

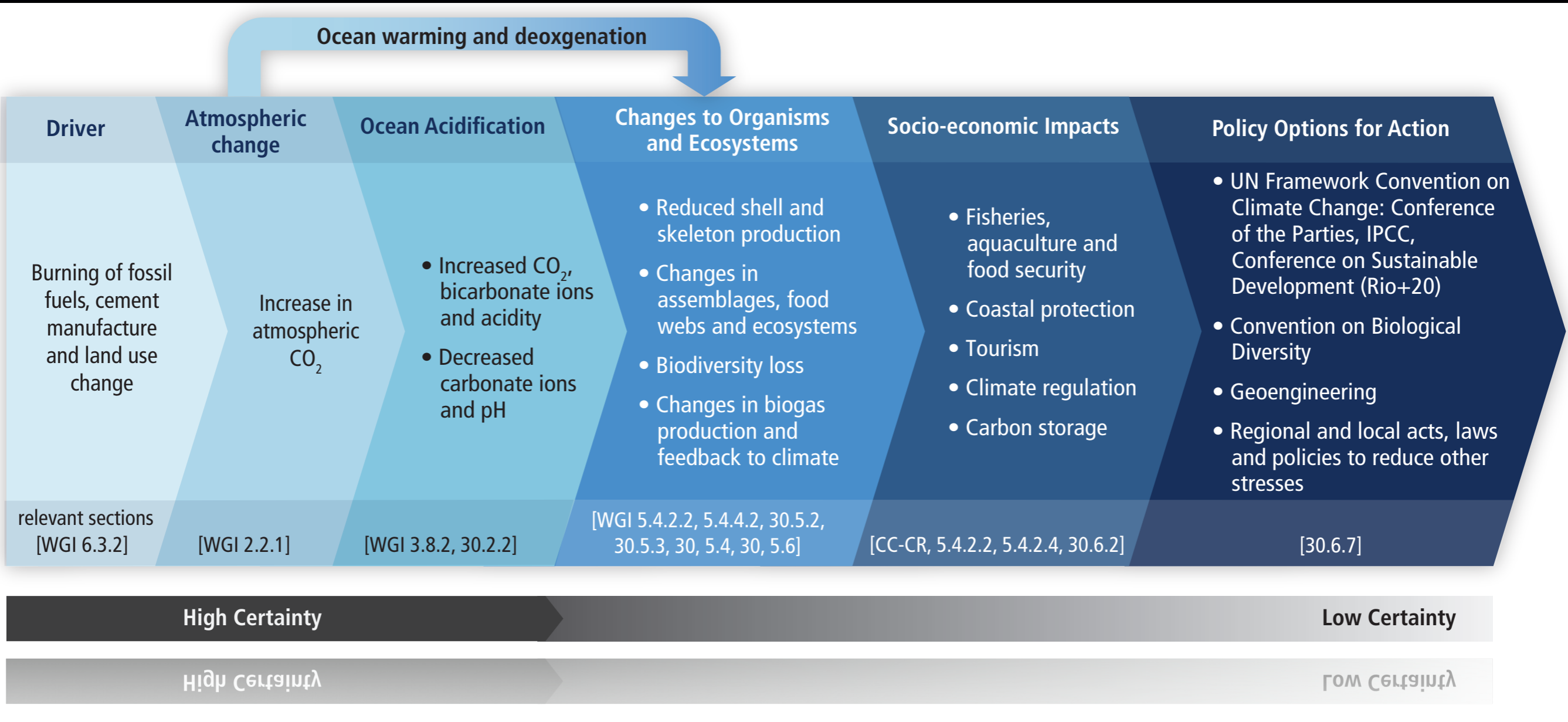
Ocean acidification: causes, impacts and solutions

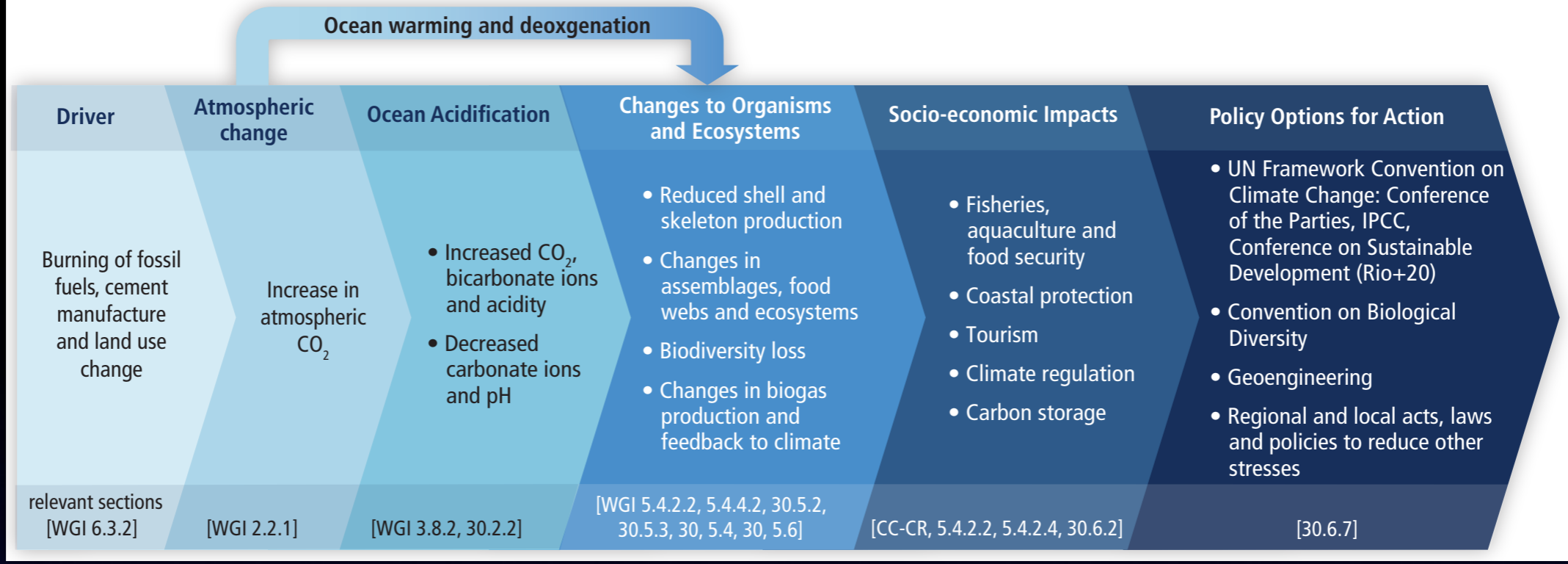
Jean-Pierre Gattuso

Laboratoire d'Océanographie de Villefranche
CNRS-Université Pierre et Marie Curie-Paris 6



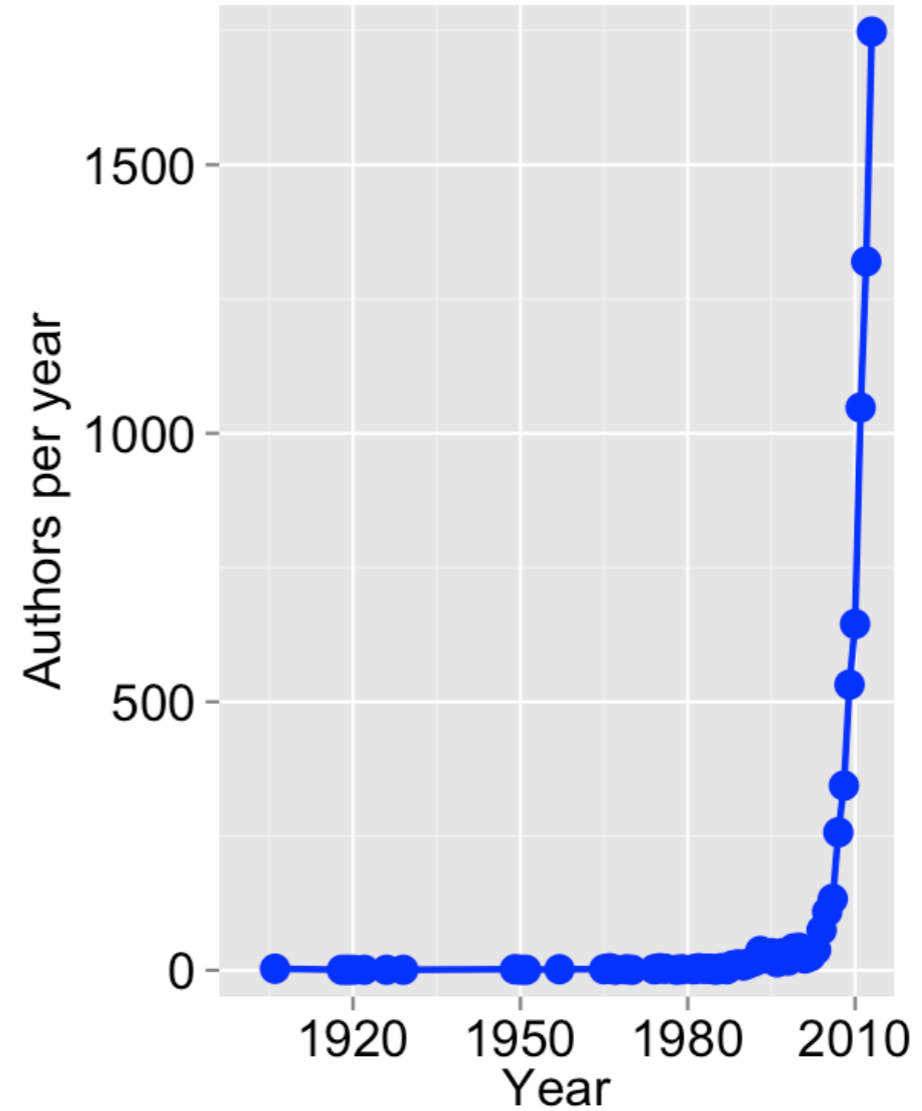
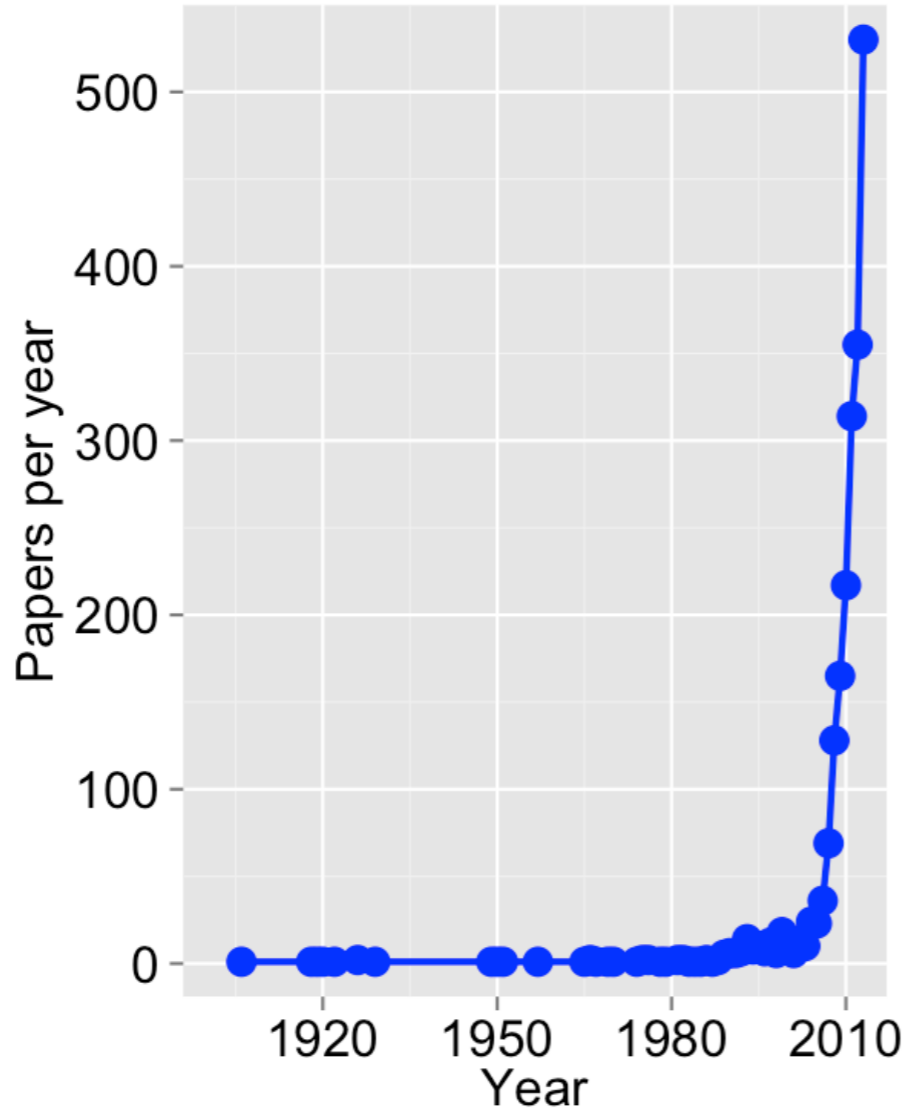
Introduction and outline

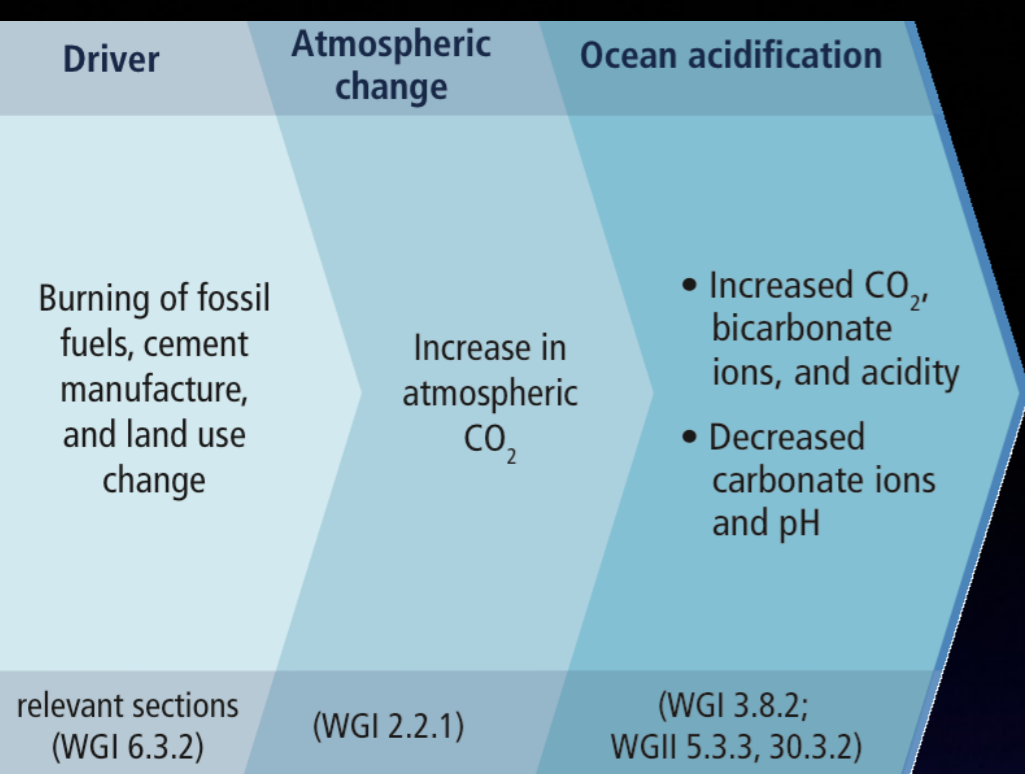




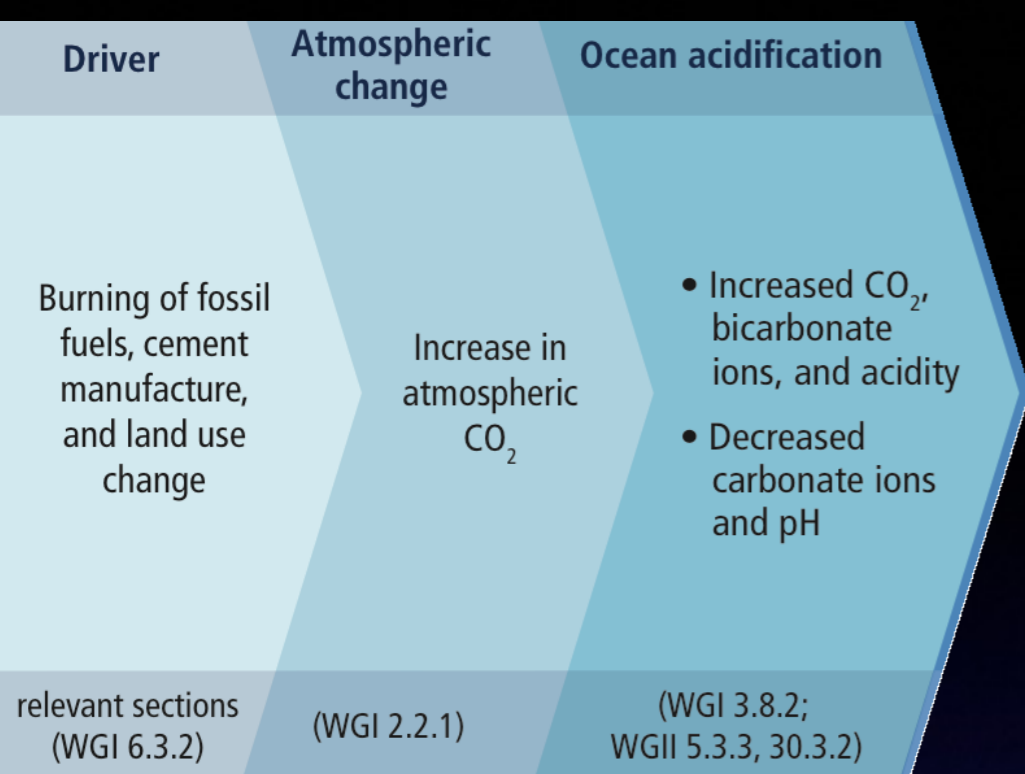
[MCI 16] (GATTUSO)

After Gattuso and Hansson (2011) and Gattuso et al. (2011)

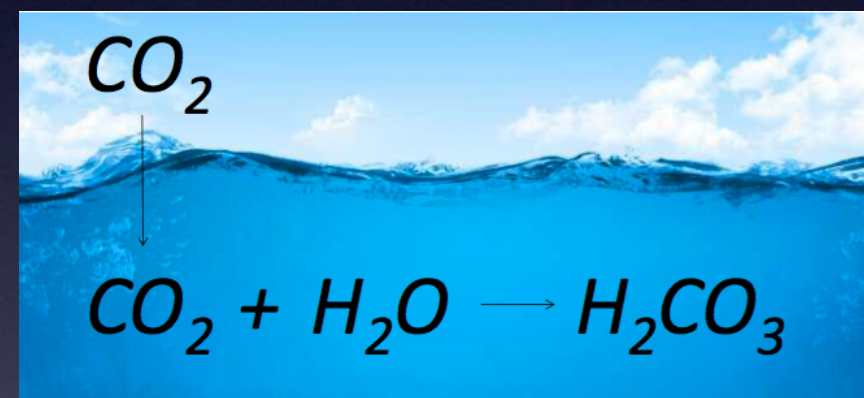




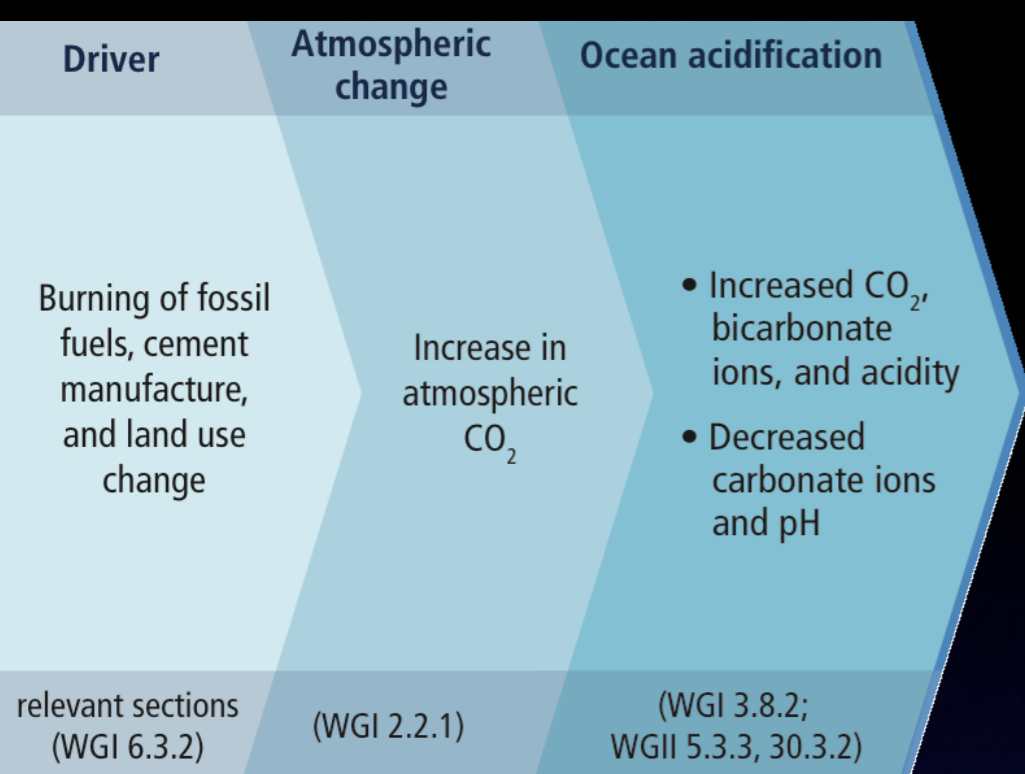
Chemistry: very high confidence



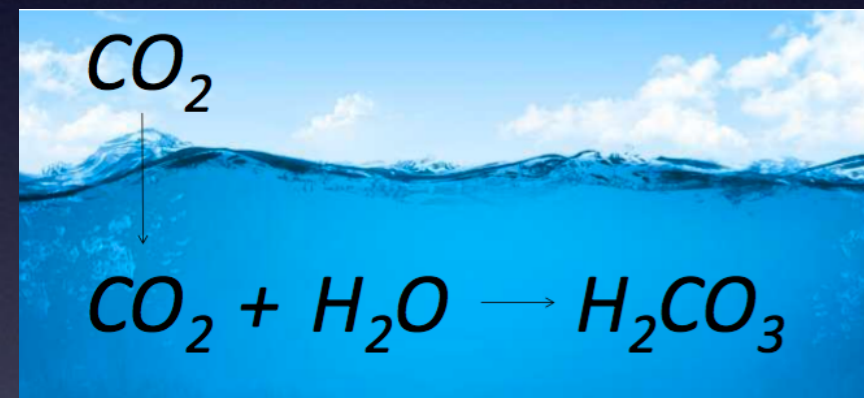
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Sam Dupont

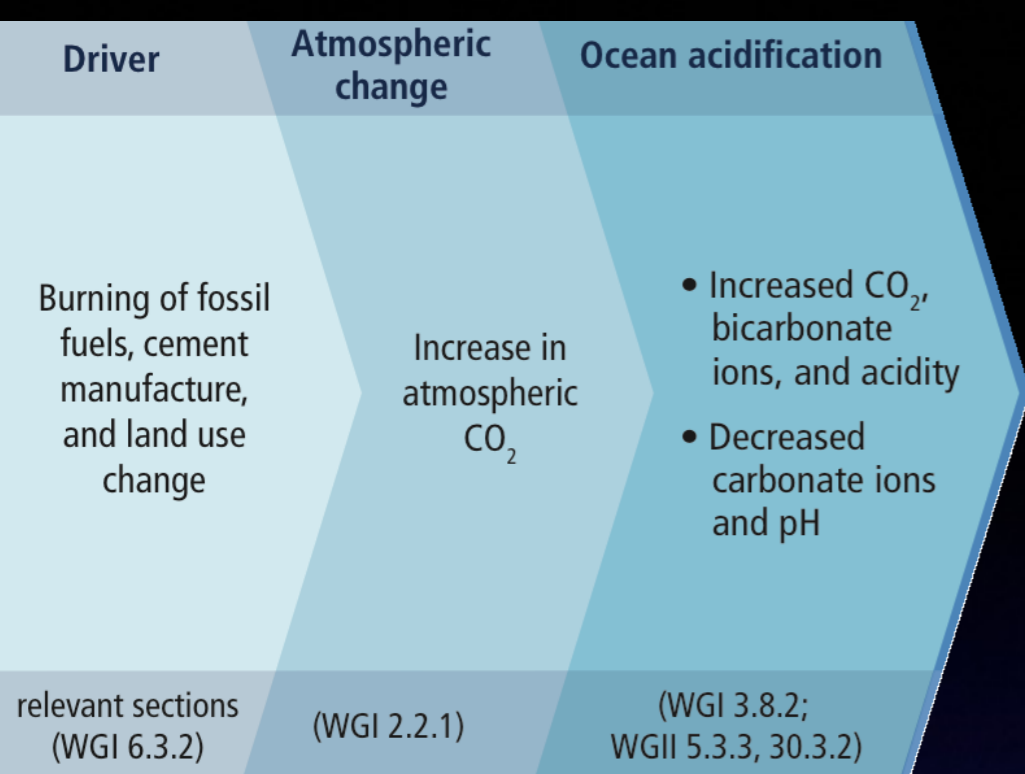


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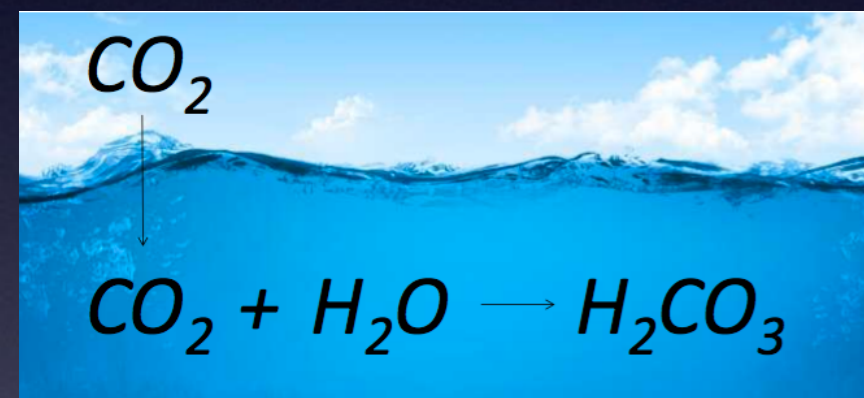
Sam Dupont



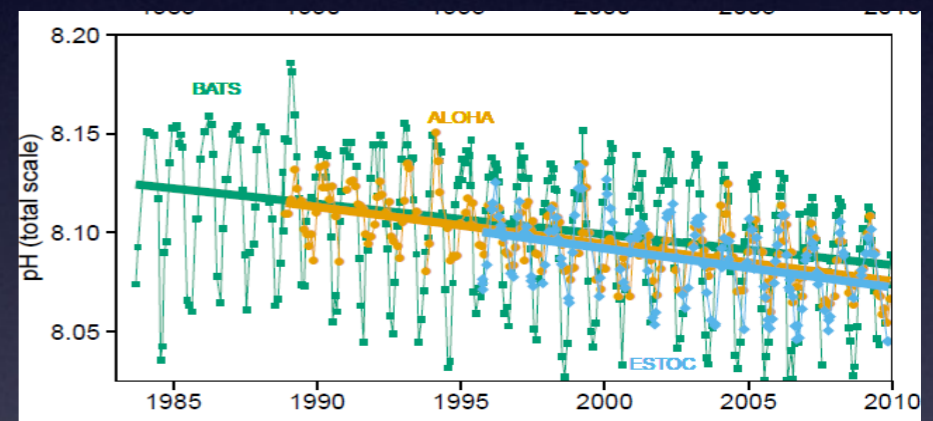
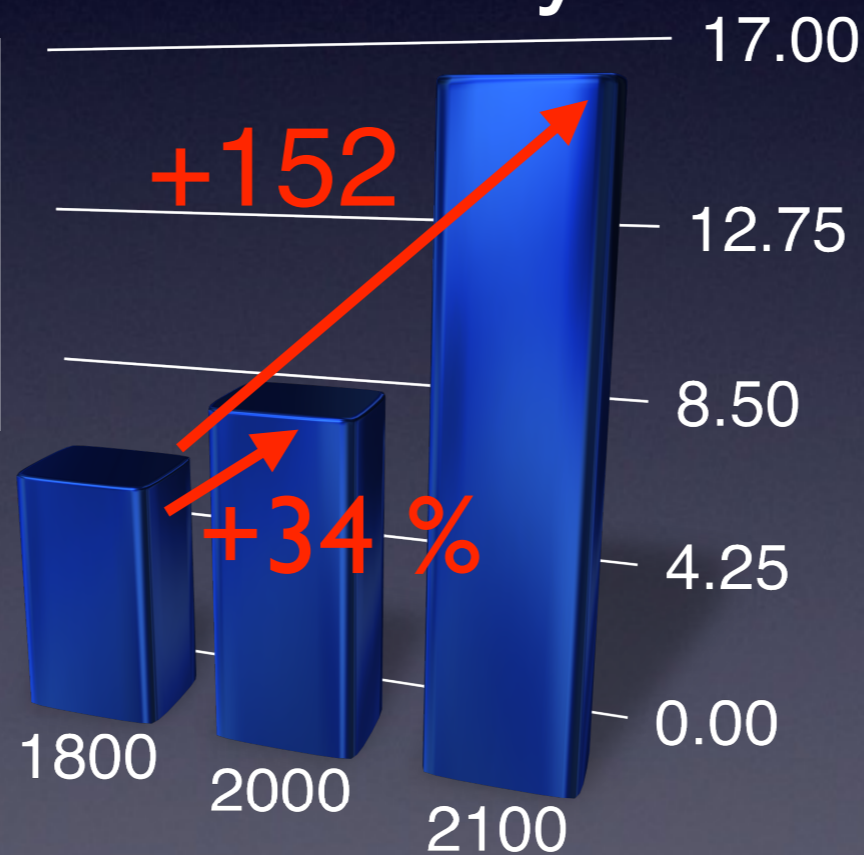


Chemistry: very high confidence

Acidity



Sam Dupont



IPCC AR5 WG1 Report, Chap. 3 (2013)

Changes to organisms and ecosystems

- Reduced shell and skeleton production
- Changes in assemblages, food webs, and ecosystems
- Biodiversity loss
- Changes in biogas production and feedback to climate

(WGII 5.4.2, 6.3.2, 30.5)

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(WGII 5.4.2, 6.3.2, 30.5)

- **Biological and ecological effects:** high to low confidence
- **Biogeochemistry:** medium to low confidence
- **Knowledge gaps:**
 - Multiple drivers
 - Evolutionary adaptation
 - Response of communities
 - Food web, up to predators

Socioeconomic impacts

- Fisheries, aquaculture, and food security
- Coastal protection
- Tourism
- Climate regulation
- Carbon storage

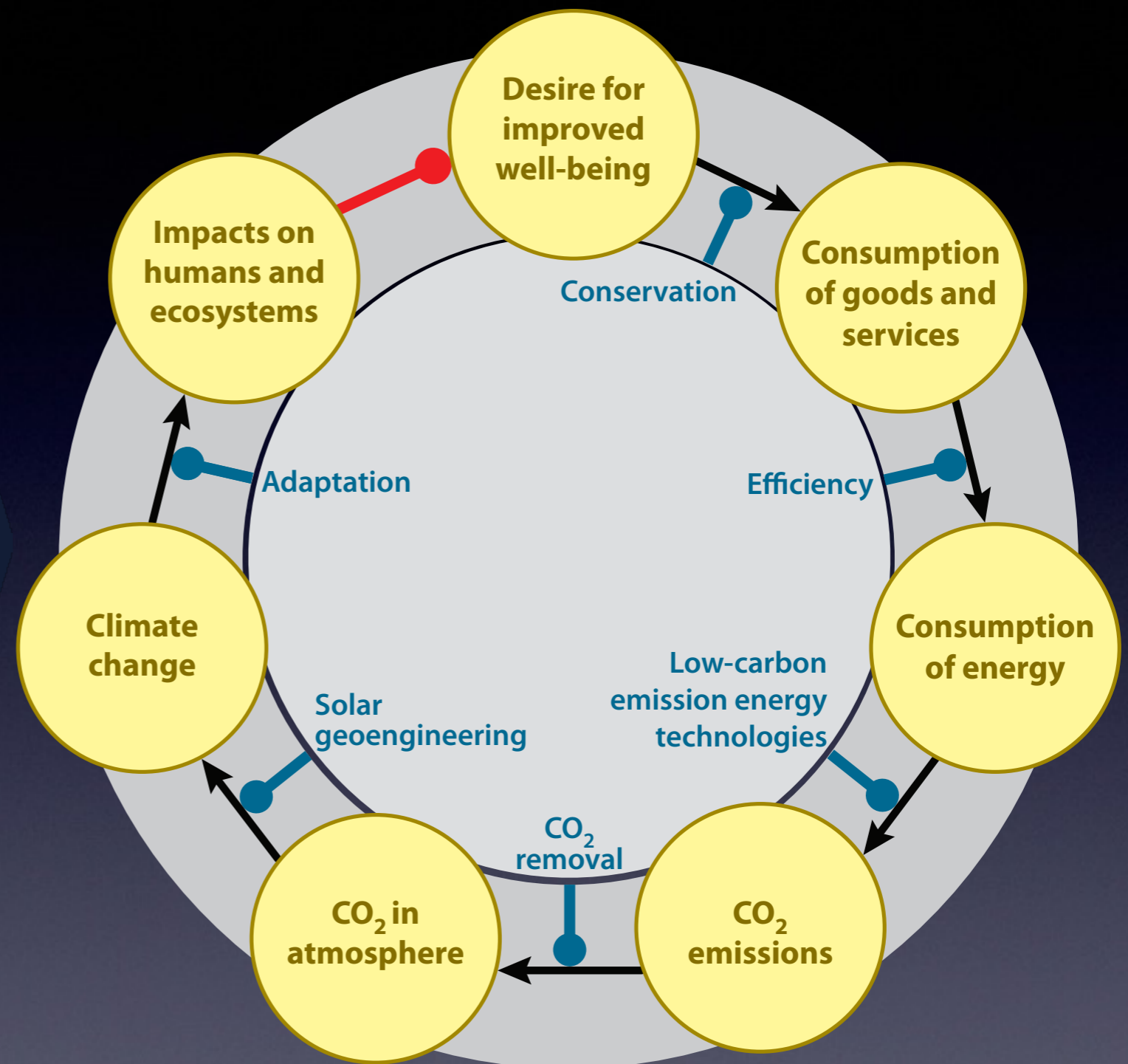
(WGII 5.4.2.2, 5.4.2.4,
30.6.2, Box CC-CR)

Society and the economy: medium to low confidence

Policy options for action

- UN Framework Convention on Climate Change: Conference of the Parties, IPCC, Conference on Sustainable Development (Rio+20)
- Convention on biological diversity
- Geoengineering
- Regional and local acts, laws and policies to reduce other stresses

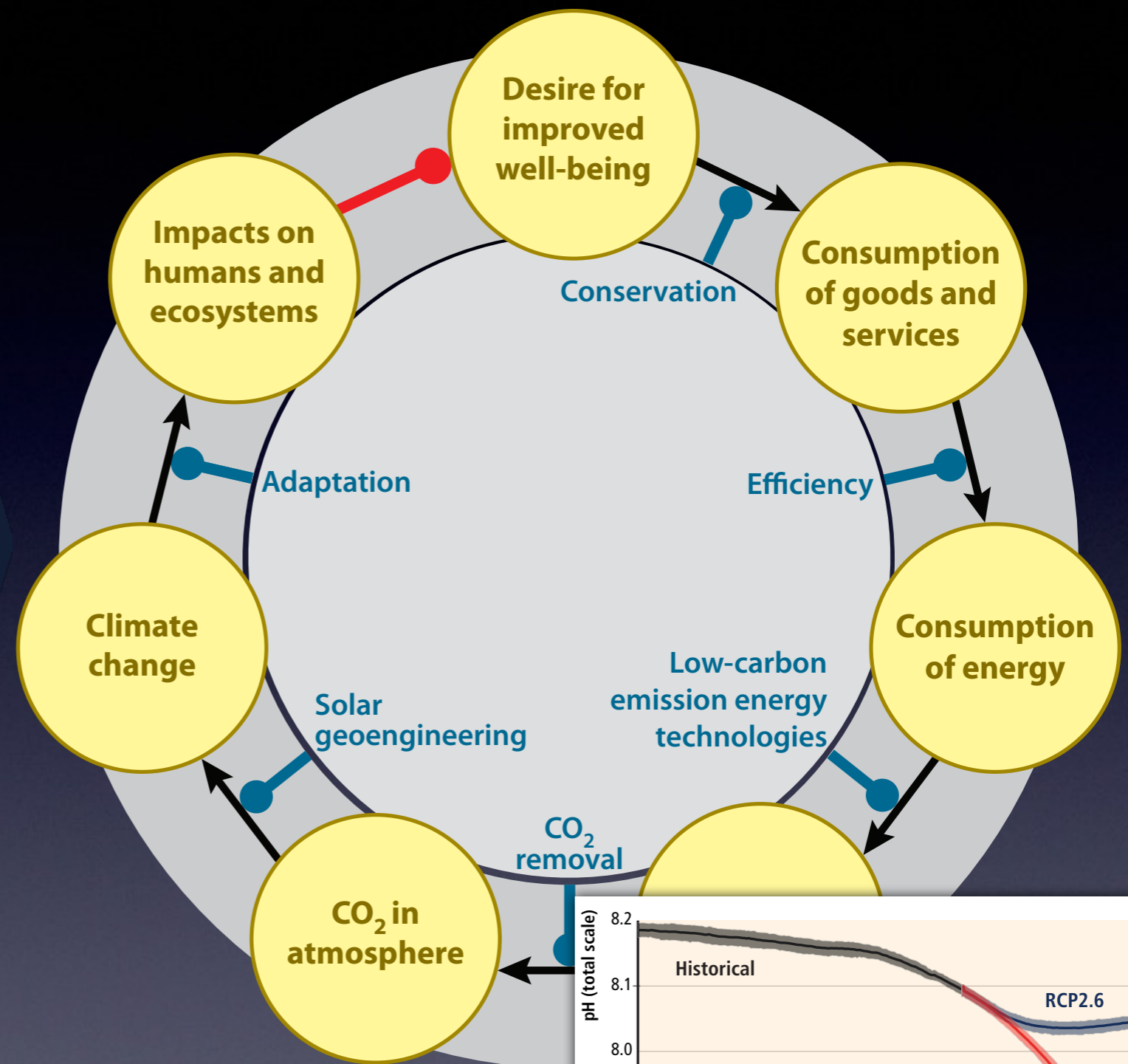
(WGII 30.6.4, 30.7.1)



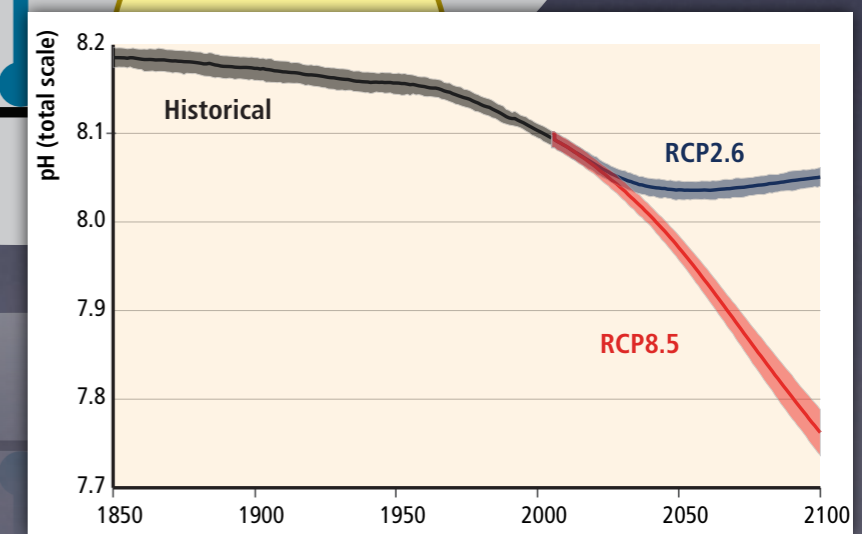
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Caldeira et al. (2013)

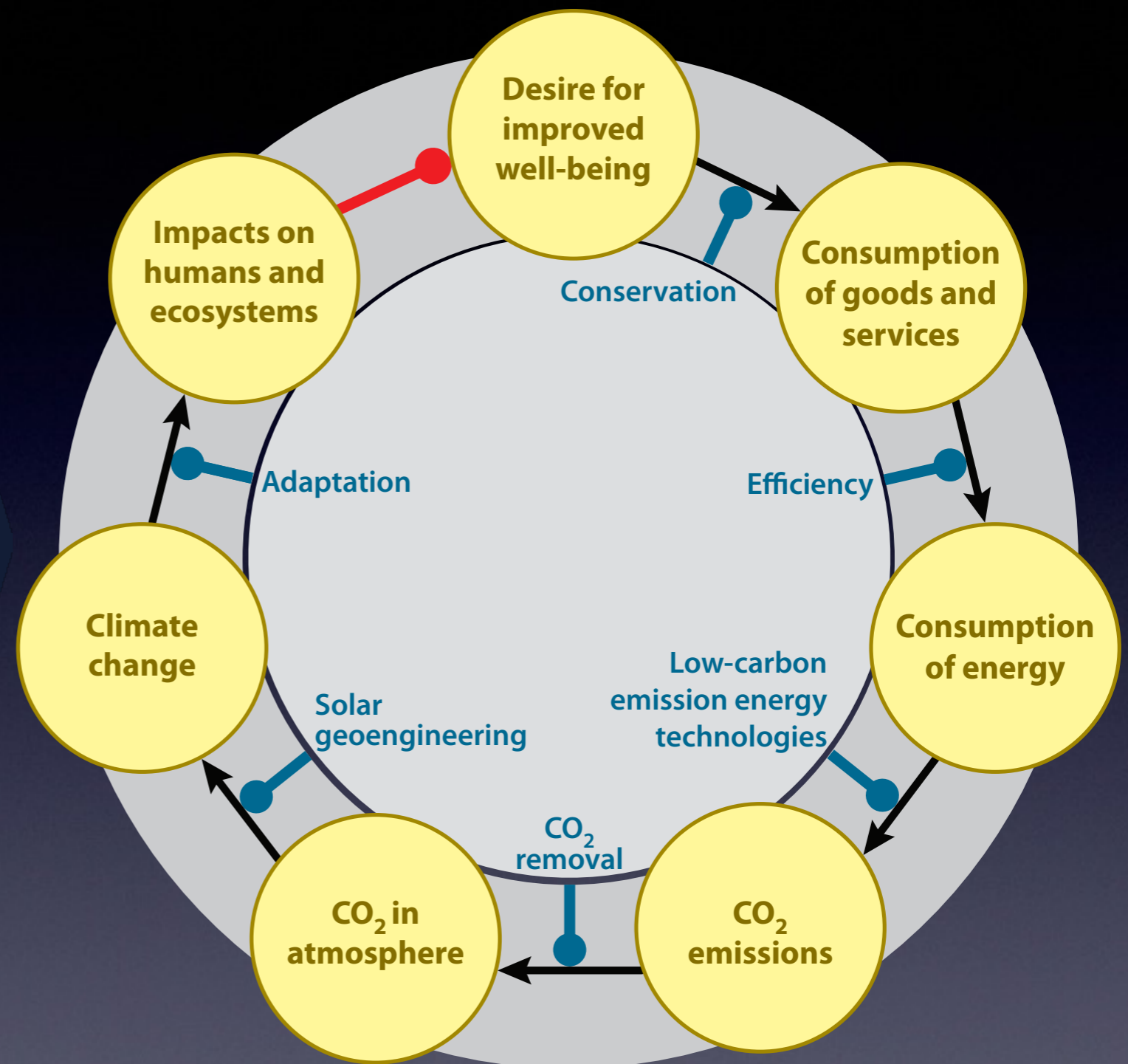


Ciais et al. (2013). IPCC AR5 WG I

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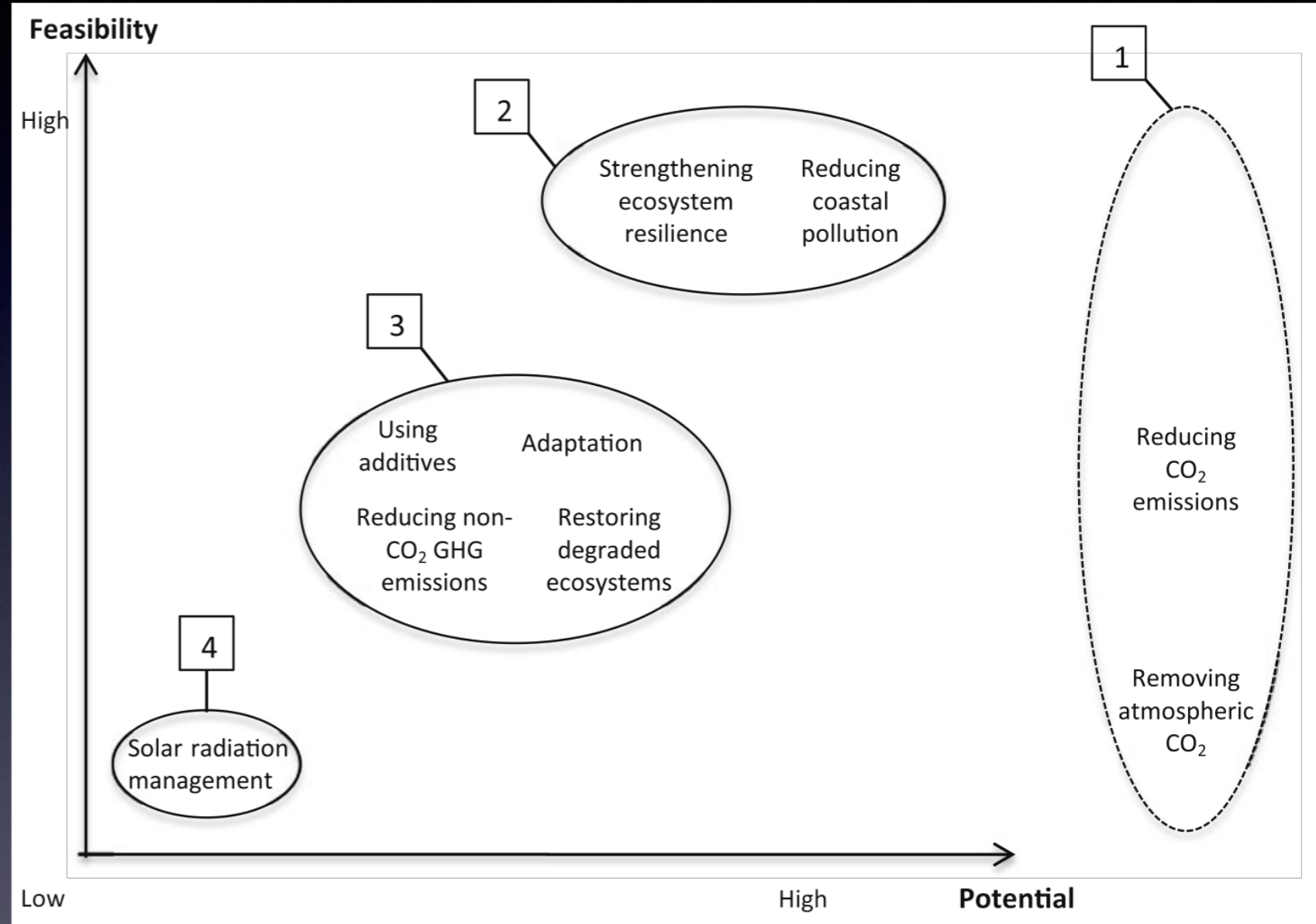
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(WGII 30.6.4, 30.7.1)



Billé et al. (2013)

*O*A*iRUG*

Ocean Acidification international
Reference User Group

- Brings together end users, leading scientists and policy advisers
- Complements OA International Coordination Center (IAEA, Monaco)
- Advises on the types of products, content, style, and how to get them out with impact
- Multilingual guides produced
- Current activities: ‘Monaco Ocean Acidification Action Plan’, and ‘Ocean Acidification – getting ahead of the curve’, focussing on forecasting capabilities

Dissemination and outreach

Messages for Rio+20

Making it clear

A special introductory guide for policy advisers and decision makers

Frequently asked questions about ocean acidification

OCB **UK Ocean Acidification Research Programme** **EPOCA**

Introduction

Ocean acidification is a new field of research in which most studies have been published in the past 10 years. Hence, there are some questions, but many questions remain. Ocean acidification is a multi-disciplinary research area that encompasses topics such as chemistry, paleontology, biology, ecology, biogeochemistry, modelling, and social sciences. Furthermore, some aspects of ocean acidification research, for example the economic assessment, are unique and cross-cutting. For these reasons, the media and the general public find some scientific issues or results confusing.

The U.S. Ocean Carbon and Biogeochemistry (OCB, www.us-ocb.org) program, supported by the European Project on Ocean Acidification (EPOCA, www.euro-ocb.org), and the UK Ocean Acidification Research Programme (UKOARP, www.ukoarp.ac.uk), has compiled a list of frequently asked questions (FAQs). These questions were widely discussed in the research community with the request to draft concise replies summarizing current knowledge, yet avoiding jargon. The replies were then subject to an open peer-review and revision process to ensure availability without any loss of scientific accuracy. The response of the community was enthusiastic. In total, 27 scientists from 19 institutions and 5 countries contributed to the whole process.

We do hope that this FAQ list will prove useful and would like to point out that it is an ongoing process. Anyone is invited to send clarifications or send comments to Sarah Cooley (scooley@ebi.ed.ac.uk). The list will be revised periodically using this input and maintained at www.us-ocb.org, www.euro-ocb.org, and www.ukoarp.ac.uk.

Jean Pierres and Richard Feely (OCB), Jean-Pierre Gattuso (EPOCA), and Carol Turley (UK Ocean Acidification Research Programme)

The name "ocean acidification"

The ocean is not acidic, and model projections say the ocean won't ever become acidic. So why call it ocean acidification?

Ocean acidification refers to the process of lowering the ocean's pH (that is, increasing the concentration of hydrogen ions) by dissolving additional carbon dioxide in seawater from the atmosphere. The word "acidification" refers to lowering pH from any starting point to any end point on the pH scale. This term is used to name other scientific areas (including medicine and food science) to refer to the addition of an acid to a solution, regardless of the solution's pH value. For example, even though seawater's pH is greater than 7 (and therefore considered "basic" in terms of the pH scale), increasing atmospheric CO₂ levels are still causing the ocean's acidity and lowering its pH. In comparison, this language is similar to the words we use when we talk about temperature. If the air temperature moves from +10°C to +5°C (+10°F to +5°F), it is still cold, but we call it "warming." — J. Orr, C.L. Sabine, R. Feely

20 FACTS about Ocean Acidification

This document presents the highlights of the *Frequently Asked Questions* about Ocean Acidification (2010, 2012, www.us-ocb.org/OCB-FAQ), a detailed summary of the state of ocean acidification research and understanding. The FAQs and this fact sheet are intended to aid scientists, science communicators, and science policy advisors asked to comment on details about ocean acidification. In all, 63 scientists from 47 institutions and 12 countries participated in writing the FAQ, which was produced by the Ocean Carbon and Biogeochemistry Project (www.us-ocb.org), the United Kingdom Ocean Acidification Programme (www.ukoarp.ac.uk), and the European Project on Ocean Acidification (EPOCA). More information and contacts can be found at any of these websites or at the Ocean Acidification International Coordination Centre's website (www.iaacp.org/ocean-acidification). The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report findings on ocean acidification can be viewed at www.ipcc.ch.

- Ocean acidification (OA) is a progressive increase in the acidity of the ocean over an extended period, typically decades or longer, which is caused primarily by uptake of carbon dioxide (CO₂) from the atmosphere. It can also be caused or enhanced by other chemical additions or subtractions from the ocean. Acidification can be more severe in areas where human activities and impacts, such as acid rain and nutrient runoff, further increase acidity.
- OA has been well documented with global observations conducted over several decades by hundreds of researchers. It has been definitively attributed to human-generated CO₂ in the atmosphere that has been released primarily by fossil fuel combustion and land use change.
- Acidity may be thought of as simply the hydrogen ion concentration (H⁺) in a liquid, and pH is the logarithmic scale on which this concentration is measured. It is important to note that acidity increases as the pH decreases.
- Average global surface ocean pH has already fallen from 8.2 pre-industrial value of 8.2 to 8.1, corresponding to an increase in acidity of about 30%. Values of 7.8-7.9 are expected by 2100, representing a doubling of acidity.
- The pH of the open-ocean surface layer is unlikely to ever become acidic (i.e. drop below pH 7.0), because seawater is buffered by dissolved salts. The term "acidification" refers to a pH shift towards the acidic end of the pH scale, similar to the way we describe an increase in temperature from 20°C to 40°C. 40°C is still cold, but we say it's "warming."
- OA is also changing seawater carbonate chemistry. The concentrations of dissolved CO₂, hydrogen ions, and bicarbonate ions are increasing and the concentration of carbonate ions is decreasing.
- Changes in pH and carbonate chemistry force marine organisms to spend more energy regulating chemistry in their cells. For some organisms, this may leave less energy for other biological processes like growing, reproducing or responding to other stresses.

SECOND INTERNATIONAL SYMPOSIUM ON THE OCEAN IN A HIGH-CO₂ WORLD
MONACO - OCTOBER 6-9, 2008

Monaco Declaration

It was while taking part in the working sessions of the scientific community, which met in Monaco last October for the second international symposium The Ocean in a High CO₂ World, that I expressed my earnest wishes for the Monaco Declaration to be drafted. The seas and oceans absorb one-fourth of the carbon dioxide emitted to the atmosphere from human activities, which in turn is driving their acidification at a rate that is unprecedented. This chemical modification will alter marine ecosystems, upon which over half of the world's population depends for its primary source of food. This declaration, based on amfubative scientific findings and signed by 155 scientists from 26 nations, sets forth recommendations, calling the policymakers to address this immense problem. I strongly support this declaration, which is in full accord with my efforts and those of my Foundation to alleviate climate change. I hope that it will be heard by all the political leaders meeting in Copenhagen in December 2009.

H.S.H. Prince Albert II

GLOBAL CLIMATE CHANGE

SCOR, IAEA, ICES, PICES, IVEI, CHYCE

Documents for policy makers – some written by EPOCA's Reference User Group of stakeholders

World leading website and blog on ocean acidification

award winning films one by school children and another by professional film makers

Dialogue with policy makers and media at climate change negotiations in Copenhagen, Cancun, Capetown and Warsaw

TIPPING POINT

A film by Laurence Jourdan
Camera: Marina Tadjik, Editing: Françoise Boutique
Underwater filming: Yves Glado

EPOCA

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Through beautifully shot underwater images and a careful scientific approach, the film tackles the main issues of this relatively new phenomenon by presenting them in an accessible way.

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The film will be available for public projections and events after the 15/12/2010. For more information please contact:

GeoramTV Productions
2 rue de la Mare
F-31400 Colomiers
France
tel: +33 93 856256
mail: georamtv@orange.fr
email: georamtv@orange.fr

GEORAMTV

TEARMA, ERT, RTP, Ushuaia TV, INKRTÉ, EUROPEAN COMMISSION, TOTAL FOUNDATION

the other CO₂ problem

A powerful animation from the younger generation on the threat and environmental implications of ocean acidification

ocean acidification

Jean-Pierre Gattuso and Lina Hansson

STARRING

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- 7** Changes in pH and carbonate ion concentrations to spend more time in their cells. For example, for other organisms, this could mean less time in their cells.

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SCOR

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A film by Camera: Marina Tullio Underwater Filmmaking

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F-33140 Gabutus
Phone: +33 93 856236
Mobile: +33 93 851956
email: georama@georama.fr

GEORAMATV

TEARMA
ERT **ATP**
Ushuaia TV **INFRTE**

EUROPEAN COMMISSION
European Research Area

TOTAL FOUNDATION

ocean acidification

Jean-Pierre Gattuso and Lina Hansson

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Shirley Stiller, PML, EPOCA, Jean-Pierre Gattuso, Lina Hansson, EPOCA, EPOCA

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