Ocean Acidification

and interacting stressors - from challenges to actions

www.oceansofimpact.global
www.goa-on.org

SUSTAINABLE DEVELOPMENT GOALS

Science for society -
working towards a sustainable ocean

Oceans of Impact

The ocean covers nearly three quarters of the Earth's surface, contains 96% of its living space, harbours enormous biological and genetic diversity, provides around half of the oxygen in the atmosphere and is an increasingly important source of protein for a rapidly growing world population. However, human activity is having an impact on this precious resource on local, regional and global scales.

The ocean has been experiencing substantial changes in marine physics, chemistry and biology including ocean acidification, rising seawater temperature, ocean deoxygenation and sea level rise. These four, often interacting factors, are expected to increase over the coming decades depending on the concentration of greenhouse gases in the atmosphere.

It is imperative that international decision-makers and stakeholders understand the enormous role the ocean plays in sustaining life on Earth, and the consequences of a high CO_2 world for the ocean and society.

Ocean Acidification

- The ocean has absorbed 27% of CO_2 emissions and when CO_2 enters the ocean it causes a series of chemical reactions decreasing pH (increasing acidity levels)
- Surface ocean acidity has already increased by 30% and could increase by 120-150% by 2100

Warming

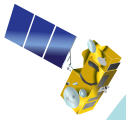
- Over 90% of the energy from warming of the Earth system has been taken up by the ocean resulting in warming of all oceans at all depths
- Surface waters have warmed on average by about 0.7°C over the last 100 years and this could increase by over 3°C by 2100

Deoxygenation

- This is the decrease in the concentration of oxygen, important for most sea animals
- Since 1960 there is about a 2% loss of oxygen in the whole ocean but this rate is increasing

Sea Level Rise

- Estimates of global mean sea level rise this century are 0.45 to 0.82 m for RCP8.5 (high emissions pathway)
- This could increase substantially in the following centuries due to loss of major ice sheets

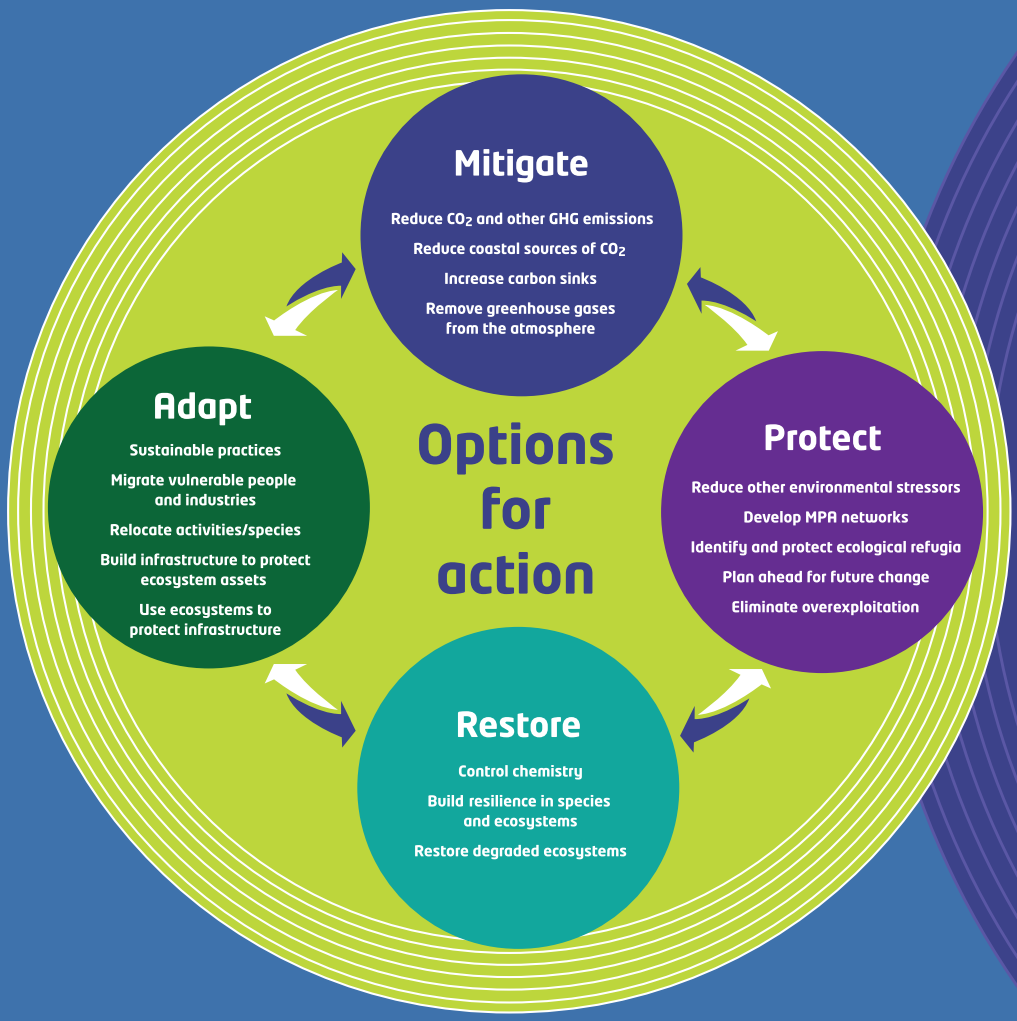


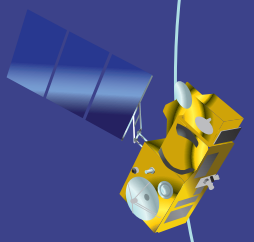
Ocean Stress Guide - Your awareness can make a difference

What the ocean will experience this century without urgent and substantial reduction in greenhouse gas emissions.

Stressor	Causes	Result	Direct effects	Impacts
Acidification Developed as a research topic in past decade	● Increasing atmospheric carbon dioxide emissions ● Coastal nutrient enrichment, methane hydrates and acid gases from industrial emissions may also contribute locally, increasing variability	● Unprecedented rapid change to ocean carbonate chemistry ● Much of the ocean will become corrosive to shelled animals and corals, with effects starting in the Arctic by 2020	● Reduced calcification, growth and reproduction rates in many species ● Changes to the carbon and nitrogen composition of organic material ● Dissolution of unprotected calcium carbonate structures in some regions	● Impeded shell or skeletal growth and physiological stress in many species, including juvenile stages ● Change to biodiversity and ecosystems, and the goods and services they provide ● Cold and upwelling waters currently supporting key fisheries and aquaculture likely to be especially vulnerable
Warming A relatively mature study area in terms of physical changes and physiology but poorly studied at ecosystem and biogeochemical levels	● Increasing greenhouse gas emissions to the atmosphere	● Temperature increase, particularly in near-surface waters ● Less ocean mixing due to increased stratification ● Increased run-off and sea-ice melt will also contribute to stratification in Arctic waters ● Increased in marine heat waves	● Decreased carbon dioxide solubility ● Increased speed of chemical and biological processes ● Reduced natural nutrient re-supply in more stratified waters	● Stress to organism physiology, including coral bleaching ● Extensive migration of species ● More rapid turnover of organic matter ● Nutrient stress for phytoplankton, particularly in warm waters ● Changes to biodiversity, food webs and productivity, with potential consequences for fisheries, coastal protection and tourism
Deoxygenation Emerging issue, poorly studied	● Reduced oxygen solubility due to warming ● Decreased oxygen supply to the ocean interior due to less mixing ● Nutrient rich land run-off stimulating oxygen removal locally	● Less oxygen available for respiration especially in productive regions, and in the ocean interior ● Extended areas of low and very low oxygen (dead zones)	● Reduced growth and activity of zooplankton, fish and other oxygen-using organisms ● Endocrine disruption	● Stress to oxygen-using organisms ● Risk of species loss in low oxygen areas ● Impacts on reproductive success ● Shift to low oxygen-tolerant organisms, especially microorganisms and loss of ecosystem services in these areas
Sea Level Rise A mature research area and a long-term issue	● Climate warming due to increased greenhouse gas emissions to the atmosphere	● Melting of glaciers and ice sheets ● Thermal expansion of seawater	● Increase in the volume of water in the ocean ● Rise in the level of seas	● Flooding of coastal and island habitats ● Erosion of shorelines ● Loss of infrastructure ● Greater risk of impacts from storms and surges

Oceans of Change: possible actions to reduce risk





This publication is an initiative by UK scientists and international partners, led by Plymouth Marine Laboratory (host of the North East Atlantic Hub of the Global Ocean Acidification-Observing Network) and funded by the UK Government Department of the Environment, Food and Rural Affairs. It provides evidence-based science for policy making on the impacts of increasing concentrations of carbon dioxide and other greenhouse gases on the ocean and human systems.

Any questions? Contact: Thecla Keizer, tke@pml.ac.uk.

Please cite this document as: Turley C, Keizer T, Seeyave S, Beckman F, Widdicombe S: Oceans of Impact. Plymouth Marine Laboratory, Partnership for Observation of the Global Oceans, Global Ocean Acidification-Observing Network, Ocean Acidification – International Coordination Centre; 2018 4pp. DOI: 10.17031/EP387W.

PML Plymouth Marine Laboratory

GOA-ON Global Ocean Acidification Observing Network

Department for Environment Food & Rural Affairs

UK Ocean Acidification Research Programme

IAEA Ocean Acidification International Coordination Centre OA-ICC

pogo

NERC SCIENCE OF THE ENVIRONMENT

UK Research and Innovation