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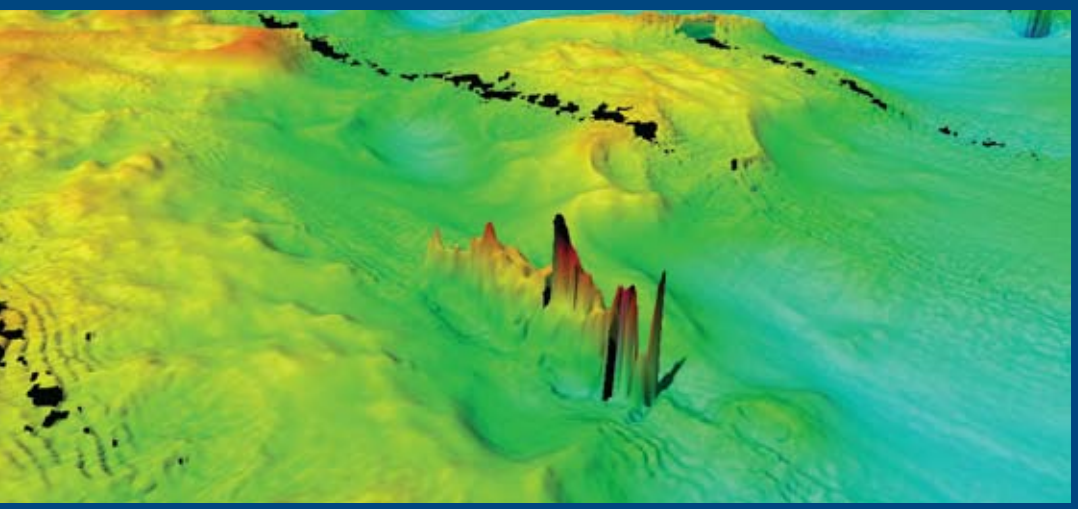
UK marine science strategy



shaping, supporting, co-ordinating and enabling the delivery of world class marine science for the UK.
2010 – 2025

UK marine science strategy

A 15 year strategic framework to support the development, co-ordination and focus of marine science in the UK, across Government, industry, Non-Governmental Organisations and other sectors.

The Marine Science Co-ordination Committee will be responsible for the delivery of the Strategy. The Committee is comprised of the Government Departments, Devolved Administrations and main delivery bodies involved in UK marine science.

Front Cover Pictures:
The Remotely Operated Vehicle *Isis* being deployed. © National Oceanography Centre, Southampton
Marine Scotland's Fisheries Research Vessel *Alba na mara* © Crown copyright
Seabed mapping of ship wreck. © Cefas Photo Library
Oil – gas platform. © Cefas photo library

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Foreword – by the Ministerial Marine Science Group

The seas around our coastlines and the oceans beyond have shaped the history and identity of our island home throughout its existence. They provide us with a rich range of economic, social and cultural benefits, including food, energy, trade routes and tourism. New knowledge and technologies are opening up exciting possibilities, such as the development of new medicines and tidal energy schemes, and form part of our continuing special relationship with the seas today.

Put simply, our seas and oceans are vital for our existence. They give us nearly half the oxygen we breathe, support 80% of the world's biodiversity, and strongly affect the world's climate.

Our impacts on the marine environment, combined with climate change, threaten our oceans and seas. We're already seeing the thinning and retreat of polar ice, ocean acidification and rising sea levels. Scientists predict that increases in sea level could directly affect the 17 million people in the UK living within 10km of the sea, as well as important national infrastructure and much of our manufacturing industry[1].

We need to understand these changes to be able to respond to them; marine science is the key to doing so.

As the Ministerial Marine Science Group, we've been guiding the preparation of the UK Marine Science Strategy by the Marine Science Co-ordination Committee. The Strategy's production has been a truly joint approach by all the UK's Administrations, the UK's leading marine research organisations and a wide range of individuals and organisations involved in marine science and marine-related activities.

The Strategy sets out a framework for shaping, supporting, co-ordinating and enabling the delivery of world class marine science for the UK. It is the first UK Marine Science Strategy to be produced, and its development was a key recommendation of the House of Commons Select Committee report, *Investigating the Oceans*[2]. UK marine science and technology has not, in the past, achieved its full potential, despite the impressive research outputs of individual scientists and UK institutions, as was recognised in the Committee's report. Greater co-ordination, collaboration and focus are needed.

The Strategy will address these issues directly. It will help us to be more efficient and effective in using the resources we have for marine science; to tackle barriers to delivery; and to work with industry and international partners. Marine science delivers the evidence we need now and for the future. The UK is recognised as a leading global player in many fields of marine science. We want to keep it that way.

We'll now be working with stakeholders across the marine community to drive forward the Strategy by identifying a dynamic action programme to deliver current and future commitments. These include an action to develop practical proposals for cross-cutting, sustained funding for priority long-term monitoring systems – a key ask of the stakeholder meetings we held at the very start of this process.

Our ultimate aim of achieving '*clean, healthy, safe, productive, and biologically diverse oceans and seas*' is several steps closer with the publication of this Strategy.

1. http://www.environment-agency.gov.uk/research/library/data/34449.aspx
2. http://www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/470/470i.pdf

Elin Jones
Minister for Rural Affairs, Wales

Edwin Poots
Minister of the Environment, Northern Ireland

Huw Irranca-Davies
Minister for Marine and Natural Environment, Defra. Chair of Ministerial Group

Jane Davidson
Minister for the Environment, Sustainability and Housing, Wales

Lord Drayson
Minister of State (Science and Innovation) Department for Business, Innovation and Skills. Minister for Strategic Defence Acquisition Reform, MOD

Lord Hunt
Minister of State, Department of Energy and Climate Change

Michael Foster
Parliamentary Under-Secretary of State, Department for International Development

Michelle Gildernew
Minister for Agriculture and Rural Development in the north of Ireland

Paul Clark
Parliamentary Under Secretary of State for Transport, Department for Transport

Richard Lochhead
Cabinet Secretary for Rural Affairs and the Environment, Scotland

John Dunn, Marine Scotland, © Crown copyright

1 Executive Summary

Research Vessel *Scotia*.

The need for a UK Marine Science Strategy

The seas and oceans are fundamental to sustaining life on earth. Marine science provides the vital knowledge and information to enable us to take key decisions on the management of our seas and oceans which will affect generations to come. As the increasing impacts of, for example, climate change, ocean acidification and human activities on the marine and wider environment become more evident, and as the growing opportunities the marine environment offers to deliver food and energy security and to generate wealth sustainably are recognised, we look increasingly to marine science to inform both our understanding and our actions. It also serves to help us better comprehend the past. To date, however, there has been no common UK view of what marine science needs to be put in place to inform strategic decisions, nor a co-ordinated approach to ensure it is delivered. This Strategy will address these key issues.

The Strategy's purpose

This Strategy sets the general direction of travel for future marine science across the UK for the period 2010 to 2025. It does so by:

- identifying **high level priority areas for marine science**; and by
- **tackling cross-cutting barriers**, to help deliver the science.

Through its approach, the Strategy provides an **agreed, strategic framework for shaping, supporting, co-ordinating and enabling the delivery of world class marine science for the UK.** It will help to produce the portfolio of evidence needed if we are to achieve the UK vision of having ***'clean, healthy, safe, productive and biologically diverse oceans and seas'.*** It is recognised that the priorities and actions, identified at the start of this process, will change over time to meet changing circumstances, and that the participation of all parts of the UK marine science community – Government, regulatory bodies, environmental agencies, industry, Non-Governmental Organisations and the research and academic sector – and relevant international engagement will be vital for the successful delivery of the Strategy.

Development of the Strategy

The Strategy has been developed jointly by the UK Government and the Devolved Administrations through the Marine Science Co-ordination Committee[3], in liaison with the UK marine science community and other key stakeholders. The development of a strategy was a key recommendation of a House of Commons Select Committee Report[4]. It does not seek to duplicate existing strategies, nor is it intended that it should be a 'strategy of strategies'. Rather it sets the broad direction for future marine science and identifies where more co-ordinated working and greater alignment can deliver the greatest results. This is a Ministerially-driven process, focused on co-ordination and results.

Wind farm off the coast of Blyth, Northumberland – the first offshore wind farm to be built in the UK.

3. The Marine Science Co-ordination Committee (MSCC) is comprised of the Government Departments, Devolved Administrations and main delivery bodies involved in UK marine science, and three non-executive members. Further details are at: http://www.defra.gov.uk/environment/marine/science/mscc.htm and at Annex III of this Strategy.

4. http://www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/470/470i.pdf

High-level science priorities

The Strategy sets out three high level priority areas:-

- **'understanding how the marine ecosystem[5] functions'**;
- **'responding to climate change and its interaction with the marine environment'**; and
- **'sustaining and increasing ecosystem benefits'**.

Within these high level priorities the Strategy describes some of the key policy questions that need to be addressed and the natural, social and economic science research required to provide the evidence to support critical policy decisions. The questions and the research identified are illustrative and not intended to provide an exhaustive list nor to indicate any hierarchy of importance.

© Northern Ireland Environment Agency

Research Vessel *Capitella* in a coastal setting near Bangor, undertaking a survey of the marine environment using a Falcon 1251 remotely operated vehicle (ROV).

Tackling the barriers to delivery

The Strategy also identifies a range of cross-cutting measures that will strengthen co-ordination between the main funders and providers of marine science in the UK and overcome barriers, thus ensuring that resources are better aligned to deliver world class marine science for current and future policy needs. Three key areas of action have been identified as priorities to be taken forward in the first phase of the Strategy:

- **Alignment of science effort** – ensuring marine science programmes, their funding and capabilities are focused effectively in areas of high impact. Topics, within the three high level priorities, will be selected via a rolling programme, to check that resources and capabilities across research funders and providers are most effectively aligned;
- **Sustained long-term monitoring** – making the process for selecting long-term observation systems for funding more transparent and providing secure, longer-term and cross-cutting funding for priority datasets; and
- **Communications** – developing a pro-active communications strategy for strengthened two-way engagement with the public on the importance of marine science and delivering an action plan for improving communication between scientists and policy makers.

The Marine Science Co-ordination Committee will also continue to **work with and through others**, to support, co-ordinate and enable barriers to delivery to be overcome, as part of its continuing business. This will include: steps to improve access to data, and the identification of future skills needs for marine science and measures for promoting

5. Ecosystem – defined as a natural unit of living things (animals – including humans – plants and micro-organisms) and their physical environment.

April 2009: Research Vessel *Cefas Endeavour* arriving in London to host a marine science exhibition during the passage of the Marine and Coastal Access Bill through Parliament.

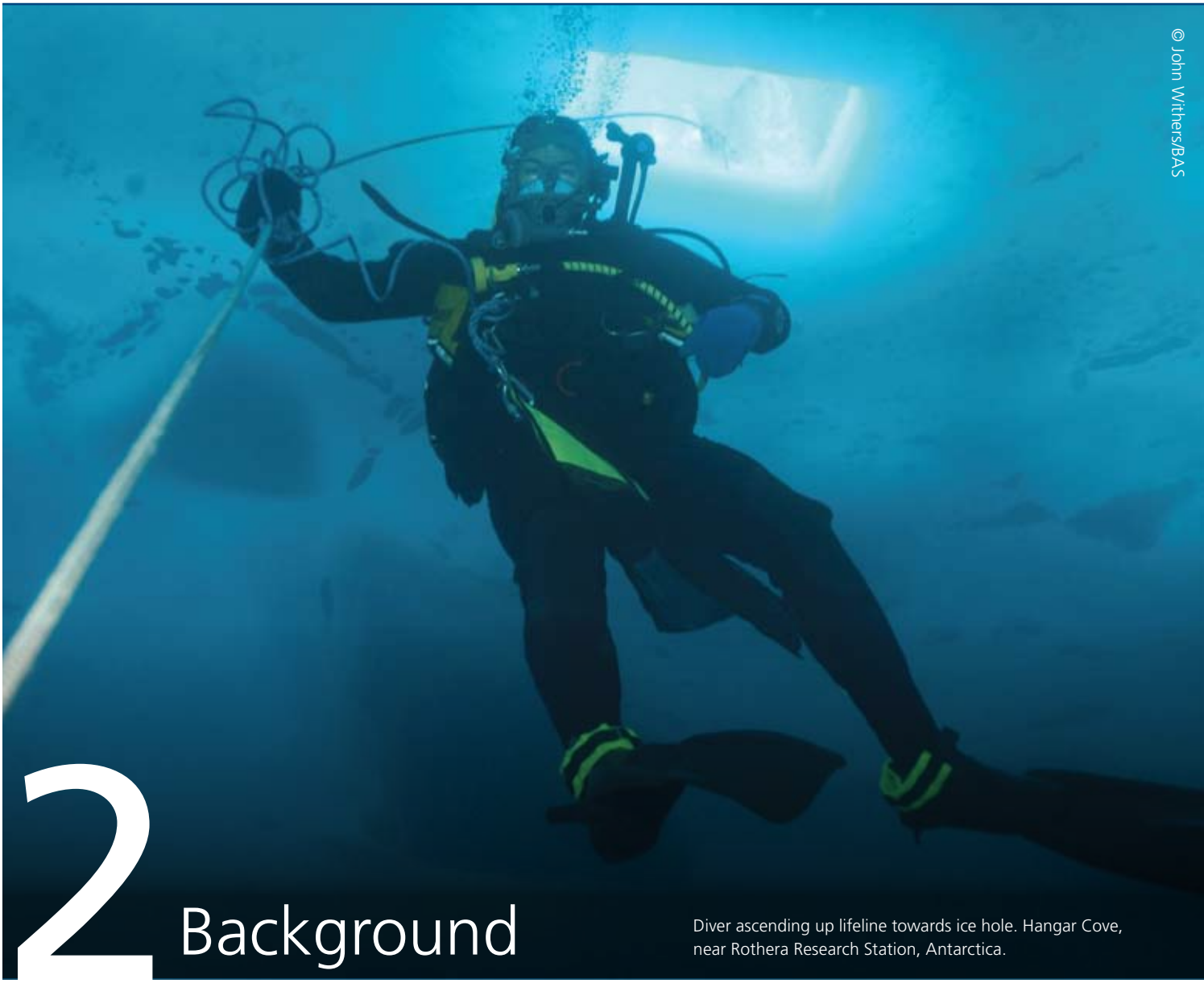
the growth of marine industries. Further actions will be developed during the life of the Strategy and **'horizon scanning'** will be a key process to help inform decisions on its future direction. The Strategy will apply to all types of marine science – from fundamental, 'blue skies' research to applied research, as well as spanning the natural, social and economic sciences. Its focus will be on publicly-funded marine science but it will take account of relevant science funded by others.

Delivery of the Strategy

The Marine Science Co-ordination Committee will drive forward the delivery of the Strategy. In doing so, it will work closely with the wider UK marine science community, with partner bodies in Europe and other countries to produce the most effective body of evidence to support science and policy decisions. The Marine Science Co-ordination Committee's work will be overseen by a Ministerial Marine Science Group, to which the Committee will provide an annual published report which will include progress on delivering the Strategy, and details of the level of public sector expenditure on marine science. The Governance arrangements for the Marine Science Co-ordination Committee, and its links to related groups, are provided at Annex I.

This Strategy represents the stable framework within which a Delivery Plan will continue to be developed. This is web-based (http://www.defra.gsi.gov.uk/environment/marine/science/mscc.htm) and will be dynamic, setting out rolling programmes of priority activities identified in collaboration with stakeholders.

This Strategy has been developed at a time when marine science is increasingly needed to inform far reaching decisions while resources are ever more constrained. The Strategy, with its strong cross-cutting, collaborative approach, will be a key tool to ensure UK marine science is delivered effectively and efficiently in the coming years and in maintaining a world class marine science base within the UK.



© John Withers/BAS

2 Background

Diver ascending up lifeline towards ice hole. Hangar Cove, near Rothera Research Station, Antarctica.

UK Marine Science Strategy Operating Principles

The Strategy will:

- apply to all science funded by the Departments, Devolved Administrations and bodies represented on the Marine Science Co-ordination Committee – see Annex II.
- complement existing strategies by highlighting UK priorities whilst not limiting what individual funders should do.
- address key barriers to the development and delivery of marine science.
- involve stakeholders in the actions being delivered.
- result in a series of regularly updated actions outlined in a publicly available Delivery Plan.
- enable a step change in the co-ordination of UK marine science, and in the ease and effectiveness of its delivery, over the next 15 years.
- help to cultivate an environment in which high quality science is consistently delivered.

The importance of marine science to the UK

This is an important and exciting time for marine science. There has probably never been a period when our need for knowledge about the seas and oceans has been greater. Fundamental decisions on the management of our seas and oceans must be taken in the next few years; they will affect generations to come.

The UK Marine Science Strategy has an important role to play as it will provide the high level direction to help us develop the marine science that will be needed to answer some of the big policy questions that are being asked, such as:

Food security – how can we secure sufficient healthy, affordable and sustainably sourced fish and marine products for an increasing world population?

Energy security – how can we capture the ocean's valuable energy supply in a way that assists us to mitigate climate change whilst not prejudicing the health of the marine environment?

Bass.

In the developing world, 60% of the people obtain more than 30% of their protein supply from fish. The global market makes food security for fish an international political issue of great complexity.

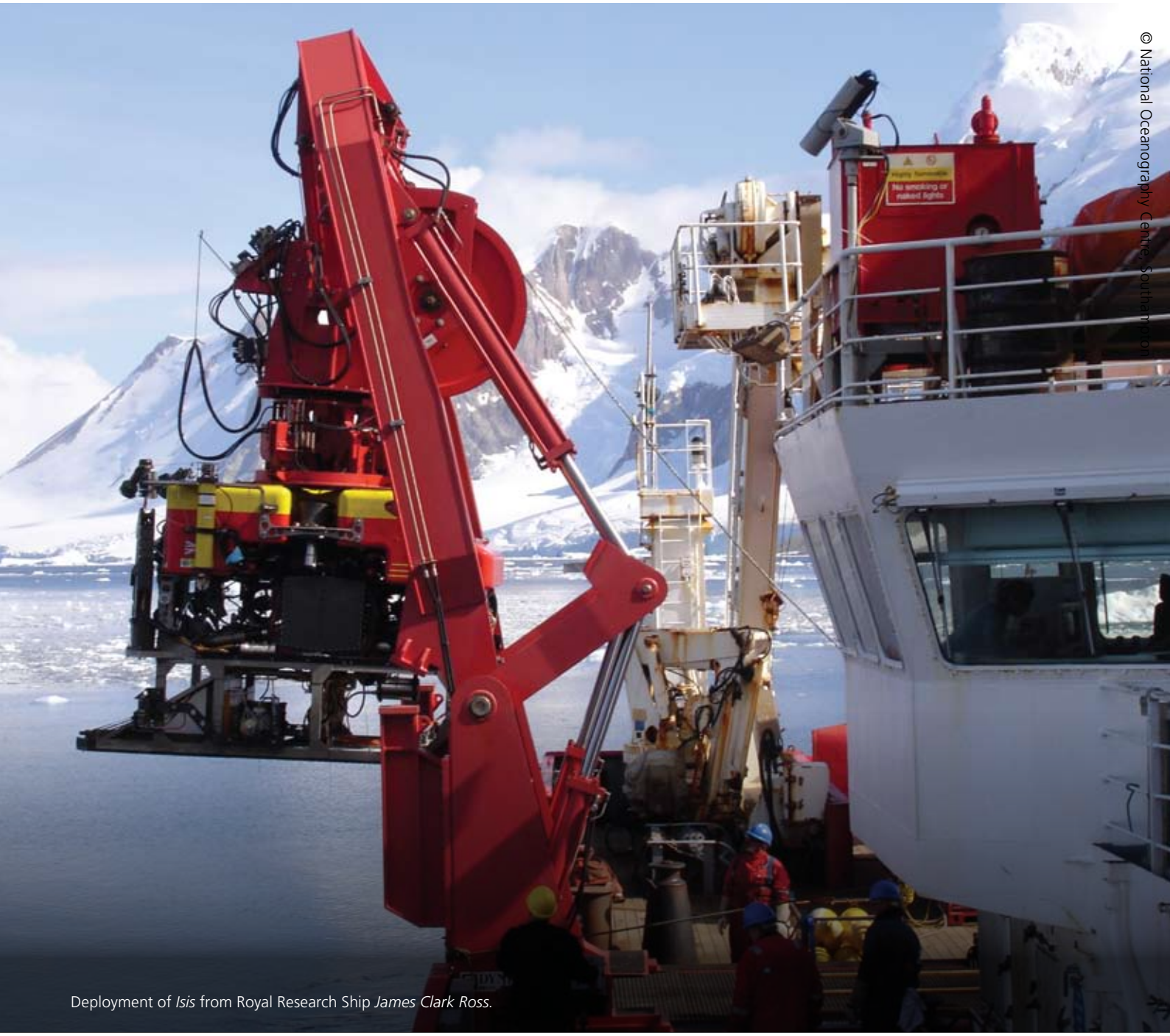
Climate change and ocean acidification – how will the seas and oceans and the life within them change as a result of increasing greenhouse gases and to what extent can they mitigate the impacts?

UK cold-water coral which is seen as a valuable indicator of anthropogenic impacts such as climate change and commercial fishing.

The global abundance of cold water corals has only recently been appreciated, following the discovery by UK researchers in the 1990s of extensive deep-water reefs in the North East Atlantic. [*The Darwin Mounds off NW Scotland are now a Special Area of Conservation.*]

Economic benefits – how can we optimise the opportunities the oceans provide for generating economic benefits sustainably, whether by sourcing new products, such as bioactive compounds, or by increasing the availability of marine-based renewable energy, or through sustainable fishing and mariculture?

Human activity – how should we seek to influence behavioural change in existing human activities, to prevent adverse impacts on the marine environment?



Deployment of *Isis* from Royal Research Ship *James Clark Ross.*

Marine science will provide the evidence upon which informed choices can be made about how we wish to balance the costs and benefits associated with the use we make of the seas and oceans, and also the way in which they influence our lives. These influences can be large and, when properly managed, can be channelled to enhance the health, wealth and wellbeing of the nation. It is essential that we understand how the seas and oceans are structured and how they function in response to some of the biggest challenges of our time – such as climate change, food security and energy availability – if we are to continue to find ingenious solutions to seemingly intractable problems. We will harness UK expertise and continue to engage with international partners to find global answers to these issues.

The changing policy landscape will also require significant decisions, for example: on bio-diversity, conservation and climate change targets; the determination of 'good environmental status', to enable implementation of the EU Marine Strategy Framework Directive; the practical application of

marine planning required by the UK Marine and Coastal Act and the Devolved Administrations' Marine Bills; and the arrangements for managing fish stocks in the review of the EU Common Fisheries Policy.

Analysis of fish egg viability allows fisheries managers to establish maximum sustainable yield.

The international dimension of UK marine science

- The oceans occupy 70% of the Earth's surface and are interconnected; having a global perspective to marine science is therefore crucial for both scientific understanding and our international obligations. However, it is beyond the capability of any single nation to conduct truly global marine science (particularly via observations) and effective international collaborations are essential to achieving these outcomes.
- Critical global issues include, for example: the interaction between the ocean and climate, understanding past oceans and atmospheric composition, the polar seas, the deep ocean, geo-engineering studies, geo-hazards, monitoring in international waters and a range of other issues. All require international interdisciplinary approaches.
- The UK is one of the few countries with the capability, and the proven track record, to carry out marine science in all parts of the world's oceans. Through the use of the UK's ocean-going research vessels, participation in international satellite remote sensing programmes, and the development and application of global computer models, UK scientists have made powerful contributions to international oceanography.
- The UK provides strong leadership of international marine science programmes spanning physical, biological, chemical and geophysical disciplines. The strength of the UK contribution has been recognised by having several international marine-related project offices sited within the UK.
- The UK's global reach is one of the reasons why the UK features so prominently in assessments of international excellence in this field. Many challenges face us on our shelf seas and much of the applied science to manage our seas is undertaken with EU partners co-ordinated by bodies such as ICES and OSPAR[6].
- International engagement will continue to be a key element of UK marine science and ways to enhance this are being considered, including improved networking of marine scientists representing the UK on international bodies and finding ways to achieve more effective participation in EU Framework Programmes that benefit UK marine science and policy.

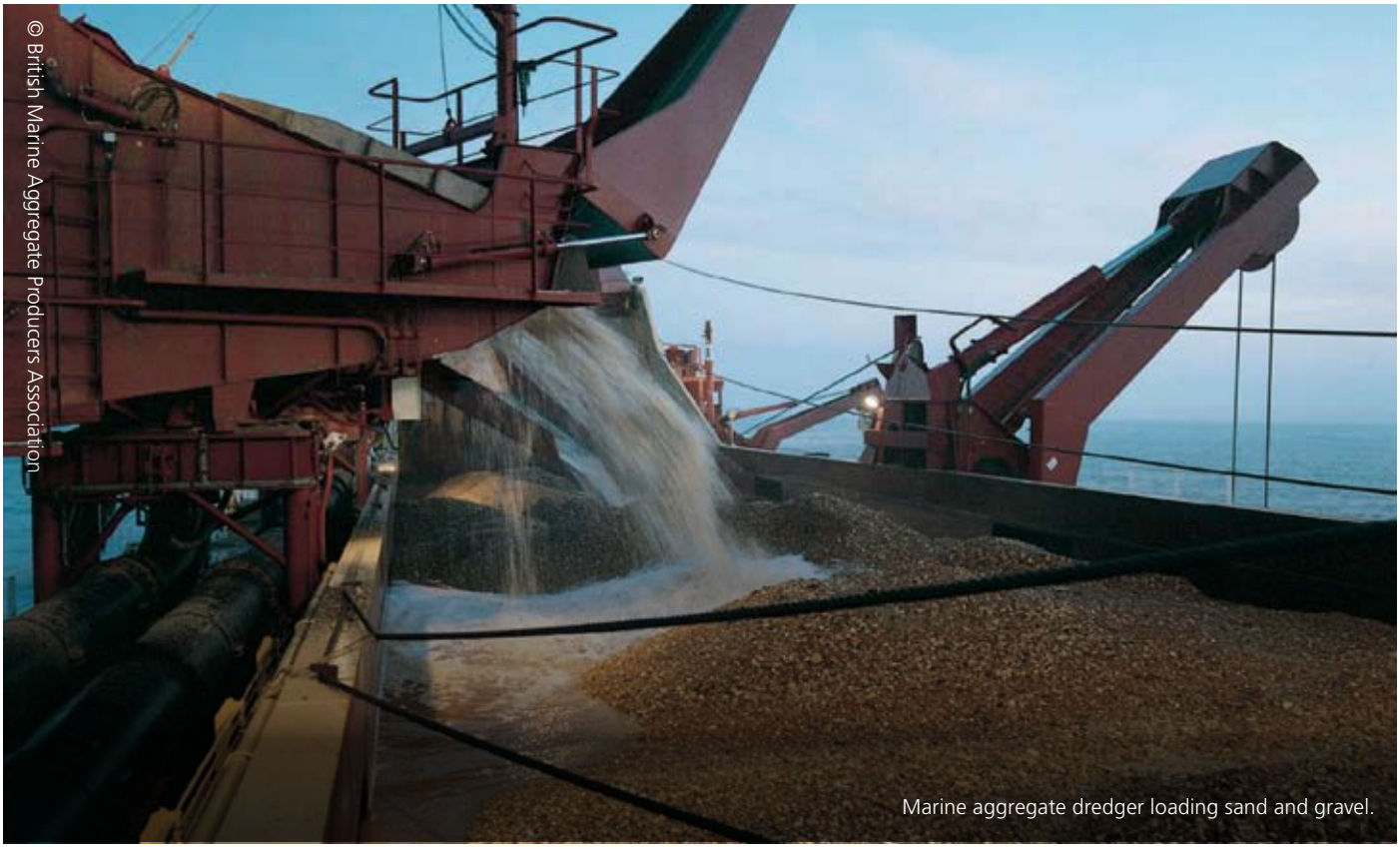
6. International Council for the Exploration of the Sea (ICES) http://www.marine.gov.uk/ICES.htm; The Oslo and Paris Commissions (OSPAR) http://www.ospar.org/

A strategic framework

The UK Marine Science Strategy provides the strategic framework for developing the marine science that will meet these evidence needs. The Strategy draws heavily on the findings of the House of Commons Science and Technology Committee's comprehensive Report, '*Investigating the Oceans*', 18 October 2007, HC 470-1: http://www.publications.parliament.uk/pa/cm200607/cmselect/cmsctech/470/470i.pdf. The Strategy has been produced jointly by the UK Government and the Devolved Administrations and will deliver significant improvements in the way marine science is prioritised, co-ordinated and delivered in the UK, including the better co-ordination of funding. This is of particular importance as we adopt a more ambitious, holistic approach to marine management with demanding requirements for scientific knowledge and understanding.

The Strategy is mainly aimed at those working within, and around, the marine science community. However, it will also be of interest to those with a more general concern for marine science issues. The Strategy also recognises the importance of marine science to society generally.

Research Vessel *Corystes* is an ocean going, multi-functional platform which facilitates marine fisheries, oceanography and sea-bed mapping.



Marine aggregate dredger loading sand and gravel.

How the UK Marine Science Strategy will make a difference

The Strategy will:

- Bring about better co-ordination of policy priorities, research programmes and funding.
- Improve value for money by establishing a long-term, simple but robust strategic framework within which priorities can be set out on a rolling basis, as they arise.
- Deliver actions not just words.
- Focus initially on a few high priority cross-cutting issues which, if addressed successfully, will make a significant difference to UK marine science.
- Introduce more effective collaboration and co-operation among member bodies of the Marine Science Co-ordination Committee and the wider marine science community.

Expertise in marine science is spread across a wide range of Higher Education Institutes (HEIs) and research institutes, and across industry, Non-Governmental Organisations (NGOs), and UK and Devolved Government departments and their agencies. It is recognised that individual organisations will have their own science priorities and geographical regions of interest, often articulated in separate strategies. Details of the research interests of the member organisations of the Marine Science Co-ordination Committee are provided at Annex III of this document. These include the work of key Government regulatory agencies, which provide an important contribution to UK marine science. The UK Marine Science Strategy is not a 'strategy of strategies' and does not seek to duplicate existing strategies or to dictate what individual funders should do. Rather it provides a framework to establish broad priorities and a rallying point for marshalling overall actions, identifying cross-cutting barriers to delivery and actions to address these over the period 2010 to 2025.

How the Strategy is organised

The following sections set out:

a) the **scope** of the Strategy – what it includes and excludes;

b) the Strategy's **objectives and policy context** – how the marine science will underpin the UK's vision for *'clean, healthy, safe, productive, and biologically diverse oceans and seas'*;

c) the **high-level science priorities** of:

- 'understanding how the marine ecosystem functions',
- 'responding to climate change and its interaction with the marine environment', and
- 'sustaining and increasing ecosystem benefits';

d) **how barriers to delivery will be tackled** – the cross-cutting issues affecting delivery of the science priorities and actions to address them;

e) the role of '**horizon scanning' and future actions** as the Strategy continues to develop over its 15 year lifespan; and

f) details of **how the Strategy will be delivered**.

Additional information on related plans, strategies and legislation can be found in the Annexes.

Every square kilometre of ocean removes, on average, around 5 tonnes of carbon from the atmosphere each year. Without this net uptake, greenhouse warming would have been around 50% faster and global temperatures might have already increased by 2˚C.

Scope of the Strategy

The Strategy has been developed by the Marine Science Co-ordination Committee[7], with significant input from the UK marine science community. The Governance arrangements for the Marine Science Co-ordination Committee, and its links to related groups, are provided at Annex I. The Strategy has an initial target life of 15 years and will be reviewed at five yearly intervals.

For the purposes of this Strategy, 'marine science' is taken to include social sciences, for example, social and economic analyses, as well as natural sciences and the technology needed to support marine science, such as instrumentation for the exploration of the oceans. At the same time, the Strategy spans the full range of science activities, from curiosity-led 'blue skies' research to directed strategic programmes. Effective integration across natural, social, economic and technological science will be key to the delivery of the marine science required by policy makers. Such an integrated approach would be needed, for example, in order to understand how sustained behavioural changes can be achieved that help to reduce the negative impacts of human activity on the marine environment.

Waves breaking on sea wall, Sidmouth, Devon.

7. The Marine Science Co-ordination Committee (MSCC) is comprised of the Government Departments, Devolved Administrations and main delivery bodies involved in UK marine science, and three non-executive members. Further details are at: http://www.defra.gov.uk/environment/marine/science/mscc.htm and in Annex III of this Strategy.

UK researchers first identified endocrine [hormone] disruption problems in marine organisms arising from anti-fouling paints and other organic compounds.

The Strategy is intended to be primarily a 'marine', rather than a 'maritime', science strategy and its focus is on the marine environment and on understanding how marine systems work – how they impact on us and how we impact on them. Science for maritime structures (such as ships, oil & gas platforms, ports & harbours, and renewable energy structures) will be included in so far as it relates to their impact on the marine environment (e.g. research on dealing with different types of oil pollution resulting from shipping incidents, understanding the importance of historic wrecks for ecosystems, and the impact of noise on marine organisms).

The geographic spread of the waters covered by the Strategy is not limited. The principle of improving co-ordination and delivery of marine science also applies to UK scientific activities, for example, in far oceans (including the waters of UK Overseas Territories). In areas of potential science and policy overlap, such as the land/sea and atmosphere/ocean interfaces, where the dividing lines are not always clear, a pragmatic approach will be taken in applying the Strategy.

The air delivers our weather, the sea our climate. More heat is stored in the top 5 m of the ocean than in all the Earth's atmosphere, and around 25% of the heat input to the UK is first absorbed by the surface waters of the North Atlantic.

Conservationists and government scientists attempt to refloat a stranded Minke Whale off the North Coast of Northern Ireland.

Key marine science stakeholders

UK marine industry:

- The UK marine industry **spans a wide range of diverse and rapidly changing activities**, ranging from fisheries, oil and gas extraction, aggregates, shipping operations, and ship and boat building and maintenance, to defence, the leisure and recreation industry, ports, insurance brokers and bankers, cable laying companies, and construction, as well as many other areas of activity.
- Marine industries play a strategic role in enhancing the UK's science base and in delivering core research and data through their own **major research, monitoring and development programmes. The industry also undertakes Government-funded marine science**.
- UK industry **develops and manufactures key, and often novel, marine research equipment** that provides the UK with greater capability, for example, to explore new parts of the oceans or to make measurements with greater precision.
- Of the £46bn Gross Value Added contribution to the UK economy in 2005-06 from direct marine-related activities[8], the majority was from UK industry activity. **UK industries' products and services are sold globally** and some, such as the leisure and recreation industry, provide a direct interface with the public.
- Industry's competitive edge is underpinned by marine science. It is important for scientists to understand the needs of the sector and to engage with them. Trade associations, such as the Society of Maritime Industries and individual companies, **participate in key national marine science discussions**, providing an important perspective to Government and others, and in **collaborative ventures** with academics, NGOs and Government in fora, such as the Underwater Sound Forum.
- The UK marine industry is a **significant employer of the country's graduates and post graduates in marine science** and has a highly skilled research base.

8. Pugh, D. *Socio-economic Indicators of Marine-related Activities in the UK economy*. The Crown Estate copyright. March 2008. ISBN: 978-1-906410-01-8.

Non-Governmental Organisations (NGOs):

- Non-Governmental Organisations (NGOs) **play an active role within the marine science community**. Their specific interests range from the protection of birds, whales and other cetaceans to the state of the wider marine environment, while professional associations, such as the Institute of Marine Engineering, Science & Technology (IMarEST), the Marine Biological Association and the Scottish Association for Marine Science, provide developmental support to the marine science community.
- They **bring important and helpful perspectives on the scientific information needed for decision making**, on how the science is commissioned, delivered and/or sustained, and on the challenges with using the marine science obtained.
- NGO input to Government initiatives, such as the development of this Strategy, is critical. They **provide direct views from users** and, as a community, **bring considerable expertise to the table**.

Research and Academia:

- **Significant numbers of marine scientists and researchers are employed within Universities, other Higher Education establishments and research institutes.**
- **Major infrastructure for marine research and monitoring includes ships, satellites, remotely operated vehicles and autonomous underwater vehicles, buoys and a wide variety of instruments.** These are funded and supported principally by the **Research Councils, Government Departments and industry**.
- Disciplines within the sector span the full range from **Mechanical, Chemical, Electrical and Electronic Engineering, and Marine Archaeology** to **Earth Sciences, Naval Architecture, Marine Sciences and Socioeconomics**. Other areas include operational oceanography, developed from the research sector, which is an essential commercial tool for supporting offshore and coastal operations, and which will require a supply of well qualified oceanographers for the growing world market.
- The sector undertakes a significant proportion of the publicly-funded marine science in the UK. The **Research Councils** (e.g. NERC, EPSRC, ESRC, BBSRC[9]), which are funded by the Department for Business, Innovation and Skills through the Science Budget, provide a large part of this support while **Government Departments** and a number of Non-Departmental Public Bodies, such as English Heritage, contribute an important part of the sector's funding. **Industry, non-Governmental organisations and other bodies also invest in research** within this sector, and this includes funding sourced from the **European Union** and **international projects**.
- The sector **contributes a significant body of knowledge and expertise** on marine science; the quality of this science base has been a key factor in maintaining the UK's position as one of the world's leaders in marine science.

9. NERC: Natural Environment Research Council; EPSRC: Engineering & Physical Sciences Research Council; ESRC: Economic and Social Research Council; BBSRC: Biotechnology & Biological Sciences Research Council.

Stakeholder involvement in delivering the Strategy:

- Working Groups established to take forward the main Strategy actions will include stakeholders drawn from the wider marine science community, as appropriate.
- Stakeholders will be kept informed of progress in the Working Groups and will be invited to comment and contribute at key stages.
- 'Link' members of the Marine Science Co-ordination Committee will provide a proactive interface between the Committee and specific sectors of the marine science community.
- Stakeholders will be asked to propose actions for future phases of the Strategy and to contribute to the delivery of actions within the Delivery Plan.

3 Strategy objectives

Menai Strait sponge monitoring.

Policy context

The UK Marine Science Strategy supports and complements UK marine policy and, in particular, the overarching vision of '*clean, healthy, safe, productive, and biologically diverse oceans and seas*'. This policy vision is described in more detail in the High Level Marine Objectives[10]. These also describe what achievement of the vision would mean for the seas and oceans in 20 years' time and the outcomes needed to make this possible.

10. http://www.defra.gov.uk/environment/marine/documents/ourseas-2009update.pdf

The High Level Marine Objectives are set in the context of the five sustainable development principles:

- Achieving a sustainable marine economy
- Ensuring a strong, healthy and just society
- Living within environmental limits
- Promoting good governance
- Using sound science responsibly.

They reflect the full range of UK Government and Devolved Administrations' policies in the marine area. The objectives will be used in the development of a UK Marine Policy Statement, which will provide a framework for achieving sustainable development. They have already been taken into account in developing the UK Marine and Coastal Access Act and the Devolved Administrations' Marine Bills. They also define the UK approach to international policy measures, such as the EU Marine Strategy Framework Directive, EU Water Framework Directive, OSPAR convention and other agreements.

In order to achieve the vision of having '*clean, healthy, safe, productive and biologically diverse oceans and seas*', major policy decisions, with implications for generations to come, will need to be taken over the next few years. These include measures to help society mitigate and adapt to climate change; develop new, clean, secure energy sources and sustainable, secure food supplies; and include measures to protect, to conserve, to halt the decline in and, where appropriate, to recover biodiversity[11].

Fishing is moving into deeper waters where fish grow and reproduce more slowly. Some species like orange roughy can live to 100 – 150 years, and this age structure needs to be taken into account when setting sustainable fishery yields.

Puffin at Sumburgh Head, Shetland.

The vision requires an holistic approach to policy making. It seeks to integrate and manage the range of demands placed on ecosystems – which are complex natural units composed of animals (including humans), plants, and micro-organisms, and their physical environment – in such a way that the ecosystem can be conserved and can indefinitely support essential services and provide benefits for all – the '**ecosystem approach**'[12].

The development of an integrated and sustainable policy approach requires an understanding of the associated coupled social and ecological systems. Social and economic drivers produce pressures on natural systems that, together with climate change, alter ecosystems and affect human welfare. Some of these changes are inevitable and require adaptation whereas others can be foreseen and avoided or their effects minimised.

It is critical that marine science and scientific data are used to help shape policy, both within the UK and Europe, to ensure that policy development is evidence-based and to enable policies to reflect

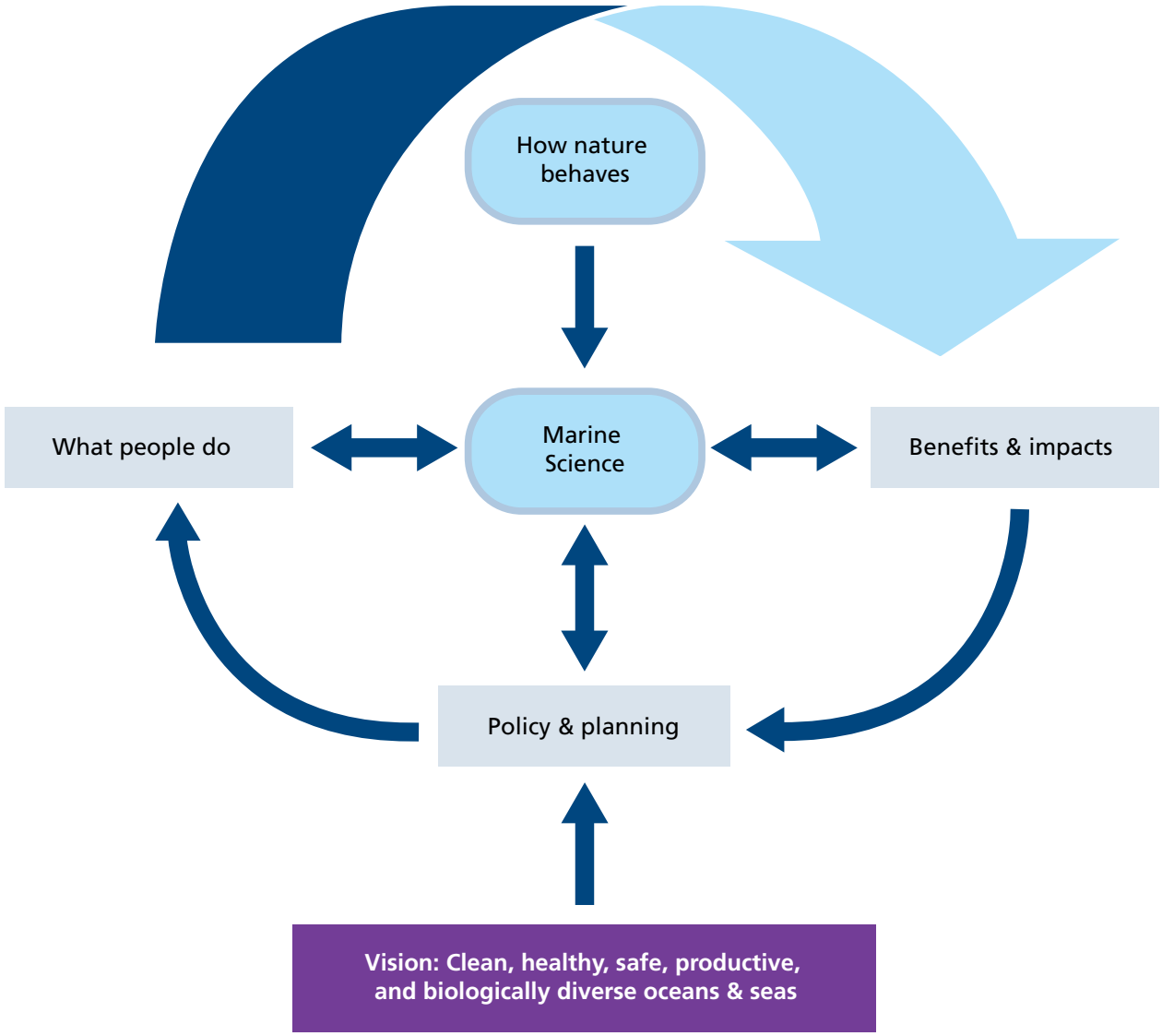
11. 'Our Seas – a shared resource'; http://www.defra.gov.uk/environment/marine/documents/ourseas-2009update.pdf
12. The ecosystem approach can be defined as 'a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way' http://www.cbd.int/decision/cop/?id=7148.).

new knowledge. We are interested in the drivers, the impacts and benefits, and how natural systems behave. We also need to understand the way they relate to one another, how they respond to change, and the options that are available to policymakers for maintaining a healthy ecosystem where benefits are maximised and adverse impacts minimised. Much of the science undertaken by Government is to support regulation, which in turn can have a role to play in positively influencing human behaviour within the marine environment. Figure 1 illustrates the central role marine science plays within the ecosystem approach to management.

High level science priorities

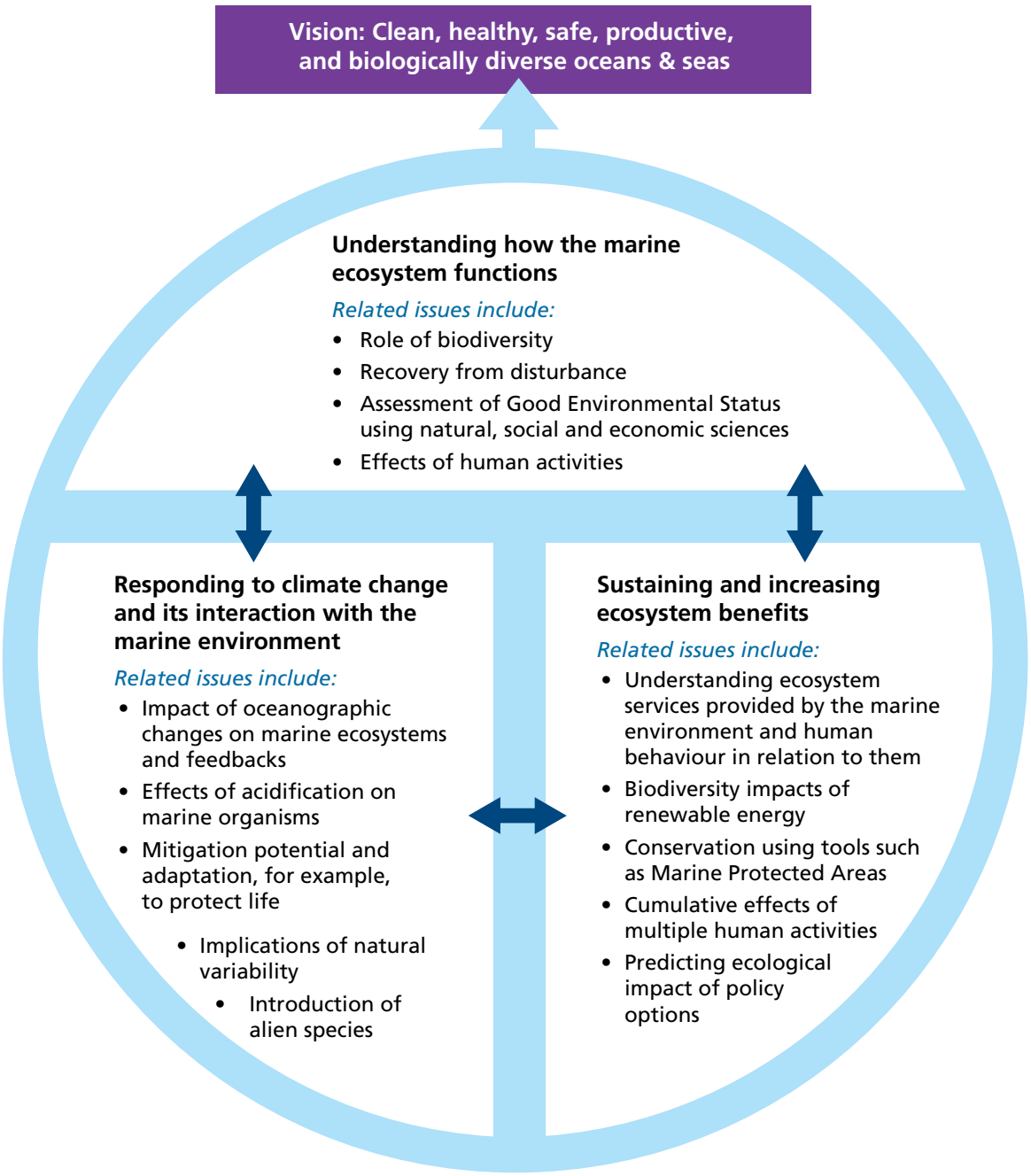
Three headline marine science priority areas have been identified as essential to underpin the ecosystems approach – '**understanding how the marine ecosystem functions**', '**responding to climate change and its interaction with the marine environment**' and '**sustaining and increasing ecosystem benefits**'. These are consistent with the themes which have emerged from discussions with stakeholders and the views of the bodies represented on the Marine Science Co-ordination Committee. They also align with other initiatives such as Living With Environmental

Figure 1: Science within the ecosystem approach to management



Change[13], a major collaborative programme agreed by 20 departments, Devolved Administrations and agencies. They are therefore already part of a broader cross-governmental strategy. The following sections explain the importance of each of the three priority areas and their policy relevance. The science issues and policy questions identified within these sections are illustrative of the range within each policy area and are not intended to be an exhaustive list nor are they presented in order of importance. It is notable that human activity affects all three areas. The relationship between the science priorities and the policy vision is illustrated in Figure 2.

Figure 2: Relationship between the science priorities and the policy vision



13. http/www lwec.org.uk/ (see also http://uknea.unep-wcmc.org/ for the UK National Ecosystem Assessment).

Understanding how the marine ecosystem functions

Related policy questions[14] include:

- What is the role of biodiversity in maintaining specific ecosystem functions?
- How long does the seabed take to recover from disturbance such as oil and gas extraction?
- How do we establish a basis for reliable Good Environmental Status indicators using both natural, social and economic sciences?
- What impacts will increased human activity have on the ecosystems of the deep sea?

The UK-hosted Continuous Plankton Recorder survey is the world's longest-running and most extensive large-scale biodiversity monitoring programme. It started in 1931, and now covers the North Atlantic and North Pacific and parts of the Southern Ocean and Arctic Ocean.

In order to underpin policy-related marine science there is a continuing need to improve our understanding of how the marine ecosystem works. It will be important to capture the implications of the new knowledge gained from all modes of research, including within the academic sector, for future policy development and implementation and this needs to be underpinned by the ongoing gathering of appropriate evidence.

Among the topics that need addressing is how, in relation to the concept of **Good Environmental Status (GES)**, we can use the best available science to develop robust indicators (as required by the European Marine Strategy Framework Directive). Assessing GES involves human value judgements and therefore **natural, social and economic science are needed** to determine

© Sir Alister Hardy Foundation for Ocean Science

The long-term use of the Continuous Plankton Recorder, being seen launched here, has allowed scientists at SAHFOS to understand how the marine ecosystem has and continues to operate.

management options. Human activity and its footprint are moving progressively into deeper waters and there is a need to close the knowledge gap concerning especially vulnerable **deep sea ecosystems**. Other topics include: the **role of biodiversity in maintaining specific ecosystem functions** (e.g. biogeochemical cycles), understanding how to deliver **resilience** and **how long it takes for the ecosystem to recover from disturbance**, such as the impact of dredging and off-shore wind-farm construction, and **identifying how to determine whether particular uses of the marine environment are sustainable**. An improved understanding of

Less than 1 sq km of the deep sea floor has been directly sampled by scientists. The UK is one of the top five nations involved in such work.

14. Based in part on Sutherland et al (2006) 'The identification of 100 ecological questions of high policy relevance in the UK', *Journal of Applied Ecology*, 43: 617-627

how the marine ecosystem functions will inform the more applied priority areas of 'responding to climate change and its interaction with the marine environment', and 'sustaining and increasing ecosystem benefits'. Both are described below.

Responding to climate change and its interaction with the marine environment

Related policy questions[15] include:

- How will changes to oceanographic conditions as a result of climate change affect marine ecosystems, and how will they impact on society as a whole?
- How will acidification of the world's oceans from rising CO_2 concentrations affect planktonic productivity and other marine organisms?
- How much will sea level rise around the UK in the next few decades and what will be its effect?
- What management measures should be adopted to mitigate against and adapt to climate change in the marine environment, including protection of human life?
- What are the implications of natural variability and how can we distinguish it from anthropogenic causes?

The oceans both drive and respond to the weather and climate. They are critical to understanding and predicting the course of future climate change because of their capacity to absorb, store and globally redistribute carbon, heat and freshwater. **Changes in the oceans themselves**, e.g. rising temperature and acidification, as a result of greenhouse gas emissions, have already become evident. They have **important consequences for the marine ecosystem**, such as impacts on marine foodwebs and the introduction of alien species. Paleoceanography[16] and long-term observations provide vital insight to these changes. This is a key policy issue but scientific knowledge is far from complete.

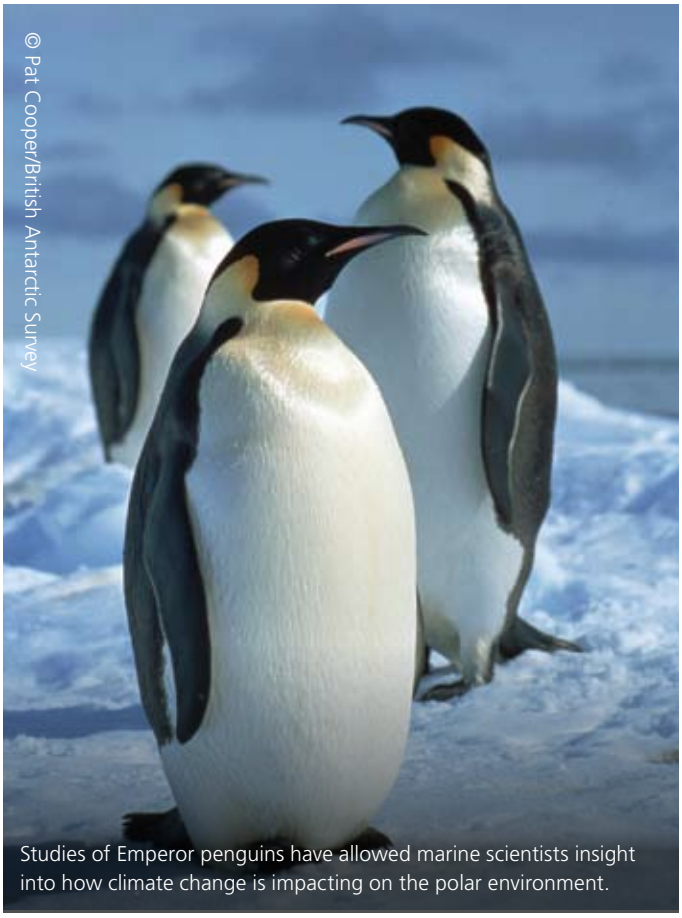
Phytoplankton: *Navicula* spp.

The ocean contains around 95% of the world's mobile carbon, and provides nearly half the oxygen we breathe.

There is a particular need to improve understanding at the national/regional scale and on decadal timescales to provide a **more robust evidence base for adaptation planning**. This includes determining **thresholds for rapid or irreversible change**, identifying the wider implications of **future changes in the polar regions** and **improved estimation of sea-level rise**. Information, for example, relating to the processes and impacts of past sea-level change on submerged archaeology will help to shed light on future changes. Suggestions that the oceans

UK researchers helped alert the world to the potential impacts of ocean acidification, particularly to corals and polar ecosystems. A major research programme will start in 2010, supported by NERC, Defra and DECC.

15. Based in part on Sutherland et al (2006) 'The identification of 100 ecological questions of high policy relevance in the UK', *Journal of Applied Ecology*, 43: 617-627
16. Paleoceanography is the study of the history of the oceans in the geologic past with regard to circulation, chemistry, biology, geology and patterns of sedimentation.

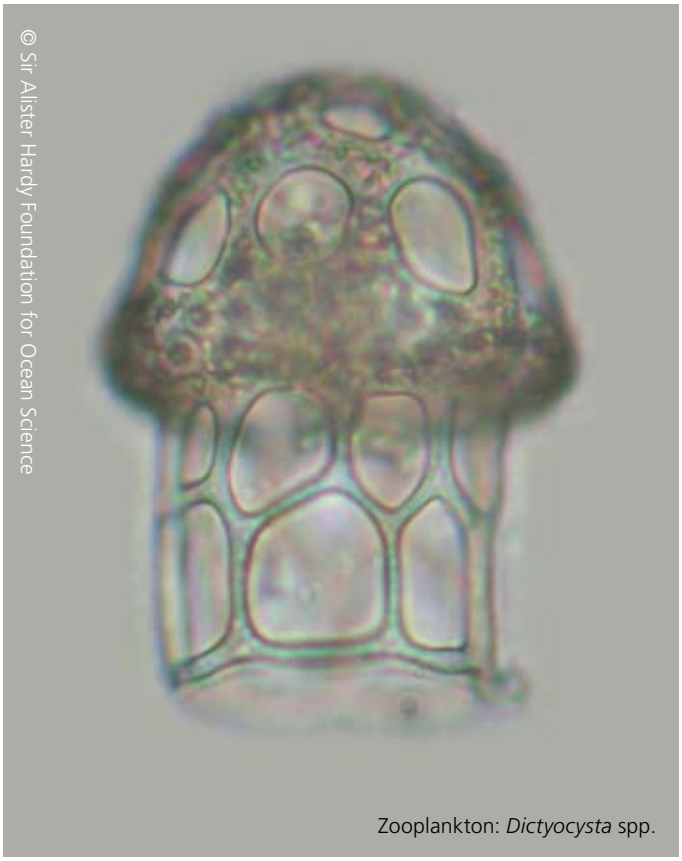


Studies of Emperor penguins have allowed marine scientists insight into how climate change is impacting on the polar environment.

could be used to **mitigate climate change**, for example by increasing their ability to absorb and store carbon, have raised concerns about possible adverse impacts. It is recognised that more research and discussion is needed in these areas to ascertain the risks and feasibility of such projects as well as the legal, social and ethical implications.

As well as changing in response to greenhouse gas emissions, the climate system is subject to **natural variability**. The oceans play a significant role in such variability, examples being the El Niño and, of greater importance to the UK, the **North Atlantic Oscillation which is linked to the Gulf Stream**. There will be a continuing need to **quantify the ocean's role in the climate system**. At shorter time scales, the influence of the seas on weather is of great societal importance, e.g. monitoring and predicting extreme events and hence **protecting the safety of life** and improving the efficiency of operations at sea.

The ability to assess the implications of climate change and variability for the marine environment in a systematic way is crucial if sound management policies are to be put into effect. In particular, there is a growing demand globally and regionally for high quality longer-range climate projection, risk analysis and advice, to enable **climate change and variability to be embedded in practical decision making** at all levels for all sectors (e.g. agriculture, water management, urban planning, energy provision, health services). Ocean information will be essential and integral to the development and continual improvement of climate information. In this context, the **Marine Climate Change Impacts Partnership** (MCCIP)[17], in which many organisations contribute to regular assessments of current and future changes, **is an example of good practice** which the Strategy will seek to support and encourage.



Zooplankton: *Dictyocysta* spp.

17. http://www.lwec.org.uk/

Sustaining and increasing ecosystem benefits

Related policy questions[18] include:

- What ecosystem services are provided by the marine environment and how can we influence human behaviour and choices in relation to them?
- What are the comparative environmental effects of newly emerging types of renewable energy, such as wave energy?
- How should the choice be made between marine protected areas (MPAs) and other conservation measures; when MPAs are appropriate, how large and where should they be located to protect biodiversity and enhance surrounding fisheries?
- How do we assess cumulative effects of multiple human activities and the effects on the ecosystem, and how can this translate into taking management action?
- With what precision can we predict the ecological impact of different policy options and the ecological effects of management action?

An electron microscope image of a coccolithophore *Calcidiscus*, the plates around the cells are formed of calcium carbonate. Marine scientists study these types of species to determine the effects of ocean acidification on the biosphere.

Ecosystems, as outlined earlier, are dynamic and complex functional units of plant, animal and micro-organism communities and their environment. It is important to acknowledge that people are also part of ecosystems – benefiting from the services ecosystems provide and support but also capable of having significant and perhaps long-lasting effects on them. This is just as true of the marine ecosystem, although the benefits and impacts may seem less obvious than on land. Decision making within the context of an ecosystem approach should seek integration between different objectives (such as when regulating the exploitation of resources), but can also involve both losing some benefits and gaining others. It is therefore important **to understand the implications of the different management options in marine planning** and to engage with affected communities as part of the decision-making process. This will require a mix of social, economic and natural science expertise. It is also important to recognise that decisions may need to be taken with incomplete or less certain data – in such cases we need to be clear as to what we do know and what we do not know.

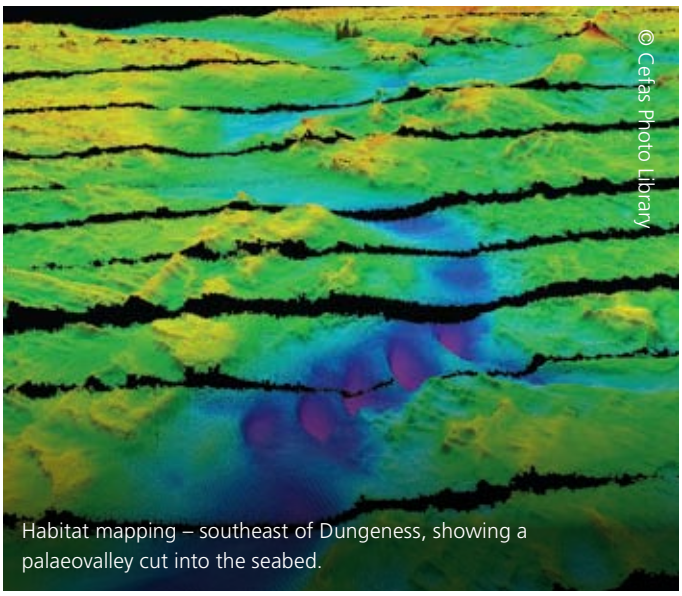
The vision, outlined earlier in this document, expresses the balanced approach to the use and management of our seas. The need to make use of the sea's resources has to be weighed against potential disruption and damage to the marine environment and to the life within it. Social science will play an important role in establishing frameworks for choice – to help reach informed decisions on possible courses of action. In order to address the policy issues around sustaining and increasing ecosystem benefits, a broad range

The UK has the largest wave, tidal and offshore wind resources in Europe. Such energy sources could potentially provide 15-20% of UK electricity.

18. Based in part on Sutherland et al (2006) 'The identification of 100 ecological questions of high policy relevance in the UK', *Journal of Applied Ecology*, 43: 617-627

of science will be needed, of which the following is illustrative.

The potential of the marine environment to **increase food and energy security** is clear but more work is needed on defining its full potential, including the limits on sustainable production and the changes in **human behaviour** needed to achieve a correct balance. In particular, attention needs to be given to the **comparative biodiversity impacts of different renewable energy technologies**, such as those exploiting wind, waves and tides, and the impact of, and recovery from, existing human activities.



Habitat mapping – southeast of Dungeness, showing a palaeovalley cut into the seabed.

Within the framework of marine planning, **there is a range of tools for conservation and other benefits, including Marine Protected Areas (MPAs), and evidence is needed to establish which tools are appropriate in particular situations.** For example, we need to understand how the location, geographical extent and connectivity of key habitats and species may impact on their conservation needs and therefore on the choice of tools best suited to protect and enhance them. We also need to understand how the submerged landscape has changed through time. Marine science will have an important role to play in informing such decisions – for example, through **seabed**[19] **and habitat mapping** – and in assessing the efficacy of such policies by monitoring and interpreting observed outcomes.

Often the potential impact of an activity is considered in isolation from others. There is a need to develop scientifically-based methods for **assessing the cumulative effects of multiple human activities and increasing population pressure on the ecosystem** and then translate this into management action. An example is **underwater sound** emitted from a variety of sources (e.g. ships, sonar, pile driving), each

The impact of man-made underwater sound has the potential to cause a range of adverse impacts on cetaceans ranging from behavioural changes to physical harm and death.

UK researchers now routinely use ocean circulation models to predict where microscopic plants will flourish (phytoplankton blooms). Such organisms draw-down carbon and support most other life in the sea; they can also be toxic and their decay may reduce oxygen levels, affecting fish.

19. Includes successive submerged landscapes.

LANDSAT image of a bloom of the coccolithophore *Emiliania huxleyi* in the English Channel, 24th July 1999. This was an exceptional bloom that developed following a period of unusually warm weather.

element of which may be within an acceptable limit but when added together may be harmful to marine mammals. Another is the combination of **high nutrient inputs** arising from river run-off, discharges to the sea and point-source **pollution** from off-shore activities.

One of the policy needs that has been identified is to know how well the **ecological impact of different policy options** can be predicted, including the effects of any management actions taken on the ecosystem. Computer models of the ecosystem, incorporating relevant *in situ* and remotely-sensed data, have potential. However more work is needed, particularly on improved understanding and representation of the biogeochemical processes involved, before they will be a reliable tool. **Ecosystem models, used for operational forecasting**, will also contribute to **safer use of our seas**, and, via warnings of algal blooms, etc., to **human health**.

Three cells of falsely coloured *Emiliania huxleyi* which are about 5µm across. The cocoliths are transparent but in blooms accumulate in such abundance that they give the water a milky appearance.

Royal Research Ship *James Cook*.

4 Tackling the barriers to delivery

Addressing these high level priorities is a major challenge. It will require **world class science** exemplified in the UK by a science community which is able to work collaboratively across disciplines, in large teams and with international partners, and whose work is internationally recognised. Maintaining the strength, capacity and focus of our marine science will be the key to success. However, barriers exist to achieving this. Identified below are a range of cross-cutting measures that will help to overcome these barriers and to ensure resources are better aligned to deliver world class marine science for current and future policy needs.

Three areas have been identified as priorities to be taken forward in the first phase of the Strategy:-

- **Alignment of science effort** – ensuring science programmes, funding and capabilities are focused effectively in areas of high impact;
- **Sustained long-term monitoring** – making the process for selecting long-term observation systems for funding more transparent and providing secure, longer-term and cross-cutting funding for priority datasets; and
- **Communications** – developing a pro-active communications strategy for strengthened two-way engagement with the public on the importance of marine science and delivering an action plan for improving communication between scientists and policy makers.

Additionally, as part of its continuing business, the Marine Science Co-ordination Committee will also support initiatives being taken forward by other bodies by:

- **Working with others**.

These are described in more detail in the following sections.

Alignment of science effort

The difficult and extensive nature of the marine environment means that research tends to be very expensive while resources and expertise are limited. Increased collaboration and co-ordination of funding can deliver more cost effective, better prioritised and more integrated research and help to avoid important areas of work being left unfunded. The commissioning process will also be key to ensuring best value for money and the Marine Science Co-ordination Committee members will ensure that they apply best practice in commissioning, through, for example, identifying the fullest practical range of providers.

We therefore need to be clear that current and planned publicly-funded science (including social and economic science) programmes addressing the high-level priority areas identified earlier, are properly aligned and coherent and are applying the best scientific methodologies. We must also ensure that the research being planned is relevant to future, as well as current, policy needs.

© Craig Wallace/ National Oceanography Centre, Southampton

Deployment of long-term mooring as part of the RAPID array at 26O N in Atlantic Ocean.

The Marine Science Co-ordination Committee will, through a rolling review programme run over the life of the Strategy, identify groups of science issues within the three high level science priorities where greater collaboration and alignment can have largest impact. The initial group of science issues will be identified during the first quarter of 2010. **The programmes funded by member bodies of the Marine Science Co-ordination Committee to address these science issues will be reviewed to identify gaps in scientific knowledge and policy development, areas of duplication and areas for further collaboration and alignment.**

It is recognised that significant programmes of marine science are being undertaken by other parts of the marine science community[20], for example, Higher Education Institutions and research institutes, Non-Governmental Organisations and industry; stakeholders will be invited to contribute to this review process.

The outcomes of the review will also feed into the **co-ordination of UK policy input to research programmes under the EU Framework Programme and other international programmes, to provide better alignment with UK priorities**.

As part of the review programme, **the capacity and capability to deliver the science will be assessed**. This will help to ensure that the necessary equipment (including research vessels), infrastructure and expertise are available and will help to identify, in particular, whether they are being used efficiently across the bodies represented on the Marine Science Co-ordination Committee.

The UK has agreements with five other European countries for shared use of ocean-going research ships and other major marine facilities.

Examples of best practice in collaboration

The **RAPID-WATCH** research programme is a strategic partnership between the NERC and the Hadley Centre (Defra and DECC funded). The programme will record the strength and structure of the Atlantic Meridional Overturning Circulation (MOC) over a ten year period. These observations will be used to determine and interpret recent changes in the Atlantic MOC, to improve assessment of the risk of rapid climate change due to MOC change, and to investigate the potential for predictions of the MOC and its impacts on climate.

The UK partnership funding of ca.£20M has, through international partnership, leveraged contributions of ca.£10M from US, German and Canadian partners and major in-kind contributions of ship-time from the US and Canadian partners. Significant co-funding has also been obtained from related EC Framework Programmes (see THOR below).

THOR – Thermohaline Overturning – at Risk? – the EC Framework research programmes allow UK marine scientists to join with others, in Europe and beyond, to address major projects of common concern that may be too large for any one country to undertake. THOR is one such example. THOR will monitor and forecast changes in the North Atlantic thermohaline circulation – the so called Ocean Conveyor. The EC Framework research programme is a €13M programme involving 26 institutes from eleven countries. Seven UK institutes will participate in THOR, contributing a range of science from observations to modelling. They include government marine science agencies, research councils and universities.

20. Pugh, D. *Socio-economic Indicators of Marine-related Activities in the UK economy.* The Crown Estate copyright. March 2008. ISBN: 978-1-906410-01-8.

The **Underwater Sound Forum** is an example of a strong stakeholder collaboration. The Forum, which is a sub-group of the Marine Science Co-ordination Committee, was formed in 2006 to focus on the possible effects of underwater sound on marine life, and in particular mammals. The Forum's membership has grown to nearly 30 organizations, representing diverse sectors – government departments/agencies, Research Councils, Higher Education Institutions, industry, conservation groups, professional bodies and learned societies – united by their interest in sound in the ocean and its potential impacts on marine life.

The Forum has proved to be an effective way of sharing information and expertise, co-ordinating inputs to consultations, identifying groupings to exploit potential funding opportunities, and of organising workshops on specific topics. The member organizations have agreed to work in a spirit of co-operation and openness even though they may have very different views on the issues raised.

The **Marine Alliance for Science and Technology for Scotland (MASTS)** is a collaborative partnership between Scotland's leading marine science universities and institutes and Marine Scotland Science. Launched in November 2009, with £18M funding from the Scottish Funding Council, its aim over the next seven years is to make Scotland's marine resources a major contributor to the economy and welfare of Scotland by pooling research talent and building a new approach to ensuring that marine science in Scotland can remain internationally competitive. Many of the MASTS theme areas strike a chord with this Strategy.

Sustained long-term monitoring

Sustained observations[21] are essential for much of marine science because changes in the marine environment generally only become apparent over extensive time scales of decades or longer. The delivery of long-term monitoring programmes was **the key issue** identified by stakeholders during the preparation of this Strategy. More specifically the particular barriers highlighted were:

i. the current lack of transparency in how decisions are made by funders to support one observation system over another;

ii. the difficulty of finding sufficient funding sources for projects which provide information for many users but where there is no clear 'owner' body; and

iii. the mismatch between relatively short-term Departmental budget policies and the long-term nature of the projects.

The Marine Science Co-ordination Committee is working with the UK Environmental Observation Framework (UK-EOF)[22] and the UK Marine Monitoring and Assessment Strategy (UKMMAS)[23] to address these issues[24]. The UK-EOF, with input from the marine science community, is developing an inventory that catalogues current data sets and identifies foreseeable requirements for long term data. It is assessing the UK's capacity to deliver these data (taking account of international activity) and, where available, alternative ways to collect the data.

21. By sustained observations we are including the whole spectrum of observations from research to compliance monitoring. To be cost-effective this requires funding from different Government sources.
22. http://www.erff.org.uk/activities/uk-eof.aspx
23. Annex I: http://www.defra.gov.uk/environment/marine/science/ukmmas/index.htm
24. The Marine Science Co-ordination Committee has established a Working Group, comprised of academics, researchers, the heads of UKMMAS groups and Government representatives, to work with UK-EOF.

Tagged plaice.

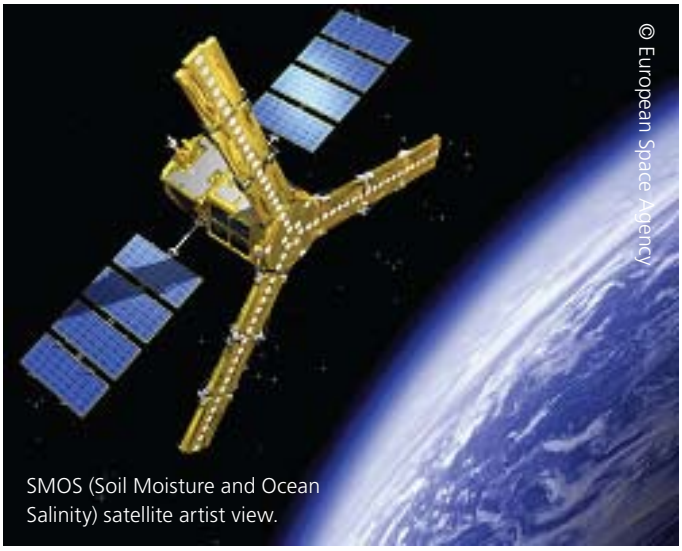
Tracking devices have been developed by UK researchers to follow the movements of fish, sea mammals and turtles. For seals, mobile phone technology is used to transmit data back to researchers.

The results of this exercise will be used, with input from stakeholders, to develop a transparent prioritisation tool to help inform decisions on the funding of observation systems (for both starting and stopping observation systems), including the contribution of remote sensing data from satellites. This will extend beyond those required to meet mandatory requirements. These outputs will be used as part of the process for delivering the UK Marine Monitoring and Assessment Strategy and to inform co-ordinated decisions on funding by the Marine Science Co-ordination Committee.

In addition to collaborating on the development of the prioritisation tool, **the Marine Science Co-ordination Committee will also develop practical proposals to provide cross-cutting, longer-term funding for priority long-term monitoring systems.**

The Marine Assessment Policy Committee, which has overall responsibility for UKMMAS, will merge with the Marine Science Co-ordination Committee. The merger will reduce potential overlap and improve overall efficiency. **Further opportunities to rationalise the co-ordination bodies in the marine science sector to reduce duplication of effort will be actively sought.**

Underwater glider.



SMOS (Soil Moisture and Ocean Salinity) satellite artist view.

Long range weather forecasts for Europe are now based on temperatures in the top 2 km of the North Atlantic. This information is automatically collected by profiling Argo floats, based on a UK invention.

Communications

As demonstrated in the opening sections of the Strategy, the marine environment is critical to the lives of everyone. **A key action will be to engage the wider public in discussions on marine science issues. This two-way exchange will involve both raising public awareness of the impact of the seas and oceans on our lives and the impact of our actions on them. It will focus on marine sustainability issues, and will listen and respond to the issues and concerns raised**. The Marine Science Co-ordination Committee will develop a communications strategy, by mid-2010, setting out key messages and providing a framework for the Marine Science Co-ordination Committee and its member organisations to engage with citizens across all social groups, including schools, through co-ordinated activities which actively publicise marine science developments in non-technical language to a wider, non-scientific audience. It will link with existing activities, such as the public engagement strand of the Science and Society initiative[25].

The oceans provide 97% of the space occupied by life on Earth.

It is also important that **the extent and clarity of communications between scientists and policy makers continue to be improved**. Gaps in the two-way flow of policy and science information have the potential to lead to key emerging scientific findings not being reflected in Government policy in a timely manner and funding opportunities being missed. The Marine Science Co-ordination Committee will develop an action plan, by mid 2010, to promote best practice for communicating science into policy, and policy development and priorities to scientists. **This approach will build on successful existing initiatives[26] and will include the development of internships jointly within Government Departments and the Devolved Administrations, to enable research scientists to gain direct experience of policy development and delivery.**

Those responsible for representing the UK across the wide range of intergovernmental marine science fora also need to have access to shared information on the emerging science. **A network of UK marine science representatives will be established by the Marine Science Co-ordination Committee to identify common marine science issues and to exchange views on the latest science thinking.**

The greatest genetic resource on Earth is in the sea. More than 100,000 species of microbes have been found at one site in the English Channel, and there is more DNA in a bucket of seawater than in the human body.

Working with others

The Marine Science Co-ordination Committee will look for opportunities to work with other bodies, to help take forward their initiatives, for example:

a. **Effective access to data** – there remain difficulties in identifying, accessing and using marine data, and in order for marine science to flourish, we need to foster a culture of data sharing and good management, including common protocols for data collection and quality assurance of the data obtained. We will work with UK stakeholders and, where appropriate, European and International bodies to address this issue. In particular, we will do so via the Marine Environmental Data and Information Network (MEDIN)[27], a subsidiary group of the Marine Science Co-ordination Committee. MEDIN is a partnership

25. http://www.dius.gov.uk/science/science_and_society/public_engagement
26. NERC – science into policy: http://www.nerc.ac.uk/publications/corporate/policy.asp
27. http://www.oceannet.org/

of UK public and private organisations and has commissioned a study, building on existing analyses, to identify the impacts and issues associated with charging and intellectual property rights specifically for marine data products. This will complement MEDIN's existing programme of work to improve access to data by collating organisations' data and information, providing direct links to data from commercial organisations and European and international bodies and its current development of a 'data discovery portal', a powerful tool for searching out marine data across organisations. These actions should help to ensure that data are increasingly re-used time and again – following the 'collect once, use many times' model – thereby making the original data collection more cost effective.

MEDIN will also consider whether developing an Information Strategy would help to address the important issues of discovery and accessibility of data, good data management and the harmonization and promotion of policies on marine data.

b. **Future skills needs** – Discussions with stakeholders have suggested that there will be some future skills gaps, for example in **mathematical modelling** and **taxonomy.** The Environment Research Funders Forum (ERFF) is reviewing skills requirements for the UK environmental sciences sector[28]. This exercise will provide an assessment of the available training and education opportunities and likely future trends, and develop actions to address any current skills gaps.

The deployment of a 'smart buoy' to monitor the waters around the UK. The Cefas data collected by this system of buoys is shared with international partners via data portals.

UK-designed 'smart buoys' provide rapid detection of environmental change in shelf sea waters with satellite-based data transmission.

c. **Development of a Marine Industry Strategic Framework** – the Department of Business, Innovation and Skills (BIS) is working with the marine industry to develop a Marine Industry Strategic Framework. This document is to be a precursor to a Marine Industry Strategy to identify measures promoting the growth of the industry through the development of new markets and improved productivity and competitiveness.

28. http://www.erff.org.uk/activities/skills.aspx

5 'Horizon scanning' and future actions

Water running off the ice cliffs in front of Rothera research station, Antarctica.

The actions identified above are not intended to be an exhaustive list but to provide a programme of work for the immediate future. Further actions will be developed during the life of the Strategy and 'horizon scanning' will be a key process to help inform decisions on the future direction of the Strategy. This will ensure that science priorities continue to remain relevant to emerging policy priorities. The Marine Science Co-ordination Committee will also take into account the outcomes from the Foresight Global Food and Farming Futures project[29] and other relevant 'horizon scanning' activities. Options for commissioning 'horizon scanning' projects will be considered by the Marine Science Co-ordination Committee during 2010/11.

29. http://www.foresight.gov.uk/OurWork/ActiveProjects/FoodandFarmingFutures/FoodandfarmingProjectHome.asp

© DTI/Defra/JNCC (SEA7 survey)

6 Delivering the Strategy

An image from the Strategic Environmental Assessment survey, showing the rich, diverse and complex ecosystems to be found in the UK marine environment.

Role of the Marine Science Co-ordination Committee (MSCC)

A key role of the Marine Science Co-ordination Committee will be to drive the delivery of the Strategy and especially the priority actions identified: **the alignment of science effort; sustained long-term monitoring; communications; and working with others.** The necessary critical mix of senior policy makers and scientists is represented on the Committee to ensure that commitments in the Strategy are delivered and that marine science is more effectively co-ordinated. At the same time, the non-executive members of the Committee provide an active, external challenge function. The Marine Science Co-ordination Committee is overseen by a Ministerial Marine Science Group[30] to which it reports directly. The Governance arrangements for the Marine Science Co-ordination Committee, and its links to related groups, are provided at Annex I.

30. The Ministerial Marine Science Group is composed of the marine Ministers of those departments represented on the Marine Science Co-ordination Committee.

While the actions within the Strategy are primarily for Government to deliver, it is recognised that the wider marine science community will also have a role to play if the Strategy is to be successfully delivered. Specific Committee members have been nominated to act as 'links' to industry, the Research and Academic sector and Non-Governmental Organisations (NGOs) to develop networks with these communities and to grow an integrated relationship with them. In addition, experts from this wider marine science community will be invited to join working groups and to provide input to projects established to take forward Strategy actions. Through these various actions and mechanisms, stakeholders will be able to access the Committee directly and contribute to the delivery of the Strategy.

The Delivery Plan

To accompany this Strategy, a dynamic, web-based UK Marine Science Strategy Delivery Plan has been created at:

www.defra.gov.uk/environment/marine/science/mscc.htm

This identifies the actions being taken to implement the Strategy. As well as providing regular updates to show progress against the three priority actions and the other commitments, it will set out a rolling programme of priority activities and operations, which will be established in co-operation with stakeholders. A measure of the success of the Strategy will be the effective completion of the proposed actions and the outcomes of the decisions taken by the Marine Science Co-ordination Committee. More detailed success indicators will be developed during 2010.

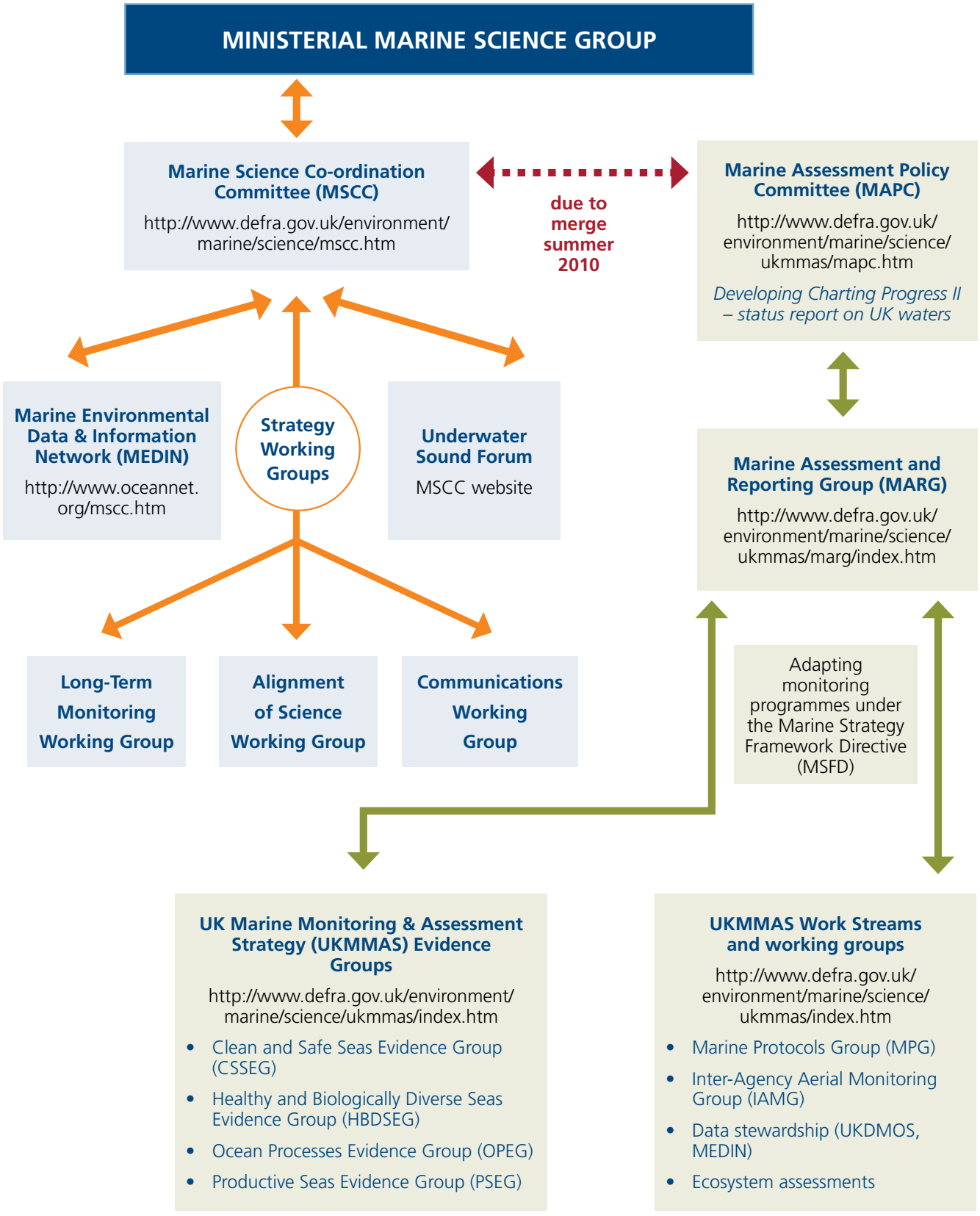
Starting with a report on its activities during 2010, the Marine Science Co-ordination Committee will report annually to the Ministerial Marine Science Group. The published reports will include progress on delivering the Strategy and the latest available details of public sector expenditure on marine science.

A Cefas marine scientist undertaking seawater quality analysis as part of monitoring the health of UK waters.

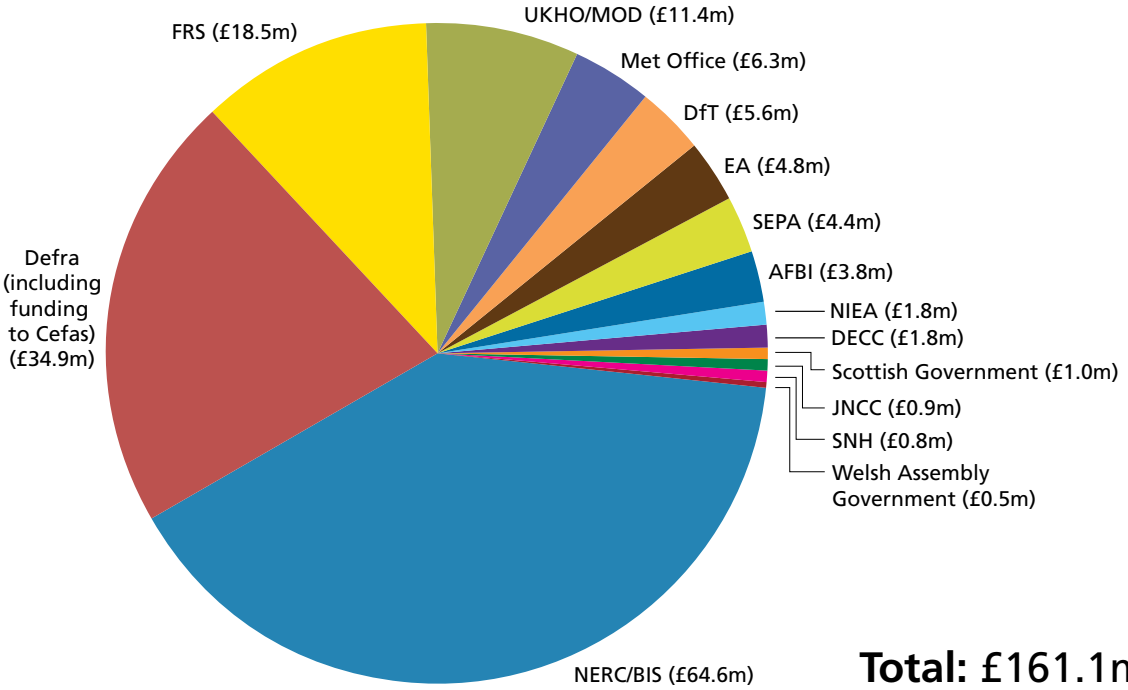
Conclusion

The challenges are significant. We need to deliver the right marine science at the right time in order to meet both current and future policy needs. This requires a clear focus on what science is needed, tighter alignment of programmes and funding and greater coherence of effort across funders and deliverers. We must at the same time find the correct balance between the marine science that helps us to understand better the world we live in now – of climate change, marine ecosystems and their impacts and benefits – and the science that anticipates the issues of the next 50, 80, 100 years. Our ultimate aim is to ensure that the oceans and seas of the future are ***'clean, healthy, safe, productive, and biologically diverse'***; this Strategy will help the UK to realise this ambition.

Annex I: How the Marine Science Co-ordination Committee links with other groups



Annex II: Marine science funded by MSCC member organisations in 2008/09(£m)



Total: £161.1m

Notes

It is difficult to obtain accurate data from past years that are consistent across MSCC members because of the different ways that organisations categorise their spending. The figures in the pie chart are the most accurate available but should be viewed with caution. In particular:

- Co-funding from EU and European Space Agency is not included.
- The figure for NERC includes the costs of running ships with the exception of those operated by the British Antarctic Survey and include only the expenditure within research centres and programmes that are wholly devoted to marine science. It is therefore not the total marine-related spend.
- In addition to Defra funding, Cefas also receives funding from the Food Standards Agency.
- The MOD funding figure is for the Defence Hydrographic Programme which is managed by the UK Hydrographic Office; MOD also funds the Defence Oceanographic Programme (£622K) which is included in the Met Office spend.
- EA figure does not include any additional marine expenditure by regional offices for conducting investigations.
- Scottish Government figure excludes development and testing of wave and tidal energy technology (£13m spread over 2008/09, 2009/10, 2010/11).
- The spend shown for the Welsh Assembly Government does not include the Countryside Council for Wales.
- DfT funding is directed through the Maritime and Coastguard Agency but the maritime component of the Public Weather Service is excluded from the figure shown. However, the Met Office figure does include spend within the Public Weather Service programme on marine R&D.
- Defra, FRS (Marine Science Scotland from 1 April 2009), EA, SEPA, and AFBI figures include vessel operating costs.

Key: NERC: Natural Environment Research Council; BIS: Department for Business, Innovation and Skills; Defra: Department for Environment, Food and Rural Affairs; Cefas: Centre for Environment, Fisheries and Aquaculture Science; FRS: Fisheries Research Services (Marine Scotland); UKHO: United Kingdom Hydrographic Office; MOD: Ministry of Defence; DfT: Department for Transport; EA: Environment Agency; SEPA: Scottish Environment Protection Agency; AFBI: Agri-Food and Biosciences Institute; NIEA: Northern Ireland Environment Agency; DECC: Department of Energy and Climate Change; JNCC: Joint Nature Conservation Committee; SNH: Scottish Natural Heritage.

Annex III: Organisations represented on the Marine Science Co-ordination Committee and associated strategies

Agri-Food & Biosciences Institute (AFBI)

http://www.afbini.gov.uk/index/about-us.htm

The Agri-Food & Biosciences Institute (AFBI) was created on 1st April 2006 as an amalgamation of the Department of Agriculture and Rural Development (DARD) Science Service and the Agricultural Research Institute of Northern Ireland (ARINI). AFBI is a non-Departmental Public Body (NDPB).

AFBI Fisheries and Aquatic Ecosystems Branch carries out R&D, monitoring, technology transfer and specialist advice, in support of sustainable management of fisheries and aquatic resources in Northern Ireland. The work programme is delivered via alignment of activities into several core themes, fulfilling requirements for evidence-based science in marine, coastal, estuarine and freshwater environments and reflecting the strategic needs of a wide range of customers.

AFBI's specialist facilities include the 53 metre research vessel, RV *Corystes*.

Centre for Environment, Fisheries and Aquaculture Science (Cefas)

http://www.cefas.co.uk

Cefas is Defra's marine science agency. Cefas plays a vital role in securing healthy marine and freshwater environments, in ensuring the sustainable use of natural resources, and in understanding associated challenges presented by climate change.

With its 500 staff, and extensive laboratory facilities, Cefas is the UK's largest applied marine science laboratory and bridges the interface between science, policy and delivery. It provides evidence-based scientific advice, manages related data and information, conducts world class scientific research, and facilitates collaborative action through wide-ranging international relationships.

Department for Business, Innovation and Skills (BIS)

http://www.bis.gov.uk

BIS's mission is building a dynamic and competitive UK economy by: creating the conditions for business success; promoting innovation, enterprise and science; and giving everyone the skills and opportunities to succeed. To achieve this BIS will foster world class universities and promote an open global economy. BIS is committed to developing a world class UK research base responsive to users and the economy, with sustainable and financially strong universities and public laboratories and a strong supply of scientists, engineers and technologists. The department funds seven Research Councils, which in turn allocate public money to support research projects and teams. BIS is currently developing its business plan which will outline in more detail how it will deliver against its priorities. Plans for former Departments include:

1) **BERR:**
   http://www.berr.gov.uk/aboutus/corporate/performance/strategic-programme/index.html

2) **DIUS:**
   http://www.dius.gov.uk/reports_and_publications%20HIDDEN/business_plan

Further information:

Science:
http://www.dius.gov.uk/science

New Industry, New Jobs – an active industrial strategy for Britain: http://www.bis.gov.uk/policies/new-industry-new-jobs

Low Carbon Industrial Strategy http://www.berr.gov.uk/files/file52002.pdf

Department of Energy and Climate Change (DECC)

http://www.decc.gov.uk/en/content/cms/about/about.aspx

The Department of Energy and Climate Change (DECC) was created in October 2008 to bring together energy policy (previously with BIS), and climate change mitigation policy (previously with Defra). Marine research at DECC is focused on responsibilities to:

1) Ensure secure, affordable and efficient energy;
2) Bring about the transition to a low-carbon Britain;
3) Achieve international agreements on climate change.

Examples of marine research being developed include the costs and benefits of offshore wind, wave and tidal energy to the marine environment. DECC is also jointly co-funding with Defra the NERC Ocean Acidification Programme (http://www.nerc.ac.uk/research/programmes/oceanacidification/) which aims to provide a greater understanding of the implications of ocean acidification and its risks to both the marine environment and the whole Earth system.

DECC funds the Advanced Along Track Scanning Radiometer (AATSR) which provides a long-term record of sea surface temperature, which is important in climate change detection, attribution and model validation work. DECC also co-funds the UK contribution to the ARGO, the global array of ocean profiling floats, which measure temperature and salinity for use in weather forecasting and climate science research.

Department for Environment, Food and Rural Affairs (Defra)

http://www.defra.gov.uk/marine/index.htm

Defra is a major supporter of marine science, spending approximately £37m in 2009/10. Defra uses the output from its research and operational science programmes to help shape and evaluate policy. Research themes include human pressures and impact, the state of the marine environment, integrated marine management, and economic and social research. Operational science includes assessing the status of commercial stocks and monitoring the marine environment and impact of human activity such as pollutants and eutrophication.

Defra's published plans and strategies include:

1) Marine Programme Plan – http://www.defra.gov.uk/marine/pdf/mpp2009-10.pdf
2) Marine Science – http://www.defra.gov.uk/marine/pdf/science/defra-role.pdf
3) UK Marine Monitoring and Assessment Strategy (UKMMAS) – http://www.defra.gov.uk/marine/science/monitoring/ukmmas.htm
4) Fisheries 2027 – http://www.defra.gov.uk/marine/fisheries/policy.htm
5) Marine objectives – http://www.defra.gov.uk/marine/environment/policy.htm
6) A strategy for promoting an integrated approach to the management of coastal areas in England – http://www.defra.gov.uk/marine/environment/iczm.htm

Department for International Development (DFID)

http://www.dfid.gov.uk/

The Department for International Development (DFID) is the UK government department responsible for promoting development, reducing poverty and improving access to safe drinking water and food. DFID works in partnership with the governments of

developing countries, international organisations, civil society organisations, the private sector and the research community. At DFID fisheries research is supported under DFID's overall research strategy. This has six main themes: growth; sustainable agriculture (includes fisheries); climate change; health and education; governance in challenging environments; and new and emerging technologies.

Department for Transport (DfT)

http://www.dft.gov.uk/about/howthedftworks/aboutthedftexecutiveagencies

The Maritime and Coastguard Agency (MCA) is an Executive Agency of the Department for Transport. The MCA evidence and research programme aims to:

1) Identify the need for or reinforce national policy change;
2) Inform the UK's influence on international policy change;
3) Address Government recommendations;
4) Present publicly credible and reliable findings to underpin MCA work;
5) Deliver and disseminate quality outcomes for the benefit of the maritime community; and
6) Work with national and global partners to encourage a more collaborative and cooperative approach to research relating to maritime safety.

Environment Agency (EA)

http://www.environment-agency.gov.uk/

The Environment Agency aims to create cleaner coasts and healthier seas by:

1) Promoting sustainable development;
2) Integrating management between land and sea;
3) Providing efficient regulation of our coasts and coastal waters;
4) Ensuring that we all value our coastal and marine environment.

Joint Nature Conservation Committee (JNCC)

http://www.jncc.gov.uk/

JNCC is the statutory adviser to Government on UK and international nature conservation. Its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural systems. JNCC delivers the UK and international responsibilities of the four country nature conservation agencies – Council for Nature Conservation and the Countryside, the Countryside Council for Wales, Natural England and Scottish Natural Heritage.

JNCC marine work programmes encompass:

- The identification of marine protected sites;
- The mapping and classification of marine habitats;
- Marine biodiversity surveillance and monitoring;
- Marine management advice.

Met Office

http://www.metoffice.gov.uk/

The Met Office contributes to marine science through its work in climate change research, seasonal forecasting, short-range ocean forecasting and marine measurements. The Met Office's primary role in respect of marine science is to use up-to-date marine science and technology to make prediction on climate, seasonal and short timescales. The Met Office Hadley Centre conducts research into the impact and likelihood of climate change. The Met Office, National Oceanography Centre Southampton (NOCS), Plymouth Marine Laboratory (PML), Proudman Oceanographic Laboratory (POL) and the Environmental Systems Science Centre (ESSC) are the members of the National Centre for Ocean Forecasting (NCOF)

which has the mission "to establish ocean forecasting as part of the national infrastructure based on world class research and development". Internationally, the Met Office contributes to the Intergovernmental Panel on Climate Change (IPCC).

Ministry of Defence (MOD)

http://www.mod.uk/DefenceInternet/Home/

The Ministry of Defence (MOD) gathers a significant amount of defence related marine observations. Meteorological, oceanographic, side scan sonar and bathymetric survey data are regularly passed to the UK Met Office or the UK Hydrographic Office to support their research and operational activities. Occasional access may be provided to Royal Navy submarine and survey platforms when scientific activities and military tasks coincide (e.g. HMS *Endurance*/British Antarctic Survey).

In addition the MOD sponsors a small amount of research into environmental and marine life mitigation strategies.

(From 1 April 2010) Marine Management Organisation (MMO)

http://defraweb.defra.gsi.gov.uk/environment/marine/documents/legislation/mmo-brochure.pdf

The UK Government intends to set up a new Marine Management Organisation (MMO) to deliver many objectives for the marine area. Key areas include:

1) Marine Planning;
2) Marine licensing and licensing enforcement;
3) Fisheries management;
4) Marine nature conservation;
5) Enforcement and prosecutions;
6) Marine emergencies;
7) Implementation of EU directives;
8) Marine science and evidence gathering for planning and licensing;
9) Data and information.

The new organisation will be a centre of marine expertise, provide a consistent and unified approach, deliver improved co-ordination of information and data and reduce administrative burdens.

Further information:

Marine and Fisheries Agency
http://www.mfa.gov.uk/

Natural Environment Research Council (NERC)

http://www.nerc.ac.uk/publications/strategicplan/documents/strategy07-overview-leaflet.pdf

The Natural Environment Research Council is the main UK funder of fundamental research in all aspects of the Earth System, including the marine environment. NERC's strategic goal is to deliver world-leading environmental research at the frontiers of knowledge:

1) Enabling society to respond urgently to global climate change and the increasing pressures on natural resources;
2) Contributing to UK leadership in predicting the regional and local impacts of environmental change from days to decades; and
3) Creating and supporting vibrant, integrated research communities.

NERC funds science in Universities and Research Centres through (a) strategic research programmes focused on the major themes of climate, biodiversity, earth system science, natural hazards, natural resources, environment, and human health and technologies; (b) investigator-led responsive research and (c) national capability, including major facilities and sustained observing programmes to support all of the above. The present Oceans 2025 programme of marine research is delivered by the National Oceanography Centre, Southampton; Plymouth Marine Laboratory; Marine Biological

Association; Sir Alister Hardy Foundation for Marine Science; Proudman Oceanographic Laboratory; Scottish Association for Marine Science; and Sea Mammal Research Unit, with contributions from several University groups.

In addition, polar marine research is carried out by the British Antarctic Survey; marine geology by the British Geological Survey; and land-based coastal research by the Centre for Ecology and Hydrology.

Further information:

http://www.nerc.ac.uk
http://www.oceans2025.org/

Northern Ireland Department of Agriculture and Rural Development (DARDNI)

http://www.dardni.gov.uk/index/fisheries-farming-and-food/fisheries.htm

The Department of Agriculture and Rural Development (DARDNI) has responsibility for sea fisheries, aquaculture and fish health policy; the enforcement of fisheries legislation; the licensing of aquaculture; fishing vessel licensing; the administering of fisheries grant schemes and supporting the operation of the Foyle, Carlingford and Irish Lights Commission (FCILC).

The key strategic research areas of DARDNI are:

1) Performance in the market place;
2) Social and economic infrastructure of rural areas;
3) Animal, fish and plant health and animal welfare;
4) Sustainable environment;
5) Cross cutting research strands.

Further information:

http://www.dardni.gov.uk/evidence_and_innovation_executive_summary_.pdf

Northern Ireland Department for the Environment (DOE)

http://www.doeni.gov.uk/

DOE has responsibility for the protection of the aquatic environment through the regulation of water quality, and the conservation of both freshwater & marine flora, fauna, and hydrological processes. In performing this duty DOE is required to have regard to the needs of industry and agriculture, the protection of fisheries and the protection of public health. The development of environmental policy and legislation is the core function of Planning and Environmental Policy Group (PEPG), whose work covers the whole range of environmental issues including water and air quality, waste control, habitat and species protection, countryside protection, climate change and GMO's.

PEPG works closely with colleagues in the Northern Ireland Environment Agency (NIEA), particularly Water Management Unit and Natural Heritage within the DOE who have responsibility for the implementation of legislation and for environmental monitoring.

Northern Ireland Environment Agency (NIEA)

http://www.ni-environment.gov.uk/water-home.htm

NIEA's water quality policy is to maintain or improve the quality of surface and underground waters in Northern Ireland. This requires general management of rivers, lakes, groundwater, estuarine and coastal waters. It also requires careful monitoring of bathing waters around the coast.

To achieve this, the Water Management Unit of NIEA:

- Monitors all water quality and aquatic ecological status and trend;
- Regulates all industrial, domestic and waste water discharges to waterways, underground strata and coastal waters;
- Regulates potentially polluting aspects of the agriculture industry;
- Minimises the impacts of water pollution by promoting pollution prevention, responding

to reports of pollution, enforcing legislation, prosecuting offenders and delivering educational programmes;

- Licensing deposits to, or under the sea bed;
- Liaises closely with other Northern Ireland, UK and Irish departments and Agencies to achieve fully integrated and effective programmes.

Scottish Environment Protection Agency (SEPA)

http://www.sepa.org.uk/about_us/policies.aspx

SEPA protects and improves the Scottish marine environment. SEPA helps customers to understand and comply with environmental regulations and to realise the economic benefits of good environmental practice. This approach benefits the environment and the economy, and means SEPA can focus resources (including our enforcement powers) on tackling the greatest environmental threats. SEPA also provides expert advice on the Scottish environment and delivers a wide range of information, guidance and public information services.

Further information:

http://www.sepa.org.uk/about_us/publications/strategy_reports.aspx

Scottish Government, Marine Scotland

http://www.scotland.gov.uk/About/Directorates/Wealthier-and-Fairer/marine-scotland

Marine Scotland, part of the Scottish Government, was established on 1 April 2009. It is the lead marine management organisation in Scotland, combining the functions and resources of the former Scottish Government Marine Directorate, Fisheries Research Services and the Scottish Fisheries Protection Agency. The goal of Marine Scotland is to manage Scotland's seas for prosperity and environmental sustainability in order to promote sustainable economic growth and the achievement of a marine vision of '*clean, healthy, safe, productive, biologically diverse marine and coastal environments*', managed to meet the long term needs of people and nature. The objectives of Marine Scotland are to:

1) Promote sustainable, profitable and well managed fisheries and aquaculture industries in Scotland;
2) Promote the marine renewables industry in Scotland through streamlined planning and regulatory frameworks;
3) Ensure a sound evidence base to inform the development and delivery of marine policy, planning and services;
4) Ensure effective compliance and enforcement arrangements;
5) Continue the integration of functions and resources and to develop the organisation's skills, competencies and capacity for new challenges, including potential new functions and responsibilities under the Marine (Scotland) Bill.

Published plans and Strategies include:

1. Marine Scotland: 2009 Strategy Statement: http://www.scotland.gov.uk/Publications/2009/03/31091025/0
2. A Fresh Start: The renewed strategic framework for Scottish aquaculture: http://www.scotland.gov.uk/Publications/2009/05/14160104/0
3. Strategic Framework for Inshore Fisheries: http://www.scotland.gov.uk/Publications/2005/03/20860/File-1
4. Sea Fisheries Strategy: http://www.scotland.gov.uk/Publications/2005/07/07105456/54577
5. Renewable energy policy framework: http://www.scotland.gov.uk/Topics/Business-Industry/Energy/Energy-sources/19185/17612/FRPIS
6. Marine Energy Road Map: http://www.scotland.gov.uk/Resource/Doc/281865/0085187.pdf

UK Hydrographic Office (UKHO)

http://www.ukho.gov.uk/Pages/Home.aspx

The UK Hydrographic Office (UKHO) is a Trading Fund agency of the Ministry of Defence and a world-renowned organisation with over 200 years experience of producing global navigational and other hydrographic products in both paper and, increasingly, digital formats. It provides advice on policy in hydrographic matters to the UK Government and represents the UK at international fora, including the International Hydrographic Organization. In fulfilling its mission to meet national, defence and civil requirements for navigational and other hydrographic information, it also helps the Maritime and Coastguard Agency to meet the UK Government's obligations under the UN Safety of Life at Sea Convention to provide hydrographic services for waters of UK national responsibility.

Welsh Assembly Government

http://wales.gov.uk/topics/environmentcountryside/consmanagement/marinefisheries/?lang=en

The Welsh Assembly Government develops and implements legislation, policy, directives and guidelines to ensure the sea thrives, environmentally, economically and recreationally. Responsibilities include marine spatial planning, marine biodiversity and nature conservation, marine licensing and licensing enforcement, fisheries management, enforcement and prosecutions, and implementation of EU directives. The Welsh Assembly Government is also committed to moving towards a low carbon economy and sees energy generation from the marine environment as key to achieving this goal.

Plans and strategies include:

1. Protecting Welsh Seas – A draft strategy for marine protected areas in Wales: http://wales.gov.uk/consultations/environmentandcountryside/marineprotectedareas/?lang=en
2. Wales Fisheries Strategy: http://wales.gov.uk/about/programmeforgovernment/strategy/publications/environmentcountryside/fisheries/?lang=en
3. Making the Most of Wales' Coast – the Integrated Coastal Zone Management Strategy for Wales: http://wales.gov.uk/topics/environmentcountryside/consmanagement/marinefisheries/iczm/welshstrategy/?lang=en
4. Ministerial Policy Statement on Marine Energy in Wales: http://wales.gov.uk/topics/environmentcountryside/energy/marineenergy/?lang=en'

Annex IV: Related European and other international legislation

This list will be maintained and updated; it will be located on the MSCC website

European Marine Strategy Framework Directive
http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

European Marine and Maritime Strategy
http://ec.europa.eu/research/press/2008/pdf/com_2008_534_en.pdf

UN Convention on the Law of the Sea
http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm

The Oslo and Paris Commissions (OSPAR)
http://www.ospar.org/

London Convention and Protocol
http://www.imo.org/home.asp?topic_id=1488

Intergovernmental Oceanographic Commission
http://www.ioc-unesco.org/

International Council for the Exploration of the Sea (ICES)
http://www.marine.gov.uk/ICES.htm

Some examples of UK marine science achievements

The UK- developed Autosub *[autonomous underwater vehicle]* made the world's first ever surveys under ice shelves in Antarctica and Greenland, providing unique data on how a warmer ocean might accelerate the loss of ice from land.

The most accurate sea surface temperature measurements from space depend on a UK invention, the Along-Track Scanning Radiometer (ATSR), developed in the 1980s by the Rutherford Appleton Laboratory.

UK scientists pioneered experiments showing that adding iron can stimulate marine productivity. For most of the ocean, this process occurs naturally; however, in some regions, adding extra iron could help slow global warming (if potential benefits were considered to outweigh potential risks).

New calculations by UK researchers and international colleagues indicate that the ocean releases around 27 million tonnes per year of sulphur to the atmosphere as dimethyl sulphide (DMS). This biologically-produced gas plays an important role in cloud formation, especially in the southern hemisphere.

UK analyses of satellite data found that Arctic winter sea ice was on average 10% [26 cm] thinner than usual in 2007/08. In the previous summer, total ice cover fell by 1.6 million sq km – more than six times the UK land area.

The UK pioneered storm surge models that combine tidal predictions, tide-gauge data and meteorological information to give up to two days warning of coastal flood events.

The UK leads the international co-ordination of research on air-sea exchange processes, climate variability and prediction, and ocean ecosystem dynamics. The UK also hosts global data centres for sea level measurements and sea-floor mapping.

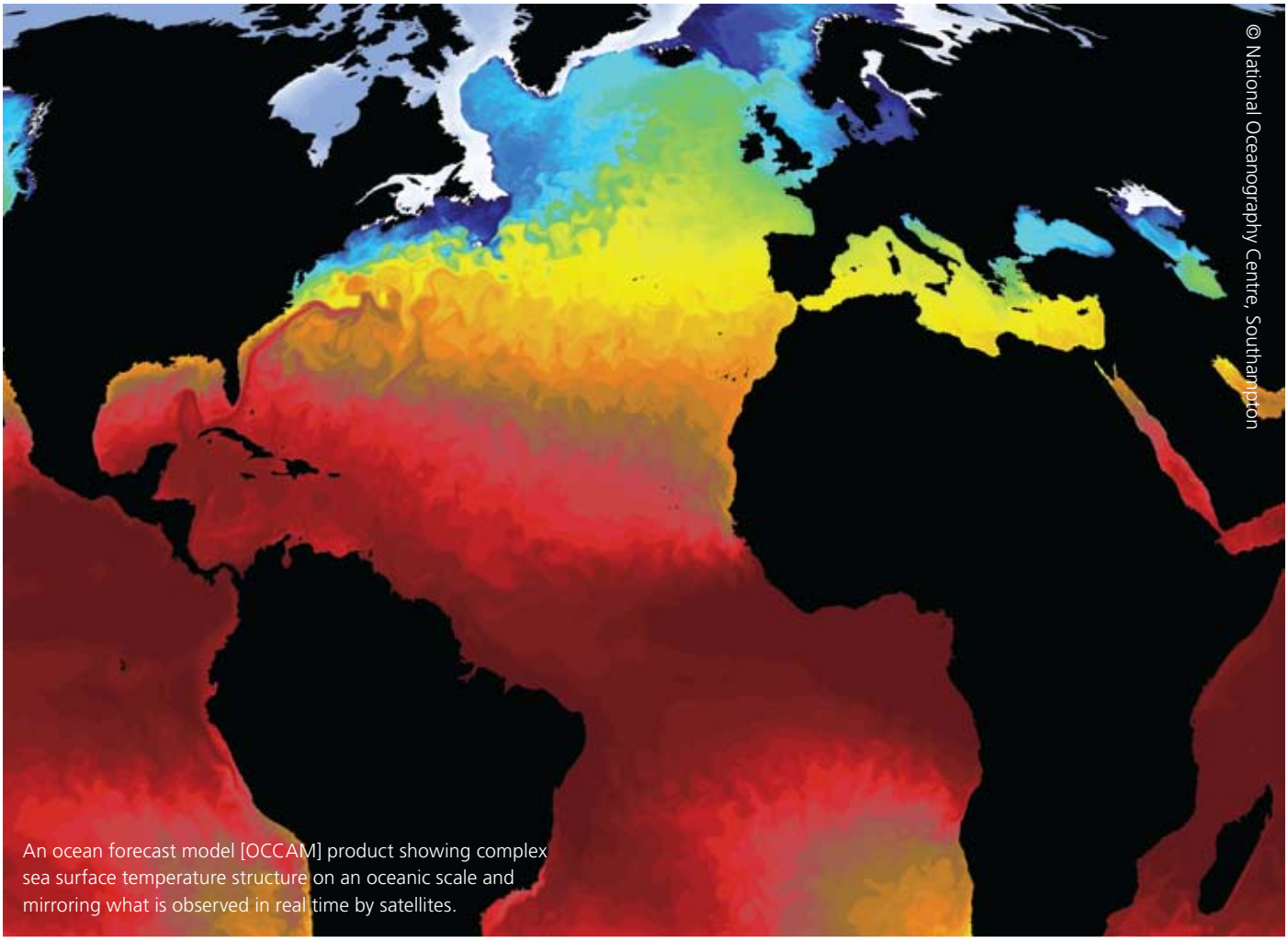
Medical equipment developed to count blood cells has been adapted by UK scientists to sort and classify marine microbes.

Human health depends on iodine from the sea. A UK scientist first identified the natural pathways that link the release of organic iodine compounds from marine algae to the trace amounts of iodine in rainfall and soil.

UK researchers pioneered the automatic measurements of upper ocean CO_2 from commercial ships. They found that the North Atlantic uptake of CO_2 halved between 1995 and 2002; since then it has partly recovered (for reasons that are not well understood).

UK researchers have identified a wide range of novel catalysts, enzymes and bioactives from marine organisms, including those with anti-MRSA and anti-cancer properties. Biologically-produced chemicals involved in cell signalling, chemical defence mechanisms and adaptation to extreme conditions all have high biotechnological potential.

Emperor angelfish *Pomacanthus imperator* in the rich lagoonal reefs of Salomon Atoll, Chagos Archipelago, British Indian Ocean Territory.



An ocean forecast model [OCCAM] product showing complex sea surface temperature structure on an oceanic scale and mirroring what is observed in real time by satellites.

Published by the Department for Environment Food and Rural Affairs on behalf of the Marine Science Co-ordination Committee.

http://www.defra.gov.uk/environment/marine/science/mscc.htm

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