

# SEA AND SOCIETY



## Environmental, social and economic benefits from our seas

Human development, and indeed survival, is dependent on the exploitation of environmental and ecosystem goods and services. The application of science is essential to ensure that our continued use of the marine environment is sustainable, efficient and equitable. PML's team of socio-economists works in close proximity with its natural scientists in all core areas of science.

### Research priorities:

- Understanding the social and economic value of human use of the marine environment, including health benefits, focusing particularly on sustainable provision of all marine ecosystem services through understanding global change and human impacts upon them;
- Environment and human health research to investigate the source, distribution, behaviour and fate of novel and emerging pollutants in the marine environment and address their feedbacks on human health;
- Biodiscovery research to seek new compounds and processes in the marine environment which have potential benefits to humankind as pharmaceuticals, enzymes or biofuels;

- Impacts and benefits of marine renewable energy applications;
- Development of decision support tools to aid governance and management of the marine environment.

### Addressing societal challenges:

- Can we sustain and increase the goods and services provided by marine ecosystems;
- How will the provision of ecosystem services, economic opportunities and health benefits provided by marine ecosystems be affected by global change and other anthropogenic activities;
- How best to communicate societal challenges of global change.

## Role in society

PML is working closely with stakeholders such as government departments, statutory advisors, Research Councils, industry and the general public to ensure its science and technology are relevant and of benefit to society. Examples include provision of support for the UK Marine and Coastal Access Act (2009) and the IPCC 4th and upcoming 5th Assessment Report Working Groups I and II.

PML co-ordinates the knowledge exchange activities for the 5 year UK Ocean Acidification Research Programme funded by the Department for Environment, Food and Rural Affairs (Defra), the Natural Environment Research Council (NERC) and the Department of Energy and Climate Change (DECC).

## Products from science

Harmful algal bloom early warning system provided to the fish farming industry - customers include the EU and the Environment Agency;

Natural products for healthcare, with collaborators including Boots and the Technology Strategy Board;

Development of biofuels for the DECC, Biotechnology and Biological Sciences Research Council and the Carbon Trust;

Development of international stakeholder role playing games addressing the sustainability of international resources;

Development of ecosystem service valuation methodologies that are transferable and adaptable to marine sites across the globe.

## Delivery & leadership



Executive Board of the UK Natural Environment Research Council strategic Oceans 2025 programme;  
Developing risk assessment methodologies to investigate marine pollution incidents for Defra;

Leading the socio-economic valuation in a Defra funded study on the Lyme Bay marine protected area;

Working for the UK Energy Research Centre, developing strategies for marine and land based energy production and greenhouse gas mitigation which limit environmental impacts;

Leading on marine economics and marine natural science for the National Ecosystem Assessment, valuing changes in the provision of goods and services in the UK.



Co-ordinating an Oceans of Tomorrow large integrated project to investigate VECTORS of change in marine ecosystems and their economic impact;

Played a major role in the leadership and management of the marine biodiversity and ecosystem functioning EU network (MarBEF).



Co-ordinator of the QUEST\_Fish project, focusing on environmental change impact on global fisheries;

PML, in collaboration with its western Indian Ocean partners, is developing research into ecosystem services for poverty alleviation.

## Services:

- Ecosystem goods and services quantification and valuation
- Socio-economics and stakeholder analysis
- Renewable energy
- Marine planning
- Marine policy
- Ecosystem indicators and forecasting
- Bio-economic modelling
- Ecosystem health, ecotoxicology and pollutant biogeochemistry
- Phytoplankton physiology
- Marine bacterial and extract culture collection
- Isolation of novel marine microbes (from algae, bacteria and viruses) for applications in drug discovery, biocatalysis, healthcare and bio-energy
- Screening capability for bioactivities and isolation of natural products and enzymes

## Contact details:

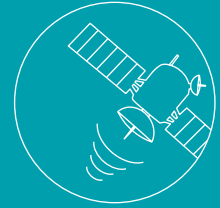
Dr Melanie Austen, Head of Science, E: [forinfo@pml.ac.uk](mailto:forinfo@pml.ac.uk)  
Plymouth Marine Laboratory, Prospect Place, The Hoe,  
Plymouth, PL1 3DH, United Kingdom

T: +44 (0)1752 633100 [www.pml.ac.uk](http://www.pml.ac.uk)

Registered charity number 1091222, company number 4178503

© Plymouth Marine Laboratory 2011

# SEA FROM SPACE



## Earth observation science and applications

As the world's population continues to grow and its impact on global ecosystems intensifies, Earth observation is an increasingly important and cost-effective tool for investigating and observing changes in the Earth's environment.

Earth observation is a proven tool for providing repeated large spatial scale observations of the sea surface, complementing *in situ* sampling from ships, moorings and other platforms. Satellites can provide measurements of a number of variables including ocean colour, temperature, height and roughness of the sea surface.

### Research priorities:

- Developing, improving and validating methods to understand marine processes, such as estimating global marine carbon production or characterising the plankton ecosystem;
- Understanding processes which impact upon inter-annual variability of natural resources such as fisheries;
- Developing processing systems to make data available in near real-time to end users. This is relevant, for example, for guiding research vessels at sea to locations of particular interest to study processes that are short-lived or dynamic in character, such as algal blooms and eddies, and for monitoring water quality or harmful algal

blooms that can cause human health problems or economic losses in the mariculture industry;

- Processing of satellite and aircraft remote sensing data to support scientists (UK, Europe and globally).

### Addressing societal challenges:

- The ocean's role in biogeochemical cycling;
- Monitoring the interactions between human society and the marine environment, such as harmful algal blooms and eutrophication.

## Role in society

Providing a service for observing water quality and algal blooms in anticipation of an EU Directive expected to require extensive water quality monitoring by 2012;

Further advisory and strategic roles, including membership of committees such as UNESCO/IOC Global Ocean Observing System; SCOR/IOC Global Ecology and Oceanography of harmful algal blooms; NERC Space Geodesy; EO Data Acquisition and Analysis Service and the Airborne Research and Survey Facility; Capacity Building Committee of the Group on Earth Observation (GEO), and the Census of Marine Life 2020 Science Council;

PML hosts the Partnership for Observation of the Global Oceans (POGO) Secretariat.

## Products from science

Development of ecological indicators from remotely sensed data, including bloom timing and duration, and phytoplankton primary production;

Analysis of oceanic fronts for applications in fisheries management, marine protected areas and for site selection for renewable offshore energy.

## Delivery & leadership



Leading the Ocean Carbon theme for the UK National Centre for Earth Observation;

Providing value added satellite data products to the UK academic community through the Plymouth node of the NERC EO Data Acquisition and Analysis Service (NEODAAS);

Hosting the Data Analysis Node of the NERC Airborne Research and Survey Facility (ARSF) processing LIDAR data for mapping topographical structure and hyperspectral visible/near-infrared imagery.



Engaged in a number of European projects within the Global Monitoring for Environment and Security (GMES) programme such as the marine core service, MyOcean ([www.myocean.eu.org](http://www.myocean.eu.org)) and CoastColour.



With a global EO processing capability PML is leading international projects such as ChloroGIN ([www.chlorogin.org](http://www.chlorogin.org)) and the Europe-Africa Marine EO network ([www.eamnet.eu/cms](http://www.eamnet.eu/cms)); PML has won a major European Space Agency contract to improve global ocean colour fields for use worldwide by marine scientists.

## Services:

- Near real-time and archive processing of ocean colour and sea surface temperature data
- Algorithm development for understanding marine processes such as the ocean carbon cycle
- Water quality monitoring, harmful algal blooms
- Ecological indicators and long-term monitoring
- Airborne optical and LIDAR data
- Ocean front detection
- Validation of ocean colour algorithms and methods
- Web based data visualisation services
- Capacity building in developing countries

## Contact details:

Steve Groom, Head of Science, E: [forinfo@pml.ac.uk](mailto:forinfo@pml.ac.uk)

Plymouth Marine Laboratory, Prospect Place, The Hoe,  
Plymouth, PL1 3DH, United Kingdom

T: +44 (0)1752 633100 [www.pml.ac.uk](http://www.pml.ac.uk)

Registered charity number 1091222, company number 4178503

© Plymouth Marine Laboratory 2011

# Cycling in the Sunlit Ocean



## Biogeochemical cycling, the oceans in climate science

Scientists at PML are aiming to quantify key processes in the cycling of major elements in the surface oceans and coastal seas in order to predict how marine productivity and climate feedbacks between the oceans and atmosphere might alter in a changing world. This important area of science builds upon the concept that Earth can regulate its climate through changes to the chemistry of the oceans and atmosphere.

PML's research focuses on the coastal environment and the surface oceans in open waters and applies an interdisciplinary approach as it spans the interface of biology, chemistry and physics.

### Research priorities:

- Identification and quantification of key mechanisms in the microbially and photochemically mediated cycling of carbon, nitrogen, sulphur and iodine in surface seawater;
- Co-ordination of the Atlantic Meridional Transect to understand ocean plankton communities and improve PML's ability to predict the role of the open ocean in the global carbon cycle;
- Acquisition of data during targeted oceanographic missions as well as from "ships of opportunity", in order to test biogeochemical models.

### Addressing societal challenges:

- Understanding how climatic and anthropogenic change affect the physical, chemical and biological functioning of the marine ecosystem, from individual organisms to the ecosystem level and how such changes feed back to the Earth system;
- Assessing the sensitivity to global change of the cycling of nutrients and marine productivity in the oceans and coastal seas;
- Developing a better understanding and quantification of the role the oceans play in atmospheric chemistry and climate via the uptake and release of climate active gases.

## Role in society

Co-ordinating the Atlantic Meridional Transect Programme which, thus far, includes 19 research cruises involving over 180 scientists from 11 countries, undertaking biological, chemical and physical oceanographic research during an annual voyage between the UK and the South Atlantic;

Further advisory and strategic roles include: co-Chair of the European Science Foundation Working Group 1 COST Action 735, Royal Society's Climate Change Advisory Network, IOC Expert Group: developing methodologies for assessment of open ocean, SCOR/IGBP Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Scientific Steering Committee and IOC-ICES Study Group for Nutrient Standards Steering Committee.

## Products from science

Pioneered the use of deliberate tracers to undertake *in situ* experiments in shelf seas and the open oceans;

Development, in collaboration with industrial partners, of new tools and technologies to make practical and reliable measurements ranging from water quality to interactions of biogases across the sea surface boundary. These include the 'Live pCO<sub>2</sub>' system, HAB-Buoy and the AquaShuttle.

## Delivery & leadership



Researching marine biogeochemical cycles in a high CO<sub>2</sub> world for the UK NERC Oceans 2025 Programme;

Investigating the role of the oceans in the cycling of oxygenated volatile organic compounds (OVOCs) for the UK NERC Surface Ocean Lower Atmosphere Study (SOLAS) and Oceans 2025 programme;

Explaining the role of volatile compounds in trophic interactions.



Evaluating the impact of ocean acidification on trace gases and nitrogen cycling for a variety of customers, including the European Union.



Quantifying the rates of production, consumption and air-sea transfer of a range of volatile iodine compounds for the NERC INSPIRE project for the Surface Ocean - Lower Atmosphere Study (SOLAS), an international research initiative comprising over 1500 scientists in 23 countries;

Testing the role of upwellings in the supply of active climate gases for the SOLAS ICON Cruise.

## Services:

- Carbon and nutrient cycling
- Biogenic gases (dimethyl sulphide, nitrous oxide, methane, halocarbons, ammonia and oxygenated volatile organic compounds)
- Ocean acidification
- Deliberate tracers to undertake *in situ* experiments in shelf seas and the open oceans
- Mesocosm experiments - enclosed bodies of water or sediment kept under controlled experimental conditions, in the field and in a laboratory
- Co-ordination of large-scale international research cruises, such as the Atlantic Meridional Transect
- Future oceans - analysing the effects of change

## Contact details:

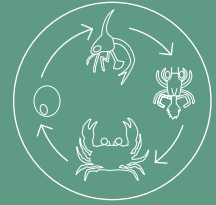
Dr Phil Nightingale, Head of Science, E: [forinfo@pml.ac.uk](mailto:forinfo@pml.ac.uk)  
Plymouth Marine Laboratory, Prospect Place, The Hoe,  
Plymouth, PL1 3DH, United Kingdom

T: +44 (0)1752 633100 [www.pml.ac.uk](http://www.pml.ac.uk)

Registered charity number 1091222, company number 4178503

© Plymouth Marine Laboratory 2011

# MARINE LIFE SUPPORT SYSTEMS



## Biodiversity, marine ecology and molecular science

We live in a rapidly changing environment where one of the great challenges is to understand, predict and mitigate the consequences of environmental change upon climate, biogeochemical cycles and use of natural resources.

Scientists at PML are studying the biodiversity of marine systems, from the basic building blocks of life (DNA, RNA and protein) to individuals, populations and communities, to give a unique insight into the role played by biodiversity in controlling ecosystem functioning and to help predict the impacts caused by human exploitation of the marine environment.

### Research priorities:

- Understanding the natural and anthropogenic processes which drive spatial and temporal patterns in biodiversity;
- Quantifying and understanding the role played by biodiversity in supporting ecosystem function;
- Developing novel tools and techniques for measuring biodiversity, interpreting and visualising complex biodiversity data;
- Predicting the impact of environmental change on biodiversity and the processes it supports;
- Developing and providing knowledge based evidence for management tools, policy development, and decision making.

### Addressing societal challenges:

- Understanding and predicting the impact of society's activities, at either local or global scales, on the biodiversity and functioning of marine ecosystems;
- The moral and legal obligation to prevent biodiversity loss and meet international commitments, for example the Convention on Biological Diversity.

## Role in society

PML scientists act in advisory and strategic roles through membership of committees, such as the IPCC and ICES working group on biodiversity; the IPCC WGI and WGII on Impacts of Ocean Acidification on Marine Biology and Ecosystems, and the ICES study group on climate related benthic processes in the North Sea;

Chair of the Research Programme writing Team and member of the Advisory Group of the NERC/Defra/DECC funded UK Ocean Acidification Research Programme (UKOARP).

## Products from science

Providing services addressing biofouling, coupling mechanistic expertise of fouling biology with impartial and extensive knowledge of antifouling technologies;

Development of a 'Guide to best practices for ocean acidification research and data reporting' within the European project on ocean acidification (EPOCA);

Virus discovery work at PML has identified compounds for possible use in anti-ageing and cancer inhibiting therapies;

The PML spin-out company, PRIMER-E, undertakes the development, distribution and support of the ecological and environmental studies software, PRIMER 6 ([www.primer-e.com](http://www.primer-e.com)).

## Delivery & leadership



Biodiversity and Ecosystem Functioning for the NERC Oceans 2025 programme;

Providing evidence for the existence of distinct bacterial and archaeal communities through the use of specific culturing techniques and metagenomics for the UK Ecology and Hydrology Funding Initiative.

---

Studying the southern North Sea, eastern and western English Channel to assess key marine species and their habitats to develop a "toolbox" to help in decision-making and planning for both sound governance and sustainable management of marine resources and human related activities;

Assessing impact of Carbon Capture and Storage (CCS) on the marine environment, leading the impact on marine biological communities.



---

Investigating the impact of ocean acidification and elevated temperatures on biodiversity and ecosystem functioning including research projects in the Arctic.

## Services:

- Benthic and pelagic experimental and observational ecology
- High CO<sub>2</sub> and climate change impact studies and prediction
- Long-term observations of marine biodiversity
- Experimental design and data analysis
- Marine molecular biodiversity and genomics
- Tools for quantifying and describing biodiversity
- Polar research
- Techniques to estimate the effects of human activity on ecosystem goods and services
- Organism physiology
- Marine viruses
- Habitat mapping
- Biofouling

## Contact details:

Dr Stephen Widdicombe, Head of Science, E: [forinfo@pml.ac.uk](mailto:forinfo@pml.ac.uk)  
Plymouth Marine Laboratory, Prospect Place, The Hoe,  
Plymouth, PL1 3DH, United Kingdom

T: +44 (0)1752 633100 [www.pml.ac.uk](http://www.pml.ac.uk)

Registered charity number 1091222, company number 4178503

© Plymouth Marine Laboratory 2011

# TODAY'S MODELS, TOMORROW'S FUTURES



## Ocean observations and ecosystem models

A major driver for ecosystem model development and coastal zone monitoring is the demand for tools to support ecosystem based management initiatives, answering questions concerning climate change, marine resource management and prediction of future trends.

PML scientists are developing coupled hydrodynamic ecosystem models combined with multidisciplinary observations of the coastal seas, such as the Western Channel, to provide real-time physical, chemical and biological measurements. Simulations of past, present and future ecosystem states are also being developed from these data.

### Research priorities:

- Developing coupled hydrodynamic ecosystem models to understand marine processes, such as marine carbon budgets, impacts of ocean acidification, biogas production and nutrient cycling;
- Developing error quantified simulations of past, present and future ecosystem states;
- Combining multidisciplinary observations of the Western Channel to provide real-time physical, chemical and biological measurements, coupled with real-time modelling systems, to provide information on the functioning of shelf seas.

### Addressing societal challenges:

- Knowledge of driver impacts is currently limited by the period over which measurements have been made. The use of dynamic simulation models with feedbacks allows assessment of driver impacts outside of the period of observations;
- Sustained measurements are critical to understanding Earth system behaviour and identifying change, not just to provide long-term data sets, but also to capture extreme or episodic events and to play a key role in the initialisation and validation of models.

## Role in society

PML has developed a European regional shelf seas capability to investigate the impact of CO<sub>2</sub> driven acidification on the ecosystem;

PML is engaged in assessing and advising on the potential harm from leakage of geologically sequestered CO<sub>2</sub>, a key UK Government emissions mitigation strategy;

PML is a strategic partner of the National Centre for Ocean Forecasting (NCOF) and leading the development of ecosystem forecast systems for shelf seas, together with NOC and the Met Office. Member of the SCOR/IOC Global ecology and Oceanography of Harmful Algal Blooms (GEOHAB) Scientific Steering Committee.

## Products from science

Developing a real-time cabled observatory, a new concept of coastal monitoring orientated towards end users ([www.medon.info](http://www.medon.info));

Process models describing the production and fate of dimethyl sulphide to quantify the biogeochemical processes controlling marine biogas production;

Development of "virtual" cells and organs.

## Delivery & leadership



Maintaining the western English Channel Observatory with over 20 years of data, studying the regional effects of ecosystem variability in the context of global climate change;

Investigating regional ecosystem and biogeochemical impacts of ocean acidification for NERC.



Leading modelling activities in the EU EURO-BASIN project, to establish predictive capacities to develop an understanding of the past, present and future dynamics of the North Atlantic and shelf sea ecosystems. EURO-BASIN is linked with similar programmes in the US and Canada;

Co-ordinating the 22 partners in the EU MEECE project which aims to explore the responses of marine ecosystems, looking at the impacts of climate and anthropogenic drivers, developing appropriate, knowledge based, management applications.



Global Coastal Ocean Modelling System (GCOMS) - a high-resolution, coupled physical/biological ecosystem model developed to model (simulate) the world's shelf seas;

Working with global partners to understand how whole ecosystems will respond to climate change.

## Services:

- Ecosystem modelling
- Global monitoring of the coastal ocean
- Shelf seas modelling
- Marine biogases
- Impact of high CO<sub>2</sub>: ocean acidification and climate change
- Operational oceanography
- Modelling uptake of contaminants
- Harmful algal blooms
- Data assimilation
- Plankton functional types
- Assessment of model performance

## Contact details:

Dr Icarus Allen, Head of Science, E: [forinfo@pml.ac.uk](mailto:forinfo@pml.ac.uk)

Plymouth Marine Laboratory, Prospect Place, The Hoe,  
Plymouth, PL1 3DH, United Kingdom

T: +44 (0)1752 633100 [www.pml.ac.uk](http://www.pml.ac.uk)

Registered charity number 1091222, company number 4178503

© Plymouth Marine Laboratory 2011