D1.1 Report on regionalized SSPs and RCPs resulting in a coherent set of climate and socioeconomic scenarios for the Baltic Sea region

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We would also like to thank BONUS secretariat for co-funding the workshop on scenarios.

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1 Introduction

This Deliverable reports on the development of long-term downscaled narratives of multiple regional drivers and pressures that determine future levels of nutrient loadings and fishing efforts in the Baltic Sea up to 2100.

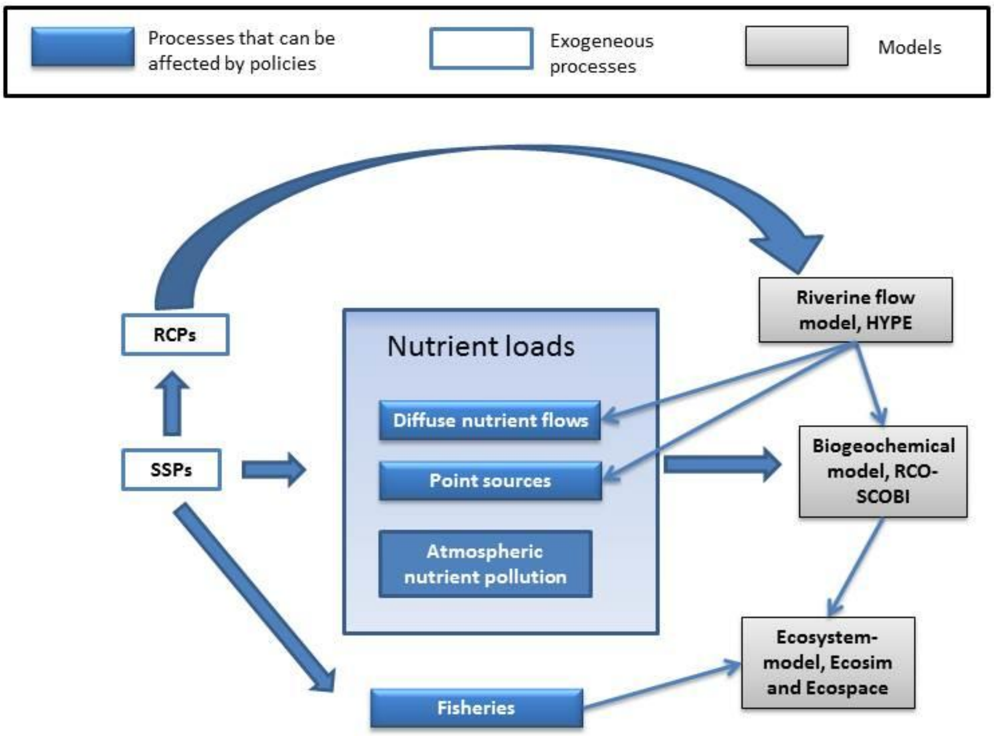
The narratives are based on recent developments of global socio-economic futures in climate change research: the Shared Socio-Economic Pathways (SSPs) (O'Neill et al., 2014; Edenhofer et al., 2010; Kriegler et al., 2012). We focus on the following SSPs: SSP1 (Sustainability); SSP2 (Middle of the Road); SSP3 (Fragmentation) and SSP5 (Fossil-fueled Development). Each of these SSPs is expanded to the areas of:

- agriculture;
- atmospheric deposition;
- waste water treatment plants (WWTPs); and
- fisheries.

The qualitative narratives on the above-listed areas provide the drivers that guide the quantification of pressures on the marine ecosystem. Combined, they aim to scan the range of possible future pressures on the marine ecosystem, *excluding* the impacts of climate change. These quantifications of the pressures from fisheries and nutrients are reported separately in "*D1.2 Forcing data sets like nutrient loads, atmospheric deposition and fishing mortalities and effort for transient simulations of the marine environment 1960-2100".*

The down-scaled, quantified SSPs will be combined with two regionalized climate trajectories: Representative Concentration Pathways (RCP) 4.5 and 8.5 to provide scenarios of plausible future impacts on the Baltic Sea, thus integrating climate change, societal developments and policy assumptions. The scenarios feed into hydrological, physical-biogeochemical and ecosystem models to assess impacts on the Baltic Sea under the different scenarios (See Figure 1).

Figure 1. Framework set-up from scenarios to impact models.



The integrated scenarios that will be the results of integrating socio-economic futures, climate developments and impacts on the marine ecosystem will help researchers and stakeholders alike to understand the range of possible futures and our possibilities to retain or improve the provision of ecosystem services from the Baltic Sea.

2 Process and Methodology

Process

The narratives presented in Section 4 build on the global SSP qualitative and quantitative narratives and have been expanded upon in a concerted effort among BONUS projects and other stakeholders. Further refinement and analysis was carried out through collaborative efforts between the BONUS BalticAPP, BONUS Soils2Sea and BONUS Go4Baltic[1] projects. The process of developing the quantitative and qualitative narratives was the following:

1. Internal BalticAPP scenario workshop held in Stockholm in September, 2015, to discuss the selection of SSPs and types of drivers and pressures of relevance for BalticAPP:
2. Background gathering and analysis of basic SSP and RCP quantitative and qualitative narratives (See Part 1 of *"D4.2 REPORT ON WORKSHOP ON SCENARIOS");*
3. Workshop on land use scenarios in January 2016 between BalticAPP and Soils2Sea:
4. BONUS Pilot Workshop on Scenarios held in Helsinki in April 2016 for researchers from interested BONUS projects and stakeholders to expand and discuss how sectors of relevance could develop in the Baltic Sea region under the different socio-economic pathways (See Part 2 of *"D4.2 REPORT ON WORKSHOP ON SCENARIOS");*
5. Refinement of qualitative and quantitative narratives in collaboration between BalticAPP, Soils2Sea and Go4Baltic; and finally
6. Workshop on finalizing the forcing dataset and qualitative narratives in August 2016 between BalticAPP and Soils2Sea.

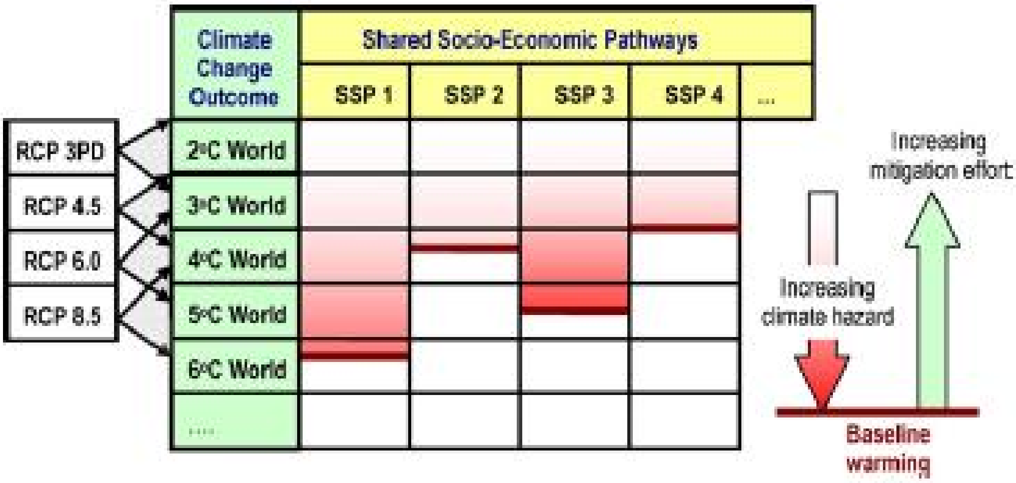
Methodological framework

The conceptual framework for downscaling SSPs to the Baltic Sea Region combines the scenario matrix structure with the DPSIR framework.

As reported in D4.2, the scenario matrix architecture is developed as a new scenario framework for climate change research to assess the effectiveness of different adaptation and mitigation strategies and the possible trade-offs and synergies (van Vuuren et al., 2013). The two main axes of the matrix include i) the level of radiative forcing (RCPs); and ii) a set of plausible trajectories of future global socio-ecological developments (SSPs).

[1] Hans Estrup Andersen

Figure 2. Matrix of socio-economic "reference" developments (SSPs) and climate change outcomes (RCPs). Source: Kriegler et al. (2012)



Each row of the matrix summarises the implications of a given level of CC on a range of possible future socio-economic conditions while each column describes the implications of increasing levels of CC (or decreasing levels of mitigation effort for a given set of socio-economic conditions). White cells in

Figure 2 indicate that not all combinations may provide a consistent scenario.

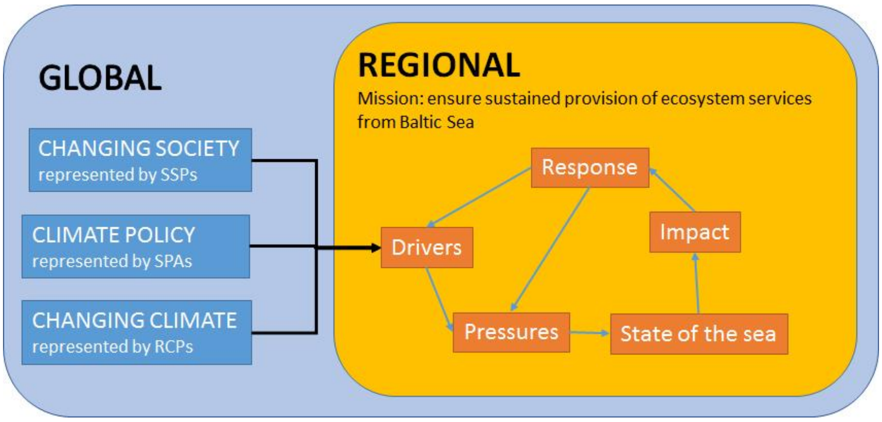
The scenario combinations that BalticAPP will assess comprise:

Table 1. Scenarios to be assessed in BalticAPP

SSPs	RCPs	
	RCP4.5	RCP8.5
SSP1	X	
SSP2	X	X
SSP3	X	X
SSP5		X

The DPSIR framework is used for analysing the pressures and impacts of future plausible climate change and societal developments on the marine environment and the possible responses (See Figure 3). Global socioeconomic developments and the consequent anthropogenic interference with the climate system drive the development of virtually all terrestrial and aquatic ecosystems. At a regional level, these trends drive the development of industries, technologies, land use, governance and all aspects of human life. Many of these aspects are also the driving forces of regional environmental problems and drivers of polluting and consumptive uses of ecosystems (D4.2).

Figure 3. Impacts of changing climate and global socioeconomic development on solving regional environmental problems in DPSIR framework



Four steps will be carried out within the DPSIR framework. This present deliverable focuses on step 2:

Step 1: Develop one (or several alternative) baseline scenario(s) for global climate and socioeconomic outcomes. This can be done by matching climate projections (RCPs), socioeconomic pathways (SSPs) and climate policies (SPA).

Step 2: Develop harmonized storylines for drivers of selected regional environmental problems that are in line with the underlying assumptions of selected global scenarios (from step 1), taking into account scenario work developed in BONUS projects.

Step 3: Use Integrated Assessment Models to project the (baseline) development of pressures using the storylines of regional drivers (from step 2) and the global developments (from step 1) as an input.

Step 4: Use projections of pressures (from step 3) as inputs to Integrated Assessment Models to describe the consequences to the ecosystem (State in Figure 3); human wellbeing (Impact) and the need for new mitigation policies (Response).

3 Current pressures and the main drivers of change

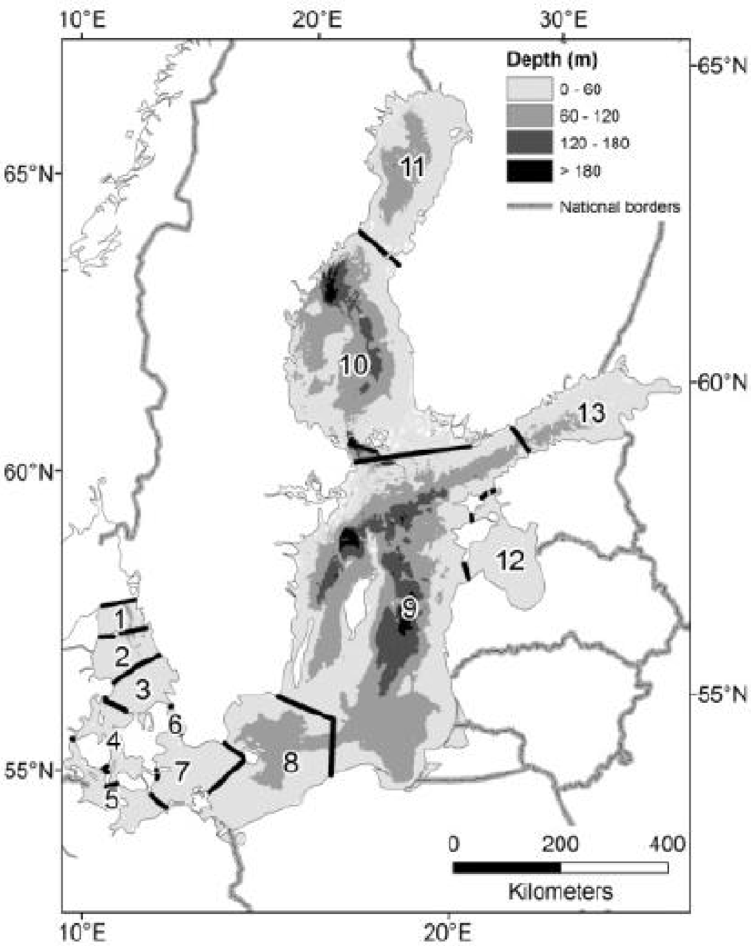
3.1. Eutrophication

Eutrophication is a consequence of excessive loads of nutrients and organic matter to the aquatic ecosystem. Nutrients and organic matter end up in the marine ecosystem from several sources. The drivers of change of these various drivers are also multiple. In order to be able to elaborate alternative futures for these various sources, we need to:

- identify the most important current sources and potential future sources of nutrients;
- identify the main drivers of change for each of these sources;
- study the future prospects of each important driver under various global futures; and
- understand the causal interactions between global and regional socio-economic developments and the drivers of nutrient loads.

Figure 4 shows the division of the Baltic Sea into sub-basins.

Figure 4. Division of Baltic Sea into sub-basins



Source: Savchuk et al., 2012

Loads and Deposition to the Baltic Sea

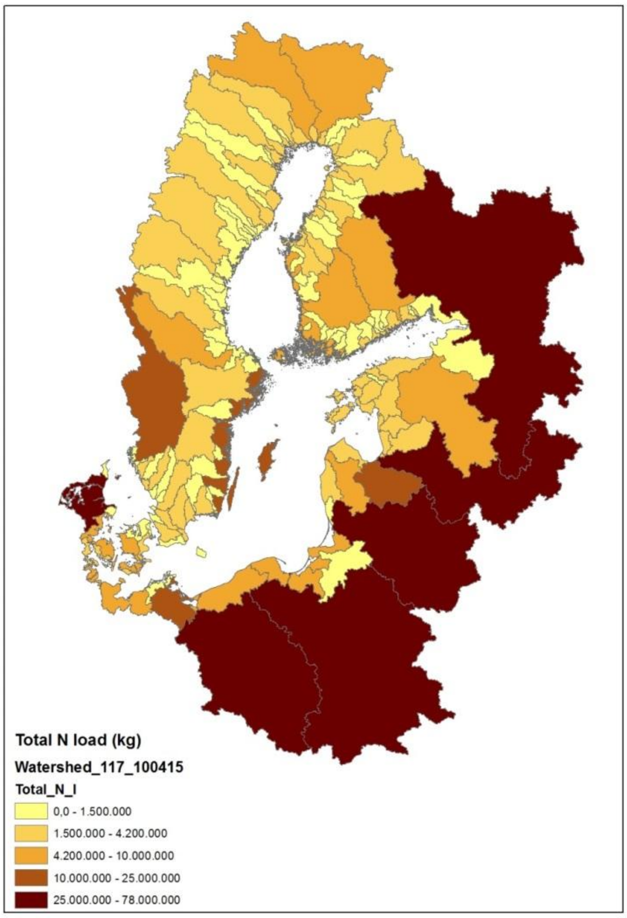
Table 2 and Source of data: Hans Estrup Andersen

Table 3 describe the approximated division of total N and P load from direct point sources and through rivers. Riverine loads include nutrients that originate from point sources draining to rivers, atmospheric deposition, background loading, agriculture and transboundary loads from non-riparian countries. The point sources include fish farm load, industrial load, municipal load, sewage waters from scattered dwellings and storm water overflow load. Background load includes also some minor anthropogenic loads monitored in managed forests from some of the catchments. In addition, Figure 5 shows the spatial origins of diffuse riverine loading to the Baltic Sea from 117 catchment areas.

Table 2. Riverine and direct point sources for total N in tons/year in 2010-2012

	Sub-basin	Point sources	Atmospheric deposition	Background	Agriculture	Trans-boundary	Total
1	Kattegat	8 647	3 594	11 158	23 500	-	46 898
2	Danish Straits	5 895	470	2 839	20 529	2 018	31 752
3	Baltic Proper	73 706	9 055	32 035	123 326	24 916	263 038
4	Bothnian Sea	13 512	2 862	22 304	12 762	-	51 439
5	Bothnian Bay	8 638	2 565	26 398	9 689	2 332	49 621
6	Gulf of Riga	9 899	1 899	9 044	24 374	37 307	82 522
7	Gulf of Finland	25 702	4 055	56 783	18 031	-	104 571
	Totals	145 999	24 500	160 561	232 210	66 572	629 841

Figure 5. Baseline total diffuse N load to the Baltic Sea by catchment.



Source of data: Hans Estrup Andersen

Table 3. Riverine and direct point sources for total P in tons/year in 2010-2012

	Sub-basin	Point sources	Atmospheric deposition	Background	Agriculture	Trans-boundary	Total
1	Kattegat	553	23	389	566	-	1 531
2	Danish Straits	1 168	18	187	350	-	1 724
3	Baltic Proper	4 684	236	1 700	6 207	1 247	14 074
4	Bothnian Sea	690	63	817	798	-	2 367
5	Bothnian Bay	403	101	1 426	718	88	2 736
6	Gulf of Riga	470	20	150	538	1 125	2 304
7	Gulf of Finland	2 003	199	3 014	1 625	-	6 841
	Totals	9 972	660	7 682	10 803	2 460	31 576

Table 4. Atmospheric deposition directly to the sea, tons/year

ATMOSPHERIC DEPOSITION TO THE SEA			
	Sub-basin	TotN	TotP
1		3 384	23
2	Kattegat	6 393	44
3		7 009	49
4		8 391	46
5	Danish Straits	10 574	55
6		1 014	5
7		10 306	67
8	Baltic Proper	24 596	184
9		72 073	796
10	Bothnian Sea	21 407	394
11	Bothnian Bay	7 341	181
12	Gulf of Riga	8 736	94
13	Gulf of Finland	11 997	150
TOTAL		193 220	2 087

The loads are average flows for the period 2010-12 from the updated Fifth Baltic Sea Pollution Load Compilation PLC5.5 (Helcom, 2015). Source apportionment has been done in accordance with Figures 4-8 and 4-9 and Table 8.4 in the Fifth Baltic Sea Pollution Load Compilation PLC5. In addition, a number of additional assumptions were made to fill in the gaps of information in the PLC5 source apportionment (Helsinki Commission, 2006):

- The shares of atmospheric deposition and agricultural load from the total load in Estonia and Latvia are assumed to be the same as in the Baltic Sea region as an average
- Unspecified load from Germany is assumed to be from point sources
- Unspecified load from Russia is divided as follows:
    - atmospheric deposition and natural background proportional to land areas as in Poland with about similar size of catchment area
    - agricultural load from Russia is proportional to the load from cultivated area as in Estonia, Latvia and Lithuania, on average
    - the remains are additional point source loads

Source apportionment was made in order to demonstrate the overall approximate distribution of loads across economic sectors and regions.

Drivers of anthropogenic loads and depositions

The great majority of the anthropogenic loads of N and P are directly related to the production of food for human consumption and handling the wastes originating from food consumption. Changes in global and regional demand of food, diets, life styles and population are the most important drivers affecting the level and structure of agricultural production. In particular, the future demand for dairy and meat products, that require clearly higher inputs (fertilizer, agricultural land) than crop production, plays a crucial role for the structure and magnitude of agricultural production, as well as on agricultural nutrient loads. Also, changes in the input prices of agricultural production (e.g. fertilizer and fuel prices), technological change (e.g. new cultivars) as well as European and national agricultural policies and agricultural support schemes are important.

The nutrient loads originating from the handling of wastes of food consumption are determined by:

- standard of waste water treatment in households not connected to municipal waste water treatment;
- standard of waste water treatment in municipal waste water treatment plants (primary, secondary or tertiary); and
- number of people under each standard of waste water treatment.

Therefore, the main drivers of change in nutrient loads are the level of technological development in wastewater treatment and the change in population and urbanization.

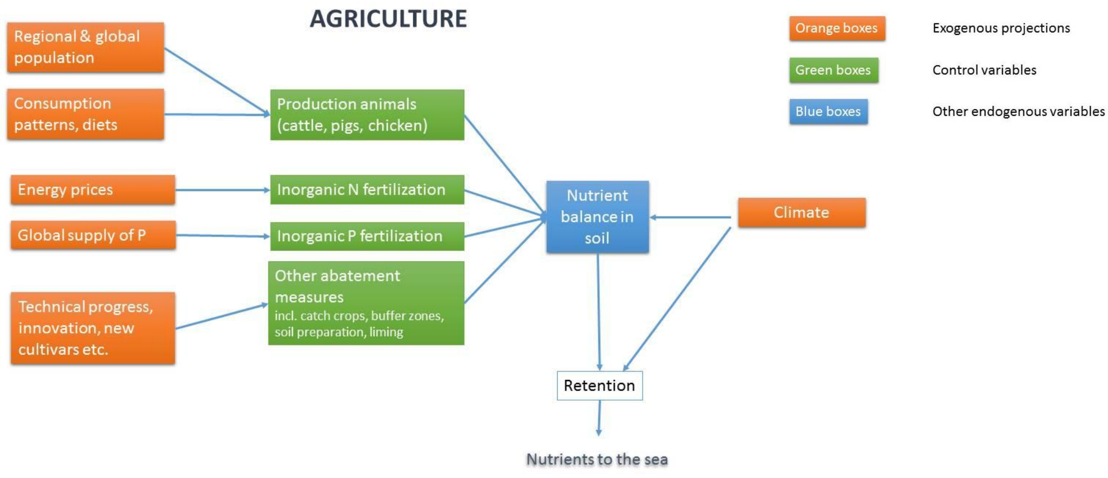
Wastewater treatment plants are typically owned by the municipalities, and governed by local town councils. Thus, the decision on the standard of wastewater management is made at municipal level. The main driving effect on the municipal decision making is the environmental awareness of the citizens and members of city council.

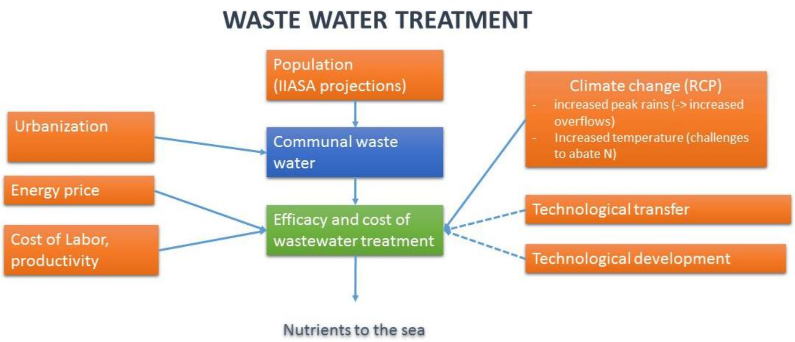
Atmospheric deposition of nitrogen straight to sea constitutes about 25% of the nitrogen load to Baltic Sea (Helcom, 2015). It originates from emissions of nitrogen oxides (NO_x) and ammonia (NH_3). Currently nitrogen oxides constitute annually around 55% of the total nitrogen deposited to the Baltic Sea from the atmosphere (Helcom, 2015). The main sources include combustion processes in energy production, industry, road transportation and shipping. The emitted ammonia comes mainly from agriculture, where the main sources comprise fertilizer application and animal manure. Some of the nitrogen oxides deposited in Baltic Sea originate from countries far from the Baltic Sea, because nitrogen oxides may travel over long distances before being deposited. In contrast, ammonia is deposited rather close to the emission source (Helcom, 2015). Evidently, the main driver of change in atmospheric deposition of nitrogen is the development of technology and extent of combustion processes (generating nitrogen oxides) and agriculture (generating ammonia).

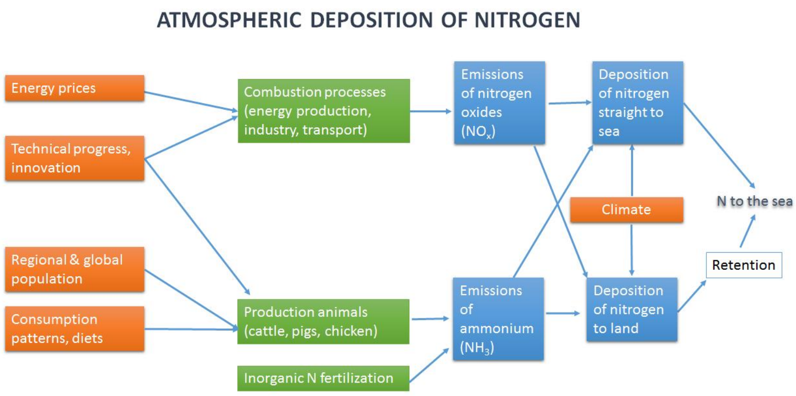
Atmospheric deposition of phosphorus is much less significant source than atmospheric N. It is transported over long distances in a form of dust aerosols. Atmospheric P loads originate from multiple natural sources such as pollen, vegetation detritus, insects, volcanic activity as well as anthropogenic activities such as coal combustion and soil preparation (see e.g. Winter et al. 2002, Tsukada et al. 2006).

Figure 6 shows the main drivers of change wit regard to agriculture, waste water treatment and atmospheric deposition. The socio-economic pathways are described through this Deliverable and the forcing data-set reported under D1.2.

Figure 6. Main drivers of change in agriculture, waste water treatment and atmospheric deposition







3.2 Fisheries

Fisheries are historically an important part of the culture for people living around the Baltic Sea. However, industrialization of fisheries and increasing efficiency of fishing gears during the twentieth century led to a decrease in the number of fishing vessels and professional fishermen, a trend that continues today. Despite the cultural importance, fisheries are economically a small and relatively unsuccessful sector. In addition to commercial fishing, recreational fishing is important in the Baltic and recreational catches of targeted species are high (HELCOM, 2015).

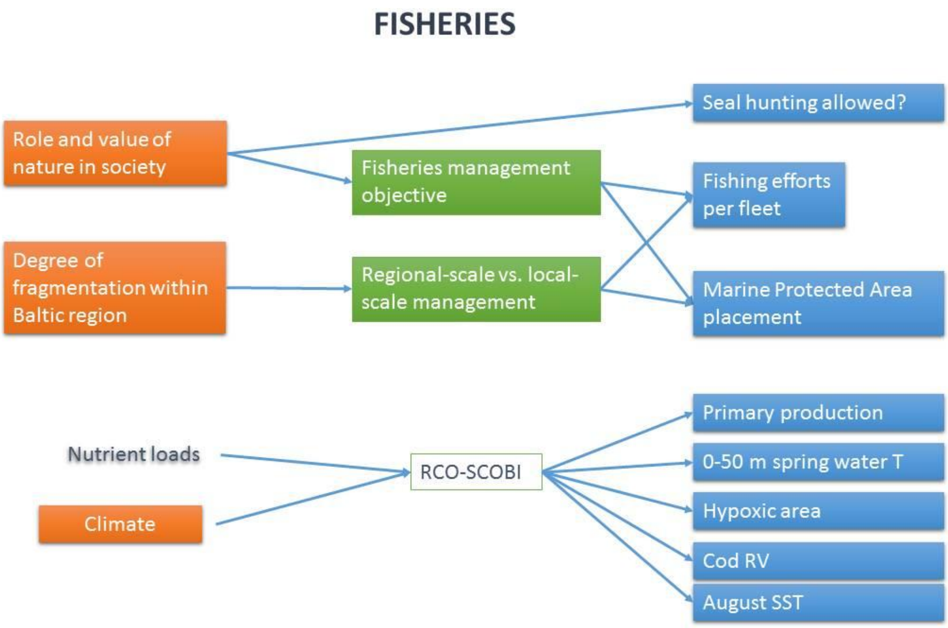
The three main target species accounting for most of the catch are cod, herring and sprat. Besides these species, some others such as salmon and flounder and at the coast sea trout, whitefish, pike and pikeperch are caught (HELCOM, 2010). Cod and other demersal species are mostly caught by mobile gears (bottom trawls and to some extent demersal seines). Among mobile gears, most vessels are in the length group 12-18 m, while 24-40 m vessels catch the highest volume (Hutniczak, Nieminen, Hoffmann, & Yletyinen, 2015). Inshore cod fishery, traditionally conducted by gillnets and longlines, has been suffering increasing damage caused by the growing grey seal population (S. Königson, Lunneryd, Stridh, & Sundqvist, 2009). Alternative fishing gears such as traps and pots are currently being developed and tested for being an effective seal-safe way of catching cod (S. J. Königson, Fredriksson, Lunneryd, Strömberg, & Bergström, 2015). Demersal fish are caught for human consumption. In contrast, sprat and herring are sold as animal feed as well, and consequently have a relatively low economic value. These species are mostly caught by large (24-40 m) pelagic trawls (Lassen, 2011).

There are nine countries that have shorelines along the Baltic Sea and their Exclusive Economic Zones overlap, so several countries fish in the same areas. The largest fishing nations in terms of catches and generated value are Sweden, Finland, Poland and Denmark (OCEANA, 2011). As all Baltic countries except for Russia are Member States of the European Union, fisheries are managed according to the EU's Common Fisheries Policy. Total Allowable Catches are negotiated annually for cod, herring and sprat, and Baltic countries hold a fixed share of quotas for each species. Quotas for cod are typically set higher than suggested by scientific advice (ICES, 2016). In addition, there are various other management measures in place, such as effort regulation, temporary closures of fishing areas and seasonal bans on cod fishing in place (Popescu, 2010).

There are several types of protected areas in the Baltic Sea, with spatial overlaps among them: national nature reserves or conservation areas, Natura 2000 sites with marine components and MPAs within the OSPAR and HELCOM networks (Baltic Sea Protected Areas, BSPAs). HELCOM MPAs covered a total marine area of 48392 km^2, 11.7% of the total surface area of the Baltic Sea in 2013. Most of the MPAs fall within national territorial waters, a smaller fraction in EEZs. Natura 2000 sites are designated following the Birds and Habitats Directives, while BSPAs are mostly designated because of biological values of regional importance (HELCOM, 2013).

Figure 7 depicts the main drivers of change (orange boxes) in fisheries, which, for the socio-economic pathways are described through this Deliverable and D1.2.

Figure 7. Main drivers of change in fisheries



4. Storylines

4.1. SSP1 – Sustainability

General social trends

In a sustainable future, existing European Directives and international agreements on the environment are fully implemented (WFD, BSAP, Gothenburg Protocol, NECC Directive). Food consumption changes towards demanding more local and organic produce as well as a move towards an increasingly plant-based, organic and local diet. The reduction in livestock in the region leads to a significant change in land use and application of manure.

The world is characterised by an open, globalised economy with relatively rapid technological development employed to improve the environmental performance of industrial processes and agricultural management. Economic growth rates are medium high in the region.

Overall, population in the region decreases at significant rate, but with very different developments in the region. For instance, while Sweden, Finland and Denmark experience strong population increases, Latvia and Lithuania need to deal with a halving of their population. Urbanisation is rapid but dense, in particular in Poland and the Baltic countries, where urbanization up to today has been slow. Because of increased environmental consciousness and concern to increase material efficiencies, densification of cities avoids urban sprawl. More nature areas in vicinity to urban centres are established on former agricultural land to provide enhanced recreation opportunities.

Nutrients - agriculture

Due to a significant change in the composition of food demand, agricultural land cover in the region decreases significantly due to increased efficiencies and reduced numbers of livestock that frees up agricultural land. Excess agricultural land is converted into perennial crops for bioenergy purposes or recreational nature areas in vicinity to urban areas. Intensity of farming increases, albeit not to the same extent as in SSP5. Farmers and policy makers focus on enhancing efficiency in order to minimize environmental pressures, leading to increased nitrogen use efficiency.

Nutrients – waste water treatment plants

Municipal wastewater treatment plants in the Baltic Sea region apply more sophisticated and comprehensive treatment and the sewage system is geared to avoid pollution load due to sewer overflows. This corresponds to a full implementation of current EU policies and in addition full compliance with the HELCOM recommendations[2], which i.a. recommend improved phosphorous removal in the Baltic Sea area at 95% and 50% removal rate for nitrogen. All waste water treatment plants are updated to tertiary during a transition period of 30 years.

2 (Helcom, 2007)

Nutrients – atmospheric deposition of nitrogen

The relatively rapid development in clean energy technologies combined with successfully implemented policies to control air pollutants lead to an extremely significant reduction in nitrogen oxides emissions and subsequently in the deposition of nitrogen oxides (O'Neill et al., 2015). The ammonium emissions, and thus deposition, decrease significantly because of the reduction in livestock, improved storage and spreading technologies of manure and reduced agricultural land cover in the region.

Fisheries

The Baltic Sea region focuses on sustainable fisheries that operate at a level that maintains the health of the ecosystem with the long-term objective of obtaining a Good Environmental State (GES) in the Baltic Sea. High quality marine nature conservation is established, i.a. doubling the marine protected areas (MPAs) from the current 174 HELCOM MPAs and ensuring a coherent and well managed network of MPAs. Fisheries are highly regulated and fishing bans are possible on certain species and time periods.

Management of marine resources is ecosystem-based and fish consumption is levelled to what is considered sustainable regionally and globally. Fisheries are managed primarily to provide long-term economic gain, a sustainable source of protein or cultural and recreational values. In either case, maintaining viable fish, bird and marine mammal populations and high benthic diversity are of primary importance.

Trawl and other habitat damaging fishing approaches are prohibited and quotas for industrial fisheries are reduced. In contrast, small-scale fisheries are promoted as a local food source. Recreational fisheries of trout and salmon may be increased as a basis for local tourism. Fish farming that are based on plant-based feed and optimized feeding systems to minimize emissions increase in areas where the ecosystem is robust enough to allow it. Compensatory measures to off-set impact may be implemented.

Fish products are used predominantly for human consumption, not for animal feed. Abundant resources are invested in monitoring, ecosystem science and sophisticated spatial planning. During the latter, trade-offs among areas designated for protection, aquaculture, fishing, shipping and renewable energy production are made conscious. Due to improved environmental conditions, reproductive potential for demersal spawning fish increases.

Technological development

Technological development related to agricultural practices involves risks and the experiments (needed at development stage) need to be regulated. Potential role for GMOs, for example in aquaculture is openly debated in society. The sewage sector applies more sophisticated and comprehensive treatment. Air pollution reduces along with cleaner energy production and the growing number of electric vehicles. Fishing gears become more selective to minimize bycatch, and more efficient to decrease fuel use.

4.2. SSP2 – Middle of the Road

General social trends

In a 'Middle of the Road' future, existing European Directives and international agreements on the environment are only partially implemented (WFD, BSAP, Gothenburg Protocol, NECC Directive). Food consumption patterns remain relatively stable compared to today. The share of organic and local produce increases slightly, but remains a niche.

The world is characterised by partially functioning and globally connected markets with a medium technological development, which only lead to some improvements in the environmental performance of industrial processes and agricultural management. Economic growth rates are medium in the region.

Population in the region decreases at a modest rate. More people move to urban centres, but generally at a central rate. In particular Poland will experience a strong urbanization trend. Because of a lack of systematic integration of environmental issues in spatial planning and decision-making, densification of cities is not successful, and urban areas expand proportionally with increases in urban population. Existing nature areas used for recreation are sought kept to the extent possible, leaving relatively less urban green areas for the growing number of future urbanites.

Nutrients – agriculture

The extent of livestock in the region remains overall the same as today, but agriculture intensifies substantially in Poland and the Baltic countries. Agricultural land cover in the Baltic Sea region remains stable, but farms evolve into larger units, with increased industrialisation and production efficiency, following the trend from Denmark. Some efforts are made to increase N efficiencies, but to varying success. Fertilizing rates continue at current economic optimum and WFD management plans are only partly implemented. Environmental pressures remain overall the same, but with local differences.

Nutrients – waste water treatment plants

The sewage sector expands as urbanization increases at a central rate and applies efficient waste water treatment. Rural areas, however, lag behind in improving waste water treatment. There is compliance with current regulations in urban areas but not in rural areas. The HELCOM recommendations on municipal waste water treatment plants are only partially implemented in urban areas.

Nutrients – atmospheric deposition of nitrogen

Medium technological development and declining energy use intensity lead to a significant reduction in nitrogen oxides emissions and deposition. Even though there are no changes in the livestock population in the region, the ammonium emissions and deposition decrease slightly as a consequence of the improved storage and spreading technologies of animal manure.

Fisheries

The Baltic Sea region fisheries policies is managed at a sub-optimal level, i.e. based on quotas that are guided by Maximum Sustainable Yields (MSY) levels, but exceed ICES advice, as is currently the case. The sub-optimal management leads to an unstable system and unpredictable behaviour of the fish stock. Existing MPAs are maintained but no new areas are added. Maintaining viable fish, bird and marine mammal populations and high benthic diversity are of not of primary importance. Marine aquaculture expands at medium rate, necessitating increasing imports of fishmeal and fish oils.

Trawl and other habitat damaging fishing approaches continue to be allowed. Pressure on nursery grounds also continues to increase as people will want to live at the coast and the coastal built environment expands. The trend toward falling number of fishermen active in the industry and larger fishing vessels continues. Fishing is mostly for local demand, few exports. The quality of fish decreases due to continued pollution (e.g. herring dioxin content).

Technological development

Technological development related to agricultural practices leads to increased industrialisation and production efficiency at a moderate rate with some N efficiency in place. The sewage sector expands as urbanization increases, thereby decreasing loads from point sources. Air pollution reduces somewhat following medium rate of technological development.

4.3. SSP3 – Fragmentation

General social trends

In a Fragmented Future, policies are defined by national interests rather than advancing common visions and goals. The Common Agricultural Policy framework breaks down, making way for national subsidy schemes that strongly support security and safety of food supply at national and regional level. Existing European Directives and international agreements on the environment are abandoned (WFD, BSAP, Gothenburg Protocol, NECC Directive) and HELCOM ceases to exist.

The world is characterised by de-globalisation, customs and taxes on trade are reintroduced, restricting the level of international trade severely, agricultural produce and fish. The EU splits into regional blocs, of which the Baltic Sea region is one bloc. Economic growth is low, particularly in Germany. Low investment in technological development leads to abandonment over time of environmentally friendly technology, reducing the environmental performance of industrial processes and agricultural management. The share of meat and dairy in food demand remains stable, but is sourced from within the region.

Overall, population in the region decreases at a significant rate. Particularly strong declines in population will be found in Germany, Estonia and Poland with populations dwindling to half or even less. Urbanisation is slow, in particular in the Baltic countries and Poland.

Nutrients – agriculture

Agricultural land cover in the Baltic Sea region decreases significantly due to reduced international trade with other blocs and falling population in the region. Focus in production is on self-sufficiency with only marginal space and demand for organic farming on the market. A general abandonment of environmental regulations and also the WFD management plans lead to a lack of focus on N efficiencies and subsequent increasing load per ha. Farm restructuration towards larger and more efficient units is reversed and the sector productivity drops significantly due to ageing farm equipment and technologies and a lack of investments.

Nutrients – waste water treatment plants

After the currently planned waste water plants have been established in the former East bloc, municipal waste water sector undertakes no technology update or replacement of current technology due to lack of public investment. A low urbanization rate combined with a strong population decline means that small and medium sized rural waste water treatment plants in Poland and the Baltic countries continue to serve a fair share of the population. After end of lifetime, facilities with tertiary treatment regress to secondary and secondary to primary. The HELCOM recommendations are far from fully implemented.

Nutrients – atmospheric deposition of nitrogen

The restricted international trade and transport of consumables and people together with slow economic development cause reductions in nitrogen oxides emissions and deposition. The ammonium emissions and deposition tend to decrease because of the reduction in the agricultural land cover in the region.

Fisheries

Fisheries management in the Baltic Sea region is characterized by a lack of coordinated efforts to ensure a sustainable fishery, which reduces the role of ICES and cross-national regulations. Some countries may attempt to apply fisheries quotas according to scientific advice while others have low ambitions or lack the resources to follow.

All ‘blocks’ aim to maximize exploitation of the stocks they have access to, aiming for high yields to ensure local and regional food security. Freshwater and marine aquaculture therefore expands at a strong pace without a focus on minimizing loads to the Baltic Sea. The current 174 HELCOM MPAs are reduced to only a few and there is no control over seal hunting. Fisheries are either managed sub-optimally or not at all leading to an unstable system and unpredictable behaviour of fish stocks. On a positive note, the decline in human population in the Baltic Sea Region and slow urbanisation rate leads to only a low degree of habitat disturbance, especially in coastal areas that serve as nursery grounds for fish. In the extreme case of an open conflict among blocs, fishing is stopped.

Technological development

Only low technological development occurs in the different sectors, leading to no focus on nutrient efficiencies in agriculture or on addressing air pollution, no fulfilment of the HELCOM recommendations on municipal wastewater treatment plants, a regression over time in WWTPs technology.

4.4. SSP5 – Fossil-fueled development

General social trends

In a societal development that follows conventional development first, focus is on ensuring a robust economic growth to address social and economic problems. The world is characterised by an open, globalised economy with rapid technological development employed to improve profitability of individual sectors and engineered solutions to climatic and environmental pressures. Focus is on keeping production costs down, improving conditions for industry and trade, and enhancing productivity. Technological development is rapid and some environmental efficiencies may be obtained as a result, although this is not the primary focus. As a result, economic growth is high with significant increases in trade and transport. Agricultural subsidies are gradually removed to allow for international competition and market driven innovation.

Environmental regulation of air pollution, point source pollution and agriculture is more lenient. WFD, BSAP, the NECC Directive will be modified to require only relative targets as opposed to absolute reduction targets, where relative improvements follow advances in technological developments.

Globally, food consumption changes towards demanding significantly more meat and dairy products, where food quality and price are key factors.

Population growth and urbanization rate are both rapid. As there is little concern for conserving land from urban encroachment, low density housing in former green belts and retail developments develop rapidly in suburban areas adjacent to larger urban centres. Largest changes will be found in Poland and the Baltic countries, but also in Denmark, Finland and Sweden, which may see a doubling or more of population over the century, with the vast majority of the population will be living in urban and peri-urban areas. Spatial planning is lax, allowing for private housing to expand on agricultural land, nature areas and in the coastal zone but does not provide new public green spaces for recreation. Existing green urban areas will be subject to urban sprawl and experience fragmentation or decline as people will want to live in green areas.

Nutrients – agriculture

The combination of more meat and dairy in the food demand composition in general and a strong global population growth, the Baltic Sea Region leads a policy on increasing the exports of agricultural produce, where emphasis is on high productivity with increasing inputs and no application of nitrogen efficiencies. Smart agriculture may increase efficiency and lead to relative environmental benefits, although this is not the primary focus. Organic farming only occupies a niche in the market. Agriculture in Poland and the Baltic countries will intensify substantially compared to today and export of meat and dairy products increases significantly from the region. The increase in livestock in the region leads to a significant change in land use and application of manure. Imports of livestock feed of soya and fishmeal increases significantly.

Nutrients – waste water treatment plants

Upgrade and expansion of the sewage water infrastructure does not follow the urban rapid development and population increase due to a lack of priority. More wealthy areas have high cleansing technology while less wealthy municipalities do not.

Nutrients – atmospheric deposition

Despite a growing and fossil-fuel dependent economy, rapid technological progress leads to reductions in nitrogen oxides emissions and deposition. The ammonium emissions and deposition increase significantly because of the increase in livestock.

Fisheries

Fisheries in the Baltic Sea Region focus on maximising profits. The management regulations allow the use of trawling and other habitat destructive approaches in order to increase productivity; and MPAs are only preserved if they do not reduce productivity in the short term. The current quota system relaxes to go beyond maximum sustainable yield (MSY) or is abandoned altogether. A reactive management is implemented where fishing restrictions are strongly enforced temporally and spatially after stock collapses, but exploitation quickly increased again after stocks regenerate.

Fishing gears are highly technologically developed and effective allowing for targeted fisheries. This may change the genetic composition of fish stocks over the long term. Fish products are also used for feeding the growing livestock production.

Freshwater and marine aquaculture are developed at an industrial scale for own consumption and for a growing exports of fish products. As in agriculture, there is no focus on minimizing nutrient emissions from aquaculture and fish feed will largely be imported.

Nursery grounds are under strong pressure as people will want to live at the coast and the coastal built environment expands rapidly together with the sprawling urban developments. Pressures from increased marine traffic (oil spills, invasive species) and climate change further reduces environmental quality. Climate change may impact fish processing practices, e.g. fish may need to be frozen sooner, on board.

Technological development

Technological development related to agricultural practices involves risks and the experiments (needed at development stage) need to be regulated. Potential role for GMOs, for example in aquaculture is widely applied. The sewage sector applies more sophisticated and comprehensive treatment in wealthy areas only. Fishing gears become highly technological and more targeted to optimise value of catch. The local impacts of air pollution are addressed effectively by technological solutions, but global impacts are neglected (O’Neill et al. 2015).

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