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CLIMATE CHANGE AND THE BALTIC SEA - HOW TO BE PREPARED IN A SUSTAINABLE WAY

TURKU AMK
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BACHELOR'S THESIS | ABSTRACT

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CLIMATE CHANGE AND THE BALTIC SEA - HOW TO BE PREPARED IN A SUSTAINABLE WAY

Climate change and its effects are a growing concern, not only for the most affected countries but for the planet Earth itself. Climate and global environmental changes have been widely discussed, controversial and researched topics over the last decade. We need to take account more than just one factor for the overall effects on a complex subject like the Baltic Sea. There are many different changes the Earth has gone through and will be going through in modern times and the future.

The Baltic Sea is a unique brackish water sea with low resistance and resilience to continuously increasing stress from multiple factors. The economy, energy production, agriculture, environmental changes, large drainage basin with a human population around 85 million, varying environmental policies, climate, and long-term natural changes all affect the condition of the sea.

The overall effects of human actions vary from preserving and giving longevity to the sea to destroying all life and contaminating the sea. It is exceedingly important to have ethically working laws, to enforce them, and a fair division for all surrounding countries and related companies, organizations and partners. Mankind has proven to be able to achieve both end results.

The main point of this thesis is how to anticipate and prepare for the issues brought about by the effects of climate change on the Baltic sea area. In this thesis I analyze the effects of natural, environmental and manmade changes. I studied evidence of how the changes impact the Baltic sea and provide insight on the current status and what is needed in the future. I will shortly go through some effects of agricultural and economic aspects as well as planetary changes. I will compare how things are done in the surrounding countries to the Baltic Sea to other continents and countries. I researched the climate change topic as I based my study on factual evidence.

The responsibilities of the surrounding countries are often critical in impact and are planned through organizations, politicians, scientists, other specialists and partners. The actions of an individual play a critical role on the overall effects on the health of the Baltic Sea. It is important to know at least the basic effects of actions and how they affect the sea. New research about climate issues and earth changes are crucial in trying to solve what actions need to be taken and how to prepare. Ecological energy, products and living are important trends around the world which affect the current conditions and how to prepare in the future. The results I found about climate change conflict with the accepted norm. I placed focus on factual evidence and considered both viewpoints on the issues. Research about energy production led me to see how the future is planned to be in cooperation with surrounding countries of the Baltic Sea. Research and technology advances regarding climate issues are still lacking, but in some fields, actions have already been taken.

Keywords: Climate change, the Baltic Sea, Earth changes, Sea protection, Green energy, Environmentalism

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Tommi Luoma

ILMASTONMUUTOKSEN VAIKUTUKSET ITÄMEREEN JA KUINKA VARAUTUA KESTÄVÄLLÄ TAVALLA

Ilmaston muutos ja sen vaikutukset ovat kasvava huolenaihe. Vaikutuspiiriin ei kuulu vain eniten kärsivät maat, vaan koko Maapallo. Historiassa ilmasto ja maan muutokset ovat paljon kiistelty, puhuttu ja tutkittu aihealue. Kokonaisuuden laajista vaikutuksista Itämereen on otettava huomioon muitakin tekijöitä kuin ilmastonmuutos.

Itämeri on ainutlaatuinen murtomeri. Sen vastustuskyky ja resilienssi on alhainen pitkäaikaisiin ja monipuolisiin stressitekijöihin. Ekonomia, energian tuotanto, maanviljelys, ympäristön muutokset, valtava valuma-alue, ympärysmaiden vaihteleva ympäristöpolitiikka, ilmasto, ja pitkän aikavälin luonnolliset muutokset kuten magneettikentän vaihtelut ja mannerlaattojen liikkeet vaikuttavat meren terveyteen.

Ihmistoimintojen kokonaisvaikutukset voivat antaa merelle joko pitkäikäisyyttä ja suojelua tai pahimmillaan aiheuttaa meren täysivaltaisen tuhoamisen ja saastumisen. On hyvin tärkeää ylläpitää eettisiä ja toimivia lakeja sekä varmistaa niiden täytäntöönpanoa kaikissa ympärysvaltioissa, yrityksissä, organisaatioissa ja muilla yhteistyökumppaneilla. Taakan jako tasaisesti ja reilusti on myös erittäin tärkeää.

Tässä opinnäytetyössä käydään läpi, kuinka ennakoida ja valmistautua tuleviin ilmastouhkiin ja Maan muutoksiin Itämeressä. Käyn läpi keskitetysti ympäristön, luonnollisten, ihmislähtöisten muutoksista sekä vaihtelevien tietojen ja faktojen vaikutukset. Puhun lyhyesti maatalouden, planetaaristen muutoksien, ja ekonomian vaikutuksista. Tutkin merien suojelua ja hallintaa muissa maissa, organisaatioissa ja maanosissa.

Ympäröivien maiden vastuut ovat usein vaikutukseltaan kriittisiä toiminnan suhteen, ja ne suunnitellaan organisaatioiden, poliitikkojen, tiedemiesten sekä muiden asiantuntijoiden ja yhteistyökumppanien kanssa. Yksilön teot vaikuttavat suuresti Itämeren tilan kokonaisterveyteen. On tärkeää tietää yksittäistekojen perusperiaatteet ja miten ne vaikuttavat mereen. Uudet tutkimukset ilmasto-ongelmista ja Maan muutoksista ovat tärkeitä selvittäessä, miten toimia ja varautua. Ekologinen energia, tuotteet ja asuminen on tärkeä trendi ympäri maailmaa, joka vaikuttaa olosuhteiden nykytilaan ja siihen, miten valmistautua tulevaisuudessa. Tulokset ilmastonmuutoksesta ovat hyväksytyn normin vastaisia. Kuitenkin keskityn faktoihin ja käyn läpi useamman näkökulman liittyen ongelmiin. Tutkimuksessani energian tuotannosta selvitin tulevaisuuden keinoja ja kuinka kyseisiä keinoja tullaan käyttämään eri maissa. Tutkimukset ja teknologia ilmasto-ongelmiin on tällä hetkellä vielä vajavaista, mutta kehitystä ja valmistautumista löytyy tietyillä osa-alueilla.

ASIASANAT:

Ilmastonmuutos, Itämeri, Maan muutokset, Meriensuojelu, Vihreä energia, Ympäristönsuojelu

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1 INTRODUCTION

For the topis of this thesis, I chose climate change and how it affects the Baltic Sea and all the surrounding countries because it's wellbeing should be concern for all who use it. All the seas of the world in a similar sense are important and should be taken care of as some changes can be irreversible and threatening. The topic of climate change has been discussed for decades, always changing and the focus changing from one topic to another. I found it and finding solutions for the multiple problems the changes cause an important topic of study.

Finding out about all the factors that affect the changes our planet goes through, and how they affect the climate, is in a grand scale a new topic for researchers and the information necessary to assess the different situations can be challenging to compile, and the causes and effects can be hard to pinpoint.

The research and discussion about the topics can be seen in different conflicting viewpoints and I find it concerning that some topics are underrated while others are accepted as the truth. In science, consensus is irrelevant, and what is relevant is reproducible results. The greatest scientists in history are known because they broke the consensus. Consensus is invoked only in situations where the science is not solid enough (Crichton, 2019). In my thesis, I aim to provide factual evidence and discussion about the important topics of climate change and research. The environmental sciences are intertwined with other fields of study and different organizations and countries have varying approaches to the issues. I found it important to connect these fields in a way that is fair and tries to be net positive in all aspects. The ways for improvement I found in the research are a guideline for action.

The thesis focuses on giving an insight into important topics such as what kind of research should be done in the situation of Baltic Sea, how to predict the future changes and what is the best way to be prepared for the coming challenges in the field of environmental sciences. According to HELCOM (Helsinki Commission, an intergovernmental organization working to protect marine environment of the Baltic Sea) many issues brought by climate change are still under research and an action plan is being formulated.

The core studies of my thesis include basic information of the current status of Baltic Sea, how it has been in the past and how it is predicted to be in the future. I start with the topics of the current status of the sea and what are the main issues of concern. I focus on environmental threats with weight on climate change as I believe it is the most important issue the sea currently faces and will face in the future. I delve into the topic of the threats contaminants and possible new compounds have and will have for the sea. Next, I go to the history of international research to give a viewpoint on how things have once been and how relations have advanced since then.

Protection is the final topic of this thesis and I cover current regulations, directives and how environmentalism with product development can drive the discussion and research into the right tracks. Finally, I focus on green energy and the choices and possibilities the alternatives provide. An interview with HELCOM gave me some insight from an organization with a long history in working for improving the state of the Baltic Sea.

Sometimes aspects such as economical obstacles or natural occurrences cannot be overcome and instead another solution must be found. Solutions can be unknown at the present or currently being researched. Therefore, it is important to fit the right kind of puzzle piece in the grand scheme of improvement.

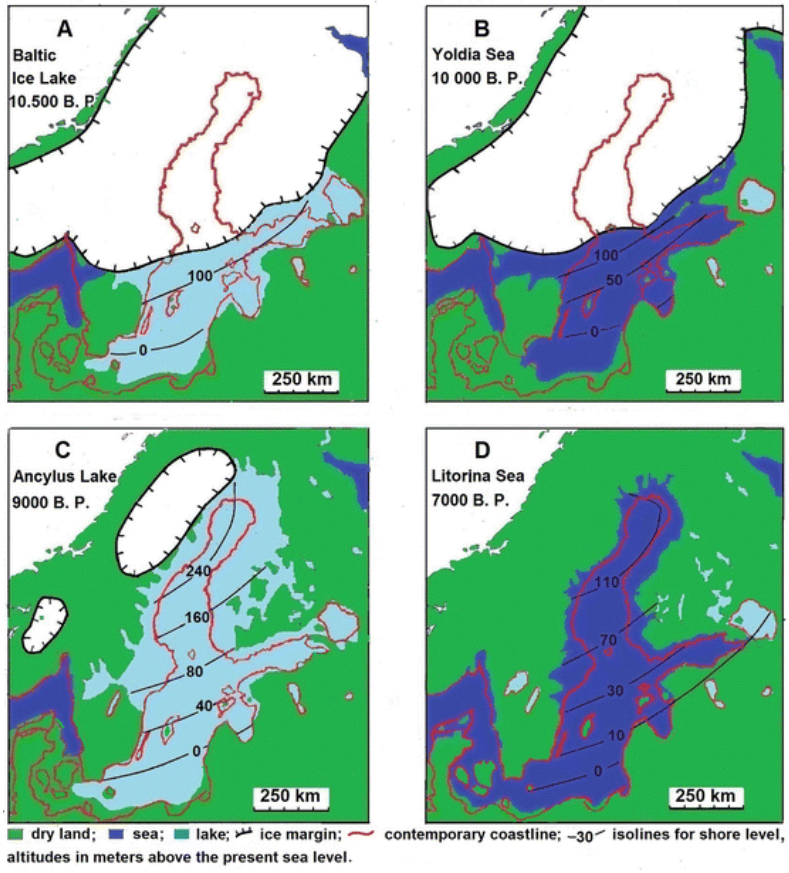
2 HISTORY

The importance of nature and how to take care of it has always been critical to the advancement of human evolution. For thousands of years, human life has been living hand to hand with nature. Intellectual advancement, cultural growth, strong will and hope for a better tomorrow has always sparked more ways to improve life and to make civilizations flourish.

The seas of the world have been used since the beginning of mankind to provide a means of living and travel. Life in the sea has been evolving in its own cycles and is at the same time fascinating, wondrous and dangerous.

2.1 The recent history of the Baltic Sea

The Baltic Sea is a depression in the Eurasian continental plate. It was formed through a series of postglacial progressions. Starting from the The Baltic Ice Lake about 10,000 bp (before present) until the Littorina Sea which lasted for 7,800-4,500 bp culminating at the present Baltic Sea. The Baltic Ice Lake was a less saline phase in the history following with a phase called Yoldian Sea, and the Ancylus Lake and Littorina Sea phases after that. Development into the Baltic Sea we currently have can be seen in the Picture 1.



Picture 1. The Development of Baltic Sea (Springer)

The salinity of the Baltic Sea used to be much higher in the past compared to today, but it has always been less than the level of a great ocean during its sea phases. (Myrberg & Leppäranta 2019, 12.) During its more lake-like phases, the sea has been more like the freshwater lakes we have in modern days.

The Baltic Sea has been at the current level for about two thousand years with minor changes to the natural landscape. In the northern areas, the post-glacial rebound of the land is at the most noticeable level, 10-20 meters in two thousand years. The Fennoscandia glacier started to withdraw at the end of the the last interglacial period called the Eemian. The temperature was 1-2 degrees higher than our current one, with Greenland's temperature being 5 to 8 degrees higher and that of the Antarctic 3 to 5 degrees above preindustrial levels, with possible spatial and temporal sampling biases. (Dutton *et al*.: 2015.) During the colder climate seasons the area was covered by a continental glacier. The Baltic Sea and the neighboring countries were at times covered by glaciers, and sometimes free of ice in a tundra-like climate. (Myrberg & Leppäranta 2019, 8.)

2.2 Planetary changes

Changes in our planet are affected by multiple variations, such as the activity of the Sun, magnetic field changes, core activity, and outer factors such as how the planets in the solar system affect the Earth. It should be noted that change is the only constant for our planet as everything has changed in our planet during its history. How these changes affect the life forms can be inspected and studied through research in history and predictions to the future. Glacial periods, warm periods, pole changes, quality changes in substances and organisms are all part of the history and can be expected to be part of the cycle of our future as well.

“Changes in the Earth's orbital parameters from today (greater obliquity and eccentricity, and perihelion), known as Milankovitch cycles, probably led to greater seasonal temperature variations in the Northern Hemisphere” (Berger et al.: 2006). The Milankovitch cycles describe collective effects of the Earth’s movements affecting the climate that explain long term effects on climate and are used in researching effects of orbital forcing, how past climates changed and how solar radiation contributes to the earth changes. (Berger *et al*.: 2006, 131–136.)

These cycles, pole movements, past glacial periods, magnetic changes, extinction events and sun activity all play a role in the total changing of our planet. Currently the effects are studied and reliable models are made to describe what has happened during the history of the Earth and how those same factors could be applied in modern day research fields, and what they can tell us about the global warming and climate change.

Planetary changes usually take centuries or longer to show an impact so they are not as immediate as some of the challenge’s climate change brings but can in combination make climate change more effective or decrease the effect in some areas. However, the effects are considered currently to be minor when compared to changes that human actions bring.

3 GENERAL FACTS OF BALTIC SEA

3.1 Surrounding countries

There are nine countries that border the Baltic Sea and a total of 14 countries in the drainage basin. The area of the drainage basin is roughly four times the surface area of the sea itself. (Myrberg & Leppäranta 2019, 25.) The Baltic Sea drainage basin covers more than 1.7 million km^2. The biggest landscape for the drainage basin consists of forests (48% coverage), second largest area is arable land (20%) followed by non-productive open lands (17%). The majority (60%) of the forest land is owned by Sweden and Finland and most of the agricultural land is in Poland. Eight percent of the drainage basin is covered by wetlands. (Sweitzer *et al*.: 2020, 2-3) The size of the basin covers a big territory as shown in picture 2.

Picture 2. The Baltic Sea and the surrounding countries (HELCOM)

85 Million people in total live by the Baltic Sea drainage basin. 22 million of those live within metropolitan areas. Roughly half (45%) live in either towns or small cities. 29 percent of the area is rural. (Sweitzer *et al*.: 2020, 2.) The landscape is expected to

change in the future and overall population and industrial growth is expected. As the area is large, the factors of individual impact must be considered. With increasing technological advances, changes that will happen in individual behaviors in the personal life and consumer behaviors should be added into how everything affects gradually overtime in the whole area of the Baltic Sea region.

3.2 Salinity and water circulation in the Baltic Sea

The term brackish water is used to describe waters that are between the salinity levels of lakes and seas. The requirement for the salinity is to be over 1 promille but less than 25 promilles. The salinity levels of The Baltic Sea change from the varying sea areas of the Gulf of Bothnia 4-6 ‰ to 7-12 ‰ in the central pools and over 25 ‰ at the Kattegat area. (Myrberg & Leppäranta 2019, 24.) Brackish water seas are rare and the species that have adapted to the conditions of the sea are few and vulnerable to changes.

The balance sheet for the fresh water is positive, which means that the sea gains more fresh water than it evaporates. The saline water of the Baltic Sea is stratified. The salinity of the water makes it heavier and the heavier water makes the water rotation in vertical depth very difficult. (Myrberg & Leppäranta 2019, 30-31.)

Saline waters challenge the life of all life forms in the different layers of the sea. As species must adapt or migrate when the salinity levels change, alien species and succession modify the landscape to form a new one that suits the winning species. The number of species in the Baltic Sea is low and rapid changes can bring exodus to the few accustomed locals, also with danger of becoming endangered.

Full circulation is an important phenomenon, and it is especially important for the life of a lake. Circulation happens in the spring and fall, and it mixes up the body of the water from the surface to the bottom. Lakes can be classified by the number of full circulations they go through. (Myrberg & Leppäranta 2019, 29-31.) Circulation in the Baltic Sea is different from the circulation that happens in lakes due to the salinity of the water, and circulations happen in lakes connected to the Baltic and affect portions of the sea through long term changes. In smaller areas of the sea, the Kvarken for example, circulation occurs in flads and gloe lakes more consistently.

What makes the sea especially vulnerable is the fact that the water turnover is slow, and the sea is very shallow. The average depth of the Baltic Sea is 54 meters, and the

deepest spot is 459 meters at Landsort's depth. Only once in 40-50 years the waters turnover from the North Sea and through the narrow straits of Denmark. (Myrberg & Leppäranta 2019, 24-31.) These strong saltwater currents are called salt pulses as the effects are displayed in Figure 1. The inflow brings in water containing high levels of saline and oxygen which mix with the lower layers of water with depleted oxygen. The bottom water eventually turns into uplifted formerly highly saline bottom water as can be seen in the Figure 1.

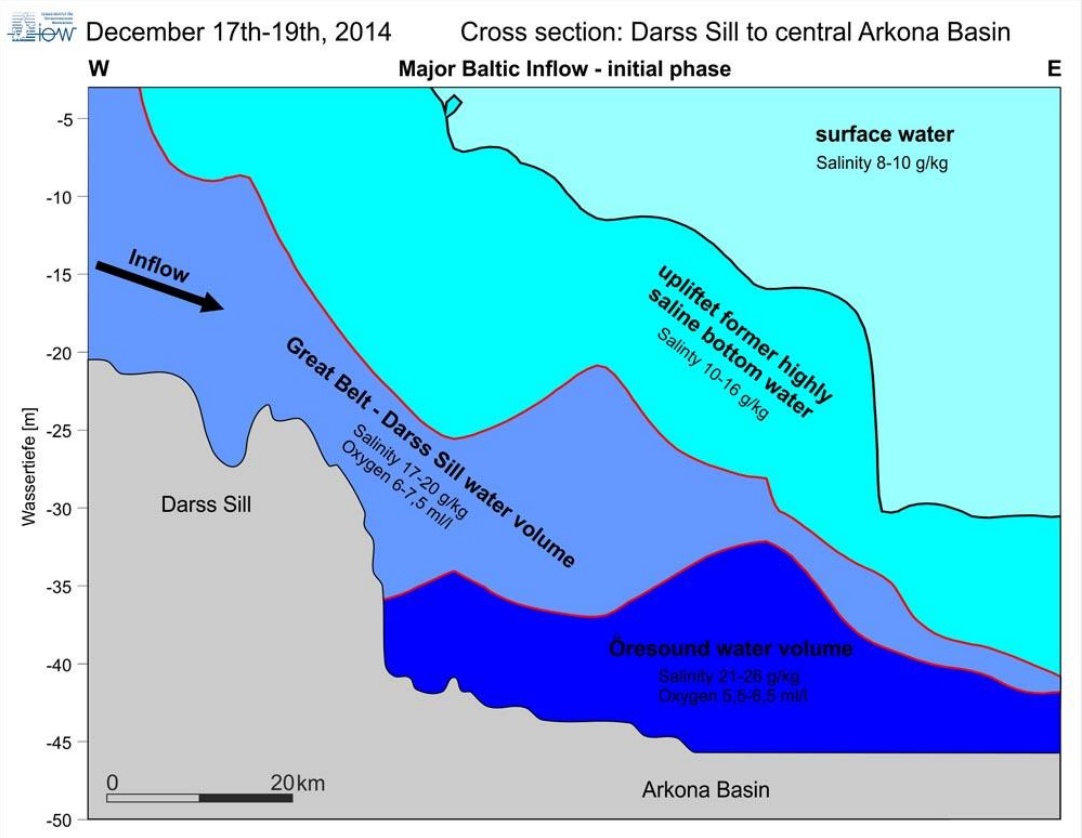


Figure 1. Saltwater inflow through Darss Sill to Arkona Basin. (Baltic inflow of December 2014.)

3.2.1 Sea to lake transformation in the Gulf of Bothnia

The slow water turnover is a great reason why the waters stay at certain salinity levels and why human actions cannot reduce the amount of water circulation or salinity changes to a great extent. Being a naturally occurring event, the waters are becoming less and less saline over the years and it is happening at an accelerated rate in the Bothnian Bay. With glacial rebound it is possible that in the next couple of thousand years

the sea could turn to resemble a lake which is familiar to the area from the recent lake-like phases. These phases can already be seen on a smaller scale in the area of Kvarken Archipelago.

Flads and gloe lakes are a type of a brackish lagoon typical to the flat land of the Finnish part of the Kvarken. The process happens in four stages where the saline bay slowly turns into a lake with less and less impact from the saline sea water. These part sea, part lake flads turn into gloes with no contact to the sea except during high tide or storms. A gloe turns into a gloe lake when all contact to the sea has been lost. (Ympäristö, 2020.) This can be seen with a long history in the Eastern Finland with its thousands of freshwater lakes formed from the Ancylus Lake. It remains to be seen how much the climate change and the polar melt will nullify the effects of the glacial rebound.

3.3 Annual freezing and the effects of reflectivity

One of the special qualities of the Baltic Sea is the freezing of the ocean. There are only a handful of seas on Earth that get an ice cap annually. The icy winter of the Baltic Sea lasts from six to seven months in the northern parts with no winter at all in the southern parts. (Myrberg & Leppäranta 2019, 35.) The ice formation starts usually during October-November from the coasts of the northern Bay of Bothnia and the inner Gulf of Finland. The Ice spreads to the Quark, Bay of Bothnia and the coasts of Sea of Bothnia.

During normal winter, the Sea of Bothnia, the Archipelago Sea, the Gulf of Finland and parts of northern Baltic Proper have an ice cover. In mild winters there is no ice at The Sea of Bothnia and only partial ice cover on the Gulf of Finland. During severe winters however the ice covers the Danish Sounds and the central Baltic Proper, with the last area of freezing being north-east of Bornholm. The melting season usually starts in April from the southern parts up to the northernmost parts of the Gulf of Finland. At the beginning of May there is ice left only in the northern Bay of Bothnia with the remaining ice melting by June. (The Nautical Institute, 2020.)

Albedo means the reflectivity of a surface with a numeric value from 0% to 100%. Snow and ice have high reflectivity with 90% of the sunlight returned to space. Sea water however has low reflectivity with under 10% reflected and the rest of radiation absorbed by the water. This logic applies when thinking about the overall warming of the sea as the “white sea” stays cooler and the “dark sea” warm. Worldwide, the reflectivity is a

small thing, but in The Baltic Sea its effects are severe as it is a large sea with a floating ice cap during winter. (Smith 2010, 164-166.) If the predicted glacial melt continues at the expected pace, more warm sea water and decreased ice cover is eventually going to be only partial to that of what it is today.

4 ENVIRONMENTAL THREATS

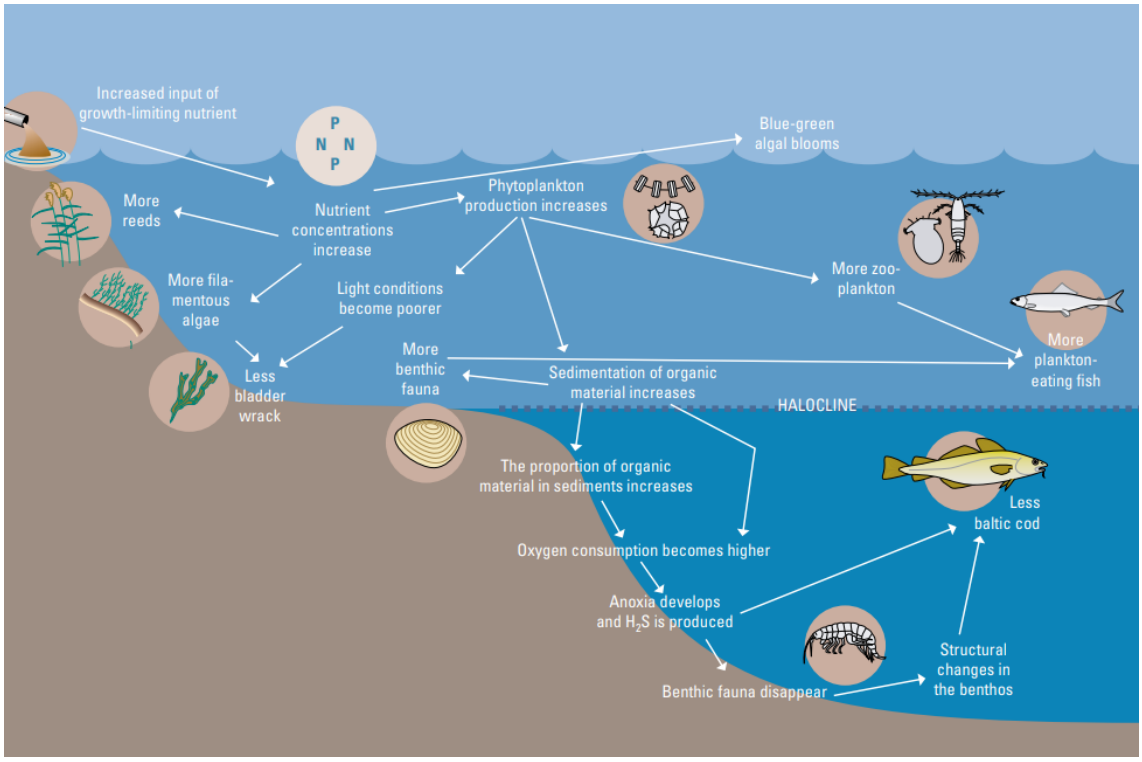
Climate change and minor changes in the global environment could cause problems to vulnerable seas like the Baltic Sea even with minor alterations. Extra care is necessary with man made changes in the sea and the surrounding countries.

The effects and causes of climate change are a widely discussed subject with research about everything starting from the core of the earth to the upper atmosphere and effects. Man made changes affect the environment without a doubt, but how much effect do they have? A lot of research has been done on certain factors of effects and to finding out what does have a known effect and what needs to be taken into consideration when planning protection and unified rules for all the involved countries.

4.1 Eutrophication

Aquatic life needs a sustainable source of nutrients to maintain stable growth. When there is an abundance of nutrients the plants and species begin to form altered growth and forms. The Baltic Sea has a eutrophication problem with nitrogen and phosphorus and combined with other factors limiting the resistance and resilience of the sea they have major effects on the total eutrophication. Anthropogenic nutrient input is the main cause for eutrophication but natural processes, such as capacity and release of internal phosphorus in the sea and atmospheric nitrogen(N_2) deriving from blue-green algae make the effects multiplied. (Furman *et al*.: 2013, 55.)

From a human perspective, eutrophication has positive and negative effects with often the effects being positive up to a certain threshold. Increased primary production with ever increasing zooplankton overflow, benthic fauna and fish that can utilize the increased plankton results in increase for the following fish catches. Picture 3 shows an overall process of how eutrophication occurs.



Picture 3. Processes of eutrophication (The Baltic Sea 2013)

An increase in eutrophication ultimately causes the negative effects to start taking over the positive aspects. The effects on the ecosystem become increasingly challenging. Algae blooms follow the planktonic algae growth which are a frequent phenomenon seen in the Baltic Sea. When algae blooms increase the harm to ecosystem, and the harm becomes greater than what the positive changes provide.

Massive algae blooms occur during peak seasons and are harmful to the recreational and economical resources the sea provides. Toxics appear during algae blooms, some of which are harmful to the health of animals and humans. A good example is cyanobacteria produced by the yearly blue-green algae blooms. Increases in turbidity caused by eutrophication lead to a decrease in water transparency as penetration of light is lowered. (Furman *et al*.: 2013, 55.)

During algae blooms algae mats are formed from both living and dead material. The mats eventually settle on the seafloor in well covered places. Decomposition follows which depletes the oxygen in the lower water layers. Poor oxygen conditions affect benthic faunal communities with the effects growing more severe with lowering oxygen levels. Sedimentation increases with the primary production as more organic material is released in the deeper levels with the deepest areas acting as a material sink. Anoxia is

a condition where the water is completely depleted of oxygen. With oxygen gone, the bacteria start releasing hydrogen sulfide (SO_x), which is highly toxic. Under anoxic conditions, phosphorus is released from the sediment into the water column which in turn further increases the blooms of blue-green algae. Nutrients have been deposited in the bottom sediments over thousands of years, the rate of sedimentation and thus the amount of nutrients being stored has increased greatly due to anthropogenic inputs of nutrients in recent decades. In the 20th century the sedimentation rate has increased by 60%. The living conditions become nearly impossible with the life slowly fading as fish move away to more suitable areas, and the benthic fauna massively dying due to lack of oxygen. Eventually the sea floor is devoid of life. (Furman et al.: 2013, 55.)

4.1.1 The vicious cycle

Anthropogenic input of nitrogen and phosphorus as well as the internal loading which happens naturally can both be due eutrophication. The interconnected, potentially self-sustaining process is called the vicious cycle and the Baltic Sea especially suffers from it. The cycle is hard to break without reducing both anthropogenic nitrogen and the phosphorus load forming under anoxic conditions in the deeper layers. So, reducing the anthropogenic nutrient load leads to reduced internal loading. (Furman *et al*.: 2013, 56.)

The accumulation of nitrogen is great from the agricultural diffuse load and from the natural background load which make it difficult to reduce. The communal wastewater phosphorus load was reducing in the 1990s when the wastewater plant technology improved. The reduction was compensated by the increase in the internal load. This has been especially noticeable in the Gulf of Finland with the wide blooms of cyanobacteria. Water protection has improved by leaps, but the coastal areas still show no improvement.

The diffuse load from the land has not decreased as it is hard to restrict: the nutrients do not come from one large source but from many small sources. The nutrients ending up in the sea continue to affect the Sea at least over the water turnover time even when the diffuse load has decreased. (Myrberg & Leppäranta 2019, 254-255.) A simple solution would be to avoid any unnecessary load getting into the Baltic Sea from the agricultural outputs. According to the interview with HELCOM, such maneuvers are currently being implemented. Farmers are given recommendations in using closed loop system farms where no point source releases would occur, however seasons, rain, and unpredictability

prove to be a challenge to the current action plan. An updated plan is to be released in 2021 with an improved management strategy. (Littfass 2020).

4.2 Climate Change

The climate of planet Earth has always been changing. Species either adapt or go extinct from the effects. Currently the Earth is still recovering from the last ice age that happened at the end of the Eemian period c. 115,000 – c. 11,700 years ago. Even the "small ice age" from 1450 to 1850 with much colder climate than average is currently affecting the recovery. During the 20th century, the temperature increased by one Celsius, more in the northern parts. The debate about man influenced effects on the climate started at the end of 1900s. Generally, researchers agree that greenhouse gases, particularly carbon dioxide, have affected the warming of the climate. (Myrberg & Leppäranta 2019, 273.)

Multiple studies have been done about the impacts of climate change on different spheres of influence. Research about the extinction of species predict that 15-37% of our current species are going to be extinct by 2050 if the increasing climate trend continues. (Thomas *et al*.: 2004, 145-148.) Combined with the previous extinctions during the last glaciation it would be the sixth great extinction on Earth. The last one was 65 million years ago in the Cretaceous period that ended the dynasty of dinosaurs. (Smith 2010, 172.)

As the temperatures rise the species in the northern and mountain areas will have to move to less habitable areas. An indirect mechanism is the separation of dependent species in the food chain when the cycle of biological functions is disturbed. Another indirect mechanism is that the increasing temperatures enable pests, accelerated succession, competing species, easier adaptation for alien species, increase in diseases and the rapid growth of general species like rats and raccoons to overtake more region distinctive species. One more mechanism is the fast pace of the climate change. The change is so rapid that some of the more lasting species like trees will not be able to adapt. (Smith 2010, 172.)

By the end of the century, in predictions about CO_2 emissions, 10-48% of the surface of the Earth will have lost its current climate and 12-39% of the surface will have developed a new and unprecedented climate, especially in the tropical and subtropical zones. (Williams *et al*.: 2007, 5738-5742.)

Long term effects include the position of the Earth, orbit, changes in solar radiation, the division of the seas and continents and the position of the largest mountain ranges. Volcanic activities also have their own effects on local climates. (Myrberg & Leppäranta 2019, 273.)

4.2.1 Ethical environmentalism

Climate change is a moral issue to many as one must consider the future and the life of others and what the current day humans give or leave for the future generations. In the recent decade, climate action plans have taken a more prominent role and companies and countries are taking action to prepare for the changes. Fight for the cause has sparked a lot of conversation, research and different views as to what would be the best way for deal with the coming changes.

Being the cover image for climate change, dying polar bears and melting polar ice have driven the hearts and minds of people to a certain direction to act in preventing such drastic outcomes. However, sometimes the media driven topic can be damaging to the local communities. The US Geological Survey estimated the global population of polar bears at 24,500 in 2005. In 2015, the IUCN Polar Bear Specialist Group estimated the population at 26,000 (range 22,000–31,000) but additional surveys published 2015–2017 brought the total to near 28,500 However, data published in 2018 brought that number to almost 29,500 with a relatively wide margin of error (Crockford 2018.) The Inuit researchers in Nunavut are also disagreeing with other scientists and going as far as labeling environmentalists and scientist as the enemy.

An editorial in Nunavut newspaper had some harsh words to say about the current situation. In Nunavut, the damage that environmentalists have inflicted on their cause will likely last for generations. Growing numbers of people in Nunavut not only believe polar bears are a threat to public safety, but also believe that scientists and government wildlife managers are their enemy. On that last point, the condescending attitudes of some researchers and government officials have been rather less than helpful. For example, the federal Department of Environment and Climate Change stated last fall, in a submission to the wildlife management board, that the Inuit position is ‘inconsistent with the federal listing of the polar bear as a species of special concern in Canada.’ That tone-deaf response simply reinforces the Inuit belief that governments value the lives of polar bears more than they value the lives of human beings. (Bell 2019.)

The Inuit's also have political power in Canada to legislate such changes that will be taken into action whether the scientists and federal officials agree or not. The implications are huge as two-thirds of the world's polar bears live in Canada and most of them in the Nunavut area. (Crockford 2018.)

Some aspects have taken a turn for the worse. Science should stay in a field out of personal biases, fiction, politics, manipulation and stay true to the evidence. As an example, these studies done in Nunavut prove that some research with conceived facts can be harmful to the local environment.

4.2.2 New sources for warming.

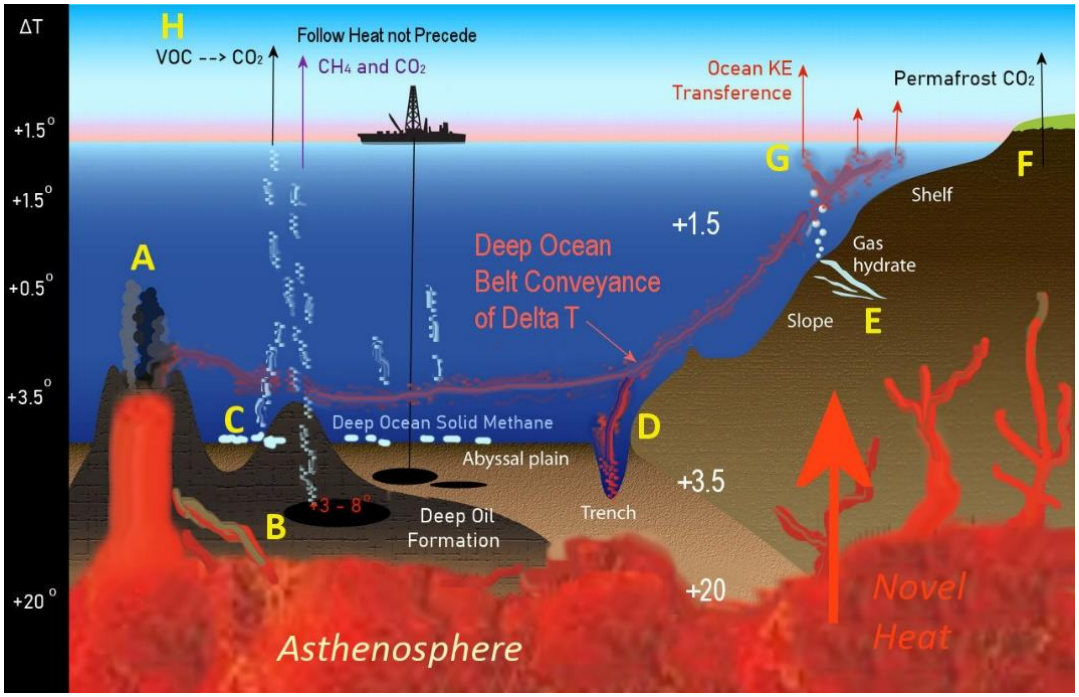
New reasons to the changing climate are still being researched and as more information is uncovered, certain factors can be added to the total function of climate change. The impact the Sun has on the climate of our planet has been studied recently and it was concluded in model calculations by the Swiss National Science Foundation that the fluctuations in solar activity could have a tangible impact on the climate. Studies conducted by the Foundation expect human-induced global warming to tail off slightly over the next few decades. It is also expected that the next solar maximum will increase the temperature in similar sense. (SNSF 2017.) It is difficult to quantify exactly how much these solar activities will affect our climate.

Another study done by a team of researchers at the University of North Umbria predicted that the Earth could be heading to a "mini-ice age" in 15 years. The study was done based on predictions from a new model that shows the activity of the Sun. The model studied the solar pattern of the last 11 years. Based on the solar cycle pattern data, the device predicts that sunspots could decline by nearly 60 percent by 2030 which would lead to a mini-ice age. Same kind of an anomaly was experienced during the Maunder Minimum period in 1645-1715 which led to colder than usual winters. (Bhatia 2015). The same kind of history for warming or cooling of the climate can be seen in the history as these periods have been a natural cycle for Earth. When thinking about climate change and pondering on reasons, every aspect must be included to have a conclusive answer as to why the climate is warming up.

A study that was recently done centers in the core of Earth and how the changes in the core affect our seas, climate and magnetic fields. The study concludes that the Earth's

core is undergoing extreme exothermic change where it is shredding high-latent-energy hexagonal close pack (HCP) iron into the mantle where it converts to face centered cubic (FCC) iron. The exothermic heat content from this eventually reaches the asthenosphere. Ancient abyssal ocean conveyance belts pull novel heat content from small footprint yet now much hotter contribution points exposed to the asthenosphere – and convey this novel heat content to the surface of the ocean. Oceans in turn heat the atmosphere much more readily than the atmosphere heats oceans. (The Ethical Sceptic 2020.)

Picture 4 describes the process in which the energy travels from the asthenosphere to the atmosphere through all the phases. Magnetic permeability of the Earth's inner core falls, which leads to Earth's magnetic field weakening and the geo-magnetic north begins to wander in position. Schumann Resonance, which is a set of spectrum peaks in the extremely low frequency portion of the Earth's electromagnetic field spectrum, (NASA 2013.) ranges into higher and higher amplitude power-bands, which historically correlates with higher global temperatures.



Picture 4. Heat transfer from asthenosphere to the atmosphere

4.2.3 Climate change in the Baltic Sea

In the northern areas habitat losses and pollution is not as big a threat as in other countries like China and India. The coniferous forest area, tundra, and mountains contain part of the wildest and the least man affected areas. As the ecosystems and the food chains are connected in multiple and complex ways, the changes cause side effects that are unknown to us.

The special features of the climate of the Baltic Sea are also an outcome of its unique location. The Baltic Sea is next to the marine climate of the Atlantic Ocean and the continental climate of Russia. Human activities have affected the climate since the beginning of known history. Forestry, irrigation and animal herding have been practiced for various reasons over the centuries. The industrial era saw the effects stronger than before with the increase of various greenhouse gases, small particles, atmospheric toxins and the changing land use.

It is predicted that from the 2000 to 2100, the temperature in the Baltic Sea will rise by 2-4 Celsius. If the rains increase, it will lead to changes in the sensitive ecology of the sea. With the warming climate the ice levels of the icecap will decrease and grow thin, but will not completely disappear, unless a dramatic change occurs. The decrease in ice would cause spring blooming of phytoplankton and that would in turn lead to changes in nutrient distribution and spring algal blooms (Myrberg & Leppäranta 2019, 274.)

Major reasons of why the climate change is so radical in the northern latitude is the melting of sea ice as the open sea releases heat and the milder air currents warm the southern colder areas. The change in the albedo of the surface of the sea is one of the strongest self-reinforcing reasons to the warming of Earth. Compared to the continental ice the sea ice is thin, only 1-2 thick, weak and short lived. The greenhouse effect causes the ice to melt slightly which causes a heat amplifying circle which is stronger than the greenhouse effect.

When the melting gets stronger the increased effect causes temperature changes. The effect also works reversely so a colder temperature would cause more ice to form and with increased albedo it causes stronger local cooling, which would increase the local ice level. This effect is especially strong in the polar regions as warming or melting of the ice would cause an effect called polar amplification where the melting poles would release more and more warm water and air to other areas. (Smith 2010, 165-167.)

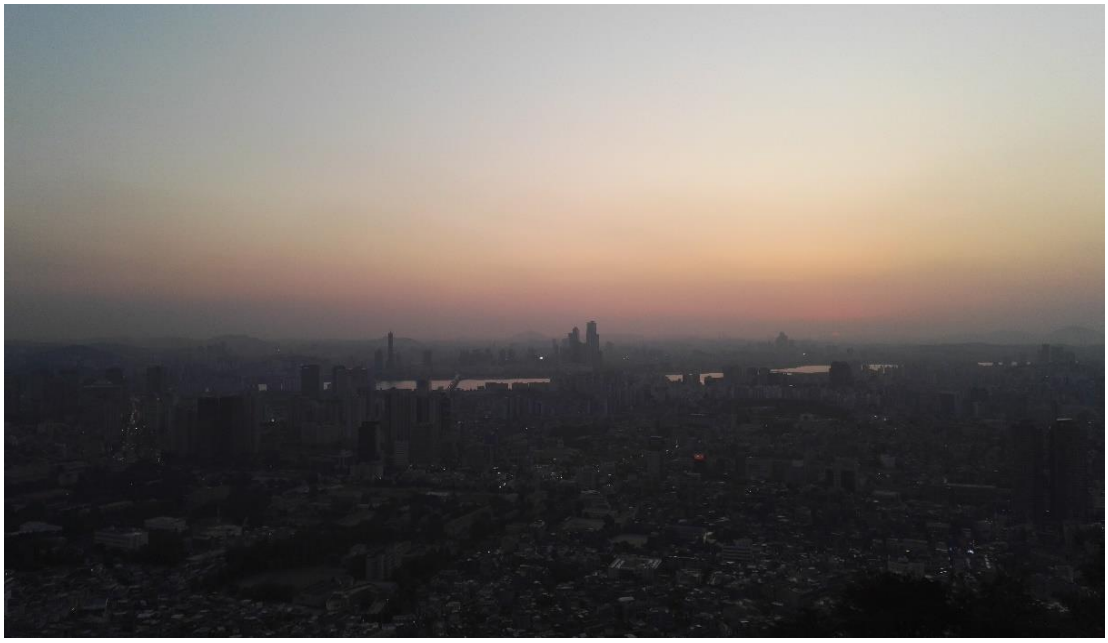
The predictions for rains in most countries of the Earth is hard as cloudiness and rainfall amounts are hard to calculate. This however does not apply in the northern regions, as all of the climate studies agree that the rains increase in the form of either snow or rain especially during winters. (Smith 2010, 162.)

By the laws of physics, the rains must increase, as when the lakes and the sea are unfrozen for longer, they release more water vapor (Clausius–Clapeyron relation). Effectively this will be increase in the snowy winters and more flowing rivers. This will be especially threatening in lowlands and wetlands for example in Scandinavia, Southwestern Finland and Central Russia. (Milly *et al*.: 2005, 347-350.)

4.2.4 Same Earth, multiple threats

What is undoubtedly true is that the changes brought about by the climate change prove to be one of the greatest challenges to mankind. What we know, what we can do and what we should do are the greatest questions at hand. Problems we face are manifold, and the resources we can place on fighting these problems are sparse and usually not enough. Countries and continents have their own challenges and ways for combating the problems, like the main issue being eutrophication in Baltic Sea. Many countries lack resources to do anything about the problems they have. Research should be put on factual evidence and should be aimed at growing issues like pollution, the energy crisis and overpopulation.

Emissions prove to be a threat to the climate of the Earth. Pollution, environmental dangers and natural threats have been increasing at a steady pace, although changes for reductions have started. At the present, in countries like South-Korea, India and China the problems are already causing widespread preparation since the effects have been severe for decades. Pollution has been causing massive health problems ever since the start of industrialization. It causes the sky to be obscured in mist like smog due to the high concentrations of pollution it contains as seen in Picture 5.



Picture 5. Air pollution is almost constant in South-Korea.

Citywide warnings are given due to the high level of pollution. While natural disasters can be catastrophic for the whole country, just as important are the preparations and research for the changes brought by the changing climate to avoid the coming threats like unexpected tsunamis, earthquakes, wildfires, volcanic eruptions, hurricanes and other threats known to mankind. These other more known threats include hunger, overpopulation and energy crisis. Models have been done predicting the future with current phases. Preparation is necessary to prevent catastrophic events.

4.3 Contamination

The Baltic Sea is one of the most contaminated seas. It receives a large portion of man-made contaminant substances. What makes the situation worse is that the substances

dilute over a small portion of water and the exposure time is long as the water turnover time is long. That makes the sea especially vulnerable to contamination and the protection measures affect the sea with a delay. The Baltic Sea draws contamination from a drainage basin that is four times larger than the sea itself. The load from all these countries has been large and long-lasting. The differing economic and social standards have affected efficient waste management and agricultural fertilizer regulations in some countries. (Myrberg & Leppäranta 2019, 248.)

Seas were used as garbage yards before the 1960s. For that reason, there used to be and still are a lot of trash like bottles, tires, plastic containers and all kinds of small trash in the bottom of the sea and beaches. The long-term effects from the catastrophe of the Chernobyl nuclear power plant are still measurable as radiation in the Baltic Sea and its inhabitants. It will take multiple years for the readings to get to pre-Chernobyl levels. (Myrberg & Leppäranta 2019, 261-263.)

The contamination in the recent years has been controlled by the countries and non-governmental organizations but the effects from the last century are still influencing the current conditions. Every source of emission that has occurred or happens now takes years to completely circulate, with some sources being more permanent. An example would be the highly toxic chemical weapons that were dumped into the sea during the Second World War. (Obluska, 2019).

4.3.1 Harmful substances

The reasons for accruing harmful substances are the same as for the eutrophication: the large drainage basin, relatively small size and slow water turnover time. In addition, the cold climate slows the dissolution of the substances. That in turn promotes the spread and accumulation of the most dangerous substances in organisms on top of the food chain. The chemical contamination of the sea peaked in the 1960-1970 decades. The classic environmental toxins – mercury, DDT (Dichlorodiphenyltrichloroethane) and PCB (polychlorinated biphenyls) caused great damage to marine mammals and birds.

Heavy metals include a lot of important micronutrients, but too high concentrations make them harmful. This applies to iron, copper and zinc, for example. The conditions for the organisms regarding heavy metals in the Baltic Sea have improved noticeably. The concentration of heavy metals in the bottom sediments rose during the industrial era, but

currently the amount is decreasing. Dioxins are one of the most harmful substances. They come from the paper, metal and chemical industry, from the use of fossilized fuels and traffic. (Myrberg & Leppäranta 2019, 258.)

4.3.2 New compounds

Even when chemical contamination from the known substances is in control, new problems arise with new compounds whose negative effects are unknown. These new compounds include bromine, fluorine, plastics, medical waste, cosmetics, drugs and air pollution. Micro and nano sized particles are also a huge threat to the sea and the research on the effects are new and inconclusive. The fallout to the Baltic Sea from the Central and Eastern Europe is unaffected by the influence of the surrounding countries.

A large part of the harmful substances ends up in the Baltic Sea via the rivers from the businesses and in increasing amounts from the household emissions. The compounds are used in washing and cleaning chemicals, glues, solvents, corrosion solutions, paints, lubrication and coloration substances. (Myrberg & Leppäranta 2019, 259-261.)

Picture 6 Cycle of plastics (Microplastics)

Decomposition of plastics in nature is slow and requires mechanical attrition. The plastic problem is global and alarming as the production and the use of single use packages is growing. Social and economic factors affect the quality and the quantity of plastics and

the sea currents drive the plastics to open seas. Picture 6 shows the cycle of how plastics end up inside marine life.

The emissions from medicine and drug use to the sea has been under public discussion in the recent years. Drugs and medicine are still being flushed down the toilets, and the technology in the water treatment plants is not advanced enough to remove the drug residues from the wastewater. Antihypertensives have been found from cleaned wastewater and from surface waters. NSAIDS (Nonsteroidal anti-inflammatory drugs), epilepsy medication and painkillers have been found from the sea. (Myrberg & Leppäranta 2019, 261.)

4.3.3 Oil

The knowledge from the combustion processes is mostly about dioxins and the PAH-composites (Polycyclic aromatic hydrocarbon) which are derived from oil production and its processed products. The largest oil emissions to the Baltic Sea come from shipwrecks and accidents, but the small continuous emissions from for example wastewater and illegal emissions are also a large environmental threat. (Myrberg & Leppäranta 2019, 259.)

A big part of the increased traffic in the area is caused by the increasing oil shipping in the Baltic Sea. An oil spill would be a huge catastrophe to a vulnerable sea like the Baltic Sea, and it would have wide effects to the sensitive environment and human activities. Recreational areas in the sea, beaches, travel, tourism, fishing and industrial plants that use water would have varying problems if an oil spill were to occur. Oil spill response must be quick in order to prevent cumulative effects of spreading in the long term. To effectively prevent the problems, it is necessary to have a good enough oil spill countering vessel capacity in all the coastal countries of the Baltic Sea. (Ulkoasianministeriö 2010, 40.)

The risk for an oil related accident increases annually with increased traffic in the Baltic Sea region. An accident in the area is especially serious as the distances are long and darkness and the cold affect the oil cleaning work in the north. The catastrophe would be extremely harmful for nature as well. In the north, the growing season for plants is much shorter than in the southern areas. The resilience and resistance of the sea is a

great factor in cold areas as the negative effects are usually long term and sometimes irreversible.

The greatest way to combat oil spills according to Kirsten Jørgensen from SYKE (Finnish Environmental Institute) depends on the circumstances in the accident area and the quality of the oil. Jørgensen's advice would be to focus on multiple potential countering measures instead of having only the best choices for certain types of leaks. The weather conditions present the single greatest source for problems in the accident area. She also says that pre-emptive actions are important and how to prepare for a crisis. Having the equipment close by in case of an accident and having trained people available are major factors as well. (YLE, 2018.)

4.3.4 Alien species

Species move from the original area to new areas where they will compete with the existing species. This is natural. However, with the help of humas the moving of species from the place of origin to new areas has increased. In the recent decades, human actions have had a great effect on the invasion of alien species to the Baltic Sea. A very effective way for the species to move is with maritime transportation. In a worst-case scenario, alien species could be a threat to the future of the Baltic Sea. Worldwide they are one of the biggest threats to the diversity and uniqueness of sea ecosystems.

They also have economic effects as when a species has adapted to the new environment, disposal or control is virtually impossible. During the last 200 years at least 170 alien species have arrived at the Baltic Sea and about 80 have permanently stayed in the area. In theory, alien species can enrich the area when they do not displace the original species. Often new species must compete for the nutrients and living space and they have long term effects. In the best-case scenario, a new species can be harmless or even be a source of nutrients to existing species. Usually, however, the species cause problems as they disturb the balance of the ecosystem. The reproduction and spreading of the species are monitored closely as their ecological and economic effects can be surprising. (Myrberg & Leppäranta 2019, 264-265.)

Continuous environmental change by alien species, succession, migration or extinction can be catastrophic to the overall landscape. That is why many directives aim to limit the threats that can be brought by these factors. In the long term there may be many new

major species replacing the native ones. The whole area can potentially change to a more unhospitable environment for the native species where dramatic changes can occur.

5 INTERNATIONAL RESEARCH

5.1 International research history

International cooperation has been an important part of the history of the Baltic Sea and the effects and research done is not centered in one country or place but is a result of intertwining actions from multiple sources. Advances are made by forerunners of research, groups of dedicated scientists and explorers. During the early days of research, the people interested in research were ready to commit themselves to studying and working in harsh conditions in unmapped territories.

The Baltic Sea is one of the most studied seas in the world. With advances in the natural sciences in the 18th century, the humans begun to have a better understanding of how the Earth works. The next century brought a lot of new views such as the theory of evolution, the ice age theory and the findings of the deep-sea conditions. (Myrberg & Leppäranta 2019, 46.)

The studies of The Baltic Sea begun in 1703 in Saint Petersburg, which Peter the Great founded at a strategically important location in the mouth of the Neva river. The research of the sea level begun immediately after founding of the city as it was an important factor for a city where the water is only 1,5 meters lower than the median sea level. Marine research trips began in the 19th century when The Baltic Sea was surrounded by only four countries. (Myrberg & Leppäranta 2019, 46-47.)

During 1834, Prussian Alexander von Humboldt, a forerunner of the modern geography, was measuring the salinity and the temperature of the sea when he discovered the upwelling phenomenon which causes the surface temperature to drop suddenly due to wind peeling off the warm surface water. (Myrberg & Leppäranta 2019, 47.) Upwelling has ever since been used in various studies and explained reasons previously unknown.

1902 saw the establishment of the Baltic Sea research center in the German town of Kiel. During the following years, the Baltic Sea research saw a lot of modernized research with technological equipment. In the 1920s in Denmark the research focused on the Danish Straits. The University of Copenhagen was the forerunner in studying the light conditions of the sea. The sea water used to be much brighter than today as

the lowered water quality and eutrophication has decreased visibility over the years. (Myrberg & Leppäranta 2019, 52-53.)

The inertia motion was discovered by Swedish researchers Torsten Gustafsson and Börje Kullenberg when studying flow patterns in the central areas of the Baltic Sea. They discovered that inertia is caused by the rotation of the Earth. In a windless weather objects will continue to circle in an attenuating pattern and the circulation period depends on the latitude. (Myrberg & Leppäranta 2019, 54-56.)

5.2 Difficult relations

Unfortunately for the environment of the Baltic Sea, it has been a theatre of war and affected by politically and ecologically induced actions, and even more so in the recent decades due to industrial growth and modernization.

The 1940s was a hard time for sea research. Conducting measurements in the sea was dangerous and usually impossible to perform. War times and the following years were harmful and caused stops in many time series of research. After the second world war communication and cooperation with countries got more difficult as the Baltic Sea was split into three parts. The Warsaw Union in the east and south, NATO in the southwest and the neutral countries of Finland and Sweden in the north and west. Soviet Union had a strong level of competence in physical and mathematical sciences which translated into a good level of research in marine sciences. (Myrberg & Leppäranta 2019, 57.)

The Soviet Union, Estonia and Finland formed a Gulf of Finland working group to coordinate the research and conservation work. It was important to form new relations and improve them even when the research was ineffectual. Germany was split into West and East and research between the institutes was hard due to tense atmosphere and was thus nonexistent during the Cold War. Even with the political changes international cooperation between the countries continued as the Baltic Sea is a shared sea and thereby a point of interest for all the countries. (Myrberg & Leppäranta 2019, 56-58.)

In 1969-1970 when the world was in a breathtaking lockdown during the Cold War, the countries of the Baltic Sea held an official Baltic Sea year with twelve research vessels. They did consistent measurements in 39 different measuring points and each point was

visited at least once per month by the researchers. (Myrberg & Leppäranta 2019, 60.) This is a good example which shows that people can work together with a common goal even in the hardest times.

5.3 Towards modern research

The true state of the Baltic Sea was slowly starting to be uncovered by researchers in the 1960s. The research uncovered the unquestionable problems that finally started to get attention from the citizens and the political leaders. Not long after the surrounding countries of the Baltic Sea signed the Helsinki Treaty which obliges the countries to follow the guidelines for decreased loads in all emission sources, to protect the nature of the sea and to preserve the diversity of the species. The treaty came into force in 1980, despite the Cold War, and the Baltic Sea protection commission HELCOM was established in Helsinki. This was a big step in the right direction in the protection of the Baltic Sea. (Myrberg & Leppäranta 2019, 61.)

A modernized and more binding protection treaty was signed in 1992 covering all the countries of the Baltic Sea with all their drainage basins. It was accepted as part of the national legislation in the year 2000. The parties included the European Union and Russia, so environmental cooperation is possible. In the recent year's researchers have loudly protested the current political atmosphere in the research centers which has brought fear and manipulation into play as often the management has personnel who have contacts with state security services. The Russian and European "Firewall" also makes research cooperation harder. (Myrberg & Leppäranta 2019, 62-65.)

The growth of NATO has increased military tensions in the area. The Gulf of Finland is a unique area as it is bordered by the neutral Finland, Russia and the NATO country Estonia. Cooperation has however increased and improved as the worry about the common sea has been more important than politics. (Myrberg & Leppäranta 2019, 62-65.)

5.4 Modern research

The challenges for modern research include the state of the sea, the problems of the sea environment, scientific research and finding sustainable solutions. Modern real time solutions for the conditions of the sea require modern observation systems and mathematical models. The systems are needed for sea safety and prevention of environmental accidents. There have been significant developments in this field, especially in underwater devices which are taking the knowledge forward in big steps. Seafaring, harbors, coastal activities and travel agencies need the information to be as reliable as possible. Saving the Baltic Sea is more of a political and an economical problem than a scientific one. (Myrberg & Leppäranta 2019, 65.)

The surrounding countries have been working together to solve past issues and the cooperation they have shown with organizations like HELCOM is a sign of countries still willing to work together even when the countries have differing ideologies, governments and companies. Currently countries and companies are adapting well to the standards HELCOM and governing organizations are setting for them. Some countries have a greater responsibility and more difficult obstacles to solve. This is where other countries, companies or organizations can assist or provide solutions and resources.

A big factor for working together in research is the continued cooperative work between countries and the integrity and future goals for and in the EU. If EU makes decisions toward more “open market” with less integration, there are risks of decreasing interest in supranational coordination and less funding from independent sources. With less universal goals in mind, the focus turns to individual action with exemplary actions and more requirements for more networking for companies. (Finnish Ministry for Foreign Affairs 2010, 78-79.)

6 PROTECTION OF THE BALTIC SEA

It is important to provide protection for our sea in all levels. All countries, the EU, companies, energy producers, organizations, institutions, researchers, individuals and entrepreneurs should follow the rules and guidelines. Rules must be fair and should take all factors into consideration whereas some countries would have more responsibilities and actions to take when comparing the relation of the countries to the effects. This is where organizations like HELCOM step in and set the standards and guidelines for countries and authorities to follow.

6.1 Regulations and directives

Protection of the Baltic Sea is a shared goal for the surrounding countries and even a globally pressing issue. The Baltic Sea protection committee HELCOM accepted an action plan in 2007 with the goal set at achieving a good environmental status for the Baltic Sea by 2021. The resources used for the protection is a small price to ensure a prosperous and healthy future for the sea. If the ecological level of the sea is poor, it has a poor chance of surviving from stress factors like environmental or climate changes. The action plan of HELCOM covers the worst environmental problems which are affiliated with eutrophication, harmful and dangerous substances, diversity of life, natural protection, marine activities and seafaring environmental safety. Many different directives are in use in the EU and Russia. Among the most important for sea protection are the Marine Strategy Framework Directive and the Water Policy Framework Directive. (Myrberg & Leppäranta 2019, 250.)

The Marine Strategy Framework Directive “establishes a framework within which the Member States shall take the necessary measures to achieve or maintain good environmental status of the marine environment by the year 2020 at the latest” (HELCOM, 2007). The environmental ministries in accord with other ministries and authorities make national sea protection plans which cover territorial waters and the economic zone. The Water Policy Framework Directive provides common principles for all the member states’ water protection policies. The goal has been a good state for all the rivers, flowing waters, lakes, ground waters and coastal waters by the year 2015. The goal has not been reached and the work is continuing. Other goals include

preservation and protection of water environmental ecological functionality and to secure high-quality drinking and domestic water in a sustainable way. Important aspects are also pre-emptive planning and work against the effects of floods and droughts and limiting the number of emissions from harmful substances in water systems. (Myrberg & Leppäranta 2019, 250.)

For countries with high levels of emission loads and pollution it is imperative to enforce rules and regulations that would work. For countries with high levels of emissions, it would be most important to educate their citizens and companies about the issues and to make sure the right steps to reduce harmful substances are taken and the populace is protected. Even though many countries have already started working for more environmentally friendly ways, actions are still necessary to be taken to reduce future pollution and emissions.

6.2 Environmental thinking

The importance of one's actions is great as in the end it is the users who determine what to buy. A person can single-handedly live in a way whereby they reduce emissions just by buying the right products, recycling, selecting energy from a green source or choosing the best way of travel. Reducing overall actions to save more energy will cause long-term saving and is safer for the environment. An important factor is how the ecologically relative information is shared and does the information reach the right crowd. In the recent years, the media has been advising and informing people about the threats of emissions and pollution and the benefits of ecological living.

As environmentalism has been growing through the 20th century and the concern for the health of the Baltic Sea is ever growing, new ways of protection have been established in different fields. A good example of adapting to environmentally friendly ways comes from the 1990s when Estonia started high speed traveling between Helsinki and Tallinn with new catamarans, the trip taking only ninety minutes and speed being 74km/h. This started a new unforeseen effect of high waves. The phenomenon has been well documented in the island Aegna where the ships were passing by with full speed. On a calm day, the researchers were measuring waves as high as 1,8 meters. The waves have caused erosion and in couple of years Aegna has seen significant changes. The catamarans have since been replaced with greater ships which cause smaller back

waves. Since then, the regulations for speed have been strict in the archipelago to protect the environment. (Myrberg & Leppäranta 2019, 244.)

In the recent years there have been multiple plans aiming to help the state of the Baltic Sea. Oxidation of hypoxic and anoxic zones has been tried with success in smaller areas like lakes. Although the Baltic Sea is a relatively small sea, the oxygen problems cover a wide area in the Gotland basin which is too large to be oxidated technically. Salinity stratification is a basic attribute of the Baltic Sea and oxidation does not affect this internal load increasing factor. (Myrberg & Leppäranta 2019, 256.)

Another logistical problem would be how to apply the side products of animal husbandry to farming as it would decrease the total output load. In farmland management, to decrease the phosphorus output to the drainage areas and eventually to the sea, gypsum has been added to the soil to improve binding of dissolved phosphorus to the soil and to make the soil more absorptive and resistant to rain carrying to water systems. The effects of plastering the farmland increase the yield of some crops and last up to five years. (ELY-Keskus 2020.)

The fastest and the most economically effective way to affect the state of the Baltic Sea is to improve municipal wastewater treatment. (Myrberg & Leppäranta 2019, 256.) The improvement of the wastewater management plants in the recent years in the St. Petersburg area has improved the state of the eastern Gulf of Finland and the phosphorus load to the sea has decreased by approximately 1,700 tons per year. The amount is over twice the load discharged from Finland to the Gulf and its archipelago. St. Petersburg now treats 98,4 percent of its wastewater compared to the 67% of early 1990's. This also brings down the total phosphorus load of the Baltic Sea from St. Petersburg down from 40% to 15%. (Pöyry, 2020.)

In 2017 a wastewater treatment plant at Kaliningrad was officially opened and it reduces the overall nitrogen load by 300 tons and the phosphorus load by 120 tons which represent 0.7 and 0.08 per cent of total loading of the main basin of the Baltic Sea from surrounding countries (Ympäristö, 2017). It can be concluded that the Russian Federation has improved the quality of wastewater management in a relatively short period to the HELCOM standards and the work to reduce overall load is improving from the weak levels of 1990's. It also proves that modern cooperation is possible between countries with different ideologies, goals and governments. Similar cooperation can be

expected to continue in the future if the relations stay at similar levels and the importance of the health of the Baltic Sea stays as a priority.

The highly toxic emissions from ships are starting to be part of history as shipping companies have agreed to follow new guidelines with environmental values. The passengers also value green companies and values when choosing ways to travel so environmental and economical values fit well together. The passenger ships functioning with liquefied natural gas have low emissions and are designed to work for decades. The nitrogen load can be decreased by as much as 85% compared to sea diesel. The CO_2 load is estimated to decrease as much as 25-30 percent. The airborne nitrogen load to the Baltic Sea is a great threat from the viewpoint of eutrophication. It comprises approximately 25% of the total nitrogen load to the Baltic Sea. With the recent decision by IMO (International Maritime Organization) all ships built after 2021 must reduce the nitrogen oxide loads by 80% from the current level. The decision aims to reduce eutrophication and improve the level of air quality. (Myrberg & Leppäranta 2019, 244.)

6.3 Product development

When combining product development with environmental thinking we can start to have products and services that are not harmful to the local ecosystem, do not pollute or release emissions. It is important to have a healthy economic growth and predictions as companies work on profit. Profitability has always been a major factor for companies and during the last hundred years it has unfortunately been an overwriting factor for the importance of environmental protection. Thus, we have a lot of man-made problems affecting the planet.

Companies that act as forerunners for environmental action are needed to show the way for the majority and to determine the rules and basis for future companies. Focus on environmental safety over profitability is needed to show how business and production can be done with care for environmental safety with profitability. A healthy public image for a company nowadays always includes environmental aspects, and the way people think about companies and about product usage includes whether it is produced in a healthy way.

Enough research should be done before product development and the effects should be determined, and protective measures should be considered before the product has a

chance to cause actual damage. The rapid development and improvement of products has led into situations where products like cosmetics, medicines, plastics and nanoproducts cause unpredicted damage to the environment. This creates situations where companies can shift the problem solving to future generations, also shifting the blame to other factors due to of insufficient research. With long term neglect, situations like overflowing amounts of plastics in seas can arise.

6.3.1 Green Kayak

An example of an environmentally friendly organization is a Danish ecological kayak renting nonprofit organization called GreenKayak. The aim for the company is to do kayaking combining it with a focus on environmental action. The company started with private trash collecting tours in the waters of Copenhagen and was called at that time Miljøkajakken. Tobias, the professional sea kayaking instructor was collecting the plastics and other trash with the groups. The next day he realized the trash was ever increasing and to fight it, help was going to be needed by everyone willing to help. The free offer was well received, and bookings have been done months in advance ever since. (GreenKayak 2020.)

In 2018, the amount of waste collected was more than 10 tons including beach clean-ups with the power of roughly 3000 volunteers dedicating their time to collecting trash on land and sea. The company realized there was a greater opportunity to do something not only for the environment in Denmark, but also for the local aquatic environments around Europe and the world. The people in Denmark saw that as a fun way of helping and the company realized that they could make a global change working together with local communities around other cities and countries. After the 2018 season, Oke joined the team and the company re-branded from Miljøkajakken to GreenKayak and decided to become a global movement. In 2019, the company expanded the operations from Denmark to four additional European countries growing the fleet from 3 to 48 GreenKayaks. During the season, the kayaks removed more than 14.3 tons of mainly plastic waste from the waters with the help of more than 10.600 volunteers. (GreenKayak 2020.)

Greenkayak is an amazing and effective way to have citizens participate in local action in a fun way and have a dialogue about what it will take of us to battle the plastic pollution in all seas. Examples and forerunners are needed to educate the public about

environmentalism and to show there is a way companies can work in unison with the nature, not only to exploit and drain the resources. The public pressure can also affect local decision makers in setting regulations towards more environmentally friendly ways or rewarding companies with environmental goals in mind.

6.4 Green Energy

Efficient energy usage is a new and effective solution fighting against pollution and climate change. Overall reduction in greenhouse gases, pollution and emissions when considering energy production is a great factor why it should be considered a primary energy solution for companies and a gateway into more ecological development in energy usage and product design.

6.4.1 Electric advances

Electricity is a huge factor among worldwide end-uses of energy. If the trend of electricity usage continues, it is obvious that we need to produce more energy to be able to sustain the communities in modern life. Improving living conditions and increasing income and population means many millions of added electrical appliances, “smart” devices and cooling systems. Electricity is a factor in supplying heat and mobility, alongside with traditional domains which allow for the share of final consumption to rise nearly a quarter. The need for electricity explains why the investments in electricity overtook the market from oil and gas for the first time in 2016. (Ingmarsson & Hüffmeier 2019, 6.) The need for more electricity is expected to rise as technology is more and more implemented in everyday life. It should also be a topic of focus in how to reduce the energy usage of products and how to minimize energy deficit. Some of these problems could be solved with implementation of nanotechnology.

6.4.2 Water energy

Sea energy remains a largely untapped renewable energy source, despite decades of development efforts. Wave energy converter demonstration projects are mostly in pre-commercial stage. Thermal energy conversion and salinity gradient technologies are also far from commercial usage with only couple of pilot projects. Reasons for not having

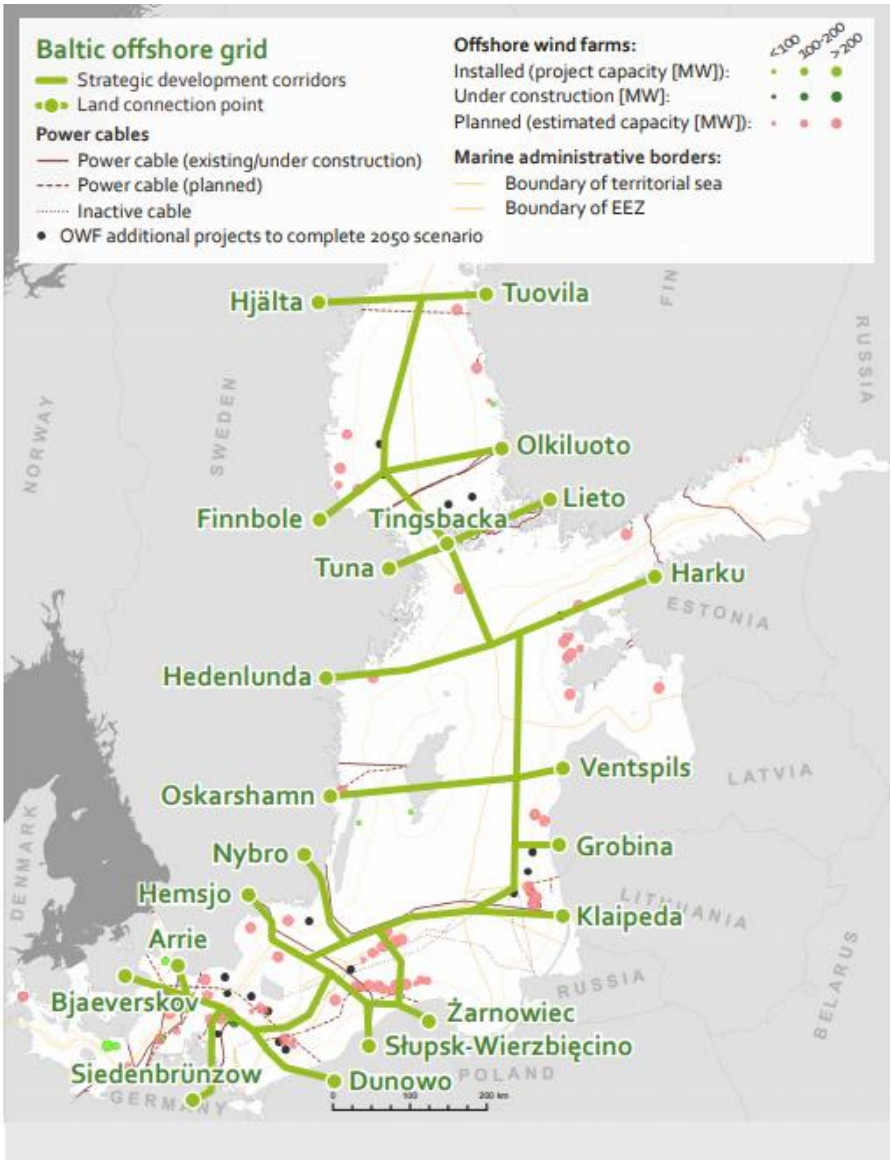
commercial success include financial problems, high risk industry, heavy upfront costs and the need for improved planning, consenting and licensing procedures (Ingmarsson & Hüffmeier 2019, 11.)

The problem with the Baltic Sea, however, is what forms of production can and cannot be used sustainably. Hydropower production methods that apply for other seas do not generally work well in the Baltic Sea due to sea conditions being completely different from other great seas.

Different forms of water energy are a great source for investment. Water is also flexible in the way it can be used for thermal energy, as a drinking source, and in multiple different forms it can be used to create energy. With advancing technology, it is certain that water energy will have more attention from companies interested in fields of energy production, thermal energy, and as a resource for nutrient. Water is also a side product that is needed for multiple processes like cooling and pressurizing, and as a composite material and a chemical base. Any research in water usage is overall positive for all fields, also for the Baltic Sea and its limited power production.

6.4.3 Wind energy

Offshore wind energy expected to be installed in the Baltic Sea in 2050 was estimated by BVG Associates to be 35 GW from the “80% renewable energy sources scenario” of the 2050 EU Roadmap, which proposes that offshore wind should provide 758 TWh per year of electricity across the EU, of which 145TWh per year in the Baltic Sea. The capacity required to produce this is approximately 35GW. The current plans for the installation of offshore wind farms and interconnectors, the main component of BOG 2050, would be a combination of the south-western and south-eastern meshed grids. (Ståhl 2019, 49.) Segments executed are dependent on the balance of costs and benefits which will in turn largely be determined by the distances involved and the availability of transmission technology. Which farms, and when they are built, are also factors to consider.



Picture 7 The Baltic Offshore Grid concept for 2050 (Baltic InterGrid).

“The Baltic InteGrid project considered all risks of irreversible deterioration of the environment or its components potentially caused by the implementation of BOG 2050. The cumulative effects of all the components of existing and planned projects in the Baltic Sea were considered, as were possible cases of noteworthy residual impact likely to remain after measures to mitigate primary problems would be implemented.” (Ståhl 2019, 53). Picture 7 shows a map of the planned BOG 2050 grid. This grid would provide a viable energy solution for the surrounding countries of the Baltic Sea when all the environmental threats are considered, and the grid is built according to the legislation of each country and with the cooperation of all relevant countries.

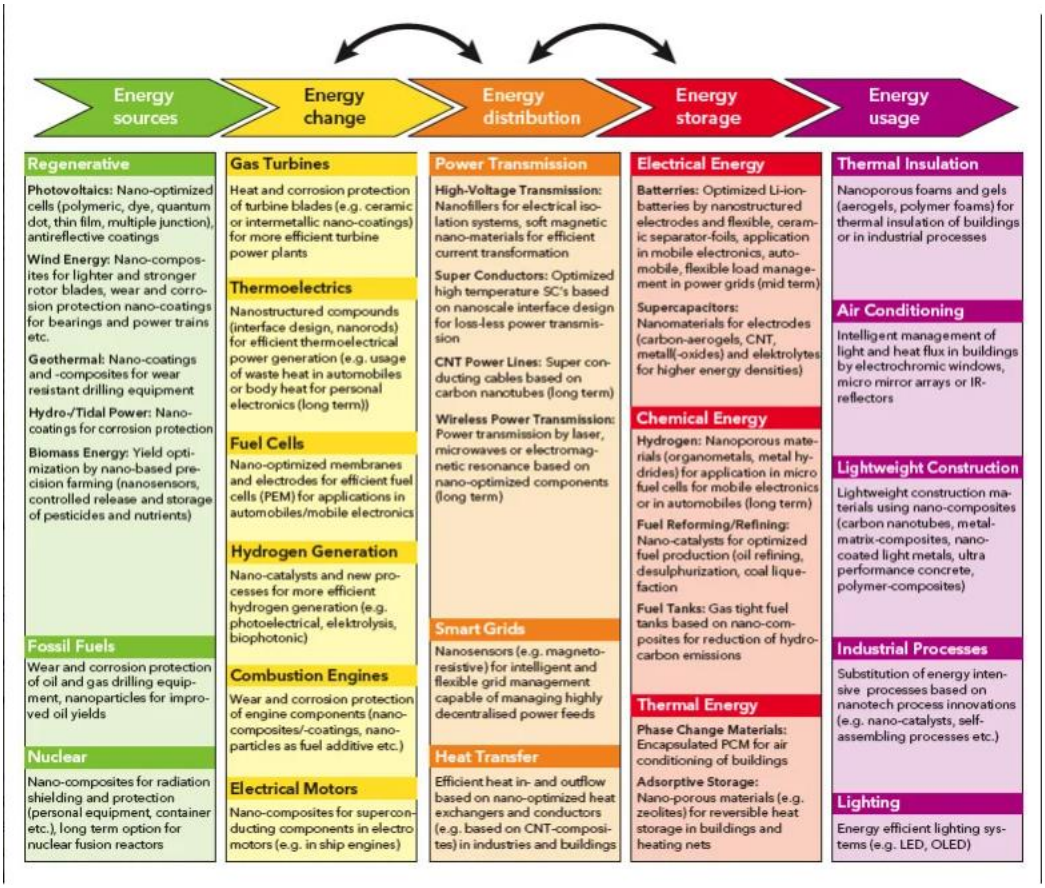
6.4.4 Bioenergy

Marine biofuel is predicted to be minor before 2050 due to technical issues that need to be overcome. The areal requirements for marine biofuel technologies have three separate sources to consider. These include the exploitation of natural seaweed stocks, the use of drift seaweed and the cultivation of seaweed at either coastal sites or in offshore infrastructure. Biomass resources for annual production are estimated to be 1.2kg of dry matter per square meter of sea surface. Using 25% of the available space in future Baltic Sea wind parks, more than 1,000,000 tons of biomass could be harvested yearly. (Ingmarsson & Hüffmeier 2019, 52.) Marine biofuel thus could be a great opportunity in large scale biofuel production if a cost-effective solution for renewable energy processes is found. Large scale production would require extensive research on technologies that will help to reduce costs.

Algae could offer a 2 to 20 times higher yield than existing biofuel feedstock including corn stover, corn, sorghum and beet, and is likely to open new avenues for the industry growth over the projected period. Technological challenges and high investments in algae biomass and fuel production are expected to slow down the industry growth in the future. (Ingmarsson & Hüffmeier 2019, 7.)

6.4.5 Nanotechnology & new technology

Nanotechnologies provide the potential to enhance energy efficiency across all branches of industry and to economically leverage renewable energy production through new technological solutions and optimized production technologies. There are multiple ways they could be implemented in all parts of the life of energy production from the source and all steps of the way to the usage. Picture 8 shows how this could be implemented in steps.



Picture 8. Nanotechnology in energy applications (VDI TZ GmbH).

Automatic AI would be another great solution to help clean the Baltic Sea of all the unnecessary natural and unnatural substances. There have been promising experiences of using the “industrial cleaning robots” in different fields already. Some of the abilities of these robots include wall climbing robots for boiler wall cleaning, cleaning, polishing and paint removal for vessels and tanks, and robotic hull cleaning of large ships. (Robotics Online 2020.) Maybe one day in the future these robots could be cleaning the phosphorus or nitrogen from the greatest point sources and turning it into a fuel.

Research on new technologies and ways to produce energy is just as important as having enough resources to implement and improve current “new” green energy solutions. In 50-100 years, there would predictably be new or improved ways of energy production if we look at the trend of the new ways for energy production that have been developed in the last 50-100 years. These new ways could include fusion technologies currently researched but flawed at execution.

However, these technologies are not efficient universally and the Baltic Sea needs specified and working production methods. It has been calculated that the Baltic Sea has an energy potential of 24 TWh that could be used in coastal areas of the Baltic Sea countries (Bernhoff *et al*.: 2006). The choice for a suitable kind of technology and adjusting it to local conditions can bring about optimal production of wave energy. Interviews with developers reveal that there is little interest of deploying in the Baltic Sea until the technology is proven to be efficient in other places where resources usage is more challenging. Until 2050 the developers see no need for any areas to be reserved for sea energy arrays. (Ingmarsson & Hüffmeier 2019, 37, 52.)

6.5 Interview with HELCOM

An interview with HELCOM communications secretary Dominik Littfass gave me insight in the topics of the thesis and where things are headed in the fight against climate change. I interviewed him about the current state of the sea, the threats we are facing now, what has been done to be prepared for the threats in the future, what will be the challenges to come and how the legislation and implementing the plans work in cooperation with all the countries. Dominik provided me with information crucial to my study about the status of the sea and what the predicted actions are going to be in fighting the threats. Below are the questions and the answers.

1. What are HELCOMs plans for countering new substances like cosmetics, pharmaceuticals, micro/nano plastics, and newly developed products with unknown effects?

Currently there is a project running on analyzing the pathways of the microplastics to the sea. This is crucial in trying to understand how the particles enter the seas. For example, in Finland, SYKE and Luke work with HELCOM to assess the situation and set the standards. The data is gathered from those national companies as they have the tools and the resources to operate. HELCOM is mainly working with governmental organizations and not so much with private sector.

HELCOM has not really thought about microplastics, it still being researched.

Preemptive methods are being taken now and monitoring programs are in place. The same is valid for other substances. HELCOM is developing indicators for these substances and where to combat the problem.

2. Is there any collaboration or legislation planned with countries or companies who develop new products?

HELCOM is an instrument of law as an intergovernmental organization so they can only provide recommendations. It is up to the countries to follow the recommendations. After the data about the problem is found, an action plan is formed. The Baltic Sea Action Plan is being updated, it contains points about marine litter and other substances. The updated version is planned to be ready and announced by 2021. The BSAP Contains concrete actions and measures that should be followed by the countries. Responsibility is still a national issue.

The countries use HELCOM as a vehicle to implement some of the changes. HELCOM has their own indicators that they share with the Baltic Sea countries to give insight. Some of them are used to assess and provide information. Every country is supposed to report back to EU what actions they have undertaken regarding the Marine Strategy Directive and the other directives, like the Water Framework Directive and Birds Directive that overlap with the work of HELCOM. There are synergies between corporations that work very well. However, these are separate from the BSAP. The plan serves to implement actions reaching the targets and try to be in line with UN targets, biological targets and biodiversity targets. The UN targets refer particularly to SDG 14, aka conserve and sustainably use the seas and marine resources for sustainable development.

3. Eutrophication: Are there plans to oxidate more hypoxic/anoxic areas in areas where it is possible? For example, the Gulf of Bothnia. Recent plans to affect the eutrophication?

The bioengineering solution that oxidated the anoxic areas worked for a while, but after a year the problem was back. Addressing the root cause is the only way to improve the situation.

The plans are the same as the original strategy, mostly focusing on not adding any more nutrients to the system. How to deal with internal reserves is still in its research stages and there are no concrete plans until further research. As we have been pumping stuff into the sea for the past 50 years, it takes a long time to recover and normalize from that.

4. Any plans to reduce the nitrogen and phosphorus loads from the farmlands from countries with high emissions like Poland and Sweden in the future? For example, widespread gypsum usage?

HELCOM works with the representatives for farmers to develop more sustainable choices. Timing is the key as to when to reduce the nutrients. The farmers try to keep the nutrients in a closed loop and to avoid minerals and additional nutrients getting into the waters. This comes with a good management, but so far there has not been a strategy in place. HELCOM is developing a nutrient strategy by 2021, which is also included in the BSAP.

Gypsum is a short-term solution and is not viable for long term usage. The solution to reduce loads to the sea is simple, you just need to ensure that the nutrients will not end up in marine environments. The nutrients that are required in the field are focused on recycled usage.

5. Climate change: Baltic Sea Action Plan and how climate change is planned in the near future of 2020-2030

It was a previously unaddressed challenge, and a new challenge. Climate change is a defused pressure, with multiple origins. Even with mitigation measures, it is a global threat. The aim is to increase the resilience of the Baltic Sea for its effects, including making the ecosystem as strong as possible. Addressing all the small issues that we can deal with is the primary goal. Having multiple threats, like loss of biodiversity,

eutrophication, loss of habitat, anoxic bottom waters are already affecting the sea so adding climate change on top of that would escalate the situation.

Salinity changes, already changing and expected to keep changing in the future and ice cover changes will force existing populations to have to either adapt or migrate to more suitable environments. Ecosystems can adapt but not at the current speed things are changing. It is a cause for concern for example in the Baltic proper where anoxic zones have formed.

6. Does HELCOM have plans for the effects of predicted increase in earthquakes that could create so called “European tsunamis or earthquakes from the plate movements.”

No. It is not an issue that currently affects the Baltic Sea in the immediate future. HELCOM is focusing on issues they can do something about.

7. Melting polar ice: High increases in water level have previously occurred in the history at the end of the last glacial period. There could be an unexpected polar ice melting at a fast rate of 5-10 years according to worst case scenarios. And are there plans to counter high flooding and high rain that would occur?

No active mitigation methods at this stage. But the response is to adapt and to understand the effects and trying to predict what is going to happen. The Baltic Sea is warming just as the Poles are. Glacial rebound will counter some of the changes but other changes like the rise in wave lengths, wind speed changes and other effects must be taken into consideration as well. There is a working group in HELCOM that is currently looking into these issues, but the research is new.

8. Are there any plans to increase the effectivity of salt pulses and the intake of water through the Danish straits from the North Sea?

No, as this is a natural process and currently what man could do is limited. It is doubtful that changes would have a meaningful impact. Stratification would still exist and cause problems.

9. Increasing the level of public knowledge about the issues and public action. Any campaigns or action plans?

Mixing policy and science does not really work with what HELCOM is currently doing. HELCOM is geared towards different audiences, and not that related working with citizens. The cooperation is more with governments and scientific organizations. Another problem is that HELCOM is working in English, so it would be hard to provide information to all groups.

HELCOM is involved with some groups, however, for example the Ocean Literature campaign which was run by the EU. The issues focused on this campaign was eutrophication and domestic issues like littering.

7 CONCLUSIONS AND SUGGESTIONS

I personally think that the time of “maybe” has passed and we are now living in a time of “should be” or “have to”, by which I mean changes are necessary to be made right now for them to have an impact for change, or before it is too late to turn the negative direction things are heading towards. When finding solutions to the problems, I value factual evidence and solutions that are viable according to multiple sources. I also find it important to have an open discussion on all topics, without censorship and by considering the viewpoints of others. A good goal can be reached by multiple different paths in which many possibilities present themselves, for better or worse. Time has always been an issue, but in modern times haste should be considered as some issues occur faster than predicted. A negligence on the importance of haste on some issues has already caused massive problems in countries where new problems such as unprecedented natural catastrophes are currently occurring. Similar changes and natural events have happened in the long history of the Baltic region.

7.1 The future of the Baltic Sea

In the Baltic Region the predicted climate changes can bring positive changes, with increasing landmass and warmer seasons for farming. But also, the threat of a changing climate and landscape can bring new challenges as the issues are still under research and novel. It is important to have ongoing research and discussion about possibilities and the direction change can be driven to. HELCOM and related partners are already on the right path in researching the possibilities and gathering more information about climate issues. Unexpected changes are also a factor that companies should be aware of, for example a risk in the future for “a European tsunami” is steadily increasing with the increasing of core activity, magnetic fields losing potency, sun behavior, pole movement and all the other unknown changes that scientists are currently trying to find out.

What can be done about natural cycles of the Baltic Sea? Not much on a grand scale, according to the current statement by HELCOM. (Littfass 2020). In similar sense the nature is too big of a challenge to our current technology and applying it. The current resources however can be used to combat the problems caused by human activities and

even to some extent control the natural aspects in a way that is positive for all parties. Considering the future, there however are chances for new technologies and new policies to assist with the problems the Baltic Sea has.

A hypothetical example would be to have a massive water circulation system from the North Sea to the Southern Baltic Sea through Danish traits to constantly pump in fresh water and take out hypoxic water without damaging the marine ecosystem. This kind of a megastructure is very expensive and requires a lot of resources. It may not be possible to realize with the current resources, but it could be considered in the future.

A similar idea could be used to bring in fresh water from the Arctic Sea, but that kind of a structure would require even more resources. However, similar smaller structures have been constructed before, for example the Päijänne tunnel in Finland which pumps drinkable water from Päijänne to Helsinki. This is the largest connected tunnel in the world at 120 kilometers long. (Rytsä 2008).

Eutrophication is the largest current issue in the Baltic Sea and something countries have been worried about for decades. Involved countries and non-governmental organizations have been setting standards to do the best with the current knowledge they have about varying issues. In the recent three decades, eutrophication has increased, and the reasons, legislation and plans have not been up to date as to what companies and countries should do and what has been causing the increase. Slowly the actions and legislation have caught up with what is necessary to be done to combat the issues.

The current state of solving the problems is at a good level and knowledge about the issues causing eutrophication is available. What can be done about the point sources are currently being planned by HELCOM with the intent of reducing the number of excess inputs of nitrogen and phosphorus from farming countries and to reducing the amount of emissions and pollution from the companies and individual sources. The action plan is planned to be released by 2021. (Littfass 2020).

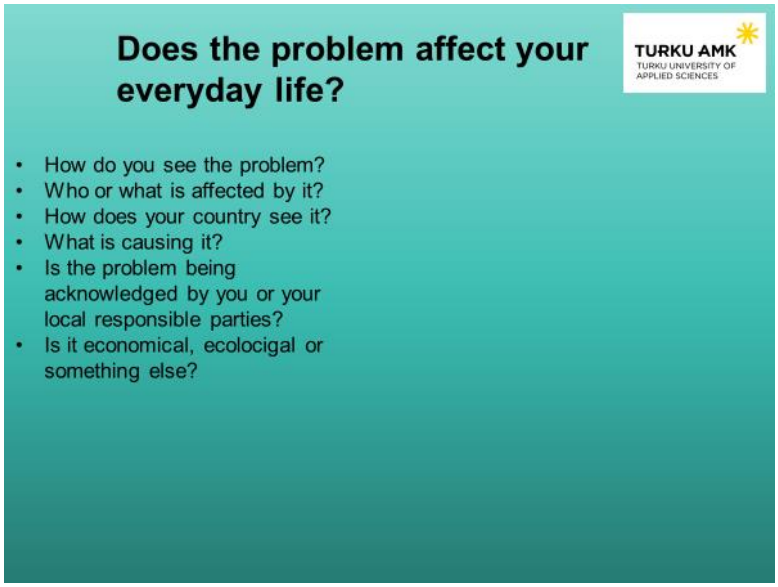
What more could be done about eutrophication or any other issues? What I believe is important and what organization like HELCOM cannot do actively, being non-governmental, is educating individual people and giving insight about the issues on the ways a single person can act upon, either by individual actions or by utilizing personal skills. What a country can do is educate its companies and citizens about the issues in more direct and indirect ways.

7.2 The power of knowledge

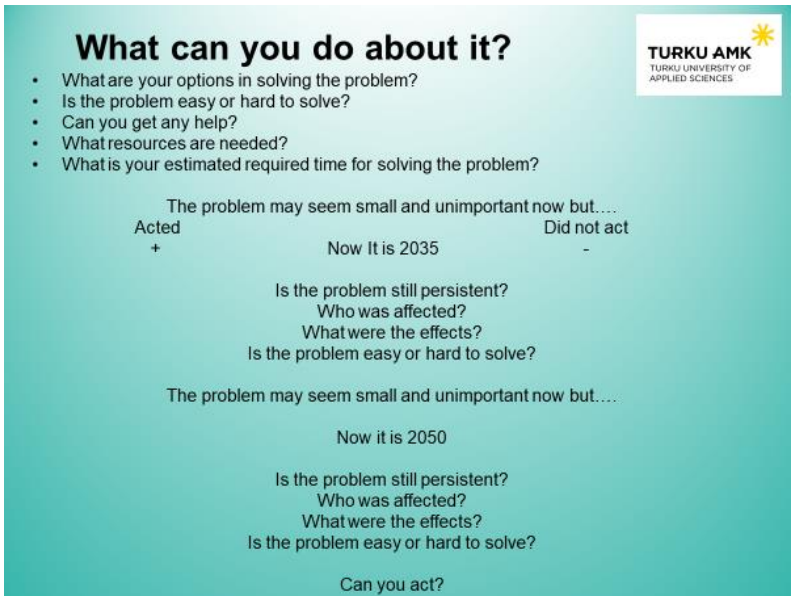
Critical thinking is an important tool and should be taught at schools, as nowadays in many schools and countries media education and fact checking is lacking according to my discussions with people with different backgrounds and my own experiences abroad. At some schools, for example in Finland, it is a part of the mandatory courses in some fields for students. Even when the duration of the class is be short, it is more than no education at all.

I was an organizer in an International course “GetFinternational” where I would make a lesson educating exchange students about environmental issues. I believe the class was successful in educating people with poor knowledge on the basics of the field about environmental studies and what kind of problems different countries are facing. In class, the students were divided into groups with different backgrounds after which they had an assignment focusing on a problem, they themselves or their country saw as a big problem.

The students did not have a lot of experience in the field of environmental sciences. Picture 9 shows the core structure of the questions I presented to the students. Picture 10 follows with the important factors that need to be considered when thinking about the problem and what would be the predicted foreseeable future for the problem with or without actions.

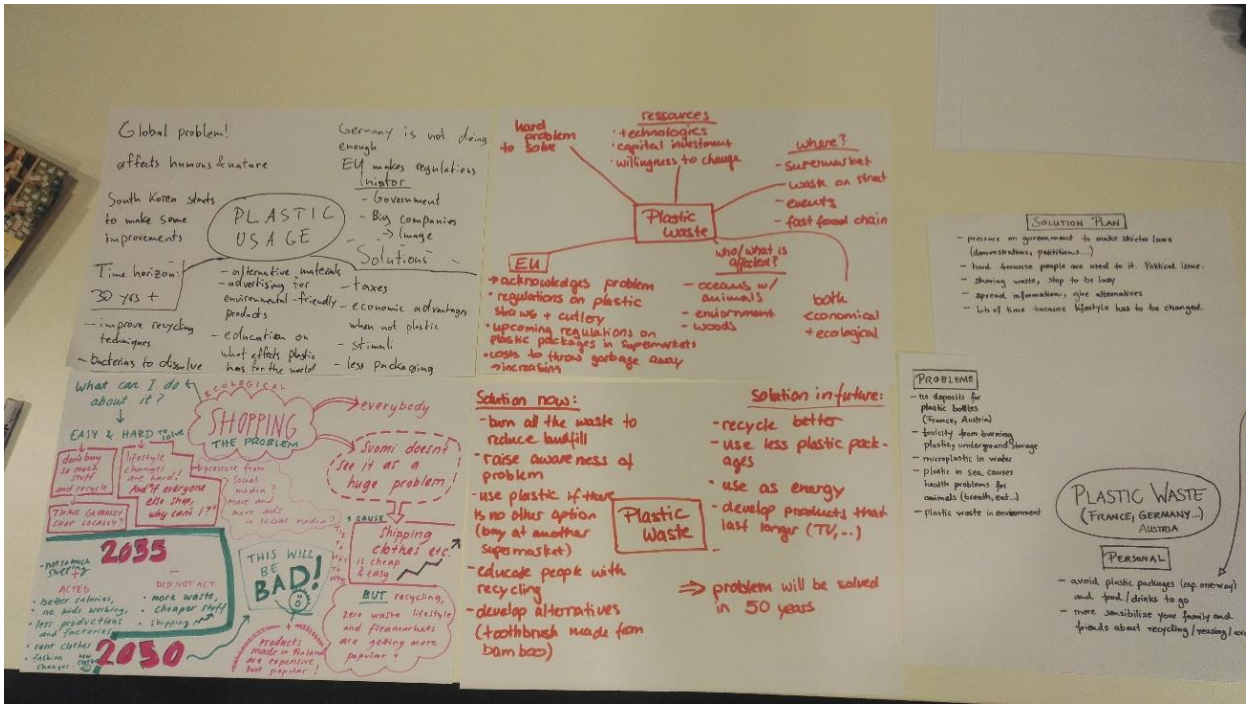


Picture 9. The problems country may be facing.



Picture 10. Planned solutions to the problems.

The groups with different backgrounds interestingly focused mostly on plastics with 4/5 having a plastics related topic and one group with the major problem on shopping. The groups mostly focused on what an individual can do and how the EU should regulate the issue more actively. Awareness of the problems was also found as a common solution on how to deal with the plastics. Picture 11 is a sketch of the solutions the students came up with.



Picture 11. Solutions by exchange students

7.3 Energy development

Energy requirements and the need for more viable solutions are a challenge for now and for the future. For the Baltic Sea, multinational plans to increase energy production have been made and solutions for energy production include all the forms we are currently using, just increased in great scale. Natural gas and bio energy as a resource provide good solutions for ships to use as fuel. Innovative energy decisions with economic support could provide a sustainable way to research working ways to implement more bio-based fuels into a resource that could be used in a variety of ways. One example would be to develop a system that collects algae from water while ships are moving and either store it or turn it into a viable resource. The efficiency rates however need to be high enough to be also economically efficient.

Advances in the field of nanotechnology, robotics and new energy technologies can bring more viable ways of energy production or more better ways for energy usage. It remains to be seen which solutions of those work well in energy production in the Baltic Sea region. Especially energy production focusing on different forms of water energy production has been highly focused on the past years. Those solutions however are

planned to be more viable decades later when more information about their usage is available.

7.4 Climate change and you

Climate change is a topic that consist of multiple different factors. It is imperative to work with the facts and try to find the best solutions with cooperation rather than petty fighting and discrediting opposing studies. An open “research climate” would be healthy where stepping to the unknown area would be looked with wonder and excitement instead of negative opposition. Mankind would have advanced technologically a lot faster in its history if the “climate” had not been hostile. Open research agreements between countries, cooperation with different cultures, policies, organizations and governments would be the key to healthier growth with understanding and wonder for the new and unknown. Climate change begins with a single mind. After changing the “inner” climate, it is easier to work in unison trying to find solutions for the problems we can do something about. Being a global effect with multiple aspects, working solutions must be working well with all fields of study.

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