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SEABASED
SEABASED MEASURES IN
BALTIC SEA NUTRIENT MANAGEMENT

STATE OF THE PLAY REPORT - SEABASED MEASURES IN THE BALTIC SEA

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JOHN NURMINEN FOUNDATION

SEABASED Project *(Seabased Measures in Baltic Sea Nutrient Management)*

Eutrophication is one of the most large-scale problems of the Baltic Sea. While the nutrient load from land-based sources has been cut significantly during past decades, nutrients that are stored in the seabed and are being released from the sediment back to the waterbody under anoxic conditions are currently slowing down the recovery of the ecosystem. The SEABASED Project (2018-2021) will assess measures that potentially improve the status of marine area by reducing this "internal load" of nutrients from the seabed. The project will also implement small scale local pilots on selected measures in Finland, Åland and Sweden.

Currently, there are pilot activities, projects, plans and research on sea-based approaches going on in both Sweden and Finland, but at the same time, a lack of comprehensive cross-sectoral discussion exists, both within and between sectors and countries. Thus, one of the aims of SEABASED Project is to strengthen cooperation and share knowledge between scientific communities as well as among authorities, political decision makers and third sector actors of the region on the feasibility, risks and sustainability of the different sea-based approaches in different scales and sea areas, as well as on their financial sustainability.

The John Nurminen Foundation (JNF) is the Lead Partner of the SEABASED Project and facilitates the cross-regional discussion. Regional authorities are key actors for local water quality improvement – therefore the partnership involves regional authorities from Sweden, Finland and Åland: County Administrative Board of Östergötland, the ELY Centre of Southwest Finland and the Government of Åland. Local pilots will be implemented in their regions. In addition, practical tools will be developed for utilization of sea-based methods in the future, if they are found applicable. Also, the sustainability of the measures will be assessed, taking into consideration ecological, social, legislative and financial aspects. The private sector's interest in improving water quality locally and Baltic Sea wide will be represented by JNF as Project Lead Partner (LP), and the Fishfarmers' Association, managing part of the pilot activities in Åland.

The SEABASED Project is co-financed by the EU Interreg Central Baltic Programme.

More information: www.seabasedmeasures.eu

Introduction

Measures to reduce land-based nutrient pollution have been carried out for several decades in Finland and Sweden, and in other countries surrounding the Baltic Sea to improve the state of the sea. As most of the cost-effective mitigation measures have already been implemented e.g. in wastewater treatment, there is an increasing interest in sea-based approaches to complement the measures on land and to improve local water quality in the coastal sites. During the past few years, it has also been brought to discussion that to reach international targets on reducing eutrophication (HELCOM, BSAP, EU MSFD, EU WFD, SBSR) and revive the Baltic Sea, new activities may be needed to tackle the internal nutrient sources and to complement traditional land-based nutrient load reduction measures.

Ideas of different sea-based measures have recently been brought up to discussion, especially in Finland and Sweden, and the development of some practical applications for them have also been started by different organizations. However, these measures cannot yet be directly applied by governments, authorities or third sectors actors, as most of the ideas are novel and not applied before in marine environment. Single measures like oxygenation of the seabed (e.g. BOX, PROPPEN) have been tested regionally in pilot projects and some ideas of large-scale applications have also been brought up. However, there is a lack of comprehensive understanding of risks, effects, costs, feasibility and financial sustainability of different measures. Thus, there has not been enough information and practical knowledge on their applicability. Moreover, applicability of specific measures is often site-specific and to gain more comparable information, the measures would need to be piloted in different scales, regions and sea areas. HELCOM contracting parties as well as scientists are not unanimous but have adopted different approaches to these new measures.

This Report focuses on summarizing the current status of so called “sea-based measures” in improving the ecological status of the Baltic Sea. Information have been gathered from e.g. published scientific studies, project reports and outcomes of some recent national and regional workshops on the matter. As the purpose of this report is to give a review on the state-of-the play of sea-based measures in the Baltic Sea Region, the potential risks and benefits of these measures will not be assessed here, nor will any conclusions or recommendations on their applicability be given. However, this work will be included in the further work in the SEABASED project.

Sea-based measures, their potential risks and applicability are also assessed in the recent report by Vahanen Environment (2018): *Speeding up the ecological recovery of the Baltic Sea by engineering*. This report partly refers to some of the findings and conclusions of that work.

What is internal nutrient load?

The physical, chemical and biological characteristics and the main environmental challenges of the Baltic Sea are well described in detail e.g. in HELCOM 2018 and Vahanen Environment 2018 reports, therefore describing them again is not in focus of this report but only a short, general explanation on the term “internal load” is provided.

The main cause of eutrophication of the Baltic Sea are the excessive nutrient inputs during several decades, especially from 1950’s to 1980’s, from human activities on land: wastewaters, industries and agriculture. The symptoms of eutrophication can be seen e.g. in increased biomass of algae, murky waters and oxygen

depleted sea bottoms (anoxia). It has also been shown that chemical conditions in anoxic sediments change the ratio of available nitrogen and phosphorus in the water, to a direction that favors the growth of cyanobacteria (blue-green algae) which have a role in sustaining eutrophication in the Baltic Sea, thus creating a self-sustaining "vicious circle" of eutrophication in the sea (Conley et al. 2009, Vahtera 2007).

According to current research, the nutrient inputs have been significantly reduced beginning from the 1990's, and, thus, the internal nutrient flux, especially phosphorus, from the anoxic bottom sediments, exceeds the annual inputs from land-based sources. However, also the internal nutrient reserves originate from land-based nutrient load, and, thus, the flux of phosphorus from the sediment is not a new source of loading but rather circulating the accumulated "old" land-based phosphorus back to the use of algae. (Baltic Sea Centre 2018, HELCOM 2018). The biogeochemical processes that store phosphorus in sediments and release it into the water are complex and dependent on the surrounding circumstances: the interaction of organic matter, minerals, metals, oxygen, and the physical characteristics like water movements in the sea (Conley et al. 2009, Baltic Sea Centre 2018). Therefore, it is difficult to estimate which measures affecting these cycles would have a desired effect on enhancing the recovery of the sea.

As the nutrients entering the Baltic Sea are partly flushed to the North Sea through the Danish Straits and partly buried in the bottom sediment, it is evident that by reducing external load of nutrients the total pool of available nutrients will also be reduced in time. Therefore, further studies and piloting of new sea-based measures for enhancing the recovery of the sea have been seen by scientists as a potential for complementing the methods for reducing nutrient load from land, but not for replacing it. (Baltic Sea Centre 2018, HELCOM 2018).

Overview on different measures and pilot projects

In this Report, a "sea-based measure" refers to any measure that is taken in the marine environment, aiming for ecosystem restoration – either by removing the nutrients from the sea, binding them permanently into the bottom sediment or by some other way changing the nutrient balances to reduce the amount of nutrients available for algae growth in the marine areas suffering from the consequences of excess nutrients. The different applications of measures can be either technical, chemical or biological by their nature. There are only a few pilot projects implemented in the marine environment so far, and very little published information exists. However, many of the measures have been tested or utilized in lake restoration already for years or even decades, both in Finland and Sweden.

Experiences from lakes

Most of the restoration measures in lakes aim to control the internal nutrient reserves restored in lake bottom sediments and to reduce their availability to algae growth. Depending on the circumstances and the history of external loading at individual lakes, the results of restoration measures have varied from relatively poor to quite successful cases. Consequently, the measures applied should always be planned for each lake individually, based on careful consideration of all local factors affecting the status of the water environment; from morphology of the lake to human activities within the lake's drainage area.

Most commonly utilized measures in lake restoration have been oxygenation of hypoxic basins, binding phosphorus with chemicals (iron or aluminum compounds) or food web biomanipulation by reduction fishing of large amounts of non-predatory fish, usually the cyprinids that often become abundant in eutrophic lakes. Also dredging of nutrient-rich sediment is sometimes used. Food web biomanipulations usually aim to strengthen the stocks of predatory fish and with their top-down control on other levels of the food web, to

maintain a strong zooplankton community which then regulates the growth of planktonic algae. In addition, by removing biomass, a certain amount of nutrients is also being removed from water environment.

Presentations and further references from e.g. Jukka Horppila, Jouko Sarpala & Ilkka Sammalkorpi at the seminar on effectiveness of lake restoration measures: https://www.ymparisto.fi/fi-FI/Vesistokunnostusverkosto/Tapahtumat/Jarvikunnostusten_vaikuttavuus_seminaari(48909)

Examples on binding phosphorus into bottom sediment

Projects and pilot activities where different chemicals or other substances are used for binding soluble phosphorus bottom sediments of in marine ecosystems usually aim at decreasing the so-called internal load, the leakage of phosphorus from anoxic seabed to the water. When the availability of phosphorus in water is reduced, the algae growth is expected to decrease. Consequently, there will be less oxygen consuming organic matter entering the bottom when the algae die, which might create a positive feedback and in time also improve the oxygen conditions in eutrophic bays with anoxic/hypoxic bottom areas. However, there is not yet any long-term monitoring results from the Baltic Sea region pilot projects existing to verify the hypothesis. Some recent results also indicate, that using aluminum for phosphorus binding might mobilize hazardous substances from the sediments (Wikström 2018)

Aluminum treatment in Björnöfjärden, Sweden (Living Coast, BS2020)

In a project carried out by BalticSea2020 Foundation in 2011–2016, a full-scale aluminum treatment with dissolved polyaluminum chloride was carried out in severely eutrophied Björnöfjärden (area 1.5 km2, maximum/mean depth 25/6 m). The treatment was carried out in two stages, with a special equipment that was planned to spread the chemical evenly over the bottom sediment. After the treatment, a follow-up monitoring was carried out in Björnöfjärden and in a relatively similar reference area nearby (Fjällsviksviken, area 0.7 km2, maximum/mean depth 15/4 m) and the conditions of these two bays were then compared.

As a result of the treatment, much lower phosphorus concentrations were measured in the treated area than in the reference bay, and the overall supply of phosphorus was reduced over 90%. Good results were also obtained in water clarity and the ecological status improved in several different aspects. The concentration of aluminum in fauna living in the bay was also monitored, and no harmful effects were found, however a short-term rise in the concentration of aluminum was observed in certain fish and bottom fauna right after the treatment. By the time of publishing the monitoring results, however, the sediment of the bay still remained anoxic/hypoxic, and it remains to be seen whether the ecosystem in the bay is capable of restoring itself to correspond to the situation before severe nutrient loading and eutrophication had started. (Rydin et al. 2017)

Project on phosphorus binding in shallow eutrophic bays—which substances work? (BS2020)

Another, still ongoing project of BalticSea2020 investigates which substances would work best for binding phosphorus and tackling eutrophication in shallow eutrophied bays. The project seeks to identify alternatives to aluminum, which was tested in Björnöfjärden, as aluminum was found not to be optimal in shallow eutrophic areas.

Iron is one of the natural binders of phosphorus in marine sediments and iron chemicals are also commonly used for precipitating phosphorus in wastewater treatment. The efficiency in phosphorus binding of two different iron compounds, aluminum chloride and marl will be compared in tests carried out in one pilot bay (Gran Bay) with chamber-like enclosures. Results from these tests will be compiled in a final report that has not been published at the time when this report has been written.

Binding phosphorus with marl (SEABASED, Stockholm University)

Marl in general refers to a mixture of fine-grained minerals. Blomqvist and Björkman have investigated in the project "Permanent binding of phosphorus in the Baltic Sea bottom", financed by BS2020, whether Gotland marl, a calcium-based byproduct from limestone mining industry, can effectively bind phosphorus in the Baltic Sea bottom sediment. In these studies, it was found that in laboratory tests marl adsorbs phosphorus efficiently from the water. The residue marl is stored in Gotland in large piles.

In the SEABASED project, three pilot examples with marl application to phosphorus-rich bottom sediments will be implemented in coastal bays in Sweden (Östergötland, Stockholm) and Finland (Archipelago Sea). The pilot started with a short development phase to define exact amounts of marl application, after which the measure will be implemented. There are no existing on-site pilots or measurements yet on the binding capacity of the piloted substance. One of the main targets of the pilot is to gather comparable and reliable information on the reduction of internal phosphorus load with this measure.

In addition to the phosphorus binding capacity of marl, other effects in pilot areas will be thoroughly monitored, and information will be gained e.g. on the duration of the effects and suitability of the method in further use. After application, the effects of the measure on phosphorus concentrations as well as on sediments and biota will be assessed. Based on the results, Stockholm University will compile guidelines for marl application as a method for binding phosphorus to bottom sediments in the Baltic Sea region. All information will be included in the Practical Guidelines on Seabased Measures that is compiled from results of all different pilots during the SEABASED project.

Clay bombing

One idea that has been brought up e.g. by Mikko Kiirikki (Luode Consulting) is utilizing the clay from dredging sites for binding phosphorus in eutrophic basins. The hypothesis of “clay bombing” is that as clay naturally contains iron compounds (Fe(III)oxides), adding clay on sediment surfaces would promote phosphorus binding to these iron compounds. Thus, the binding capacity of the sediment would be increased and phosphorus leakage from the sediment would be reduced (Mikko Kiirikki and Markku Ollikainen, 2017, pers. comm.). The method is also described in Vahanen Environment report, 2018. However, as no pilot studies exist yet, there are no results currently available on the real applicability of the measure.

Pilot projects on oxygenation

Oxygenation has been a commonly used method for rehabilitating eutrophied lakes already for decades, and it has also recently been tested in the marine environment in a couple of pilot projects (e.g. PROPPEN, BOX). The target of oxygenating the near-bottom waters or the sediment surface is to improve the phosphorus binding capacity of the sediment. In well oxygenated sediment phosphorus is bound to e.g. iron compounds as in anoxic conditions phosphorus is released from these compounds to the water body. By reducing the flux of phosphorus from the sediment to the water, there is less phosphorus available also for algae growth and reductions in algae biomass can be expected (Conley et al. 2009, Lehtoranta et al. 2012). However, there are still gaps in knowledge in understanding the role of anoxia in biogeochemical cycles of nutrients in the Baltic Sea, and, thus, there is no consensus among the scientists that oxygen concentration is the only factor controlling the internal load (Conley et al. 2009, McCrackin 2018).

Even though the method is commonly used in lakes, the results vary a lot depending e.g. on the local conditions, load history and duration of oxygenation. In most lakes also the anoxic conditions on the bottom tend to return if pumping of oxygenated water ends. (Conley et al. 2009, McCrackin 2018, Horppila 2018: presentation in seminar on lake restoration methods). Some examples from coastal marine areas in the U.S. are also mentioned in Vahanen Report, and the experiences form these projects imply that hypoxia easily tends to return on oxygenated areas also in the marine environment if the pumping of water or air rich in oxygen is stopped (Vahanen Environment 2018).

Experiences from pilot projects PROPPEN & BOX (2009–2012)

Both projects PROPPEN and BOX were carried out within a program launched by the Swedish EPA in 2009. The main goal of these projects was to test if pumping of oxygen-rich water to hypoxic or anoxic bottoms in coastal bays could oxygenate the sediment surface and increase the phosphorus binding capacity of the sediment, eventually preventing the long-term leakage of phosphorus from the sediment to waterbody.

Projects had altogether three pilot sites, two in Sweden and one in Finnish coast. However, due to technical challenges e.g. insufficient pumping capacity at the Finnish site (Sandöfjärden), only the tests at the two sites in Sweden were successful (Byfjorden on the western coast and Lännerstasundet in the Stockholm archipelago). The implementation and results of the projects were evaluated afterwards by a scientific referee group.

Both projects showed that pumping of well oxygenated water in coastal scale is technically possible. Increases in the oxygen concentration in the near-bottom water and decreases in phosphorus were also observed at both sites (Byfjorden and Lännerstasundet) during the pumping. The conclusions from PROPPEN suggest that these results were achieved partly because pumping of water increased the flow of oxygen-rich water from nearby basins to pilot area which resulted in increase of oxygen also in the near-bottom water also in the pilot basin. PROPPEN also concludes that the method could be applicable in small, coastal scale in certain conditions but further tests and information on ecological and physical effects is needed on the applicability on larger scales (Rantajärvi et al. 2012). However, the conclusion of BOX project, on the contrary, was that the potential risks are smaller than ecological benefits of the measure, even in larger scales (Stigebrandt et al. 2015).

According to the referee group evaluation of PROPPEN and BOX, a proper ecological risk assessment for oxygen pumping was not included in neither of the projects even though it was included in the original project requirements set by Swedish EPA. As the pumping periods in both projects were relatively short, the long-term effects of the measure remain unclear. It was also observed in both projects, that pumping of warm surface water to the bottom caused an increase of water temperature in near the bottom, which resulted in an unwanted consequence, increased oxygen consumption in the sediment. The evaluation also concludes that the time of the pumping was too short for observing e.g. the effect of the method on the long-term release of harmful substances (e.g. heavy metals, hazardous organic compounds) from the sediments.

In further discussion, it has been suggested that water should be pumped to the deep bottoms from the middle layers of water body instead of surface waters. The effects of largescale oxygenation of the Baltic Proper have been evaluated in the BOX-WIN Project, however, the results are based on modeling scenarios only (Stigebrandt 2018). The Vahanen Report also evaluates the biological risks and advantages of large scale oxygenation against GES (Good Ecological Status, EU MFD), however it is clearly stated in the scientific referee evaluation of BOX and PROPPEN projects that the ecological risks were not studied nor evaluated sufficiently even in the small-scale pilots.

Seabed restoration by removing sediment

Like other restoration measures, removing organic sediments has been used in restoration of eutrophied lakes in both Finland and Sweden. Within few years this measure has also been proposed for the Baltic Sea and, in Sweden, also a new, patented technique for removing only a thin sediment surface layer without causing turbation of the sediment on the bottom have been developed by KTH and TechMarket. The technique has also been tested in coastal lakes (e.g. Barnapasjön) and even at a 120m deep basin in Oxelösund in 2014–15 (Bengt Simonsson TechMarket,pers. comm.). Some other pilot projects are currently

ongoing in Sweden (e.g. LifeSURE, LIFE IP Rich Waters, Ramboll 2017), and other companies providing the same kind of methodology have also emerged.

A project on thin layer sediment dredging in 2015 at Lake Barnapasjön (Jönköping, Sweden) was financed by the Baltic Sea Action Plan Trust Fund (Nefco 2015) in August 2015. According to Nefco and TechMarket, who carried out the project, the project resulted in doubled oxygen levels and reduced eutrophication of the lake. However, no scientific report is available on the results and no monitoring data on the pilot site was found when writing this report.

LifeSURE Project in Malmfjärden, Kalmar (2017–2021) targets to improve the environmental quality of a pilot bay by removing 40 000 m^3 of sediments. A low-flow dredging equipment will be constructed, tested in small scale and then piloted in the Malmfjärden bay. The project also aims at demonstrating an ecologically sustainable process for retrieving and recycling sediments into a resource. The project is led by Kalmar municipality, and the total budget of the project is approximately 3.5 million euros.

As scientific studies on the effects of such dredging projects does not yet exist, further studies, monitoring results and assessment of ecological effects of the measure are needed. The method will also be piloted in Finland in project SEABASED, including thorough monitoring of effects.

Removing nutrients with biomass (e.g. mussels, fish, reed, algae)

Management fishing

Fishing is the most traditional way of removing nutrients from the marine environment. Management fishing of low valued fish, like the cyprinids, has long traditions in lake restoration. The results have been varying, depending on e.g. the local conditions of individual lakes. Overview on the results from Finnish lakes also show that the measure should be well planned to gain sustainable effects (Sammalkorpi 2018). The cyprinid fish contain approximately 0,008% (wet weight) of phosphorus (Setälä et al. 2012), so the phosphorus removal is relatively easy to estimate and verify.

In Finland, the management fishing of cyprinids has been piloted first in a governmental project in 2010–2011, and then in the Local Fish Pilot of Project NutriTrade by John Nurminen Foundation, with the aim of commercializing the use of cyprinids for human food. Even though the NutriTrade Project is finalized, the Local Fish Project is still ongoing. The current results seem promising: the annual catches have grown from 35,000 kg in 2015 to 200,000 kg in 2018 and the first consumer product was launched with Finnish supermarket chain Kesko in 2017. Sustainability of the fishing is ensured in the project with specific preconditions, according to which e.g. all bycatches like predatory and migratory fish are released alive back to the sea.

In 2018, a Finnish governmental financing program for enhancing nutrient recycling and improving the state of the Archipelago Sea searched projects for advancing ecologically and economically sustainable management fishing in Finland, and just recently also in Sweden governmental financing has become available for similar attempts.

Mussel farming

In addition to fishing, mussel farming for removing nutrients with living biomass has been piloted in the Baltic Sea in several projects in Sweden and Finland (e.g. Baltic Blue Growth, NutriTrade). A lot of potential has been put on mussel farming as a water protection measure. However, despite of several attempts, no commercial use for Baltic Sea blue mussel has yet been found and the measure has been estimated to be quite expensive in relation to other nutrient reduction methods. The challenges with Baltic blue mussel are partly related to the fact that as a marine species, these mussels grow very slowly in the brackish waters of the Baltic Sea and remain a lot smaller that in oceanic waters. Thus, the commercial sustainability is hard to

reach. In addition, techniques for treating the mussels e.g. for producing animal feed are not mature enough for commercial production (e.g. Minnhagen 2017, Baltic Eye).

Seaweeds and reed

Several national and international projects on cutting of reed for removing nutrients and developing utilization possibilities have been implemented in recent years. Most of the projects have taken place on lakes, but also some coastal pilots exist. During the summer, the fresh reed contains less than 1% phosphorus (dry weight) (Project SAAVI). However, reed is relatively easy to collect and several potential utilization possibilities (biogas, construction, utilization on fields) have been identified. Attention needs to be given to biodiversity issues if reed is planned to be cut down in large areas. Projects on utilizing reed can be found at https://www.ymparisto.fi/fi-FI/Ruoko/Hankkeet (in Finnish).

Collection of seaweed from beaches have been suggested as one way of circulating nutrients from the Baltic Sea. Some local projects have been implemented and utilization of seaweed for e.g. biogas production have been tested. In Project BIOFISK—bioeconomy in organic feed innovation for beach municipalities, utilization of seaweed in a chain for animal feed production is being studied. The project targets to extract nutrients from the sea with seaweed and to provide a new means of producing animal feed in the future.

Overview of the ongoing discussion on sea-based measures

Lately, Sea-based measures have been discussed in several regional seminars and workshops among authorities, scientists and other stakeholders. Different measures and Baltic Sea scenarios have been presented in these events, and a simplified outcome of the discussion in the events is summarized below. Links to the presentations or descriptions of the events are also provided, and some of the seminar presentations are also still available online via the links.

In a **Seminar on sea-based measures** hosted by Baltic Eye, Stockholm University, (February 12th, 2015) several measures from large-scale oxygenation to mussel farming were presented. However, the organizers and the participants of the seminar, consisting of nearly 140 scientists and other stakeholders, concluded that there is not yet enough information on how the sensitive marine ecosystem would react on large scale ecoengineering efforts, and especially the long-term effects are very much unknown.

Presentations of the seminar available at: https://www.su.se/ostersjocentrum/english/baltic-eye/artificial-respiration-for-the-baltic-sea-1.225237/4-seabased-measures-in-perspective-1.234864

HELCOM-EUSBSR (Strategy for the Baltic Sea Region) **Workshop on internal nutrient reserves,** November 28th–29th 2017 in Gothenburg, with approx. 50 scientists and stakeholders from Sweden, Finland, Latvia, Lithuania and Germany discussed the biogeochemical cycles and nutrient dynamics in the Baltic Sea. In addition, potential methods for improving the state of the Baltic Sea were presented: binding phosphorus with aluminum and marl, oxygenation, low-flow dredging of bottom sediment and biological methods like fishing or mussel farming. The workshop was organized by Swedish Agency for Marine and Water Management and the Finnish Ministry of Environment.

The workshop concluded that there could be potential in some of the sea-based measures to speed up the recovery of the sea, however, it was also stressed that the activities should not cause additional pressure on

the Baltic Sea ecosystems. A concern was raised about unknown risks which cannot be managed. Poorly tested measures may cause unpredictable changes in the ecosystem with potential disastrous consequences if implemented in a large scale.

However, the workshop found pilot tests for management of the sea's internal nutrient reserves possible to be implemented in coastal bays or lakes to gather more understanding on the effects and applicability of sea-based measures, taking into account potential unpredictable adverse impacts related to these measures. The assessment of potential adverse environmental effects should also consider the Marine Strategy Framework Directive descriptors as well as HELCOM indicators. A need for thorough risk assessments of pilot tests as well as development of regional principles for any large-scale measures were recognized.

Memo of the HELCOM-EUSBSR Workshop on internal nutrient reserves 28–29 November 2017 Gothenburg: https://portal.helcom.fi/meetings/HELCOM-EUSBSR%20WS%201-2017-498/MeetingDocuments/MEMO%20OF%20THE%20HELCOM-EUSBSR%20WORKSHOP_rev.pdf

Summary of the workshop outcome by Baltic Sea Center Scientists, Stockholm University: https://www.su.se/ostersjocentrum/english/about-us/news/we-don-t-know-enough-to-fix-the-baltic-sea-with-geo-engineering-1.374498

Discussion event on the internal nutrient reserves of the Baltic Sea and the potential remediation measures was organized on 26th March 2018 by the Finnish Ministry of Environment, related to the publication of the report *Speeding up the ecological recovery of the Baltic Sea by engineering 2018,* by Vahanen Environment (*EUTROPH6, assignment by the Finnish Ministry of Environment)*. Conclusions of the report were presented, and the nutrient reserves and dynamics of the sea as well as the potential ecological and legislative risks related to sea-based measures were discussed.

In the Vahanen Environment's report, the main conclusions are, that more information is needed on internal nutrient loading and the internal processes of the sea, the risks and impacts as well as the costs and benefits of different measures. However, the report encourages towards implementation of local scale pilot tests for gathering the information needed in evaluating the potential benefits and applicability of different measures, and, also, calls for comparison of ecological Baltic Sea models for enhancing e.g. the evaluation of the potential effects of scaling up the local pilots.

Different measures are also evaluated in the report, mainly focusing on technical, so called "environmental engineering" methods, like oxygenation and sediment retrieval, and chemical binding of phosphorus e.g. with aluminum. When comparing the measures, it is concluded in the report that the most technically mature and potential methods for further testing and future applications in local scale would be oxygenation of near-bottom water and chemical binding of phosphorus into the sediment. Small-scale local trials have been implemented on these measures in research projects in Sweden and Finland (e.g. PROPPEN and BOX, Rydin et al. 2017), with partly promising results. However, the long-term effects of both measures remain yet to be determined.

Related documents:

Vahanen Environment 2018, Speeding up the ecological recovery of the Baltic Sea by engineering.

Rantajärvi (ed.) et al. 2012. Controlling benthic release of phosphorus in different Baltic Sea scales: Final Report on the result of the PROPPEN Project.

Stigebrandt et al. 2015a. An experiment with forced oxygenation of the deep-water of the anoxic By Fjord, western Sweden. (BOX Project)

Rydin, E. et al. 2017. Remediation of a Eutrophic Bay in the Baltic Sea.

In the SEABASED project, measures have been discussed in two events by the end of 2018, in a **SEABASED National Stakeholder Forum** in Stockholm on 3rd October 2018 and in a **Scientific Workshop** in Finland in October 30th-31st, 2018.

In the National Stakeholder Forum in Sweden, several crucial aspects were discussed, focusing on questions that need to be solved somehow before further steps towards sea-based applications can be taken, e.g.

- How can initiatives be compared—which criteria and measurements can be applied?
- What scales can be used in future pilots?
- How can benefits of various approaches be measured and compared?
- How can the initiatives be monitored?

The workshop did not conclude any answers to these questions but focused on summarizing and collecting the stakeholders' views on the main environmental, social, legal and economical questions that are important to consider in further discussion and when compiling the Practical Guidelines of Sea-based Measures during the SEABASED Project. https://stephenhinton.org/questions-from-the-stockholm-stakeholder-workshop/

The **Scientific Workshop in Finland** discussed the ecological risks related to new sea-based measures, as well as the suitable ways of assessing these risks when planning to apply such measures. The workshop concluded that in small scale pilots the risks remain manageable if the pilot sites are well selected (e.g. closed or semi-closed eutrophied areas with anoxic bottoms) and the potential risks are thoroughly assessed beforehand for each of the pilots. 15 Finnish scientists representing e.g. marine ecology and food webs, physics and sediment geology were invited to the discussion event. Similar, national scientific event will be organized in Sweden during 2019 and it will be followed by an international discussion event, where researches from both countries, representing several fields of marine sciences will be invited to share their views on potential benefits, risks and applicability of sea-based measures. A suitable risk assessment framework for these measures will also be discussed with the scientists.

Conclusions & next steps

Referring to the existing data and scientific views on implemented pilots and emerged ideas for helping the Baltic Sea to recover and reducing the eutrophication of the sea, it seems evident that more information is needed, not only on the measures and their technical or economical applicability but also on the natural processes taking place in the sea, e.g. related to the biogeochemical nutrient cycles and the effects of warming climate on eutrophication of the sea (e.g. Baltic Sea Center 2018, HELCOM 2018).

Results from new research, scientific discussion and researchers' views will be closely followed in the SEABASED project during the following two years. Researchers will be also be invited to participate in workshops and to comment on the project outputs. The pilots implemented during the SEABASED project will be thoroughly monitored, and, thus, more data will be available on the effects of piloted measures in the future. In addition to data related to indicators of the state of pilot areas, also social, legislative and technical issues will be documented thoroughly during the pilot implementation.

Based on the information gathered from the pilots, Practical Guidelines on sea-based measures will be compiled, targeted for authorities and policymakers for assessing, selecting and discussing the possibilities of applying sea-based measures in water protection policy in the Baltic Sea Region. The Guidelines development will be interlinked with regional work of building up a risk assessment framework for evaluating future application possibilities of the new measures, e.g. in relevant HELCOM working groups.

Evaluation of commercialization potential and future financing of sea-based measures will be included in the work, with an objective to proceed from project-based approach in Baltic Sea protection into sustainable long-term financing scheme if some of the measures are found applicable and efficient.

Guideline development work will include cross-sectoral discussion within and between countries and different stakeholders, to be able to achieve comprehensive understanding on sustainability and possibilities of these measures. Key stakeholders from different sectors are engaged into the discussion in workshops and roundtable events during the SEABASED project.

A thorough sustainability assessment, based on scientific data and the results from project pilots, will be included in the Guideline documents. Stakeholders and relevant target groups will have the possibility to comment on the documents during the development process. By the end of the project, the Guidelines will be shared to all interested stakeholders.

References:

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