Björn Carlsons Östersjöpris

The Björn Carlsons Östersjöpris 2023 is awarded to Jacob Carstensen, Professor in Marine System Management at the Department of Ecoscience, Aarhus University, Denmark and Daniel Conley, Professor in Biogeochemistry, at the Department of Geology, Lund University, Sweden.

Jacob Carstensen and Daniel Conley are awarded for playing critical roles in shaping key research on eutrophication, water quality, hypoxia, and underlying biogeochemical processes in the Baltic Sea. Through groundbreaking collaboration, Carstensen and Conley have combined expertise from different fields, and thus, their research has transformed, developed and broadened this field of research.

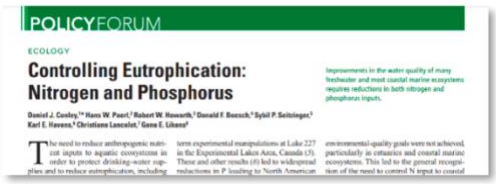
Introduction to the research area: The Baltic Sea is strongly affected by human activities, including nutrient loading, resulting in eutrophication. One of the most important effects of eutrophication is low oxygen levels or hypoxia. The Baltic Sea is indeed the largest man-induced hypoxic area in the world. Lack of oxygen adversely impacts bottom-living organisms and fish, and alters the breakdown of organic matter and the cycling of important nutrients, such as nitrogen and phosphorus. Actual oxygen levels result from a complex interplay between air, water, sediments and organisms. To understand these processes, advanced biogeochemical analyses and experiments, and huge amounts of data need to be produced, analysed and managed by adequate statistical methods. Deep and extensive knowledge of complex processes, and variability of spatial and temporal scales, is needed, as well as a seamless and innovative collaboration between scientists from different disciplines, such as professor J. Carstensen and professor D. Conley. Such ground-breaking collaboration can only be established through years of collaborative work, where the researchers both challenge and support each other.

Detailed justification for the award: Professors Jacob Carstensen and Daniel Conley have played critical roles in shaping key research on eutrophication, water quality, hypoxia, and underlying biogeochemical processes in the Baltic Sea. Their contributions have transformed, developed, and broadened this field of research.

They have jointly, and with other collaborators, produced several highly cited papers, such as Hypoxia related processes in the Baltic Sea (Conley et al. 2009), Deoxygenation of the Baltic Sea during the last century (Carstensen et al. 2014), and Hypoxia is increasing in the coastal zone of the Baltic Sea (Conley et al. 2011).

Their work is interdisciplinary, combining expertise in environmental statistics, biogeochemistry, ecology, and marine biology, and has resulted in ground-breaking scientific publications. Their research, based on e.g. advanced experiments, long-term data sets, modelling and simulations, has shown the long-term effect of nutrient loading and eutrophication in the Baltic Sea and contributed to recommendations on measures for improving its water quality. Those recommendations have been actively communicated to policy makers, both nationally and to the entire Baltic Sea community via HELCOM working groups, contracting parties, and publications. In this way, they have had a direct impact on the management of the Baltic Sea environment, the implementation of the Baltic Sea Action Plan and the development of quantitative targets for the reduction of nutrient loading from water-borne sources to the Baltic Sea.

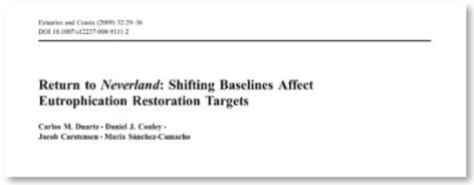
Description of the awardees' research: Professor Conley led the work to produce the first comprehensive review of the biogeochemical and physical processes involved in Baltic Sea hypoxia, showing the importance of phosphorus and nitrogen loading for eutrophication in the Baltic Sea, as well as globally. In several papers, Conley has also demonstrated the human impact on the aquatic biogeochemical cycles in nutrient-enriched inland and coastal waters. These papers show how deficiency in essential nutrients may have consequences for nutrient fluxes in and between sediments and water, that control algal blooms both in freshwaters and marine systems. His review from 2002 has been cited as evidence that the current distorted biogeochemical cycles exceed planetary boundaries (Steffen et al. 2015).


POLICYFORUM

ECOLOGY

Controlling Eutrophication: Nitrogen and Phosphorus

In a highly influential paper with Duarte, Conley and Carstensen showed that coastal systems recovering from eutrophication seldom return a state similar to that before the human impact, since shifting baselines and regime shifts hinder ecosystem recovery. The concept and evidence of shifting baselines and regime shifts are very timely now that it appears that the recovery of coastal and marine waters has not proceeded as expected, and takes longer than anticipated to reach target values for nutrient and phytoplankton indicators. Therefore, the message of this paper has current policy implications, as coastal managers need to evaluate how to reach good environmental status under climate change.


Return to *Neverland*: Shifting Baselines Affect Eutrophication Restoration Targets

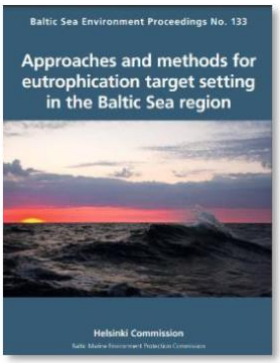
Conley, Carstensen and co-authors have also contributed significantly to the discussion of solutions to the hypoxia crisis in the Baltic Sea. They made a convincing case that long-lasting improved water quality can only be achieved by reducing nutrient loads.


Save the Baltic Sea

In other joint work, Conley and Carstensen tackled many additional critical questions regarding water quality in the Baltic Sea, showing the potentially positive role of macrofaunal activity in recovery from hypoxia, quantifying the deoxygenation of the Baltic Sea during the last century, demonstrating the rise in hypoxia in the coastal zone, analysing spatial variation in the efficiency of the coastal zone as a filter for nutrients, and assessing the past, present and future eutrophication status of the Baltic Sea.

Both Carstensen and Conley are extremely productive scientists that have impressive track records using conventional science citation indexes. Jacob Carstensen has published more than 160 peer-reviewed articles in international scientific journals. Daniel Conley has published more than 180 peer-reviewed articles in international scientific journals.

Science to policy: Professor J. Carstensen and professor D. Conley have widely and effectively communicated the results of their research concerning measures to improve water quality in the Baltic Sea, through scientific and popular publications, lectures, interviews, and other outreach.



Their work has been of direct use for HELCOM, for the implementation of the EU Water Framework Directive and the Marine Strategy Framework Directive, as well as for national environmental protection agencies in Sweden and Denmark. Daniel Conley coordinated the scientific work to develop reference conditions, that is the baselines to which the current ecological status is compared in the assessment of the Baltic Sea coastal areas for the EU Water Framework Directive. Together Conley and Carstensen have contributed to the assessment of the eutrophication status of coastal waters and estuaries, where they analysed the long-term trends of oxygen and nutrients in coastal waters, particularly in the southern Baltic Sea.

Jacob Carstensen led the scientific work to develop quantitative ecological targets for eutrophication and the indicators used for the assessment of the eutrophication status of the Baltic Sea. These targets were used to revise and agree on the maximum allowable inputs of nutrients to the Baltic Sea, including the provisional country-wise nutrient reduction figures. This ultimately ensures an appropriate set of measures to improve the eutrophication status of the Baltic Sea.
With many collaborators, Carstensen continues to provide expert advice to HELCOM working groups (latest HELCOM advice in 2020). He participated in a recent comprehensive review for identifying knowledge gaps and future research needs in the field of marine biogeochemistry in the Baltic Sea. This paper summarized the external loads, transformations in the coastal zone, changes in organic-matter production (eutrophication) and

remineralization (oxygen availability), and the role of sediments in burial and turnover of carbon, nitrogen, and phosphorus, as well as changes in the marine CO_2 system (Kulinski et al. 2022).

The Baltic Sea research by Conley and Carstensen is also used in the global context, to understand the deoxygenation of the global ocean and coastal waters worldwide. The International Oceanographic Commission of UNESCO has launched the UN Decade of Ocean Science for Sustainable Development (2021-2030) and the Ocean Decade programme GOOD – Global Ocean Oxygen Decade – that aims to raise global awareness about ocean deoxygenation and provide knowledge for understanding causes, mitigation, and adaptation. Both Conley and Carstensen contributed to a global overview of drivers of low oxygen in marine systems, ranging from the open ocean, to continental shelves, enclosed seas and coastal environments. This paper addressed the physical and biogeochemical processes and trends of oxygen availability, allowing the identification of causal relationships, and is a priority output from the Global Ocean Oxygen Network (GO2NE) under the GOOD programme.

An important area for further research: The input of excess nutrients over the last century has altered the balance between oxygen supply and consumption in the Baltic Sea, and hypoxia is now widespread in its bottom waters. An increase in temperature, due to climate change, will increase the problem, as warmer waters can hold less oxygen. The situation may be temporarily improved by storms and influx of deep, cold water, but this is not expected to counteract the effects of anthropogenic pollution in the long run. The work of professor Carstensen and professor Conley shows the importance of applying modelling and simulation approaches to big data sets to gain insights into the dynamics of complex environmental systems, influenced by multiple stressors, such as the Baltic Sea.

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