Updating what we know about ocean acidification and key global challenges

It is amazing to think that just ten years ago hardly anyone had heard of ocean acidification. It is now much more widely understood that the increasing amount of carbon dioxide (CO_2) we are emitting into the air by our activities is reacting with the ocean to alter its chemistry and push it along the scale towards acidity and is, amongst other effects, reducing the availability of carbonate ions needed by many marine animals and plants to build their shells and skeletons.

This paper from the International Ocean Acidification Reference User Group, in partnership with national research programmes, provides essential information, and highlights the actions needed on ocean acidification by Governments.

There is little doubt that the ocean is under-going dramatic changes that will impact many human lives now, and ever more so in the coming generations, unless we act quickly and decisively.

Previous acidification events in the Earth's geological record were often associated with extinctions of many species. Whilst the causes of such extinction episodes are complex, it is notable that the biodiversity recovery took hundreds of thousands and – after mass extinctions – millions of years.

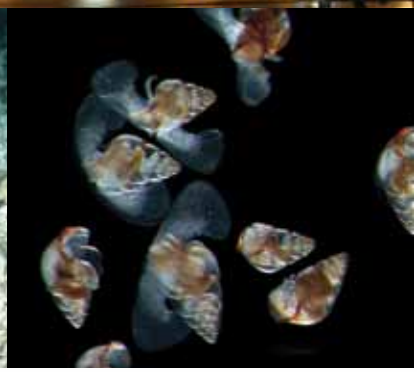
Ocean acidification at Rio+20 and beyond

RIO+20
United Nations Conference on Sustainable Development

Nations of the world met in June 2012 in Rio de Janeiro at the United Nations Conference on Sustainable Development. Ocean issues featured more highly than ever before. In the outcome document *The Future We Want*, world leaders observed (paragraph 166):

> *'We call for support to initiatives that address ocean acidification and the impacts of climate change on marine and coastal ecosystems and resources. In this regard, we reiterate the need to work collectively to prevent further ocean acidification, as well as enhance the resilience of marine ecosystems and of the communities whose livelihoods depend on them, and to support marine scientific research, monitoring and observation of ocean acidification and particularly vulnerable ecosystems, including through enhanced international cooperation in this regard.'*

As a means to help achieve this goal, the International Atomic Energy Agency (IAEA) announced at Rio that it would be launching a new Ocean Acidification International Coordination Centre to serve the scientific community, policy makers and the wider public. The centre, the formation of which resulted from the concerted actions of the global ocean acidification research and user communities, will focus on international activities that are not currently funded at national or international levels. It will be supported by several IAEA Member States, with advisory overview by the U.N. Intergovernmental Oceanographic Commission, the U.S. National Oceanic and Atmospheric Administration, the U.N. Food and Agriculture Organization, the Fondation Prince Albert II de Monaco, the International Ocean Acidification Reference User Group and others.



Key facts about ocean acidification

- Currently, each year the ocean absorbs approximately 25% of all the CO_2 emitted by human activities.
- This hidden ocean 'service' has been estimated to represent an annual subsidy to the global economy of US$86 billion per year, though there is a large uncertainty around this figure[1].
- Ocean acidity[2] has increased by 30% since the beginning of the Industrial Revolution and if CO_2 emissions continue to increase, the rate of acidification will accelerate in the coming decades. This rate of change, to the best of our knowledge, is many times faster than anything experienced in the last 250 million years.
- Numerous animals and plants in the sea have calcium carbonate skeletons or shells. Many are sensitive to small changes in acidity, particularly young life stages and there is evidence that some of these calcifying species are already being affected. Physiological processes and behaviour also show sensitivity to ocean acidification in other species.
- Some marine organisms may apparently benefit from ocean acidification (e.g. photosynthetic algae as well as other marine plants like seagrasses). However, it is important to bear in mind that even positive effects on one species can have a disruptive impact on food chains, community dynamics, biodiversity and ecosystem structure and function.
- Many of the most sensitive species are directly or indirectly of great cultural, economic or ecological importance, for example, warm-water corals that reduce coastal erosion and provide habitat for many other species.

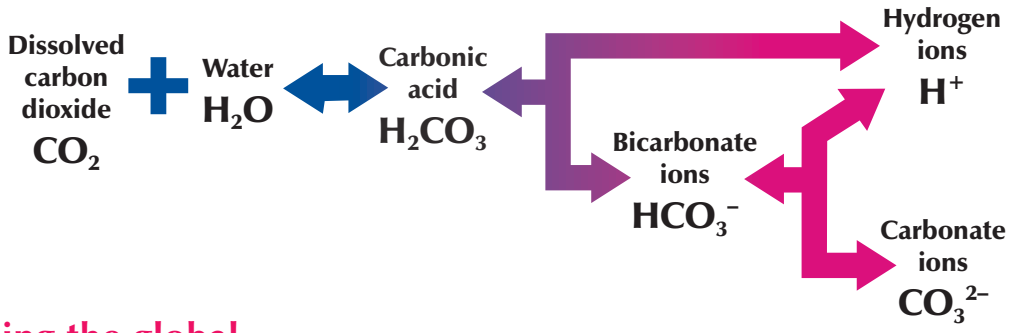
1. This assumes a theoretical replacement cost based on sequestration of 2Gt C/yr at a possible future carbon credit price of $43/tC, and should be considered as a nominal monetary value for services which are unlikely to be replaceable in practice.

2. As measured by hydrogen ion (proton) concentration.

Key challenges

- *Acknowledge* that ocean acidification is a direct consequence of increasing atmospheric CO_2 concentration. The current atmospheric CO_2 concentration (~395 ppm) may already be having an effect, and important marine ecosystems are likely to be harmed if it exceeds 450 ppm.
- *Recognize* that significantly reducing the build-up of anthropogenic CO_2 in the atmosphere is the only practicable solution to mitigating ocean acidification.
- *Support* the implementation of actions to reduce global CO_2 emissions by at least 50% of 1990 levels by 2050 and continue to reduce them thereafter.
- *Reinvigorate* action to reduce, or where possible prevent or eliminate at the regional or local scale, other environmental stressors, such as overfishing, pollution, nutrient loadings and eutrophication which are considered to magnify impacts.
- *Strengthen* ocean resilience by allowing the ocean space and time for recovery from human impacts, through designating and ensuring protection of an effective network of marine reserves and by implementing effective marine planning.
- *Support* the international coordination of integrated ocean acidification research.

The burning of fossil fuels not only increases CO_2 in the atmosphere but also in the ocean. As a result, the concentration of hydrogen ions increases (increasing acidity) whilst the concentration of carbonate ions decreases. Source University of Maryland.



Building the global policy framework

The most effective way of preventing dangerous climate change is to stabilize and reduce the level of greenhouse gases in the atmosphere, particularly of CO_2 (the main driver of climate change and the major cause of ocean acidification). This is reflected in the ultimate goal of the United Nations Framework Convention on Climate Change (UNFCCC) and all affiliated bodies to achieve 'stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system' (UNFCCC, 1992, Article 2).

The actions urged through this paper must form part of a broader strategy to address ocean acidification alongside other key threats to the marine environment such as overfishing and pollution. The ocean is an integral part of the global climate system and by absorbing large amounts of CO_2 it plays an important role in helping to moderate the rate and severity of climate change. Unfortunately this benefit jeopardizes the health of the ocean and its ability to continue to provide important ecosystem services, food production and support sustainable economic development.

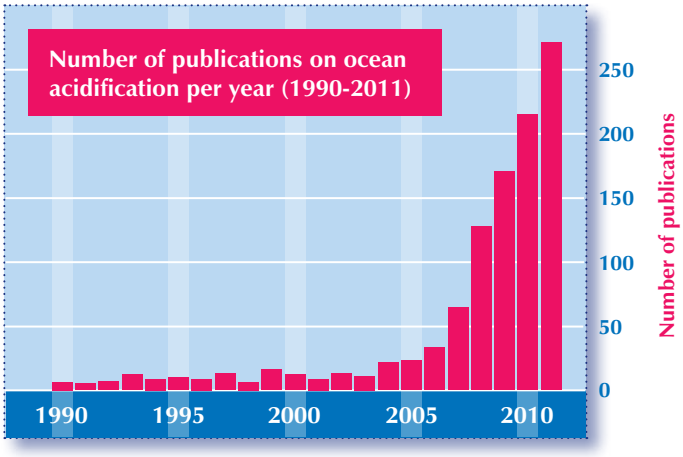
Ocean acidification is no longer on the periphery of international debates on climate or the environment. Although not a consequence of global warming, it is a concurrent problem with wide potential consequences for habitats, species and humankind. The UNFCCC is considered to be the most appropriate body to address the mitigation of ocean acidification but other global environmental conventions, such as the Convention for Biological Diversity, must play their part if successful actions are to be taken.

One of the fundamental adjustments required involves the recognition of the differences between the mitigation strategies of the interlinked problems of ocean acidification and climate change, as this will ultimately influence the types of measures that are used to address them. Measures focusing on regulating emissions of other greenhouse gases such as methane, while a vital contribution to tackling climate change, will have no impact on the progressive acidification of the ocean.

Furthermore, proposals for alternative 'geoengineering' strategies aimed at reducing global temperatures through solar radiation management would not contribute to stabilization or reduction of levels of atmospheric CO_2 and would therefore be similarly ineffective in addressing ocean acidification, irrespective of any benefits and drawbacks in relation to climate change.

Who is taking action on ocean acidification?

In the last few years there has been a significant growth in scientific studies to understand what is happening now and what may happen in the future as a result of ocean acidification. The figure demonstrates the rapid increase in availability of literature on this issue during the past few years.



Extracted from the EPOCA bibliographic database.

Current scientific studies focus on understanding the consequences and mechanisms of this global problem to identify the best strategies for addressing it. There is a need to ensure that the concerns of developing countries are adequately addressed, and also that new findings are rapidly disseminated as they emerge in the research community.

In November 2010, the Monaco Scientific Centre (CSM) and the International Atomic Energy Agency (IAEA) (sponsored by the USA Peaceful Uses Initiative) jointly hosted an international workshop with the endorsement and support of the Principality of Monaco, the Oceanographic Museum, The Prince Albert II of Monaco Foundation and the French Ministry of Ecology, Energy, Sustainable Development and the Sea. This meeting on the Economics of Ocean Acidification: Bridging the Gap between Ocean Acidification Impacts and Economic Valuation produced a set of recommendations as a basis for policy decisions concerning ocean acidification (www.iaea.org/nael/page.php). Another workshop is planned for 2012 to further develop the natural and social scientific collaborations.

Major studies underway or in advanced stages of planning

European Union

In 2008 the European Commission funded the European Project on Ocean Acidification (EPOCA), as the first multinational effort to investigate ocean acidification and its consequences. The project, which has now ended, brought together 32 laboratories located in 10 European countries. This four year research project aimed to monitor ocean acidification and its effects on marine organisms and ecosystems, to identify the risks of continued acidification, and to understand how these changes affect the Earth system as a whole. In 2011 the European Commission funded the Mediterranean Sea Acidification in a Changing Climate project (MedSeA) which assesses uncertainties, risks and thresholds to Mediterranean Sea acidification and warming at organism, ecosystem and economic scales and potential regional adaptation and mitigation strategies. The MedSeA project is funded for three years and involves over 110 researchers from 20 institutes located in 12 countries mainly from the Mediterranean.

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EPOCA CO_2 experiments

Australia

Ocean acidification research in the Australasian region focuses on impacts from the Southern Ocean through to the Great Barrier Reef and into Papua New Guinea. Research in the Southern Ocean by the Antarctic Climate & Ecosystems Cooperative Research Centre (a multidisciplinary partnership of 21 national and international organizations) includes monitoring sea water chemistry changes and the responses of key species. The Integrated Marine Observing System (IMOS) deploys a range of observing equipment in the oceans around Australia and makes all of the data freely and openly available through the IMOS Ocean Portal.

China

Ministry of Science and Technology (MOST) and National Science Foundation of China (NSFC) have started to support research into ocean acidification. CHOICE-C is a newly funded five year project to study high CO_2 and ocean acidification issues in Chinese marginal seas, a joint project of seven major institutes. NSFC started to fund projects on ocean acidification in 2006, and there are several ongoing national level projects exploring the impacts of ocean acidification on calcifying organisms.

Germany

The Biological Impacts of Ocean Acidification (BIOACID) programme involves 15 research institutes and universities and is funded by the Federal Ministry of Education and Research (BMBF). After completing an initial three year period starting in September 2009, BIOACID will continue for at least another three year period until 2015. Its main focus is on the effects of ocean acidification on the marine biota at the sub-cellular to ecosystem levels and their potential impacts on ecosystem services and biogeochemical feedbacks.

Japan

Five major programmes in Japan fund research relevant to ocean acidification. Japan's Ministry of Environment supports research programmes to elucidate the future impact of ocean acidification on various marine organisms using sophisticated mesocosm facilities (e.g. AICAL, Acidification Impact on CALcifiers). The Ministry of Education, Science, Sport and Culture (MEXT)) and the Japan Agency for Marine Science and TEChnology (JAMSTEC) also support ocean acidification research such as modelling efforts on the Earth Simulator supercomputer to predict future ocean conditions.

Korea

The Korea Science and Engineering Foundation is funding the five year Korea Mesocosm Project to examine the effects of elevated CO_2 and temperature on natural phytoplankton assemblages, which involves five Korean laboratories.

Monaco

In October 2011, the IAEA Environment Laboratories began a Coordinated Research Project (CRP) entitled Ocean Acidification and the Economic Impact on Fisheries and Coastal Society, supported by the United States Department of State. The CRP seeks to engage developing countries in research on impacts of ocean acidification on fisheries, aquaculture, and marine ecosystem services that support sustainable food security and human well-being.

United Kingdom

The five year UK Ocean Acidification (UKOA) research programme (www.oceanacidification.org.uk) began in 2010, and now involves over 120 researchers in 26 laboratories. UKOA research includes experimental and observational studies, as well as modelling and palaeo analyses; the field focus is on European shelf seas, the Arctic and the Southern Ocean. The programme is funded by the Natural Environment Research Council (NERC), the Department for Environment, Food and Rural Affairs (Defra) and the Department of Energy and Climate Change (DECC).

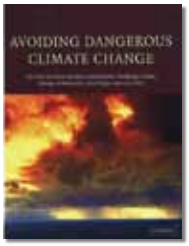
United States

The Federal Ocean Acidification Research and Monitoring Act of 2009 (FOARAM Act) was signed by President Obama in March 2009. The Act requires that the National Oceanic and Atmospheric Administration (NOAA), the National Science Foundation (NSF) and other federal agencies work together through the Interagency Working Group on Ocean Acidification (www.st.nmfs.noaa.gov/iwgoa/) to develop an integrated national programme on ocean acidification that started in 2010. Ongoing research and programmatic activities are supported by NSF, NOAA, Department of State (DOS), Bureau of Ocean Energy Management, (BOEM), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), and the U.S. Navy.

Finding out more about ocean acidification – useful sources of further information

Ocean acidification featured as a new topic in the press release from the first global meeting on The Ocean in a High CO_2 World, supported by the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO). Since that meeting in 2004, a rapid expansion in work and concern on this issue has occurred.

Key reports that together provide a comprehensive source of knowledge



The first time many policy advisers became aware of ocean acidification was through the 2005 international conference on *Avoiding* Dangerous Climate Change: A Scientific Symposium on Stabilisation of Greenhouse Gases. This took place under the United Kingdom's presidency of the G8, with the participation of around 200 internationally renowned scientists from 30 countries. It examined the link between atmospheric greenhouse gas concentration, and the 2 °C (3.6 °F) ceiling on global warming thought necessary to avoid the most serious effects of climate change.

The first major publication on ocean acidification rapidly followed. The Royal Society 2005 policy document *Ocean acidification due to increasing atmospheric carbon dioxide* recognized ocean acidification as a significant threat to many calcifying organisms with the potential to alter food chains and other ecosystem processes and lead to a reduction of biodiversity in the oceans. The appointed working group made specific policy recommendations, including limiting the accumulation of CO_2 emissions to avert impending damages from ocean acidification.

In 2006 the German Advisory Council on Global Change released *The Future Oceans – Warming Up, Rising High, Turning Sour*. This document presents the hazards of acidification within the context of other climate change processes in the ocean. Policy makers were urged to acknowledge the role of CO_2 as an ocean hazard during future negotiations under the United Nations Framework Convention on Climate Change (UNFCCC).

Impacts of Ocean Acidification on Coral Reefs and Other Marine Calcifiers: A Guide for Future Research came from a joint effort by NSF, NOAA and USGS. This is a 2006 summary report on the state of the science regarding the biological consequences of acidification, particularly as they affect calcifying organisms. The report concludes with a recommended research agenda and underscores the need for research to place the long term biological changes induced by acidification into a historical context.

In 2006 a report was produced from The Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention). *Effects on the Marine Environment of Ocean Acidification Resulting from Elevated Levels of CO_2 in the Atmosphere* was a product of The Scoping Workshop on Ocean Acidification Research.

From 2007 onwards ocean acidification began to regularly feature in reporting in the UK on marine climate change impacts. These took the form of *Annual Report Cards* produced by the Marine Climate Change Impacts Partnership (MCCIP). In April 2009 more significant coverage was provided on ocean acidification through their publication *Exploring Ecosystem Linkages*. This builds on the previous Annual Report Cards to show how the interconnected nature of the marine ecosystem magnifies the many discrete impacts of climate change.

The U.S. Ocean Carbon and Biogeochemistry Program (OCB) sponsored a workshop in conjunction with NOAA, National Aeronautics and Space Administration (NASA) and NSF at the Scripps Institution of Oceanography to develop a U.S. research strategy. Around 100 scientists developed a plan to investigate the impacts of ocean acidification on four marine ecotypes: coral reefs, coastal margins, tropical-subtropical open-ocean systems, and high latitude regions. The recommended research was reported in 2008 in *Present and Future Impacts of Ocean Acidification on Marine Ecosystems and Biogeochemical Cycles*.

Also in 2008, a significant policy document was provided for the Australian government: *Position Analysis: CO_2 Emissions and Climate Change: Ocean Impacts and Adaptation Issues*. This document sought to describe the process of acidification, outline the biological and human effects and to advise the Australian government on issues relevant to policy development. It was accompanied by a one page fact sheet *Ocean Acidification: Australian Impacts in the Global Context* that discussed ocean acidification in terms of the science: what is known, what needs to be known and what can be done.

In 2008 The Nature Conservancy and the International Union for Conservation of Nature (IUCN) held a meeting on ocean acidification that resulted in the *Honolulu Declaration*. This identified two major strategies that must be implemented urgently and concurrently to mitigate the impacts of climate change and to safeguard the value of coral reef systems: 1) limit fossil fuel emissions; 2) build the resilience of tropical marine ecosystems and communities to maximize their ability to resist and recover from climate change impacts.

In 2008 the European Geosciences Union, Asia Oceania Geosciences Society and the Japan Geosciences Union produced a joint *Position Statement on Ocean Acidification*. This concluded that the impacts of ocean acidification may be just as dramatic as those of global warming (resulting from anthropogenic activities on top of natural variability) and the combination of both are likely to exacerbate consequences, resulting in potentially profound changes throughout marine ecosystems and in the services that they provide to humankind.

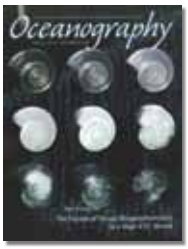
In 2009 a further milestone report was produced. The *Monaco Declaration* arose from the 2nd international symposium The Ocean in a High-CO_2 World, and was approved by 155 scientists from 26 countries with the support of HSH Prince Albert II of Monaco. It calls on policymakers to act quickly to stabilize atmospheric CO_2 at a safe level, not only to avoid dangerous climate change but also to avoid the additional problem of ocean acidification.

Another result of the 2008 2nd international symposium The Ocean in a High-CO_2 World was the production of a *Summary for Policy Makers* of the new research findings presented at the symposium. More detailed information is synthesised in a scientific report, *Research Priorities for Ocean Acidification* (2009), available from www.ocean-acidification.net.

In 2009 the International Ocean Acidification Reference User Group produced a guide to ocean acidification, setting out in plain language the *Essential facts for policy makers and decision takers on ocean acidification*. Available in English, French, Spanish, Chinese and Arabic the guide was launched in Copenhagen at the UNFCCC COP15 and provides an introduction to the topic, summarizing key issues around this important topic. This will be updated in 2013.

The Interacademy Panel (IAP) statement on ocean acidification (2009) was signed by more than100 National Academies. It stated that marine food supplies are likely to be reduced and that coral reef and polar ecosystems will be severely affected by 2050, or potentially earlier; furthermore, even with stabilization of atmospheric CO_2 at 450 ppm, ocean acidification would have profound impacts on many marine systems. Large and rapid reductions of global CO_2 emissions are therefore needed, by at least 50% by 2050.

The *European Science Foundation Science Policy Briefing on Impacts of Ocean Acidification* (2009) included recommendations for improved coordination of ocean acidification research and collaboration both at national and international levels, together with integration of efforts between natural and social sciences, in order to understand the impacts on natural resources and humans.



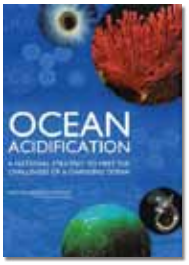
In 2009 a special issue of *Oceanography* was devoted to understanding the present and future impacts of ocean acidification in a high CO_2 world. The special issue contained review articles on processes and impacts of acidification to marine ecosystems.

The Convention on Biological Diversity (CBD) published a synthesis report on *Impacts of ocean acidification on marine biodiversity* in 2009. The CBD subsequently decided to develop a series of joint expert review processes to monitor and assess the impacts of ocean acidification on marine and coastal biodiversity. The first Expert Meeting (Montreal, 19-20 October 2011) agreed that in order to preserve biodiversity, CO_2 emissions must be reduced and ecosystem resilience managed.

Ocean Acidification Frequently Asked Questions (2010) was published by OCB, EPOCA and UKOA in response to the growing research across disciplines and the increasing need for clear answers by experts to frequently asked questions. In total, 27 experts from 19 institutes and five countries contributed.

In 2010 the International Ocean Acidification Reference User Group produced their *second guide on ocean acidification to provide answers to some key questions*, to say how sure the international scientific community is about what is already happening to the ocean, to discuss what the future may hold for the ocean in a high CO_2 world, and to explore the consequences for all of us of what is now happening. The guide is available in English, French, Spanish, Chinese, Arabic and German.

Environmental consequence of ocean acidification: a threat to food security. UNEP Emerging Issues Bulletin (2010). With 1 billion people relying on marine protein as their sole protein source, and an expanding global population increasingly reliant on marine food sources including aquaculture, this is the first time ocean acidification has been linked to a potential risk to food security.

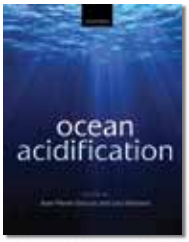


The National Research Council of the US National Academies *Ocean Acidification. A National Strategy to Meet the Challenges of a Changing*

Ocean (2010). This publication, requested by Congress, is one step amongst many that US scientists and funders are taking towards forming a National Ocean Acidification Research Programme.

The Intergovernmental Panel on Climate Change's (IPCC) *4th Assessment Report* (2007) recognized ocean acidification for the first time in an IPCC report. Since then an IPCC WGII/WGI Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems was held in Okinawa, Japan in January 2011. The 5th IPCC Assessment Report due in 2014 will include a more in-depth assessment of both ocean climate change and acidification.

In 2011, the Antarctic Climate & Ecosystems Cooperative Research Centre created a Southern Ocean focused report card at the Australian government's request, *Southern Ocean Acidification Report Card*, to clearly communicate what we know, what we need to know and what's at risk due to ocean acidification in the region.



The book *Ocean Acidification* (eds Gattuso and Hansson, 2011) includes chapters on impacts on marine organisms, ecosystems and biogeochemistry, projections of the consequences of CO_2 emission scenarios on future acidification, and socio-economics, policy responses and societal challenges.

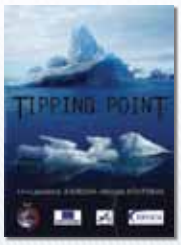
Hot, Sour and Breathless: Ocean under stress. Over the coming decades and centuries, ocean health will become increasingly stressed by at least three interacting factors: rising seawater temperature, ocean acidification and ocean deoxygenation. This document summarizes current knowledge on these three stressors and how they may react together in ocean 'hot spots' of vulnerability. It was jointly produced by Plymouth Marine Laboratory, UK Ocean Acidification Research Programme, European Project on Ocean Acidification, Mediterranean Sea Acidification in a Changing Climate Project, Scripps Institution of Oceanography at UC San Diego and OCEANA. Its message has been supported by major international organizations and programmes and featured at the UNFCCC COP17 in Durban, Planet Under Pressure Conference in London, and the Rio+20 UN Conference on Sustainable Development.

Films

In the past few years a number of films have also been produced to explain ocean acidification to a wide audience and how the issue is being tackled by scientific studies and new innovative science-policy-outreach partnerships. Four key films released in the past few years are:

Acid Test, a film produced in 2009 by the National Resources Defence Council (NRDC), narrated by Sigourney Weaver, was made to raise awareness about the largely unknown problem of ocean acidification, which poses a fundamental challenge to life in the seas and the health of the planet.

A group of 11-15 year old students from Ridgeway School in Plymouth, working with Plymouth Marine Laboratory, have made their concerns about the state of the world's oceans clear through a hard hitting film. *The Other CO_2 Problem*, released in 2009, is a seven and a half minute animation starring characters from King Poseidon's Kingdom beneath the sea and laments the fact that Doctorpus, Britney Star, Michelle Mussel, Derek the Diatom and other subsea creatures are suffering as the ocean becomes more acidic as a result of human activities. The children and their animation won the Royal Society of Chemistry's Bill Bryson Prize for Science Communication. The DVD has been translated into French, Spanish, Italian and Catalan.



The movie *Tipping Point* released in 2011 mostly describes research performed in the framework of the European Project on Ocean Acidification (EPOCA). In June 2011, it received the Prince Rainier III Special Prize at the 51st Monte-Carlo Television Festival. It has also been awarded 'Best 2011 science documentary' at the 15th International Festival of Scientific Documentary and Movie and the 'Best Scientific Movie' award at the Mediterranean film festival.

A powerful short film *Ocean acidification: Connecting science, industry, policy and public*, was released in 2011 by Plymouth Marine Laboratory as part of the UK Ocean Acidification Research Programme's outreach. The film brings together a wide range of stakeholders including, HSH Prince Albert II of Monaco, school children, a Plymouth fishmonger, the UK government Chief Scientific Adviser, representatives from industry and policy making departments, as well as a group of internationally recognized expert scientists. Sub-titled versions of this 12 minute film are available in Brazilian Portuguese, French and Korean. The English version has been shown at major events around the world, including the UNFCCC COP17 in Durban and Planet Under Pressure Conference in London, the Korean version has been shown at World Expo 2012 and at the East Asian Seas Congress while the Brazilian Portuguese version was shown extensively during the Rio+20 UN Conference on Sustainable Development.

Online paper

Download a copy of this new paper on ocean acidification and learn more about this issue at www.epoca-project.eu/index.php/Outreach/RUG/

What is the International Ocean Acidification Reference User Group?

A key challenge is ensuring that ground-breaking science on issues such as ocean acidification addresses the questions that need to be answered and that these answers get quickly and effectively into the hands of policy advisers and decision makers so that action can be taken. The International Ocean Acidification Reference User Group (IOA-RUG) draws on European and international experience in fast-tracking the exchange of information between scientists and end users.

The original RUG was established in 2008 to support the work of the European Project on OCean Acidification (EPOCA), and now supports complementary studies in Germany (BIOACID), the UK (the UK Ocean Acidification research programme, UKOA), the Mediterranean through the Mediterranean Sea Acidification in a Changing Climate (MedSeA), with strong links to similar processes in the USA and the Australian ocean acidification RUG. The IOA-RUG draws together a wide range of end users to support the work of leading scientists on ocean acidification, to facilitate the rapid transfer of knowledge, and help the effective delivery of quality science.

This paper draws on the experience of the RUG, coupled with the knowledge of the leading experts on ocean acidification, to provide an introduction for policy advisers and decision makers on this critical and urgent issue.

Further details and contacts

Further details on the work of the International Ocean Acidification Reference User Group and its membership can be found at www.epoca-project.eu/index.php/Outreach/RUG
If you have any further enquiries please contact us at policyguide-epoca@obs-vlfr.fr

Sources and contributors

This paper draws from previous RUG presentation and associated materials. It also draws on the recent publication by Harrould-Kolieb & Herr (Ellycia R. Harrould-Kolieb & Dorothée Herr (2011): Ocean acidification and climate change: synergies and challenges of addressing both under the UNFCCC, Climate Policy, DOI:10.1080/14693062.2012.620788).

We are grateful to all the scientists and experts who contributed to the development of this report. Their contributions have ensured that it represents a broad consensus of the key information and actions needed on ocean acidification.

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The paper was produced with financial support from UK Ocean Acidification research programme, and is based on best practice communication approaches pioneered by the UK's Marine Climate Change Impacts Partnership.