



## Oceans 2025 Annual Science Meeting 11- 13 May 2010 at the Holiday Inn, Plymouth

The 2010 Annual Science Meeting (ASM) includes greater opportunity for discussion, with an emphasis on engagement with stakeholders, the evolution and implementation of NERC themes, and a 'forward look' approach for UK marine science. These changes were made in response to feedback from the 2009 ASM.

This guide provides a summary timetable, oral and poster abstracts, and other basic information. For additional details on the Oceans 2025 programme and the associated Strategic Ocean Funding Initiative (SOFI), see [www.Oceans2025.org](http://www.Oceans2025.org).

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### Valuables

Please do not leave valuables in any of the meeting rooms – the Edgcumbe Room off Reception is a secure area if needed. Please ask Reception for access.

### WiFi

Facilities available - please ask reception for a password.

### Presentations

Presentations and poster abstracts will go on the Oceans 2025 website after the meeting.

### Evening social event: Tuesday 11 May 19.15 – 21.00 at the National Marine Aquarium

There will be an evening reception for delegates at the National Marine Aquarium ([www.national-aquarium.co.uk](http://www.national-aquarium.co.uk)). A welcome drink and canapés will be served from 19.15. A cash bar will be available and delegates will have the opportunity to enjoy a short tour of the aquarium. The NMA is easily accessible via a footbridge from the Barbican, a short walk from the Holiday Inn. Please note that the bridge closes at 21.30.



# Oceans 2025 Annual Science Meeting: Plymouth, 11 - 13 May 2010

## TIMETABLE

### Tuesday 11 May

	1130	Programme Advisory Board (PAB) session #1
	1230	<b>Lunch</b>
Chair: Ian Boyd	1330	Welcome/Introduction <i>Stephen de Mora, Chief Executive PML</i>
	1340	<u>Marine science in context of NERC strategy</u> <i>Phil Heads, NERC Head of Strategy</i>
	1355	<u>Science to meet societal needs: Stakeholder interests and requirements</u> Defra perspective: science-policy interface and priorities for marine research <i>Darius Campbell, Defra</i>
	1420	<u>International science-to-policy</u> <i>Boram Lee, International Oceanographic Commission</i>
	1445	Discussion
	1500	<b>Tea/coffee</b>
Chair: Stephen de Mora	1520	<u>Research responses:</u> 10 min Oceans 2025 overview <i>Phil Williamson, Oceans 2025 Science Coordinator</i> 30 min National Oceanography Centre <i>Phil Weaver &amp; Andrew Willmott</i> 15 min Plymouth Marine Laboratory <i>Manuel Barange</i>
	1615	Discussion
	1620 15 min	Scottish Association for Marine Science <i>Laurence Mee</i>
	10 min	Marine Biological Association <i>Colin Brownlee</i>
	10 min	Sea Mammal Research Unit <i>Ian Boyd</i>
	10 min	Sir Alister Hardy Foundation for Ocean Sciences <i>Peter Burkill</i>
	1705	Discussion
	1715-1800	<b>Poster session #1</b> <i>refreshments</i> All posters to be displayed, with odd-numbered posters to be presented by authors
	1915-2100	<b>Reception and light buffet: National Marine Aquarium</b>

### Wednesday 12 May

Chair: Andrew Willmott	0900	<u>Technology development and application</u>
	15 min	Private sector perspective <i>Richard Burt (Chelsea Technologies Group)</i>
	10 min	Overview of NERC Technology theme <i>Bill Eason (NERC Swindon Office)</i>
		Oceans 2025/SOFI presentations:
	15 min	<a href="#">On the threshold of a dream</a> <i>Gwyn Griffiths (NOC)</i>
	10 min	<a href="#">The contribution of gliders to a realtime network of observations from the Scottish west coast to Rockall</a> <i>Toby Sherwin et al (SAMS)</i>
	10 min	<a href="#">Novel analytical instrumentation is leading to breakthroughs in biogeochemical cycles</a> <i>Phil Nightingale et al (PML)</i>
	10 min	<a href="#">Marine system modelling in Oceans 2025: towards seamless modelling</a> <i>Icarus Allen, Adrian New, Tom Anderson &amp; Jason Holt (PML, NOC)</i>
	10 min	<a href="#">The application of cellular and genomics technologies to understand biogeochemical processes</a> <i>Glen Wheeler et al (PML, MBA)</i>
	1020	Discussion

	1030	<b>Coffee/tea</b>
	1050	<p>Four parallel break-out groups on technology, each introduced by 2-3 short (5 min) presentations:</p> <p>a) <u>Platforms and sensors</u>  Autosub6000 trials and science results, and introduction to Autosub long range  <i>Steve McPhail (NOC)</i>  From MYRTLE I to MYRTLE X <i>Stephen Mack (NOC)</i>  Dense <i>in situ</i> biogeochemical sensing: innovation, progress &amp; the future <i>Matt Mowlem (NOC)</i></p> <p>b) <u>Telemetry and tracking</u>  Longterm GPS tracking of pelagic fish offers new direction in bioresource monitoring  <i>David Sims (MBA)</i>  Technological advances in marine mammal science <i>Bernie McConnell (SMRU)</i></p> <p>c) <u>Future modelling and data-gathering needs</u>  Large-scale ocean modelling with adapting unstructured mesh methods  <i>Matt Piggott (Imperial)</i>  Creating a legacy - new insights from new hydrographic sections in the North Atlantic  <i>Brian King (NOC)</i></p> <p>d) <u>Molecular biology and biotechnology</u>  Transcriptomic response of different <i>Emiliania huxleyi</i> isolates to elevated seawater pCO<sub>2</sub> conditions <i>Frederic Verret (Essex/MBA)</i>  Genomics of host-pathogen interactions in marine algae <i>Claire Gachon et al (SAMS, Aberdeen)</i></p> <p>Each group to consider:</p> <ul style="list-style-type: none"> <li>• What are the gaps and needs?</li> <li>• Are Oceans 2025 researchers using the best tools available?</li> <li>• How will technological advances on 5-10 yr timescale change marine science?</li> <li>• What should be the priorities/new ideas for the NERC Technology theme?</li> <li>• What are the constraints on commercial exploitation?</li> </ul> <p>Summary written reports to be prepared by each group.</p>
	1200	<b>Lunch</b>
	1240	<b>Poster session #2</b> All posters to be displayed, with even-numbered posters to be presented by authors
Chair Colin Brownlee	1330	<u>Ecosystem services</u>
	15 min	Policy perspective <i>Dan Laffoley (Natural England)</i>
	15 min	Oceans 2025/SOFI presentations: Trends in marine ecosystem services and their values – the marine habitat chapter of the UK National Ecosystem Assessment <i>Mel Austen et al (PML, MBA, SAMS &amp; Cefas)</i>
	15 min	A new estimate of the strength of the ocean's biological carbon pump <i>Stephanie Henson, Richard Sanders et al (NOC)</i>
	10 min	A strategy for Marine Environment and Human Health in the UK <i>Icarus Allen (PML)</i>
	10 min	Climate change effects on coastal and shelf seas, and consequences for primary production <i>Jason Holt et al (NOC, PML)</i>
	1435	Discussion
	1445	<b>Group photograph outside the Holiday Inn</b>
	1500	<b>Tea/coffee</b>

Chair: Laurence Mee	1515	<u>Energy and its implications</u>
	15 min	Policy perspective <i>Mike Cowling (The Crown Estate)</i>
	15 min	Oceans 2025/SOFI presentations: <i>How might marine organisms interact with wave and tidal-stream energy devices or the mass culture of marine plants for biofuels? Michele Stanley &amp; Ben Wilson (SAMS)</i>
	10 min	<i>Marine mammals and marine renewables: providing advice to stakeholders Dave Thompson (SMRU)</i>
	10 min	<i>Assessing the impacts of CCS leakage on marine organisms Steve Widdicombe (PML)</i>
	1620	Discussion
	1630	<u>Defence and security</u>
	15 min	Policy perspective <i>NOC (Roland Rogers)</i>
	15 min	Oceans O2025/SOFI presentations: <i>Environmental risk management [in naval context] Ian Boyd (SMRU)</i>
	10 min	<i>Submarine-based science in the Arctic Jeremy Wilkinson, Tim Boyd &amp; Peter Wadhams (SAMS, Cambridge)</i>
10 min	<i>The Luminescence and Marine Plankton (LAMP) project Stuart Painter &amp; Adrian Martin (NOC)</i>	
1735-45	Discussion	
1745-	PAB session #2 (to ~18.45)	
1930	<b>Dinner for PAB and Directors</b> (own arrangements for other ASM participants)	

## Thursday 13 May

Chair: Ed Hill	0900	<u>Evolution and implementation of NERC themes</u>
		Plenary overviews: [Technology already covered]
	10 min	Earth System Science <i>Tim Jickells (NERC Theme Leader; UEA)</i>
	10 min	Climate System <i>Richard Wood (NERC Theme Leader; Met Office) tbc</i>
	10 min	Biodiversity <i>tba</i>
	10 min	Sustainable Use of Natural Resources <i>Chris Franklin (NERC Swindon)</i>
	10 min	Risks and Hazards <i>John Rees (NERC Theme Leader; BGS)</i>
	10 min	Environment, pollution and human health <i>Tim Jickells (on behalf of Roy Harrison)</i>
	1000	Discussion groups (x 5) on NERC theme action plans, research gaps/opportunities and linkages between research programmes and National Capability activities. Group topics: <ul style="list-style-type: none"> <li>• NERC Arctic programme: biogeochemistry and climate components</li> <li>• Marine biodiversity: research priorities (linkage to ecosystem services)</li> <li>• Physical oceanography: mesoscale processes and/or ocean-shelf exchanges</li> <li>• Coastal sediment dynamics, including implications for marine renewable energy</li> <li>• Marine environmental health, including impacts of offshore decommissioning</li> </ul>
	1130	<b>Coffee/tea</b> <i>Distribution of written reports from Technology discussion groups</i>
Chair: Peter Burkill	1145	Oral reports from discussion groups based on NERC themes and research priorities (5 x 5 min)
	1210	Living with Environmental Change (LWEC) and marine science <i>Andrew Watkinson (LWEC Director, UEA)</i>
	1230	Concluding remarks <i>Ed Hill (director, NOC) and Peter Liss (Chair, Programme Advisory Board)</i>
	1240	<b>Lunch</b>
	1315 -	PAB session #3 [Private or with Oceans 2025 Directors; to ~1430]

Oceans 2025 and SOFI science community  
**Oral presentation abstracts**

**TECHNOLOGY DEVELOPMENT AND APPLICATION**

**On the threshold of a dream**

*Gwyn Griffiths (NOC)*

There has never been a better time to be a marine scientist seeking a particular platform or sensor technology to tackle scientific and related policy questions. Over the next 5-10 years, we should see a plethora of new instruments used routinely to address difficult questions such as those on understanding marine ecosystems functions and determining the contribution of melting ice sheets to rising sea level. A number of these new capabilities are emerging from the current Oceans 2025 Theme 8 programme. A big challenge is to ensure that the technology gets into the hands of users; accessing NERC's mechanisms Pathfinder and Follow-On will be one crucial approach, ultimately we need effective take-up by industry.

**The contribution of gliders to a realtime network of observations from the Scottish west coast to Rockall**

*Toby Sherwin, Estelle Dumont, Colin Griffiths & Lovro Valcic (SAMS)*

By drawing together discrete realtime monitoring of a sea loch, a shelf sea station and the NE Atlantic SAMS is developing a synoptic zonal view from very near shore to open ocean. The realtime array comprises: 1) A shore-cabled mooring in the upper basin of Loch Etive (EU funded), a mid-shelf mooring (Tiree Passage, Oceans 2025 Theme 10 SO12) and an ocean going glider (Oceans 2025 Theme 10 SO4). Throughout last winter our Seaglider patrolled the Rockall Trough measuring basic ocean parameters (T/S, DO, transmittance, backscatter and velocity) over the upper 1000 m and relaying its data to SAMS every 6 hours via an Iridium link. In so doing it filled a seasonal gap in our monitoring of the Rockall Trough that has existed since RRS *Challenger* was withdrawn from service in 1996. Gliders are at the cutting edge of oceanography and have the potential to overcome one of the main problems with monitoring the ocean - the contamination and aliasing of data by mesoscale and seasonal variability. In so doing, and by being able to work in conditions and for durations that far exceed those of conventional ships, they provide very real and cost effective improvements in our ability to monitor the ocean climate. Last winter's mission was the first operational deployment of a glider in UK waters and has demonstrated that gliders are fit for purpose. In addition, by presenting the data online in realtime we reach out to interested scientists, the public and relevant agencies; see <http://dalriada.sams.ac.uk/glider>.

**Novel analytical instrumentation is leading to breakthroughs in biogeochemical cycles**

*Phil Nightingale, Stephen Archer, Ruth Airs, Rachael Beale, Darren Clarke, Glen Tarran & Susan Kimmance (PML)*

The talk will cover four areas: i) work on oxygenated volatile organic compounds (OVOCs) via developments we have made to proton transfer reaction mass spectrometry (PTRMS) re air-sea fluxes and production mechanisms; ii) work on dimethylsulphoniopropionate (DMSP) using the new flow cytometry to sort and target particular plankton species and their role in sulphur cycling; iii) development of liquid chromatography mass spectrometry (LCMS) to shed new knowledge on the cycling of glycine betaine; and iv) gas chromatography mass spectrometry (GCMS) techniques developed at PML to determine nitrification/denitrification and related pathways and processes.

**Marine systems modelling in Oceans 2025: towards seamless modelling**

*Icarus Allen (PML), Jason Holt & Tom Anderson (NOC)*

Combinations of climate change and direct anthropogenic drivers are causing changes in temperature and ocean circulation, sea-ice cover and marine ecosystems structure and function. These effects in turn impact directly on for example, sea level and flood risk, biogeochemical cycling, carbon sequestration and fisheries. The Oceans2025 modelling community is near- unique in the world in having coordinated groups of scientists across different centres working together to develop and apply models of ocean physics, sea ice, shelf seas hydrodynamics and marine ecosystems. It is only by coordinating our efforts that we can begin to develop a seamless modelling approach for application to, for example, a coordinated

UK Earth Systems modelling strategy, the NERC-Met Office Joint Climate Research Programme, the Living With Environmental Change programme and the National Centre for Ocean Forecasting. We describe recent progress in the development of NEMO-ocean, NEMO shelf, sea-ice and ecosystem modelling. Fundamental problems include: i) establishing the appropriate level of complexity that will enable ecosystem models to have the most skill in predicting biogeochemical fluxes, requiring different biogeochemical / ecosystem modelling approaches; ii) establishing the appropriate resolution and process representation as models span from the global ocean to shelf seas and estuaries; and iii) establishing a realistic representation of ocean mixing processes on the global scale. Finally for simulations to be useful in a policy context it is crucial that model uncertainty is quantified. The above points will be illustrated with simulations of past and future ocean states.

### **The application of cellular and genomics technologies to understand biogeochemical processes**

*Glen Wheeler (PML), Declan Schroeder, Andrea Baker, Abdesslam Chrachri & Colin Brownlee (MBA)*

The need to understand processes driving biogeochemical fluxes at a cellular mechanistic level is important for predictive modelling at the population and community levels. Recent advances in functional genomics are allowing improved understanding of underlying mechanisms. However, combining functional, population and meta-genomics approaches will be essential to begin scaling up from a molecular level understanding of individual components and their responses to environmental perturbations to population and community responses. Some examples of how these approaches are being applied with increasing success and some of the major hurdles ahead will be discussed.

### **Technology discussion group: Platforms and sensors**

#### **Autosub6000 – trials and science results, and Introduction to Autosub Long Range**

*Steve McPhail (NOC)*

Autosub6000 carried out deep water trials in 2009, as part of the Oceans 2025 funded RRS *Discovery* Cruise 343. The AUV dived to 5600m, and demonstrated the effectiveness of its recently installed forward-scanning collision avoidance sonar, safely executing close in (to 5 m altitude) runs over the Casablanca seamount. I will also report on the results of its operations in search of hydrothermal activity in the Cayman Rise area in April 2010. I will introduce Autosub Long Range, and discuss the potential science missions which could be enabled by its unique combination of capabilities. With a 6000 km range and 6000 m depth capability, its first sea trials are scheduled for January 2011.

#### **MYRTLE I to MYRTLE X**

*Stephen Mack (NOC)*

MYRTLE (Multi Year Return Tide Level Equipment) is a POL-developed, long term deep sea lander, measuring bottom pressure for up to 5 years in a single deployment. The instrument consists of releasable data pods which store all the data, transmitted via infra red from a central system. These pods can then be released and recovered or data transmitted back via satellite. Since 1992 there have been three separate deployments of a MYRTLE each returning a long term data set. MYRTLE X is a new development proposing to stay on the seabed for up to ten years. This presentation will outline the concepts and advantages of a MYRTLE system and show the evolution of the instrument to make MYRTLE X possible including several test deployments of a prototype system designed to develop and evaluate the technology required for a potential ten year deployment.

#### **Dense *in situ* biogeochemical sensing: innovation, progress and the future**

*Matt Mowlem (NOC)*

A suite of sensors and analytical systems capable of dense spatial and temporal sampling and high performance metrology in aquatic environments are in development at the Centre for Marine MicroSystems based in Southampton. Innovations, technical developments and progress towards commercialisation are described. We present initial results from deployment of integrated microfabricated conductivity and temperature sensors. We describe two patented techniques for the manufacture of low-cost optofluidic, and microfluidic devices from polymers. Data from deployment of electrochemical, optical, and microfluidic reagent based chemical sensors is presented and compared to performance analysis in the laboratory. We describe quantitative phytoplankton RNA analysis on chip, and microfluidic cytometry of seawater. These results represent major advancements in the technology readiness level of these metrology systems for which there is high demand. Future developments and opportunities are discussed.

## **Technology discussion group: Telemetry and tracking**

### **Long-term GPS tracking of pelagic fish offers a new direction in bioresource monitoring**

*David Sims (MBA)*

Satellite tracking of large pelagic fish provides insights on free-ranging behaviour, distributions and population structuring. Up to now, such fish have been tracked remotely using two principal methods: direct positioning of transmitters by Argos polar-orbiting satellites, and satellite relay of tag-derived light-level data for *post hoc* track reconstruction. Error fields associated with positions determined by these methods range from hundreds of metres to hundreds of kilometres. However, low spatial accuracy of tracks masks important details, such as foraging patterns. Despite this, GPS tracking has not been used previously to track fish in the open sea. We have tested a fast-acquisition global positioning system (Fastloc GPS) tag with remote data retrieval to track long-term movements of the world's largest bony fish, the ocean sunfish *Mola mola*. Fish were tracked for > 90 days in near real time and position accuracy of < 70 m with nearly four times as many locations obtained by the GPS tag than by a conventional Argos transmitter, and which enabled identification of specific foraging behaviour. The study demonstrates the feasibility of GPS tagging to provide tracks of unparalleled accuracy for monitoring fish movements, and signals the potential of GPS-tagged pelagic fish as detectors of resource 'hotspots' in the blue ocean - providing a new capability for understanding large pelagic fish behaviour and habitat use, relevant to ocean management and species conservation.

### **Technological advances in marine mammal science**

*Bernie McConnell (SMRU)*

Collecting and analysing the marine mammal data required to meet the needs of stakeholders requires technological and analytical innovation and low cunning. Current examples include:

- Development and use of hi-accuracy GPS-GSM telemetry tags to describe seal movements in relation to marine renewable energy systems
- Development and use of networks of seal-borne CTD & fluorimetry tags that provide real near-time data to the oceanographic community,

Examples in development include tag attachment methods for small cetacea, and Intelligent passive acoustic monitoring. Other work at SMRU encompasses the whole range of Technology Readiness Levels. Our ability to provide technological solutions for stakeholders into the future depends as much on a sustainable and integrated framework as it does the ingenuity of NERC engineers and scientists.

## **Technology discussion group: Future modeling and data-gathering needs**

### **Large-scale ocean modelling with adapting unstructured mesh methods**

*Matt Piggott (Imperial College London) [SOFI award]*

ICOM is being developed as a 'next-generation' community model for oceanographic applications. It possesses a number of novel aspects such as the ability to represent coupled multi-scale phenomena optimally through the use of dynamically adaptive mesh resolution. A concerted effort is now underway to move the model from idealised (e.g. process scale) applications to more real-world large-scale problems. This includes the development of additional model functionality and quantitative comparisons with real-world data and multi-model inter-comparison projects. This presentation will update the community on the recent progress made in these research directions.

### **Creating a legacy - new insights from new hydrographic sections in the North Atlantic**

*Brian King (NOC)*

During 2009 and 2010, the UK has undertaken three major hydrographic expeditions in the North and South Atlantic through the combined efforts of Theme 1 at NOC and SOFI at UEA, revisiting cruise tracks occupied at intervals of 5 to 20 years back to the IGY in 1957. Analysis and interpretation of careful and complete observations, in which every generation pushes its available technology to the limit, provides the basis for the IPCC assessments of global change. Higher- frequency measurements from programs like Argo and RAPID-WATCH are combined with less frequent but more comprehensive cruise data to interpret the temporal character of observed changes. Results from Theme 1 sections at 24S and 24N will be shown, including an update on the strength of the Atlantic Meridional Overturning Circulation in Jan/Feb 2010. Under the banner GO-SHIP (Global Ocean Ship-based Hydrographic Investigations Program, [www.go-ship.org](http://www.go-ship.org)), the international community is entering a new era of basin-scale hydrographic measurements for climate science undertaken by the world's leading oceanographic institutions. The UK has the opportunity to be the leading European contributor to the leadership and delivery of this new initiative which will be discussed in the context of the legacy from Oceans 2025.

## **Technology discussion group: Molecular biology and biotechnology**

### **Transcriptomic response of different *Emiliana huxleyi* isolates to elevated seawater pCO<sub>2</sub> condition**

*Frederick Verret (Univ of Essex & MBA) [SOFI award]*

Ongoing increase in atmospheric carbon dioxide concentration is lowering surface seawater pH and carbonate ions concentration. Laboratory and field experiments carried out to study the consequence of such physicochemical perturbation on the most abundant coccolithophore species *Emiliana huxleyi* have so far produced contradictory results. These apparent inconsistencies can be explained by differences concerning the strain used, the environmental conditions (laboratory cultures vs. natural assemblages) and the methodology employed to lower the pH (acid added vs. CO<sub>2</sub> bubbling). Here we test the hypothesis that *E. huxleyi* with different coccolith morphologies and isolated from different oceanic regions share a common molecular and physiological response to increased seawater pCO<sub>2</sub>. *E. huxleyi* isolates have been grown in pH-stat cultures under 180 (glacial), 300 (present), 500 and 1000 (projected) ppm pCO<sub>2</sub>. Transcriptomic response has been analysed using two complementary technologies: SOLEXA tag-based approach and whole genome tiling microarrays. In parallel, physiological parameters such as growth rate, photosynthesis efficiency, carbon and nitrate consumption, coccolith morphology, production of particulate organic and inorganic carbon have been measured. We aim to give a broader understanding of the molecular & physiological response of the *E. huxleyi* species complex to elevated pCO<sub>2</sub>.

### **Genomics of host-pathogen interactions in marine algae**

*Claire Gachon, Laura Grenville-Briggs, Frithjof Küpper (SAMS) & Pieter van West (Univ of Aberdeen) [SOFI award]*

Like any other living organism, marine algae are plagued by diseases. The intracellular pathogen *Eurychasma dicksonii* is the most widespread eukaryotic pathogen of marine brown algae. It is also the most basal representative of the oomycete lineage, a group that encompasses devastating agricultural and aquacultural pathogens. It not only has the largest reported host range among marine pathogens - infecting virtually every brown algal species tested so far, but is also the most prevalent eukaryotic pathogen in natural brown macroalgal populations. As part of our strategy to develop a comparative, evolutionary-driven approach to understand *Eurychasma* infection strategies, we participated in the genome annotation of the plant root pathogen *Pythium ultimum*, in parallel to exploiting our EST data generated on *Eurychasma*. We will also report on the identification of candidate receptors in the genome of the first-ever fully sequenced marine seaweed, *Ectocarpus siliculosus*, which is a host for *Eurychasma*. We will discuss how our findings challenge current views on the evolution of immunity in eukaryotes. *Reference available.*

## **ECOSYSTEM SERVICES**

### **Trends in marine ecosystem services and their values – the marine habitat chapter of the UK National Ecosystem Assessment**

*Mel Austen, Caroline Hattam, Stephen Mangi (PML), Mike Burrows (SAMS), Matt Frost (MBA) Stephen Malcolm & Grant Stentiford (Cefas)*

The current understanding of the status and trends in delivery of all of the ecosystem services and benefits by UK marine ecosystems is being collated in a marine habitat chapter for the UK National Ecosystem Assessment (UK NEA). The UK NEA is the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. Part of the Living With Environmental Change (LWEC) initiative the UK NEA, commenced in mid-2009. The marine habitat chapter of the UK NEA covers all UK marine waters and includes coasts, estuaries and all of the intertidal. It is highly linked with information arising from Defra's *Charting Progress 2* report due to be released in July 2010.

### **A new estimate of the strength of the ocean's biological carbon pump**

*Stephanie Henson, Richard Sanders, Esben Madsen, Paul Morris, Fred Le Moigne, & Graham Quartly (NOC)*

A major term in the global carbon cycle is the ocean's biological carbon pump (BCP) which is dominated by the sinking of small organic particles from the surface ocean to its interior. Without this storage of organic carbon, atmospheric CO<sub>2</sub> would be substantially greater than it is today, the BCP thus represents a massive ecosystem service which the oceans offer to the planet. The current best estimate of the magnitude of carbon export is derived from experimental observations of the relationship between temperature and the f-ratio. This relationship, applied to satellite-derived temperature and primary production fields, yields an estimated global export of 12 GtC yr<sup>-1</sup>. However, significant uncertainties exist

in whether the f-ratio approach correctly represents the magnitude of new production, and hence in the validity of the global estimate of carbon export. Here we show that the true magnitude of the biological carbon pump is ~ one-third lower than the current best estimate. We used >100 measurements of particulate carbon export derived from a thorium isotope tracer, combined with satellite-derived estimates of primary production, to calculate the fraction exported as particulate matter. This yields a new global carbon export estimate of 7.8 GtCyr<sup>-1</sup>, roughly one-third lower than our previous best estimate of the magnitude of the biological carbon pump. Our results demonstrate that our knowledge of a major planetary carbon flux is incomplete.

### **A strategy for marine environment and human health in the UK**

*Icarus Allen (PML)*

There is developing awareness of the need to manage the world's seas on a sustainable basis to help ensure the continued diversity and quality of life on Earth. Both natural and man-made stresses may have large functional impacts, resulting in adverse human health and economic consequences. In order to monitor, understand and predict those impacts, it is necessary to establish the processes and interactions involved. The research area of *Marine Environment and Human Health* (MEHH) aims to integrate a range of scientific disciplines to investigate the present and potential future effects of oceanic and coastal processes and biota on human health and wellbeing. Such effects can arise from exposure to substances that occur widely in marine ecosystems, including bio-toxins, endocrine disrupters, heavy metals, nano-particles, pathogens and synthetic organic pollutants. A wide range of complex processes are involved – and their elucidation requires information and knowledge from the biomedical, ecological, physical and social sciences. A recent SOFI workshop on this topic identified research priorities in this area, together with a unifying conceptual framework for future work on the impacts of pollutants on ecosystem services and wider socio-economic implications. This strategy will be presented.

### **Climate change effects on coastal and shelf seas, and the consequences for primary production**

*Jason Holt, James Harle (NOC) Robert Holmes, Icarus Allen & Manuel Barange (PML)*

We investigate how projected changes in climate affect the circulation, mixing and stratification of coastal and shelf seas around the world, and how these physical effects in turn influence the supply of nutrients to the euphotic zone and the net primary production. The Global Coastal Ocean Modelling System allows us to automatically deploy a regional coupled hydrodynamic-ecosystem model (POLCOMS-ERSEM) in any/all of the coastal and shelf seas around the globe. Working as a synergy between Oceans 2025 and the QUEST-FISH project, our focus here is on 20 large marine ecosystems that account for over 60% of global fish production. These are divided among 12 model domains, forced by a single coupled ocean-atmosphere climate simulation to represent conditions typical of four time slices: pre-industrial, present day, 2050s and 2080s. This enables us to investigate how different shelf sea types potentially respond to climate change in quantitatively and qualitatively different fashions. The results are considered in the context of satellite and *in situ* observations. Other components of the QUEST-FISH project build on these results to investigate the consequences for fish production and the economic impact on fisheries.

## **ENERGY AND ITS IMPLICATIONS**

### **How might marine organisms interact with wave and tidal-stream energy devices or the mass culture of marine plants for biofuels?**

*Michele S Stanley & Ben Wilson (SAMS)*

With global energy demands rising, peak oil imminent and fossil fuel usage directly linked to climate change, Governments are setting increasingly ambitious targets for CO<sub>2</sub> reduction. Consequently the drive to develop large scale renewable energy technologies is gathering increasing momentum. The marine environment offers numerous opportunities from sustainable energy exploitation. Of these the UK is at the forefront of engineering and testing technologies to derive energy from waves and tidal-streams and harnessing the intense productivity of marine plants. In this presentation we will explore some of the potential impacts on marine organisms posed by these rapidly developing industries. In particular we will focus on issues associated with the underwater perception, avoidance and collision by marine vertebrates of wave and tidal-stream energy devices and the potential ecological implications of mass macroalgal

cultures. While the engineering of many design concepts is advancing rapidly, the potential environmental consequences of any of these remain poorly known. The current (EIA driven) staged “deploy and monitor” approach offers a potential for assessing impacts device by device but not for a generic understanding that would alter the relative balance of the developing industry towards particular devices or concepts (% wave to %tidal-stream etc). Thus there is an urgent need for generic research that will provide an academic understanding of the environmental consequences of these whole industries and allow more strategic planning to be undertaken.

#### **Marine mammals and marine renewables: providing advice to stakeholders**

*Dave Thompson (SMRU)*

Marine mammals are popular and tidal turbines look dangerous. If you put them together you can generate concerns as well as energy. The rapid development of the marine renewables industry is generating demand for information on a range of marine mammal issues. Providing support for regulators and developers requires that monitoring programmes are focussed on appropriate spatial and temporal scales. Methods for collecting and analysing the requisite data need to be developed and exploited. Finally, systems for providing appropriate advice and/or access to information and its interpretation need to be in place. We describe how we are using SMRU’s monitoring programme to serve these functions.

#### **Assessing the impacts of carbon capture and storage (CCS) leakage on marine organisms**

*Steve Widdicombe (PML)*

Political, social and environmental pressures to reduce carbon dioxide (CO<sub>2</sub>) emissions have led several governments to seek new options for CO<sub>2</sub> mitigation. One such option involves injecting CO<sub>2</sub> into underground porous reservoir rocks; known as geological storage. This technique has been in use at the Sleipner West gas field in the Norwegian sector of the North Sea since 2000, where around a million tons of CO<sub>2</sub> are being sequestered each year. At the Gleneagles Summit in July 2005, the leaders of the world’s major economic powers (Canada, Italy, France, Germany, Japan, Russia, UK and the US) declared they would “work to accelerate the development and commercialization of CO<sub>2</sub> capture and storage (CCS) technologies”. Whilst offshore storage sites would be selected and operated in such a way as to minimize the potential for leakage, there remains the concern, particularly from the public, that mechanical failure or human error could lead to a release of CO<sub>2</sub> into the marine environment. So, before large-scale geological storage can be implemented it will be necessary to demonstrate that the risks associated with such a release are fully appreciated. Unfortunately, whilst the impact of such a release on seawater chemistry is fairly well understood, the scale and nature of impacts on marine organisms and biological processes is far less well known. Through the application of laboratory and field based experiments researchers at the Plymouth Marine Laboratory are working to provide a greater understanding of how benthic marine organisms, communities and biogeochemical processes will be affected by exposure to elevated levels of CO<sub>2</sub>. Through this knowledge we will be able to gain a better appreciation of the environmental risks associated with CCS and thereby facilitate the development of sub-seabed CO<sub>2</sub> storage as a potentially important tool in reducing CO<sub>2</sub> emissions.

## **DEFENCE AND SECURITY**

#### **Environmental risk management: application to naval activities**

*Ian Boyd (SMRU)*

Most NATO navies have identified the presence of risks to marine mammals as a result of their anti-submarine sonars as one of the top risks to the integrity of their own operational capability. In a case brought before the US Supreme Court in late 2008 the US Navy was permitted to continue the use of its ASW sonars but was required to include appropriate levels of mitigation for marine wildlife. SMRU has worked in partnership with BAE Systems to design and install an environmental risk management capability (ERMC) in ships of the Royal Navy and a modified system is being developed for use by the US Navy and for risk assessment in connection with offshore industrial development. The system ensures that the chain of command has a strategic (planning) and tactical advisory tool that is built upon appropriate risk management procedures and uses the best data available.

### **Submarine-based science in the Arctic**

*Jeremy Wilkinson, Tim Boyd (SAMS) & Peter Wadhams (Cambridge)*

For several decades, submarines on deployment in the Arctic Ocean have supported measurements that have contributed to our knowledge and understanding of the Arctic system, in particular with respect to the impacts of climate change on sea-ice and the upper ocean. These measurements were conducted during a variety of missions ranging from dedicated science cruises to opportunistic sampling during otherwise operational missions. Recognizing the unique capability of submarines to conduct measurements in the Arctic Ocean regardless of ice conditions, a workshop was held recently to promote discussion among marine scientists, representatives from the Royal Navy, and program representatives on submarine-based sampling in the Arctic. This short talk will summarize the results of that workshop, which was held April 28-29 at SAMS, in Oban, Scotland.

### **The luminescence and marine plankton (LAMP) project**

*Stuart Painter, Adrian Martin, John Allen, Charlotte Marcinko, Martha Valiadi  
& Debora Iglesias-Rodriguez (NOC)*

Marine bioluminescence, the production of light by marine life, has been observed since ancient times, in organisms ranging from bacteria to squid. Intrinsic beauty and fascination aside it is often investigated as a potential tool, its applications ranging from diagnosing the 'health' of ecosystems to tracking vessels. The biochemical dynamics whereby organisms produce light are reasonably well known. However, the cues for, and controls on, its generation by organisms are much less understood. This is particularly true for dinoflagellates, recognised as one of the dominant producers of bioluminescence in the pelagic open ocean. Dinoflagellates are the only group of phytoplankton which luminesce but this group is very large; it includes a wide variety of autotrophs, heterotrophs and mixotrophs.

The Luminescence and Marine Plankton (LAMP) project at the National Oceanography Centre is a blue skies funded programme with the Ministry of Defence on bioluminescence modeling. This is a tough objective which requires further understanding of dinoflagellate bioluminescence within the ocean, addressing basic uncertainties regarding the distribution, intensity and likelihood of occurrence. The LAMP is applying a variety of techniques: new field observations have provided insights into spatial and temporal variability of bioluminescence; molecular approaches have been used to design a 'probe' to test for the presence of bioluminescent organisms; and modelling work has explored the potential to predict when dinoflagellate bioluminescence is most likely to occur. The project therefore provides an excellent example of using a multidisciplinary approach to tackle an applied problem in oceanography.

# Oceans 2025 and SOFI science community

## Poster presentation abstracts

Posters grouped by Oceans 2025 theme (although some cover more than one). Authors of odd-numbered posters to be available for discussion at first poster session (Tuesday 11 May, 17.15-18.00) and of even-numbered posters at the second poster session (Wednesday 12 May, 12.40- 13.30)

### Theme 1: Climate, ocean circulation and sea level

<b>1.</b>	<p style="text-align: center;"><b>Initial result of the application of PSI to tide gauge sites around the coast of Great Britain</b></p> <p style="text-align: center;"><i>Ligia Adamska, Andrew Sowter, Richard Bingley (University of Nottingham), Felix Teferle (University of Luxembourg), Doug Tragheim (BGS) &amp; Simon Williams (NOC) [SOFI award]</i></p> <p>The tide gauges around the British coast record changes of mean sea level (MSL) which may rise by up to 1.8 metres over the next century. To better understand these long-term sea-level changes, it is important to identify the contribution of any land-level changes at the tide gauges. The Interferometric radar technique of Persistent Scatterers (PSI) enables the identification of vertical land motions by a time series analysis of dense arrays of naturally occurring consistently bright points in the radar imagery. Hence, PSI provides estimates of land-level changes over a wide spatial extent, which complements the precise levelling and continuous Global Positioning System (CGPS) installations at the tide gauge location. Following an initial evaluation of the available radar imagery for ten tide gauge sites around the British coast, four sites equipped with CGPS stations have been selected for further investigation and preliminary results are presented.</p>
<b>2.</b>	<p style="text-align: center;"><b>The roles of surface heat flux and ocean heat transport convergence in Atlantic temperature variability since 1960</b></p> <p style="text-align: center;"><i>Jeremy Grist, Simon Josey, Robert Marsh, Andrew Coward, Beverly deCuevas, Steven Alderson, Adrian New (NOC/Univ of Southampton), Simon Good (Met Office), Gervan Madec (Laboratoire d'Océanographie et du Climat: Expérimentation et Approches Numérique, Paris and NOC)</i></p> <p>The temperature variability of the Atlantic Ocean is investigated using an eddy-permitting (<math>1/4^\circ</math>) global ocean model (ORCA-025) forced with historical surface meteorological fields, from 1958-2001. The simulation of volume-averaged temperature and the vertical structure of the zonally averaged temperature trends are compared with those from observations. In regions with a high number of observations, in particular above a depth of 500m and between <math>22^\circ\text{N}</math> and <math>65^\circ\text{N}</math>, the model simulation and the data set are in good agreement. The relative contribution of variability in ocean heat transport (OHT) convergence and net surface heat flux to changes in ocean heat content is investigated with a focus on three regions: the sub-polar and sub-tropical gyres, and the tropics. The surface heat flux plays a relatively minor role in year-to-year changes in the sub-polar and sub-tropical regions. For example, the strongest signal during the study period is a cooling of the sub-polar gyre between 1970 and 1990, which subsequently reversed as the mid-latitude OHT convergence transitioned from an anomalously weak to an anomalously strong state. However, in the tropical North Atlantic the influence of surface heat flux on ocean heat content variability is found to be of a similar significance to that of the ocean heat transport convergence.</p>
<b>3.</b>	<p style="text-align: center;"><b>Diapycnal diffusivities in deep sea, integrated over a long time period from a tracer release experiment</b></p> <p style="text-align: center;"><i>Craig Rye, Marie-Jose Messias, Andrew Watson, Andrew Brousseau (UEA), Jim Ledwell (WHOI) &amp; Brian King (NOC)</i></p> <p>Following an intersection of the Brazil Basin Tracer Release Experiment (BBTRE) tracer plume during a hydrographic cruise in March 2009, a long time period estimate of the diapycnal diffusivity in the Brazil Basin deep sea was made 13 years after the tracer release. The recent tracer measurements were made along <math>24^\circ\text{S}</math> providing a longitudinal section in local diapycnal diffusivity estimates across the Brazil Basin. Estimates were calculated by comparing the initial and most recent observations of the Brazil Basin Tracer Release Experiment (BBTRE) tracer plume. These results are representative of a time period from the tracer release in 1996 to the most recent survey in 2009. A 1D advection-diffusion equation was used to model the vertical spread of the tracer over time thus yielding estimated values for the diapycnal diffusivity (<math>k</math>). Estimates of <math>k</math> qualitatively show a gradient in vertical mixing which increases with decreasing distance towards the eastern side of the basin, the Mid Atlantic Ridge (MAR) and increasing topographic roughness parameter. A mean tracer profile is created with associated diapycnal diffusivity estimate <math>k=3.3\pm 1.4\text{cm}^2\text{s}^{-1}</math>. The diffusivity result is very similar to previous surveys of the tracer plume (Ledwell <i>et al</i> 2000) and indicative of the validity of both the mean diapycnal diffusivity value and of the tracer release experimental method.</p>

4.	<p style="text-align: center;"><b>Late glacial evolution of a mid-shelf glacial incision, Sea of Hebrides, UK</b></p> <p style="text-align: center;"><i>John Howe, Kate McIntyre, Karl Attard (SAMS), David Long (BGS) &amp; Alix Cage (Manchester Metropolitan Univ)</i></p> <p>The Muck Deep is a 318m deep mid-shelf depression extending over 20km long and up to 5km wide, oriented east-west located 15 km west-south-west of the Isle of Muck, Sea of Hebrides, on the UK continental shelf. A dataset combining multibeam bathymetry, backscatter with seismic reflection profiles and sediment vibro and mega cores reveals the late glacial origin of the deep and subsequent depositional history over the last 20,000 years. The origin of the deep is via multiple, high volume, subglacial meltwater discharge events originating beneath a fast flowing Devensian-age ice stream extending across the Sea of Hebrides draining toward the south-west. The distinctive east-west steep-sided flanks of the deep, the appearance of numerous channels and the crag-and-tail and teardrop shape of the outcropping rocks on the deep floor are also indicative of an origin from subglacial meltwater. Sub-glacial drainage channels have been excavated from the north-east of the deep with multiple meltwater events subsequently eroding the main basin of deep toward the west, cutting through resistant Torridonian sedimentary and Palaeocene basalt lavas. After the retreat of the ice and coeval with a post-glacial rise in relative sea level, sediments of the Jura Formation were deposited in a relatively short period of time, (&lt;5,000 yr). These sediments comprise glaciomarine and marine ice proximal and ice distal mud and muddy sand. Holocene tidal action and the influence of the Scottish Coastal Current have produced a distinctive style of modern sedimentation with enhanced deposition of fine-grained sediment on the slopes of the deep. The central deep is relatively non-depositional and dominated by muddy sand. The modern sediment transport direction is along the axis of the deep, from the east toward the west.</p>
5.	<p style="text-align: center;"><b>Atlantic storage of natural and anthropogenic carbon</b></p> <p style="text-align: center;"><i>Dorothy Bakker, Ute Schuster, Marie-Jose Messias, Andrew Watson, Pete Brown, Agatha De Boer, John Brindle, Andrew Brousseau, David Cooper, Gareth Lee, Shaun Scally &amp; Stephen Woodward, Arie Louwense, Elizabeth Jones (UEA), Mario Hoppema (AWI), Sheldon Bacon, Brian King, Elaine McDonagh, Alberto Naveira-Garabato, Jennifer Riley, Oliver Legge (NOC) &amp; Mike Meredith (BAS) [SOFI award]</i></p> <p>An ambitious programme is underway to quantify regional storage and transports for inorganic carbon in the Atlantic Ocean and the Atlantic sector of the Southern Ocean, including their rates of change. In particular, we aim to distinguish between natural and anthropogenic carbon and to detect long-term changes in carbon storage. The sea-going fieldwork consists of seven full-depth hydrographic sections across different parts of the Atlantic and Southern Ocean in 2008-2010: the Arctic Gateway (west and east); 24°N; 24°S; Drake Passage (west and east); Northern Weddell Gyre (west and east). Additional Atlantic sections are being carried out by US scientists, notably A10 (30°S) and IR6. The UK sections repeat several WOCE sections with earlier measurements of carbon and tracers (A21, A04, S4A). Dissolved inorganic carbon (DIC), total alkalinity (TA), chlorofluorocarbons (CFCs) and sulphur hexafluoride (SF<sub>6</sub>) are measured on the hydrographic sections. These new observations will be compared to earlier observations. Models of ocean physics and biogeochemistry will be used to establish the underlying factors giving rise to long-term changes. Carbon and tracer measurements have been completed for four sections (Drake Passage A21 and SR1B, 24°S, 24°N) and the eastern part of the Weddell Gyre section. We present the distribution of natural carbon for the recent sections.</p> <p><i>Also relevant to Theme 2</i></p>

## Theme 2: Marine biogeochemical cycles

6.	<p style="text-align: center;"><b>Export flux and its transfer efficiency during the North Atlantic spring bloom</b></p> <p style="text-align: center;"><i>Patrick Martin, Richard Lampitt, Richard Sanders (NOC) &amp; Mary Perry (Univ of Maine)</i></p> <p>High latitude diatom blooms are thought to contribute significantly to the downward flux of particulate organic matter (POM) in the oceans. A key question yet to be resolved is whether exported particles during diatom blooms are mostly remineralized in the mesopelagic or transferred efficiently to greater depths. We present measurements of POM flux taken in the mesopelagic with neutrally-buoyant sediment traps (PELAGRA) during the subpolar North Atlantic spring bloom (61°N 26°W). Fluxes between 200 and 750 m depth rose from initially 10–30 mg POC m<sup>-2</sup> d<sup>-1</sup> to 160 mg m<sup>-2</sup> d<sup>-1</sup> within just three days. The trap samples consisted primarily of diatom aggregates, with <i>Chaetoceros</i> resting cysts contributing &gt;50% of recognisable cells. This material contained up to 50% opal by mass and was rich in transparent exopolymer particles (TEP). Subsequently, POC flux decreased to ≤100 mg m<sup>-2</sup> d<sup>-1</sup>, and mixed layer Si concentrations were consistently below 2 μmol L<sup>-1</sup>, suggesting that the main sedimentation event had finished. <sup>234</sup>Th disequilibria suggest that export out of the euphotic zone reached 200–400 mg POC m<sup>-2</sup> d<sup>-1</sup>, implying a transfer efficiency to 750 m of 25% or greater. The cumulative POC export diagnosed from the <sup>234</sup>Th disequilibria amounted to 2 g POC m<sup>-2</sup> – just 10% of the annual export predicted from models. Annual export flux in the region is therefore either highly variable, or overestimated. Alternatively, the post-bloom period of the growing season may be more important for annual export than the short pulse of high POM flux during the bloom. Our observations are consistent with the hypothesis that TEP are required for export of diatom aggregates.</p>
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7.	<p align="center"><b>Twilight zone to deep-ocean floor: Developing an understanding of particle dynamics and trophic interactions using a molecular experimental approach</b></p> <p align="center"><i>George Wolff, Jens Holtvoeth &amp; Kostas Kiriakoulaki (Univ of Liverpool) [SOFI award]</i></p> <p>In the open ocean the biological pump fuels export of carbon to the deep sea by the vertical flux of particulate organic matter (POM). The chemistry of the sinking particles is certainly modified in the water column but the transfer efficiency of sinking POM through the twilight zone (TZ) remains poorly characterised. We have collected sinking and suspended particles through and below the TZ at the Porcupine Abyssal Plain (NE Atlantic Ocean) in summer 2009. In this presentation we will discuss their composition and show how the POM pools are chemically distinct through the water column. The POM biogeochemistry allows us to distinguish key processes in flux diminution through the TZ (e.g. grazing) and to assess the degree of POM degradation.</p>
8.	<p align="center"><b>Coccolithophores and the efficiency of the biological carbon pump</b></p> <p align="center"><i>Alex Poulton, Toby Tyrell, Paul Morris &amp; Richard Sanders (NOC)</i></p> <p>Coccolithophores are one of the major calcite (Cinorg) producers in the modern ocean, having dual roles in the Biological Carbon Pump (BCP): as calcifiers they remove alkalinity, causing CO<sub>2</sub> out-gassing and decreasing the efficiency of the BCP; while their organic carbon (Corg) production, and calcite ballasting of organic carbon export, increases BCP efficiency by promoting in-gassing of CO<sub>2</sub>. Clearly, the balance of Cinorg:Corg production and calcite ballasting (the 'rain ratio') both control the overall impact that coccolithophores have on the BCP. Here, we examine the ratio of Cinorg to Corg on several scales, from the individual cell to the whole community and to the sinking particle. We also examine the possible factors controlling these ratios and highlight future work to clarify the role of coccolithophores in the efficiency of the BCP.</p>
9.	<p align="center"><b>High consumption of bacterioplankton by the smallest oceanic algae</b></p> <p align="center"><i>Mike Zubkov (NOC)</i></p> <p>Planktonic algae &lt;5 µm in size are major fixers of CO<sub>2</sub> in the open ocean. Traditionally, large and small algae are viewed as having a critical growth dependence on inorganic nutrients, which small algae can acquire at lower ambient concentrations owing to their higher surface area to volume ratios. Nonetheless, our experiments in the North Atlantic subtropical gyre have suggested that small algae obtain phosphate indirectly, possibly through feeding on bacterioplankton. There have been many microscopy-based observations of algal feeding on bacterioplankton as well as mathematical modelling of the ecological importance of algal mixotrophy. However, methodological limitations have, until now, prevented a direct comparison of protozoan and algal feeding on oceanic bacterioplankton. Such a comparison revealed that smallest algae carried out 40-95% of the bacterivory in the temperate North Atlantic in summer and 35-70% in the tropical North East Atlantic, suggesting the global significance of algal mixotrophy. This finding reveals that the smallest algae are less dependent on inorganic nutrients than previously thought and could obtain a quarter of their biomass from feeding on bacterioplankton. This has important implications how nutrient acquisition and limitation of CO<sub>2</sub>-fixation in the ocean is perceived.</p>
10.	<p align="center"><b>Advances in mapping high resolution nitrate variability under Oceans 2025</b></p> <p align="center"><i>Rosalind Pidcock &amp; Mark Hartman (NOC)</i></p> <p>Despite growing evidence from modelling and theoretical perspectives of the potential contribution of processes at the mesoscale and submesoscale to nutrient cycling, mechanisms have remained poorly quantified in-situ due to the difficulties of collecting simultaneous hydrographic and nitrate data at the required time and space scales. We present data from an integrated deployment of a UV spectrophotometer, the SUV-6, on board a SeaSoar towed vehicle during a mesoscale survey of a developing eddy dipole in the Iceland Basin during the summer of 2007. This approach has allowed new and innovative observations of nitrate concentration at high resolution and high-sensitivity (0.2 µM for a single measurement). For the first time, filamentary scale nitrate variability has been adequately resolved within an open ocean mesoscale feature alongside simultaneous hydrographic and oxygen measurements. We demonstrate that this approach constitutes a powerful new tool for quantifying the role of mesoscale and submesoscale vertical nutrient fluxes to the euphotic zone.</p>
11.	<p align="center"><b>New concepts challenging old paradigms: nitrogen cycling in the sunlit ocean</b></p> <p align="center"><i>Darren Clark, Pete Miller, AMT &amp; SOLAS-ICON teams (PML)</i></p> <p>Nitrogen is an essential component in biological cells although its availability in the sunlit oceans frequently places an upper limit on the growth of photosynthetic micro-organisms. In upwelling systems (investigated during the UK-SOLAS programme (ICON) and PML's µ-layer cruise) nutrient rich waters are brought into the sunlit ocean from great depths and the elevated concentration of 'new' inorganic N supports phytoplankton proliferation. In contrast, for regions where new-N supply is very low, such as the oligotrophic gyres of the open oceans (e.g. AMT), phytoplankton productivity is sustained by the recycling of N through bacterial activity. Over recent years, N-cycling investigations in these contrasting regions have highlighted the importance of the interactions between N-assimilation by marine phytoplankton and N-regeneration by the heterotrophic microbial community. Most significantly, the concept that nitrification is insignificant in the sunlit ocean has been over-</p>

	<p>turned. Nitrification regenerates <math>\text{NO}_3^-</math> from <math>\text{NH}_4^+</math> and was assumed to be restricted to the very low light or aphotic depths of the ocean. However, we now know that low rates of nitrification persist throughout the sunlit open ocean and rates in upwelling regions can be extremely high. The discovery that <math>\text{NO}_3^-</math> regeneration and assimilation takes place simultaneously in the sunlit ocean has forced a re-evaluation of global productivity and C-export flux since <math>\text{NO}_3^-</math> assimilation cannot be equated to the assimilation of new-N. Moving into the future, pelagic N-biogeochemistry in an acidified ocean is a new and important area of exploration.</p>
12.	<p style="text-align: center;"><b>Methanol cycling unravelled on global scales</b>  <i>Joanna Dixon, Racheal Beale &amp; Philip Nightingale (PML)</i>  <i>In preparation for publication</i></p>
13.	<p style="text-align: center;"><b>Time series measurements of net community production at the Western English Channel Observatory</b>  <i>Johanna Gloel (UEA/PML) [SOFI award]</i></p> <p>Ocean productivity is an important parameter for estimating <math>\text{CO}_2</math> budgets. In many regions there are still not enough measurements undertaken to constrain the seasonal cycle of production and respiration. This poster shows results from <math>\text{O}_2/\text{Ar}</math> measurements at station L4 in the Western English Channel. The <math>\text{O}_2/\text{Ar}</math> ratio offers a possibility to get in-situ measurements of the biological contribution to <math>\text{O}_2</math> saturation and can be used to calculate net community production from wind speed. A time series study has been conducted since September 2009 and phases of net heterotrophy and autotrophy in the seasonal cycle have been identified.</p>
14.	<p style="text-align: center;"><b>Phytoplankton nutrient dynamics in response to sediment resuspension and potential impacts of marine renewable structures</b>  <i>Boris Kelly Gerryn (NOC), Fay Couceiro, Gary Fones (Univ of Portsmouth), Peter Statham, Chris Woods &amp; Charlie Thompson (Univ of Southampton)</i></p> <p>Elevated concentrations of suspended sediments resulting from the operation of marine renewable energy structures have the potential to be a key factor in regulating the amount of primary production in coastal and shelf seas. Suspended sediments reduce underwater irradiance and therefore lower rates of photosynthesis. In contrast, algal growth can be fuelled by the nutrients (nitrogen, phosphorus and silicon) released from resuspended bottom sediments. Understanding the balance between these opposing influences of suspended sediments on phytoplankton production should be an important focus of a research programme investigating the interactions between marine renewable energy structures and sediments. As a first step towards such an understanding, we present the first ever study combining <i>in situ</i> and laboratory experiments together with modeling to examine the role of resuspension on nutrient release in coastal shelf sediments (Oyster Ground, North Sea). We show that concentrations of nitrate, phosphate and dissolved silicon in waters overlying muddy cohesive sediments increase by between 50% and 120% while DON and DOC levels decrease by 20% following realistic resuspension events. Eleven minutes of resuspension released the equivalent of 18 hours of nitrate by diffusive flux. Curiously, less than 10% of the change in water column nutrients was attributable to porewater inventories. This intriguing result will be discussed along with attempts to model and scale up the processes to the wider North Sea area.</p>
15.	<p style="text-align: center;"><b>Identifying the molecules and mechanisms underlying calcification and pH homeostasis in coccolithophores</b>  <i>Glen Wheeler (MBA &amp; PML), Alison Taylor (MBA &amp; Univ of Wilmington, NC), Abdul Chrachri &amp; Colin Brownlee (MBA)</i></p> <p>We have carried out genomics and cell physiological studies to begin to characterise the roles of key transport systems that are likely to underlie calcification in coccolithophores. Our cell physiological work has focussed on electrophysiological and imaging studies of <math>\text{H}^+</math> transport and regulation of intracellular pH. These have revealed the presence of a significant <math>\text{H}^+</math> permeability of the coccolithophore plasma membrane. A voltage-regulated <math>\text{H}^+</math> conductance underlies this <math>\text{H}^+</math> permeability. We have shown that this conductance is required for intracellular pH regulation. Parallel studies that have manipulated intracellular pH while monitoring calcification rate in single cell <i>in vivo</i> has shown that this regulation of intracellular pH is essential for calcification. Genome studies have revealed the presence of a single copy <math>\text{H}^+</math> channel homologue in the <i>Emiliana huxleyi</i> and <i>Coccolithus pelagicus</i> genomes. These have been cloned and shown to be able to generate outward <math>\text{H}^+</math> currents when expressed in mammalian cell lines. This opens the way for full characterization of this novel <math>\text{H}^+</math> channel and elucidation of its role in the calcification process. We have also begun to characterise the roles of two further transporters, the expression of which have been shown to be up-regulated in calcifying cells of <i>E. huxleyi</i>. These include putative <math>\text{Ca}^{2+}/\text{H}^+</math> and <math>\text{HCO}_3^-/\text{Cl}^-</math> exchangers. Their roles in the calcification process will be discussed.</p>

<b>16.</b>	<p style="text-align: center;"><b>Alternative physiological responses to ocean acidification amongst genotypes of <i>Emiliana huxleyi</i></b></p> <p style="text-align: center;"><i>David Suggett (Univ of Essex) [SOFI award]</i></p> <p>The response of coccolithophores, and in particular the globally ubiquitous species <i>Emiliana huxleyi</i>, to predicted ocean acidification (OA) conditions has been the focus of much recent research; unfortunately, these investigations have yielded many contradictory results most likely as a result of differences in approach (CO<sub>2</sub>/pH control) and speciation (genotype). Here, we present physiological responses from several <i>E huxleyi</i> genotypes grown under OA conditions using state-of-the-art pH-stats to demonstrate that whilst some common responses (e.g. increases of cell size) are observed measures of light harvesting, productivity and ultimately growth rate can vary significantly. Our results highlight that widespread implications of OA drawn from such experiments, e.g. biogeochemical cycling and ecosystem function, will critically depend on the choice of genotype; therefore, better understanding of the genetic 'signature' of key species in nature is required to contextualise results from the growing number of OA experiments.</p>
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### Theme 3: Shelf and coastal processes

<b>17.</b>	<p style="text-align: center;"><b>Spatial and temporal variation in the provision of ecosystem services by coastal marine sediments</b></p> <p style="text-align: center;"><i>Vas Kitidis, Karen Tait, Amanda Beesley, Denise Cummings, Carolyn Harris, John Stephens, Caroline McNeil, Sarah Dashfield &amp; Steve Widdicombe (PML)</i></p> <p>Many of the ecosystem services provided by the marine coastal zone (e.g. productivity, provision of food, climate regulation and recreation) are underpinned by nutrient cycling, particularly in sediments. Here, we describe a survey programme investigating the spatial and temporal variability in coastal sediment nutrient cycling in the western English Channel. This ongoing, multi-disciplinary survey addresses variability from the relevant physical and biological components (e.g. irrigating fauna distribution), to the direct determination of key processes, nutrient fluxes as well as molecular characterisation of the microbial community. Our preliminary results suggest that the processes involved are highly dynamic in space and time. As this variability is currently not addressed in biogeochemical and ecosystem models, our results will help to improve modelling and prediction capabilities.</p>
<b>18.</b>	<p style="text-align: center;"><b>Recent research into emerging contaminants and nanoparticles in coastal waters</b></p> <p style="text-align: center;"><i>James Readman, Patricia Frickers &amp; Eniko Kadar (PML)</i></p> <p>Urban and industrial sewage effluents contain important quantities of emerging and priority pollutants (including pharmaceuticals, personal care products and endocrine disrupters). However, whilst many of these substances have broad usage, our lack of knowledge concerning quantities emitted into the environment, their environmental behaviour and long-term ecotoxicological impacts need to be addressed if we are to understand the environmental, economic and human health implications. Once in the environment (rivers, estuaries and coastal waters), there are substantial analytical difficulties to detect and accurately quantify the compounds to elucidate their transport, uptake and fate. Recent PML research on the input and environmental behaviour of a range of contaminants (including nanoparticles) has included: comparison of analytical techniques for measurement of steroidal estrogens; carbon nanoparticle-induced lysosomal membrane injury in blood cells of marine mussels; impact of silver nanoparticle contamination on bacterial genetic diversity in estuarine sediments; evaluation of GC/MS and PTV-GC/MS determination of pharmaceuticals, personal care products, phenolic endocrine disrupters and faecal steroids; inputs and distributions of synthetic musk fragrances in an estuary and coastal waters; influence of Fe<sub>2</sub>O<sub>3</sub> nanoparticles and soluble (FeCl<sub>3</sub>) iron on the toxicity caused by CO<sub>2</sub>-induced seawater acidification; and antifouling biocides in discarded marine paint particles. Papers on these topics have been published in <i>Environmental Science and Technology</i>, <i>Talanta</i>, <i>Nanotoxicology</i>, <i>Environmental Pollution</i>, <i>Analytica Chimica Acta</i> and the <i>Marine Pollution Bulletin</i>.</p>
<b>19.</b>	<p style="text-align: center;"><b>The potential impact of the proposed Severn Barrage – an impact assessment revisited</b></p> <p style="text-align: center;"><i>Richard Warwick, Paul Somerfield &amp; Reginald Uncles (PML)</i></p> <p>The severity of the physical regime in the hypertidal Severn Estuary and Bristol Channel decreases in intensity in the seaward direction. As a result, the diversity of benthic macrofaunal species is very low in the Estuary and Inner Channel, but is still relatively low in the Outer Channel compared with more benign conditions elsewhere in the UK. Nevertheless, the taxonomic spread of species (taxonomic distinctness) throughout the area is no lower than expected. Barrage construction would result in an increase in the area of soft sediment relative to hard bottom benthic assemblages and the disappearance of reduced communities seaward of the barrage, although the time-scale of such a change is not known. Above the barrage the overall species richness, density and biomass of the benthos are likely to increase, factors that will ameliorate the loss of intertidal area.</p>

20.	<p style="text-align: center;"><b>The migration of large scale bedforms in the Dee Estuary</b> <i>Oliver Way (Bangor Univ) [SOFI award]</i></p> <p>Continuous monitoring of large scale bedforms in the estuary mouth and the wave and current forces responsible for the migration of these features will help to understand the evolution of the estuary. Remote measurements of dune height will allow more accurate model simulations of bedform and current interaction. The TELEMAC modelling system is used to show the driving forces behind bedform migration. Images from the X-Band marine radar station deployed on Hilbre Island are used to infer the bathymetry and to track the movement of wave breaker patterns over large intertidal sand dunes. A 2-D cross correlation tracking algorithm is applied to monthly averaged radar images to estimate dune migration from wave breaker patterns. This method will help establish whether large scale bedforms are moving in areas of the Dee where migration is expected. A variation on the 'waterline' method is used to show intertidal bathymetry from the X-band radar images. This research will ultimately show if remotely measuring the dimensions of sand dunes will enable an accurate calculation of bedform roughness to be made and included into modelling systems such as TELEMAC.</p>
21.	<p style="text-align: center;"><b>Sediment dynamics in estuaries: suspended sediment transport</b> <i>David Todd (Bangor Univ) [SOFI award]</i></p> <p>The mouth of the Dee Estuary is a high-energy environment split into two main channels with a tidal range which may exceed 10m on Spring Tides. Two month-long moored instrument observations were undertaken in February and May 2009 as part of the FORMOST project to investigate the properties of suspended sediment transport within the estuary. The observed patterns in suspended particulate material (SPM) through the annual cycle are both interesting and diverse. Initial investigations into the CTD data are presented, along with observations of an apparent bimodal flocculation signal from the LISST data.</p>
22.	<p style="text-align: center;"><b>A multi-disciplinary study of topographically enhanced mixing on the NW European Shelf: research cruise <i>Discovery 340B</i>, July 2009</b> <i>Mark Inall, Keith Davidson (SAMS) &amp; J Murray Roberts (Heriot Watt Univ)</i></p> <p>A 10- day Theme 3 cruise took place in June-July 2009 on <i>RRS Discovery (D340b)</i>. The scientific aims were to study: i) the physical response of tidal flows to topographic features of the shelf seas to the west of Scotland, in terms of stratification and turbulent mixing; ii) the consequent response of the water column chemistry and phytoplankton community structures; and iii) the benthic response of the hard coral reefs systems commonly found in this area. The early results of the cruise will be presented.</p>
23.	<p style="text-align: center;"><b>Eddy correlation measurements of benthic oxygen uptake rates: Case studies from two different but common benthic environments</b> <i>Henrik Stahl, Ronnie Glud, Andrew Hume (SAMS) and Peter Berg (Univ of Virginia) [SOFI award]</i></p> <p>Eddy correlation is a novel and versatile approach for quantifying benthic oxygen exchange rates in a variety of aquatic environments. It has several advantages compared to more conventional techniques (e.g. benthic chambers), including integrated measurements over a significantly larger area of the sea-floor (up to ~50m<sup>2</sup>) compared to the conventional chambers (typically 0.04-0.5m<sup>2</sup>). Although recent studies have indicated good agreement between the two techniques in certain types of soft bottom sediments, conventional techniques fail to include the contribution from larger epifauna and do therefore not manage to capture the total benthic activity. Furthermore, due to the non-invasive nature of the eddy correlation technique, it is not constrained to soft muddy bottoms but has the potential for oxygen exchange measurements in a wide variety of environments including heterogeneous hard bottom substrates covered in epifauna, which in many coastal areas can be the dominating type of benthic substrate. Here we will present: i) first ever <i>in situ</i> measurements of oxygen exchange rates from hard-bottom sediments covered in epifauna in a sub-Arctic fjord and ii) eddy correlation measurements in soft-bottom sediments densely populated by macrofauna in a tidally influenced temperate fjord. Results will be discussed in relation to substrate type, climatic gradient and in comparison to conventional techniques.</p>

#### Theme 4: Biodiversity & ecosystem functioning

24.	<p style="text-align: center;"><b>Linking patterns of biodiversity with species interactions and environmental drivers: decomposing spatial variation and establishing scale-dependent associations</b> <i>Mike Burrows (SAMS)</i></p> <p>Ecological information collected over wide geographical areas can yield much in terms of the strength of associations between potential drivers and biodiversity responses. We have developed a statistical modelling approach that allows us to calculate scale-dependent correlations among measures of species abundance, primary productivity and species diversity, and with biological and physical characteristics of the nearshore ocean: phytoplankton, temperature, and wave exposure, among others. Associations with site-specific factors</p>
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	(1cm to 100m, such as the abundance of other species), small-scale factors (0.1-50km, habitat-related like wave exposure and tidal flow) and regional factors (<50km scales, oceanographic and climatic variation: temperature, nutrients) point strongly to the dominant effects, and repeatedly emphasise the importance of bottom-up control mechanisms in coastal ecosystems.
25.	<p style="text-align: center;"><b>The signal-based relationship between <i>Ulva</i> and bacteria</b></p> <p style="text-align: center;"><i>Matthew Twigg, Steven Atkinson, Miguel Camara, Paul Williams (Univ of Nottingham), Karen Tait (PML)</i> [SOFI award]</p> <p>Zoospores of the green seaweed <i>Ulva</i> utilise the bacterial signal molecules <i>N</i>-acyl homoserine lactones (AHLs) for surface selection. In addition, bacteria are required for the development of <i>Ulva</i> into mature plants; their absence results in aberrant growth. To test the hypothesis that there is a functional relationship between the signal-producing bacteria responsible for settlement and those required for healthy growth, the bacteria populations associated with <i>Ulva</i> surfaces was compared to those attached to rocks colonised by <i>Ulva</i>. 16S RNA clone libraries revealed both habitats are dominated by similar groupings of bacteria. Representative bacteria of these groups were isolated from <i>Ulva</i> thallus, and screened for the production of signal molecules. LC-MS indicates that the isolates produce a wide range of AHLs, including representatives of the Bacteroidetes, a bacterial phylum previously not known to make AHL signal molecules. Preliminary studies have revealed these isolates accelerate the rate of zoospore germination.</p>
26.	<p style="text-align: center;"><b>Combining biological traits and biogeographic databases to understand large-scale patterns of benthic diversity</b></p> <p style="text-align: center;"><i>Tom Webb, Lizzie Tyler (Sheffield), Paul Somerfield (PML)</i> [SOFI award]</p> <p>Efforts to understand patterns of diversity at large scales have typically focused on databases of classic biogeographic traits, for instance the abundance and distribution of species within an assemblage. Such initiatives have successfully documented many robust macroecological patterns and relationships. In order to move from pattern to mechanism, however, it is necessary to consider how the biological traits of constituent species influence community-level patterns. We have combined data on the distribution and abundance of the North Sea benthic infauna with information on various life history traits to unravel the processes influencing large-scale patterns in diversity. We show how regional-scale diversity patterns are influenced by species-level traits including body size and larval reproductive mode, and link these results to macroecological theory.</p>
27.	<p style="text-align: center;"><b>Marine bacterial diversity peaks on the winter solstice</b></p> <p style="text-align: center;"><i>Jack Gilbert (PML)</i></p> <p>The role of the environment as a driver of microbial diversity is poorly understood. To test the role of sunlight (day length) in determining levels of diversity in microbial communities we generated 72 chronologically ordered 16S V6 rDNA tag-pyrosequenced samples (2003-2008) from the "L4" station in the Western English Channel Coastal Observatory, United Kingdom. The bacterial diversity (S) in this community peaks at the winter solstice and shows remarkable synchronicity with seasonal light regimen. Day-length, which explains ~66.3% of the variance observed, has the best explanatory power compared to a combination of other variables (including temperature and nutrient concentrations). Sunlight also results in a strong seasonal structuring of this community. This evidence suggests that day-length is a major force in structuring microbial communities.</p>
28.	<p style="text-align: center;"><b>What's on the menu? Feeding rates and selectivity of meroplankton larvae in the Western English Channel</b></p> <p style="text-align: center;"><i>Elaine Fileman, Claudia Halsband-Lenk, James Highfield &amp; Penelope Lindeque (PML)</i></p> <p>Meroplankton larvae may be an important link in the coastal marine food web, providing food for a variety of fish larvae and other organisms. They are planktotrophic and a common component of the coastal zooplankton community during the reproductive season. In order for meroplankton larvae to survive, develop successfully and return to the benthos, it is important for them to obtain a good source of nutrition in the early stages of life. It is thought that the larvae ingest both autotrophic and heterotrophic prey but few studies have characterised their feeding rates and little is known about their feeding preferences in coastal waters of the English Channel. As part of the Western Channel Observatory time series, we determined the temporal distribution of meroplankton larvae and the ingestion rates of decapod and bivalve larvae. We conducted feeding experiments between May and November to determine larval ingestion rates on a natural mixed phytoplankton and microzooplankton assemblage. Complementary gut content analysis was performed using a polymerase chain reaction (PCR)-based method for detecting prey DNA on animals from the laboratory feeding experiments and those taken directly from the field. Results suggest that the larvae feed on a range of food items from nanoeukaryotes through to the larger diatom chains and that they can be highly selective, as they do not always choose the most abundant prey species present. Since these organisms show highly seasonal abundance peaks in many coastal systems, our results have important implications for understanding planktonic food web dynamics in mid-latitudes. The role of meroplanktonic larvae and their top down control within pelagic food webs, investigated through classical feeding experiments and complementary molecular studies, will be discussed.</p>

<b>29.</b>	<p style="text-align: center;"><b>Size-fractionated assessments of biodiversity and ecosystem function using novel analysis techniques and a global model</b></p> <p style="text-align: center;"><i>Glen Tarran, Andrew Rees, Timothy Smyth, Patrik Strömberg, Icarus Allen (PML), Mikhail Zubkov, Ross Holland (NOC), Colin Prentice &amp; Sarah Cornell (Univ of Bristol)</i></p> <p>We present here how measurement techniques are evolving and how the data are being used to assess new global models of respiration (release of CO<sub>2</sub>) and plankton community size spectra to better understand biodiversity and ecosystem function in contrasting open ocean provinces. Thousands of measurements have been made to quantify plankton standing stocks and biogeochemical cycling processes and to discover whether the Atlantic Ocean is undergoing noticeable climate-related changes. The data presented have been collected over several years of the Atlantic Meridional Transect (AMT) Basin-scale Observatory which has been traversing the Atlantic Ocean since 1995, completing 19 cruises to date and, in the process producing over 185 peer-reviewed publications to enhance our knowledge of the Atlantic Ocean.</p>
<b>30.</b>	<p style="text-align: center;"><b>Breaking down resilience: do sea urchins have the right toolkit?</b></p> <p style="text-align: center;"><i>Adam Hughes (SAMS)</i></p> <p>Echinoderms are responsible for some of the most dramatic phase shifts in marine ecosystems. What enables sea urchins to overcome ecosystem resilience, turning kelp forests into rocky barrens? Can studying the sea urchins' 'toolkit' help us to better understand ecosystem resilience?</p>
<b>31.</b>	<p style="text-align: center;"><b>Changes in <i>Emiliana huxleyi</i> assemblages over four decades</b></p> <p style="text-align: center;"><i>Andrea Baker, Steve Ripley, Declan Schroeder (MBA), Peter Miller (PML), Anthony Walne (SAHFOS)</i></p> <p>Methods have been developed for extraction of analysable DNA from the sample archive of the SAHFOS Continuous Plankton Recorder, allowing analysis of past population of phytoplankton. We have focussed attention on bloom populations of the coccolithophore <i>Emiliana huxleyi</i> and the coccolith morphology-related gene GPA. Analysis of coccolith morphology motifs of this gene along with other genetic markers over several decades from North Atlantic bloom populations has revealed significant temporal variability in <i>E. huxleyi</i> population genetic structure. A comprehensive record of genetic changes over four decades has now been established. A comparable record has also been established for <i>E. huxleyi</i> virus populations. Work is currently focussing on relating these population genetic changes to underlying physical and biological factors.</p>

## Theme 6: Sustainable marine resources

<b>32.</b>	<p style="text-align: center;"><b>Can we value the ecosystem services generated by Plymouth Sound?</b></p> <p style="text-align: center;"><i>Caroline Hattam, Stephen Mangi &amp; Mel Austen (PML)</i></p> <p>There is growing interest by environmental decision-makers in the valuation of marine ecosystem services and the wider benefits society obtains from the marine environment. The rationale behind this is simple: the impacts of human activity can be more easily compared when social, economic and environmental effects are all measured with the same unit. Using Plymouth Sound and Estuaries European Marine Site (SW England) as a relatively data rich case study, we have identified a variety of ecosystem services delivered by marine ecosystems in Plymouth Sound. Using the wealth of ecological data available for this area, we have begun examining how ecosystem service delivery has changed over the past 50 years for selected ecosystem services. A number of environmental valuation techniques are being applied to estimate how the values of these services have changed during the same period. Future extensions to this work are explored.</p>
<b>33.</b>	<p style="text-align: center;"><b>Assessment of the potential for leaks from carbon capture and storage to cause regional scale effects</b></p> <p style="text-align: center;"><i>Jerry Blackford (PML)</i></p> <p>If carbon capture and storage is to be adopted as a CO<sub>2</sub> mitigation strategy, it is important to understand the associated risks. The risk analysis consists of several elements such as leakage probability, assessing the strength of environmental perturbation, and quantifying the ecological, economic, and social impacts. Here, the environmental perturbation aspect is addressed by using a marine system model of the North West European Shelf seas to simulate the consequences of CO<sub>2</sub> additions such as those that could arise from a failure of geological sequestration schemes. Little information exists to guide the choice of leak scenario and many assumptions are required; for consistency the assumptions err towards greater impact and what would be in likelihood extreme scenarios. The simulations indicate that only the largest leakage scenarios tested are capable of producing perturbations that are likely to have environmental consequences beyond the locality of a leak event. It is shown that, given the available evidence, the chemical perturbation of a sequestration leak, regionally</p>

	<p>integrated, is likely to be insignificant when compared with that from continued non-mitigated atmospheric CO<sub>2</sub> emissions and the subsequent acidification of the marine system. The key unknowns that must be addressed in the ongoing UK and international research are the fine scale dispersion of CO<sub>2</sub> and the ability of ecological systems to recover from perturbation.</p>
34.	<p><b>Decadal scale variability in phytoplankton functional types as seen from satellite remote sensing</b></p> <p><i>Robert Brewin, Paul Russell, Samantha Lavender (Univ of Plymouth), Nick Hardman-Mountford, Shubha Sathyendranath, Jim Aiken (PML), Taka Hirata (Kokkaido Univ, Japan) &amp; Rosa Barciela (Met Office)</i></p> <p>Recently a variety of empirical bio-optical models, developed using oceanographic data applied to interpret remotely-sensed data from satellite-sensors, have been used to identify and differentiate between different phytoplankton functional types (PFTs) on synoptic scales. Intercomparison studies, focusing on phytoplankton size class (PSC), indicate that approaches based on abundance are the most reliable (Brewin <i>et al.</i> 2008). Here, a 3-component model has been developed based on insights into two previous size-class models (Uitz <i>et al.</i> 2006; Devred <i>et al.</i> 2006) designed to identify the fractional contribution of three PSCs (micro-, nano- and picoplankton) for a continuum of total chlorophyll-a concentrations (TChl). The model was parameterised using HPLC pigment data, taken between 1997-2004, and validated using independent satellite and <i>in situ</i> match-up data encompassing the same time period. The model was applied to monthly data from the Sea-viewing Wide Field-of-view Sensor (SeaWiFS) from 1997-2004. Inter-decadal trends in size class are then compared with inter-decadal physical trends driven by natural and anthropogenic changes in climate forcing. On a global scale, a strong positive correlation is seen between smaller-sized phytoplankton (picoplankton) and the Multivariate ENSO Index (MEI) and a strong negative correlation between larger-sized phyto-plankton (nano- and microplankton) and MEI. Tight coupling between ocean stratification anomalies and MEI (<math>r = 0.762</math>, <math>p &lt; 0.001</math>) during the period (1997-2004) verify a strong positive correlation between smaller-sized phytoplankton and increased stratification and a strong negative correlation between larger-sized phytoplankton and increased stratification. It has been suggested that in a warmer climate there may be a potential transition to permanent El Niño conditions (Wara <i>et al.</i> 2005). In such a scenario, we may see an increase in picoplankton at the expense of nano- and microplankton.</p> <p><i>References available</i></p>
35.	<p><b>Molecular markers reveal spatially-segregated cryptic species in a critically endangered fish, the common skate (<i>Dipturus batis</i>)</b></p> <p><i>Andrew Griffiths, David Sims &amp; Martin Genner (MBA)</i></p> <p>Many sharks and skates are particularly vulnerable to overfishing due to their large size, slow growth, late maturity and low fecundity. In Europe, dramatic population declines have taken place in common skate (<i>Dipturus batis</i> L.), one of the largest demersal fish in regional shelf seas, and it has been extirpated from substantial parts of its former range. In this study we report the discovery of cryptic species in common skate collected from the north-east Atlantic continental shelf. Data from nuclear microsatellite markers indicated little evidence of recent admixture between two clearly distinct clades, and phylogenetic analysis of mitochondrial DNA sequences demonstrated monophyly of each. Capture locations showed evidence of strong spatial segregation, with one taxon occurring mainly in waters off the southern British Isles and around Rockall, while the other was restricted to more northerly shelf waters. These apparently cryptic species showed overlapping substrate and depth preferences, but distributional limits were closely related to temperature gradients, potentially indicating thermal limits to their distributions. This discovery of hidden diversity within a large, critically endangered marine vertebrate has important management implications and demonstrates how marine biodiversity can be underestimated, even in such a relatively well-studied and heavily exploited region.</p>
36.	<p><b>Environmental interactions of marine renewable energy developments: research at SAMS</b></p> <p><i>Ben Wilson (SAMS)</i></p> <p>The poster will show a schematic of ongoing research in this area at SAMS. Our renewable energy research includes work on risks of collisions of fish and mammals with energy devices, the acoustic impacts of such devices, effects of offshore engineering on distributions of native and invasive species, the ecological impacts of kelp harvesting and the development of artificial reefs as protection against scour. Close integration of ecologists with physical oceanographers at SAMS is establishing the physical context. The work is largely being delivered through a series of co-ordinated PhD projects funded from non-NERC agencies.</p>
37.	<p><b>Body size-dependent responses of a marine fish assemblage to climate change and fishing over a century-long scale</b></p> <p><i>Martin Genner, Matthew McHugh &amp; David Sims (MBA)</i></p> <p>Commercial fishing and climate change have influenced the composition of marine fish assemblages worldwide, but we require a better understanding of their relative influence on long-term changes in species abundance and body-size distributions. In this study we investigated long-term (1911-2007) variability within a demersal fish assemblage in the western English Channel. The region has been subject to commercial fisheries throughout</p>

	<p>most of the past century, and has undergone interannual changes in sea temperature of over 2.0°C. We focussed on a core 30 species that comprised 99% of total individuals sampled in the assemblage. Analyses showed that temporal trends in the abundance of smaller multi-species size classes followed thermal regime changes, but that there were persistent declines in abundance of larger size classes. Consistent with these results, larger-growing individual species had the greatest declines in body size, and the most constant declines in abundance, while abundance changes of smaller-growing species were more closely linked to preceding sea temperatures. Together these analyses are suggestive of dichotomous size-dependent responses of species to long-term climate change and commercial fishing over a century scale. Small species had rapid responses to the prevailing thermal environment, suggesting their life history traits predisposed populations to respond quickly to changing climates. Larger species declined in abundance and size, reflecting expectations from sustained size-selective overharvesting. These results demonstrate the importance of considering species traits when developing indicators of human and climatic impacts on marine fauna.</p>
38.	<p><b>Climate impacts on the marine ecosystem of the NE-Atlantic shelf: assessment of the current state and future projections</b></p> <p><i>Yuri Artioli, Momme Butenschön (PML), Sarah Wakelin, Jason Holt (NOC), Rob Holmes (PML), James Harle (NOC), Jeremy Blackford &amp; Icarus Allen (PML)</i></p> <p>Understanding how climate regulates the marine ecosystems, and hence how the climate change could affect them, is an important step to assess the services that marine environment can provide to human society. For instance, increased coastal eutrophication could lead to economic loss in coastal activities like tourism or fisheries; ocean acidification could affect important commercial special species like bivalves; and any changes in primary production are also likely to have implications for fisheries. To assess the impacts of climate on the NE-Atlantic ecosystem, we completed a 40 years hindcast of the coupled model POLCOMS-ERSEM, and made some first projections to evaluate the possible change occurring in the ecosystems.</p>

## Theme 8: Technology development

39.	<p><b>Telemetry systems</b></p> <p><i>Jeffrey Pugh (NOC)</i></p> <p>The current telemetry technologies in use at NOC Liverpool, cover a wide range of telecommunications platforms from the standard dial-up modems through to high speed broadband satellite communication systems. These systems are used to monitor sea level variations from significant areas of the world such as the South Atlantic, Antarctica and the Indian Ocean and form part of the Global Sea Level observation system (GLOSS) and the Tsunami monitoring system. The primary aim of the NOC (Liverpool) Telemetry Systems is to provide a global sea level monitoring network providing high quality sea level data in real time.</p>
40.	<p><b>Developments in <i>in situ</i> observing technologies at SAMS</b></p> <p><i>David Meldrum &amp; Keith Jackson (SAMS)</i></p> <p>At the last science meeting we reported on the development of novel thermistor chains for the elucidation of the processes involved in the creation and decay of Arctic sea ice, an area that is not well understood and is poorly modelled. Further improvements and deployments have since taken place, in both the Arctic and Antarctic. Moreover, the simple bus architecture of the sensor chains has suggested new applications in a) high resolution sea-surface temperature measurements for the validation of satellite remote sensing and b) the determination of the density structure of new snow falling on polar ice sheets in support of CryoSat-2 validation. This latter application will also benefit from developments in GPS and satellite communication technology that are being explored at SAMS under Oceans 2025 and other initiatives.</p>
41.	<p><b>Shear micro-structure payloads on Autonomous Underwater Vehicles (AUVs)</b></p> <p><i>Mark Inall, Tim Boyd (SAMS) &amp; Mike Smithson (NOC)</i></p> <p>Recent acquisitions of AUVs equipped with microstructure sensor packages are enabling OCEANS2025 institutions to make cutting-edge measurements of the horizontal variability of turbulent mixing in UK coastal waters and beyond. SAMS operate a propeller-driven Hydroid vehicle which, since summer 2009, has been tested on the Scottish west coast, including observations of enhanced mixing beneath near-surface bores. Near future plans for the SAMS AUV include the OCEANS2025 2010 Arctic cruise. NOC have recently acquired a variable-buoyancy Webb glider fitted with microstructure probes which will be used during a study of inertial mixing in the Celtic/Irish Seas in June this year.</p>

42.	<p align="center"><b>The use of autonomous underwater gliders as part of the RAPID system for monitoring the meridional overturning circulation</b></p> <p align="center"><i>David Smeed, Paul Wright, Lucas Merckelbach, Gwyn Griffiths &amp; Stuart Cunningham (NOC)</i></p> <p>The NOC underwater gliders have now completed 600 glider days at sea and over 16,500km of operation in 15 deployments. Two of these missions were undertaken to assess the contribution that autonomous gliders could make to monitoring of the MOC, with a specific focus on their use as substitute moorings at the eastern boundary. These glider missions took place from 15 September - 24 November 2008 and from 21 May - 21 July 2009 between the Canary Islands and the coast of Morocco. This part of the RAPID array has suffered loss of instruments, in large part due to suspected fishing activity on the continental slope. Furthermore, the first three years of the RAPID array have shown that the largest contribution to the seasonal variation in the MOC is the variability of density on the eastern boundary in the upper 1000m. It is expected that gliders will be less susceptible to loss by fishing (in particular trawling) than the moored instruments. Another advantage of gliders is that data may be retrieved in real-time via Iridium satellite communications, thus further reducing the risk of data loss. Comparison with data from moored instruments has shown that the quality of the glider data is good. When calculating the MOC the ability of the gliders to measure close to the surface is shown to be an important advantage. Underwater gliders were the subject of a two-day workshop organised by NOC for the Royal Navy in summer 2009. Presentations focused on the capability of current commercially available gliders and included a simulated deployment.</p> <p><i>Also relevant to Theme 10.</i></p>
43.	<p align="center"><b>MYRTLE I to MYRTLE X</b></p> <p align="center"><i>Stephen Mack (NOC)</i></p> <p>MYRTLE (Multi Year Return Tide Level Equipment) is a POL-developed, long term deep sea lander, measuring bottom pressure for up to 5 years in a single deployment. The instrument consists of releasable data pods which store all the data, transmitted via infra red from a central system. These pods can then be released and recovered or data transmitted back via satellite. Since 1992 there have been three separate deployments of a MYRTLE each returning a long term data set. MYRTLE X is a new development proposing to stay on the seabed for up to ten years. This presentation will outline the concepts and advantages of a MYRTLE system and show the evolution of the instrument to make MYRTLE X possible including several test deployments of a prototype system designed to develop and evaluate the technology required for a potential ten year deployment.</p>
44.	<p align="center"><b>Automatic Fault Detection for Autosub 6000 (AFDA)</b></p> <p align="center"><i>Richard Dearden, University of Birmingham</i></p> <p>We report on progress in the first 18 months of the AFDA project. We present models of two subsystems of Autosub 6000 and demonstrate them diagnosing faults that occurred on Discovery Cruise 343. We also describe a tool that generates diagnosis models automatically from the AUV's mission script, allowing diagnosis to be tailored to the specific mission. We show that the diagnosis models generated by this tool allow us to detect faults that are undetectable otherwise. In particular, we show that the fault that caused a mission abort on Mission 12 could have been detected earlier with our software.</p>

## Theme 9: Next generation ocean prediction

45.	<p align="center"><b>New insights into coupled ocean-atmosphere modelling with the CHIME model</b></p> <p align="center"><i>Alex Megann, Adrian New, Adam Blaker &amp; Bablu Sinha (NOC)</i></p> <p>The Coupled Hadley-Isopycnic Model Experiment (CHIME) has been constructed to be as similar as possible to the Hadley Centre's HadCM3, but with a different ocean component, comprising constant density layers in the ocean interior, as opposed to fixed levels. Here we present key differences between 200-year control simulations of the two models, and early results of climate change experiments. In the control simulations we focus our attention on the respective abilities of the two models to maintain the structure of water masses which are important to the climate system, and use the insights gained to throw light onto the differences in the sea-surface temperatures and the rate at which the upper layers of the ocean warm or cool. The climate change experiments reveal insights into likely uncertainties in climate predictions arising from structurally different ocean components. Results will also be presented relating the variability of the Atlantic Meridional Overturning Circulation (AMOC) in CHIME to variability in surface air temperature over the UK and Western Europe.</p>
46.	<p align="center"><b>Developments in hydrodynamic modelling approaches for the coastal ocean</b></p> <p align="center"><i>Hedong Liu &amp; Jason Holt (NOC)</i></p> <p>We demonstrate some of our works on the development of a general grid method in ocean modelling and a</p>

	<p>novel pressure Jacobian horizontal pressure gradient algorithm in this poster. To improve the efficiency and flexibility of ocean modelling, especially with a coastal region included, we propose a general grid method which has the ability to discretise the model domain with structured and unstructured grid in the horizontal, and sigma-coordinate and zeta-/density- coordinate in the vertical. By distributing the unstructured grid in coastal ocean area and structured-like grid in the deep open ocean, we aim to achieve the synergy between the structured and unstructured grid methods: the robustness of representing the irregular ocean boundary and make local grid refinement, fewer grids in the whole domain and high order numerical scheme on the structured-like grids. The combination of sigma-coordinate and zeta-/density coordinate in the vertical seems to be a good way to deal with the non-linear free surface and realistic vertical mixing. A novel pressure Jacobian horizontal pressure gradient algorithm for sigma-/s- coordinate has been developed and incorporated in NEMO-shelf. The principle of this method and the comparison with some other existing methods has been presented.</p>
<p><b>47.</b></p>	<p style="text-align: center;"><b>An alternative explanation of the Sargasso Sea DMS “Summer Paradox”</b></p> <p style="text-align: center;"><i>Luca Polimene, Stephen Archer, Momme Butenschön &amp; Icarus Allen (PML)</i></p> <p>In the Sargasso Sea, maximum dimethylsulfide (DMS) accumulation occurs in summer, concomitant with the minimum of chlorophyll and two months later than its precursor, dimethylsulfoniopropionate (DMSP). This phenomenon is often referred to as the “summer DMS paradox”. It has been previously suggested that the main agent triggering this pattern is increasing irradiance leading to stress-induced DMS release from phytoplankton cells. In the present work, by the use of numerical simulations, we offer an alternative explanation to the “summer DMS paradox”. We suggest that the increased efficiency of bacterially mediated DMSP(d) to DMS conversion due to the seasonal increase in nutrient limitation is, along with phytoplankton community succession, the main element causing the summer accumulation of DMS. In particular, by means of this processes we are able, for the first time, to qualitatively simulate the temporal decoupling between maximum accumulations of DMSP and DMS. Our results underline the major role that bacteria potentially play in DMS production and fate, indicating that bacterial involvement in DMS dynamics should not be overlooked in future modelling studies.</p> <p><i>Also relevant to Theme 2</i></p>
<p><b>48.</b></p>	<p style="text-align: center;"><b>Modelling the carbon fluxes of the northwest European continental shelf</b></p> <p style="text-align: center;"><i>Jason Holt, Sarah Wakelin (NOC), Jerry Blackford, Icarus Allen, Momme Butenschon &amp; Yuri Artioli (PML)</i></p> <p>Phytoplankton growth in surface waters converts CO<sub>2</sub> into organic carbon, reducing the pCO<sub>2</sub> and prompting a draw down of atmospheric CO<sub>2</sub>. Regions of high biological productivity, such as the northwest European continental shelf, are potentially important sinks for atmospheric CO<sub>2</sub> provided that the carbon taken up by the phytoplankton is transported away from surface waters and isolated from the atmosphere. Estimates of a carbon budget for the northwest European continental shelf during the period 1988 - 2007 are obtained from a coupled hydrodynamics/ecosystem model (POLCOMS-ERSEM). Inputs from rivers, the Baltic Sea and the atmosphere are the major sources of carbon, while the horizontal transport out of the region is the dominant loss term. We find little carbon burial over this region, with settling, erosion and benthic respiration being in long term balance.</p> <p><i>Also relevant to Theme 3</i></p>
<p><b>49.</b></p>	<p style="text-align: center;"><b>Arctic Ocean simulations with a high resolution NEMO model coupled with biogeochemistry and sea-ice</b></p> <p style="text-align: center;"><i>Katya Popova, Andrew Yool, Tom Anderson, Yevgeny Aksenov, Adrian New (NOC)</i></p> <p>The summer extent of sea-ice cover in the Arctic has been declining in recent decades. Diminishing sea-ice cover has important consequences for ecosystem dynamics, associated biogeochemistry and the capacity of the Arctic Ocean to absorb atmospheric CO<sub>2</sub>. The impact of sea-ice on biological productivity is perhaps most evident through its control of solar irradiance incident on the sea surface. Ice edge blooms, a conspicuous feature of Arctic ecosystems, and potentially the main mode of its productivity, occur when water laden with nutrients is exposed to sunlight during ice melt. At the same time sea-ice affects vertical stratification by presenting a barrier to heating and wind-driven mixing of the water column, as well as contributing surface fresh water inputs during spring and summer time that, reinforced by the riverine fresh water input, inhibits nutrient resupply from below and provides an additional constraint on primary production. Modelling provides an ideal tool for unifying and quantitatively studying the relative roles of different factors in controlling primary productivity and associated biogeochemistry in the Arctic Ocean. Here, we investigate the effect of sea-ice and ocean physics as controls on primary production in the Arctic using a global 3D high resolution coupled physical, biological and ice model based on the NEMO system. The model is verified for different regions and its suitability assessed in terms of making realistic predictions for the Arctic Ocean.</p>

## Theme 10: Sustained Observations

50.	<p style="text-align: center;"><b>The Atlantic Meridional Transect</b> <i>Andy Rees (PML), Mike Zubkov (NOC) et al.</i></p> <p>The 20<sup>th</sup> cruise of the Atlantic Meridional Transect (AMT) observing system will take place during October and November 2010. Participants during this voyage joining the regular National Capability funded research berths come from the USA, E.U. and other UK researchers who are supported by NERC standard grants and SOFI studentship funding. The AMT programme undertakes biological, chemical and physical oceanographic research during the passage of one of the UK research fleet between the UK and the South Atlantic (previously the Falkland Islands or Cape Town, in 2009 Punta Arenas Chile) a distance of up to 13,500 km. This transect crosses a range of ecosystems from sub-polar to tropical and from euphotic shelf seas and upwelling systems to oligotrophic mid-ocean gyres. This unique spatially extensive decadal dataset continues to be deposited and made available to the wider community through the British Oceanographic Data Centre. The programme is hosted by Plymouth Marine Laboratory in collaboration with the National Oceanography Centre, Southampton and provides an exceptional opportunity for nationally and internationally driven collaborative research and provides a platform for excellent multi-disciplinary oceanographic research. As an in situ observation system, AMT informs on changes in biodiversity and function of the Atlantic ecosystem during this period of rapid change to our climate and biosphere. Here we review a number of outputs from recent cruises.</p>
51.	<p style="text-align: center;"><b>The characteristics of sinking particles in the upper ocean at the Porcupine Abyssal Plain</b> <i>Jennifer Riley (NOC)</i></p> <p>Sinking particles are an important part of the biological carbon pump, transferring carbon to the deep ocean. For a particle to sink it needs to have a density sufficiently greater than that of seawater and to have a suitably low drag coefficient so that it can overcome the viscous drag of seawater which is significant for small particles. However it is unclear which of these two factors (excess density or drag coefficient) is most important in allowing particles to sink in the ocean. To address this issue we collected particles from the base of the mixed layer using the Marine Snow Catcher during a cruise to the Porcupine Abyssal Plain (48N, 20W) in summer 2009. Samples were classified according to morphology, their sinking rates measured and high quality images and microscopic measurements taken to allow drag coefficient and excess density to be calculated. Four morphologically distinct categories of particle were identified (with sinking speeds): i) aggregates (0.17 cm sec<sup>-1</sup>); ii) spiny protists (0.2 cm sec<sup>-1</sup>); iii) aggregate protist complexes (0.3 cm sec<sup>-1</sup>); and iv) non spiny protists (2.26 cm sec<sup>-1</sup>). Statistical analysis suggested that non spiny protists sank faster than all other categories and that aggregate-protist complexes sank faster than aggregates. Spiny protist sinking speeds are thought to be resultant of the spine morphology. Water molecules stick to the spines due to the no slip condition, thereby effectively increasing the drag coefficient and the total area of the protist. Consequently the excess density of non-spiny protists is significantly decreased in comparison to protists, thus explaining the observed difference in sinking speed. To determine which of excess density and drag coefficient primarily governs settling velocity, we calculated the theoretical changes in excess density and drag required to solely account for the observed variability in sinking rate. Observed differences in excess density were too small to account for the measured variations in sinking speed. However calculated drag coefficients were larger than required to account for variations in settling velocity. This result implies that aggregate formation and the resultant change in particle shape has a greater influence than particle composition on particle sinking rates at the PAP site in mid-summer.</p> <p><i>Also relevant to Theme 2</i></p>
52.	<p style="text-align: center;"><b>Long-term variability of downward particle flux to the deep ocean: causes and trends</b> <i>Richard Lampitt (NOC)</i></p> <p>At 3000m depth at the PAP sustained observatory in the Northeast Atlantic the downward flux of particulate matter shows substantial seasonal and interannual variation. Complete annual records for 8 of the past 14 years have been examined in the light of mixing depths derived from the OCCAM general circulation model, and surface chlorophyll concentration and productivity derived from a satellite colour sensor. The annual flux was particularly high in 2001 due to a late summer deposition exceeding previous records several fold and this year was also characterised by very early shoaling of the mixing depth in spring and a very high surface spring chlorophyll concentration. A clear mechanistic relationship between upper ocean processes and deep ocean particle flux remains elusive but various explanations for this will be presented and which should form the basis for future research. In the spring, the timing of first shoaling of mixing, enhancement of productivity and increased particle flux at depth have all advanced during the 14 years of study by about 2 days per year suggesting a similar trend as has been observed for surface phytoplankton, mesozooplankton, fish and seabirds probably caused by wide-scale environmental changes.</p> <p><i>Also relevant to Theme 2</i></p>

53.	<p style="text-align: center;"><b>Porcupine Abyssal Plain deep ocean observatory</b>  <i>Richard Lampitt, Kate Larkin, Jon Campbell, Corinne Pebody, Sue Hartman, Maureen Pagnani, A Gkritzalis, Henry Ruhl, Andrew Gooday, David Billett (NOC)</i></p> <p>The Porcupine Abyssal Plain (PAP) sustained observatory (SO) in the Northeast Atlantic (49°N, 16.5°W) is the longest running open ocean interdisciplinary observatory in Europe. The site has produced a high-resolution dataset on environmental and ecologically relevant variables from the surface to the benthos for over twenty years. Since 2002 a fixed-point mooring has been in place with autonomous sensors. The PAP-SO is led by the National Oceanography Centre, Southampton and is one of 9 open-ocean observatories within the EuroSITES network (<a href="http://www.eurosites.info">www.eurosites.info</a>), the European contribution to the OceanSITES global array (<a href="http://www.oceansites.org">www.oceansites.org</a>). Through OceanSITES, PAP-SO contributes significantly to the <i>Group on Earth Observations</i> (GEO) as part of task AR-09-03c 'Global Ocean Observing Systems'.</p> <p>Autonomous datasets produced in the past 8 years include euphotic zone measurements of temperature, salinity, chlorophyll-a fluorescence, nitrate and pCO<sub>2</sub>. Many of these data are sent in near real-time from the upper 1000 m through satellite telemetry to shore stations. In addition time-series data in the mesopelagic and seafloor environments include deep ocean particle flux and studies on benthic faunal abundances and processes. These combined time-series results enable various temporal processes to be further understood including short-term (daily to seasonal) variation and longer-term trends (climate driven). In addition, a continuous high resolution time series allows episodic events, which are otherwise missed, to be sampled. These episodic events including storm surges, eddies and phytoplankton blooms, often significantly shape the marine environment and ecosystem. The full depth and multidisciplinary nature of the datasets are also vital for addressing the interconnections and feedbacks between the climate, surface productivity, carbon export, biogeochemical cycling and benthic community dynamics.</p> <p>In 2009 the PAP-SO was the location for EuroSITES process studies and sensor trials. This included the first open-ocean deployment of the oxygen consumption sensor IODA<sub>6000</sub>. Developed by EuroSITES partners CNRS, this sensor should revolutionise our understanding of carbon cycling in the mesopelagic zone, the biological pump and the oceans' role in the carbon cycle. In addition NOCS trialled a device for long-term sampling of mesozooplankton abundance and diversity and this will be deployed again in 2010. Other major field work planned in 2010 includes the deployment, in collaboration with the UK Met Office, of an improved full-depth mooring. This will include meteorological sensors to complement the suite of subsurface multidisciplinary physical and biogeochemical sensors. In 2010 collaboration between EU projects EuroSITES and ESONET (MODular Deep-Ocean Observatory: MODOO) will substantially enhance infrastructure at the PAP-SO with a seafloor lander system and sensor suite. This will send physical, biogeochemical, and ecological data to shore in near real-time via acoustic telemetry through the water column infrastructure.</p> <p>The PAP observatory has provided some unique insights into the biogeochemistry of an important region of the world's ocean and the developments currently taking place will further expand this capability to create a vital and unique asset in our quest to understand ocean processes.</p>
54.	<p style="text-align: center;"><b>Decadal-scale changes in shallow-infaunal foraminiferal assemblages at the Porcupine Abyssal Plain, NE Atlantic</b>  <i>Andrew Gooday, Nina Rothe &amp; Brian Bett (NOC)</i></p> <p>Trends in the abundance, diversity and taxonomic composition of rose Bengal stained foraminiferal assemblages were analysed in replicate multiple corer samples collected at the Porcupine Abyssal Plain over a 13-yr period (1989-2002). Total densities were significantly higher in 1996-2002 compared to 1989-1994, a change coincident with a spectacular rise in the density of the holothurian <i>Amperima</i>. Multivariate analyses revealed three assemblages represented by samples collected in 1989-1994, 1996-July 1997 and October 1997-October 2002. These reflected temporal changes in the densities of higher taxa and species, notably a small undescribed species of Trochamminacea. These longer-term trends may reflect a qualitative change in the phytodetrital food, repackaging of food by megafauna, increased megafaunal disturbance of the surficial sediment, or a combination of these factors. On the other hand, bimodal patterns in the abundance of other species (<i>Alabaminella weddellensis</i> and <i>Epistominella exigua</i>) may be linked to seasonal phytodetritus inputs. <i>Also relevant to Theme 2</i></p>
55.	<p style="text-align: center;"><b>Monitoring the Atlantic Meridional Overturning Circulation at 26.5°N</b>  <i>Stuart Cunningham, Brian King, Harry Bryden &amp; Chris Atkinson (NOC)</i></p> <p>Since the 1st April 2004 the RAPID-WATCH/MOCHA Array has been measuring the strength, vertical structure and associated heat transport of the Atlantic meridional overturning circulation (AMOC) at 26.5°N. Measurements of the Florida Current, direct velocity measurements of shallow and deep western boundary currents, Ekman and mid-ocean geostrophic transports combine to give twice-daily estimates of the meridional velocity profile. The AMOC time-series is now four years long and the data are available from <a href="http://www.noc.soton.ac.uk/rapidmoc">www.noc.soton.ac.uk/rapidmoc</a>. Whilst the array provides high temporal resolution of the basin-wide circulation, hydrographic cruises have been made across the basin in 2004 (D279) and 2010 (D346) providing an</p>

	<p>independent estimate of the AMOC circulation but also measuring in detail the interior distribution of temperature, salinity, carbon and other tracers for flux studies. Both these cruises were funded by the sustained observing programme of O2025. Here we present a comparison of data sets from the two cruises, including an update on the strength of the Atlantic MOC in Jan/Feb 2010.</p>
56.	<p style="text-align: center;"><b>Argo float deployment and coordination</b> <i>Brian King (NOC)</i></p> <p>The UK continues to be a major contributor to the international Argo program, maintaining the sixth largest number of active floats after the USA, Japan, Australia, France and Germany, as well as being a vigorous contributor to the international leadership of Argo. The poster will review the status of the program, will report on some recent technical difficulties, their solution and their possible impact on the program, some consequences of which users must beware, and show some examples of scientific use of Argo data.</p>
57.	<p style="text-align: center;"><b>Antarctic Circumpolar Current</b> <i>Brian King (NOC)</i></p> <p>A sustained hydrographic section across Drake Passage has been occupied in all but two years since 1993. This makes it the best-observed of the high-priority sections in the new Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP), an initiative launched at the OceanObs09 conference. The UK section consists of 30 full-depth CTD stations, between Burdwood Bank and Elephant Island. For each section, cross-track speed has been calculated using geostrophic shear relative to zero velocity at the deepest common level between adjacent stations. This velocity field can be integrated into a total transport, and the transport-weighted mean temperature, which is equivalent to a heat flux through Drake Passage. While the mean temperature shows a strong seasonal cycle, neither the total volume flux calculated in this way, nor the mean temperature have a decadal trend that can be distinguished from the interannual variability with the length of record available. The volume of water carried by the Antarctic Circumpolar Current dwarfs the Gulf Stream, so even small future changes in its properties could have a profound impact on the rest of the world's oceans: the longer the record grows, the better will be our ability to detect gradual long-term changes within the natural ocean variability. The properties of Sub-Antarctic Mode Water and Antarctic Intermediate Water, as observed in northern Drake Passage, do however show significant decadal trends. The poster will discuss the decadal records in both the integral and local properties.</p>
58.	<p style="text-align: center;"><b>FerryBox informs policy on acidification and eutrophication</b> <i>David Hydes, Boris Kelly-Gerreyn &amp; Denise Smythe-Wright (NOC)</i></p> <p>This poster demonstrates the contribution the Pride of Bilbao FerryBox is making to key policy areas on acidification and eutrophication in UK waters. The FerryBox system enables appropriate stewardship of our seas by acquiring high quality scientific understanding that can both resolve the relevant time and space scales of the processes affecting the health of our seas as well as differentiate between natural and human-induced changes. Ocean acidification and eutrophication are processes affecting ecosystem health driven by anthropogenic changes against a background of relatively large and cyclical natural behaviour. To unambiguously detect and understand these changes we need frequent, sustained and cost-effective observations, such as can be readily provided by FerryBoxes. The FerryBox operation began between Portsmouth and Bilbao in 2002. The value of this work ranges from the identification of controls of salinity and nutrients in the English Channel (which have fed into the Defra's "Charting Progress 2") to inter-annual variation in the uptake of CO<sub>2</sub> driven by differences in water temperature. The Ferry has also provided a platform for developing new methods of estimating ecosystem productivity and looking at climate-relevant gas exchange processes through the measurement of dissolved oxygen and nitrogen. 2009 will see the implementation of an autonomous robotic sampling system for the study of phytoplankton by flow cytometry and pigment measurements. The value of FerryBox sampling has been recognised by Defra through the DEFRApH project on ocean acidification in UK waters. DEFRApH is the first study to provide baseline, year-round data on the variation of the carbonate system in UK related waters. This enables actual changes in organism response to be observed in-situ through full annual cycles. <i>Also relevant to Themes 2 and 6. References available.</i></p>
59.	<p style="text-align: center;"><b>Climate-quality surface marine observations and products</b> <i>Elizabeth Kent, David Berry, David Cromwell, Christine Gommenginger, Graham Quartly &amp; Margaret Yelland (NOC)</i></p> <p>Recent work at NOC on the development of high quality datasets using data collected by operational observing programs will be presented. Dataset development activities include the NOC surface meteorology and flux dataset (NOCS v2.0) and a dataset of wave parameters from satellite altimetry. Other activities include improving rain detection for satellite altimetry and the development of novel techniques for obtaining wind and wave parameters from Global Positioning System "signals of opportunity". The poster describes recent progress on the development of data products and give details of users and applications for NOCS v2.0. In addition to recent work, planned activities under Oceans 2025 will also be outlined along with potential leveraged contributions to the ESA climate change initiative and NERC's Changing Water Cycle programme.</p>

60.	<p style="text-align: center;"><b>The Western Channel Observatory – a cascade of timescales</b></p> <p style="text-align: center;"><i>Tim Smyth, David Sims (MBA), James Fishwick, Chris Gallienne, Momme Butenschon, Peter Miller, Claire Widdicombe, Claudia Halsband-Lenk, Rachel Harmer, Andrea McEvoy, Malcolm Woodward, Carolyn Harris, Damien Eloire, Denise Cummings, Glen Tarran, &amp; Ricardo Torres (PML)</i></p> <p>Observations have been made in the western English Channel (WEC) for over a century. During that period there have been tremendous changes in measurement types and techniques, fuelled in part by technological advances. Each distinct dataset is able to inform the scientist, stakeholder or policy-maker about different aspects of the biological, chemical and physical variability of the WEC. For information on climatic variability, centennial scale observations are required: temperature (1903 - present) shows a warming of around 0.8 °C over the past 20 years; nutrients (1934 - present) show decadal variability; the effects of climate change and fishing on fish stocks (1911 - present) are beginning to be disentangled. The restart of the L4 time-series in 1988 has given insight into the large inter-annual variability in zooplankton (1988 - present) and phytoplankton (1992 - present). The advent of satellite technology and the computer revolution of the 1980s and 1990s resolved the synoptic scale variability of the WEC from observational (sea-surface temperature, 1981 - present; ocean colour, 1997 - present) and ecosystem modelling standpoints. Finally, the deployment of two data buoys (2009) has shown unprecedented temporal resolution on an hourly basis allowing the linkages between the Tamar estuary, the coastal and open-shelf to be revealed.</p>
61.	<p style="text-align: center;"><b>Irish Sea Liverpool Bay Observatory</b></p> <p style="text-align: center;"><i>Clare O'Neill, Matthew Palmer &amp; John Howarth (NOC)</i></p> <p>A pre-operational Coastal Observatory has been functioning since August 2002 in Liverpool Bay, Irish Sea. Its rationale is to develop the science underpinning the ecosystem-based approach to marine management, including distinguishing between natural and man-made variability, with emphasis on eutrophication and predicting responses of a coastal sea to climate change. Liverpool Bay has strong tidal mixing, receives fresh water principally from the Dee, Mersey and Ribble estuaries, each with different catchment influences, and has enhanced levels of nutrients. Horizontal and vertical density gradients are variable both in space and time. The challenge is to understand and model accurately this variable region which is turbulent, turbid, receives enhanced nutrients and is productive. The main scientific challenges remain to understand the processes and to translate this understanding into predictive models whose accuracy has been quantified. The challenges relate to physics (salinity, circulation in Liverpool Bay, the flow through the Irish Sea, flushing events); the role of sediments in the optical characteristics of the water column; the ecosystem and eutrophication.</p>
62.	<p style="text-align: center;"><b>Macroscale ecophysiology of <i>Calanus finmarchicus</i> in the North Atlantic Ocean</b></p> <p style="text-align: center;"><i>Pierre Helaouet (SAHFOS)</i></p> <p>Understanding how the environment controls the spatial distribution of a species is crucial for issues ranging from climate change projections to endangered species to resource management. A macroecological approach was applied first, based on standardised Principal Component Analyses (PCAs), to determine factors affecting the spatial distribution of <i>C. finmarchicus</i> and to characterise its realised niche. We chose to characterise the realised niche by using SST and an index reflecting the concentration of diatoms. While the species is at the centre of its niche in the subarctic gyre, our analysis shows that it is at the edge of its niche in the North Sea, making the species more vulnerable to temperature changes. Our approach indicates that climate change is having a strong impact on <i>C. finmarchicus</i> in the North Sea and enables patterns of changes observed for this species to be understood and anticipated with greater confidence.</p> <p><i>Also relevant to Theme 4</i></p>
63.	<p style="text-align: center;"><b>Monitoring jellyfish outbreaks with the Continuous Plankton Recorder (CPR)</b></p> <p style="text-align: center;"><i>Priscilla Licandro (SAHFOS)</i></p> <p>In recent years jellyfish outbreaks have been increasingly recorded worldwide. A basic information gap in population dynamics, composition and spatial distribution of jellyfish has been pointed out while investigating possible causes of those 'blooms' events that can be detrimental for fisheries, aquaculture, tourism and public health. The taxonomic identification of jellyfish by molecular genetic analysis of samples collected by the Continuous Plankton Recorder (CPR) provides new possibilities for the inshore and offshore monitoring of jellyfish in the North Atlantic and North Sea. A recent study (Licandro <i>et al.</i>, 2010) has shown that the warm-temperate scyphomedusa <i>Pelagia noctiluca</i> is the main species present in CPR samples collected over a large area in the Northeastern Atlantic, where the increase in jellyfish frequency are greatest. Swarms of <i>P. noctiluca</i> in British waters appeared to have increased due to a combination of climate driven changes in surface ocean currents, associated with a greater northwards water inflow from mid-temperate latitudes, and warmer sea temperatures that may extend the reproductive period of this jellyfish over winter months.</p> <p><i>Reference available on request. Also relevant to Theme 4</i></p>

<b>64.</b>	<p style="text-align: center;"><b>How well do ecosystem indicators communicate the effects of anthropogenic eutrophication?</b> <i>Abigail McQuatters-Gollop (SAHFOS), Alison Gilbert, Jan Vermaat (Univ of Amsterdam), Laurence Mee (SAMS)</i></p> <p>Anthropogenic eutrophication affects Europe's seas to various extents. Responses to nutrient loading and methods of monitoring relevant indicators vary regionally, hindering interpretation of ecosystem state changes and preventing a straightforward pan-European assessment of eutrophication symptoms. Here we use time-series of selected pelagic indicators to compare responses to nutrient enrichment in the Black and North Seas. Indicator interpretation is strongly dependent on sea-specific knowledge of ecosystem characteristics, and no single indicator can be employed to adequately compare eutrophication state between European seas. Communicating eutrophication-related information to policy-makers could be facilitated through the use of consistent indicator selection and monitoring methodologies across European seas. This work is discussed in the context of the European Commission's recently-published Marine Strategy Directive.</p> <p><i>Also relevant to Themes 4 and 6</i></p>
<b>65.</b>	<p style="text-align: center;"><b>The Extended Ellett Line - The changing balance of water masses in the Northeast Atlantic</b> <i>Jane Read (NOC) and Toby Sherwin (SAMS)</i></p> <p>Thirty-four years of measurements along the Ellett Line, in the Rockall Trough west of Scotland, have shown an increase in temperature and salinity in the top 800 m of the water column since the mid 1990's. The temperature anomaly peaked at 0.8°C in 2008, while salinity reached a maximum in 2003, with an anomaly 0.08 above the long term mean. Measurements on the extension, between Rockall, 60°N 20°W and Iceland, cover only 20 years, but they too show increases in temperature and salinity. These results illustrate the changing balance of water masses in the Northeast Atlantic, with more warm, saline water from the south and a decrease in the importance of fresher water from the North Atlantic Current. In this poster we will review the latest results.</p>

## National Facilities and Corporate

<b>66.</b>	<p style="text-align: center;"><b>Permanent Service for Mean Sea Level (PSMSL) - the next 75 years</b> <i>Lesley Rickards (PSMSL/NOC)</i></p> <p>The PSMSL was established in 1933 and operates under the auspices of the International Council for Science. It is the global databank for long term sea level change information from tide gauges and provides a wider Service to the sea level community. In 2008 PSMSL celebrated its 75<sup>th</sup> anniversary with three special events including 'Liverpool, Home of Sea Level Science: Sea Level Rise and Climate Change' at the British Association Festival of Science in Liverpool. The poster provides an overview of the new PSMSL database, software tools and web-site, which incorporates improved data delivery and allows exploration of the database using Google Earth. It will also describe some of the products available from PSMSL and provide an update on linkages with the GLOSS high frequency delayed mode data set, and look to future developments.</p>
<b>67.</b>	<p style="text-align: center;"><b>CCAP: a National Capability underpinning the sequencing and biofuels revolutions</b> <i>John Day, Claire Gachon, Christine Campbell, Frithjof Küpper &amp; Michele Stanley (SAMS)</i></p> <p>The Culture Collection of Algae and Protozoa (CCAP) located in SAMS European Centre for Marine Biotechnology (ECMB) is a National Facility funded under Oceans 2025. It holds a uniquely diverse collection of live protists, multi-cellular algae and cyanobacteria, originating from freshwater, terrestrial, marine and hypersaline niches. The sequencing and genomic revolutions are rapidly changing our capacity to understand and exploit biodiversity. The CCAP, in association with collaborators, is in the process of barcoding its holdings. These, with other genomic data, and their linkage with live specimens will be pivotal to future research developments in biodiversity, earth systems science and sustainable use of natural resources. The biodiversity and culturing experience of CCAP have been crucial to the recent developments in algal biofuels. The collection has been providing materials, advice and services to the emerging algal-biofuels sector in the UK and world-wide. CCAP is also active in two major projects at SAMS: Biomara and the Carbon Trust funded COG project.</p>
<b>68.</b>	<p style="text-align: center;"><b>UK Marine Science Strategy and the MSCC</b> <i>Steve Hall (NMCO/NOC)</i></p> <p>Launched February 2010, the UK marine science strategy is a 15 year strategic framework for shaping, supporting, co-ordinating and enabling the delivery of world class marine science for the whole of the UK, across Government, Devolved Administrations, industry, Non-Governmental Organisations and other sectors. The Strategy identifies high level priority areas for marine science; and seeks to address barriers that prevent the science from achieving maximum impact, such as funding for long-term observations. The Marine Science Co-ordination Committee, comprised of the Government Departments, Devolved Administrations and main delivery bodies involved in UK marine science, is responsible for the delivery of the Strategy.</p>

