Document title	Update from ACTION Project WP5 Conditions that influence good status
Code	4-7
Category	CMNT
Agenda Item	4 – Implementation and update of the HELCOM Baltic Sea Action Plan
Submission date	24.10.2019
Submitted by	Secretariat and ACTION Project
Reference	

Background

The HELCOM ACTION Project is an EU co-funded project for which HELCOM is the coordinator. The project works closely with the HELCOM *ad hoc* Platform on Sufficiency of Measures (SOM Platform) focussing on four major topics: by-catch (WP1), impacts on the seafloor (WP2), Marine Protected Areas, MPAs (WP3) and input of nutrients (WP4). Work Package 6 (WP6) of the ACTION project is developing proposals on the methodology to analyse sufficiency of measures.

Work package 5 (WP5) examines conditions that influence the achievement of good environmental status (GES). In addition to developing information that can support the analysis of the sufficiency of measures all WPs will further assemble important data and deliver results that can support the BSAP update and long-term HELCOM work. The inception report, the outcome of the project partner kick-off meeting, in which methods and plans for the work for each WP is available at this link. Ongoing developments, such as workshops and reports, will be added to the HELCOM ACTION website as the project progresses.

WP5 in the HELCOM Action project is designed to contribute to broader HELCOM processes (e.g. the update of the Baltic Sea Action Plan) by gaining an understanding of conditions that can influence the achievement of good status in the marine environment, additionally offering support to HELCOM Contracting Parties that are also EU Member States by gathering information that can be valuable for updating and implementing the Marine Strategy Framework Directive's programme of measures. The attached draft summary report from HELCOM Action WP5 includes two sections a) *EU member states use of exceptions for not achieving good status* - A collection of member state reports to the EU Commission regarding use of exceptions for not achieving good environmental status under the Marine Strategy Framework Directive or good ecological or chemical status under the Water Framework Directive. b) *Time-lag between measures and effects due to natural conditions – Review of scientific literature and reports*.

WP5 will continue with further analysis on how natural conditions influence the recovery of the Baltic Sea from eutrophication and how future changes in climate are projected to affect the Baltic Sea.

Comments on the initial information collated or guidance from Contracting parties on other important issues that the project may be able to address would be welcomed.

Action requested

The Meeting is invited to take note of the information and provide comments or input to guide further work in the project.

Draft summary report for HELCOM Action project Work Package 5

Preface

This summary report is one of the products from work package five in the HELCOM Action project, which is designed to support EU member states in updating and implementing the Marine Strategy Framework Directive's programme of measures and to contribute to the update of the Baltic Sea Action Plan by 2021. The HELCOM Action project consists of seven work packages where work package five (WP5) will focus on natural conditions that influence achievement of good environmental status (GES) in the Baltic Sea mainly related to eutrophication but also on selected aspects of biodiversity and hazardous substances.

WP5 will analyse the current knowledge on natural conditions that influence the recovery of the Baltic Sea from eutrophication. The analysis also include how future changes in climate is projected to affect the Baltic Sea and the effectiveness of implemented or planned measures to improve the Baltic Sea environmental state. WP5 will feed in to work package six on sufficiency of measures.

Two tasks from the ongoing analysis in WP5 are included in this report. One task is to gather information on EU member states' use of exception for not achieving GES in the Baltic Sea and their justification. Another task is a review of scientific literature and recent project reports to identify gaps or delays in achieving good environmental status due to natural conditions or possible effects of climate change.

Introduction

In 2017 HELCOM published an assessment of the environmental state in the Baltic Sea in 2011-2016 'State of the Baltic Sea' [1]. The report covers pressures on the Baltic Sea and their effect on the environmental status for a broad range of aspects such as pelagic and benthic habitats, fish, birds, and mammals in sub-basins of the Baltic Sea. Seven human-induced pressures are assessed: 1) nutrients/eutrophication, 2) hazardous substances, 3) marine litter, 4) underwater sound, 5) non-indigenous species, 6) species removal by fishing and hunting, and 7) seabed loss and disturbance. The assessment shows that most of the Baltic Sea is not in good status, and it seems unlikely to achieve good status by 2021 which is the overall target in the Baltic Sea Action Plan.

HELCOM member states have adopted the Baltic Sea Action Plan in 2007 which aims at restoring good ecological status of the Baltic marine environment by 2021 by setting goals and ecological objectives for eutrophication, biodiversity, hazardous substances, and maritime activities. The Baltic Sea Action Plan was updated at the ministerial meetings in 2010, 2013, and latest in 2018. Implementation of measures to improve the Baltic Sea environmental status are ongoing, and the latest inventory of joint and national actions accomplished showed that by 2016 on average 68 % of all actions agreed under the Baltic Sea Action Plan and the HELCOM Ministerial Declarations in 2010 and 2013 were accomplished [2]. The actions are designated 'joint' or 'national' actions depending on whether the actions are implemented in cooperation through HELCOM or by the respective countries. National actions mainly include implementation of measures set in the programmes of measures under the water framework directive or the marine strategy framework directive. Only 23 % of all national actions have been implemented by all countries [2].

An ecosystem will not respond from one day to the other on implementation of a measure, but for the Baltic Sea, a number of natural condition means that a long time-delay must be expected between implementation of a measure and its full effect, i.e. the time it will take for an ecosystem to recover from the current state.

According to the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD) the member states are to maintain or achieve good status in coastal and marine waters by 2015/2021/2027

and 2020, respectively. When member states have reported their programme of measured under MSFD and their river basin management plans under WFD they can request for an exception for not achieving good status. The following section a) is a collection of member states reports to the EU Commission for not achieving good status regarding eutrophication, biodiversity, or hazardous substances due to natural conditions in the Baltic Sea. This section is followed by a review of scientific literature concerning a natural time-lag between measures and their effects on the marine environment in the Baltic Sea (section b)).

a) EU member states use of exceptions for not achieving good status

A collection of member state reports to the EU Commission regarding use of exceptions for not achieving good environmental status under the Marine Strategy Framework Directive or good ecological or chemical status under the Water Framework Directive.

According to the Marine Strategy Framework Directive (MSFD) member states are to achieve or maintain good environmental status in the marine environment by 2020. Exceptions from this is e.g. if natural conditions do not allow for timely improvement in the status of the marine waters (article 14.1.e). Member states shall clearly identified this in its programme of measures.

Similar, the Water Framework Directive article 4.4 and 4.5 state that the time limit for achievement of the objectives may be extended if natural conditions do not allow timely improvement in the status, or that the member states may aim to achieve less stringent environmental objectives if natural conditions make the achievement infeasible or disproportionately expensive.

This part of the summary report give an overview of exceptions applied by EU member states that are also member of HELCOM regarding natural conditions or processes that hinder achievement of good status in the Baltic Sea. All contracting parties of HELCOM is included except for Russia as Russia is not an EU member.

The use of exceptions for not achieving good environmental status under MSFD is reported by the member states under the program of measures in the first cycle of the MSFD. A summary on under which descriptors the exceptions were reported is given ion Table 1. Information related to eutrophication, biodiversity, or hazardous substances is collected from the EU Commission's assessments of the member states' Program of Measures [3, 4, 5] and shown in Table 1. The use of exemptions for not achieving good ecological or chemical status under WFD is reported by the member states under the second cycle of the river basin management plans. The information regarding WFD in Table 2 is collected from the EU Commission report on the implementation and the country-specific assessments for EU member states' second river basin management plans [6, 7, 8].

Table 1 only includes application of exceptions where the reason is reported to be natural conditions. Change in climatic conditions is also included as 'natural conditions' though this is mainly due to anthropogenic activities. It is included as this is something each country cannot solve individually.

Even though some of the member states' marine areas are not in good status, and it is unknown when the areas will be in good status, some member states have not requested for exceptions with the reason that gaps in knowledge and data do not allow them to conclude whether or not an exception is required at this stage of implementation.

Table 1. *Summary of reported exceptions by the Member states when reporting on Program of Measures. Summary is given by MSFD Descriptors..*

Country	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
Denmark					X						
Estonia	X			X	X			X			

Finland			X		X				X		
Germany											
Latvia					X						
Lithuania	X	X		X	X			X	X		
Poland	X	X		X	X	X		X			
Sweden					X			X			

Table 2. *Member states' request to apply exception under the Marine Strategy Framework Directive or the Water Framework Directive for not achieving good status timely due to natural conditions in the Baltic Sea, article 14.1 e) in MSFD or article 4(4) or 4(5) in WFD). Lithuania is not included regarding the reporting under WFD as the EU Commission have not evaluated measures reported by Lithuania. It is unknown if this is because Lithuania did not report under the second cycle of the river basin management plans. Information is retrieved from [3, 4, 5, 6, 7, 8].*

<table>
<tr><th></th><th>REPORTING UNDER MSFD
1. CYCLE OF POM</th><th>REPORTING UNDER WFD
2. CYCLE OF RIVER BASIN MANAGEMENT PLANS</th></tr>
<tr><td>EUTROPHICA-TION</td><td>All but one (Germany) of the HELCOM contracting parties which are also EU member states have applied an exception for not achieving good environmental status regarding eutrophication due to natural conditions in the Baltic Sea.
The arguments from the member states are that due to historically high nutrient loads to the Baltic Sea, the sediment are enriched with nutrients. This pool of nitrogen and phosphorus in the sediments will continuously be released (partly due to oxygen-deficient deep areas) to the water column and cause eutrophication effects for several years to decades because it will keep the nutrient concentrations in the water column high even when the nutrient load targets are reached. This will cause a delay between measures implemented and their effects. Finland argue that this is particularly relevant for phosphorus stored in the sediment. The time-lag from reducing the loadings to a positive effect is observed in the concentrations further delay the recovery of the ecosystem. Sweden reported that a realistic time frame might be 100 years.
Poland expand the time lag for ecosystem recovery also to include groundwater and inland surface waters as the reaction time here also can be very long.
The reduction in nutrient concentrations is apart from the released from the</td><td>All HELCOM contracting parties which have reported their second cycle of the river basin management plans to the EU Commission use at least one exemption for not achieving good ecological status in their surface waters. All but Poland argue that this is for some of their water bodies due to natural conditions in the Baltic Sea.

Following table show the percentage of water bodies for which at least one exemption has been used and for how many water bodies natural conditions are used as a reason.

<table>
<tr><th></th><th>Exemption (%)</th><th>Natural conditions (%)</th></tr>
<tr><td>Denmark</td><td>4</td><td>2</td></tr>
<tr><td>Estonia</td><td>35</td><td>8</td></tr>
<tr><td>Germany</td><td>90</td><td>50</td></tr>
<tr><td>Finland</td><td>20</td><td>10</td></tr>
<tr><td>Latvia</td><td>10</td><td>100</td></tr>
<tr><td>Poland</td><td>60</td><td>0</td></tr>
<tr><td>Sweden</td><td>60</td><td>2</td></tr>
</table>
</td></tr>
</table>

	sediment dependent on the exchange of water masses. A very narrow in- and outflow of water to and from the Baltic Sea causes a low water exchange with the North Sea and this together with deep areas result in a high residence time of 20-30 years. Some countries (Poland, Finland, Latvia, Lithuania) argue that their marine waters are affected by other Baltic countries and do not only depend on actions undertaken by them.	
BIODIVERSITY	**Fish:** Poland and Finland reported use of an exception for not achieving good environmental status regarding fish due to natural conditions. Finland reported that at will take time before measures actually allow fish species to increase in abundance and achieve a sustainable stock status given the duration of the reproductive cycles. Poland reported that the indicator for fish is strongly dependent on size of the cod, which is strongly correlated with temperature and salinity. Further, larger anoxic areas, cause either by eutrophication or climate change, may affect food resources available, spawning success and result in smaller cods. Natural changes in seal population may also affect fish populations. **Mammals:** Poland and Estonia reported use of an exception for not achieving good environmental status regarding mammals due to natural conditions. Estonia reported that good status might not be achieved for species that depend on climatic conditions e.g. the extent of the maximum winter ice cover which can affect the range of the ringed seal. Poland reported that they are not able to achieve GES for harbour porpoises due to migratory nature of the species and stated that most by-catch occurs outside Polish marine waters because the species population size is larger in other countries. **Food webs:** Lithuania reported use of an exception for not achieving good status regarding food webs. Lithuania reported that the exception applied for food webs is linked to eutrophication (D5), for which another exception has been	

<table>
<tr><td></td><td>applied, and also linked to non-indigenous species.
Seabed habitats: Poland reported use of an exception for not achieving good status in benthic habitats. Poland reported that the improvement of the benthic habitat is a slow and long-term process. Firstly because benthic ecosystems and species are characterised by slow growth, secondly due to a significant impact from a few non-indigenous species and their spreading, and thirdly due to naturally occurring low oxygen concentrations in some areas. Further, global warming will affect the recovery of the benthic habitats.</td><td></td></tr>
<tr><td>HAZARDOUS SUBSTANCES</td><td>Five (Estonia, Finland, Lithuania, Poland, Sweden) of the HELCOM contracting parties have applied an exception for not achieving good status regarding hazardous substances.
All member states argue that historically contaminant events have resulted in accumulation of persistent contaminants in the sediment and biota. The natural long decay period for these substances together with the high water residence time delay the system recovery.
Furthermore, the member states report that atmospheric deposition or inflow from neighbouring waters either dissolved in the water masses or incorporated in biota e.g. fish affect their marine waters.</td><td>Except for Denmark, all HELCOM contracting parties which have reported their second cycle of the river basin management plans to the EU Commission use at least one exemption for not achieving good chemical status in their surface waters. All but Poland argue that this is for some of their water bodies due to natural conditions in the Baltic Sea.

Following table show the percentage of water bodies for which at least one exemption has been used and for how many water bodies natural conditions are used as a reason.

<table>
<tr><th></th><th>Exemption (%)</th><th>Natural conditions (%)</th></tr>
<tr><td>Denmark</td><td>0</td><td>-</td></tr>
<tr><td>Estonia</td><td>2</td><td>2</td></tr>
<tr><td>Germany</td><td>100</td><td>8</td></tr>
<tr><td>Finland</td><td>50</td><td>30</td></tr>
<tr><td>Latvia</td><td>5</td><td>5</td></tr>
<tr><td>Poland</td><td>5</td><td>0</td></tr>
<tr><td>Sweden</td><td>100</td><td>1</td></tr>
</table>
</td></tr>
</table>

b) Time-lag between measures and effects due to natural conditions – Review of scientific literature and reports

Low water exchange

The Baltic Sea has a surface area of 420.000 km^2 and a drainage area about four times larger than this [1]. About one-third of the Baltic Sea is shallower than 30 meters, but it has some deep areas. The Baltic Sea is connected to the North Sea through the narrow Danish straits, the Sound, Little Belt, and Great Belt, and, therefore, the water exchange is low and the residence time is about 30 years [(9), 10]. Due to the long turn-over time, the concentrations of different compounds in the water column such as nutrients will be diluted slowly as the Baltic Sea water is replaced with North Sea water. Hazardous substances such as heavy metal and pharmaceuticals which are persistent or slowly degradable are widespread in the Baltic Sea and removal are slow due to the long turn-over time [11].

Salinity gradients

The high-saline and more dense North Sea water move into the Baltic Sea as bottom water and the low-saline and less dense Baltic Sea water move out of the Baltic Sea area as surface water creating a high vertical salinity gradient in the water column. Water from the large drainage areas enter the Baltic Sea from rivers, especially in the Northern part. This result in a salinity gradient from North to South with a salinity of 15-18 in the Sound, a salinity of about 8 in the Baltic Proper, and a salinity of 0-2 in the North-East parts [12]. Studies have shown that salinity is an important parameter for shaping marine communities both in pelagic and benthic habitats [13, 14].

Areas with natural occurring hypoxia act as sink/source for nutrients

As a consequence of the slow in- and outflow of water masses, the deep areas in the Baltic Sea have naturally low oxygen concentrations or even hypoxia as only storms can feed oxygen-rich North Sea water into the deep areas. The oxygen concentration impact the benthic habitats and also the sediments ability to act as a sink or source for nutrients. The oxygen concentration and consumption have been shown to be tightly coupled to phosphorus release [15, 16]. The structure of the sediment and the extent of bioturbation can also affect the phosphorus release [15, 17].

Benthic habitats

Bacteria and the microbial activity in the sediment is important for the decomposition in the sediment. The level of hypoxia, temperature, and salinity is recognized to affect the microbial activity, composition as well as the way the benthic community function [18].

Apart from the microbial activity, the more fundamental issues such as the substrate type is of huge importance for the ecosystem. A natural lack of suitable hard substrate (rocky bottom) limit the spatial distribution of canopy-forming macroalgae and similar for sandy habitats in relation to seagrasses [19]. This impact e.g. the resuspension of material from the seabed, the water clarity, and function as shelter for organisms e.g. fish. A study by [20] with assessment of different scenarios effect on ecosystem services showed that enlarging macrophyte belts is perceived as the one that generates the highest additional ecosystem service output. Differences in grain size in the sediment is shown to affect the diversity of the macrofaunal communities with higher diversity, abundance, and biomass in coarser sediment and habitats with more vegetation [21].

Effects of historical high nutrient loadings

The historical high nutrient loadings mainly from riverine inputs [22] affected the Baltic Sea ecosystem in several ways. The marine ecosystem is still suffering from the historical eutrophication effects with higher nutrient concentrations, high amounts of nutrient bound in organic matter and biota, high phytoplankton

biomass leading to efficient capture of light and hence a high pelagic production, enrichment of sediments with lower oxygen concentrations at the seabed and in the sediment, lower bioturbation, and lower water clarity [23, 24].

Topics covered by the analysis

Eutrophication: The recovery of the Baltic Sea and the time delay that can be expected between load reduction and signs of improved GES will be analysed in relation to the following MSFD criteria: D5C1 (nutrient concentrations), D5C2 (chlorophyll a), D5C4 (water transparency), D5C3 (harmful algal blooms), and D5C5 (dissolved oxygen). Main reasons for delay are the natural specificities of the Baltic Sea – **very closed marine area, limited water exchange** with the North Sea and **accumulation of nutrients in the seabed sediments** over the past decades. Time-lags also occur due to **retention of nutrients in the drainage area**. **Climate change** could cause further time-lags, e.g. expanding the extent of oxygen-deficient areas in the deeper basins, possibly leading to **the release of nutrients from sediments** and increased levels of dissolved nutrients in the water column.

Hazardous substances: The analysis will be carried out mainly in relation to MSFD criterion D8C2 (concentration of hazardous substances). A number of factors have been identified as contributing to natural time lags in recovery from hazardous substances, including: **burial in sediments and re-dispersal** (e.g. via disturbance from trawling, dredging, shipping), **slow degradation rates** of legacy contaminants, and **long-range transport** of some substances (e.g. atmospheric mercury transport). The Hazardous Substances Topic Team (as part of the HELCOM SOM Platform) identified **Hg (Mercury), TBT (tributyl-tin), PFOS (perfluorooctane sulphonate), and Diclofenac as the substances** they would focus on since these substances (substance groups) reflected a spectrum of factors inclusive of long range transport, legacy contamination, current concern and emerging substances. In addition **the PFAS group** is being looked at where information is available since this larger group of substances, into which PFOS is nested, reflects a large and currently not fully assessed range of potentially hazardous substances. **PBDEs (polybrominated diphenyl ethers), dioxins and PCBs (Polychlorinated biphenyls)** are also considered as relevant candidates to gather information on.

Biodiversity: Not achieving GES for biodiversity is partly caused by natural conditions and changes in climatic conditions. The following topics are analysed: **Food webs and benthic habitats – poor oxygen conditions** in deep waters of the Baltic Sea limit benthic fauna distribution and can alter food web productivity. **Fish –** achievement of a sustainable stock status given **the duration of the reproductive cycles** takes time; **cod status** depends on **oxygen, temperature and salinity. Mammals –** GES might not be achieved for species that depend on **climatic conditions (ringed seals);** inadequate nutritional condition of **grey seals** may be explained by the seal population approaching its ecological carrying capacity (natural population plateau), which beside human impacts (e.g. overfishing) could reflect **natural ecosystem processes.** While Baltic Sea salinity and temperature regimes may limit the spread and establishment of some non-indigenous species, the predicted changes in climate could weaken such barriers. These natural conditions and possible future changes will be analysed to reveal their impacts on achieving GES regarding the following MSFD criteria: D1C2 (species abundance), D1C4 (species distributional range), D2C1 (newly- introduced non-indigenous species), D2C2 (abundance and spatial distribution of established non-indigenous species), and D6C3 (spatial extent of habitats).

References

1. HELCOM, *State of the Baltic Sea - Second HELCOM holistic assessment 2011-2016.* Baltic Sea Environment Proceedings, 2018. **155**.
2. HELCOM, *HELCOM Activities Report - Implementation of the Baltic Sea Action Plan.* Baltic Sea Environment Proceedings, 2018. **154**.

3. EU-Commission, *Commission staff working document - Accompanying the document 'Report from the Commission to the European Parliament and the Council assessing Member States' programme of measures under the Marine Strategy Framework Directive*. 2018: Brussels.
4. EU-Commission, *Commission staff working document - Marine Strategy Framework Directive - assessment of programmes of measures for Denmark, Estonia, Greece, Croatia, Lithuania, Romania and Slovenia*. 2019: Brussels.
5. EU-Commission, *Report from the Commission to the European Parliament and the Council assessing Member States' programme of measures under the Marine Strategy Framework Directive*. 2018.
6. EU-Commission, *Commission staff working document accompanying the document 'Report from the Commission to the European Parliament and the Council - implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC)'*. 2019: Brussels.
7. EU-Commission, *Report from the Commission to the European Parliament and the Council on the implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC) - Second River Basin Management Plans, First Flood Risk Management Plans*. 2019: Brussels.
8. EU-Commission, *WFD and FD Implementation Reports - The fifth Water Framework Directive Implementation Report - assessment of the second River Basin Management Plans and the first Floods Directive Implementation Report -assessment of the first Flood Risk Management Plans*. 2019.
9. Boesch, D.F., *Barriers and Bridges in Abating Coastal Eutrophication.* Frontiers in Marine Science, 2019. **6**.
10. Stigebrandt, A., *Physical Oceanography of the Baltic Sea*. 2001. p. 19-74.
11. Bjorlenius, B., et al., *Pharmaceutical residues are widespread in Baltic Sea coastal and offshore waters - Screening for pharmaceuticals and modelling of environmental concentrations of carbamazepine.* Science of the Total Environment, 2018. **633**: p. 1496-1509.
12. HELCOM. *Hydrography and oxygen in the deep basins*. HELCOM Baltic Sea Environmental Fact Sheets 2018; Available from: http://www.helcom.fi/baltic-sea-trends/environment-fact-sheets/hydrography/hydrography-and-oxygen-in-the-deep-basins/.
13. Wrange, A.-L., et al., *Importance of plasticity and local adaptation for coping with changing salinity in coastal areas: a test case with barnacles in the Baltic Sea.* BMC Evolutionary Biology, 2014. **14**(1): p. 156.
14. Darr, A., M. Gogina, and M.L. Zettler, *Functional changes in benthic communities along a salinity gradient- a western Baltic case study.* Journal of Sea Research, 2014. **85**: p. 315-324.
15. Puttonen, I., T. Kohonen, and J. Mattila, *Factors controlling phosphorus release from sediments in coastal archipelago areas.* Marine Pollution Bulletin, 2016. **108**(1-2): p. 77-86.
16. Walve, J., et al., *A Baltic Sea estuary as a phosphorus source and sink after drastic load reduction: seasonal and long-term mass balances for the Stockholm inner archipelago for 1968-2015.* Biogeosciences, 2018. **15**(9): p. 3003-3025.
17. Danielsson, A., et al., *Effects of re-oxygenation and bioturbation by the polychaete Marenzelleria arctia on phosphorus, iron and manganese dynamics in Baltic Sea sediments.* Boreal Environment Research, 2018. **23**: p. 15-28.
18. Lindh, M.V. and J. Pinhassi, *Sensitivity of Bacterioplankton to Environmental Disturbance: A Review of Baltic Sea Field Studies and Experiments.* Frontiers in Marine Science, 2018. **5**.
19. Lappalainen, J., et al., *Substrate limitation of a habitat-forming genus Fucus under different water clarity scenarios in the northern Baltic Sea.* Estuarine Coastal and Shelf Science, 2019. **218**: p. 31-38.
20. Schernewski, G., M. Inacio, and Y. Nazemtseva, *Expert Based Ecosystem Service Assessment in Coastal and Marine Planning and Management: A Baltic Lagoon Case Study.* Frontiers in Environmental Science, 2018. **6**.
21. Gammal, J., et al., *Environmental Context Mediates Biodiversity-Ecosystem Functioning Relationships in Coastal Soft-sediment Habitats.* Ecosystems, 2019. **22**(1): p. 137-151.
22. HELCOM, *Sources and pathways of nutrients to the Baltic Sea*, in *Baltic Sea Environment Proceedings*. 2018.
23. Knudsen-Leerbeck, H., et al., *Seasonal dynamics and bioavailability of dissolved organic matter in two contrasting temperate estuaries.* Biogeochemistry, 2017. **134**(1-2): p. 217-236.

24. Markager, S., C.A. Stedmon, and P. Conan, *Effects of DOM in marine ecosystems*, in *Dissolved organic matter (DOM) in aquatic ecosystems: A study of European catchments and coastal waters*, M. Søndergaard and D.N. Thomas, Editors. 2004, The Domaine project.