



ACTING ON OCEAN ACIDIFICATION

Improving prospects by planning ahead

Ocean acidification impacts are already happening. They are progressive. How rapidly these changes take hold all depends on the scale of emission cuts. Whilst cuts are needed urgently, we also now need to plan ahead. We need to invest for the future. This plan is designed to help us do just that.



Foreword

OCEAN ACIDIFICATION is measurable and is already starting to cause economic problems and concerns in a number of countries. Over time the problems can only increase and the number of affected regions will simply spread. Our current emissions of carbon dioxide have locked us into worsening conditions of ocean acidification for generations to come. Recovery of the ocean's chemistry will take far longer. Only by planning ahead, creating forecasting capabilities and making the right types of investments now can we improve our prospects in the future.



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Acting on ocean acidification – at a glance



This summary report has been compiled by the Ocean Acidification international Reference User Group (OAIrUG), working with representatives of industry, users, and non-governmental organizations on the front line of ocean acidification, and with many of the world's leading scientists and research programmes. For the full report see *Acting on Ocean Acidification – Improving prospects by planning ahead* found at <http://www.iaea.org/ocean-acidification/page.php?page=2198>

The overall messages are simple. Locked-in changes to the ocean from our carbon dioxide (CO₂) emissions will continue to drive progressive ocean acidification for decades to come. In order to be in a better position for countries and governments to cope with this situation, a series of systematic and strategic investments need to be made now by the international community in policy, science, capacity building, systems development, and community involvement. This is alongside the overarching imperative of countries achieving ambitious and significant reductions in CO₂ emissions – thus stemming the flow of CO₂ that causes ocean acidification. The key aim of such investments should be to secure the following outcomes by 2025:

- **An ocean acidification forecasting system** informed by a fully operational, multi-stakeholder, well-resourced Global Ocean Acidification Observing Network, facilitating the production of high resolution vulnerability maps to drive ongoing adaptation, mitigation and conservation strategies at global to local scales.
- **Appropriately scaled computational models to predict ocean acidification effects** in coastal regions of the ocean that can be used to generate coastal community vulnerability assessments to ocean acidification along with the other stressors.
- **Comprehensive, coordinated, networked national science programmes** studying thematic and regional impacts of ocean acidification, and contributing essential information into global assessments and forecasting systems.
- **A good understanding of the impacts of ocean acidification on human health** (e.g. disease and nutrition) and economies through a targeted research programme.
- **A fully coordinated international ocean acidification outreach, education and communication effort.**
- **An effectively resourced and managed coordination network for international and regional science, policy and stakeholder groups**, responsive to research and policy needs.
- **A strong political 'blue alliance' of countries and sovereign governments** bringing together those most affected by climate-related issues with those in the front line of ocean acidification impacts.

- **An international fund for development and exchange of science, knowledge and adaptation techniques**, accelerating the growth of capacity and 'know-how' needed by vulnerable ocean-dependent communities and nations, in order to cope with increasing multiple stresses in a high-CO₂ ocean.
- **Private industry delivering innovative customer-focused and service-led products and means** to monitor and mitigate ocean acidification based on customer needs and market demand.

An unprecedented rate of change

Increasing ocean acidification is directly related to the excessive CO₂ emissions to the atmosphere from a range of human activities. It is the first time since modern-day humans have been on Earth that we have dramatically altered the fundamental chemistry of such a large part of the global ecosystem. Unlike problems such as the hole in the ozone layer which has proved to be reversible through enforced and 'quick' political actions, the chemistry changes taking place in the ocean are far more extensive and, can be considered irreversible at least for the next 50–60 years even with dramatic emissions reductions and / or novel mitigation measures. We are in effect in the process of conducting an experiment on a planetary scale that takes us into uncharted territory that will require immense effort and resolve for it to be reversed.

Ocean acidification by numbers

0.5	The % annual increase in H ⁺ ion concentration in sea water which gives an indication of how much 'acidity' is changing
4	The number in kg of CO ₂ per day on average that is taken up by the ocean from each person's activities
30	Percentage increase in acidity (as concentration of H ⁺ ions) caused by CO ₂ pollution since the Industrial Revolution
120	Percentage increase in acidity (as concentration of H ⁺ ions) projected by 2100, due to CO ₂ pollution since the Industrial Revolution
280	The level of CO ₂ in the atmosphere measured in parts per million immediately prior to the Industrial Revolution (1760 – c1840)
400	The level of CO ₂ in the atmosphere in May 2015 measured in parts per million by the Mauna Loa observatory in Hawaii
936	The level of CO ₂ projected to be in the atmosphere by 2100 on a 'business-as-usual' scenario (i.e. RCP 8.5)
55 million	Years since the earth experienced anything close to the current level of ocean acidification, which happened back then over a much longer time period (thousands not hundreds of years)
107 million	The amount annually in \$ to the US economy that the Washington, Oregon and California shellfish industry alone – already impacted by ocean acidification – is worth, employing some 3200 people

A significant new dimension to global risk

The risks arising from climate change are now widely acknowledged as a major cause for concern, and yet awareness of ocean acidification is still far less prevalent although it is growing. The fundamental and underlying facts associated with ocean acidification are clear:

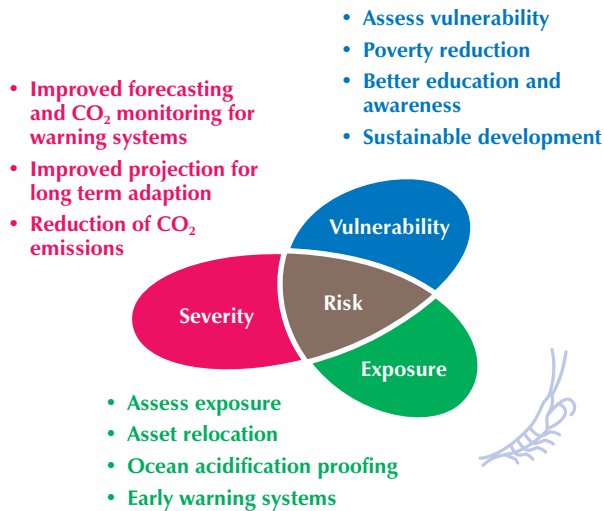
- Delay amplifies the consequences: the more CO₂ emitted, and the longer it takes to significantly cut emissions, the greater the scale of the acidification problem in the ocean that the current and future generations are left to cope with.
- Ocean acidification coupled with ocean warming and deoxygenation are now rapidly progressing close to or maybe possibly beyond the tipping point for some keystone species – i.e. species that play fundamental roles in maintaining healthy marine ecosystems.
- Critical fisheries resources are already being impacted by direct or indirect effects of ocean acidification (e.g. shellfish).



- The socio-economic and / or cultural impacts of ocean acidification on local communities are potentially high, with some countries as a result projected to be much worse off in the future (e.g. reduced food security, loss of employment, changes to cultural practices).

Some key mechanisms and actions to better inform the assessment of risk posed by ocean acidification

Adapted by C. Turley from IPCC 2012: Managing the risks of extreme events and disasters to advance climate change adaptation.



Ocean acidification risk assessments are starting to demonstrate the problems posed to particular aspects of national economies – e.g. the known exposure of ocean-based food sectors (capture fisheries) that will affect a number of small island nations and coastal communities of the developing and developed world.

A ten year proactive plan

The widely held response to ocean acidification is the need to urgently cut emissions of CO₂ into the atmosphere at a sufficient scale and speed to avoid the worst impacts. This continues to be **the** over-riding priority and one that must be addressed by governments and the international community. However, as our understanding on ocean acidification grows, cutting emissions alone will not prepare communities for the impacts of acidification that will inevitably occur. Within the next 10 years we need in place:

Observing and forecasting systems

- Effective observing and forecasting systems to manage future risks.
- High resolution vulnerability maps informed by the Global Ocean Acidification Observing Network for both oceanic and coastal areas.

Assessing impacts on coastal zones

- Priority will be given to those locations where changes in ocean chemistry could lead to early-onset non-linear change, substantially altering a community's level of risk and where a policy response is required.
- Simulation and forecasting models will be refined to the resolution necessary to predict ocean acidification effects combined with other stressors in the coastal regions of the ocean.

Linkages to human and ecosystem health and well-being

- Research questions should build on recent scientific information, involve matters of relevance to society for cultural and economic sustenance, and be multidisciplinary in design and ideally bring together chemistry, biology, and economics where it matters most to vulnerable people.
- We will have dramatically improved our understanding of the impacts of ocean acidification on human well-being (disease and nutrition) through an ambitious interdisciplinary research programme.
- We will have dramatically improved our understanding of the impacts of ocean acidification on ecosystems (species, populations, communities, ecosystems, food-webs) through a comprehensive research programme.
- We will have created 'safe havens' to preserve biodiversity (notably coral reefs) for future generations.



Generating risk awareness

- A key part of the success of introducing any strategic plan will be to better communicate to relevant stakeholders how ocean acidification relates to their circumstances.
- A coordinated international ocean acidification outreach, education and communication effort will result in 70% of humanity knowing what it is and 50% of coastal nations having put in place policy to help their communities prepare for and adapt to in the impacts of ocean acidification.

Scientific coordination and cooperation

- Involving seafood producers, mariners, coastal planners, governments, and other stakeholders in the design of and products coming from research efforts and observing systems is an important engagement route to bring support for this agenda and to increase its effectiveness.
- In five years' time the ocean acidification community will be more effectively integrated both globally and regionally, and increasingly responsive to research and policy needs, with open access to data and information.

Political leadership

- A unified message that can be championed by political leaders is necessary to enact global change and spur international cooperation and action on ocean acidification.
- An alliance of countries will be in place bringing together those affected by climate related issues such as sea-level rise, extreme weather events and coral bleaching with those in the front line of ocean acidification impacts.

Ocean-based food security vulnerability ranking

Top 10 countries of those assessed considered at risk from ocean acidification through threats to their food security



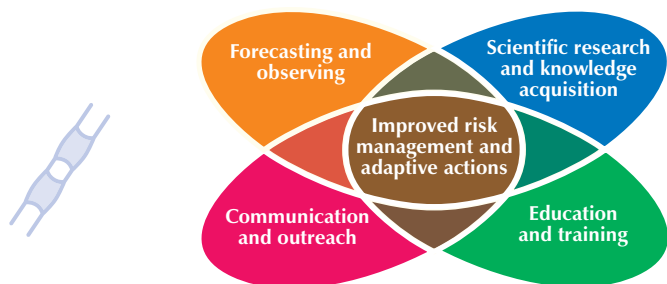
Innovative customer-related and service-led partnerships

- Increased monitoring by industry will help identify, in an increasingly compromised ocean, favourable areas to establish ecotourism industries, and best areas for aquaculture development.
- Private industry will be delivering innovative products and services to monitor and mitigate ocean acidification based on customer needs.
- People will see different values in different parts of the agenda depending on their perspective and situation.

Investing for the future

Turning a 10- year plan into action and securing the necessary investments will require coordinated and coherent actions by the ocean acidification community to drive the necessary processes forward. The investment portfolio to obtain the anticipated outcomes includes four main pillars, which are framed around the overarching theme of improved risk management and adaptive actions:

Major areas of investment required by the international community to deliver the expected outcome of the ten year ocean acidification capabilities plan



Component 1 Forecasting and observing

Observing and forecasting should be long-term commitments required for creating an effective response to ocean acidification.

Ocean acidification observing strategies should follow the guidance of the internationally vetted and approved GOA-ON Requirements and Governance Plan¹¹. New and improved observation strategies should include a wide range of marine environments and habitats emphasizing the development of ocean observation systems in countries where ocean acidification impacts endanger livelihoods.

Forecasting will require integrated global and regional models. While the operational readiness for global models has been mostly achieved, regional model skills still have to be improved, which will require significant investment. Exploiting the applicability of existing models to new regions should facilitate and increase the efficiency of this operation.

Component 2 Scientific research and knowledge acquisition

To build accurate and meaningful ocean acidification observing and forecasting capacity, key scientific information advances are needed to improve the underlying knowledge base, to understand impacts of economic values, to improve forecasting capabilities, inform adaptation strategies, and improve management practices and these needs will evolve as our understanding does. Some major needs are listed here but the list is by no means exhaustive:

- A better understanding of biological responses to ocean acidification.
- A better understanding of the impacts of ocean acidification on economic activities, e.g. fisheries through direct and indirect effects.
- Scientific and technical advances and their distribution in new, low cost observing assets.
- A better understanding of how the ocean carbon reservoir will respond to future global change.

- Forecast models need to link from chemistry to socio-economic impacts (including biological and cultural impacts).
- Development of globally distributed, regional coastal models will require fundamental research into key processes and drivers of specific regions.

Component 3 Education and training

In order to be able to conduct sound science, capacity building through training and technology transfer has to be supported globally. This includes specific tools for engaging developing countries in data collection, and identifying regions for model development. In some cases this will be hands on, and in other cases virtual training materials can be implemented successfully. In the short term, training is needed for observing skills, data management, ocean acidification impact assessment, and to identify forecasting needs.

Component 4 Communication and outreach

A comprehensive communication strategy is critical for several key reasons:

- To raise awareness of risks associated with ocean acidification and thus garner attention to the importance of mitigation (i.e. reduction in CO₂ emissions).
- To show that real-time data and forecast products are essential at providing scientific background information for effective adaptation strategies.
- To raise political support to enable significant steps to be made by policy makers.
- To raise the necessary funding to produce the ocean acidification observational and forecasting capacity needed to inform human response.

Leadership and action

Funding the required capacities and capabilities is essential but will not achieve the transformative actions needed alone – leadership at all levels is required to secure the engagement and actions required.

Due to the progressive nature of ocean acidification an increasing number of nations are becoming more vulnerable. The increasing political awareness and improved scientific knowledge is leading to numerous international efforts to align actions across oceans.

Online paper

Download a copy of this summary and the full report at:
<http://www.iaea.org/ocean-acidification/page.php?page=2198>

Sources and contributors

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