

A Coastal Futures Conference

Climate Change and the Marine Environment

The state of knowledge and our responses

November 30th 2006 London

Sponsors:

- Cefas
- Marine Climate Change Impact Partnership
MCCIP
- Meteorological Office
- WWF

Welcome to the conference

This information gives the answers to some of the most frequently raised questions that arise at the conferences we organise.

Conference Outputs

- **Key Lessons** – Feedback to delegates. We have designed the day to cover a number of key ideas and see what lessons can be taken from these. We would like to capture your thoughts on the evaluation sheet at the end of these delegate notes. The final sheet asks for next steps and actions that you think should follow from the day. We will type these and make them available to you after the event.
- **The Power Point presentations** will be available shortly after the event on websites www.coastms.co.uk. We will notify you by email when these have been placed on the site.

Questions If you have any questions during the event about bookings, finances, or logistics please see Christina Beech at the registration desk; she will be pleased to help.

Timing We will try to ensure that the conference runs on time to allow the allocated time for speakers and as importantly for discussion. A bell will be rung 5 minutes before the start of sessions.

Refreshment Breaks In running events in London over the last 10 years we have used two main refreshment breaks during the day that enable us to split the sessions and breaks more evenly. A sandwich buffet is available in the first break and sweet course during the second.

Food There is always ample food at the events and you can come back for more. Once you have collected your food could you move away from the serving table. Catering staff are on hand if you need anything, including extra drinks.

Evaluation form There is an evaluation form at the end of delegate notes; your views will help us improve future events. Please leave these at the registration desk along with your badge when you leave.

Valuables If you have anything you value keep it with you i.e. do not leave laptops unattended.

Before you leave Check you haven't left anything in the conference hall. Please also take any leaflets or reports.

Introduction to the Conference

It is now widely recognised that climate change is *the* major challenge facing society and this will continue to be the case for the foreseeable future. The range of international, European and national initiatives is enormous and growing by the day.

The work on climate change related activities is now taking on ever growing proportions across a wide range of different UK Government departments and a plethora of other organisations. Most recently in *Securing the Future* the UK Government's strategy (2005) for sustainable development a UK climate change action plan was put forward and Government has recently created an Office for Climate Change (OCC) to work across government. Whilst in a terrestrial context considerable progress has been made and organisations like the UK Climate Impact Partnership (UKCIP) have made considerable progress the equivalent developments in collaboration in the marine environment are at a very early stage.

The meeting is timely coming at the culmination of the Marine Climate Change Impact Partnership's (MCCIP) work on its first annual report card and after a number of specialist workshops on the Arctic, ocean acidification and methane hydrates. The meeting will provide a forum for the marine community across a wide range of disciplines and sectors to appreciate recent developments.

The aim of this conference is focus directly on *marine* climate change work placing this in:

- the context of current Government policy,
- the developing programme of the Marine Climate Change Impact Partnership,
- the extensive body of research and science that is currently underway and
- to discuss this work to enable progress to mitigate the very real challenges we face.

The objectives of the conference are to:

- Bring together a wide range of interests involved across disciplines and sectors involved in the marine climate change debate
- To showcase and assist the work of the Marine Climate Change Impact Partnership (MCCIP) and help develop the networking process – including the new *Annual Report Card*
- To highlight some of the major bodies of work being undertaken and look for the common ground between them including:
 - Meteorological perspectives
 - Changes in the Arctic
 - Ecosystem scale changes to nature communities
 - Ocean acidification
 - Methane hydrates
 - Carbon capture and sequestration
- To make the links to the perspectives of industry operating in the marine environment who will play a key role in mitigating the effects of climate change

This meeting will focus on the science and impact of what we understand of climate change in predominantly northern seas it will also highlight a range of questions that need to be resolved and taken forward across sectors that are looking to mitigation of climate change effects.

Programme

9.00 Registration and refreshments

Session 1 Introduction Chair: Kathy Kennedy Cefas

9.50 Policy context and overview of UK climate change initiatives

Beth Greenaway & Adrian Butt Defra

10.10 Introduction to the Marine Climate Change Impact Partnership and the Marine
Climate Change Annual Report Card Paul Buckley Cefas & MCCIP

10.30 Metocean conditions – climate trends and extreme events

Mark Hannam, Jason Lowe & Matt Huddleston Meteorological Office

10.50 Headlines from the Arctic workshop Ralph Rayner

Chairman of the Marine Information Alliance and Vice President of IMarEST

11.10 Oceanic change in the North Atlantic, Nordic Seas and Arctic: measuring key
components of the Global Ocean Circulation Stephen Dye Cefas

11.30 Ecosystem changes – regime shift in planktonic systems

Chris Reid, Sir Alister Hardy Foundation for Ocean Science

11.50 Network break 1 - Buffet and refreshments

Session 2 Chairman: Ian Townend H R Wallingford

12.30 Responses of marine ecosystems to climate change and other impacts

Stephen Hawkins, Nova Mieszkowska, David Sims and M Burrows MBA & SAMS

12.50 Ocean acidification

Carol Turley Plymouth Marine Laboratory

13.10 Methane hydrates and climate change – future challenges Dave Long & John Rees
British Geological Survey

13.30 Carbon Capture and Storage in the North Sea Tony Espie BP Alternative Energy

13.50 Network break 2 Refreshments

Session 3 Chairman: Paul King Director of Campaigns, WWF

14.30 Renewable Energy perspectives – the potential for low carbon energy from the sea
Stephanie Merry Focus Offshore & Renewable Energy Association

14.40

15.00 Discussion

There will be a wide ranging discussion of key points raised enabling the delegates to express their views; questions arising could include:

- Communicating climate change science – challenges?
- Is the science/research agenda moving fast enough to cope with actual changes?
- Enabling and stimulating MCCIP – what more can people do – views on the report card
- What opportunities arise for mitigation?

15.50 Summing up

16.00 Close & Refreshments

Joining the science of Climate and Marine Issues to UK Policy making

Beth Greenaway

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''Climate Change is probably the greatest long term challenge facing the human race and a top priority'' March 2006, Tony Blair Prime Minister

In March 2005, Charting Progress concluded that the greatest threats to the marine environment were fisheries and climate change. The UK Climate Programme 2006 committed the UK to national action whilst recognising this can only be part of a much bigger global and EU strategy and there may be regional responses relevant to the devolved administrations.

For the marine environment, this committed us to a review of impacts, an assessment of the changes in the distribution and abundance of marine species, and to combining knowledge through the Marine Climate Change Impact Partnership.

MCCIP was launched in March 2005, with the aim of providing a co-ordinating framework for Great Britain and Ireland for the transfer of high-quality marine climate change impacts evidence and advice to policy advisors and decision makers, and to act as the primary focus for the supply of evidence and advice to partners to enable them to individually and collectively plan for the challenges and opportunities presented by the impacts of climate change on the marine environment.

To date MCCIP has collated existing science knowledge on marine impacts and produced briefing notes on the issues. Headline bullets have been inserted into a Report Card which was peer reviewed by independent scientists and agreed across the steering group of sponsors. The first card will be (was) launched by Defra Ministers on 29th November 2006.

The main messages of the card are that:

- Climate change is affecting all aspects of the sea – the functioning, the marine life and the basic chemistry.
- This means that how we use and manage the sea – all our interactions with it will be affected and we need to adapt. The Government recognises the importance of mainstreaming adaptation in order to deal with these cross-cutting issues.
- The rates of change are concerning and impacts largely unknown therefore ecosystem/ holistic management of the sea is essential.

In 2002, Safeguarding Our Seas; outlined the UK Government vision for 'clean, healthy, safe, productive and biologically diverse oceans and seas'. It said that the seas should be managed as an ecosystem, (that is in an holistic way), to allow for Sustainable Development. It also contained a commitment to make a difference in one generation. Climate change was a key chapter.

This leads us to suggest that we should treat ''climate change'' as an additional pressure that the sea is under but a key challenge is to understand these and distinguish climate change impacts from all the natural variability of the oceans.

The MCCIP provides a focus for understanding across the UK of climate impacts. This understanding should lead us to action in a number of areas including:

- i) securing sustained funding streams to enable the collection and analysis of long term records and models;
- ii) improving the mechanism for ensuring timely quality controlled data and information reach decision makers and users of the marine ecosystem (e.g. the UK MCCIP);
- iii) adapting to climate change, by determining and reducing the combined stresses on the marine environment through flexible, holistic management of human activities (such as fisheries) and protection of marine ecosystems;
- iv) allowing for adaptive management processes at all levels (local, regional and international) to respond to the changing risks. (i.e. flexible policy instruments);
and
- v) strongly encouraging mitigation measures

Introduction to the marine climate change impacts partnership and the marine climate change annual report card

Paul Buckley

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The UK government has set out a vision for 'clean, safe, healthy, productive and biologically diverse oceans and seas', yet as recently as 2005, 'charting progress', was unable to assess the potential impacts of climate change on the UK's marine environment. MCCIP has come together to inform key decision makers about these issues.

MCCIP is a partnership between marine scientists and sponsors from government, its agencies and NGOs. Our principal aim is to develop a long-term multi-disciplinary approach to understanding and communicating the implications of marine climate change.

The marine climate change annual report card (ARC) will provide one of the most important outputs of the MCCIP programme, synthesising the previous years work in a highly accessible and actionable format. As this first report card will set the scene for our understanding of climate change impacts on the UK marine environment, we have adopted a wide-ranging approach to assess the current state of understanding through reviews submitted by leading UK marine and climate scientists. Each of the scientists has also rated their level of confidence in the evidence presented.

The ARC begins with a summary of climate changes in the marine environment, setting the context for the subsequent assessments of impacts on our vision for an ecosystem that is healthy and biologically diverse; clean and safe; and (commercially) productive. The high level statements presented in the ARC are supported by more detailed reports from each of the contributing scientists. These reports are fully accessible through the online version of the report card and set out the supporting case for the headline messages presented in the ARC. These notes are fully referenced and key sources of information highlighted so that the user can explore each subject in greater depth.

Our first online newsletter is also due to be launched, which will be used to communicate the activities of MCCIP and to highlight relevant marine climate change news and events. The newsletter will be published every two months and subscription will be available through our website.

MCCIP aims to expand its activities significantly in 2007 when we will be running workshops and seminars, developing a response centre for marine climate change enquiries and exploring applications of UKCIP marine climate change scenarios. Further details and dates for these activities will be made available on our website.

Links:

Website and newsletter: www.mccip.org.uk

Online annual report card (ARC) www.mccip.org.uk/arc

Metocean Conditions Climate Trends and Extreme Events

Mark Hannam

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Dr M Huddleston -Met Office Consulting

Jason Weeks - Hadley Centre

This presentation will provide a synthesis of the metocean climate and long range forecasting capabilities of the world renowned Hadley Centre and National Ocean Forecasting Centres on behalf of the UK Met Office. The implications of uncertainty in the use of predictive techniques and the pioneering methods being applied to respond to this challenge are explored.

Insight into global and regional perspectives will be taken including the ramifications of climate change in spatial and temporal context using extensively researched phenomena such as the thermo-haline circulation(global conveyor belt), depletion of the polar ice caps and El Nino. Sensitivity to recognised scenarios recognised by the IPCC The trends of increasing frequency and intensity of extremes events ranging from surge induced flooding rise in sea level), incidence of freak waves and tsunamis to tropical cyclones are considered using high profile examples.

The paper concludes with an appreciation of the potential impacts from changing metocean conditions having regard to major international research and advances in the forecasting of climate using probabilistic, seasonal and decadal techniques. The critical interface between metocean conditions and both atmospheric and terrestrial outcomes and the importance of these interactions in understanding climate impacts is highlighted. Both adaptation and mitigation will be considered in the context of both global, regional, and local response to the imperatives for tackling climate change. The challenges of managing the ongoing exploitation of marine resources and the opportunities for sustainable management practice will be examined in this context.

Headlines from the Arctic Workshop

Ralph Rayner

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The Arctic, a resource rich and strategically important area of the planet, came under the spotlight at a recent workshop when over a hundred key decision makers from a range of sectors, including oil and gas, shipping, ports, defence, fisheries, tourism, insurance, environment and policy met to look to the future of the region.

The workshop saw delegates debating the sectoral priorities for data, information and knowledge to support improved understanding, management and regulation of the area north of 66° 33'N¹.

The workshop was organised by the Institute of Marine Engineering, Science and Technology – IMarEST); the Inter-Agency Committee for Marine Science and Technology (IACMST); and the Marine Information Alliance (MIA); and sponsored by the National Centre for Ocean Forecasting (NCOF), BP and the Scottish Association for Marine Science (SAMS).

An analysis of the outcomes of the Arctic Workshop will permit starting to better define the needs for long-term monitoring of the Arctic region. This long-term monitoring must satisfy the needs of all stakeholders concerned with protecting the environment, informing sound policy and ensuring that Arctic operations can be conducted safely.

Headlines from then Arctic workshop will comprise a summary of the state of knowledge about climate change in the Arctic region and present key outcomes from the Workshop regarding regulation of Arctic development and the priorities for long-term monitoring to support environmental protection, development and safe operations.

The Marine Information Alliance www.infomarine.org

The Institute of Marine Engineering, Science and Technology www.imarest.org

The Arctic Climate Assessment www.acia.uaf.edu

National Centre for Ocean Forecasting www.ncof.gov.uk

Scottish Association of Marine Science www.sams.ac.uk

Oceanic change in the North Atlantic, Nordic Seas and Arctic: measuring key components of the Global Ocean Circulation

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When we think of the global ocean circulation we tend to think of changes happening over long time scales – hundreds of years – however, increasingly as our measurements of key components of this system improve we see change progressing much more quickly.

This presentation will focus on the nature of this change and how we are improving our knowledge of the system with particular reference to 3 major programmes and how the measurements made by each of them interlink:

1. IROC (ICES Report on Ocean Climate) At the North Atlantic Scale the work of the ICES Working Group on Oceanic Hydrography on reporting on ocean climate. This looks at the North Atlantic Sub-polar Gyre in relation to surface temperature and salinity to help understand regional scale changes over decades.
www.noc.soton.ac.uk/JRD/ICES_WGOH/iroc.php
2. ASOF (Arctic and Sub Arctic Ocean Fluxes) This programme aims to bring together the measurements and models that hope to improve our understanding of the variability of the fluxes between the Arctic and Atlantic that plays an important role in decadal-scale climate variability.
www.asof.npolar.no
3. DAMOCLES (Developing Arctic modelling and observing capabilities for long term environmental studies) As well as the most convoluted acronym this is the largest of the 3 programmes. It is an EU FP6 Integrated Project and contribution to the International Polar Year 2007 – 2008. Over the next 4 years will form an integrated Ice-Atmosphere-Ocean observing system that aims to reduce uncertainty in understanding climate change in the Arctic and its impacts.
www.damocles-eu.org

Ecosystem changes – regime shifts in planktonic systems

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- The surface waters of the European Continental shelf have been warming over the last few decades. This has caused extensive changes in the planktonic ecosystem in terms of plankton production, biodiversity, species distribution which has had effects on fisheries production and other marine life (e.g. seabirds)
- In the North Sea the population of the previously dominant and important zooplankton species has declined in biomass by 70% since the 1960s. Species with warmer-water affinities are moving northward to replace the species but are not numerically as abundant.
- There has been a northward shift in the distribution of many plankton and fish species by more than 10° latitude over the past thirty years.
- The seasonal timing of plankton production also altered in response to recent climate changes. This has consequences for plankton predator species, including fish, whose life cycles are timed in order to make use of seasonal production of particular prey species.
- The decline of the European cod stocks due to overfishing has been exacerbated by climate induced changes in plankton production. The survival of young cod in the North Sea appears to depend on the abundance, seasonal timing and size composition of their planktonic prey.

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Responses of marine ecosystems to climate change and interaction with other impacts

Stephen Hawkins

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S.J.Mieszkowska, N., Sims, D. & Burrows, M.T. (SAMS)

Climate change is real and is influencing patterns of marine biodiversity, with consequences for ecosystem functioning. The influence of low amplitude, low frequency climate drivers need to be segregated from regional (fishing, eutrophication) and local impacts (sea defences, point-source pollution) that are often of greater amplitude and higher frequency. To do this, long-term studies are required. Examples are given of changes in marine ecosystems around the British Isles, focusing on the well-studied Western English Channel and on rocky shore indicator species. Datasets stretching back over 50 years provide a unique opportunity to study not only the effects of recent climate warming, but put them into a longer-term context. These highlight the need to examine interactions between climate and additional impacts such as fishing and sea defences.

Several warm water species of intertidal invertebrates and algae have extended their northern range limits polewards in Britain since the current period of warming began. Concurrent increases in abundance and the frequency and magnitude of recruitment success have occurred at their distributional range limits. Pelagic fish species have also shown northwards shifts in their geographic distributions in British coastal waters during the last few decades. Interestingly the southern limits of some cold water species have retracted to a lesser extent in Britain, with associated declines in abundance and reproductive output. The role of the UK Marine Environmental Change Network is highlighted in integrating broadscale observations and delivering them to policymakers.

Useful websites:

Marine Biodiversity and Climate Change Project: MarClim
www.mba.ac.uk/marclim

Marine Environmental Change Network: MECN
www.mba.ac.uk/MECN

Marine Biological Association of the UK
www.mba.ac.uk

Marine Climate Impacts Partnership
<http://www.mccip.org.uk/index.html>

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Ocean Acidification: its Impacts and Relevance to Climate Change Policy

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The world's oceans contain an enormous reservoir of carbon, greater than either the terrestrial or atmospheric systems. The fluxes between these reservoirs are relatively rapid such that the oceans have taken up around 50% of the total carbon dioxide (CO₂) released to the atmosphere via fossil fuel emissions and other human activities in the last 200 years. Whilst this has slowed the progress of climate change, CO₂ ultimately results in acidification of the marine environment. Ocean pH has already fallen and will continue to do so with certainty as the oceans take up more anthropogenic CO₂. Acidification has only recently emerged as a serious issue and it has the potential to affect a wide range of marine biogeochemical and ecological processes. This presentation will summarise some of the research in this newly evolving area of science, how it is increasingly being recognised by policy makers associated with climate change and will assess the confidence that researchers have in some of the policy relevant statements that are arising from this area.

Here are some ocean acidification web links:

1. <http://www.royalsoc.ac.uk/document.asp?id=3249> for the Royal Society Working Group report on ocean acidification published in 2005. This is partly written for policy makers and contains a very useful summary of ocean acidification and the potential impacts.
2. Avoiding Dangerous Climate Change Conference book on:
<http://www.defra.gov.uk/environment/climatechange/internet/dangerous-cc.htm> See Section 1, Chapter 8, Turley, C., Blackford, J., Widdicombe, S., Lowe, D., Nightingale, P.D. & Rees, A.P. (2006) Reviewing the impact of increased atmospheric CO₂ on oceanic pH and the marine ecosystem. In: Avoiding Dangerous Climate Change, Schellnhuber, H J., Cramer, W., Nakicenovic, N., Wigley, T. and Yohe, G (Eds), Cambridge University Press, 8, 65-70.
3. <http://www.ospar.org/eng/html/welcome.html> Follow the "What's new link" for the following report on ocean acidification: Haugan, P.M; Turley, C; Poertner H.O, 2006. Effects on the marine environment of ocean acidification resulting from elevated levels of CO₂ in the atmosphere, DN-utredning 2006-1. This is data rich report for potential impacts on the OSPAR region (N Atlantic)
4. Report on impacts of high CO₂/acidification on marine calcifiers including corals by Kleypas et al. (2006): http://www.ucar.edu/communications/Final_acidification.pdf

Methane hydrates

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Introduction

Methane hydrate is an ice-like substance that has molecules of methane trapped within a cage of water molecules. This allows the methane molecules to be held much closer together than in a free gas. Up to 164 m³ of gas at standard temperature and pressure, and 0.8 m³ of water occur in 1 m³ of solid hydrate. Such substances are known as clathrates. Methane hydrate exists under high pressures and low temperatures. Such conditions exist on the continental slopes around the world and under permafrost. Vast global reserves are often quoted for methane hydrate with estimates dwarfing all other hydrocarbon energy reserves; these have in recent years been reduced but still are comparable with all natural gas discoveries. However, their occurrence and relationship with host sediments is poorly understood and it is only with improvements in this that their input to the global carbon cycle and how we might exploit them safely will be better understood.

Global distribution

Initially, gas hydrate in the natural environment was looked on as little more than a curiosity. However, recognition of hydrate dissociation effects in shallow sediment cores combined with widespread presence of bottom simulating reflectors (BSRs) in seismic surveys pointed to a huge volume of methane bound up in the gas hydrate reservoir. Global hydrate estimates have moderated in recent years to a value of about 2×10^{14} m³ of methane in natural gas hydrate (Soloviev 2002). This is about 30 times the amount of methane in the present atmosphere, where it is a powerful greenhouse gas. It is also comparable as a carbon store with other fossil fuels. As well as being found in water depths generally greater than 500m on virtually all continental margins, hydrates associated with permafrost have been encountered in Siberia, Alaska and the Canadian Arctic (Kvenvolden & Lorenson, 2001). Like much of Europe there is a paucity of evidence for the presence of methane hydrates on the deep waters west of the UK. Although the conditions for its formation exist, it may be that the normal tell-tale signs such as free gas accumulations below the hydrate are missing so BSRs are not created. There is currently extensive funding by Japanese sources into methane hydrates with the desire to exploit resources located just offshore these energy deficient islands. Similarly the US is funding numerous studies as methane hydrate is preserved to be clean energy source and extensive deposits have been identified under the permafrost of Alaska and offshore the Carolina and in the Gulf of Mexico. However there are many difficulties in developing extraction methodologies as the resource is shallow and does not flow like oil or gas.

Hazards associated with methane hydrates

However natural hydrates may also be considered a hazard as changes to their environment may lead to their dissociation. As hydrates occur within the upper few hundred metres of the seabed, disturbance by drilling, installation of foundations, during development or production can cause the hydrate to melt, releasing gas around pipework and foundations weakening the soil. Alternatively gas seepage to the seafloor within the HSZ has been known to form hydrate over seabed installations including the BOP (blow-out preventer). This gas seepage may be from the breakdown of hydrates below seabed, or more deeply sourced methane forming hydrates as it rises up a conduit. Hydrate dissociation and changes in the geotechnical properties of the host sediment have been suggested as a cause for instability of continental slopes. Many of the world's largest submarine landslides occur in areas where

methane hydrates have been found, or suspected, on the basis of BSRs. To change the stability regime of hydrates over large areas in the short term requires global changes in sea level and/or temperature, in the longer term regional uplift will produce similar effects.

Climate Change

However, because it is ~25 times as effective a greenhouse gas as carbon dioxide, methane from the global hydrate reservoir reaching the atmosphere can also significantly modify the global climate. During a cooling part of the glacial cycle, the lowering of the global sealevel by 100m or more will change the pressure conditions on any offshore methane hydrates. Hydrates outcropping on the seafloor will melt, this will probably be gradual with methane become dissolved in the oceans. However melting will also occur at the base of the methane hydrate stability zone, leading to the build up of free gas. This will change the strength of the sediments and can lead to submarine landsliding. When such events occur it is thought that the volumes of methane gas released will be too large to dissolve that they will reach the atmosphere. This is likely to constrain the glacial cooling thereby providing negative feedback. However in the warming part of the glacial cycle rising sealevel and rising temperatures are likely to melt permafrost that is trapping methane hydrate, the rise in temperature will feed down into the hydrate leading to the release of methane direct to the atmosphere. Thus there is the real potential to develop a positive feedback system in which gas hydrate release rapidly responds to, and accentuates, global warming. Also in the change from glacial to interglacial conditions, oceanographic currents change and may cause warming of the seafloor in high latitudes which could also release methane such as by landsliding.

This linkage of methane release has led to the "clathrate gun hypothesis" where hydrates are intimately involved in the global warming at the end of each ice age (Kennett *et al.* 2003). However, others have suggested that climate change, including major sea level rise, began before increases in methane in the atmosphere and that the higher methane concentrations were the result of increased vegetation, particularly in swampy areas (Maslin and Thomas, 2003). Sudden changes in atmospheric composition elsewhere in the geological column have also been attributed to hydrate dissociation, for example at the Palaeocene/Eocene boundary, even contributing to the K-T and P-T boundary stories (Max *et al.* 1999; Retallack 1999). The Paleocene-Eocene Thermal Maximum was a short period (10-20,000 years) when intermediate to deep ocean water temperatures increased between 6 and 8 °C. This was accompanied by distinct changes in the carbon isotope ratios, with a shift of -2.5 $\delta^{13}\text{C}$ in marine environments and at least -5 $\delta^{13}\text{C}$ in terrestrial environments. This implies that approximately 2000 gigatons of isotopically depleted carbon was released into the ocean - atmosphere system, with the melting of methane hydrates the most likely source (Dickens 1999; Thomas *et al.* 2002). Such rapid changes are comparable with anthropogenic inputs and may provide a model for the consequences of climate change attributed to present day activities of mankind.

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CO₂ Storage in Geological Formations

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Without significant action, global greenhouse gas emissions are projected to double by 2050. Whilst climate change is a long term issue, the immediate goal is to take urgent but informed measures that will stabilise atmospheric greenhouse gas concentrations. No single solution can deliver the necessary reductions in global emissions in the timescale that appears to be required. However, there is a portfolio of technologies that have been demonstrated at scale which collectively offer the opportunity to make the necessary reductions over the next fifty years. Because the world is expected to remain largely dependent on fossil fuels for the next fifty years, fossil fuel-based technological solutions for carbon mitigation will be one of the major contributors to stabilisation.

Power generation accounts for 40% of global anthropogenic greenhouse gas emissions. CCS technology can be used to "decarbonise" fossil fuels used in power generation by converting them into hydrogen (H₂) and carbon dioxide (CO₂). The CO₂ can be permanently stored in subsurface structures such as depleted oil and gas reservoirs or saline formations, thus ensuring that it does not re-enter the atmosphere. The hydrogen can be used to generate baseload electricity.

There is now over 30 years experience in the injection of CO₂ for Enhanced Oil Recovery and around 10 years experience in the injection of CO₂ for long term storage. BP is now moving to the next key milestone in the deployment of CCS with the announcement of the worlds first commercial scale hydrogen fired power stations with CCS. This presentation will present an industrial perspective on the issues involved in the large scale deployment of CCS.

Renewable energy perspectives: the potential for low carbon energy from the sea

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Sources of renewable energy – marine, wind, hydro, geothermal, biomass, solar, energy from waste - can deliver partial solutions to the problems of climate change, fossil fuel depletion and security of energy supply. Some technologies such as wind power are already mature; others, particularly energy from marine sources, need further development to reach commercial viability.

It has been estimated that just 0.1% of the global ocean energy resource (that is, the energy from tides, waves, thermal gradients and salinity gradients) would be sufficient to power the whole world five times over. The UK possesses some 35% of Europe's wave energy resource and 50% of its tidal resource. In the long term, marine renewable energy could meet 15 – 20% of the UK's current demand for electricity. The potential for this level of deployment gives wave and tidal energy strategic importance as a contributor to the UK's aspiration of supplying 20% of electricity from renewable sources by 2020 and its intention to reduce carbon emissions by 60% in 2050.

Tidal stream energy is extracted from the natural currents generated by the rise and fall of tides, rather than by the more familiar tidal barrage concept, such as the structure across the river Rance at Dinard in France. One example is the 300kW Seaflow device, which is a machine resembling an underwater wind turbine located off the Devon coast. This concept presents an attractive and unobtrusive addition to more established renewable energy technologies, such as wind, biomass and solar. A combination of these technologies are suitable to service a compact waterside residential or industrial development via private wire electricity distribution, backed up by a central CHP boiler for those times when the renewable energy resources cannot meet power demand.

There is also potential for large scale, commercial exploitation of tidal stream energy for export to the national grid from numerous tidal races around the coast of the UK. The extractable energy is on the order of 100s of MW at each tidal race, with the advantage that the time of maximum tidal flow at subsequent coastal locations is sequential, thus "smoothing" the intermittency of the tidal energy resource.

The presentation at the conference on 30th November will explain the concept of tidal stream energy and its potential applications in more detail and describe various novel devices for tidal energy extraction that are currently being developed and demonstrated.

**Climate Change and the Marine Environment
The State of Knowledge and our Responses
30th November 2006, SOAS, London**

Meeting Evaluation

1. Name: _____ Phone No: _____

2. How valuable did you find the meeting? (circle)

Not valuable

Very valuable

1

2

3

4

5

3. Having listened to all the presentations, what actions and next steps would you like to see taken?

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4. What would you do to improve the event?

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