

Swedish efforts to address ocean acidification, including links to climate change

SUSTAINABLE DEVELOPMENT GOALS, TARGET 14.3:

Minimise and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.



EXECUTIVE SUMMARY

- Substantial emissions reductions in line with the Paris agreement will benefit the mitigation of both climate change and ocean acidification. The latter is a strong call for an upscaling of ambition in line with the Paris agreement and SDG 13.
- Adaptation to ocean acidification critically depends on the implementation of all other targets of SDG 14. Reducing other environmental stressors can help to increase the resilience of ecosystems to ocean acidification (and vice versa). Adaptation is only feasible in a limited range and over short timescales and is not a long-term alternative to cutting CO₂-emissions.
- There are good examples of enhanced scientific collaboration at the national, regional and international levels. Yet, there is a need for a more strategic approach to address pressing knowledge gaps such as cumulative impacts of multiple stressors, and effective and cost-efficient tools to manage and address ocean acidification.

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Introduction and challenges

The IPCC Climate Change 2014 Synthesis Report [1] finds that since the beginning of the industrial era, oceanic uptake of CO₂ has resulted in acidification of the ocean. The pH of ocean surface water has decreased by 0.1 units, corresponding to a 26 % increase in acidity, measured as hydrogen ion concentration. Earth System Models project a further global increase in ocean acidification for all RCP [representative concentration pathway] scenarios by the year 2100, with a slow recovery after mid-century under RCP2.6 [high mitigation]. There is high confidence that ocean acidification will increase for centuries if CO₂ emissions continue, and will strongly affect marine ecosystems.

Rising rates and magnitudes of warming and other changes in the climate system, accompanied by ocean acidification, increase the risk of severe, pervasive, and in some cases irreversible detrimental impacts. Some risks are particularly relevant for individual regions, while others are global. The overall risks of future climate change impacts can be reduced by limiting the rate and magnitude of climate change, including ocean acidification. A number of global and regional assessments of ocean acidification (e.g. [2-5]) are in line with the findings of IPCC [1]. Although the ocean's uptake of atmospheric CO₂ is by far the major driver of ocean acidification globally, additional pollutants (runoff from agricultural, industrial, and domestic sources) can be important regionally or locally and specifically near coasts [6, 7]. Long-term mitigation of ocean acidification can only be achieved by actions that reduce CO₂-emissions. In the short-term, resilience of ecosystems to ocean acidification can be strengthened by reducing other, regional and local, pressures but is not a long-term alternative to addressing the cause of the problem [1-7].

National efforts

Swedish efforts focus on the implementation of SDG 14.3 through established environmental collaboration and networks. Selected examples at different levels are described in the following.

Sweden has a long record of accomplishment in environmental policies and introduced a carbon tax as early as 1991.

Sweden now has the ambition of zero net-emissions of greenhouse gases by 2045 [8]. The Swedish Parliament has adopted 16 environmental quality objectives (EQO), describing what state and quality of the country's environment are sustainable in the long term. The Swedish parliamentary committee for environmental objectives has proposed new emissions targets and a new climate change strategy [9]. The Swedish Parliament ratified the Paris agreement in November 2016. The Swedish Government adopted a proposal for Sweden's first climate act on 2 February 2017. The act and new climate goals will give Sweden an ambitious, long-term and stable climate policy in line with the requirements of the Paris agreement. Provided a positive vote in parliament in June, the act will enter into force on the first of January 2018. The aim is to keep the global rise in temperature as far below 2 °C as possible, and to strive to limit it to 1.5 °C. The Swedish government's budget bill for 2017 is the largest environment and climate budget ever presented in Sweden, comprising investments for the climate of SEK 12.9 billion during 2017–2020.



SWEDISH EFFORTS to minimise and address the impacts of ocean acidification focus on the implementation of SDG 14.3 through established environmental collaboration and networks.

Ocean acidification reduction can also benefit from Swedish air quality work targeting acidifying substances such as sulphur and nitrogen. Enhancing the co-benefits, and avoiding the negative trade-offs, of air quality and climate change policies have been Swedish priorities for many years. This is reflected in Sweden's strategy on emissions targets and climate change, the Swedish implementation of the EU Industrial Emissions Directive (IED), and national



EMISSION REDUCTIONS

in line with the Paris agreement will benefit the mitigation of both climate change and ocean acidification. Shifting from fossil fuels to renewable energy sources is key. More than half of Sweden's energy production now comes from renewable sources.

research projects. In this context, legislation of specific relevance to ocean acidification includes IMO regulation [10] and the EU Sulphur Directive [11]. IMO aims to limit SO_x release to the atmosphere by restrictions on fuel-oil sulphur content but also provides for secondary control methods. Non-binding guidelines have been adopted for exhaust gas cleaning systems which operate by water washing the exhaust gas prior to discharge to the air [12], although this may also increase local acidification of seawater [13].

SDG 14.3 “[...] address the impacts of ocean acidification” is implemented in Sweden in line with the overall ambition to achieve a balanced marine environment (EQO6) and Sweden's work towards the European Marine Strategy Framework Directive (MSFD) with a view to achieve Good Environmental Status (GES). Actions such as eelgrass restoration can provide multiple benefits, including mitigation of climate change (“blue carbon”), adaptation (e.g., reduced risk of coastal erosion, wave dampening) and support of biodiversity and marine resources.

Sweden supports research on ocean acidification both nationally and through international research cooperation [e.g. 14-16]. Several major project grants have addressed the direct and indirect effects of CO₂-driven acidification on key species and ecosystems in Swedish coastal waters. These include effects of acidification on bloom-forming phytoplankton, early life-stages of invertebrates, calcifying shellfish, and larger-scale mesocosm investigations in planktonic, and seagrass ecosystems.

Regional efforts

European cooperation of relevance to SDG 14.3 includes work in line with EU-legislation such as the MSFD, Water Framework Directive (WFD), Marine Spatial Planning Directive (MSPD) as well as the Sulphur Directive (SD). The SD revision of 2012 follows the provisions of the International Maritime Organization (IMO) and introduces the concept of SO_x Emission Control Areas (SECAs). Sweden also contributes to achieving the EU climate targets, including energy efficiency.

Regional conventions and collaborations with links to SDG 14.3 include OSPAR, HELCOM and ICES. A common denominator of these collaborations is the goal of sustainable management of the marine environment. A joint working group of ICES and OSPAR produced a comprehensive report on the monitoring of ocean acidification and its impacts [17]. SDG 14.3 is also addressed by several of the working groups under the Arctic Council (e.g. AMAP, CAFF, PAME).

The Swedish EPA (SEPA) provides expertise on climate change and air pollution to working groups of the Nordic council of ministers (NMR). SEPA supports the environmental working group of the Barents Euro-Arctic Council and the implementation of an action plan on climate change. SEPA also provides expertise to the Arctic council's expert group on black carbon and methane. This group aims to develop a “Summary of Progress and Recommendations” based on the national reports and other relevant information, and to develop an ambitious, aspirational and quantitative collective goal on black carbon. The UN Convention

on Long-Range Transboundary Air Pollution (CLRTAP) focuses on improving air quality on local, national and regional levels, on continents and oceans. SEPA currently chairs the convention.

Examples of regional research projects with relevance to ocean acidification and resilient ecosystems are the European Project on Ocean Acidification (EPOCA) [18], which produced the Guide to Best Practices for Ocean Acidification Research [19], BALTIC-C [20], which investigated the fate of CO₂ and organic carbon in the Baltic, and SHEBA [21], which investigates sustainable shipping and environment of the Baltic Sea region. Examples of research funding collaborations include BONUS, NMR, the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans), Water challenges for a changing world (Water JPI) and JPI Climate. Sweden participates in JPIs through Formas (Oceans, Water, Climate), the Swedish Research Council (Climate) and SWAM (Oceans, Water). The European Earth observation initiative Copernicus provides extensive amounts of open near real time and archived data from a series of Earth Observation satellites and six thematic services, supporting marine and climate change science and management [22].

International efforts

International efforts include Swedish work within Global Framework Conventions relevant to ocean acidification (e.g. UNFCCC, CBD, UNCLOS), regional and sectoral agreements, scientific collaborations such as IPCC, WOA, IPBES, and environmental networks such as IUCN. Swedish scientists contribute to the recently established SCOR Working Group 149 on Changing Ocean Biological Systems. In addition, there are several international environmental monitoring initiatives. The Global Ocean Acidification Observation Network GOA-ON [23] is a collaborative effort to coordinate the monitoring of ocean acidification, which has Swedish representation. The Group on Earth Observations (GEO) [24] has initiated the Blue Planet Task [25], and is aligning its work on the coordination of Earth observation with the specific objective of supporting Agenda 2030 and the SDGs [26]. Sweden also cooperates with various UN-organisations relevant to ocean acidification.

The Action Platform for Source-to-Sea Management (S2S Platform) [27] is a multi-stakeholder initiative that helps freshwater, coastal and marine experts to contribute to global knowledge generation on source-to-sea interconnections, connect and engage in collaborative projects, promote

SEAGRASS RESTORATION can provide multiple benefits. Seagrasses support biodiversity and marine resources and contribute to the mitigation of climate change and ocean acidification through carbon sequestration.



best practices, and take collaborative action to improve the management of land, water, coastal and marine linkages. S2S has broad Swedish involvement (SIWI, SEI, SWAM). SEPA provides ongoing assistance to the government in connection to climate negotiations within the framework of UNFCCC and their recurrent COPs and working groups. SEPA is also coordinating a long-term global program on environmental and climate cooperation with countries of strategic importance.

Good Examples

Enhanced scientific cooperation at all levels: Sweden has an active and collaborative research community in the field of ocean acidification. Many projects have contributed, and are presently contributing, to improved understanding of the chemical and biological impacts of ocean acidification. Current projects are also identifying possible policy and management responses. Unique knowledge gained from Swedish regional studies of the Arctic and the low-salinity Baltic Sea is making valuable contributions to the wider international context.

Minimise the impacts of ocean acidification: Sweden has an international reputation as a climate leader and has presented an ambitious climate strategy. Mitigation of ocean acidification and climate change share the same solution. Thus, there are opportunities for cross-fertilisation of SDG 14.3 with the Paris agreement and SDG 13. The latter should be used as a lever for an upscaling of Intended Nationally Determined Contributions (INDCs) and should also be highlighted in the conference's "Call for Action" document.

Address the impacts of ocean acidification: Ocean acidification and climate change are cross-cutting to other environmental questions, and solutions will require broad, effective and efficient collaborations. Sweden benefits from well-established legal frameworks, institutions and processes (national environmental objectives, EU directives, regional conventions, regular assessment cycles, management frameworks, international processes). This provides multiple opportunities:

- To help poor countries achieve energy independence and break reliance on fossil fuels through increased use of renewable energy sources. The potential to enhance climate action at local levels is demonstrated by recent Swedish initiatives (e.g. "The Climate Step", Klimatklivet [28]);
- To help poor countries, specifically Small Island Developing States (SIDS) and least developed countries (LDCs), with adaptation and establishment of climate-proof (and climate-smart) infrastructure. The latter is an absolute necessity if the target SDG 14.7 is to be reached in the context of acidifying and warming oceans, rising sea levels and other climate related risks;
- To encourage integrated ecosystem-based management of marine, brackish, and freshwater systems. A good example is the multi-stakeholder platform S2S that aims to support knowledge generation on source-to-sea interconnections, promote best practices, and take collaborative action to improve the management of land, water, coastal and marine linkages. Such linkages are integral to understanding the impacts of ocean acidification in the low-salinity Baltic Sea system. Thus, S2S also provides opportunities for a concerted approach to mitigation of – and adaptation to – ocean acidification;
- To advocate for reductions of other environmental stressors with a view to increase the resilience of ecosystems and their ability to tolerate ocean acidification and climate change. The latter includes actions on dangerous substances and litter that negatively impact the marine environment, e.g. upstream actions that reduce terrestrial sources (links to S2S), and reducing fishing effort, eutrophication and coastal pollution;
- To highlight the importance of biodiversity and to advocate for increased MPAs. Lessons learned from regional collaborations, e.g. in the Arctic, should be valuable in a wider international context, in particular with a view to adaptive management and connective networks that can ameliorate the unavoidable impacts of climate change and ocean acidification.

CHALLENGES AND GAPS

Implementation of SDG 14 requires translation of the SDG targets to national policies and targets. As a corollary, there is a need for a more explicit and strategic approach to address ocean acidification in the Swedish national EQO framework. Links of SDG 14.3 to other targets of SDG 14 (and other SDGs, notably SDG 13), need strengthening. Implementation of SDG 14.3 requires increased awareness of ocean acidification, its impacts and associated environmental management options.

Key gaps and associated research needs include:

- Understanding of the effects of ocean acidification on Swedish marine ecosystems and ecosystem processes (as distinct from marine species) is poor. To develop strategies to address impacts on Swedish marine ecosystems there is a need to understand:
 - The cumulative effects of additional stressors (e.g. fishing, eutrophication, hazardous substances, climate change impacts) and, specifically, which stressors amplify, and which reduce, the detrimental effects of ocean acidification;
 - The capacities of key species to acclimate and genetically adapt to ocean acidification over the medium to long-term;
 - The importance of biodiversity and ecosystem restoration for resilience of Swedish coastal ecosystems to ocean acidification.
- The economic consequences of ocean acidification are poorly quantified. Research is urgently needed to identify:
 - Key ecosystem services that will be negatively impacted by ocean acidification, and estimate their monetary value;
 - Future costs and economic consequences of ocean acidification for Swedish coastal communities, and the Swedish national economy.
- Understanding of societal responses to the consequences of ocean acidification (as distinct from climate change) is lacking. To develop relevant policy tools there is a need to identify:
 - The value of informative instruments in changing societal norms, and hence increasing public participation and engagement in addressing ocean acidification;
 - Effective market-based policy-tools that aid mitigation and adaptation.

Compilations made by SwAM for SDG 14, Life below water

- This document represents one out of nine compilations made by the Swedish Agency for Marine and Water Management (SwAM) to highlight Sweden's key efforts and initiatives for Sustainable Development Goal 14 of the 2030 Agenda for Sustainable Development. It has been developed as a part of Sweden's work in support of The Ocean Conference in New York, June 5–9, 2017.
- Several other Swedish agencies and institutions have contributed to the content in these compilations: the Swedish Environmental Protection Agency, the Swedish International Development Cooperation Agency (Sida), the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Board of Agriculture, the Swedish Chemicals Agency, the Swedish Transport Agency, and the Swedish Institute for the Marine Environment (SIME).
- The documentation focuses on a situation assessment and does not constitute a complete picture of Sweden's initiatives being carried out in order to achieve the goal and targets. A starting point for the content is operational areas within national authorities, but the content has also been expanded to include other significant aspects based upon existing contacts and knowledge.
- Furthermore, the Swedish Environmental Research Institute (IVL) has been commissioned by SwAM to compile initiatives and examples from Sweden's industry and blue growth sector. The Sustainable Development Solutions Network (SDSN) Northern Europe has also composed a complementary compilation of efforts from innovative blue growth initiatives. The result of this work is presented in separate reports.
- The Swedish Institute for the Marine Environment has been commissioned by SwAM to produce two syntheses in support of the conference. One concerns mitigating marine eutrophication in the presence of strong societal driving forces, with a focus on impacts and measures, and the other concerns impacts and measures regarding marine litter in small island developing states.

