

NOVEMBER 2017

## OCEAN ACIDIFICATION

- As carbon dioxide ( $\text{CO}_2$ ) dissolves in sea water, it forms carbonic acid, decreasing the ocean's pH, a process collectively known as ocean acidification.
- Present ocean acidification occurs approximately ten times faster than anything experienced during the last 300 million years, jeopardising the ability of ocean systems to adapt to changes in ocean chemistry due to  $\text{CO}_2$ .
- Ocean acidification has the potential to change marine ecosystems and impact many ocean-related benefits to society such as coastal protection or provision of food and income.
- Increased ocean temperatures and oxygen loss act concurrently with ocean acidification and constitute the 'deadly trio' of climate change pressures on the marine environment.
- To combat the worst effects of the deadly trio,  $\text{CO}_2$  emissions need to be cut significantly and immediately at the source.
- Sustainable management, conservation, restoration and strong, permanent protection of at least 30% of the ocean are urgently needed.

### What is the issue?

Ocean acidification is a direct consequence of increased human-induced carbon dioxide ( $\text{CO}_2$ ) concentrations in the atmosphere. The ocean absorbs over 25% of all anthropogenic emissions from the atmosphere each year. As  $\text{CO}_2$  dissolves in sea water it forms carbonic acid, thereby decreasing the ocean's pH, leading to a suite of changes collectively known as ocean acidification. Ocean acidification is happening in parallel with other climate-related stressors, including ocean warming and deoxygenation. This completes the set of climate change pressures on the marine environment – heat, acidity and oxygen loss – often referred to as the 'deadly trio'. Interaction between these stressors is often cumulative or even multiplicative, resulting in combined effects that are more severe than the sum of their individual impacts.

### Why is this important?

Present ocean acidity change is unprecedented in magnitude, occurring at a rate approximately ten times faster than anything experienced during the last 300 million years. This rapid timeline is jeopardising the ability of ocean systems to adapt to changes in  $\text{CO}_2$  – a process that naturally occurs over millennia. Changes in ocean pH levels will persist as long as concentrations of atmospheric  $\text{CO}_2$  continue to rise. To avoid significant harm, atmospheric concentrations of  $\text{CO}_2$  need to get back to at least the 320-350 ppm range of  $\text{CO}_2$  in the atmosphere.

Compared to other similar events in Earth's history, ocean acidification, over hundreds of years, has been happening very fast. However, its recovery has been

very slow due to the inherent time lags in the carbon and ocean cycles.

#### Oceans are acidifying fast



From: Laffoley, D. d'A. and Baxter, J.M. (eds) (2010) *Ocean Acidification: Questions Answered*.

Ocean acidification has the potential to change marine ecosystems and impact many ocean-related benefits to society such as coastal protection or provision of food and income. Although more knowledge on the impacts of ocean acidification on marine life is needed, changes in many ecosystems and the services they provide to society can be extrapolated from current understanding. Some of the strongest evidence of the potential effects of ocean acidification on marine ecosystems stems from experiments on calcifying organisms.

Increased sea water acidity has been demonstrated to affect the formation and dissolution of calcium carbonate shells and skeletons in a range of marine species, including corals, molluscs such as oysters and mussels, and many phytoplankton and zooplankton species that form the base of marine food webs.

Changes in species growth and reproduction, as well as structural and functional alterations in ecosystems, will threaten food security, harm

# Ocean Acidification Research Paper

**Barry Dalal-Clayton, Barry Sadler**



## **Ocean Acidification Research Paper:**

**The Federal Ocean Acidification Research and Monitoring Act** United States. Congress. House. Committee on Science and Technology (2007). Subcommittee on Energy and Environment, 2008      **Review of the Federal Ocean Acidification Research and Monitoring Plan** National Research Council, Division on Earth and Life Studies, Ocean Studies Board, Committee on the Review of the National Ocean Acidification Research and Monitoring Plan, 2013-06-03 The world's ocean has already experienced a 30% rise in acidity since the industrial revolution with acidity expected to rise 100 to 150% over preindustrial levels by the end of this century Potential consequences to marine life and also to economic activities that depend on a healthy marine ecosystem are difficult to assess and predict but potentially devastating To address this knowledge gap Congress passed the Federal Ocean Acidification Research and Monitoring FOARAM Act in 2009 which among other things required that an interagency working group create a Strategic Plan for Federal Research and Monitoring of Ocean Acidification Review of the Federal Ocean Acidification Research and Monitoring Plan reviews the strategic plan on the basis of how well it fulfills program elements laid out in the FOARAM Act and follows the advice provided to the working group in the NRC's 2010 report Ocean Acidification A National Strategy to Meet the Challenges of a Changing Ocean This report concludes that overall the plan is strong and provides a comprehensive framework for improving our understanding of ocean acidification Potential improvements include a better defined strategy for implementing program goals stronger integration of the seven broad scientific themes laid out in the FOARAM Act and better mechanisms for coordination among federal agencies and with other U.S. and international efforts to address ocean acidification      [Ocean Acidification](#)

Jean-Pierre Gattuso, Lina Hansson, 2011-09-15 The ocean helps moderate climate change thanks to its considerable capacity to store CO<sub>2</sub> through the combined actions of ocean physics chemistry and biology This storage capacity limits the amount of human released CO<sub>2</sub> remaining in the atmosphere As CO<sub>2</sub> reacts with seawater it generates dramatic changes in carbonate chemistry including decreases in pH and carbonate ions and an increase in bicarbonate ions The consequences of this overall process known as ocean acidification are raising concerns for the biological ecological and biogeochemical health of the world's oceans as well as for the potential societal implications This research level text is the first to synthesize the very latest understanding of the consequences of ocean acidification with the intention of informing both future research agendas and marine management policy A prestigious list of authors has been assembled among them the coordinators of major national and international projects on ocean acidification      *Review of the Federal Ocean Acidification Research and Monitoring Plan* National Research Council, Division on Earth and Life Studies, Ocean Studies Board, Committee on the Review of the National Ocean Acidification Research and Monitoring Plan, 2013-07-03 The world's ocean has already experienced a 30% rise in acidity since the industrial revolution with acidity expected to rise 100 to 150% over preindustrial levels by the end of this century Potential consequences to marine life and also to economic activities that depend on a

healthy marine ecosystem are difficult to assess and predict but potentially devastating To address this knowledge gap Congress passed the Federal Ocean Acidification Research and Monitoring FOARAM Act in 2009 which among other things required that an interagency working group create a Strategic Plan for Federal Research and Monitoring of Ocean Acidification Review of the Federal Ocean Acidification Research and Monitoring Plan reviews the strategic plan on the basis of how well it fulfills program elements laid out in the FOARAM Act and follows the advice provided to the working group in the NRC's 2010 report Ocean Acidification A National Strategy to Meet the Challenges of a Changing Ocean This report concludes that overall the plan is strong and provides a comprehensive framework for improving our understanding of ocean acidification Potential improvements include a better defined strategy for implementing program goals stronger integration of the seven broad scientific themes laid out in the FOARAM Act and better mechanisms for coordination among federal agencies and with other U S and international efforts to address ocean acidification

**Handbook on the Economics and Management of Sustainable Oceans** Paulo A.L.D. Nunes, Lisa Emelia Svensson, Anil Markandya, 2017-02-24 The trans disciplinary thematic areas of oceans management and policy require stocktaking of the state of knowledge on ecosystem services being derived from coastal and marine areas Recently adopted Sustainable Development Goals SDGs especially Goals 14 and 15 explicitly focus on this This Handbook brings together a carefully chosen set of world class contributions from ecology economics and other development science and attempts to provide policy relevant scientific information on ecosystem services from marine and coastal ecosystems nuances of economic valuation relevant legal and sociological response policies for effective management of marine areas for enhanced human well being The contributors focus on the possible nexus of science society and science policy with the objective of informing on decision makers of the governmental agencies business and industry and civil society in general with respect to sustainable management of Oceans

**Reflecting on our Changing Climate, from Fear to Facts** Constantin Cranganu, 2024-03-07 This book contains reflections about climate change an intrinsic reality of our planet's history over the past 4.6 billion years including both natural and anthropogenic variations More recently the phrase climate change has become a euphemism for carbon dioxide emissions While focusing on CO<sub>2</sub> emissions is crucial for understanding climate change solely using this term in scientific discussions may lead to overlooking other complex factors contributing among other things to extreme weather events potentially affecting the quality of evidence analysis The shift towards using climate change interchangeably with carbon dioxide emissions within scientific circles while highlighting a key driver necessitates ensuring comprehensive discussions that encompass the diverse evidence related to all climate sub systems Therefore using the phrase like a changing climate opens a bigger umbrella that facilitates covering multiple and complex climate manifestations The book will be useful to students researchers and policy makers working and studying in the vast and often contentious landscape of climate change debates

**The risks and vulnerability of the sardine fisheries sector in the Republic of the Philippines to climate**

**and other non-climate processes** Labaria, E.C., Fernandez de la Reguera, D., Poulain, F., Siar, S., Vasconcellos, M., 2021-11-25 This publication represents the proceedings of the national workshop Risks and Vulnerability of the Sardine Fisheries Sector to Climate and other Non Climate Processes held in Quezon City Republic of the Philippines in September 2019 Chapter 1 It also presents the baseline reports compiled for the workshop **Ocean Acidification** National Research Council, Division on Earth and Life Studies, 2012-07-29 Over recent years human activities such as the burning of fossil fuels have increased the amount of carbon dioxide gas emitted to the atmosphere and the amount that dissolves into the ocean Now so much carbon dioxide has been absorbed by the ocean that the chemistry of seawater is changing causing the ocean to become more acidic Based on a National Research Council report this booklet describes the well understood chemistry of ocean acidification and explores the many questions that remain How will ocean acidification impact marine life such as fish corals and shellfish How will the effects on individual species scale up to whole ecosystems What will ocean acidification mean for aquaculture the fishing industry and coastal tourism Recent Advancements in Artificial Intelligence Richi Nayak, Namita Mittal, Manoj Kumar, Zdzislaw Polkowski, Ajay Khunteta, 2024-05-01 This book features research papers presented at the Second International Conference on Recent Advancements in Artificial Intelligence ICRAAI 2023 held at Poornima University Jaipur India during 15-16 December 2023 The book presents original research work in the areas of computational intelligence artificial intelligence machine learning data science and data analytics cloud computing and internet of things The book is beneficial for readers from both academia and industry Marine Environmental Epigenetics Jose M. Eirin-Lopez, Hollie Putnam, 2021-07-05 *Deep-ocean climate change impacts on habitat, fish and fisheries* Food and Agriculture Organization of the United Nations, 2019-03-22 This publication presents the outcome of a meeting between the FAO UNEP ABNJ Deep seas and Biodiversity project and the Deep Ocean Stewardship Initiative It focuses on the impacts of climatic changes on demersal fisheries and the interactions of these fisheries with other species and vulnerable marine ecosystems Regional fisheries management organizations rely on scientific information to develop advice to managers In recent decades climate change has been a focus largely as a unidirectional forcing over decadal timescales However changes can occur abruptly when critical thresholds are crossed Moreover distribution changes are expected as populations shift from existing to new areas Hence there is a need for new monitoring programmes to help scientists understand how these changes affect productivity and biodiversity The principal cause of climate change is rising greenhouse gases and other compounds in the atmosphere that trap heat causing global warming leading to deoxygenation and acidification in the oceans Three dimensional fully coupled earth system models are used to predict the extent of these changes in the deep oceans at 200-2500 m depth Trends in changes are identified in many variables including temperature pH oxygen and supply of particulate organic carbon POC Regional differences are identified indicating the complexity of the predictions The response of various fish and invertebrate species to these changes in the physical environment are analysed using hazard and

suitability modelling Predictions are made to changes in distributions of commercial species though in practice the processes governing population abundance are poorly understood in the deep sea environment and predicted distributional changes are not always as expected and may be manifested as simple disappearance of species or ecosystems The publication underscores the fact adaptive monitoring and management mechanisms must be in place to ensure that fisheries are sustainable and the environment remains healthy and productive Suggestions are provided as to the actions necessary

**Climate Change Impacts on Fisheries and Aquaculture** Bruce F. Phillips, Mónica Pérez-Ramírez, 2017-09-20 The first comprehensive review of the current and future effects of climate change on the world's fisheries and aquaculture operations The first book of its kind Climate Change Impacts on Fisheries and Aquaculture explores the impacts of climate change on global fisheries resources and on marine aquaculture It also offers expert suggestions on possible adaptations to reduce those impacts The world's climate is changing more rapidly than scientists had envisioned just a few years ago and the potential impact of climate change on world food production is quite alarming Nowhere is the sense of alarm more keenly felt than among those who study the warming of the world's oceans Evidence of the dire effects of climate change on fisheries and fish farming has now mounted to such an extent that the need for a book such as this has become urgent A landmark publication devoted exclusively to how climate change is affecting and is likely to affect commercially vital fisheries and aquaculture operations globally Climate Change Impacts on Fisheries and Aquaculture provides scientists and fishery managers with a summary of and reference point for information on the subject which has been gathered thus far Covers an array of critical topics and assesses reviews of climate change impacts on fisheries and aquaculture from many countries including Japan Mexico South Africa Australia Chile US UK New Zealand Pacific Islands India and others Features chapters on the effects of climate change on pelagic species cod lobsters plankton macroalgae seagrasses and coral reefs Reviews the spread of diseases economic and social impacts marine aquaculture and adaptation in aquaculture under climate change Includes special reports on the Antarctic Ocean the Caribbean Sea the Arctic Ocean and the Mediterranean Sea Extensive references throughout the book make this volume both a comprehensive text for general study and a reference guide to further research for fisheries scientists fisheries managers aquaculture personnel climate change specialists aquatic invertebrate and vertebrate biologists physiologists marine biologists economists environmentalist biologists and planners

**The International Law of the Sea** Yoshifumi Tanaka, 2015-04-16 A systematic examination of all topics in law of the sea courses fully updated to include contemporary issues

**Impacts of climate change on fisheries and aquaculture** Food and Agriculture Organization of the United Nations, 2019-01-06 This report indicates that climate change will significantly affect the availability and trade of fish products especially for those countries most dependent on the sector and calls for effective adaptation and mitigation actions encompassing food production

**Feeling The Heat** Jo Chandler, 2011-05-01 In Feeling the Heat journalist Jo Chandler sets out on a quest that takes her across the Antarctic ice under the seas and through

the tropical rainforests of far north Queensland Her mission is to explore one of the defining mysteries of our age climate change The story Chandler tells is an epic adventure complete with heroes and villains It s a love story for those with an affection for nature A reality show like no other It s also a story of science in its most glorious pure form Chandler takes us into wild landscapes in the company of scientists trying to decode climate information that will be critical to the decisions we make for the future of the planet Written in the vein of Susan Orlean s The Orchid Thief and by turn lyrical funny and achingly sad Feeling the Heat reveals startling truths about that delicate confounding organism we call Earth Winner 2012 Bragg UNSW Press Prize for Science Writing Shortlisted 2011 Queensland Premier s Literary Awards Science Writer Award Longlisted 2012 John Button Prize World Ocean Assessment Alan Simcock,2017-04-17 This United Nations report examines the current state of knowledge of the world s oceans for policymakers and provides a reference for marine science courses **Research Handbook on Climate Change, Oceans and Coasts** Jan McDonald,Jeffrey McGee,Richard Barnes,2020-12-25 This topical Research Handbook examines the legal intersections of climate change oceans and coasts across multiple scales and sectors covering different geographies and regions With expert contributions from Europe Australasia the Pacific North America and Asia it includes insightful chapters on issues ranging across the impacts of climate change on marine and coastal environments It assesses institutional responses to climate change in ocean and marine governance regimes adaptation to climate impacts on ocean and coastal systems and communities and climate change mitigation in marine and coastal environments Through a plurality of voices disciplinary and geographical perspectives this Research Handbook explores cross cutting themes of institutional complexity fragmentation scale and design trade offs

**Climate Change 2014 - Impacts, Adaptation and Vulnerability: Global and Sectoral Aspects** Christopher B. Field,Vicente R. Barros,2014-12-29 This latest Fifth Assessment Report of the Intergovernmental Panel on Climate Change IPCC will again form the standard reference for all those concerned with climate change and its consequences including students researchers and policy makers in environmental science meteorology climatology biology ecology atmospheric chemistry and environmental policy Oceanography and Marine Biology S. J. Hawkins,A. J. Evans,A.C. Dale,L. B. Firth,I. P. Smith,2018-09-03 Chapter 3 of this book is freely available as a downloadable Open Access PDF under a Creative Commons Attribution Non Commercial No Derivatives 3 0 license [https://s3.us-west-2.amazonaws.com/tandfbis-rt-files/docs/Open+Access+Chapters/9781138318625\\_oachapter3.pdf](https://s3.us-west-2.amazonaws.com/tandfbis-rt-files/docs/Open+Access+Chapters/9781138318625_oachapter3.pdf) Oceanography and Marine Biology An Annual Review remains one of the most cited sources in marine science and oceanography The ever increasing interest in work in oceanography and marine biology and its relevance to global environmental issues especially global climate change and its impacts creates a demand for authoritative reviews summarizing the results of recent research OMBAR has catered to this demand since its foundation more than 50 years ago Following the favourable reception and complimentary reviews accorded to all the volumes Volume 56 continues to regard the marine sciences with all their various aspects as a unity Physical chemical and biological aspects

of marine science are dealt with by experts actively engaged in these fields and every chapter is peer reviewed by other experts working actively in the specific areas of interest The series is an essential reference text for researchers and students in all fields of marine science and related subjects and it finds a place in libraries of universities marine laboratories research institutes and government departments **Sustainability Appraisal** Barry Dalal-Clayton, Barry Sadler, 2014-03-26

Sustainability Appraisal is a sourcebook of the state of the art of this rapidly emerging and diversifying area It draws on a wealth of international experiences and approaches to illustrate the status and scope of Sustainability Appraisal Assessment SA This comprehensive guide highlights how SA can be used to analyse and integrate the key environmental social and economic pillars of sustainability into decision making at all levels from policy to project to investment by government business and industry or international organizations Distilling both published and unpublished materials and with contributions from a range of leading experts organizations and agencies this book will be of significant value to professionals everywhere who are in need of a solid reference guide to what constitutes SA practice and more importantly how and when it can be applied



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