2010 UK-AUSTRALIA FRONTIERS OF SCIENCE

MARINE SCIENCE MEETING

Perth, Western Australia
9–13 October

THE ROYAL SOCIETY

Australian Academy of Science

PROGRAM

Contents

Program

Saturday 9 October 2010

5.30pm **Welcome Reception**

Welcome
Professor Suzanne Cory AC FAA FRS
President Australian Academy of Science

Welcome
Professor Lorna Casselton FRS
Foreign Secretary and Vice President Royal Society

Sunday 10 October 2010

8.30am **Welcome**
Professor Lyn Beazley AO
Chief Scientist of Western Australia

8.40am **Introduction by Co-Chairs**

United Kingdom Chair
Dr Tom Webb
University of Sheffield

Australian Chair
Dr Elvira Poloczanska
Australia's Commonwealth Scientific and
Industrial Research Organisation (CSIRO)

8.50am **SESSION 1: Climatology – Mitigating climate change:**
Enhancing carbon sequestration in the ocean

Geo-engineering techniques to enhance carbon sequestration in the ocean
Dr Peter Strutton
University of Tasmania

Ocean fertilization: Practice, theory and ethics
Professor Anya Waite
University of Western Australia

Mitigating climate change: The role of ocean geoengineering
Dr Nem Vaughan
University of East Anglia

Open discussion led by Session 1 Chairs
Dr Helen Coxall
Cardiff University
Dr Elvira Poloczanska
CSIRO

10.50am	**Morning Tea**
11.10am	**SESSION 2: Microbiology – Symbiosis: From reef builders to deep sea vents**
	Microbes and symbiosis: Sentinels for marine ecosystem health Dr Nicole Webster Australian Institute of Marine Science
	The 'Bacterial-Algal Plug-In' model: **A concept to describe symbioses in the surface ocean** Dr David H Green Scottish Association for Marine Science
	Corals and their associated microbiota: **Implications for health, bleaching and disease** Dr David Bourne Australian Institute of Marine Science
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	Ocean climate models: How can we judge their skill? Professor Matthew England University of New South Wales
	Resolving the ocean mixing problem: Progress through observations Dr Stephanie Waterman National Oceanography Centre / Grantham Institute for Climate Change
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4.10pm	**Afternoon Tea**
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Monday 11 October 2010

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Australian Institute of Marine Science

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10.50am **SESSION 4: Chemistry – How GEOTRACES is shaping our knowledge of marine biogeochemical cycles**

An Introduction to the GEOTRACES Programme
Dr Alex Baker
University of East Anglia

Different biogeochemical processes drive seasonal iron supply in the Southern Ocean south of Australia
Dr Andrew Bowie
University of Tasmania

Understanding global marine biogeochemical cycles: Why measure isotope ratios on every single GEOTRACES cruise?
Dr Tina van de Flierdt
Imperial College London

Open discussion led by Session 4 Chairs
Dr Michael Ellwood
Australian National University

Dr Maeve Lohan
University of Plymouth

12.50pm **Lunch**

1.50pm **SESSION 5: Macrobiology – The effect of ocean acidification on marine ecosystems**

An introduction to ocean acidification
Dr Paul R. Halloran
Met Office Hadley Centre

Cold and old: The problems of understanding implications of ocean acidification for cold-water marine organisms
Dr J Murray Roberts
Heriot-Watt University

Climate change effects in tropical marine ecosystems
Dr Nick Graham
James Cook University

Open discussion led by Session 5 Chairs
Dr Jennifer Cobcroft
Tasmanian Aquaculture and Fisheries Institute

Dr Debora Iglesias-Rodriguez
University of Southampton

3.50pm	**Afternoon Tea**
4.10pm	**SESSION 6: Physics – Deep water formation: Past, present and future**
	High latitude sources of deep water formation Dr Simon Marsland CSIRO – Marine and Atmospheric Research
	Stability of North Atlantic deep water formation Dr Willem Sijp University of New South Wales
	Deep water formation: Past, present and future Dr Babette Hoogakker University of Cambridge
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7.00pm	**Pre-Dinner Drinks at The WA Aquarium**
7.30pm	**Dinner at The WA Aquarium**

Tuesday 12 October 2010

8.30am **SESSION 7: Applied Ecology – People as drivers of change in marine ecosystems**

People as drivers of change in marine ecosystems
Dr Jasmin Godbold
University of Aberdeen

**Understanding human-induced change:
Determining historical baselines of exploited
marine ecosystems**
Dr Julia Blanchard
Imperial College London

**Embracing change:
Exploring implications of climate change for marine ecosystems**
Dr Beth Fulton
CSIRO – Marine and Atmospheric Research

Open discussion led by Session 7 Chairs
Dr Natalie Ban
James Cook University

Dr Tom Webb
University of Sheffield

10.30am **Morning Tea**

10.50am **SESSION 8: Geosciences – The time machine on the ocean floor**

A new Pacific record of carbonate compensation depth
Dr Heiko Pälike
University of Southampton

Using microfossil records to understand global climate change: Small is beautiful
Dr Samantha Gibbs
University of Southampton

The tropical time machine: Past changes, future challenges
Dr Steven Phipps
University of New South Wales

Open discussion led by Session 8 Chairs
Dr Leanne Armand
Macquarie University

Professor Andy Ridgwell
University of Bristol

12.50pm **Conference Close**
Summing up by Co-Chairs

United Kingdom Co-Chair
` Dr Tom Webb
University of Sheffield

Australian Co-Chair
Dr Elvira Poloczanska
Australia's Commonwealth Scientific and
Industrial Research Organisation (CSIRO)

Conclusion
Professor Lorna Casselton FRS
Foreign Secretary and Vice President Royal Society

Dr Sue Meek FAICD FTSE
Chief Executive Australian Academy of Science

1.00pm	**Lunch**
2.00pm	**Coach departs for site visit**
2.30pm	**Site visit at University of Western Australia Oceans Institute**
5.15pm	**Coach departs for Rendezvous Observation City Hotel**
	FREE EVENING (Optional evening in Fremantle)

Wednesday 13 October 2010

9.00am	**Coach departs for site visit**
9.30am	**Site visit at CSIRO**
12.30pm	**Lunch – CSIRO cafeteria**
1.15pm	**Coach departs for Perth Airport and then Rendezvous Observation City Hotel**

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Australian Academy of Science

Introduction

The Australian Academy of Science was established by Royal Charter in 1954 by Her Majesty Queen Elizabeth II. Modelled on the Royal Society of London, it is the national institution representing science in Australia. Although the Academy receives some financial support from the Australian government, it is an independent body and has no statutory obligation to government.

The Academy's objectives are to promote science through a range of activities. It has five major program areas:

- recognition of outstanding contributions to science
- national science education
- public awareness of science
- science policy
- international scientific relations.

Structure of the Academy

The work of the Academy is founded on the knowledge and experience of its Fellows. The Fellowship of the Academy is made up of approximately 430 of Australia's top scientists, eminent in some branch of the physical or biological sciences.

The Council manages the business of the Academy. The decisions of the Council are carried out by the secretariat in Canberra, overseen by an Executive Committee.

Sixteen Fellows are elected to the Academy each year by their peers, and occasionally Corresponding Members or additional Fellows join through special elections. Fellows contribute to the Academy in an honorary capacity by serving on Council, committees and as advisers.

Recognition of excellence

The Academy encourages and rewards excellence in science through a number of medals and lectures. Outstanding research by both early-career and senior researchers is recognised through several annual awards, such as the Pawsey and Gottschalk medals.

Public awareness of science

The Academy produces reports, conference proceedings and other publications. The Academy shares editorial responsibility with CSIRO for eleven Australian journals of scientific research. *Interviews with Australian scientists* is a DVD series in which some of Australia's greatest scientists talk about their research and scientific achievements.

National science education

The Academy advises governments on science education and produces a number of educational materials. *Nova: Science in the news* is an online educational resource for schools. Another innovative initiative linking the teaching of science with the teaching of literacy in Australian primary schools is an Academy program called *Primary Connections*. The success of *Primary Connections* has recently led to the development of another science education program, *Science by Doing*, aimed at secondary school teachers and their students.

Science policy

As an independent body of Australia's leading research scientists, the Academy brings together experts from universities, industry and government to consider and report on scientific issues. The Academy supports 21 National Committees that foster a designated field of science and serve as a link between Australian and overseas scientists in that field. The committees comment on proposals and advise on science policy. The Academy has published many reports and position statements on public issues such as stem cell research, genetic engineering and climate change. It also makes submissions to government ministers and parliamentary enquiries.

International scientific relations

The Academy represents Australia on the International Council for Science and about 30 of its affiliated bodies. As well as organising several regular international symposia on a range of scientific issues, the Academy operates a program in international scientific collaborations to improve Australian access to global science and technology in North America, Europe and north-east Asia. The Academy is also active in organising significant national and international scientific conferences

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The Royal Society

Introduction

The Royal Society is a Fellowship of the world's most distinguished scientists, which promotes the advancement of science and its use for the benefit of humanity and the good of the planet.

Founded in 1660, the Society has three roles: as the UK academy of science promoting the natural and applied sciences, as a learned society, and as a funding agency.

The Royal Society has had a hand in some of the most innovative and life-changing discoveries in scientific history. It supports the UK's best and brightest young scientists, engineers and technologists, influences science policy, debates scientific issues with the public and much more.

Fellows of the Royal Society

The Society's foundation is its Fellowship, which is made up of almost 1400 of the most eminent scientists, engineers and technologists from the UK and the Commonwealth, as well as 143 Foreign Members from around the world. Previous Fellows include Isaac Newton, Christopher Wren, Michael Faraday, Charles Darwin, Ernest Rutherford and Dorothy Hodgkin. The President of the Royal Society is Lord Martin Rees PRS, and the Foreign Secretary is Professor Lorna Casselton FRS

Funding

Through its research fellowships and funding programs, the Royal Society works in partnership with universities and industry to invest in more than 1600 scientists to develop the ideas that will improve the quality of our lives. Our support ranges from postdoctoral level to senior professorships and grants for various purposes ranging from conference travel to the modernisation of laboratories. Our international grants program enables high calibre scientists to initiate collaborations, exchange ideas and experience from the world's leading researchers.

Science policy and international work

The Society's work in science policy is moving up a gear through the establishment of the Science Policy Centre, formally launched for our 350th anniversary. A growing range of critical areas of public policy have scientific dimensions, and the Royal Society has an important role to play in offering expert advice and analysis.

The Science Policy Centre undertakes a range of activities to ensure that the Royal Society is one of the world's most influential and authoritative sources of scientific advice. Its work covers four broad themes: sustainability, innovation, governance and diplomacy. Each year, we publish three or four in-depth reports and we undertake many other types of activity, including workshops and seminars, short statements, private briefings for policymakers and responses to media enquiries.

International engagement has always been an integral part of the Royal Society's mission. Our international work encourages global cooperation on science policy and promotes individual and institutional scientific capacity-building in developing countries. The Society is an active and influential member of many international scientific organisations and supports an international grants program to initiate partnerships between UK scientists and the world's leading researchers.

Science communication

The Society's innovative program of inspirational activities helps us reach a wider audience. From talks, lectures, prizes, awards and exhibitions to the increased use of new media, we stimulate interest around important scientific issues.

We offer direct access to the scientists behind some of the very best of UK science. Our annual Summer Science Exhibition comprises competitively selected exhibits with plentiful hands-on and interactive participation, giving visitors the opportunity to talk to the scientists behind the work.

Education

The Society's interest in education stems from a belief that knowledge of science and mathematics is important for an individual's success in life. Our unique position in the science community, combined with an excellent reputation in the education community, means that we can provide influential and unique policy advice, and support activities that bring together the best of science and education for the future of young people.

Centre for the history of science

An extraordinary and unrivalled record of the development of science that spans nearly 350 years, the Society's Centre for the History of Science is home to our priceless archives. It also focuses on widening access to our collections through the online presentation of heritage material, through a series of talks, lectures and conferences, and by encouraging a community of historians to see the Society as a hub for debate and research.

For more information on any of the Royal Society's activities,
please visit http://www.royalsociety.org
or contact Miss Ruth Cooper (ruth.cooper@royalsociety.org).

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Dr Elvira Poloczanska, Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia (Climatology) – **Australian Co-Chair**
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Dr Tracy Ainsworth, James Cook University, Australia (Microbiology)
Dr Michael Steinke, University of Essex, UK (Microbiology)
Dr Agatha de Boer, University of East Anglia, UK (Physics)
Dr Ming Feng, CSIRO, Australia (Physics)

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Miss Ruth A Cooper, The Royal Society, UK

Speaker abstracts

Applied ecology – People as drivers of change in marine ecosystems

People as drivers of change in marine ecosystems

Dr Jasmin Godbold
Postdoctoral researcher, University of Aberdeen

As a significant proportion of the human population is dependent on the marine environment for the provision of food, shelter, economic prosperity and wellbeing, marine ecosystems are continually subjected to intense human pressures. Coastal and open ocean systems are affected directly by exploitation, pollution, habitat destruction and transformation, and indirectly through climate change and related perturbations of ocean biochemistry.

Whilst human activities are known to have reduced marine biodiversity, altered food-web dynamics, reduced the abundance of habitat-forming species, and shifted species distributions, the ecological consequences of human-induced climate change are increasingly emerging, indicating direct effects on ecosystem processes and human wellbeing.

Over the past 100 years the world's oceans have not only acted as the planet's heat sink, with surface waters increasing by 0.6°C, but have also absorbed about one-third of anthropogenic CO_2, resulting in ocean acidification of surface waters. Such changes in ocean chemistry have had strong impacts on key biological processes, including the distribution, abundance, size and productivity of marine organisms throughout the world's oceans. These changes have also impacted life-history characteristics of many species. Alterations in global phytoplankton communities have already reduced annual primary production by 6% since 1980, while changes in community composition and life-history characteristics of other marine organisms have further altered the overall functioning, biogeochemistry, and food-web dynamics of coastal and open-ocean ecosystems.

Understanding human-induced change: Determining historical baselines of exploited marine ecosystems

Dr Julia Blanchard

Research Fellow, Imperial College London

Marine ecosystems have been greatly impacted by fishing and other human activities. Conservation aims to restore marine ecosystems closer to pristine states, although these states are often not straightforward to determine.

Two sources of information are available for assessing what a 'pristine' marine ecosystem would look like: (1) historical data on the state of marine ecosystems under conditions of lower human impact, and (2) models that represent natural dynamics under current conditions that can predict the state of ecosystems without fishing.

Historical data available for most marine ecosystems do not extend back more than 20-30 years, although they have been exploited for millennia. Data over these time scales have shown that the abundance of large predatory fish has fallen with rising exploitation rates. Changes can be difficult to interpret, however, when they coincide with major fluctuations in environmental conditions, such as rising sea temperatures.

Simple ecosystem models suggest that total biomass of large fish under current levels of exploitation is 90-99% lower than without fishing. The relative abundance of large fish reported in a historical dataset a century ago suggests the same magnitude of change has occurred.

Although both approaches have limitations, combining models and long-term datasets can help to improve understanding of the key processes that drive ecosystems undergoing directional change. Future research on comparing the vast array of models and data may help to develop appropriate target baselines that take into account a wider range of impacts and natural changes occurring in the world's oceans.

Embracing change: Exploring implications of climate change for marine ecosystems

Dr Beth Fulton

OCE CSIRO Science Leader, Head of Ecosystem Modelling CSIRO Marine and Atmospheric Research

Understanding is a key component of successful management. The competing demands on marine systems and their changing nature can make them a management challenge – both uncertain and complex. Models can help simplify the task by providing tools for system understanding and for exploring alternative management options. In particular, models can get beyond direct impacts to explore the (often crucial) role of indirect effects and trade-offs between system components and objectives of different user groups. As an example, one area where significant insights can be gained is around the potential effects of global climate change on marine ecosystems.

Feedback and change are fundamental features of ecosystems, something global change has highlighted. Changes in the physical environment will see shifts in species ranges, community compositions and ultimately the form and function of ecosystems and the human societies that exploit them. What these shifts will be depends on which of the competing (and potentially counteracting) mechanisms dominates through space and time. This means that changes are unlikely to be simple or linear; there will be winners, losers and surprises. It also means that management will be complex and non-stationary, presenting management, scientific and statistical challenges.

Chemistry – How GEOTRACES is shaping our knowledge of marine biogeochemical cycles

An introduction to the GEOTRACES program

Dr Alex Baker

Reader, University of East Anglia

GEOTRACES is an international study of the global marine biogeochemical cycles of trace elements and their isotopes. The GEOTRACES mission is:

To identify processes and quantify fluxes that control the distributions of key trace elements and isotopes in the ocean, and to establish the sensitivity of these distributions to changing environmental conditions.

The GEOTRACES mission can be expressed as three overriding goals:

- to determine full water column distributions of selected trace elements and isotopes, including their concentration, chemical speciation, and physical form, along a sufficient number of sections in each ocean basin to establish the principal relationships between these distributions and with more traditional hydrographic parameters;
- to evaluate the sources, sinks, and internal cycling of these species and thereby characterise more completely the physical, chemical and biological processes regulating their distributions, and the sensitivity of these processes to global change; and
- to understand the processes that control the concentrations of geochemical species used for proxies of the past environment, both in the water column and in the substrates that reflect the water column.

GEOTRACES will be global in scope, consisting of ocean sections complemented by regional process studies. Sections and process studies will combine fieldwork, laboratory experiments and modelling. Beyond realising the scientific objectives identified above, a natural outcome of this work will be to build a community of marine scientists who understand the processes regulating trace element cycles sufficiently well to exploit this knowledge reliably in future interdisciplinary studies.

This presentation will provide an overview of the GEOTRACES program, as an introduction to the following two talks. Further details about GEOTRACES can be found at http://www.geotraces.org/.

Different biogeochemical processes drive seasonal iron supply in the Southern Ocean south of Australia

Dr Andrew Bowie

Senior Research Scientist Antarctic Climate and Ecosystems Cooperative Research Centre, University of Tasmania

Climate change is projected to significantly alter the delivery (stratification, upwelling, boundary currents, aridification of land masses, glacial melt) of iron to the Southern Ocean. During the International Polar Year (2007-2009), three Australian-led GEOTRACES projects set out to investigate spatial and temporal differences in trace element supply, their relative importance for Southern Ocean productivity, and how these mechanisms may alter with future climatically-driven change. Here, we present a synthesis of these observations for the subantarctic and polar Southern Ocean and the Antarctic sea-ice zone south of Australia. Distinct spatial and temporal variability indicated differences in the mode and strength of iron supply mechanisms, with higher stocks and fluxes observed in northern subantarctic waters. Subantarctic phytoplankton blooms were thus driven by both seasonal iron supply from southward advection of subtropical waters and by wind-blown dust deposition, resulting in a strong decoupling of iron and nutrient cycles.

Biological uptake across the broader Southern Ocean during the growing season resulted in widespread iron limitation during autumn, with little evidence of resupply later in the season. Instead, upwelling of circumpolar deep water resulted in elevated iron supply in the Antarctic divergence. Our data also indicate the importance of iron delivery from bottom sediments and hydrothermalism for the deep ocean inventory, sources that have not previously been included in biogeochemical models for the region. We discuss the broader global significance of our observations for other ocean regions sensitive to climate-driven changes in iron supply.

References

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www.acecrc.org.au
www.austracemarine.net
www.geotraces.org
www.ipy.org

Understanding global marine biogeochemical cycles – why measure isotope ratios on every single GEOTRACES cruise?

Dr Tina van de Flierdt

Senior Lecturer, Imperial College London

The overall goal of the international GEOTRACES program is to understand the cycling of trace elements and their isotopes (TEIs) in the ocean. TEI cycling in the ocean is critical to the functioning of ocean ecosystems and to the carbon cycle, and monitoring TEIs in the ocean can reveal information on human pollution and water mass movement. However, our current understanding of the distribution of TEIs in the ocean, the processes that determine these patterns, and their vulnerability to changing environmental conditions, is very limited. This lack of knowledge in turn affects our ability to use TEIs to reconstruct biogeochemical cycles in the past – a key component in unravelling past climate change. This talk will focus on how we can use isotope systems (stable, radiogenic and radioactive) to constrain modern and past processes in the ocean. The focus will be on the radioactive and radiogenic isotope systems that will be measured on every GEOTRACES cruise (i.e. Pa-231, Th-230, Pb isotopes, Nd isotopes), and will extend to a discussion of new and promising isotope systems (i.e. Cd isotopes).

Climatology – Mitigating climate change: Enhancing carbon sequestration in the ocean

Geoengineering techniques to enhance carbon sequestration in the ocean

Dr Peter Strutton

Associate Professor, Institute for Marine and Antarctic Studies, University of Tasmania

This session considers geoengineering techniques to enhance carbon sequestration in the ocean. This introductory talk will describe the range of techniques that have been proposed to date, followed by elaboration from the subsequent speakers.

Of the current geoengineering techniques on the table, iron fertilisation has been subject to perhaps the most popular attention and scientific experimentation. Primary productivity in vast areas of the global ocean – the north Pacific, tropical Pacific and Southern Ocean – is limited by the availability of dissolved iron, an essential plant nutrient. Addition of iron was proposed as a mechanism to stimulate productivity and export of biogenic carbon to the ocean sediments, but experiments thus far have produced far less export than predicted. Enhancing ocean mixing, perhaps by the installation of 'upwelling tubes', could enhance nutrient fluxes to the surface, but also possibly enhance the release of CO_2 to the atmosphere, depending on elemental ratios and subsequent drawdown. Coastal vegetation and ecosystems represent a small areal component of the ocean, but have potential for increased carbon storage and have been considered as sites of manipulation.

While the aforementioned techniques focus on the oceans' 'biological pump', there are also proposals to manipulate the 'solubility pump' by increasing ocean alkalinity. More direct methods of carbon storage include injection of CO_2 into the deep ocean in 'lakes' or directly into geological formations.

This introductory talk will briefly describe the theory, implementation and pros and cons of each of these techniques.

Ocean fertilisation: Practice, theory and ethics

Professor Anya Waite

Professor, University of Western Australia

Over the last 20 years, ocean fertilisation experiments have tested the notion that artificial algal blooms can be used for carbon sequestration. Here I explore the scientific and practical challenges of these experiments, including outcomes from the first Southern Ocean experiment (SOIREE) in 1999, where I made the first measurements of iron-induced vertical carbon fluxes in the Southern Ocean. I then discuss the opportunities and challenges offered by these approaches, assess the long-term impact of patch fertilisation work, and highlight the most recent controversies in the field both scientifically and ethically.

Mitigating climate change: The role of ocean geoengineering

Dr Nem Vaughan

Tyndall Centre for Climate Change Research Fellow, University of East Anglia

Enhancing carbon sequestration in the ocean is one of a number of 'geoengineering' ideas. To assess the role of ocean geoengineering it is essential to provide the broader context, both in terms of the scale of the mitigation challenge and in terms of what alternative geoengineering ideas have to offer. Geoengineering is defined as large-scale intervention in the Earth system intended to counteract man-made climate change, and can be broadly split into two types, (1) carbon dioxide removal (CDR), i.e. enhancing carbon stores on land or in the ocean, or engineered CO_2 removal; and (2) solar radiation management (SRM), i.e. reflecting more sunlight back to space. Using a simple Earth system model that incorporates carbon cycle-climate feedbacks, the capacity of, and interactions between, geoengineering (CDR and SRM) and mitigation (man-made CO_2 emission reductions) are investigated. Results are presented in terms of atmospheric CO_2 concentration, changes to major carbon reservoirs, and global mean temperature. These results illustrate the magnitude and timing constraints of mitigation, outline some key challenges for geoengineering 'solutions' and highlight a third component, adaptation. In addition to large-scale questions of capacity, there are a number of other metrics by which ocean geoengineering ideas can be compared and contrasted with alternative geoengineering interventions, such as side effects, reversibility, verification, deployment scale and timing. Based on a review of the literature, a summary of these metrics is presented and, along with the modelling results, is used to highlight some of the critical challenges for ideas to enhance carbon sequestration in the ocean.

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Geosciences
– The time machine on the ocean floor

A new Pacific record of carbonate compensation depth

Dr Heiko Pälike

Reader, University of Southampton, School of Ocean & Earth Science

Integrated Ocean Drilling Program (IODP) Expeditions 320 and 321, 'Pacific Equatorial Age Transect' (Sites U1331-U1338), were designed to recover a continuous Cenozoic record of the palaeoequatorial Pacific by coring above the palaeoposition of the equator at successive crustal ages on the Pacific plate. These sediments record the evolution of the palaeoequatorial climate system throughout the Cenozoic. It was possible to drill an age-transect ('flow-line') along the position of the palaeoequator in the Pacific, targeting important time slices where the sedimentary archive allows us the reconstruction of past climatic and tectonic conditions. The Pacific Equatorial Age Transect (PEAT) cored eight sites from the sediment surface to basement, with basalt aged between 53 to 18 Ma. The PEAT program allows the reconstruction of extreme changes of the calcium carbonate compensation depth (CCD) across major geological boundaries during the last 53 m.y. A very shallow CCD during most of the Palaeogene makes it difficult to obtain well-preserved carbonate sediments during these stratigraphic intervals, but we recovered a unique sedimentary biogenic sediment archive for time periods just after the Palaeocene-Eocene boundary event, the Eocene cooling, the Eocene/Oligocene transition, the 'one cold pole' Oligocene, the Oligocene-Miocene transition, and the middle Miocene cooling. Together with older ODP and DSDP drilling in the equatorial Pacific, we can also delineate the position of the palaeoequator and variations in sediment thickness from approximately 150°W to 110°W longitude. We will present a preliminary reconstruction of the Pacific carbonate compensation depth (CCD) throughout the time interval recovered.

Using microfossil records to understand global climate change: small is beautiful

Dr Samantha Gibbs

Royal Society University Research Fellow, University of Southampton, School of Ocean & Earth Science

Through their 220 million year fossil history, calcareous nannoplankton have experienced a wide spectrum of carbon cycle and climate perturbations from the local to the catastrophic. How they have responded to these events is crucial for our understanding of what has shaped our modern plankton diversity and also what fate they may suffer with our current climate change scenario. Calcareous nannoplankton have, arguably, the most complete (taxonomic and stratigraphic) fossil record of any group of organisms. Each sample of pelagic sediment can contain up to millions of microfossils per gram of sediment, with a diverse array of species, permitting the collection of huge data sets. The fossil record therefore presents an opportunity to examine the cumulative biotic outcome of climate change events, including macro- and micro-evolutionary patterns and local and regional-scale migrations. Coupled with the development of increasingly more sophisticated techniques for documenting changes in species composition, geochemistry and morphometry, we can also utilise 'microfossils' as sensitive proxies for reconstructing environmental change, invaluable in the modern fields of palaeoceanography and palaeoclimatology.

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The tropical time machine: Past changes, future challenges

Dr Steven Phipps

Research Fellow, University of New South Wales

The Earth's climatic history is written on the floor of its oceans. In shallow tropical seas, the annual growth rings of corals record seasonal changes in temperature and salinity. Elsewhere, chemical signatures in marine sediments can be used to reconstruct past changes in ocean temperature on timescales ranging from thousands to millions of years.

This presentation will focus upon the tropical oceans, and particularly upon the story of El Niño. The dominant mode of natural variability within the climate system, El Niño influences climate extremes across the globe. Yet fossil corals from across the Pacific Ocean show that major changes have taken place in its behaviour over the past 10,000 years. El Niño events have become stronger and more frequent, with evidence of rapid shifts between different regimes of variability. By combining the coral data with climate model simulations, we can explore the physical mechanisms that have driven these changes. This reveals that cyclical changes in the Earth's orbit around the sun were the dominant driving mechanism but that other, as yet unidentified, mechanisms were also at work.

Two challenges face the next generation of scientists. The first is to extend the temporal and spatial coverage of the marine record, particularly in the southern hemisphere. The second is to fully integrate the data with climate system models, providing a framework within which to enhance our understanding of climate system dynamics. If we can rise to these challenges, then the time machine on the ocean floor will be able to tell us about the future, as well as the past, of the Earth's climate.

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Macrobiology – The effect of ocean acidification on marine ecosystems

An introduction to ocean acidification

Dr Paul R. Halloran

Ocean Biogeochemistry Research Scientist, Met Office Hadley Centre

When considering the response of our climate to possible future CO_2 emissions, we rely on the oceans absorbing a large component of the emitted CO_2, and therefore significantly mitigating climate change (IPCC, 2001). Although from a climatic standpoint this CO_2 uptake is beneficial to society, in the ocean that CO_2 dissociates to carbonic acid, reducing the pH, significantly modifying marine chemistry (Zeebe and Wolf-Gladrow, 2001), and potentially exerting extreme stress on marine ecosystems (Raven et al., 2005). I will briefly introduce the chemical consequences of ocean acidification, and then examine the uncertainty within the biological response. Focusing on calcium carbonate-producing organisms as a case study, I will consider how gaps in our biological understanding feed back to produce further uncertainty within the climate and socially relevant biological systems.

The mode of operation of the carbon cycle varies over different timescales; throughout this talk I will therefore ask what lessons we can usefully learn about contemporary ocean acidification from looking back at previous periods of high atmospheric CO_2 concentration, reconstructed from the geological record.

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Cold and old – the problems of understanding implications of ocean acidification for cold-water marine organisms

Dr J Murray Roberts

Reader in Biodiversity, Heriot-Watt University

Ocean acidification, sometimes termed 'the other CO_2 problem', has become one of the most pressing concerns facing human society and our stewardship of the seas. It has been estimated that the oceans have absorbed approximately a quarter of anthropogenic CO_2 emissions and this is fundamentally altering the chemistry of the seas by reducing their pH and lowering the concentration of carbonate ions available to marine organisms that make shells or skeletons from calcium carbonate. Recent estimates suggest that the oceans are now 30% more acidic than they were before the industrial revolution. From the fossil record we know that past perturbations in seawater carbonate chemistry have caused mass extinctions of organisms like scleractinian corals, but the rate of change we are now seeing is unprecedented. What effects will these changes have on marine organisms? Will they be able to adapt or will the rate of change simply be too rapid? What lessons, if any, can we learn from the fossil record? This talk will review work that has attempted to understand how ocean acidification might affect marine animals, particularly the ecosystem engineering species that create habitat for others. It will consider the methods used to create acidified ocean conditions and the mismatch in timescales between laboratory projects and the growth rates and reproductive cycles of marine species – particularly those in cold waters with long life spans and slow growth rates.

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Climate change effects in tropical marine ecosystems

Dr Nick Graham

Research Fellow, James Cook University

Climate change is altering the structure and function of tropical marine ecosystems in a myriad of ways. Tropical marine ecosystems are typified by high biological diversity, and a high dependence of people in adjacent countries on natural resources. Therefore, understanding the effects of climate change on these ecosystems and how these effects may be mitigated is a crucial challenge. Carbon dioxide concentration in the atmosphere is expected to exceed 500 parts per million by 2050 to 2100, which is leading to acidification of seawater. This talk will discuss the impacts of ocean acidification of tropical marine species, from plankton, to habitat-forming reef corals and crustose coralline algae and finally the development and behaviour of fishes. The interplay between ocean acidification and sea surface temperature increases and anomalies will be explored, with a focus on the structural integrity and long-term maintenance of complex marine ecosystems. There will be winners and losers in tropical marine ecosystems with our changing climate, and this is becoming more predictable. This information, and the vulnerability of assemblages to other anthropogenic impacts, will be synthesised to assess if local management actions may buy time for tropical marine ecosystems while the climate is stabilised.

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Mathematics
– Small things matter

How and why do small things matter?

Dr Andy Hogg

Fellow, Australian National University

The large-scale ocean circulation is comprised of a system of gyres and currents that transports heat, salt and nutrients around the globe. Modelling of these large scales is motivated by climate-related questions: how does the ocean take heat from one region of the Earth to another; and how might this change in the future? However, if heat transport is achieved primarily via large-scale currents, why would we care about the smaller scales of motion?

In this talk, I will begin by defining the different scales of motion – from large (1000 km) scale to the mesoscale (10-100 km) and beyond to the tiny (mm) scales of turbulence. I will provide examples of how and why small scales in the ocean can either directly alter the larger-scale circulation, or else can generate phenomena which dominate ocean behaviour. Examples of small scales altering the circulation include the non-linear interaction between ocean eddies (mesoscale) and the subtropical gyres (large scale), as well as turbulent mixing (on the mm scale) influencing the global ocean stratification. On the other hand, the Southern Ocean provides a location where the flux of heat towards Antarctica is dominated by eddy mixing, while the poleward transport of heat by the mean flow is negligible.

Taken together, these examples indicate the need for future ocean-climate models to either explicitly resolve more scales of motion, or else to improve parameterisations in an effort to improve representation of the global flow field.

Ocean climate models – how can we judge their skill?

Professor Matthew England

ARC Federation Fellow and joint Director of the Climate Change Research Centre, University of New South Wales

Around 80% of the additional heat trapped by anthropogenic greenhouse gases has been absorbed by the oceans, along with about one-third of the world's industrial carbon emissions. In addition, the oceans fundamentally moderate extremes in climate and transport vast amounts of heat from the tropics to high latitudes. They are thus central to the planet's climate, its variability, and future change. Yet the models used to represent the ocean in climate prediction systems do not explicitly resolve important fundamental physics – particularly eddies and ocean convective overturn. In this talk I will outline the essential workings of ocean climate models, how they behave, and what physics they are based on. This will include an evaluation of how to test their skill, their shortcomings, and how they can still be improved.

Resolving the ocean mixing problem: Progress through observations

Dr Stephanie Waterman

Research Fellow / Research Associate, National Oceanography Centre / Grantham Institute for Climate Change

Uncertainty about the rates and mechanisms by which small-scale dissipation and mixing occur in the oceans remains one of the outstanding issues in physical oceanography. Mounting evidence from regional studies reveals dramatic spatial and temporal variability in ocean mixing. However, knowledge of the global landscape is far from complete and the implications of patchy mixing for global circulation patterns are largely unknown. Furthermore, mixing in all contexts is conditioned by the larger-scale flow in ways that are likely important but poorly understood.

In this talk I will describe the 'ocean mixing problem' and an observational project that seeks to contribute to its resolution. The Southern Ocean Fine Structure (SOFINE) project aims to observe components of the ocean circulation in a mixing hotspot of the Southern Ocean at various time and length scales, and from these observations map and understand the distributions of dissipation and mixing. The big picture questions concern characterising the rates and mechanisms of observed mixing, understanding their implications for the larger-scale circulation, and appreciating the physical processes required to accurately represent mixing in numerical models of the ocean circulation.

I will describe SOFINE results that point to the importance of the large-scale flow in modulating the highly spatially variable map of turbulent dissipation and mixing we observe in the region. I will argue that this has important implications for the global map of energy dissipation, the dynamics of the large-scale circulation in the Southern Ocean, and our parameterisations of turbulent mixing processes in numerical models. Finally, I will suggest possible ways to translate understanding gained from SOFINE into a dynamically-based and geographically-variable parameterisation of turbulent diffusion, which is required not only to properly represent the current state of the ocean, but also to be able to predict its future evolution in a changing climate.

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Microbiology – Symbiosis: From reef builders to deep sea vents

Microbes and symbiosis: Sentinels for marine ecosystem health

Dr Nicole Webster

Research Scientist, Australian Institute of Marine Science

In the marine environment, microbes are involved in symbiotic relationships with a wide range of organisms. These obligate symbiotic partnerships are vital for the continued health of the animal with microbes undertaking many important functions, including nutrition, reproduction, structural support, metabolism of waste products from the host, chemical defence and the production of secondary metabolites. There are also many examples of symbioses where the nature of the relationship between the host and their symbionts is not yet understood. With such a wide range of functions, environmental conditions which disturb the distribution or abundance of symbiotic marine microbes could have significant effects on host fitness and survival. Symbiotic microbes are ideal indicators for stress in marine systems as they are sensitive to small environmental perturbations.

With measurable increases in sea surface temperatures over the last 30 years, the severity and frequency of coral bleaching events have increased. This has resulted in a large research effort directed towards understanding the impact of elevated seawater temperature on the symbiotic relationship between corals and zooxanthellae. However, in more recent years there is growing recognition that 1) microbial partners other than zooxanthellae represent an important component of coral symbioses, and 2) microbial symbiosis is critical for a wide range of other marine plant and animal species. For instance, the common Great Barrier Reef sponge *Rhopaloeides odorabile* is an ideal model to assess the impact of climate change on reef health. This sponge hosts incredibly dense and diverse microbial communities which are highly stable over wide geographic and temporal gradients. Experimental research has shown that environmental stressors such as heavy metal pollution, elevated seawater temperature and disease cause a disruption to the stable symbiotic microbial community that is correlated with a decline in sponge health. Breakdown of symbiosis and stress in sponges occurs under the same conditions that cause coral bleaching, emphasising the need to explore multiple models when assessing the broader implications of climate change. Marine symbioses represent a useful 'canary in the mine shaft' model for evaluating how climate change will impact on the larger marine ecosystem. Shifts in the microbial partners of these close symbiotic associations will provide an early indication of stress and impact.

The 'bacterial-algal plug-in' model – a concept to describe symbioses in the surface ocean

Dr David H Green

Lecturer in Molecular Microbial Ecology, Scottish Association for Marine Science

The life cycle of marine algae in the oceans is of fundamental importance to all life on this planet. About 50% of the oxygen we breathe is produced by marine algae, they are a major sink of carbon dioxide and they form the basis of the marine food web. It is clearly important that we understand the physiology of these organisms, both as key components in global biological processes, and for their biotechnological potential. The central dogma is that the appropriate combination of light, temperature and nutrients governs algal growth. However, over several decades some researchers have emphasised that this process is more complex and that algae are dependent on an environment that contains bacteria. These bacteria are generally recognised as consumers of algal organic matter, but their frequent co-association with marine algae suggests that they may also contribute to algal fitness. Yet, very few concrete examples have demonstrated how bacteria benefit algal growth. This may be because the interaction is at a very small scale, or it may be that they are so intricately linked with the life of algae that it is very difficult to differentiate their roles, or indeed that this positive association does not exist. This presentation will put forward a concept – the 'bacterial-algal plug-in' model of symbiosis – of what these beneficial interactions may look like and how they operate in the oceans. Examples will be given to illustrate these points focusing on our algal-bacterial interaction work, and more recently, iron cycling. The greatest significance of these interactions may be to 'future-proof' primary productivity in the face of environmental change, through the co-evolution of algae and their bacterial partners.

Corals and their associated microbiota: Implications for health, bleaching and disease

Dr David Bourne

Research Scientist, Australian Institute of Marine Science

Increasing sea surface temperatures present a major challenge to the health of the world's coral reefs, particularly in light of evidence that bleaching and disease outbreaks have contributed to significant loss of both key reef organisms and coral cover [1]. Corals shape their microbial partners, creating complex associations with shifts in the coral microbiota providing an indicator of stress that contributes to reduced coral fitness. During a natural bleaching event on the Great Barrier Reef, the normal microbial community shifted with increasing temperature and colony bleaching correlated with distinct changes in the microbial community [2]. A metagenomic approach was adapted to investigate how bleaching affected the microbial functional component of the coral holobiont during this natural bleaching event. Bacteria of the genus *Vibrio* have been implicated in a number of coral diseases, often as a response to compromised health and changing environmental parameters. With increasing sea surface temperatures predicted to enhance coral disease outbreaks, the molecular-based mechanisms of bacterial infection and their response to environmental triggers is currently one area of active study. Development of robust diagnostic tools is also an important resource to understand disease outbreaks. A quantitative PCR (qPCR)-based *Vibrio coralliilyticus* detection assay has been successfully developed and validated to target this coral pathogen. The assay represents a novel approach to coral disease diagnosis and provides a useful tool that allows coral pathogen detection, pathogen load monitoring, and identification of pathogen sources, vectors, and reservoirs. Investigations of another coral disease, black band disease (BBD), have demonstrated the importance of light and temperature in enhancing the progression of the microbial mat implicated in coral death [3]. These environmental factors are also important in driving shifts in the complex microbial community with increase in sulphate-reducing bacteria within the lesion particularly facilitating the pathogenesis of BBD.

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Physics – Deep water formation: Past, present and future

High latitude sources of deep water formation

Dr Simon Marsland

Senior Research Scientist, CSIRO Marine and Atmospheric Research *and* Centre for Australian Weather and Climate Research, a partnership between CSIRO and the Bureau of Meteorology

The deep ocean is predominantly replenished with dense waters that are formed at high latitudes. Freezing air temperatures over the Arctic and Southern Oceans drive the formation of sea ice. New sea ice undergoes a process of brine rejection, releasing considerable quantities of salt to the upper ocean. The resultant increase of ocean salinity increases the density of seawater, as does the cooling of the ocean surface via the flux of heat from the relatively warm ocean to the much colder atmosphere. The increase in density of the ocean surface water leads to gravitational instability that drives deep convection that can directly replenish the deep ocean. Alternatively, over the relatively shallow continental shelves, convection penetrates to the bottom and produces dense shelf waters that can overflow down the continental slope and into the abyssal ocean. In the northern hemisphere these processes result in the formation of North Atlantic Deep Water (NADW). In the southern hemisphere they produce Antarctic Bottom Water (AABW). The global circulations of both NADW and AABW are the major components of a global thermohaline (heat and salt) circulation (THC). The THC is of great importance in the ocean's storage and cycling of heat, fresh water, carbon, and other ocean properties. Understanding how the THC will change under global warming is essential for determining the magnitude of climate change over decadal to centennial timescales. Changes are already detectable in sea ice coverage (particularly a reduction in the Arctic summer minimum), and in deep ocean watermass properties (for example the cooling and freshening of bottom waters in the Southern Ocean).

Stability of North Atlantic deep water formation

Dr Willem Sijp

ARC Australian Research Fellow, University of New South Wales

The North Atlantic is a region of deep water formation where warm saline water is drawn north and sinks to great depths upon heat release to the atmosphere. This process is responsible for significant northern hemisphere warming and constitutes a key part of the global oceanic meridional overturning circulation. Several modelling studies indicate that this process may halt under sufficient freshening at the sinking regions by, for instance, enhanced precipitation. It is uncertain whether an absence of deep sinking can remain indefinitely, or whether a recovery of this circulation is inevitable. In the southern hemisphere, very cold water originating from marginal seas sinks to great depth, ventilating the bottom ocean. In contrast to the northern hemisphere, enduring cessation of this sinking process in response to melt water discharge does not occur. Nonetheless, the latitudinal position of the southern hemisphere westerlies exerts a strong influence on the ventilation rate of the deep ocean from Antarctica. Furthermore, the nature of this deep sinking process depends on the depth of the Drake Passage sill. A shallower sill allows a greater oceanic heat transport to Antarctica, leading to warmer conditions there.

Deep water formation: Past, present and future

Dr Babette Hoogakker

Postdoctoral Researcher, Department of Earth Sciences, University of Cambridge

Meridional overturning circulation may change in the future, either through natural or anthropogenic perturbations. Understanding how ocean circulation responds to different climate states (e.g. glacial versus interglacial) is therefore crucial. As there are few direct observations available before the industrial revolution, most of our understanding originates from (interpretation of) deep sea sediment proxy-measurements and model simulations.

Here, I will review various proxies that are used to reconstruct deep water palaeo-nutrients, flow speed and sources, and discuss how they have contributed to our understanding of glacial overturning circulation.

Today, most deep and intermediate water is formed in the high latitudes, with deep water formation in the Nordic Seas and Weddell Sea, and intermediate convection in the Labrador Sea, the subantarctic zone, and to a lesser extend the North Pacific. During glacial times, deep water formation in the Nordic Seas was significantly reduced, allowing Glacial Antarctic Bottom Waters to penetrate the North Atlantic to shallower water depths (up to ~2.8 km). Glacial North Atlantic and North Pacific Intermediate water formation were likely enhanced, but overall glacial overturning circulation was only slightly weaker.

In contrast, episodes of fresh water release in convective areas during glacial times, either through discharge of icebergs during Heinrich cold events in the northern hemisphere or melting of the Antarctic ice sheet during warming events in the southern hemisphere, caused large-scale reduction in Glacial North Atlantic Intermediate and Glacial Antarctic Bottom Water formation respectively.

Science Policy

Dr Ian Poiner

Chief Executive Officer, Australian Institute of Marine Science

Title and abstract to be provided at the meeting

Poster abstracts

Dust inputs to the (sub)tropical North Atlantic Ocean; influence on ocean biogeochemistry

Achterberg, E P[1], Patey, M[1], Rijkenberg, M[1], Steigenberger, S[1], Moorem, C M[1], Hill, P[1], Powell, C[2] and Mahaffey, C[3]

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The (sub)-tropical North Atlantic receives high dust inputs, originating in the Sahara. This presentation will discuss findings from the winter 2008 UK-SOLAS cruise. The cruise was undertaken in winter, when dust inputs to the ocean are enhanced due to strong northeasterly tradewinds bringing dust from north-west Africa. The nutrient concentrations were at nanomolar levels (nitrate 3-260 nM; phosphate 2-99 nM). Two major dust events were encountered during the cruise, resulting in an enhanced supply of Fe, Al, P and N to the surface waters.

Enhanced surface water dissolved Al (up to 50 nM) and Fe (up to 0.37 nM) concentrations were observed in regions subjected to enhanced dust inputs. The dust inputs did not yield immediate important changes in the bacterial community structure or to their productivity. The dust inputs however had a strong influence on diazotrophy in the study region. The diazotrophs have high iron requirements which are met by the supply of atmospheric iron.

Acknowledgement: This project was funded by the Natural Environment Research Council ((NE/C001931/1),) as part of the UK SOLAS project. The title of our project is: The impact of atmospheric dust derived metal and nutrient inputs on tropical North Atlantic near surface plankton microbiota.

High-resolution palaeoceanographic change over 49 kyr in the Southeast Indian Ocean.

Armand, L K, Quilty, P G, Howard W, Fink, D, Shemesh, A, Burckle, L, Crosta, X and Cortese, G

A high-resolution deep-sea Holocene and Late Quaternary record is presented for the first time from the Southeast Indian region. Located at 59°S, close to the modern winter maximum sea-ice boundary and within the Permanently Open Ocean Zone (POOZ), USNS Eltanin core E27-23 provides a high-resolution history with an average sedimentation rate of >20 cm/ky over the first 15,000-17,000 years then ~35.45 cm/ky back to ~ 49,000 years BP. Significant variation in the plankton community enables, by proxy analysis, a detailed picture of the changing cryogenic and oceanographic conditions across the Last Glacial maximum and into the Holocene. Additional isotopic and sedimentological analyses also contribute to the picture of change in establishing the position of the polar front and its influence on the region.

Extreme deepening of the Atlantic overturning circulation during deglaciation

Barker, S

In addition to orbital-scale changes in insolation, the ubiquitous occurrence of millennial-scale climate oscillations associated with glacial terminations of the late Pleistocene suggests that they may be a necessary component of deglaciation. The collapse and resumption of Atlantic Ocean circulation during these terminal oscillations is predicted to lead to an overshoot of the circulation on its resumption, but this phenomenon has not yet been observed. Here we use benthic radiocarbon measurements and carbonate preservation indices to reconstruct ventilation changes in the deep South Atlantic during the last ~40 ka. Our results provide evidence for a particularly deep expansion of the Atlantic overturning cell during the last deglaciation, directly following the weak mode associated with Heinrich Stadial 1. Our modelling results suggest that North Atlantic Deep Water export during this event was greater even than for the interglacial mode. We also show that a similar phenomenon occurred during Dansgaard-Oeschger interstadial event 8 at ~38 ka, following Heinrich Stadial 4. The CO_2 rise and resultant warming associated with an especially weak circulation are apparently sufficient to trigger a switch to particularly vigorous circulation while a wholesale transition to interglacial conditions requires additional forcing at an orbital scale.

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Biogeochemical iron budgets of the Southern Ocean south of Australia: Decoupling of iron and nutrient cycles in the subantarctic zone by the summertime supply

Bowie, A[1], Lannuzel, D[1], Remenyi, T[1], Wagener, T[2], Lam, P[3], Boyd, P[4], Guieu, C[2], Townsend, A[5], Trull T[1,5,6], Griffiths, B[1,6] and SAZ-SENSE team

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Primary productivity in open Southern Ocean waters is limited by the availability of the essential micronutrient iron. Despite this, sources and sinks of iron (both north and south of the polar front) are poorly constrained, resulting in a limited ability to model the effects of climate variability on Southern Ocean ecology, biogeochemical processes, and the uptake of atmospheric carbon dioxide. During austral summer 2007, our comprehensive suite of measurements enabled the construction of the most detailed iron biogeochemical cycles to date, at three contrasting sites in the high-nitrate low-chlorophyll subantarctic and polar frontal Southern Ocean south of Tasmania (Australia). Distinct spatial differences in dissolved and particulate iron forms were observed at the different sites, indicating differences in the mode and strength of the iron supply and removal mechanisms to each region. Our data were consistent with a strong iron source during summer, which resulted in intense phytoplankton blooms (as observed by the MODIS satellite) to the south-east of Australia. In contrast, production in polar frontal waters was primarily driven by iron supplied through Ekman-driven upwelling, resulting in a tight iron-nutrient coupling. Seasonal iron budgets for the three regions demonstrate the multiple sources of iron, their interplay and the complexity of the biogeochemical cycling of iron, and we discuss their broader global significance for other sectors of the Southern Ocean.

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www.acecrc.org.au
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BLUElink> Ocean Model, Analysis and Prediction System (OceanMAPS)

Brassington, G

BLUElink is a joint project of the Bureau of Meteorology, CSIRO and the Royal Australian Navy to develop ocean analysis and forecasting for Australia. In August 2007 the BLUElink> Ocean Model, Analysis and Prediction System (OceanMAPS) was implemented as an operational system through the Bureau of Meteorology offering routine public forecasts of the ocean state and circulation at ~10 km resolution (see www.bom.gov.au/oceanography/forecasts). Applications have included temperature stratification for defence operations; non-tidal coastal sea level for flood warnings and port management; coastal upwelling for public health warnings, coastal fog warnings and marine productivity; surface currents for ship routing, oil-spill tracking, search and rescue, ship salvage and towing, offshore platform operations and marine weather; heat content for tropical cyclone forecasting, marine park management for coral bleaching and climate impacts to coastal precipitation; and numerous eco-tourism, recreational and research applications. BLUElink forecasts produced positive impacts for operations for AMSA operations in the Montara Well oil-spill incident in 2009. The BLUElink project was renewed in 2007 to further improve the performance of the ocean forecasts providing comparable or better performance in the Australian region to other leading international systems. BLUElink-3, to begin in 2010, will undertake to develop a global eddy-resolving prediction system as well as leading research in high-resolution coupled modelling for improved ocean, wave and atmospheric forecasting.

Early Oligocene glaciation and productivity in the eastern equatorial Pacific: Insights into global carbon cycling

Coxall, H

Initiation of Antarctic glaciation approximately 34 million years ago marks the abrupt end of Earth's last natural greenhouse climate and a fundamental step in the evolution of our modern glacial climate state. We present new climate proxy records of glaciation and ocean productivity during this time from eastern equatorial Pacific (EEP) Ocean Drilling Program Site 1218. Stable isotope records ($\delta^{18}O$ and $\delta^{13}O$) of deep-sea benthic foraminifera confirm a stepped-pattern of $\delta^{18}O$ increase indicating rapid ice growth over ca. 400,000 years (kyrs), which is consistent with model predictions of non-linear expansion of Antarctic ice. A new high-resolution record of benthic foraminifera accumulation rate (BFAR) indicates a transient (ca. 500 kyrs) two- to three-fold increase in BFAR relative to baseline Oligocene values associated with Antarctic glaciation. It is possible that improved preservation of benthic foraminifera associated with deepening of the calcite compensation depth (CCD) contributes to the peak, but a number of lines of evidence indicate that the main control is a temporary increase in export productivity. Correlation of our BFAR data set with records of opal accumulation in the Southern Ocean suggests an association between the high and low latitude oceans in this respect. These findings lend support to the idea that the increase in benthic $\delta^{13}C$ across the E-O transition is traceable to increased organic carbon (Corg) burial and associated drawdown in atmospheric CO_2, acting to stabilise early Cenozoic ice-sheets. Intriguingly, however, early Oligocene sediments in the EEP are extremely Corg-poor; proxy pCO_2 records indicate a transient rebound or increase associated with peak early Oligocene glaciation and CCD deepening and the Corg burial hypothesis finds comparatively little support from the results of geochemical box model experiments.

Observed and simulated regional patterns of ocean warming and sea-level rise

Domingues, C M[1], Church, J A[2,3], White, N J[2,3], Monselesan, DP[2], Gleckler, P J[4], Wijffels, S E[2], Barker, P M[3] and Dunn, J R[2]

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Thermosteric sea level (due to ocean warming) is a major factor contributing to the observed global mean sea-level rise in the latter half of the 20th century and is likely to be one of the largest contributing factors in the 21st century. Regional patterns of sea-level rise are produced in response to dynamical processes. Coupled Model Intercomparison Project (CMIP3) model simulations disagree in regional patterns. Comparisons with observations are required to help understand these differences and to increase confidence in projections of regional sea-level rise. Here, we describe updated estimates of thermosteric sea level at global and regional scales, and compare them with CMIP3 climate model simulations. Our estimates indicate a global mean thermosteric sea-level rise of about 0.59 ± 0.07 mm yr-1 for 1961-2008 in the upper 700 m of the oceans, with 15% contribution from the Indian Ocean, 35% from the Atlantic Ocean and 50% from the Pacific Ocean. The thermosteric contribution is about 25-35% of the total sea-level rise. Regional patterns of observed sea-level change are complex and sensitive to the period over which trends are calculated. Comparison with CMIP3 simulations (1961-1999) shows that the ensemble average of models without volcanic forcing lack the observed Pacific Ocean trend patterns and overestimate the observed mean trend. The ensemble average of models with volcanic forcing compare better with the observed Pacific patterns but agree less in the South Atlantic and South Indian oceans. They also underestimate the observed global mean trend. Thermosteric sea-level rise along 40°S is strikingly stronger in non-volcanic models than in volcanic models but intriguingly missing in our observed patterns.

Characterising the macro- and micro-nutrient status of the North Tasman Sea

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The Tasman Sea is one of the most sensitive oceanic regions to changes in climate and iron supply. Current predictions are for this region to warm by 2° by 2060, potentially resulting in a floristic shift in the plankton community toward nitrogen fixers, which have a high iron requirement. However, it remains uncertain to what extent an increase in aerosol iron supply (dust) would aid this floristic shift and its associated impact on the marine food-web. Despite iron being the fourth most abundant element in the Earth's crust (5.63%), the concentration of soluble iron in seawater is a million-fold lower in the nano- to pico-molar range (10^{-9} to 10^{-12} mol L-1). Three research voyages were conducted in 2005, 2006 and 2010 to examine the degree of nitrogen limitation and the role of macro- (ammonium and phosphate) and micro- (iron, zinc and cobalt) nutrients in stimulating the phytoplankton community in the north Tasman Sea. Water column measurements confirmed that these waters are oligotrophic, with surface nitrate and phosphate concentrations less than 10 nmol L-1 and 60 nmol L-1 respectively, and dissolved iron concentrations varying between 0.05 and 0.7 nmol L-1, depending on sporadic dust inputs. Deck-board incubation experiments involving the addition of macro- (ammonium and phosphate) and micro- (iron, zinc and cobalt) nutrients confirm nitrogen availability to be the primary control on phytoplankton production, with phosphate and iron availability playing secondary roles. Future work in the region is focused on using the iron isotope composition of seawater and algae to elucidate iron sources and fluxes.

The role of Indian Ocean temperature anomalies in modulating regional rainfall variability and long-term change

England, M, Ummenhofer, C, Sen Gupta, A and Taschetto, A

In a series of atmospheric general circulation model simulations, the potential impact of Indian Ocean sea surface temperature (SST) anomalies in modulating low- to mid-latitude precipitation around the Indian Ocean rim countries is explored. The relative importance of various tropical and subtropical Indian Ocean SST regions is quantified, both individually and in combination, with a focus on regional rainfall. A mechanism for the rainfall modulation is proposed, by which the SST anomalies induce changes in the thermal properties of the atmosphere, resulting in a reorganisation of the large-scale atmospheric circulation across the Indian Ocean basin. Across western and southern regions of Australia, rainfall anomalies are found to be due to modulations in the meridional thickness gradient, thermal wind, and baroclinicity, leading to changes in the moisture flux onto the continent. The pattern of large-scale circulation changes over the tropical Indian Ocean and adjacent land masses is consistent with an anomalous strengthening of the Walker cell, leading to variations in precipitation of opposite sign across western and eastern regions of the basin. Links between long-term changes in Indian Ocean surface properties and regional precipitation changes in Indian Ocean rim countries are also discussed in a broader context with implications for water management and seasonal forecasting.

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Should we protect the strong or the weak? Risk, resilience and the selection of marine protected areas

Game, E

It is thought that recovery of marine habitats from uncontrollable disturbance may be faster in marine reserves than in unprotected habitats. But which marine habitats should be protected, those areas at greatest risk or those at least risk? We first defined this problem mathematically for two alternate conservation objectives. We then analytically solved this problem for both objectives and determined under which conditions each of the different protection strategies was optimal. If the conservation objective was to maximise the chance of having at least one healthy site, then the best strategy was protection of the site at lowest risk. On the other hand, if the goal was to maximise the expected number of healthy sites, the optimal strategy was more complex. If protected sites were likely to spend a significant amount of time in a degraded state, then it was best to protect low-risk sites. Alternatively, if most areas were generally healthy then, counterintuitively, it was best to protect sites at higher risk. We applied these strategies to a situation of cyclone disturbance of coral reefs on Australia's Great Barrier Reef. With regard to the risk of cyclone disturbance, the optimal reef to protect differed dramatically, depending on the expected speed of reef recovery of both protected and unprotected reefs. An adequate consideration of risk is fundamental to all conservation actions and can indicate surprising routes to conservation success.

Volcanic CO_2 vents reveal the ecosystem effects of ocean acidification

Hall-Spencer, J

The global oceans currently absorb over 25 million tons of human-made CO_2 every day, causing unprecedented changes to ocean chemistry. As well as lowering pH, increased CO_2 has caused declines in carbonate ions and calcium carbonate saturation states but has increased bicarbonate ion concentrations. We are using volcanic carbon dioxide vent systems as 'natural laboratories' to find out how long-term changes in seawater carbonate chemistry affect whole ecosystems in situ. So far, macroalgae, seagrasses, motile invertebrates and sessile invertebrates have been investigated along volcanic gradients in CO_2 levels, revealing winners and losers within benthic communities. All calcifiers (coralline algae, molluscs, polychaete spirorbids, foraminiferans) are strongly reduced in abundance or are absent from acidified areas (mean pH <7.8) and the overall benthic biodiversity is around 30% lower than in normal conditions. However, 67% of the species observed (including seagrass, polychaetes, peracarid crustaceans and invasive species of algae) are resilient to long-term exposures to CO_2 levels predicted for the end of this century and beyond. Recruitment and transplantation experiments show that the combined effects of abnormally high summer temperatures and ocean acidification are detrimental to key groups such as corals and bryozoans.

These in situ observations give support to concerns, based on model predictions and short-term laboratory experiments, that ocean acidification will likely combine with other stressors (e.g. temperature rise and lower oxygen levels) to cause a decrease in coastal marine biodiversity and lead to shifts in ecosystem structure.

Atmospheric CO_2 seasonality and the air-sea flux of CO2: Glacial terminations and future variability in high-latitude CO2 uptake

Halloran, P R

The amplitude, phase and form of the seasonal cycle of atmospheric CO_2 concentration varies on many time and space-scales. Intra-annual CO_2 variation is primarily driven by seasonal uptake and release of CO_2 by the terrestrial biosphere. Variability in the magnitude, spatial distribution and seasonal drivers of terrestrial Net Primary Productivity will be induced by planetary orbital variability, anthropogenic CO_2 release, and land-use change. I show that the co-variability of the seasonal cycles in atmospheric CO_2 concentration, ocean temperature, and sea-ice extent allow for rapid changes in the air-sea flux of CO_2 at high latitudes. At high latitudes the annual atmospheric CO_2 concentration peak occurs over an ice-covered ocean, and the trough over predominantly ice-free waters, the annually averaged air to sea CO_2 flux is therefore reduced relative to that in a perennially ice-free basin. Equatorward of the seasonally ice-covered waters, ocean CO_2 uptake is enhanced under increased seasonality because the solubility of CO_2 follows an approximately synchronous seasonal cycle to that in atmospheric CO_2 concentration. Whether these mechanisms will respond to an increase in the amplitude of the atmospheric CO_2 seasonal cycle with a net positive or negative change in the air-sea flux of CO_2 will depend on the maximum extent of sea-ice cover. One may therefore predict an increased out-gassing of CO_2 by the ocean during cold periods of high planetary orbital obliquity (tilt), and therefore of high sea-ice and atmospheric CO2 seasonality (conditions consistent with glacial terminations). Conversely, during warm periods with low sea-ice cover and high atmospheric CO_2 concentration seasonality (the coming decades), one would predict a relative increase in oceanic CO_2 uptake. These feedbacks will not be captured within prescribed CO_2 concentration experiments such as those currently being run for the fifth IPCC climate assessment.

Antarctic link to deep ocean circulation changes during rapid climate deteriorations

Hoogakker, B

An understanding of the response of ocean circulation to rapid climate change in the North Atlantic can be gained through examining the period 60,000 to 30,000 years ago; an interval set apart by a series of abrupt climatic deteriorations with a 1500 to 4000 year pacing. During stadial (cold) events, northern hemisphere climate was much cooler (5 to 10°C) and dryer. Several severe stadial events are further characterised by massive surges of icebergs, which caused major surface ocean freshening. Colder temperatures during stadial events caused a shift from North Atlantic Deep Water (NADW) formation in the Nordic Seas to intermediate water formation south of Iceland, whereas surface ocean freshening may have caused cessation of NADW formation and slowdown in ocean circulation, with Southern Source Waters (SSW) replacing North Atlantic deep and intermediate waters (Ramstorf, 2002; McManus et al., 2004). The Western Boundary Undercurrent (WBUC), of eastern America, is a principal route for southward transport of North Atlantic Waters and southward return of SSW. Recent bottom water mass and physical flow speed reconstructions (3.5 km water depth) of the palaeo-WBUC, however, reveal that 1) SSW occupied the site whereas NADW was absent over the entire interval, and 2) the majority of slow flow speed events occurred when Antarctic temperatures were warming and not during northern hemisphere melt water events, suggesting that Antarctic climate exerted a stronger control on deep north Atlantic flow speed by controlling the flux of SSW (Hoogakker et al., 2007; Gutjahr et al., in press).

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Internal wave dynamics on the Australian North West Shelf

Jones, N L, Ivey, G N, Rayson, M D, Bluteau, C E, Lim K and Meuleners, M

We are using a combination of laboratory and field measurements with numerical modelling to understand the fundamental processes that dictate internal wave dynamics on the Australian North West Shelf (NWS). The NWS has a rich and complex internal wave climate due to macro-tides, persistent stratification and complex topography. Laboratory experiments were used to study internal wave generation on idealised continental shelf topography under a range of stratification and forcing conditions. A range of behaviors was observed, including both internal wave beams and boluses. Field data, from multiple sites on the NWS, reveal the complexity and variety of generation processes that occur in this region. For example, at the outer shelf break the dominant baroclinic response is beams; however, the inner shelf break exhibited a low mode baroclinic response. Three-dimensional numerical modelling has been employed to aid the interpretation of the field data and to examine the dynamics over larger regions. For example, model output has allowed the examination of the process of wave steepening and the baroclinic transfer of energy which leads to the formation of large amplitude internal waves on the NWS. We will present an examination of the processes leading to the generation and affecting the evolution of large amplitude internal waves on the NWS utilising both experimental and numerical modelling data.

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The parameterisation of eddy-induced transports sets the strength of the Antarctic Circumpolar Current in climate models

Kuhlbrodt, T

The Antarctic Circumpolar Current (ACC) is the strongest current in the global oceans. Yet its theoretical understanding is still incomplete, which is due to the complex interaction of forcing fields (wind, fluxes of heat and freshwater) and processes within the ocean (eddy-induced transports, bottom form stress) on various spatial scales. In the current class of global coupled climate models, as used for the IPCC AR4, the strength of the ACC is not well constrained. At the end of the control runs, the volume transport through Drake Passage ranges from 34 Sv to 338 Sv, compared with the observed 137 Sv (1 Sv=10^6 m^3 $^{s-1}$). We have looked into which field or quantity explains best this large variation across the climate models. The eddy-induced transports play a special role since they are not resolved by this class of models. Instead, the vast majority of the models use the Gent & McWilliams parameterisation of eddy-induced transports. In our analysis of 23 climate models, the correlations of the ACC strength with the wind stress and the density gradient individually are weak, while the correlation with the eddy-induced diffusivity from the Gent & McWilliams parameterisation is strongly negative, at least for those models where this parameter is fixed. To some extent this result can be understood using a simple scaling for the ACC. The study brings out the paramount role of the Gent & McWilliams parameterisation in setting the strength of the ACC in coupled climate models.

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Total dissolved and particulate metals distribution in Antarctic sea ice

Lannuzel, D

Samples were collected in East Antarctic sea ice in late winter/early austral spring 2007 in order to assess the spatial and seasonal distributions of trace metals. Total dissolved and particulate concentrations were measured by Magnetic Sector Inductively Coupled Plasma-Mass Spectrometry in snow, sea ice and underlying seawater. Results show that the concentrations of particulate metals were one to two orders of magnitude higher in sea ice than in snow and seawater. Dissolved metals were one order of magnitude higher in sea ice as compared to snow, although they were not enriched in sea ice as compared to data reported in the literature for Antarctic surface waters. An analysis of dissolved-to-total metal ratios showed that all studied metals were found almost exclusively in the dissolved phase in Antarctic sea ice.

Barite maxima within the ice cover at all sites may indicate heterotrophic activity. Particulate metals distributions suggest a signal from Antarctica's shelf sediments. On the other hand, dissolved metals distributions indicate that (i) spatial variability does not seem to be strong and (ii) the continental margin would mainly contribute as a lithogenic source of particulate trace metals in the studied area. Our results also demonstrate that dissolved aluminium, chromium, molybdenum and barium behaved conservatively with bulk ice salinity gradients. This would confirm that the main source of trace metals to Antarctic sea ice comes from seawater and not from direct atmospheric deposition. Finally, seasonal ice melt does not seem to contribute significantly to the supply of dissolved bioactive metals other than iron to Antarctic surface waters.

Near-surface eddy heat and momentum fluxes estimated from observations and the POP model in the Antarctic Circumpolar Current in Drake Passage

Lenn, Y-D

The role of eddies in the Antarctic Circumpolar Current (ACC) momentum balance is evaluated from new estimates of eddy momentum and heat fluxes in the near-surface layer (above 250 m) derived from a 7-year record of high-resolution velocity and temperature observations in Drake Passage. Eddy fluxes are also estimated from a 3-year data set archived from an eddy-resolving simulation of the Parallel Ocean Program (POP) numerical model. In both POP and the observations, the eddy momentum fluxes show that eddies exchange momentum with the mean subantarctic and polar fronts in a manner consistent with the divergence and convergence of the mean ACC fronts. The comparison between POP and observed eddy heat fluxes was less favourable due partly to model bias in the water mass stratification. Observed cross-stream eddy heat fluxes are generally surface-intensified and poleward in the ACC fronts of up to 290±80 kW/m^2 in the polar and southern ACC fronts. Interfacial form stresses, derived from observed eddy heat fluxes in the subantarctic front, support the theory that eddies fluxing heat polewards can simultaneously transmit wind-input momentum vertically downwards.

Ancient corals reveal the changeable moods of El Niño-Southern Oscillation

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The El Niño-Southern Oscillation (ENSO) system consists of warm El Niños and cool La Niñas recurring every 2-7 years. These events play a significant role in modulating climate across the globe and ENSO is particularly dominant in determining the climate of Australasia; drought in southeastern Australia is often associated with El Niño events. It is unclear whether or not El Niños will become more frequent and/or larger amplitude in a future warmer world, and a key challenge identified by the IPCC is to improve predictions of ENSO. A major barrier to better understanding ENSO is the shortness of the instrumental record from which ENSO models are tested.

To this end our research uses the oxygen isotope ratios ($\delta^{18}O$) of fossil corals from Kiritimati Island, central Pacific, to extend the record of ENSO variability and to provide insights into the processes that may lead to changes in ENSO behaviour. The Kiritimati coral $\delta^{18}O$ correlates strongly with sea surface temperature and the NINO3.4 Index, both key parameters for defining ENSO events. Initial fossil coral $\delta^{18}O$ results suggest that large amplitude El Niño events may have been commonplace 2000 years ago; several large amplitude anomalies similar in magnitude to, if not larger than, the 1997/1998 El Niño 'event of the century' have been identified. In contrast, corals that lived about 4500 years ago show a suppressed ENSO signal. The large changes documented by the coral $\delta^{18}O$ could be due to interactions between the seasonal cycle and ENSO. Future work will focus on integrating the coral results with climate models to further define how climate changes translate into an ENSO response.

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The value of time-series data to track climate-driven changes to intertidal systems and provide policy-relevant evidence and advice

Mieszkowska, N

Climate change is having a profound impact on coastal regions globally. Changes in species distributions, invasions and localised extinctions are driving alterations in biodiversity. The greatest effects are occurring in the regions of biogeographic breakpoints where many species reach their distributional limits. One of the longest studies globally, the MarClim project, focuses on European intertidal species. Comparisons of historical (back to the 1950s) and current data highlight some of the fastest distributional changes globally since onset of warming in the mid-1980s. Rapid poleward extensions of warm water species have occurred at rates of up to 50 km per decade, with concurrent increases in abundance over several degrees of latitude. Slower poleward retreats of cold water species are also occurring. Phenological shifts including earlier onset of reproduction, shifts in reproductive strategy and significant alterations in overwinter survival of recruits are driving these biogeographic changes. The rapid response time of these sessile or sedentary organisms makes them good indicator species, the 'canaries in the coalmine' for climate change. Non-native species are also increasingly colonising natural shores, enhanced by warming coastal climates. The species-specific nature of changes are driving alterations in community composition and have implications for coastal marine biodiversity. The methodology has recently been applied to New Zealand, with a national intertidal survey being carried out to establish a baseline from which to measure future changes.

MarClim also provides fit-for-purpose expert scientific advice and evidence to UK government agencies. This is used in the development of effective management and adaptational strategies for marine biodiversity resources and ecosystem services, informing management and mitigation strategies to ensure compliance with national and European policy directives.

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Adaptive management options in marine systems

Mieszkowska, N, Poloczanska, E S and Richardson, A J

Ecological management for climate change will require frameworks for adaptive management. Such frameworks need to recognise that climate change can act at a range of ecological scales, that climate change can alter ecological processes, that sensitivity and resilience is determined by the components of the ecosystem and adaptive management may not always be feasible or desirable.

The framework presented was customised for a variety of marine ecosystems (e.g. coral reefs, kelp forests) through a workshop of key experts with marine impacts and adaptation experience and through a consultation process via the National Climate Change Adaptation Research Facility (NCCARF) network for Marine Biodiversity and Resources to identify adaptation options and develop a risk-feasibility framework. The adaptation options link back to the altered processes, anthropogenic impacts, and compromised resistance and resilience. The framework is being applied to several contrasting marine systems in Australia and the UK. This framework will allow us to identify adaptation options that are of highest priority, lowest risk, and most desirable in terms of greenhouse gas mitigation.

Adaptation approaches include managing water quality, regulation of tourism and fishing, marine protected areas, species translocation and, in some cases, genetic manipulation through selective breeding or introduction of regionally new genotypes.

Phenological changes in intertidal conspecific gastropods in response to climate warming

Moore, P, Thompson, R and Hawkins, S

There is substantial evidence from terrestrial and freshwater systems of species responding to climate change through changes in their phenology. In the marine environment, however, there is less evidence. Using historic (1946-1949) and contemporary (2003-2007) data we investigated the effect of recent climate warming on the reproductive phenology of two conspecific intertidal limpet grazers, with cool/boreal and warm/lusitanian centres of distribution. Reproductive development in the warm/lusitanian limpet, *Patella depressa*, has advanced, on average, 10.2 days per decade since the 1940s, with a longer reproductive season and more of the population reproductively active. The peak in the proportion of the population in advanced stages of gonad development was positively correlated with sea surface temperature (SST) in late spring/early summer, which has increased between the 1940s and 2000s. The advance in peak reproductive development of this species is double the average observed for terrestrial and freshwater systems and indicates, along with other studies, that marine species may be responding faster to climate warming. In contrast, the cool/boreal limpet, *Patella vulgata*, has experienced a delay in the timing of its reproductive development (on average 3.3 days per decade), as well as an increase in reproductive failure years and a reduction in the proportion of the population reaching advanced gonad stages. These results are the first to demonstrate a delay in the reproductive development of a cool-temperate, winter spawner, towards cooler more favourable environmental conditions in response to climate warming. Such a delay in spawning will potentially lead to trophic miss-matches, resulting in a rapid non-linear decline of this species.

The effects of ocean acidification and temperature on oysters and the potential of selective breeding to ameliorate climate change

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Acidifying and warming oceans are predicted to fundamentally alter marine ecosystems. Recent studies have shown that the early life history stages of estuarine and marine species are perhaps most susceptible. This study compared the synergistic effects of elevated pCO_2 (ocean acidification) and temperature on the early life history stages of two ecologically and economically important oysters: the Sydney rock oyster, *Saccostrea glomerata* and the Pacific oyster, *Crassostrea gigas*. Gametes, embryos, larvae and spat were exposed to four pCO_2 (375, 600, 750, 1000 ppm) and four temperatures (18, 22, 26, 30°C) in acute exposure experiments. At elevated pCO_2 and suboptimal temperatures there was a reduction in the fertilisation success of gametes, a reduction in the development and size of larvae and spat and an increase in abnormal morphology of larvae. These effects were greater for *S. glomerata*.
To date little is known about the potential for genetic adaptation of marine organisms to ocean acidification. In a second study we found that certain selectively bred lines of *S. glomerata* and *C. gigas* were remarkably resilient to elevated pCO_2 and temperature. Some selectively bred lines had more than twice the levels of growth than the non-selected (wild) oysters when exposed to elevated pCO_2 and some were not significantly affected by elevated pCO_2 or temperature. This indicates the genetic potential of larvae and spat from selectively bred lines of *S. glomerata* and *C. gigas* populations to adapt to changes in climate over the next century. Preliminary proteomic analysis using two-dimensional electrophoresis detected a significantly greater number of protein spots in CO_2-resilient, compared to CO_2-sensitive, D-veliger larvae. In addition, our results showed that a number of proteins were up- or down-regulated at elevated pCO_2. Our results are the first to demonstrate the potential adaptive capacity of an ecologically significant marine organism to ocean acidification.

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Networking across global marine 'hotspots'

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Major changes consistent with the fingerprint of global warming have been reported for nearly every ecosystem on Earth. The assessment of impacts and development of adaptation options in the marine realm, however, lag considerably behind that for terrestrial systems. Here, we identify 24 marine regions at the 'front-line' of climate change – areas in which waters are warming faster than 90% of the world's oceans. These regions, including highly vulnerable areas such as South-east Asia, western Africa, and the eastern tropical Pacific, need to be at the forefront for assessing impacts and developing, evaluating and implementing adaptation options. Marine natural resources, such as fisheries, provide significant social and economic benefits globally, and early warning of changes in resource availability is required to minimise social tensions (e.g. increased poverty and changes in resource allocation) and societal costs (e.g. income redistribution and government restructuring). We are coordinating a global network of researchers, managers and policymakers working in global marine hotspots. Information from these regions can be integrated and synthesised, contrasted and compared across locations providing us, globally, with the best possible learning opportunity to address the challenges of climate change. Networking and synthesising outcomes from across these marine climate change hotspots will facilitate accelerated learning and indicate sensible pathways for maximising adaptation and minimising impacts for other marine regions.

New 3-D observations of velocity in the Antarctic Circumpolar Current

Phillips, H

Measuring ocean velocity has been expensive and technically challenging. Consequently, what we know of ocean circulation has largely been inferred from extensive ocean temperature measurements, sea surface height gradients from satellite altimetry, and isolated direct velocity measurements.

A new instrument, the EM-APEX profiling float, is the merging of two mature technologies: the Argo float that measures temperature and salinity; and an electromagnetic velocity sensor returning horizontal ocean velocity. For less than twice the cost of a standard Argo float, we can now measure profiles of temperature, salinity and velocity with a vertical spacing of measurements as fine as 2 metres. Furthermore, the sophisticated controller of the EM-APEX allows real-time changes to the float's operation.

We present new results from the deployment of 8 EM-APEX in the Antarctic Circumpolar Current funded by the Australian Research Council. The scales of variation of the current and density fields observed by this high-resolution survey are astounding. Some of the features we have found in the data are 1) internal waves propagating through the region; 2) Ekman spirals, which are well understood in theory but rarely and only recently observed; and 3) vertically tilted eddies. All of these features, while small in space, are important components of the global overturning circulation, and all of these features are not well represented in global climate models. Process studies such as these are relatively inexpensive to mount and provide the observations needed to improve our understanding of both the ocean circulation, and its representation in models.

Feeling the heat: What corals and computers tell us about the past, present and future of the tropics

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It is of critical importance to human society to be able to predict future climate variability and change. El Niño is the dominant mode of natural variability within the climate system, and influences climate extremes across the globe. In Australia, El Niño events can cause severe droughts, while La Niña events can bring flooding rains. Yet current predictions of how El Niño might evolve under future climate change are highly uncertain.

Past climatic changes provide an opportunity to learn more about the dynamics of El Niño, and to explore the physical mechanisms that can drive changes in its behaviour. In the tropical Pacific Ocean, the annual growth rings of corals capture the history of El Niño. Fossil corals show that El Niño events have become stronger and more frequent over recent millennia. There is also strong variability on decadal timescales, accompanied by rapid switches between different modes.

To learn from the coral record, a computer model is used to simulate the evolution of the global climate over the past 8000 years. The simulations provide a dynamical framework within which physical links can be explored. They reveal that, on millennial timescales, cyclical changes in the Earth's orbit around the sun are the dominant influence on El Niño. On shorter timescales, however, volcanic emissions and changes in solar luminosity become important, while random variability within the climate system also becomes increasingly significant.

This work suggests that there are fundamental limits on our ability to predict changes in El Niño during the 21st century. The signal-to-noise ratio is such that unpredictable random variability may swamp any underlying trend arising from increasing concentrations of greenhouse gases.

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A report card of marine climate change impacts and adaptation for Australia

Poloczanska, E S, Richardson, A J and Hobday, A J

Effective communication of climate change is a key issue in developing adaptation strategies. The first Report Card of Marine Climate Change for Australia (2009) reported on a number of key climate variables (e.g. temperature, sea level) and key biological taxa (e.g. mangroves, pelagic fish and sharks). The aim of the Marine Report Card is to connect science and policy. The Marine Climate Change Report Card clearly and concisely communicates state-of-the-art knowledge on climate change impacts, knowledge gaps and adaptation strategies to a broad audience. It provides useful information to environmental managers, fishing communities, marine users, scientists and students. To promote accurate, insightful information, we engaged the leading experts within each field to review and assess impacts and adaptation options. The Report Card was produced by 77 scientists from 35 institutions and sponsored by the CSIRO Climate Adaptation Flagship, the Australian Climate Change Science Programme and the National Climate Change Adaptation Research Facility. Four thousand print copies have been distributed so far. The website receives around 1780 unique visitors and 47,000 hits a month.

The Report Card also served to concentrate fragmented knowledge on climate change in Australia, so benefiting the science community as well as policy and decision makers and the general public. It became clear that, for biological systems, Australia is lacking in long-term baselines compared to other countries and our knowledge of many biological taxa such as zooplankton and macrolagae is poor. Our vision is to elaborate on this first Report Card with biennial reporting and to include greater investigation of adaptation options.

View the Marine Climate Change Report Card for Australia at www.oceanclimatechange.org.au.

Marine climate change impacts: A global comparison across species, trophic levels and regions

Poloczanska, E S, Brander, K, Brown, C, Bruno, J, Buckley, L, Burrows, M T, Duarte, C, Moore, P, O'Connor, M, Pandolfi, J, Parmesan, C, Sanchez-Camacho, M, Schoeman, D, Sydeman, B and Richardson, A J

The IPCC 4th Assessment Report reported 28,671 significant biological changes globally but information from marine systems was overlooked, accounting for less than 0.3% of included biological changes. This fundamental information is critical for developing integrated and adaptive management strategies to protect marine environments and fisheries in the future. We have assembled as a working group at the National Center for Ecological Analysis and Synthesis (NCEAS, USA) to address key questions concerning the vulnerability of marine systems to climate change, such as which marine species, taxonomic groups and systems are most sensitive? What are the similarities and differences in the types and rates of responses in tropical, temperate and polar seas? To what extent do human stressors such as fishing increase vulnerability of species and habitats to climate change? We are building a marine climate impacts database employing an innovative tiered approach to classify impacts. To date, fish and seabird studies are dominant in the database.

Most evidence comes from studies that relate shifts in a climate factor to an ecological response over time; changes in sea surface temperature or sea ice are identified as the main drivers of change in many of the database studies but 64% do not consider other drivers of change. The lack of control conditions and the complexity of natural systems pose a challenge for testing the mechanisms of responses and developing a predictive understanding of the ecological impacts of climate change. We suggest that studies should incorporate comparisons to past conditions, experiments, and conceptual and mathematical models to address the mechanisms driving ecological responses. A robust framework for studying ecological impacts of climate change is critical not only to a comprehensive scientific understanding of the natural world, but also to inform societal policies.

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www.nceas.ucsb.edu/featured/richardson

Biodiversity research for integrated marine zone management

Przeslawski, R

The northern marine bioregion of Australia has recently become the focus of much environmental research due to its resource potential and probable unique ecosystems. As part of the Australian government's program of collecting pre-competitive regional information on seabed habitats, Geoscience Australia recently collaborated with the Australian Institute of Marine Science to conduct a survey along a representative channel of the Van Diemen Rise in the Joseph Bonaparte Gulf (50-250 km off the coast of Darwin). A range of methods was used to collect physical and biological data including multibeam sonar, towed underwater video, oceanographic moorings, sediment sampling, and epibenthic sampling. Biological communities and habitats were characterised across different geomorphic features, with rich sponge and octocoral gardens common on almost all banks but rarely found on other geomorphic features. In contrast, infaunal assemblages were most diverse in soft sediment plains. Several environmental factors (e.g. depth) were correlated to biodiversity in the area, thereby offering the potential to use environmental surrogates to broadly predict biodiversity patterns in the region. Species-level identifications will help determine whether biological communities are unique or representative, thereby broadening our regional understanding of the rich variety of ecosystems. Such information can be used to help set baseline conditions for monitoring the efficacy of proposed marine protected areas and help Australia's offshore and gas industry draft environmental approvals for proposed infrastructure in the region.

Geological insights into the workings of the biological pump

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Understanding the mechanisms of transport of particulate organic carbon and associated nutrients to the ocean interior is a prerequisite to reliable predictions of how the marine carbon cycle will respond to future changes in the circulation and carbonate chemistry (acidification) of the ocean. A variety of different transport mechanisms have been proposed, often based on sediment trap observations. Yet these observations primarily provide evidence for correlations between fluxes rather than pin-pointing any particular mechanism. Despite this, global models tend to adopt one or other mechanism (e.g. ballasting) and frequently without formal justification or independent support.

The geological record may help here, as the evolution of pelagic ecosystems through the Phanerozoic has seen, for example, the emergence of multicellular animals (and faecal pellets) and calcification (ballast minerals), with each evolutionary innovation presumably fundamentally altering the nature of the biological pump in the ocean. Moreover, catastrophic and transitory events, in which pelagic ecosystems are temporary disrupted and biological pumping mechanisms altered, may produce a tell-tale marine geochemical signature and help elucidate the working of the biological pump.

Here, we focus on the bolide impact at the Cretaceous-Palaeogene boundary as it induced an enigmatic 'collapse' in surface-to-deep carbon isotope ($\delta 13C$) gradients, previously interpreted as representing a complete cessation of biological carbon pumping in the ocean. Contemporaneous with this was a pronounced extinction amongst planktic calcifiers and an order of magnitude reduction in carbonate burial in deep-sea sediments. On face value, these inferences (no ballast minerals, ceased organic carbon transport to depth) are consistent with a dominant (carbonate) mineral ballasting mechanism. However, a collapsed surface-to-deep δ13C gradient does not necessarily imply a cessation of the biological pump as the solubility pump also impacts an isotopic signature to the ocean. Using an Earth system model we demonstrate that a weakening in organic matter transport to depth of no more than 60-70% is needed to explain the isotopic observations. A corollary is that a minimum 30-40% of sinking organic matter reaching the deep sea cannot depend on mineral ballasting, at least in the Cretaceous ocean.

Using proteomics to investigate prey recognition by planktonic flagellates: A challenging but powerful approach

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It is widely recognised that flagellate grazers are a major force in the movement and fate of microbial biomass in aquatic environments. Through selective feeding, flagellates play a fundamental role in structuring bacterial and phytoplankton communities. Although recent evidence indicates that flagellates can select food based on cell surface properties of their prey, the underlying mechanisms are poorly understood. We present a proteomic approach that can be utilised to reveal a suite of prey-binding proteins, potentially involved in prey recognition by the heterotrophic dinoflagellate *Oxyrrhis marina*.

Occurrence of the parasite genus *Hematodinium* (Alveolata: Syndinea) outside its benthic crustacean hosts

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Benthic crustaceans world-wide are infected with alveolate parasites of the genus *Hematodinium*, causing population crashes and substantial losses to crustacean fisheries. The distinct seasonality in *Hematodinium* occurrence in their main benthic crustacean hosts, as well as the absence of successful transmission attempts, and the incomplete description of the parasites' life cycle suggests the existence of *Hematodinium* life stages outside benthic crustaceans. Here, we present a nested PCR method that is highly sensitive for the detection of *Hematodinium* rDNA in the environment and in potential alternative hosts. This method was used to screen seasonal environmental samples from the Clyde Sea, Scotland, for the presence of *Hematodinium*. The study examined particulate organic matter (POM; 2μm–10mm) within the water column, including both phytoplankton and zooplankton. *Hematodinium* rDNA was detected and amplified from isolated larvae of known crustacean hosts, including *Nephrops norvegicus* (15% of larvae) and miscellaneous crab species (12% of larvae). In addition, *Hematodinium* was identified in mixed plankton samples (>2 μm in size) devoid of crustacean larvae. This indicates that *Hematodinium* occurs in the water column and is harboured by planktonic organisms when notably absent from its benthic crustacean host. These results imply that changes in plankton dispersal may result in the temporal and spatial variability in *Hematodinium* infection prevalence in benthic crustacean populations.

Developing ocean basin-scale study of cold-water coral ecosystems

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Our present understanding of cold-water coral habitats relies to a large extent on studies designed and targeted to specific study sites and topics. Research along the Atlantic margins of Europe and North America has now shown that cold-water coral habitats occur extensively on both sides of the Atlantic, but we understand little of how these habitats are linked and connected. Certain cold-water corals have also emerged as key palaeoceanographic archives but no study has yet attempted to use coral temperature and water mass proxies at the scale of an ocean basin. The Trans-Atlantic Coral Ecosystem Study (TRACES) is the first attempt to create an integrated, basin-scale study of cold-water corals in terms of their biodiversity and climate archives. Following a successful proposal to the European Science Foundation, EuroTRACES was launched as a call for proposals in early 2010. Research is organised into four themes: (1) Linkages and connectivity, (2) Biodiversity and biogeography, (3) Coral biology and reproduction, and (4) Climate change and palaeo records. TRACES not only maximises use of expensive offshore research infrastructure but has created a new trans-Atlantic network of cold-water coral workers from biological, geological and palaeoceanographic backgrounds.

Kelp forests may reduce the effects of climate change

Russell, B

Recent evidence shows that climate change will combine with local stressors, such as nutrient pollution, to exacerbate ecosystem degradation. Moreover, predictions about the ecological consequences of oceanic uptake of CO_2 have been preoccupied with the effects of ocean acidification on calcifying organisms. This focus overlooks the direct effects of CO_2 on non-calcareous taxa, particularly those that play critical roles in ecosystem shifts. Therefore, it would be predicted that under combined climate and local stressors currently observed ecosystem shifts would be accelerated, such as the shift from kelp forests to habitats dominated by turf-forming algae on temperate marine coasts. However, recent evidence shows that the presence of photosynthetic plants can use CO_2 in marine waters, thereby buffering changes to water chemistry. To test whether this is the case, we used experimental mesocosms containing kelp 'ecosystems' to assess the ability of biogenic habitats to alter the physical conditions that lead to habitat shifts, reducing the impact of stressors and increasing resistance to change. We found that the presence of kelp reduced the growth of turf-forming algae which facilitate ecosystem shifts, even under elevated nutrient and CO_2 conditions. Importantly, this result indicates that the presence of kelp forests may ameliorate the effects of human activities and that actions to preserve them into the future will reduce the frequency of ecosystem shifts.

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Understanding marine microbial ecology from a microbes point of view

Seymour, J

Microorganisms represent the base of the marine food-web and are responsible for driving the ocean's major chemical cycles. Although oceanographic research often considers the role of microbes across large scales (hundreds of metres to kilometres), the lives of individual microbes are defined on much smaller scales (< centimetres). Marine bacteria inhabit a world characterised by tremendous patchiness of resources and the way in which they exploit chemical 'hot-spots' has been proposed to significantly influence bulk-scale fluxes of carbon, nitrogen and organic sulfur throughout the ocean. We used microscale sampling equipment to demonstrate the patchy nature of microbial distributions in different ocean environments. The potential role of bacterial behaviour in driving these distributions was then examined, using microfluidic channels to study the chemotactic capabilities of marine microbes. These experiments revealed that marine microbes employ sophisticated foraging strategies to exploit microscale nutrient patches and that these behaviours may ultimately influence chemical flux rates in the ocean.

Living in a high CO_2 world

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Since the end of the first industrial revolution in the 1830s widespread burning of fossil-fuels, deforestation and cement production has released more than 440 billion tons of CO_2 into the atmosphere (half of it in the last 30 years). The ocean has taken up 25% of this carbon, thereby slowing the rate of CO_2 rise in the atmosphere. This uptake of CO_2 changes the chemical balance of the ocean and decreases the pH. Ocean acidification is measurable and predictable.

There is less certainty, however, on possible biological impacts from ocean acidification because we have not experienced such changes and different groups of marine organisms appear to be more or less sensitive to changing seawater chemistry. Organisms might react with decreased growth rates, changes in porosity, thickness and crystallinity of the skeleton or shell.

We would predict that short-lived species, such as foraminifers reproducing monthly, have a greater capacity to respond phenotypically to rapid environmental change, because generation times are short and hence each new generation experiences conditions only slightly different from the preceding one. In comparison, long-lived species tend to have far less capacity to adapt quickly and may react with mineralogical changes in their skeleton.

In this poster, I will show data on changes and stability in the skeleton/shell of planktic foraminifers, a deep sea coral, bivalve and several bryozoans. I will be relating the pH in the habitat with the pH in the calcifying medium as a way to address potential organismal differences in vulnerability to ocean acidification.

Does dimethyl sulphide (DMS) protect dinoflagellate symbionts (*Symbiodinium* sp.) from oxidative stress?

Steinke, M, Brading, P, Kerrison, P, Warner, M E and Suggett, D J

Dimethylsulfide (DMS) and dimethylsulfoniopropionate (DMSP) are sulfur compounds that may function as antioxidants in algae. Symbiotic dinoflagellates of the genus *Symbiodinium* show strain-specific differences in their susceptibility to temperature-induced oxidative stress and have been shown to contain high concentrations of DMSP. We investigated continuous cultures of four strains from distinct phylotypes (A1, A1.1, A2 and B1) that can be characterised by differential thermal tolerances. We hypothesised that strains with high thermal tolerance have higher concentrations of DMSP and DMS in comparison to strains with low thermal tolerance. DMSP concentrations were strain-specific with highest concentrations found in A1 (225±3.5 mmol L-1 cell volume) and lowest in A2 (158±3.8 mmol L-1 cell volume). Both strains have high thermal tolerance. Strains with low thermal tolerance (A1.1 and B1) showed DMSP concentrations in between these extremes (194±19.0 and 160±6.1 mmol L-1 cell volume, respectively). Normalising our DMSP data to the concentration of chlorophyll-a resulted in a similar distribution and the DMS data did further confirm this general pattern with high DMS concentrations in A1 and A1.1 (4.1±1.22 and 2.1±0.37 mmol L-1 cell volume, respectively) and low DMS concentrations in A2 and B1 (0.3±0.06 and 0.5±0.22 mmol L-1 cell volume, respectively). Hence, the strain-specific differences in DMSP and DMS concentrations did not explain the different abilities of the four phylotypes to withstand thermal stress. Future work should quantify the possible dynamics in DMSP and DMS concentrations during periods of high oxidative stress in *Symbiodinium* sp. and address the role of these antioxidants in zooxanthellate cnidarians.

The impact of oceanic iron fertilisation on stratification and the mixed layer heat budget

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Current climate change scenarios predict upper ocean warming which will enhance stratification at the base of the mixed layer. Oceanic iron fertilisation has been suggested as a climate change mitigation mechanism to enhance the biological sequestration of atmospheric CO_2 into the deep ocean. This poster draws connections between these two processes by demonstrating the potential impact of iron fertilisation on upper ocean stratification and surface heat budgets. Using the Community Climate System Model (CCSM) we simulated large phytoplankton blooms at geoengineering spatial and temporal scales in each of the three major iron-limited provinces: The north Pacific, the equatorial Pacific and the Southern Ocean. The blooms enhanced the attenuation of solar radiation in the mixed layer, leading to temperature increases of the order of 1°C. This warming in turn generated changes in the sensible and latent heat fluxes of between 1 and 5 W/m^2 from the ocean to the atmosphere. The increased stratification reduced the vertical mixing of nutrients (required to sustain productivity) by 50%. These temperature and heat flux signals will be discussed in the context of smaller perturbations due to climate change, vertical nutrient fluxes required to sustain the blooms, and the potential for geoengineering success.

Understanding the mechanistic basis for environmental selection of corals' symbiotic microalgae (zooxanthellae)

Suggett, D J, Brading, P, Lawson, T, Smith, D J and Warner, M E

A unique symbiosis between microalgae of the genus *Symbiodinium* (collectively termed zooxanthellae) and cnidarians enables coral reef systems to thrive in otherwise nutrient impoverished environments. However, the nature of this symbiosis appears to be highly susceptible to environmental and climatic change, with large changes to the primary factors that regulate microalgal growth (light, temperature and CO_2) selecting for specific genotypes of zooxanthellae: (i) The capacity to modify how much absorbed light can be processed (rather than how much light can be absorbed) appears a key trait that will determine which genotypes respond best to changing light availability (1,2), e.g. via coastal sedimentation or sea level rise; and (ii) availability of additional pathways to process excess absorbed light, e.g. electron cycling, quenching of free radicals and high rates of protein repair, determine whether zooxanthellae genotypes can tolerate (are selected for) temperature change, and hence thermal stress/coral bleaching events (3,4,5). (iii) Finally, the existence of active pathways for acquiring CO_2 elevates productivity and/or growth under increases of CO_2 and thus will be a selected trait under ocean acidification. Whilst these observations provide mechanistic evidence for the capacity to adapt to environmental change, no single zooxanthellae genotype examined to date appears to posses all traits. As such, understanding how light, temperature and CO_2 act together (synergistically or antagonistically) across zooxanthellae genotypes is now key. Furthermore, identifying which and how zooxanthellae genotypes are most 'available' to corals will determine the extent to which future environmental selection of zooxanthellae will ultimately impact coral growth and biodiversity.

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The history of the Great Barrier Reef: IODP Expedition 325 'Great Barrier Reef Environmental Changes'

Thomas, A L & Expedition 325 scientists

During 2010, expedition 325 of the Integrated Ocean Drilling Program, 'Great Barrier Reef Environmental Changes', drilled 33 cores into drowned reefs, seaward of the modern barrier reefs, in 50-160 m water depth. The aims of this expedition were to investigate sea level and environmental change during the ~120 m of sea level rise from the last glacial maximum (LGM, ~20,000-28,000 years ago), and the response of the reef systems to these changes. Preliminary chronology based on uranium-thorium and radiocarbon measurements demonstrate that Exp 325 has successfully recovered a complete sequence of coral material from the LGM, through the first half of the deglaciation up to 10 ka. Therefore, these corals will enable investigation of the magnitude and nature of sea level around the LGM, as well as the rise of sea level out of the glacial. The rise of sea level during the early stages of deglaciation will also be investigated through further chronological and palaeoenvironmental analysis. Periods of interest for sea level change and environmental reconstruction, from which Exp 325 has recovered material, include: Melt Water Pulse 1A (and 1B); the '19 ka' melt water pulse; the Younger Dryas, the Bølling-Allerød, as well as Heinrich Events 1 and 2. The distribution of ages of corals recovered during Exp 325 also fills a gap in the global coral record from 14.7-16.8 ka. Paired U-Th:radiocarbon measurements from corals that fill in this gap will be crucial in providing data to refine the radiocarbon calibration and therefore enabling investigation into the carbon cycle during this period of environmental change.

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Microbial buffering: Protecting the Great Barrier Reef against human impact

Tyson, G

Coastal pollution from agriculture, urbanisation and other land development is a major threat to coral reef systems globally. Microbes commonly play an important role in sequestering and transforming excess nutrients and pollutants in human-impacted systems. We hypothesise that planktonic marine microbes 'buffer' coral reef systems against the full effects of land-based anthropogenic pollutants, and that their viruses may rapidly transfer the genes necessary for such functions from one microbe to another. To test these hypotheses, we are exploring planktonic microbes and their viruses in inshore Great Barrier Reef (GBR) lagoon waters along a gradient of exposure to human-impacted riverine floodwaters. Specifically, we are mapping the genes and transcripts along two environmental transects away from pollutant sources. This will allow us to identify which microbial groups are 'first responders', how the community responds over the course of a flood event and which degradation and uptake pathways are used by the microbes to transform or utilise compounds introduced by the floodwaters. High throughput sequence-based approaches will be used to investigate microbial and viral community diversity and metabolic capacity along defined spatiotemporal gradients in the GBR coastal zone.

The sequence data sets will have extensive metadata for maximising interpretation from a long-term water quality monitoring program carried out by the Australian Institute of Marine Sciences. We expect that this work will identify patterns of viral-host interaction with profound ecological and evolutionary consequences relevant to understanding and protecting the Great Barrier Reef.

High temporal resolution observations of spring fast-ice melt and seawater iron enrichment in East Antarctica.

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A time series experiment was conducted in late austral spring (November–December 2010) in coastal fast ice, East Antarctica (66° 13′ 07″S, 110° 39′ 02″E). Iron (Fe) measurements were made, together with requisite meteorological, physical and biogeochemical measurements, to allow comment on the processes controlling the release of Fe into the underlying water column. Air temperature was clearly associated with changes in brine-volume-fraction. Macronutrient profiles revealed the nitrate deficient state of the sea ice sections 1-4 (i.e. the interior ice). In the basal ice, nitrate and silicate were drawn down through time but did not lead to a limiting condition. Dissolved Fe is highly diffuse and readily transferred from the surface/interior to the basal sea ice layers. In contrast, particulate Fe did not show this clear decreasing trend and correlated with Particulate Organic Carbon (POC) and chlorophyll a distributions. Factor analysis revealed two components representing 53% and 27.6% of the total variance of all the variables which were most closely correlated with POC and macronutrient distribution respectively. Over the 28 days of sampling, two distinct mean-air-temperature warming events were observed of -12.1 to -1.3°C and then -6.4 to 0.8°C. This resulted in the release of 41.9 mol TDFe per m^2 of sea ice from our coastal fast ice station into the underlying water column. Given the trace quantities of Fe required by typical Antarctic diatoms to bloom, this represents a fertilisation potential for 42,000m^3 of Fe limited Southern Ocean surface seawater, per m^2 of similar coastal fast ice.

The Southern Ocean FINEstructure project: Turbulent dissipation and mixing rates and mechanisms in a mixing hotspot

Waterman, S

The Southern Ocean FINEstructure project (SOFINE) is an observational field study that investigates various mechanisms of ocean mixing and the roles that they play in the larger-scale circulation in a mixing hotspot in the Southern Ocean. The region is potentially of special significance to closing both the Southern Ocean overturning circulation and the momentum budget of the Antarctic Circumpolar Current (ACC), as it presents both a large-scale topographic obstacle and small-scale topographic roughness in the path of multiple ACC jets, thus making it a likely site for both enhanced adiabatic (along density surface) and enhanced diabatic (across density surface) mixing processes.

Here we present the first results of the project, which relate to the rates and mechanisms of turbulent energy dissipation and turbulent mixing in the region. From the first-ever full-depth microstructure measurements in the Southern Ocean, we map the observed turbulent kinetic energy dissipation and diapycnal mixing rates in this mixing hotspot. We next explore some of the physical mechanisms that observations and theory suggest may underpin the observed distributions. This exploration leads us to a characterisation of the internal wave field in the region, and a study of some of the processes related to its generation, evolution and eventual dissipation.

Our results point to the importance of the large-scale flow field and its interaction with the bottom topography and the internal wave field in producing the spatially variable map of turbulent dissipation and mixing in the region that was observed. This will have important implications for the global map of energy dissipation, the dynamics of the overturning circulation, and our parameterisations of turbulent mixing processes which will be discussed.

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The global geochemical cycle of lead: A marine perspective

Weiss, D, Rehkaemper, M, van der Flierdt, T, Kreissig, K and Oluwafeyikemi, A

Human activities have greatly altered the natural geochemical cycles of several heavy metals, most notably lead derived from leaded-petrol and metal-smelting emissions. This inadvertent geochemical tracer experiment poses two challenges: understanding how anthropogenic lead affects human health and the environment, and quantifying its time-dependent distribution within terrestrial and marine systems. Accurate assessment of the latter relies on well-constrained historical and modern lead fluxes from proxy records and direct observations, lead source estimates from stable lead isotopes, and transport rate estimates from radionuclides.

Numerous studies support the global-scale atmospheric lead fluxes principally derived from anthropogenic activities, the short lead residence time in the atmosphere and surface ocean, and the predominance of North American and European lead emissions. Emerging observations and models are currently addressing the time-dependent evolution of this reactive tracer in the atmosphere and oceans.

Potential vorticity dynamics of the Southern Ocean

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Potential vorticity dynamics have been used to gain insight into phenomena as diverse as the existence and persistence of jets in Jupiter's atmosphere, and the resilience to transport and mixing of the boundary of the Antarctic ozone hole. Potential vorticity is a dynamical tracer, materially conserved in the absence of diabatic forcing. Its conservation provides a restoring force, allowing Rossby waves to communicate fluid perturbations over planetary scales. However, potential vorticity is difficult to estimate in the ocean's interior.

This study uses a synthesis of observations and numerical models to examine the structure of the Southern Ocean potential vorticity and to gain insight into what controls the characteristics of the complex, multiple jets of the Antarctic Circumpolar Current.

Participant research interests and contact information

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Eric Achterberg's research interests are the oceanic carbonate system and ocean acidification; the marine biogeochemistry of trace metals (including speciation); and carbon, nutrients and their interactions with organisms. This includes development of novel analytical techniques and sensor systems and their application to biogeochemical studies. His field of research activities is related to global change and ecosystem functioning. Eric's research uses two approaches: field measurements (open ocean and coastal waters) and laboratory studies. The research is multidisciplinary and undertaken in collaboration with national and international partners. Eric has >100 research publications and is a PI or co-PI on many grants. He has extensive project management experience in multi-institute NERC and EU projects, and attracted £7.5 million in research income since 1994. He was an NERC Peer Review College Member (2004-2008). He currently is on the Ocean Acidification Program Advisory Group and the NERC Marine Facilities Review Group.

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The ecological responses of all organisms to climate change are driven by their molecular, cellular and physiological responses. Tracy's research focuses on investigating these responses in reef-forming corals:

- Her research aims to understand the molecular machinery controlling apoptosis in corals during disease and stress, such as changing climate.
- The pathology of disease is not uniform in corals; very different mechanisms and cellular processes underlie very similar disease. Tracy has characterised cell types and cellular responses and aims to link our increased understanding of coral genomic capabilities with an understanding of the cell and tissue function in corals during disease.
- Previously she has investigated the microbial communities of corals in situ and is currently conducting in situ studies of microbial communities to investigate the role of host-microbe interactions in coral health.
- The world's deep ocean corals are vulnerable to increasing anthropogenic impacts, yet we understand very little about the physiological significance of microbial symbioses. Tracy is currently starting a research project investigating the bacterial communities of deep-sea corals in the Pacific.

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Dr Leanne Armand is a palaeoclimatologist and biological oceanographer specialising in the use of biological indicators (diatoms) as proxies of the oceanographic condition, be that in the past through the estimation of sea-surface temperature and sea-ice cover in the Southern Ocean, or in the modern context of iron fertilisation and community response to changing chemical and oceanographic conditions. She is one of the three leading researchers in the field of Antarctic sea-ice reconstruction, participating in the collection and use of a global core-top diatom database from which the estimates are based (e.g. MARGO). Leanne's research has recently expanded into sediment trap and iron fertilisation programs (e.g. SAZ, Prydz Bay, SOIREE, KEOPS). Here, she identifies diatom species closely associated with seasonal particle formation and estimated individual contributions to carbon export.
Her future research is focused on Antarctic shelf, NSW coastal and Heard-Kerguelen modern phytoplankton blooms in relation to seasonal changes in the marine physical environment and their use in deciphering Holocene fossil records. She was awarded the Australian Academy of Science's Dorothy Hill award in 2007.

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Dr Alex Baker is a marine biogeochemist primarily working on the exchange of matter across the air-sea interface. A large component of his recent work has been on the atmospheric supply of nutrients (nitrogen, phosphorus, iron, silicon and trace metals) to the ocean. A significant subset of that research has involved the study of the chemical speciation of those nutrients and the factors that influence their solubility. Alex also studies the speciation of iodine in aerosol, rainfall and seawater, and is interested in the marine biogeochemistry of iodine in general. Prior to his appointment to a faculty position at the University of East Anglia, Alex held postdoctoral positions at the University of the West Indies, the University of Liverpool and UEA.

Dr Natalie Ban

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Dr Natalie Ban's research interests span conservation biology, marine spatial planning, conservation planning and implementation. She obtained her PhD from the University of British Columbia, Canada, in 2008, and is currently a postdoctoral fellow at James Cook University. Her research focuses on options for the conservation of biodiversity whilst respecting people's needs and uses of resources. Natalie's current research is comprehensively assessing the role of an important and hitherto largely ignored set of biodiversity processes, patch dynamics, in conservation planning. These spatial and temporal dynamics of resources and disturbances, such as pelagic productivity and coral bleaching, are extremely important for conservation planning because the persistence of many species depends on them.

Dr Stephen Barker

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Dr Stephen Barker is a Senior Lecturer in Palaeoclimate and Climate Systems Research at Cardiff University (UK). Steve has a degree in geology from Edinburgh University and PhD from Cambridge. Before moving to Cardiff in 2006, he did postdocs at Cambridge and Lamont-Doherty Earth Observatory of Columbia University (US). Steve has a wide interest in all aspects of palaeoclimate reconstruction and mechanisms, ranging from the carbon cycle to abrupt climate change. His current research involves high resolution reconstructions of palaeoceanographic changes in the Atlantic Ocean and combining records from various archives (ice, mud and cave deposits) to improve our understanding of the mechanisms of abrupt climate change.

Dr Julia Blanchard

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Dr. Julia Blanchard is a Research Fellow in Marine Ecosystems and Fisheries Ecology at Imperial College London. Previously she was a research scientist at the Centre for Environment, Fisheries and Aquaculture Sciences (Cefas), UK. Julia has worked extensively on the development of ecological models and indicators to support ecosystem-based fisheries management. Her main research areas include the dynamics of size-structured ecosystems, ecosystem effects of climate and fishing, linking macro-ecology with food web ecology, spatial ecology, population dynamics, and linking physical-biogeochemical processes into food web models. Currently she is working on developing and testing methods for assessing the status of deep-water fish populations and potential impacts of climate change on global fish production.

Dr David Bourne

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Dr David Bourne's research background is in molecular microbial ecology. Since obtaining his PhD from the University of Queensland in 1997 on a project investigating the microbial degradation of cyanobacterial toxins, he has worked in the fields of terrestrial methanotroph ecology and marine microbiology at the University of Warwick (UK) and Bergen University (Norway) respectively. For the last eight years David has been at the Australian Institute of Marine Science and involved in a number of research themes including marine microbes for drug discovery and the microbial dynamics in aquaculture (rock lobster) larval rearing systems. More recently his research has principally been focused on coral microbiology and coral disease. This research is divided essentially into two areas, the first investigating the normal microbial communities associated with corals and their functional roles in maintaining coral fitness.
The second research focus is to elucidate pathogens and mechanism of disease onset in corals and the implications this has on a stressed reef ecosystem in light of climate change being a major driver of coral reef degradation.

Dr Andrew Bowie

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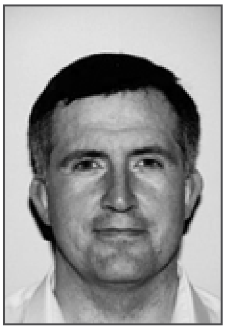
Dr Andrew Bowie is a Senior Research Scientist in the Antarctic Climate and Ecosystems Cooperative Research Centre's 'Carbon' program at the University of Tasmania. He heads a research team investigating the biogeochemistry of trace elements in Southern Ocean and Antarctic sea ice environments, with outcomes focused on assessment of trace element control of ocean productivity, ocean fertilisation and ocean carbon sequestration. Andrew has provided leadership of international chemical oceanography research expeditions and is a member of the Scientific Steering Committee of the GEOTRACES program, an international study of the global marine biogeochemical cycles of trace elements and their isotopes.



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Dr Gary Brassington is an expert in research and development of ocean prediction systems with specific focus on 'eddy'-resolved models. He is co-PI for the BLUElink project a joint initiative of the Bureau of Meteorology, CSIRO and Royal Australian Navy. Gary led the R&D team to develop the first operational ocean forecasting system for Australia that was implemented in 2008. He is the inaugural chair of the Expert Team for Operational Ocean Forecast Systems within the Joint WMO-IOC technical Commission for Oceanography and Marine Meteorology. Gary maintains a research leadership role in ocean prediction systems with new research activities in high-resolution coupled ocean-atmosphere prediction systems and adaptive ocean observing systems.

Dr Richard Brinkman

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Dr Richard Brinkman is a Senior Research Scientist and Lead Physical Oceanographer at the Australian Institute of Marine Science, where he leads and implements research projects within the broad topics of coastal oceanography and physical-biological interactions on continental shelves. Richard has a BSc in oceanography/meteorology from Flinders University and a PhD in coastal oceanography from James Cook University. He currently undertakes research on shelf dynamics, coupling of shelf and ocean circulation, sediment dynamics on tropical coasts and physical-biological interactions at regional and local scales, using a mix of field observations and numerical modelling, with a geographical focus on Australia's northern tropical waters.

Dr Jennifer Cobcroft

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Dr Jennifer Cobcroft is an Australian Postdoctoral Research Fellow (Industry) at the Tasmanian Aquaculture and Fisheries Institute (TAFI) at the University of Tasmania. She obtained her PhD in 2002 from the University of Tasmania, a BAppSci (Honours) from the University of Tasmania in 1997 and a BSc (Zoology) from the University of New England in 1996. Her research is focused on addressing bottlenecks in the hatchery production of marine finfish for aquaculture; including the management of microbial flora in culture systems, understanding parasites, larval nutrition, larval sensory organ and skeletal development and environmental conditions required for successful larval production. Jennifer's current research aims to reduce skeletal malformations in cultured marine fish by analysing the expression of genes associated with bone formation and providing improved nutrition and system operation. In the future she will research hatchery techniques to support the sustainable aquaculture of the highly prized southern bluefin tuna.

Dr Helen Coxall

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Dr Helen Coxall is a Royal Society University Research Fellow in the Department of Earth and Ocean Sciences at Cardiff University. She is a specialist in planktonic foraminifera geochemistry, taxonomy and evolution. Her research focuses on collecting micropalaentological and geochemical climate proxy data that provides insight into ocean and climate systems, especially past greenhouse climates of the early Cenozoic and the transitions between greenhouse and icehouse climate modes. She's interested in the complex puzzle of biological responses to global warming and plans on using geological records to help better understand the role of pelagic ecosystems in cycling and pumping carbon under different climate modes.

Dr Agatha De Boer

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Dr Agatha De Boer is a RCUK fellow in the School of Environmental Science at the University of East Anglia. She has a BSc (cum laude) in physics and mathematics from the University of the Orange Free State (South Africa), a BSc Honours in physics from the University of Pretoria (South Africa), and a PhD in physical oceanography from Florida State University (USA). Agatha is an expert in large-scale ocean circulation driving processes, such as winds and diapycnal mixing and the ocean's influence on climate over long timescales, both through heat and carbon fluxes. Her research, among other topics, focuses on the effect that eddy mixing and winds in the Southern Ocean have on the surface fluxes of carbon dioxide during the last glacial period. Prior to joining the UEA faculty Agatha spent three years working as a postdoctoral researcher at Princeton University's department of Atmospheric and Oceanic Sciences. She is serving on the leadership board of the Earth Science Women's Network, a 1000+ member peer-mentoring and support group, spanning more than 20 countries.

Dr Catia Domingues

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Dr Catia Domingues is a physical oceanographer with interests in sea level, ocean climate change, and the Earth's hydrological cycle. Since 2008, she has been a postdoctoral fellow with CSIRO Marine and Atmospheric Research, investigating how natural and anthropogenic contributions have influenced changes in ocean properties and sea level. Since 2005, as part of the CSIRO sea level group, she has been involved in using improved estimates of ocean warming to understand its contribution to sea-level rise. She has ongoing collaborations with scientists at the Program for Climate Model Diagnostics and Intercomparison (PCMDI), Lawrence Livermore National Laboratory (USA) and the Met Office Hadley Centre (UK). Before becoming involved with global change research, she has contributed to understanding of the Leeuwin Current System and Indian Ocean circulation during her joint PhD at Flinders University/CSIRO, completed in 2006.

Dr Rachel Dunk

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Dr Rachel Dunk's research interests are in biogeochemical cycles and global environmental change, with a focus on carbon storage (terrestrial and marine) and the ocean chemistry of the greenhouse gases (CO_2, CH_4 and halocarbons). In particular, Rachel is interested in methane gas hydrates, the behaviour, fate and impact of carbon dioxide (CO_2) in the ocean, the high CO_2 low pH ocean, and the potential of hydrothermal vents, gas vents and hydrate deposits to act as analogues for the leakage of CO_2 from sub-seafloor geological storage sites. She is currently Academic Director of the Crichton Carbon Centre, where she leads the Applied Research team and the Centre's contribution to the University of Glasgow's MSc in Applied Carbon Management.

Dr Michael Ellwood

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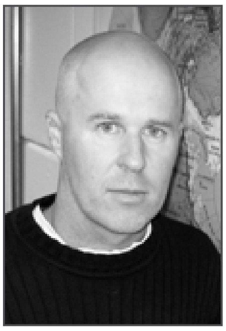
Dr Michael Ellwood's research expertise is in the areas of chemical oceanography and palaeoceanography. His main interests include understanding metal speciation in the coastal and open ocean and the use of trace elements in the skeletons of marine organisms to reconstruct changes in ocean chemistry on millennial timescales. Michael's current research is strongly focused on the cycling of trace metals, namely iron, zinc and copper, in the ocean and their influence on marine primary production. He currently has 40 peer reviewed publications in top-ranking journals.



Professor Matthew England

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Professor Matthew England is an expert in large-scale physical oceanography and global climate processes, with a particular interest in the role of the ocean in climate variability and climate change. After completing a PhD at the University of Sydney, Matthew held research appointments at the French National Center for Scientific Research (CNRS) and at CSIRO Marine and Atmospheric Research before taking up a position at the University of New South Wales, where he was awarded an ARC Federation Fellowship in 2005. Matthew is a former Fulbright Scholar and CSIRO Flagship Fellow, and winner of two Eureka Prizes. He is the current co-chair of the CLIVAR Southern Ocean panel and was a contributing author and reviewer of the IPCC Second and Third Assessment Reports.

Dr Ming Feng

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Dr Ming Feng is a physical oceanographer of CSIRO Marine and Atmospheric Research. His research interests include climate variability in the Indo-Pacific and its impact on regional oceanography and marine ecosystem in the south-east Indian Ocean. He is leading a modelling team to develop a strategy to downscale impacts of future climate change on Australia's boundary current systems and he also leads the effort to establish an Integrated Marine Observing System (IMOS) for Western Australia.

Dr Helen Findlay

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Dr Helen Findlay is a biological oceanographer whose research involves using a combination of modelling, observational and experimental data to investigate the impacts of climate change and ocean acidification on marine organisms and ecological functioning. She is involved in the European Project on Ocean Acidification (EPOCA) and has contributed to the UK government's Marine Climate Change Impacts Programme. Helen has recently returned from an Arctic expedition gathering data on carbon cycling and ocean acidification in the high Canadian Arctic. She will be continuing with Arctic research over the next few years. Helen is also involved in several shorter projects on ocean acidification impacts on organism plasticity and adaptation. She is a co-investigator on the new UK consortium investigating ocean acidification and temperature impacts on benthic organisms, populations and ecosystem functioning.

Dr Beth Fulton

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Dr Beth Fulton works extensively with marine ecosystem modelling. She developed Atlantis and co-developed InVitro, which are used to support sustainable multiple use management options for marine environments in Australia and internationally. These tools help identify sensible development and resource use with the conservation of biodiversity and functioning marine ecosystems. Beth's current work involves implementing ecosystem-based models for regional-scale management strategy evaluation in Australia and internationally, modelling for understanding climate change effects and associated biodiversity and evolutionary shifts, leading CSIRO's marine ecological and ecosystem modelling group, and supervising two postdoctoral fellows and five graduate students.

Dr Eddie Game

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Dr Eddie Game works as a conservation scientist for The Nature Conservancy's global program (www.nature.org) and is an adjunct faculty member at the University of Queensland's School of Biological Sciences. Broadly, his research focuses on the application of decision theory to conservation problems. Although Eddie has published and worked on a wide variety of conservation-related issues, he is particularly interested in how we can translate our knowledge of coral reef resilience into good conservation decisions, and how we can approach spatial planning in highly dynamic environments such as the pelagic ocean. Working for an NGO, he plays the role both of collaborating to advance the science of conservation and also of ensuring its rapid transition to application in the field.

Dr Samantha Gibbs

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Dr Samantha Gibbs is currently a Royal Society University Research Fellow whose area of expertise is micropalaeontology and palaeoceanography. In particular, she uses the fossil record of calcareous nannoplankton to understand abrupt climate and its impact on plankton diversity. She has ten years of experience in microfossil research, beginning with a Masters degree from University College London followed by a PhD at Cambridge University. In 2005, after a postdoctoral position at Pennsylvania State University, she came to the National Oceanography Centre as a NERC research fellow. She took up her current fellowship in October 2008 and her present research focus is the effects of ocean acidification on calcareous plankton.

Dr Jasmin Godbold

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Dr Jasmin Godbold is a postdoctoral researcher at the University of Aberdeen. Her research focuses on the relationship between marine benthic invertebrates and ecosystem processes in natural systems with a view to making experiments more applicable and relevant to future scenarios of environmental change. Currently she is investigating the consequences of ocean acidification on the behaviour of key benthic invertebrates. Jasmin's interests extend to coastal wetland ecosystem services and related socioeconomic benefits, management and policy decisions. She chaired a session at the 2009 British Ecological Society Annual Meeting on ocean acidification. She received the European Marine Research Stations Network Award for Young Scientists (2006) and is an active participant in the NERC/ESRC seminar series 'Coastal Wetland Ecosystem Services' and the NERC Silwood Park workshop series on 'Consequences of environmentally forced extinction and ecological revolutions for ecosystem function'.

Dr Nick Graham

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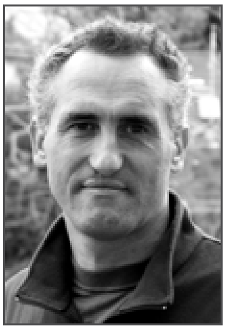
Dr Nick Graham is an applied coral reef scientist working on large-scale ecological questions directly relevant to sustainable management and conservation. He has worked extensively on the ecological ramifications of fishing and closed area management to reef systems. A major research focus has been the long-term impacts of climate-induced coral bleaching on coral reef fish assemblages, fisheries and ecosystem stability. He is now turning his efforts towards understanding the patterns and processes by which coral reefs degraded by climate change recover, and how this can be incorporated into, or influenced by, management action. Nick's research is funded by fellowships from the ARC and the Queensland Smart Futures Fund.



Dr David H Green

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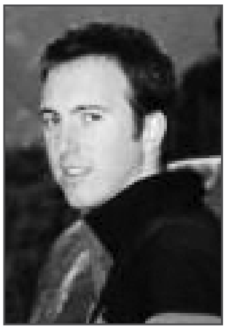
Dr David Green is an environmental microbiologist with a wide range of experience spanning public health microbiology, bacterial genetics and marine microbiology. The main focus of his research now is the diversity and functionality of the microbial flora-associated marine algae. In particular, David is interested in identifying and quantifying beneficial interactions between these two kingdoms. Ecologically, an association of oil-degrading bacteria with algae is one particular observation that extends from this work. A second research focus is the search for new sources of surface-active agents from bacteria, such as emulsifiers, and an active interest in developing products from marine algae.



Dr Paul R Halloran

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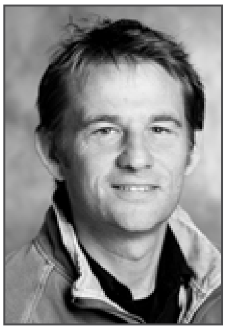
Dr Paul Halloran's work has ranged from using ocean-sediment chemistry to reconstruct the state of the tropical Pacific Ocean over millions of years, through performing experimental studies on lab-cultured plankton to develop techniques for reconstructing past climate, the quantification of ocean acidification impacts on the contemporary carbon cycle and now developing and investigating numerical models designed to simulate the possible roles played by marine biology and chemistry in the controlling the planet's future climate. Paul started this research in Oxford after completing a degree in Earth sciences in 2005, he then moved to the Hadley Centre in 2008. Paul is presently trying to improve our understanding of the biogeochemical feedbacks operating within the climate system, primarily on centennial timescales, with a focus on ocean acidification and the implications for calcifying organisms.



Dr Jason Hall-Spencer

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Dr Jason Hall-Spencer carries out applied research to provide policymakers with the scientific information needed to best manage the marine environment, ranging from improving the sustainability of fisheries and fish farming to the design of marine protected areas. He obtained a PhD in Marine Ecology from the University of London and then worked on a series of EU postdoctoral fisheries projects before becoming a university lecturer, first at Glasgow University then transferring a Royal Society University Fellowship to the University of Plymouth in 2003. He has witnessed the discovery of giant deep sea reefs using submersibles and studied the biology of remote seamounts using underwater robots. This year his students are working on newly discovered coral reefs deep in the Arctic Ocean, the use of satellite tracking of fishing vessels to design effective conservation areas and studying underwater volcanoes in the Mediterranean Sea to help predict the effects of ocean acidification due to rising atmospheric carbon dioxide levels.

Dr Andy Hogg

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Dr Andy Hogg is a theoretical oceanographer who has made contributions to the understanding of the dynamics of circulation, particularly in the Southern Ocean. He has collaborated in the development of a high-resolution model for the investigation of eddy processes, and has demonstrated that small-scale, turbulent eddy processes (not simulated by most ocean-climate models) can have controlling influences on the global-scale flow and can generate inter-decadal climate variability. Most notably, Andy has recently contributed to a new understanding of the way the Southern Ocean will respond to variations in wind stress and climate change, which carries significant implications for the development of future climate models.

Dr Babette Hoogakker

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Dr Babette Hoogakker specialises in microfossil (foraminiferal) isotopes and trace metals and flow speed proxies, to study the interaction between large-scale ocean circulation, the carbon cycle and climate change. Recent highlights include (i) the discovery that flow speed and water mass changes in the deep (<3500 m) North Atlantic ocean during glacial millennial-scale cycles are synchronous with Antarctic warm events, and (ii) a long-term decrease in North Atlantic deep water flow concurrent with rising atmospheric CO_2 over the last 6000 years. She is currently assessing North Atlantic deep water oxygen concentrations over the last glacial-interglacial cycle.

Dr M Debora Iglesias-Rodriguez

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Debora Iglesias-Rodriguez is a biological oceanographer working at the National Oceanography Centre of the University of Southampton. She is interested in the way oceans respond to human perturbation. She has recently been studying how the increasing atmospheric carbon dioxide is causing the oceans to be more acidic, and how this 'ocean acidification' affects the life of marine animals and plants. She coordinates a research team of passionate scientists investigating the biological response of calcium carbonate-producing animals and plants to ocean acidification, since the formation of their shells in some organisms has been found to respond to changes in acidity.

Assistant Professor Nicole Jones

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Assistant Professor Nicole Jones' research focus is environmental fluid mechanics. She uses a combination of field and laboratory observations as well as numerical models to study physical processes in natural water bodies. In the past, Nicole has studied the influence of breaking surface waves on mixing, the hydrodynamic control of benthic grazing and the dispersion of coastal plumes. Nicole is currently studying ocean processes along the Western Australian coast including internal wave dynamics on the Australian North West Shelf, transient upwelling at Ningaloo Reef, and the influence of island archipelagos and coastal headlands on the exchange of waterborne material along the Kimberley coastline.

Dr Till Kuhlbrodt

Senior Research Fellow

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Dr Till Kuhlbrodt is a Senior Research Fellow at the University of Reading. He is a physical oceanographer with a keen interest in the large-scale circulation in the Southern Ocean and in the Atlantic Meridional Overturning Circulation (AMOC). Working with a range of climate models he is currently analysing how the Antarctic Circumpolar Current and the meridional overturning circulation in the Southern Ocean are represented in these models. Recently, Till has begun to look into the models' oceanic heat uptake. Past work at the Potsdam Institute for Climate Impact Research (Potsdam, Germany) included studying the driving processes of the AMOC as well as conducting an integrated assessment of changes in the AMOC.

Dr Delphine Lannuzel

Postdoctoral Research Fellow

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Dr Delphine Lannuzel's research interests lie in the study of trace metal biogeochemistry in polar regions. Iron is of critical importance for phytoplankton growth in the Southern Ocean, where surface water concentrations are low. She participated in several Antarctic expeditions, where she analysed samples of sea ice, snow, brine and the underlying seawater. The data set generated during her research highlighted the accumulation of iron in the sea ice medium. The iron released annually during sea ice melt may trigger large algal blooms, and therefore play a key role in our past, present and future climate. She recently extended her research to other trace metals.

Dr Yueng-Djern Lenn

Postdoctoral Fellow

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Dr Yueng-Djern Lenn's main interests lie in understanding, through observations, the dynamics of the polar oceans and their impact on global climate. At Scripps Institution of Oceanography, she pursued PhD research that utilised upper ocean observations to characterise the mean flow, determine sources of variability and investigate mesoscale eddy dynamics of the Antarctic Circumpolar Current as it flows through Drake Passage. More recently, as a postdoctoral researcher at Bangor University, she has been studying the vertical mixing processes, heat fluxes and their impact on the transformation of water masses in the Arctic Ocean that are relevant to the global overturning circulation.

Dr Maeve Lohan

Senior Lecturer

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Dr Maeve Lohan is a Senior Lecturer at the Marine Institute at the University of Plymouth. She obtained her PhD in chemical oceanography from National Oceanography Centre, Southampton in 2003. Her research investigates the trace metal biogeochemistry with particular reference to bioactive metals (iron, zinc, cobalt and copper). She is interested in the chemical, biological, and physical processes which affect trace element distributions and behaviour in both coastal and open ocean regimes. This research combines speciation studies, trace metal uptake by phytoplankton and analytical chemistry. Maeve is actively involved in the international GEOTRACES program, looking at the distribution of trace elements and isotopes in the ocean.

Dr Simon Marsland

Senior Research Scientist

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Dr Simon Marsland is the ocean climate modeller for the Australian Community Climate and Earth System Simulator (ACCESS). He specialises in polar ocean and sea ice interactions with the atmosphere. Here form the densest waters that sink and replenish the deep ocean. Over long timescales this influences the Earth system budgets of heat, freshwater and carbon under a changing climate. Simon graduated in mathematics (Deakin University) and has a PhD in Southern Ocean modelling from the Antarctic Cooperative Research Centre (University of Tasmania). He spent four years at the Max Planck Institute for Meteorology, developing the German model that contributed to the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report. He currently develops the ACCESS model for Australia's contribution to the upcoming IPCC 5th Assessment Report. Simon is a panel member on the World Climate Research Program (WCRP) Climate Variability and Predictability (CLIVAR) Working Group on Ocean Model Development.

Dr Helen McGregor

AINSE Research Fellow

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Dr Helen McGregor's research interests are in the field of tropical climatology and past variability of the El Niño-Southern Oscillation (ENSO). El Niño events have a clear impact on global temperatures with half of the top ten warmest years on record occurring in El Niño years. Yet despite ENSO's crucial role in modulating the Earth's climate, the response of the ENSO system to global warming is highly uncertain. Longer ENSO records are required and Helen's current research uses fossil corals from Papua New Guinea and the central Pacific Ocean to more fully document the range of El Niño modes that operated over the past 6000 years.

Dr Nova Mieszkowska

MBA Research Fellow, Marine Environmental Change Network Science Coordinator

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Dr Nova Mieszkowska is a Research Fellow at the Marine Biological Association of the UK. Her international research program focuses on the impacts of global climate change and ocean acidification on coastal marine biodiversity and consequences for ecosystem structure and functioning. Current projects include a NERC Ocean Acidification Large Programme grant, Interreg UK/France non-natives project, New Zealand biodiversity research, long-term UK time-series research and collaborations with the US NASA ecological forecast project, South African UCT coastal biodiversity project and NCCARF. Her research has been highlighted in the IPCC 4th Assessment Report, EU MarBEF Network of Excellence and the 2010 ICES Position Paper on Climate Change. Nova has a strong science-policy knowledge transfer role as the Marine Environmental Change Network Science Coordinator, and is a lead author and editor on UK assessments including Defra's Charting Progress II, Marine Climate Change Impacts Partnership Annual Report Cards and the National Ecosystem Assessment 2010.

Dr Pippa Moore

Postdoctoral Fellow

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Dr Pippa Moore is an expert on marine ecological responses to climate change. In particular, her research has focused on the effects of climate warming and, more recently, on ocean acidification and on individuals and assemblages of near-shore systems (rocky intertidal and shallow subtidal). Pippa uses a variety of approaches in her research including time-series approaches, manipulative experiments and meta-analytical approaches. Her current research is focused on the physiological and ecological effects of ocean acidification and climate warming on key primary producers and associated herbivores. In particular, she is interested in understanding the effects of these two key climate stresses on primary and secondary production in marine ecosystems.

Dr Heiko Pälike

Reader

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Dr Heiko Pälike's main research curiosity is driven by exploring climate-forcing by variations of the Earth's orbit on timescales from thousands to millions of years. Achievements include exploiting the fingerprint of this astronomical metronome, and to gain further insights into the (palaeo-)climate system, by using material available through the Integrated Ocean Drilling Program (IODP). Heiko's main research interest is the palaeoceanography of the Palaeogene, using stable isotope measurements, and investigating the climate-driven evolution of the world's oceans. One of his aims is to advance the detailed calibration of the geological timescale with astronomically driven climate cycles ('Milankovitch' cycles), leading to a precise timescale for the entire Cenozoic. Building on this research, he also exploits the sediment record of past climate changes to refine astronomical models and extract physical parameters In the past, Heiko has also investigated the role of climate change on anthropological evolution.

Dr Laura Parker

ARC DIRD Postdoctoral Fellow

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Dr Laura Parker has substantial expertise in invertebrate larval development, with a particular focus on the effects of climate change stressors. She has recently completed her PhD at the University of Western Sydney (UWS), where with the help of Industry and Investment NSW, she studied the effects of ocean acidification and temperature on the early development of oysters. This work has been reported in one manuscript which has been published in *Global Change Biology* and two which have been accepted and are in review with the journal *Marine Biology*. Laura currently holds an ARC DIRD Postdoctoral Fellowship at UWS where she and her colleagues are researching the chronic effects of ocean acidification on oysters and the potential for adaptation.

Dr Gretta Pecl

Senior Research Fellow

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Dr Gretta Pecl is a Fulbright Fellow and a Senior Research Fellow leading several projects within the Climate Change Impacts and Adaptation Theme at the Tasmanian Aquaculture and Fisheries Institute. Her current research activity spans a range of topics including range extensions associated with climate change, evaluating adaptation options in socio-ecological systems, assessing population and fishery responses to climate change, and on using citizen science approaches for ecological monitoring and engagement (e.g. www.REDMAP.org.au). She was lead author of the recent Australian Federal Department of Climate Change interdisciplinary report into the impacts and adaptation response options for the Tasmanian rock lobster fishery (see http://www.climatechange.gov.au/en/publications/coastline/east-coast-rock-lobster.aspx). Gretta is currently working in Alaska for her Fulbright Fellowship, a project developed specifically to facilitate collaboration and knowledge exchange between northern and southern hemisphere marine regions facing greatest exposure to temperature increases ('hotspots' for climate change).

Dr Helen Phillips

Research Fellow, Physical Oceanography

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Dr Helen Phillips is a Research Fellow in Physical Oceanography at the University of Tasmania in Hobart, Australia. Her PhD research used moored instruments in the Southern Ocean to characterise the mean flow and eddy variability of the Antarctic Circumpolar Current south of Australia. Helen did postdoctoral work at Woods Hole, USA on the interannual variability of the North Atlantic Subtropical Mode Water, and at CSIRO in Hobart identifying the relationship between salinity variations north-west of Australia and the El Niño-Southern Oscillation. She now specialises in the study of ocean currents using novel instrumentation such as EM-APEX profiling floats, working in the Southern Ocean and in the South Indian Oceans. Helen currently leads the analysis of a high-resolution EM-APEX survey of the 3-D velocity structure of the Antarctic Circumpolar Current (ACC) north of Kerguelen Island. These unique observations are providing unprecedented information on vertical and horizontal mixing in the ACC and their impact on the meridional overturning circulation. Moreover, these data are revealing detail of ACC fronts not previously seen in hydrographic sections or other traditional measurements.

Dr Steven Phipps

Research Fellow

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Dr Steven Phipps is a Research Fellow based at the Climate Change Research Centre at the University of New South Wales. His expertise is in the field of climate system modelling, with research interests in past, present and future climate variability and change. Steven's current research seeks to reconstruct and understand past changes in El Niño, which is the dominant mode of natural climate variability. Combining climate model simulations with data from natural archives such as coral reefs, tree rings and marine sediments, he aims to understand how and why El Niño evolves over time. This knowledge will be used to explore how El Niño might change in future, including the possible impacts on the climate of Australia.

Dr Elvira Poloczanska

Research Scientist

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Dr Elvira Poloczanska's research focuses on impacts of climate variability and climate change on marine species and ecosystems at both global and Australian scales and adaptation responses to these impacts. Her work includes modelling impacts of climate change on marine communities and synthesising and disseminating climate change knowledge. Elvira is co-convener of an international working group assembling a database of marine climate change impacts and applying meta-analytical techniques to address key questions regarding vulnerability of marine ecosystems. She also leads the Report of Marine Climate Change in Australia (www.oceanclimatechange.org.au). Over 70 authors from 35 institutions contributed to the first synthesis, which summarises observed and expected impacts of climate change and highlights knowledge gaps and adaptation responses in an easily accessible form for policymakers and the general public.

Dr Rachel Przeslawski

Marine Benthic Ecologist

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Dr Rachel Przeslawski's research interests span larval ecology, global change biology, and marine habitat mapping. She completed her PhD at the University of Wollongong where she studied the effects of ultraviolet radiation and other stressors on the development of intertidal gastropods. In 2006, she began a postdoc at Stony Brook University in New York where she continued investigating larval development, as well as synthesising research on benthic invertebrates and climate change. She is currently employed as an ecologist at Geoscience Australia where she is examining the utility of abiotic surrogates for marine biodiversity. This opportunity has allowed her to participate in several deep sea and tropical surveys. Rachel is also interested in science communication and tries to regularly publish popular science articles in glossy magazines that her mother will read.

Professor Andy Ridgwell

URF/Professor in Earth System Modelling

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Professor Andy Ridgwell is a Royal Society University Research Fellow at the University of Bristol. Although in practice spending most of his time tending to the every need of six cats, his research addresses fundamental questions surrounding the past and future controls on atmospheric CO_2, and the nature of the relationship between CO_2, climate, global biogeochemical cycles, and life. He is also closely involved in research into future ocean acidification impacts and the effectiveness (or otherwise) of geoengineering. Andy develops his own numerical analytical tools ('Earth system models') to ask questions and test hypotheses regarding the functioning of the Earth system.

Dr Emily Roberts

Lecturer

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Since securing a permanent lectureship at Swansea University in 2003, Dr Emily Roberts' research interests have centred on determining the ecological relevance of planktonic protists within aquatic ecosystems, focusing on two main areas:

- Prey recognition by predatory planktonic protists: There is much evidence to suggest that protists can discriminate between similar-sized prey items based on differences in cell surface chemical composition of their prey. Emily's group is currently unravelling the mechanisms involved in biochemical prey recognition by identifying receptors used by predatory protists to bind to ligands present on the surface of their prey.
- The occurrence of *Hematodinium* outside its macrocrustacean hosts: *Hematodinium* is a protist parasite that infects many of the UK's commercially and ecologically important crustacean species. Surprisingly little is currently known about the life cycle of the parasite when it leaves the infected crustaceans. Emily's group is using molecular probes to search for *Hematodinium* DNA in the marine environment. The group is also investigating whether *Hematodinium* infects other marine organisms in addition to its known crustacean hosts.

Dr J Murray Roberts

Reader in Biodiversity

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Dr J Murray Roberts is a marine biologist who studies the biology and ecology of deep-sea or cold-water corals. These organisms vary from single solitary corals to large reef framework-forming scleractinian species. The latter, and long-lived octocorals and black corals, form structurally complex habitats on the continental shelf, slope, offshore banks and seamounts where studies over the last ten years have shown them to form local centres of species diversity and important archives of palaeoceanographic information. Murray's current research goals can be summarised as 'working to advance understanding of the biology and ecology of cold-water corals and provide the information needed for their long-term management and conservation'.

Dr Bayden Russell

Senior Research Associate

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Dr Bayden Russell is at the forefront of research to predict how local environmental conditions will interact with climate change in marine ecosystems. He has identified that the combined effects of nutrient pollution and increasing CO_2 concentrations will accelerate the degradation of near-shore systems and the associated species diversity and ecosystem services. Bayden's current research has two parts. The first is to identify if management of local conditions, such as recycling waste-water to reduce nutrient pollution, can increase the resilience of ecosystems to some of the anticipated negative effects of climate change. The second is to assess the capacity of kelp- and seagrass-dominated ecosystems to adapt to increasing CO_2 and temperature, and management actions that can increase this adaptive capacity.

Dr Daniela Schmidt

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Dr Daniela Schmidt is a Royal Society University Research Fellow in the Department of Earth Sciences at the University of Bristol. She studied marine geology at the University of Bremen and the Alfred Wegener Institute for Marine and Polar Research, focusing on our understanding of palaeoclimate proxies. She did her PhD at ETH Zurich on 'Size in planktic foraminifers', studying the effect of biotic interaction and climate change on plankton evolution. Her research focuses on the marine environment and how climate change is affecting life in the ocean. Currently, she is studying geological events of ocean acidification and their effect on marine carbonate production to inform future predictions of climate change. Dr Schmidt is lead author for the 5th Assessment Report of the IPCC in Working Group II: Impacts, Adaptation and Vulnerability.

Dr Justin Seymour

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Dr Justin Seymour is a microbial ecologist who, in an effort to better integrate the role of microbes into a mechanistic understanding of ocean function, employs the approach of considering the dynamics of marine phytoplankton, bacteria and viruses, *from a microbes point of view*. This has meant examining microbial behaviour and ecology near to the minute scales that are most relevant to the interactions of individual cells, rather than the large-volume 'bulk' scales typically employed in oceanographic research. This approach has revealed that marine microbes inhabit a dynamic and patchy world that they can exploit using specialised behaviours, which can ultimately influence chemical fluxes in the ocean.

Dr Emily Shuckburgh

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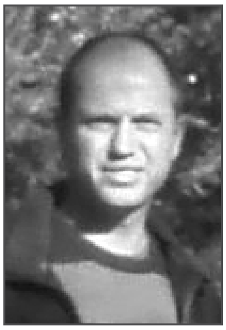
Dr Emily Shuckburgh leads the Open Oceans research group at the British Antarctic Survey, which is focused on understanding the role of the polar oceans in the global climate system. She is also a fellow of Darwin College and a faculty member of the Climate Leadership Programme at the University of Cambridge. She has previously worked at Ecole Normal Superieure in Paris and at MIT. Her personal research concerns atmosphere and ocean dynamics and she is currently focusing her efforts on understanding the circulation of the Southern Ocean around Antarctica and its impact on global climate. Emily is a fellow of the Royal Meteorological Society and presently chair of their scientific publications committee.



Dr Willem Sijp

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Dr Willem Sijp obtained his PhD in ocean and climate modelling in 2005 at UNSW, Australia. He is interested in deep-time climate problems relating to low equator to pole temperature gradients during hot house climates. Of special interest are the periods of extreme warmth during the Cretaceous and the transition towards the present-day climate at the Eocene/Oligocene boundary. Furthermore, Willem is interested in factors affecting stability of North Atlantic Deep Water formation in the present-day climate.

Dr Michael Steinke

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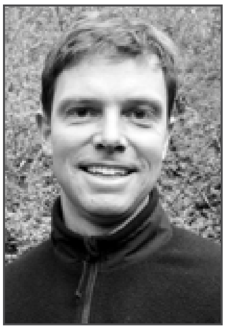
Dr Michael Steinke is a lecturer in marine science, with 15 years experience in dimethylsulfide (DMS) research. He started applying his expertise on DMS-production in algae to studies on the functional role of diffusive compounds in trophic interactions in 1996 when investigating the interactions between small phytoplankton and microzooplankton grazers. More recently, Michael started investigating the concept of infochemical-mediated tritrophic interactions in the plankton. Other facets of his research include the role of DMS and its algal precursor dimethylsulfoniopropionate (DMSP) as antioxidants in anemones and their zooxanthellate symbionts, and the application of a chemiluminescence detector for online quantification of DMS production.



Dr Peter Strutton

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Dr Peter Strutton received his degrees from Flinders University, South Australia. He was a postdoc at the Monterey Bay Aquarium Research Institute and held faculty positions at Stony Brook University and Oregon State University before taking up his Future Fellowship at the University of Tasmania. Pete's expertise is in the coupling between ocean physics and productivity with a recent emphasis on air-sea CO_2 exchange. At UTas he will use satellite and in situ data to investigate changes in these processes at decadal timescales in the Southern Ocean. Previous regions of interest include the Antarctic, equatorial Pacific, north-east Pacific and Labrador Sea.

Dr David Suggett

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Dr David Suggett specialises in understanding how the environment regulates photosynthesis by aquatic organisms, in particular phytoplankton and corals, and thus how this process affects nutrient cycling and ecosystem metabolism (the net flux of CO_2). Part of this research has developed and applied new bio-optical techniques for examining photobiology, physiology and productivity in situ. Current research examines the processes and impacts of coral bleaching and ocean acidification across a range of scales, from individual organisms to entire ecosystems. David's work has provided new insights as to how primary productivity will be impacted by environmental (climatic) change, with publications in top journals, *Nature Geosciences*, *Global Change Biology* and *Environmental Microbiology*.

Dr Alex Thomas

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Dr Alex Thomas's research is focused on the use of chemical and radiochemical measurements to understand geological and modern Earth processes. His recent work has focused on the use of fossil corals to reconstruct past changes in sea level. Specifically this has involved the drilling of drowned reefs at Tahiti, French Polynesia, and the Great Barrier Reef, Australia. Dr Thomas's interests also extend to the open ocean where he uses naturally occurring radionuclides as a tracer of past ocean circulation and particle fluxes. These two research areas are tied together by the need to establish chronological control for the timing and durations of geological events.

Dr Gene Tyson

Senior Research Fellow (QEII Fellow)

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Dr Gene Tyson is a microbial ecologist whose research applies molecular approaches to understand the structure and function of microbial communities in the environment. Gene is one of the pioneers of microbial metagenomics and metatranscriptomics and he has applied these tools to examine communities in a diverse range of natural environments. His group is currently focused on examining microbial and viral communities on the Great Barrier Reef, in permafrost at the leading-edge global climate change, and in various engineered systems. Gene's group is also involved in the development of bioinformatic tools for the analysis of microbial sequence data.

Dr Tina van de Flierdt

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Dr Tina van de Flierdt holds a Senior Lectureship in Isotope Geochemistry at the Department of Earth Science and Engineering at Imperial College London. She is a geologist by training whose academic background also includes a PhD in natural sciences from the ETH Zurich in Switzerland and a postdoctoral fellowship at Lamont-Doherty Earth Observatory of Columbia University. Tina has more than 10 years of experience in isotope geochemistry and co-leads the MAGIC isotope facility at Imperial College London. Her research spans a variety of fields, from understanding chemical cycles of trace elements in the ocean, over past ocean circulation patterns and climate, to the evolution and erosion of continental crust.

Dr Pier van der Merwe

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Dr Pier van der Merwe received his undergraduate science degree in marine biology at James Cook University. After studying tropical marine systems in far north Queensland, a passion for Antarctica led to a decidedly southward move and undertaking Honours with the Institute of Marine and Antarctic Studies in Hobart. During this time he worked on developing a novel fluorescence-based method for determining nutrient limitation in Southern Ocean phytoplankton. A successful year led to undertaking a PhD with the Antarctic Climate and Ecosystems CRC, researching the processes of iron supply, cycling and bioavailability within the Antarctic sea-ice zone. With his PhD completed, Pier's future research interests lie with the large-scale processes that control productivity and thus climatically important carbon sequestration in the world's oceans.

Dr Nem Vaughan

Tyndall Centre for Climate Change Research Fellow

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Dr Nem Vaughan is an expert on geoengineering proposals and on climate change mitigation (the reduction of man-made CO_2 emissions) over a multi-centennial timescale, allowing sufficient time for the carbon-cycle to respond. She recently completed her PhD thesis, 'Climate Change Mitigation and Geoengineering'. Nem's current research focus is the relationships and interactions between CO_2 emissions mitigation, geoengineering and adaptation. Starting in October 2010, Nem is the project manager for a new 4-year EPSRC/NERC project, Integrated Assessment of Geoengineering Proposals (IAGP), which aims to build a framework for assessing geoengineering technologies.

Professor Anya Waite

Professor

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Professor Anya Waite is a biological oceanographer whose primary research interests are the links between ocean physics, biology and biogeochemistry. She has explored the open Atlantic, Pacific, Indian and Southern Oceans, and investigated the coasts of Alaska, Canada, Sweden, New Zealand, East Timor and Australia. Her research interests are wide-ranging, and include interactions between oceans and the global climate, nutrient budgets on coral reefs, and the dynamics of rock lobster larvae in the open ocean. Anya's most recent work highlights the biogeochemistry of complex current systems in Australia's north-west. Her work brings together groups of multidisciplinary scientists in interactive research teams.

Dr Stephanie Waterman

Research Fellow/Research Associate

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Dr Stephanie Waterman is jointly appointed as a Research Fellow in the Ocean Observing and Climate Group at the National Oceanography Centre and as a Research Associate at the Grantham Institute for Climate Change, Imperial College London. Her research interests are in combining observational and theoretical oceanography to better understand how components of the ocean circulation at different time and length scales, and hence governed by different physics, interact, and how these interactions impact the large-scale circulation and the ocean's role in the climate system. She is currently involved in observational projects in the North Pacific's western boundary current jet and in the Southern Ocean's circumpolar jets. She also conducts idealised modelling studies of the processes under observational investigation. Stephanie holds a first degree in engineering physics from Queen's University (Canada), a Masters degree in aeronautics from the California Institute of Technology, and a PhD in physical oceanography from the Massachusetts Institute of Technology and the Woods Hole Oceanography Institution's Joint Program.

Dr Tom Webb

Royal Society University Research Fellow

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http://blogs.nature.com/tomwebb (blog)
http://web.me.com/tom.webb/ (under development)

Dr Tom Webb is a marine macroecologist, interested in the distribution of marine biodiversity at very large spatial scales. His research addresses several key questions. First, how can we build an accurate picture of basin-scale patterns in marine communities using data from highly scattered samples? Scaling up from local to regional involves statistical analysis of data on the distribution, abundance and life history traits of large numbers of coexisting species (e.g. North Sea benthic invertebrates). Related to this is trying to characterise the extent of our ignorance of marine ecology: how biased is our record of the distribution of marine biodiversity? How much do we know about the biology of even well-known marine communities? Finally, Tom is interested in the role of people as macroecological drivers, in particular the macroecological consequences of the effects of human activity on the distribution, abundance and body size of exploited and non-exploited species.

Dr Nicole Webster

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Dr Nicole Webster obtained a PhD in 2001 which investigated the microbial ecology of a Great Barrier Reef sponge, focusing on the stability of symbiotic associations over different latitudinal and stress gradients. Her postdoctoral research (2001-2005) was conducted at the University of Canterbury and Gateway Antarctica and focused on utilising microbial communities as sensitive indicators for human-induced stress in the Antarctic marine environment. In recent years, Nicole has been undertaking research to assess the impact of climate change (elevated temperature, sedimentation, eutrophication) on reef bacterial symbiosis. This research primarily focuses on the sponge holobiont (host sponge and microbial associates) using different life history stages (larvae, juveniles and adults) and quantifies the stress response on all symbiotic partners using a variety of molecular techniques, including 454 tag pyrosequencing and GEXP for gene expression profiling.

Dr Dominik Weiss

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Dr Dominik Weiss' research focuses on the geochemistry of trace elements in the aquatic, atmospheric and terrestrial environment. In particular, his group is interested (i) in understanding the isotope geochemistry of transition elements such as Zn, Fe and Cu, (ii) in studying mineral-water interactions of oxyanions such as arsenic and antimony, (iii) in studying dust and its role in climate change and (iv) in quantifying the impact of human activities on global trace element cycles. His work is underpinned by strong analytical research (inorganic mass spectrometry and electrochemistry). Dominik graduated from the ETH Zurich with a diploma in natural sciences (chemistry).
He completed his PhD at the University of Berne working on past atmospheric Pb fluxes and did his postdoctoral work at MIT studying the marine chemistry of Pb. In 2000, he was appointed as lecturer in environmental chemistry at Imperial College London. Dominik is co-leader of the isotope laboratory at ICL and part of the UK GEOTRACES consortium

Dr Steve Widdicombe

Head of Science (Biodiversity and Ecosystem Function)

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Dr Steve Widdicombe is a marine ecologist with expertise in using field observations and large manipulative experiments to address issues relating to benthic ecology, biodiversity and ecosystem function. In particular he is interested in quantifying the effects of disturbance on the structure, diversity and function of marine benthic communities. Much of his recent research has concentrated on the ecological impacts of ocean acidification and elevated temperatures. He is currently leading a large (£2m) consortium project examining the impacts of ocean acidification on key benthic ecosystems, communities, habitats, species and life cycles. Steve is also involved in a number of UK and EU-funded projects studying the ecological risks associated with the release of CO_2 from geological storage sites.

Dr Chris Wilson

Sea level modeller/Physical oceanographer

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Dr Chris Wilson is interested in ocean mesoscale dynamics such as jets and eddies, how they affect large-scale climate and how they are represented in numerical models. His current research focuses on the structure and stability of transport and mixing barriers in the Antarctic Circumpolar Current. Chris received his PhD in physical oceanography from the University of Liverpool in 2001, followed by postdoctoral positions at the Centre for Global Atmospheric Modelling, University of Reading, and at the Department of Earth and Ocean Sciences, University of Liverpool. Since 2006 he has been a member of the Sea Level, Ocean Circulation and Climate Group, and the National Tidal and Sea Level Facility at the National Oceanography Centre, UK.

Biographies

Professor Lorna Casselton FRS

Foreign Secretary and Vice-President of the Royal Society

Lorna Casselton is Foreign Secretary and Vice-President of the Royal Society. She is also Emeritus Professor of Fungal Genetics in the Department of Plant Sciences at the University of Oxford. Lorna researches sexual development in fungi, and is distinguished for her genetic and molecular analysis of the mushroom Coprinus cinereus. She was elected as a Fellow of the Royal Society in 1999 and became Foreign Secretary and Vice-President in 2006.

Lorna began her career in lecturing and research at Royal Holloway College, London and then moved to Queen Mary College, London where she became Professor of Genetics. In 1991 she moved to Oxford University as an AFRC/BBSRC Postdoctoral Fellow. Lorna was a Fellow of St Cross College, Oxford from 1993-2003, and was appointed Professor of Fungal Genetics at Oxford in 1997. She was a member of the Royal Society's Council from 2002-2003, and rejoined the Council in 2006.

As Foreign Secretary, Lorna's duties include overseeing the Society's international relations program, in particular its contact with other scientific academies, and its allocation of funding to both international researchers and UK researchers wanting to study abroad.

Professor Suzanne Cory AC FAA FRS

President of the Australian Academy of Science

Suzanne Cory is one of Australia's most distinguished molecular biologists. She was born in Melbourne, Australia and graduated in biochemistry from the University of Melbourne. She gained her PhD from the University of Cambridge and then continued studies at the University of Geneva before returning to Melbourne in 1971, to a research position at the Walter and Eliza Hall Institute of Medical Research. From 1996 to 2009 she was Director of the Walter and Eliza Hall Institute and Professor of Medical Biology of the University of Melbourne. Her research has had a major impact in the fields of immunology and cancer and her scientific achievements have attracted numerous honours and awards. In 2010 Suzanne was elected President of the Australian Academy of Science.

Dr Sue Meek FAICD FTSE

Chief Executive of the Australian Academy of Science

Sue Meek has 25 years experience working in a variety of capacities at the interface of industry, academia and government. Her particular interests are in promoting awareness and understanding of science and technology, and the formulation of policies and programs to stimulate the conduct and application of research and development. Sue held the position as Australia's inaugural Gene Technology Regulator from December 2001. This statutory appointment was established to administer the national regulatory system for the development and use of genetically modified organisms. Immediately prior to that, she was Executive Director of the Science and Technology Division in the Western Australian Department of Commerce and Trade. In this role she was responsible for the development and implementation of state policies on science and technology, public sector intellectual property management, and the administration of grant programs to support innovation and development of research infrastructure.

Sue has a PhD in marine biology, a Masters in oceanography, and an Honours degree in microbiology. She is a Fellow of the Australian Institute of Company Directors and of the Australian Academy of Technological Sciences and Engineering. Sue is a member of the Centre for Environmental Risk Assessment Advisory Council and was one of fourteen inaugural recipients of the James Cook University's Outstanding Alumni award.

Dr Ian Poiner FTSE

Chief Executive Officer of the Australian Institute of Marine Science

Ian Poiner is the Chief Executive Officer of the Australian Institute of Marine Science, where he is responsible for managing the day-to-day affairs of the Institute. He has significant experience in the strategic development and planning of science, both as a practising scientist and at the organisational level. This is reflected in his successful large-scale, multidisciplinary research projects and his establishment of national and international research programs to support the sustainable use, conservation and management of marine ecosystems. Ian's scientific background is research into tropical fisheries and ecological systems, including in Australia's northern Great Barrier Reef, Torres Strait and the Gulf of Carpentaria. He has also worked in Jamaica, Papua New Guinea and South-east Asia. Ian serves on a number of national and international committees. He is currently Chair of the International Scientific Steering Committee of the Census of Marine Life, a 10-year international research program to assess and explain the diversity, distribution and abundance of marine organisms throughout the world's oceans.

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