitism. This result was derived by comparing the symbiotic functioning of 'home' and 'away' communities of AM fungi, by placing the spores in soil types different to those in which they had evolved. When transplanted to 'away' soils the fungi were significantly less beneficial to plant growth, thus demonstrating that AM fungal communities function best in the soil type that they are adapted to. This has important ramifications for ecosystem management, suggesting that non-native fungal communities may not function the same if they are introduced into soils to which they are not adapted.

FIRST PRINCIPLES

While Johnson recognises that the Serengeti is an ecosystem unlike any other in the world due to its complex system of natural checks and balances, she believes that findings from the Serengeti research will help develop hypotheses that can be tested anywhere in the world. "Our ultimate goal is to develop first principles that can be used to make ecology a more predictive science," she explains.

A handful of soil contains many kilometers of AM fungal hyphae. Photo shows hyphae magnified 400X. Image courtesy of Julie Wolf.

"Insights gained from this work and from our studies elsewhere will help us develop ecological principles that are applicable to any ecosystem."

Gaining a deeper understanding of the functioning of mycorrhizas will also have practical benefits beyond the Serengeti, particularly in the development of more sustainable agricultural practices: "There is a great interest in reducing the need for inorganic fertilisers in agriculture. Proper management of AM symbioses may help achieve this goal," Johnson suggests. The insights derived from studying which fungal families are suited to different soil types and climatic conditions in the Serengeti and in other systems around the world will help farmers to manage their crops in order to maximise the mycorrhizal benefits. Selecting crops that are adapted to a particular soil type and have known benefits from mycorrhizal symbiosis could be more efficient than selecting cultivars that maximise yield but require high inputs of chemical fertilisers.

CARBON SEQUESTRATION

Because of the extensive biomass of mycorrhizas in the soil, there is also great interest in managing them to maximise their potential to sequester carbon underground. Johnson explains precisely why her recent research is so important in understanding these possibilities: "AM hyphae are potentially a sizable sink for carbon in the soil but it is necessary to understand the extent to which this carbon-sink changes with precipitation and across the season before we can fully understand the levels of carbon sequestered in AM hyphal networks". Managing mycorrhizal communities effectively to encourage sequestration of carbon belowground could have a significant impact on levels of atmospheric carbon, while encouraging symbiosis with fungal communities as opposed to inorganic fertilisers could also help to limit the impact of agriculture on the environment.

INTELLIGENCE

EFFECTS OF HERBIVORES AND MYCORRHIZAS ON N-FIXERS ACROSS SOIL AND CLIMATE GRADIENTS IN THE SERENGETI

OBJECTIVES

To provide the scientific basis for developing management strategies to maximise the benefits of mycorrhizal fungi for sustainable production of food and fibre in semi-arid grasslands, savannas and other tropical ecosystems.

KEY COLLABORATORS

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NANCY COLLINS JOHNSON has been a professor at Northern Arizona University since 1997. She earned a PhD in Ecology from the University of Minnesota with David Tilman. Johnson and her students study interactions among communities of plants and soil organisms in natural and human managed ecosystems throughout the world.

Partnership for European Environmental Research

Consisting of seven major research centres across Europe, PEER represents a major step in Europe's efforts to provide unified frameworks within which to conduct science. PEER Secretary, **Markku Puupponen**, explains their work to maximise the efficacy of Europe's environmental research activities

Could you begin by introducing the Partnership for European Environmental Research (PEER)? What is your mission?

PEER is a partnership of seven of the largest European environmental centres. It was founded in 2001 with the aim of combining forces to follow a joint strategy in environmental sciences and enhance research on ecological sustainability. This cooperation was validated by a Framework Agreement signed in 2002, renewed every five years. We are now in the process of making the third agreement.

The PEER centres are: Alterra Wageningen UR (The Netherlands), CEH - Centre for Ecology and Hydrology (UK), DCE – Danish Centre for Environment and Energy at Aarhus University (Denmark), Irstea – National Research Institute of Science and Technology for Environment and Agriculture (France), JRC-IES - Joint Research Centre's Institute for Environment and Sustainability of the European Commission, SYKE - Finnish Environment Institute (Finland), and UFZ - Helmholtz Centre for Environmental Research (Germany). As the Joint Research Centre forms a part of the European Commission, it pays careful attention to its role as a PEER member and decides on its behaviour activity by activity. PEER member centres carry out basic and applied research combining different disciplines from natural and social sciences. Research covers all fields of the environment, particularly addressing the interaction between man and nature.

The PEER vision is to be a world leader in integrating knowledge and expertise for sustainable development. Our mission is:

- To build a strategic partnership of major European public environmental research centres
- To lead a European Research Area that strengthens the knowledge base for the sustainable development of a changing world
- To foster innovative interdisciplinary research and cross-cutting approaches in support of national and European policy makers, industry and society

What is your role within PEER and what led you to take this position?

I have worked as the Secretary of PEER since October 2011. All main tasks within PEER rotate between the member institutes. My centre – the Finnish Environment Institute (SYKE) – offered to take on the PEER secretarial duties starting from 2011. When my Director General, Lea Kauppi, asked if I was interested, I could not let the opportunity go!

The duties of the Secretary include preparations of the PEER Directors' meetings, reporting on the decisional process and follow-up of the activities, as well as the organisation of the PEER Institutes' contributions. We are currently in the process of developing some new joint activities; this is one example of topical issues. I work in close cooperation with the PEER Communication Group which serves our interests in many ways (eg. assisting with the production of scientific publications and information materials, the organisation of events, internal and web communication and handling external requests). The communities that turn to PEER often contact the Secretary, and of course there are ad hoc tasks to be distributed and coordinated.

How do you communicate the human dimensions of environmental change in scientific publications?

As I mentioned above, PEER is strongly addressing the interaction between man and nature. This was the starting point from the very beginning. At a large scale, research on the socioeconomic system and its complex relations with the environment is a high priority issue for us. We are also looking at these connections from the perspective of citizens.

I think that the PEER Reports offer some good examples. The first two reports – 'Europe Adapts to Climate Change: Comparing National Adaptation Strategies' (2009), and 'Climate Policy Interaction, Coherence and Governance' (2009) – represent a large-scale perspective of environmental change. The ongoing PEER Research on EcoSystems Services (PRESS) project and its reports discuss – among other themes – recreational and cultural aspects of ecosystems services. In fact, as PEER wants to emphasise multidisciplinary approaches to environmental problems, we have the human dimension onboard in most large-scale studies and activities.

Can you explain the findings of the 'Europe Adapts to Climate Change' report? Has further study enhanced your understanding since then?

It seems that this publication was a success. Its timing was excellent, as the importance of adaptation had been understood and the first national adaptation strategies had been adopted. On the other hand, many national strategies were under development and a number of countries had not yet organised such a programme. This publication was forward looking and yet it could be based on novel effort and experience.

The report was structured around six themes: motivation for adaptation strategy, science-policy interaction and research, the role of communication, multilevel governance, adaptation and sectoral policies, and the role of policy. A few years after the publication we can see that the report introduced a good conceptual framework for climate adaptation; this framework has been used widely within the scientific community and in policy shaping. The communication was also important in the sense that it offered visibility for new national adaptation strategies. It offered a framework for benchmarking, and important sectors relevant from the point of view of adaptation (forestry, agriculture, water management, ecosystems services, health, etc.) could be identified. The SWOT analysis on national adaptation strategies was an important part of the report. The message of this analysis has been taken seriously.

The paper on national European climate change adaptation strategies has created a concept that has been widely used in later work. Further studies have certainly enhanced our understanding, but this work has been based on the results of the PEER report.

Do you hope to influence public policy? How do you ensure your research is politically relevant and timely in order to achieve this?

Influencing policy is a cornerstone of our mission. PEER is striving for this through various channels. We have developed position papers and statements on important issues. Among the latest ones are the PEER Response to the Green Paper 'From Challenges to Opportunities: Towards a Common Strategic Framework for EU Research and Innovation Funding' (2011) and 'PEER Position Paper on FP8: Innovative environmental research for a changing society' (2010).

All PEER reports have a strong policy component. The first two discussed climate policy, and the two next publications focus on ecosystems services in the frames of the PRESS project. The results of Phase I were published in 2011 and the second volume will come out during 2012. PRESS results highlight policy messages in an illustrative manner.

The policy aspect is a priority in the PEER centres. This can be also seen in the contents of joint projects where some or all of the PEER institutes have worked together (eg. ALARM, Euro-limpacts, LIAISE and SCENES). In fact, these activities have supported the formation of a new scientific community and culture between the PEER centres and their partners.

Politically timely research is, of course, a big challenge. We have to admit that there is always a gap between science and policy and that both parties can try to bridge the gap with good dialogue and proactive attitude. During the last years the scientific community has recognised that it has not been able to address its message to the policy makers. I believe that we have started to learn lessons and some recent contributions are distinguished in this respect.

How has your work on sustainable development been shaped by the outcomes of the first Rio+20 Earth Summit?

The Rio process has been conducted by the UN and that may be a reason why PEER seldom refers to it – at least this is the picture I have. Of course the first summit was a very important step as it laid foundations for new environmental thinking. I also believe that Rio 1992 has had a strong impact in the PEER centres. Rio pushed forward a more holistic approach and, since then, many processes have carried on this development. Most of the statements that were made 20 years ago are relevant and the problems identified still remain.

How can the policy-science interface be organised in a way that such scientific evidence is more effectively taken into consideration?

This is one of the biggest challenges that environmental research and administration are facing – both locally and globally. The question of policy-science interface and scientific evidence should be approached from various perspectives. On one hand, we must develop the research process. It should produce both relevant and timely results. Evidence is a criterion that the scientific results should meet if we wish to provide sound background for policy making. On the other hand, we have to look at the policy-science interface. If we are able to communicate across the interface, we can be more successful. The scientific community should also try to understand the policy perspective: in real life we have options that call for different actions and involve various risks. Science should support policy makers in the comparison of these alternatives.

Environmental science has been developed for a long time, so we are able to study and assess large and complex systems which include diverse links between natural and human processes. This is not any easy task but it is also the only way to achieve successful dialogue across the policy-science interface. PEER is supporting the Berlin 2012 Conference on the Human Dimensions of Global Environmental Change – Evidence for Sustainable Development (5-6 October). This event will focus on these challenges.

The study of the pedosphere has led to innovations in our understanding and command of soil science. How has the partnership contributed to this progression in knowledge?

We have had recent discussions on soil science within PEER. We have a high level of expertise in this field, but it seems that it is rather fragmented and linked with various scientific problems and stakeholder expectations. So far, we have had very few joint activities on soil science. It will be interesting to see what the PEER centres will be able to develop.

Finally, what do you consider to be the main challenges facing environmental research today?

Perhaps the main challenge is the fact that we have to be able to study and discuss larger and larger scales and issues. It does not invalidate the pragmatic point that we also have to develop methods and practices for solving local problems. These scales represent the overall framework and the building blocks.

What we expect as the result is a sustainable community and economy. The environment should not be considered as a separate issue that has its own objectives. The current situation in Europe is somewhat alarming: it seems that we cannot afford investments in a sustainable future – our main target for 2020 and beyond.

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ENV14

The Last Word

A sea of potential

Requirements for a greater shift towards renewable energy sources continue to grow as concerns for our global wellbeing and environment increase. *International Innovation* takes a look at the potential for Europe to exploit this powerful resource

THE PROMOTION OF, and migration towards, renewable energy sources is paramount for securing the world's energy supply and creating an environmentally-friendly, low-carbon society. For the European Union – which is presently one of the leaders in the development and application of renewable energy – the conversion to a natural energy supply will ensure that reliance on foreign energy imports decreases, and that global warming aims and objectives are reached. One such energy source currently being evaluated in Europe is marine energy; a sector which is moving rapidly in terms of development and could contribute significantly to the energy mix.

There is an enormous untapped supply of kinetic energy in our oceans, a source which offers numerous investment opportunities for Europe. Marine energy can be produced by the tide, ocean surface waves, salinity gradients or ocean temperature differences. It has been estimated that a mere 0.1 per cent of the energy generated by the ocean has the potential to meet the energy needs of the Earth, five times over. The energy harnessed from converting tidal and wave power into electricity could ensure that our homes, transport and industries are securely and sustainably powered for years to come. A shift towards the use of natural energy resources – a movement which has emerged due to climate change issues, increasing oil prices, peak oil, as well as improved government support – is needed if the EU is to reach certain renewable energy criteria and legislation.

OPPORTUNITIES

There are several key opportunities available to Europe, some of which include:

- A vehicle for job creation and economic evolution (employment in the equipment and technology industry, jobs within the EU and the coastal community)
- Increasing the probability of reaching the EU's renewable energy aims (opportunity to meet 15 per cent of the EU energy demand in 2050 and prevent 136 MT/MWh of carbon dioxide emissions in 2050)
- Securing Europe's energy supply and maximising its value
- Creating a common goal and vision between the EU, Member States and ocean energy organisations
- Developing a pan-European supply chain (which further increases European investment and competitiveness)

TECHNOLOGY FEATS

According to the European Ocean Energy Association's (EU-OEA) recent Position Paper 'Towards European industrial leadership in Ocean Energy in 2020', without support at EU level, Europe could be at risk from missing out on benefits afforded by technological advancements in the marine energy sector. Close collaboration between Member States in the area of technology development is needed if Europe is to successfully harness this valuable resource and contribute effectively to the EU vision for 2020 and 2050 – something the European Commission (EC) is currently assessing. As the Paper outlines, active Member State participation in the area of technology development 'encourages an ambitious dialogue and partnership with the European Commission'. Only when this occurs can Europe reap the advantages associated with ocean energy.

The EC is focused on the creation, improvement and implementation of technology aimed at harnessing ocean energy. Converting tidal energy into electricity has been an area of interest, largely because it can be easily examined against technology used in hydroelectric power plants. However, more recently, technologies which carry wave and current energy have been developed and pre-commercially tested in order to assess their potential to go to market. In terms of thermal- and salinity-based technologies, Europe is still in the early stages of development.

Commercial-scale off-shore wind and solar energy farms are also being developed, and a few are in operation in the shallow waters of the European coastline. Building these farms in the deeper waters of the Outer Continental Shelf is in current discussion around Europe. With an eye towards the future, the EC has suggested that the creation of off-shore wind farms will be a major area of consideration. This will be done by sharing infrastructures, eg. grid connections and/or offshore platforms.

To date, more than €55 million has been spent to advance knowledge in marine energy. However, the EC is also financing research aimed at overcoming non-technical barriers that are impeding the market penetration of this type of renewable energy. Challenges have yet to be surpassed, which is why ocean energy is one of the priorities of the current EU Framework Programme.

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