GSDR 2015 Brief

Ocean Acidification

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Introduction

Scientists, organizations at the national, regional and global level, especially the United Conference for sustainable development in 2012, so called RIO+20, stressed ocean acidification as a threat for the marine environment. The final outcome document of Rio+20 'the future we want' highlighted the critical role the oceans play in all three pillars of sustainable development, and "commit[ed] to protect, and restore, the health, productivity and resilience of oceans and marine ecosystems, and to maintain their biodiversity, enabling their conservation and sustainable use for present and future generations." It contains 20 paragraphs in a dedicated section on oceans and seas, and an additional three paragraphs on Small Island Developing States (SIDS), and last but not least one paragraph urging the emerging issue of Ocean acidification.

After months of work from individuals and organizations all around the world an ocean acidification specific outcome (Number 166) is: "*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 to 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*."

Impacts of Ocean Acidification on the marine environment

In general the CO_2 content of the seas is about 50 times higher than that of the atmosphere. But as atmospheric carbon dioxide (CO_2) levels are rising, due to human activities, such as fossil fuel burning, and also the dissolved levels of CO_2 in the seawater are increasing. The absorption of CO_2 from the atmosphere changes the chemical balance of the seawater, resulting in increased carbonic acid concentrations, causing reduced pH levels, which means increasing acidity of seawater. This process is known as ocean acidification. Since the start of the industrial revolution, the ocean has absorbed approximately 30% of all CO_2 released into the atmosphere by humans. The consequence was a 26% increase in the acidity of the ocean to date (Le Quere et al. 2009). Future projections estimate an increase of ocean acidity of even 170% by 2100 compared with preindustrial levels if present CO_2 emissions are anticipated to continue (RCP 8.5)(IPCC 2013). Currently the marine environment is exposed to a rate of acidification over 10 times faster than any time in the last 55 million years, due to 24 million tonnes of CO_2 which are absorbed by the ocean every day (Hönisch et al. 2012).

Whereas the chemistry of ocean acidification is generally well understood from observations and models, the potential consequences of ocean acidification on marine organisms are inherently more complicated. A major concern is the response of calcifying organisms, such as corals, coralline algae, mollusks and some plankton, because their ability to build shell or skeletal material (via calcification) depends on the abundance of CO_3^{2-}, which is predicted to be reduced in the future ocean (e.g. Kroeker et al. 2013).

Scientists found out, that ocean acidification is a global concern and a risk to marine biodiversity, ecosystems and human society. During the past 20 years the scientific community conducted experiments and field studies to investigate how ocean acidification is and will affect the ocean at the physiological, species specific, community, and ecosystem level (IGBP, SCOR, IOC 2013):

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- Impacts start at the species level, which will cause changes in food webs and at the ecosystem level, affecting fisheries, aquaculture and hence societies.
- Multiple stressors – ocean acidification, global warming, deoxygenation, eutrophication and over-fishing – and their interactions are creating significant challenges for ocean ecosystems.
- Within decades the changes in carbon chemistry of the tropical oceans may hamper or prevent coral reef growth.
- Large parts of the polar oceans will become corrosive to calcareous marine organisms within decades due to ocean acidification.
- As the ocean takes up more carbon dioxide it becomes less efficient at absorbing this greenhouse gas and hence in moderating climate change.
- Species-specific impacts of ocean acidification have been seen in laboratory studies on organisms from tropical corals to marine snails that are important prey for fish in polar regions.
- Many organisms show adverse effects, for example, reduced ability to form shells and skeletons, reduced survival, growth, abundance and larval development.
- Conversely, there is evidence that some organisms tolerate more acidic conditions and others, such as seagrasses, may even thrive.
- All species have the potential to adapt, for example, through evolution, or relocation. But the ocean's chemistry may be changing too rapidly for many to maintain a sustainable recruitment.
- We do not fully understand the biogeochemical feedbacks to the climate system which may arise from ocean acidification.
- Predicting how whole ecosystems will change in response to rising CO_2 levels remains challenging. While we are able to expect changes in marine ecosystems and biodiversity within our lifetimes, we are unable to make reliable quantitative predictions of socio-economic impacts.
- Socio-economic impacts of ocean acidification are a real concern. For example commercial shell fisheries will have to adapt. Coral reef loss will affect tourism, food security and shoreline protection.

Mitigation/Adaption strategies for Ocean Acidification

Reducing CO_2 emissions to the atmosphere is the only way to stop ocean acidification. Until permanent CO_2 emissions cuts are achieved, adaptation strategies can be enacted at local, national, and international scales to help coastal communities, sustain livelihoods, provide food, protect shorelines, and maintain cultural traditions.

The impacts of other stressors on ocean ecosystem such as higher temperatures and deoxygenation, also associated with increasing CO_2, will be reduced by limiting enhanced CO_2 emissions, too.

Shellfish aquaculture industries already face significant economic losses due to ocean acidification and may benefit from risk assessments and analysis of strategies to reduce the impact, e.g., limit the intake of seawater with low pH, reallocation of hatcheries, selection of larvae stages or strains more resilient to ocean acidification for breeding (Cooley & Doney 2009, Narita et al. 2012).

Especially on local levels different actions can be conducted to increase the ecosystem resilience to ocean acidification (e.g. Bille et al. 2013, Pandolfi et al. 2011, Rau et al. 2012):

- Development of sustainable fisheries management practices;
- Adoption of sustainable management of habitats, increased coastal protection, reduced sediment loading;
- Application of marine spatial planning;
- Establishment and maintenance of Marine Protected Areas that help to manage endangered and highly vulnerable species, communities, ecosystems;

- Regulation and control of localized sources of acidification from river runoff and pollutants such as fertilizers.

Intergovernmental/International efforts

As said before, ocean acidification and its consequences have received growing recognition at international and especially intergovernmental levels (Herr et al. 2014). The IOC-UNESCO and the OA-ICC of the IAEA are promoting and stimulating scientific discussions about ocean acidification, in cooperation with several international programmes and projects, e.g. the IOCCP, SCOR and IGBP, which is communicated to policymakers and stakeholders (e.g. IGBP, SCOR, IOC 2013). Further the SCBD recently published an updated synthesis on impacts of ocean acidification on marine biodiversity (Aze et al. 2014).

Scientific needs – directions

The current scientific knowledge provides information about what are the chemical responses of ocean acidification, on how certain species will be impacted by enhanced CO_2 concentrations in seawater and some ecosystems. Nevertheless, to understand how ocean acidification will affect complex food web mechanisms, how marine life reacts, if different threats caused by climate change occur, scientists have to break new ways, i.e., multistressor experiments, longterm ecosystem experiments, globally coordinated field observations and assessments, as well as model projections combining chemical, physical, and biological forces (Pörtner & Farrell 2008, Gao et al. 2012, Gruber 2011, Riebesell & Gattuso 2015).

The newly gained information will enable scientists, stakeholders and policymakers to assess the generality of response to ocean acidification; to document and evaluate variation in carbon chemistry to infer mechanisms (including biological mechanisms) driving ocean acidification; to quantify rates of change, trends, and identify areas of heightened vulnerability or resilience.

Improved understanding of ecosystem response will optimize modeling of ocean acidification to reduce uncertainties of future predictions and forecasts (Dupont & Pörtner 2013).

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