



Economic and social analyses

in the Baltic Sea region –
HELCOM Thematic assessment 2011–2016

Baltic Marine Environment
Protection Commission

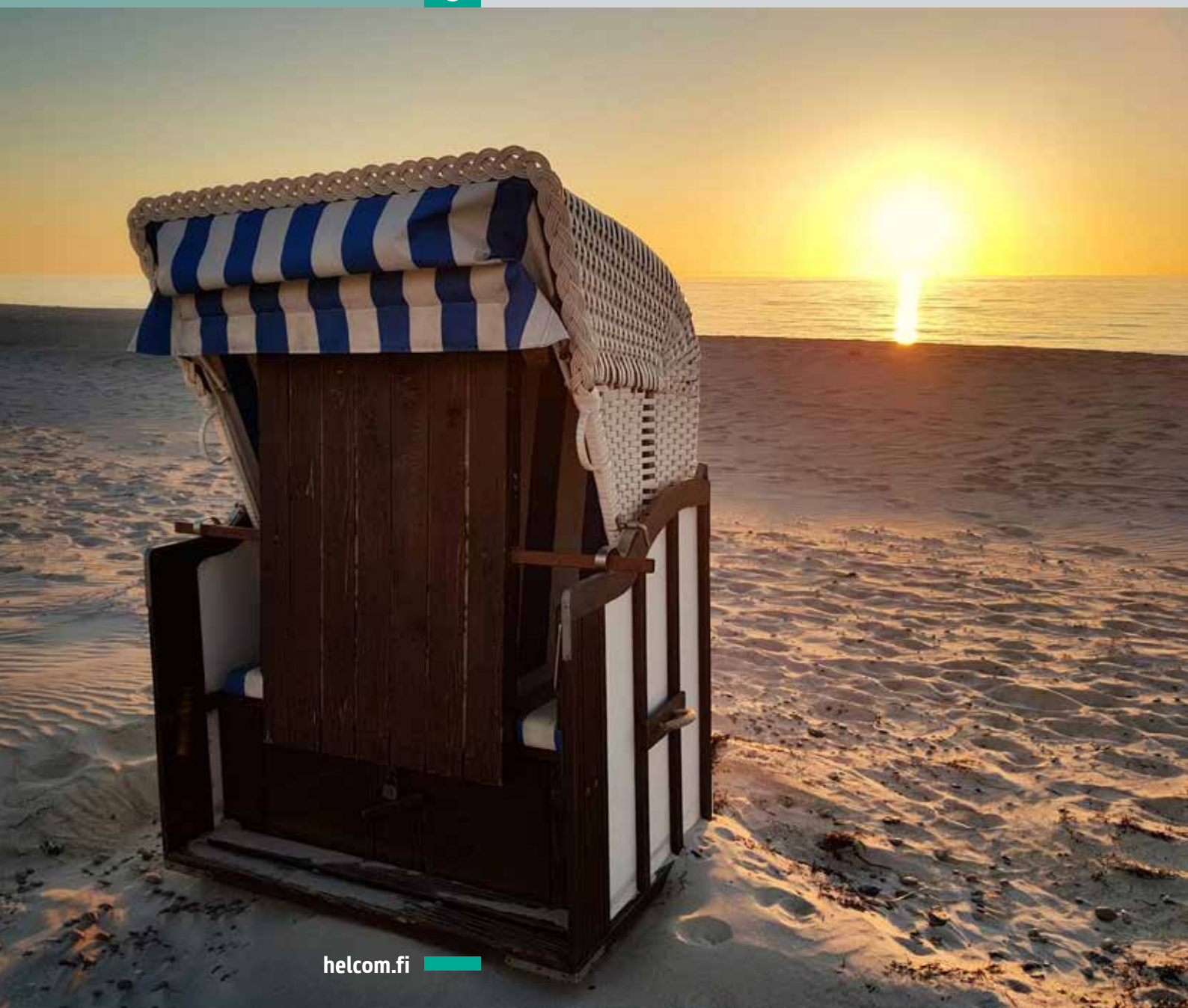
Supplementary report to the HELCOM 'State of the Baltic Sea' report (PRE-PUBLICATION)



Economic and social analyses



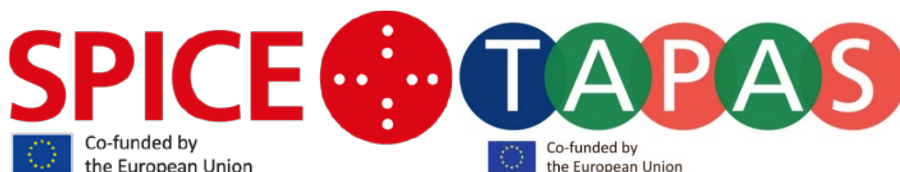
HELCOM Thematic assessment 2011–2016



Economic and social analyses in the Baltic Sea region – HELCOM Thematic assessment 2011-2016. Supplementary report to the HELCOM 'State of the Baltic Sea' report.

NOTE: This is a pre-publication version. The report will be given a professional layout and then re-published during summer 2018.

The production of this report was carried out through the HELCOM Project for the development of the second holistic assessment of the Baltic Sea (HOLAS II). The methodology and assessment were developed through the HELCOM TAPAS and SPICE projects. The work was financially supported through HELCOM and the EU co-financing of the HELCOM coordinated projects TAPAS and SPICE.



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Acknowledgements: The work presented was developed under the EU co-financed projects HELCOM SPICE and HELCOM TAPAS, and guided by the [HELCOM ESA WS 1-2015](#), [TAPAS ESA WS 1-2016](#), [TAPAS ESA WS 2-2016](#), [HELCOM ESA WS 1 -2017](#), [HOLAS II ESA WS 2 – 2017](#), [HOLAS II ESA WS 3 – 2018](#) workshops, the HOLAS II Core team and HELCOM GEAR (Group on the implementation of the ecosystem approach).

For bibliographic purposes, this document should be cited as:

HELCOM (2018): Economic and social analyses in the Baltic Sea region – HELCOM Thematic assessment 2011-2016. Available at: <http://www.helcom.fi/baltic-sea-trends/holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/>

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Summary

Economic and social analyses illustrate the importance of the Baltic Sea marine environment to society, the contribution the marine environment makes to the well-being of current and future generations, and to national and regional economies. The economic impacts originate from two sources: the use of marine waters and the state of the marine environment. Human activities that are dependent on the sea bring substantial economic benefits, both in terms of their effect on the national economy and employment and more broadly on citizens' well-being. Actions to protect the marine environment may also create economic benefits for economic sectors as well as citizens.

Human activities often create pressures on the state of the marine environment and its ability to provide goods and services. Degradation of the marine environment negatively affects the economic contribution from marine activities and sectors, and also citizens' well-being, for instance through reducing the enjoyment and opportunities for marine and coastal recreation. Moreover, people who value the existence of a healthy marine ecosystem and its species suffer from a decrease in their well-being.

Assessments to address these economic and social aspects of the marine environment can be implemented in many ways. The following report presents the approaches developed for the second HELCOM holistic assessment of the ecosystem health of the Baltic Sea, which is the first example of regional scale analysis in the Baltic Sea area. A summary of results of relevance at Baltic Sea regional scale is presented in the 'State of the Baltic Sea' report (HELCOM 2018).

The assessment is conducted within a common framework, which includes the two types of analyses requested by the MSFD Initial Assessment: the economic and social analysis of the use of marine waters, and cost of degradation.

The approach developed for the use of marine waters analysis relies mainly on the water accounts approach and statistics to measure the economic impact from the use of marine environment. Economic indicators, such as value added and employment, are collected for the sectors and activities present in the marine environment. These statistics are complemented with information on the non-market value of marine and coastal recreation, in line with the ecosystem services approach. Results from the use of marine waters analysis are presented for fish and shellfish harvesting, aquaculture, tourism and recreation, renewable energy generation and transport infrastructure and shipping. The analysis provides information on the contribution of current use of the marine environment to the economy.

The cost of degradation approach employs a mix of the thematic and ecosystem services approaches. Estimates of cost of degradation rely on economic valuation studies on changes in the state of the marine environment with regard to relevant descriptors of good environmental status and ecosystem services. Baltic Sea wide studies, providing value estimates for each coastal country, are preferred when they are available. This is the case for cost of

degradation related to eutrophication and recreation. For other descriptors and ecosystem services, the framework suggests using value transfer, where cost of degradation estimated in some of the Baltic Sea countries are transferred to those where estimates do not exist. Estimates based on value transfer are presented related to biodiversity and food webs. Cost of degradation analysis measures how achieving the good environmental status contributes to citizens' well-being.

Chapter 1. Introduction

We use the sea in many ways: for fish and shellfish harvesting and aquaculture, for tourism and recreation, as transportation routes and as a space for energy production. These sea-dependent activities bring substantial economic benefits, both in terms of their effect on the national economy and employment and more broadly on society's well-being. The economic and social analysis of the *use of marine waters*⁴ examines the current economic impacts from the activities and sectors present in the marine environment. These human activities also create pressures that affect the state of the marine environment and its ability to provide goods and services for human well-being.

The environmental impacts, including effects of e.g. nutrient loading, marine litter and hazardous substances, reduce society's well-being and benefits from the marine environment in many ways. Environmental degradation may negatively affect the economic contribution from marine activities and sectors, and also citizens' well-being through reducing, for example, the enjoyment and opportunities for marine and coastal recreation. Moreover, citizens who value the existence of a healthy marine ecosystem and its species suffer from a decrease in their well-being. The reduction in human well-being caused by the deterioration of the marine environment is the focus of the *cost of degradation* analysis.

Economic and social analyses on the use of marine waters and cost of degradation illustrate, from one perspective, the importance of the Baltic Sea marine environment to the well-being of current and future generations, and to national and regional economies.

The economic and social analyses of the use of marine waters and the cost of degradation can be interpreted and executed in many ways. This report presents a conceptual framework for the regional use of marine waters and cost of degradation analyses that form the basis for the economic and social analyses in the 'State of the Baltic Sea' report (HELCOM 2018).

The approach developed for the use of marine waters analysis relies mainly on the water accounts approach and statistics to collect economic indicators for the sectors and activities present in the marine environment. These statistics are complemented with information on the non-market value of marine and coastal recreation, in line with the ecosystem services approach. Results from the use of marine waters analysis are presented for fish and shellfish harvesting, aquaculture, tourism and recreation, renewable energy generation and transport infrastructure and shipping.

⁴ Henceforth referred to with the term *use of marine waters analysis*.

The approach for the cost of degradation analysis employs a mix of the thematic and ecosystem services approaches. Estimates of cost of degradation rely on economic valuation studies on changes in the state of the marine environment with regard to relevant descriptors of good environmental status and ecosystem services. Baltic Sea wide studies, providing cost of degradation estimates for each coastal country, are available for eutrophication and recreation. For other descriptors and ecosystem services, such as biodiversity and food webs, the framework suggests using value transfer, where cost of degradation estimated in some of the Baltic Sea countries are transferred to those where no estimates exist.

Coherent and comparable approaches and results on the economic and social aspects of the Baltic Sea marine environment have thus far been lacking. The aim of the current assessment has been to provide a regional framework for the economic and social analyses that is applicable at the Baltic Sea level and also supports national implementation of marine policies, such as the EU MSFD. The results are an outcome of expert workshops⁵, reviews of literature and data collection to provide a practical application of the concept. The chosen approaches are in line with the guidance document provided by the European Commission's Working Group of Economic and Social Analyses of the MSFD (WG ESA 2010).

The report includes an overview of the framework and concepts used to measure economic and social contribution and impacts, as well as the detailed methods and results for the economic and social analyses of the use of marine waters and cost of degradation that have been included in the 'State of the Baltic Sea' report (HELCOM 2018).

⁵ Workshop outcomes: [HELCOM ESA WS 1-2015](#), [TAPAS ESA WS 1-2016](#), [TAPAS ESA WS 2-2016](#), [HELCOM ESA WS 1 -2017](#), [HOLAS II ESA WS 2 – 2017](#), [HOLAS II ESA WS 3 – 2018](#)

Chapter 2. Conceptual approach for the regional economic and social analyses

This chapter gives an overview of the approaches for the economic and social analyses of the use of marine waters and cost of degradation used in the 'State of the Baltic Sea' report (HELCOM 2018). The details are presented in the subsequent chapters. The framework for regional economic and social analyses builds on the conceptual model developed in the HELCOM HOLAS II economic and social analyses workshop in 2015 ([HOLAS II ESA WS 1-2015](#)). In the beginning, the aim was to make an adaptation of the Driver-Pressure-State-Impact-Response (DPSIR) model and show how the use of marine waters creates pressures on the marine environment and the ecosystem services it provides, thus causing cost of degradation. Such an analysis would identify the level of economic activities that would lead to the achievement of good environmental status, and assess both the monetary contribution of the economic activities to the economy and their effect on the environmental values. It became evident that this kind of analysis was too challenging considering the availability of data and resources for the work, and thus the framework was simplified so that use of marine waters and cost of degradation would be analysed separately without explicitly linking them to each other (Figure 1).

To maintain adaptability of the analysis and present all the available information, the framework combines several approaches for the use of marine waters and cost of degradation analyses. The chosen approaches, illustrated in Figure 2, are in line with the WG ESA guidance document (WG ESA 2010) and will be further elaborated in the next sections.

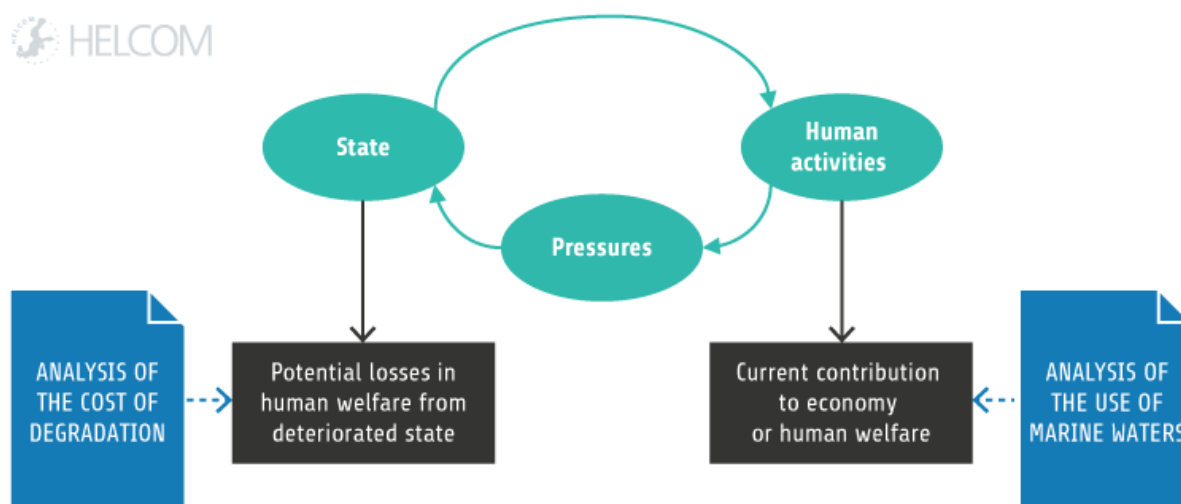


Figure 1. Roles of economic and social analyses in the holistic assessment. The human activities contribute to the national and regional economies and human welfare, which is measured by the economic and social analysis of the use of marine waters. The state of the marine environment affects human welfare. The welfare losses from not being in a good environmental status are estimated in the cost of degradation analysis. The status also affects the economic contribution from many activities, such as recreation and fish and shellfish harvesting, as shown by the link back from 'state' to 'activity'. At present, the results of the analyses do not reflect the links between activities, pressures and state of the marine environment (or vice versa).

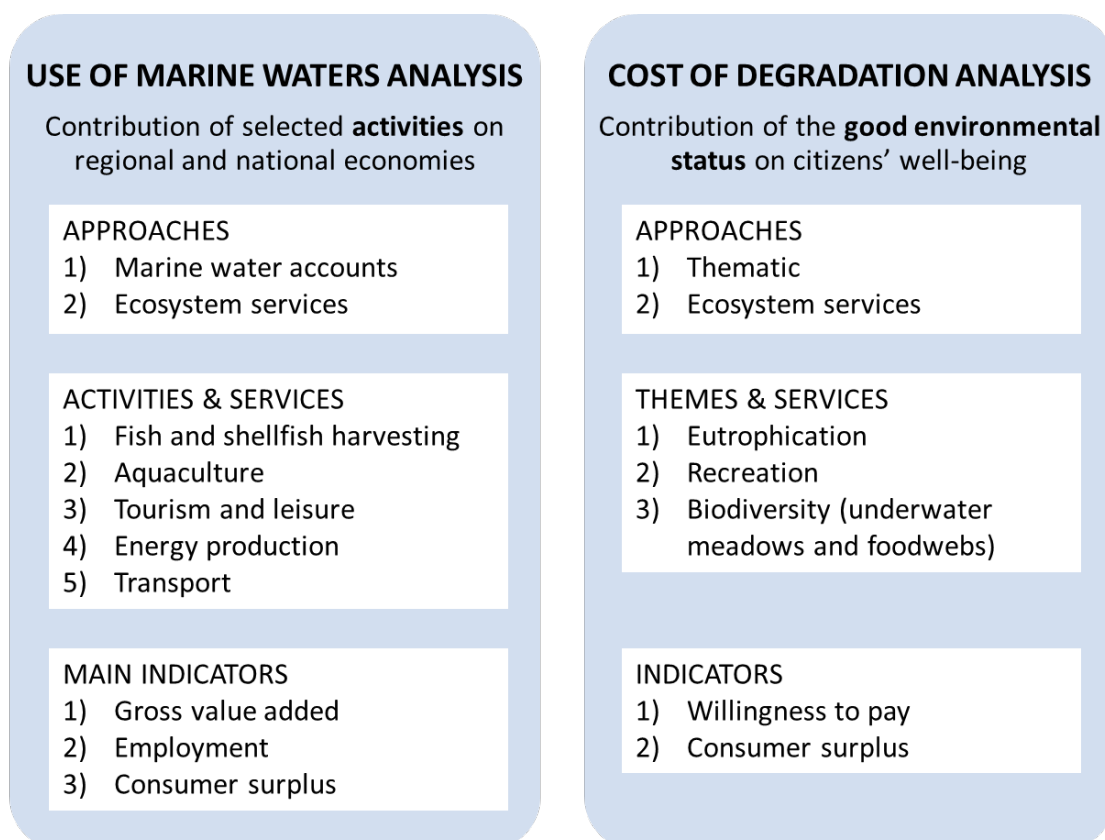


Figure 2. HELCOM HOLAS II uses mixed approaches for the use of marine waters and cost of degradation analyses.

2.1 ECONOMIC MEASURES USED IN THE REPORT

The results from the use of marine waters and cost of degradation analyses are mainly measured in monetary terms. However, it should be noted that, in most cases, the monetary estimates presented in this report are not additive or directly comparable, since they measure different effects and are calculated using different approaches and methods (as further explained in the following sections). The following presents a short description of the concepts used to measure economic and social contribution: economic impact, economic value and price.⁶ This information is important to keep in mind when viewing and interpreting the results.

Economic impact represents the money and employment generated by an activity, in other words, the economic contribution the activity makes to the economy. While economic impacts do not, strictly speaking, provide information about economic values, they are easily measured, and thus widely used in assessing the economic importance of activities and sectors.

Economic value means the contribution of a resource or goods to the well-being of an individual or the society at large, and can be measured using people's maximum willingness to pay for the goods. Since willingness to pay is not equal to the market price, economic value is not the same as market price. Related measures of economic welfare are consumer and producer surplus. Consumer surplus is the monetary gain obtained by consumers because they are able to purchase a product for a price that is less than they would be willing to pay for it. Producer surplus is the monetary gain to producers from being able to sell at a market price that is higher than the cost of production.

Measuring the willingness to pay for goods is difficult, and thus prices and revenues are often used as proxies for economic values. The problem in focusing on market prices is that some aspects of the resource that create economic value are ignored. The value of these non-market goods and services cannot be deduced based on market prices, because they are not sold in the market. The marine and coastal environment provides many non-market values, the main examples being marine and coastal recreation and the value derived from the existence of a healthy ecosystem.

In this report, the concepts are used as follows. For the use of marine waters analysis, we mainly use proxy indicators, such as gross value added and employment, to measure the economic and social impacts from the activity, i.e. the contribution the activity makes to the national economy. One exception is the analysis of recreation, for which we measure the economic value based on consumer surplus (i.e. the difference between the consumer's total willingness to pay and the total amount they pay for the good). In the cost of degradation analysis, we measure economic values based on people's willingness to pay for environmental changes and consumer surplus.

⁶ For a more detailed discussion of similar issues, see Pendleton (2009).

Chapter 3. What do we gain? Economic and social analysis of the use of marine waters

What is meant by the economic and social analysis of the use of marine waters?

As a society, we utilize the marine waters in different ways. Our various economic sectors use the sea - its resources, space, energy, etc. – and profit from doing so. As individuals, we are also employed by these economic sectors, purchase or obtain goods and services from these sectors, and enjoy using marine and coastal areas for recreation and other purposes.

While bringing certain socio-economic benefits to society, the use of marine waters also creates pressures on the marine environment. Some activities, such as fishing and recreation, are dependent on the state of the marine environment, meaning that they require a certain level of environmental quality to continue as activities. Other activities, such as the transport and energy sectors, use the sea for space, but are not themselves affected by the state of the marine environment. Some sectors, such as agriculture, impact the marine environment (use the sea as a sink) but take place elsewhere.

For this study, *use of marine waters* is defined as any human activity using the marine or coastal environment. This excludes land-based activities from the analysis.

The socio-economic analysis on the use of marine waters measures the economic impact from the use of the sea in the current state. In this analysis, this impact is measured using economic indicators which are, for the most part, based on market values. These indicators and their values do not specify the negative impacts the uses may have on the quality of the marine environment or the activities themselves. Thus, the analysis of the use of marine waters should be seen as a piece of the overall picture of how the society and the marine environment are linked.

In the economic and social analysis of the use of marine waters, human activities and sectors present in the marine environment are described using economic indicators to illustrate their economic importance and the benefits derived from the use of marine waters. There are two approaches for assessing the use of marine waters (WG ESA 2010):

1) Marine water accounts (MWA) approach:

- a) Identify and describe the region of interest.
- b) Identify and describe the economic sectors using marine waters.
- c) Identify and, if possible, quantify the economic benefits derived from the economic sector's use of the marine waters, e.g. in terms of production value, intermediate consumption, value added, number of employees, and compensation of employees.
- d) Identify and, if possible, quantify impacts on the environment generated by these sectors.

2) Ecosystem services (ES) approach:

- a) Identify ecosystem services of the marine areas in cooperation with the analysis of status and the analysis of pressures and impacts on the marine environment.
- b) Identify and, if possible, quantify and value the welfare derived from the ES using different methods to estimate the use and non-use values of these services.
- c) Identify the drivers and pressures affecting the ecosystem services.

3.1 APPROACH FOR ASSESSING THE REGIONAL USE OF MARINE WATERS

The assessment of the use of marine waters in the 'State of the Baltic Sea' report (HELCOM 2018) utilises a mixed approach which builds mainly on the marine water accounts but combines components of the ecosystem services approach with the analysis, in line with the WG ESA guidance document (WG ESA 2010). Both approaches were utilised by HELCOM countries in their 2012 MSFD Initial Assessment reporting. The mixed approach leans heavily on statistical information but complements these with non-market values and non-sectoral activities when possible (ecosystem services approach). The emphasis on the marine water accounts approach is a consequence of data availability: statistics for marine sectors and activities are more readily available than ecosystem service data and values. To increase comparability across the Baltic Sea region, sources providing data for most or all of the coastal countries have been used. Indirect use values and non-use values, mentioned in the ecosystem service approach, have not been included due to lack of data (for the definition of these values, see section *Valuing the consequences to citizens' well-being* in Chapter 4).

The approach can be characterized as follows:

General

- Utilise a mixed approach - marine water accounts approach, complemented by ecosystem service approach with non-market values
- Identify and describe the different uses of the marine waters
- Evaluate whether the activity exerts a pressure and is dependent on the state of the marine environment, based on the Baltic Sea pressure and impact index (BSPII) for pressures, expert assessment, and literature review for dependence
- Prioritise activities and sectors based on the above, as well as on data availability

Indicators and data

- Present socio-economic indicators for each activity describing the contribution of marine uses on the economy
- Select indicators for which standardised data is available across several Baltic Sea countries to ensure harmonisation (it should be noted that for the majority of the sectors, Russian data were not available)
- Include value added and employment indicators when available
- Include alternative indicators representing the activity when socio-economic indicators are unavailable

- Record data source, indicator methodology, and information about year, anomalies, etc.
- Present the indicator specific data for each sector/activity at the country level

Evaluation

- Assess the data quality and availability and provide recommendations for improvement

A shortcoming of employing only the marine water accounts approach is that the statistics exclude uses of the environment that are non-consumptive and/or are hard or impossible to measure using market prices. To overcome this, the approach employed in this report is to supplement the existing statistical indicators with indicators found from the scientific literature that measure economic benefits from non-market uses (i.e. recreation).

Human activities and sectors

The sectors are prioritised based on those which have been deemed relevant to the Baltic Sea in HOLAS II and to the MSFD Annex III (list of activities and sectors) and those which;

- create significant pressure to the marine environment
- derive significant benefits from the use of the marine environment, and/or
- are dependent on the environmental state of the Baltic Sea.

The sectors selected for the regional analysis based on these criteria are shown in Table 1. The pressures exerted on the Baltic Sea by an activity were assessed based on conclusions from the State of the European Seas report (EEA, 2015) using a Yes/No answer categories. Dependence of the activity on the state of the Baltic Sea is based on expert assessment within the HOLAS II team. All the activities mentioned in Table 1 have been included in some way in Chapter 3 'Human welfare and ecosystem health' in the 'State of the Baltic Sea' report (HELCOM 2018). An attempt to add human activities to the regional use of marine waters analysis was made by a data call to HELCOM contracting parties. The data call identified activities included in the national use of marine waters analysis and the used socioeconomic indicators. The resulting data set shows that indicators used at national scale are not directly comparable and thus not applicable in regional assessment without further analysis. Figure 3 illustrates the human activities included in the national use of marine waters analyses. Other results of the data call are shown in the coming chapters.

Table 1. Human activities and data availability for the use of marine waters analysis.

Theme	Activity	Depend on environmental state	Pressure on environmental state	Data available	In the 'State of the Baltic Sea' report
Extraction of living resources	Fish and shellfish harvesting	Yes	Yes	Fish and shellfish harvesting	Yes, Ch3
Cultivation of living resources	Aquaculture (marine)	Yes	Yes	Aquaculture - Finfish mariculture	Yes, Ch3
Tourism and leisure	Tourism	Yes	Yes	Tourism - accommodation	Yes, Ch3 (only description)
	Recreation	Yes	Yes	Marine and coastal recreation	Yes, Ch3, Box 3.3
Production of energy	Renewable energy generation	No	Yes	Offshore wind energy production	Yes, Ch3
Marine transport	Transport infrastructure	No	Yes	Transport infrastructure	Yes, Ch3
	Transport - shipping	No	Yes	Freight shipping	Yes, Ch3
		Yes/No	Yes	Passenger shipping	Yes, Ch3

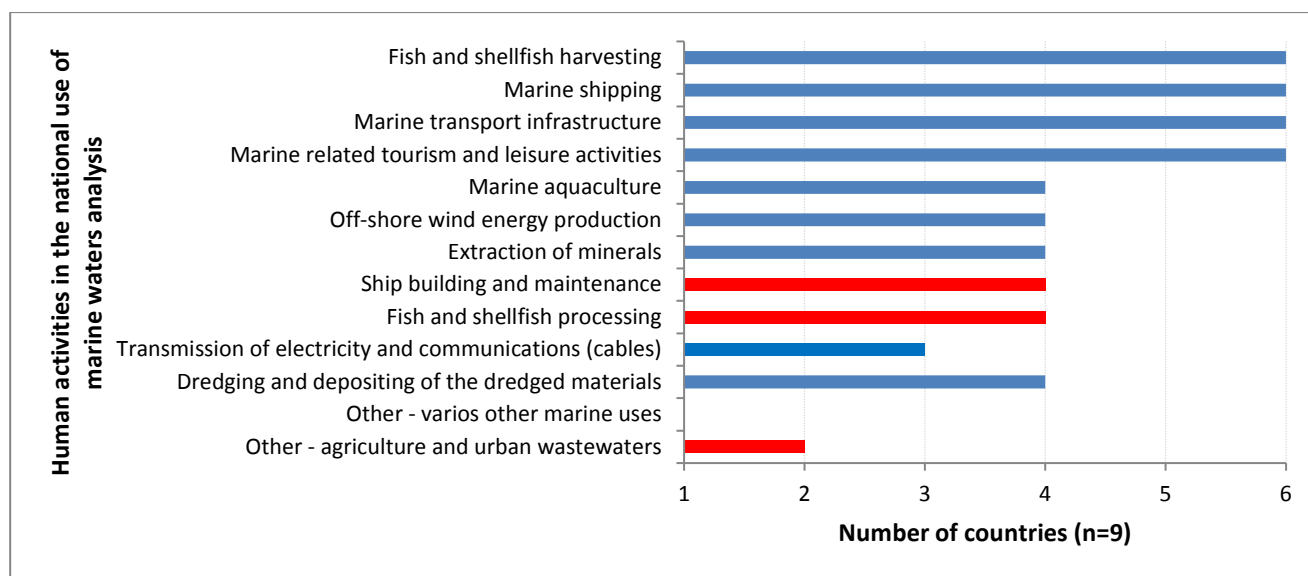


Figure 3. Number of the countries where an activity is included in the national use of marine waters analysis. Activities using the marine environment indirectly are indicated with red colour.

Socio-economic indicators

The socio-economic indicators describe the importance (or economic impact) of the activity or sector present in the marine environment. The indicators presented were selected based on availability across several countries within one source, and in order to include both economic and social aspects. As indicators, 'value added' shows the contribution of the sector to the national economy from a macro-economic perspective, while the employment indicators are more related to the social impacts from the use of marine waters. When available, we have included

indicators which can be linked to pressures and activities assessed in other parts of 'State of the Baltic Sea' report (HELCOM 2018), for example the value of fish landings. In order to include the citizen perspective, we have included non-market values for marine and coastal recreation. The data sources include Eurostat, industry associations, regional studies and national statistics.

- 'Value added' is a measure of productivity which shows the contribution of the activity or sector to the national economy. 'Gross value added' (GVA) is a recommended indicator in the WG ESA Guidance (WG ESA 2010) and is used when available. It shows the value of the goods and services that have been produced minus the cost of all inputs and raw materials that can directly be attributed to production. The Scientific, Technical and Economic Committee for Fisheries (STECF) also uses GVA and defines it using the following formula for fisheries: $GVA = \text{income from landings} + \text{other income} - \text{energy costs} - \text{repair costs} - \text{other variable costs} - \text{non variable costs}$ (STECF 2016b); and as follows for aquaculture: $GVA = \text{turnover} + \text{other income} - \text{energy costs} - \text{livestock costs} - \text{feed costs} - \text{repair and maintenance} - \text{other operational costs}$ (STECF 2016a). Eurostat uses the indicator 'value added at factor costs' which is defined as the "gross income from operating activities after adjusting for operating subsidies and indirect taxes. Value adjustments (such as depreciation) are not subtracted." (Eurostat 2017). According to STECF this indicator "is similar but does not fully correspond" to GVA (STECF 2016a).
- Employment is a proxy for a social indicator (WG ESA 2010). When possible, we use the indicator 'number of persons employed', as it is used by Eurostat Structural Business Statistics (SBS) as well as by STECF. Number of persons employed is the sum of number of employees receiving compensation for work and unpaid persons employed. It should be noted that STECF uses the expression 'total employees', which is defined the same as number of persons employed.
- Non-market valuation data are used to complement the statistics to assess the economic benefits from marine and coastal recreation. The relevant indicator is 'consumer surplus', which describes the economic benefits people obtain from recreation. Consumer surplus measures the difference between the consumer's total willingness to pay and the total amount they pay for the good (in this case recreation). Market prices or statistics of the tourism sector are either insufficient or inappropriate for capturing the full economic importance of sea-based recreation, as many recreational activities do not show in these prices or statistics.
- When the above socio-economic indicators are not available, other indicators are used. 'Turnover' is defined as totals invoiced by the observation unit during the reference period, and this corresponds to market sales of goods and services to third parties (STECF 2016a) and 'value of landings' is used for the fisheries sector as a proxy for income derived from landings calculated using price and quantity data (STECF 2016b).

- When socio-economic indicators are unavailable, quantitative indicators of activity are used, for example, number and capacity of installed off-shore wind power turbines or number of ports. Although they do not measure economic significance, they can be converted into economic figures using assumptions and conversion factors. Keeping record of non-economic data can also show sectoral and activity trends over time (growth or decline of activity).

3.2 RESULTS OF THE REGIONAL USE OF MARINE WATERS ANALYSIS

The results of the use of marine waters analysis are shown for the activities and sectors and countries for which data were available. The data are presented per country to show where the activities take place and what kind of economic and social impacts they have, and finally, the aggregate numbers of the economic indicators for the Baltic Sea region are shown in the result tables.

The indicators that are available vary for the different sectors. For most of the sectors, there are data for employment and value added. However, they are lacking for renewable energy (offshore wind energy) and marine transport infrastructure. Also, it should be noted that recreation is not a sector, but rather a human activity using the coastal and marine environment, and hence the socio-economic indicator for recreation (consumer surplus) is different in that it indicates the economic benefits obtained by citizens from taking part in this activity.

Fish and shellfish harvesting

Fish and shellfish harvesting is a sector involved in the extraction of living resources (Table 2). The socio-economic data describes commercial small-scale and large-scale fleet fishing which takes place within the Baltic Sea waters. Small-scale fleet uses vessels shorter than 12 meters using static gears, while large-scale fleet fishing includes vessels larger than 12 meters using static gears, or all vessels using towed gears.

For fish and shellfish harvesting, data specific to the Baltic Sea were available in the Scientific, Technical and Economic Committee for Fisheries (STECF) reports for all countries except for Russia (STECF 2016b, STECF 2017). Furthermore, due to the reduced number of vessels and/or enterprises in Germany and the Baltic States, data which are considered sensitive (on distant-water fleets) were not delivered to STECF. This has an impact on the regional level analysis. Data from the year 2015 is presented in the summary report and data from the years 2014 and 2015 are presented in this supplementary report.

There were an estimated 6,192 active vessels in the Baltic Sea in 2015 (STECF 2017) compared to 6,500 active vessels in 2014 (STECF 2016b) and 6,256 active vessels in 2013 (STECF 2015). The Finnish fleet was the largest, with 1,577 vessels in 2015 compared to 1,764 vessels in 2014. Among the EU member states, Estonian, Finnish and Latvian marine fisheries are fully dependent on the Baltic Sea region, while other EU member states vessels operate also in other marine fishing regions (STECF 2016b). Only vessels operational in the Baltic Sea are included in the statistics (Table 2).

The value of landings in the Baltic Sea region was in total €217 million in 2015 (STECF 2017), compared to €218 million in 2014 (STECF 2016b) and compared to the €260 million in 2012 (STECF 2015). Gross value added for the Baltic Sea area totalled €116 million in 2015 (STECF 2017), compared to €95 million in 2014 and compared to €121 million in 2012 (STECF 2015).

In terms of employment, the commercial fishing sector related to the Baltic Sea waters employs an estimated total of 9,040 people of which the full-time equivalent employment is near half (4704). The respective numbers for 2014 are 9,450 and 5,076.

Poland, Estonia and Finland have significantly higher number of persons employed in its fleets operating in the Baltic Sea region than the other countries. (STECF 2016b).

Table 2. Socio-economic indicators related to fish and shellfish harvesting.

Country	Annual value of landings (million €)		Estimated annual gross value added (GVA) (million €)		Number of persons employed	
Data year	2014	2015	2014	2015	2014	2015
Estonia	14.5	14.5	9.3	9.4	2,070	2,242
Finland	40.4	33.6	15.5	14.9	1,847	1,668
Denmark	32.8	34.2	12.6	17.3	357	299
Germany	15.1	15.1	5.1	6.0	896	810
Latvia	19.5	19.7	7.2	11.4	607	620
Lithuania	4.2	5.0	0.7	1.9	337	356
Poland	47.9	48.7	21.7	27.9	2,485	2,277
Sweden	43.5	46.3	22.7	27.2	854	768
Russia	no data	no data	no data	no data	no data	no data
TOTAL		217.1		116		9,040

Source: Scientific, Technical and Economic Committee for Fisheries (STECF) (2017, 2016b). All monetary values have been adjusted for inflation; constant prices (2015).

^a STECF does not report on Russia.

Marine aquaculture

Marine aquaculture is a sector involved in the cultivation of living resources (fish and shellfish) in the marine environment. It is a capital-intensive sector due to the equipment needed. Economic impacts from aquaculture are presented only for Finland, Denmark and Sweden (STECF 2016a, SwAM 2017).

Marine finfish aquaculture had a total turnover of €79 million in 2014, divided mainly between Finland and Denmark (Table 3). The whole value for Denmark, Finland and Sweden can be attributed to the Baltic Sea. In Denmark, marine production of rainbow trout and trout eggs in sea cage farms is the second most important type of aquaculture after land based production of trout. The Danish marine production of rainbow trout is located in the Baltic Sea along the southern coast of Jutland and a few production sites along the coast of Zealand. In Finland, marine aquaculture consists of rainbow trout production in cages.

Shellfish aquaculture is not included in the figures, as STECF does not report shellfish data separately for marine and freshwater regions. Of the Baltic Sea countries, Denmark, Germany and Sweden are involved in shellfish aquaculture,

but it has a lower significance in the Baltic Sea than finfish aquaculture. For example, Denmark produces blue mussels in the Baltic Sea with an annual turnover of 1.3 million euros.

It is pertinent to note that there is one finfish and one shellfish farm in the German waters of the Baltic Sea, but the production volumes and other types of data are confidential, hence there is information only on the locations of the farms. For all the other countries, the production is assumed to be zero (and thus the turnover, gross value added and employment), based on the national production and sales data reported to STECF.

Table 3. Socio-economic indicators related to marine finfish aquaculture (data from the year 2014)

Country	Annual turnover (million €)	Annual gross value added (GVA) (million €)	Number of persons employed
Estonia	0*	0*	0*
Finland	20.2	4.8	89
Denmark	57.4	9	155
Germany	confidential	confidential	confidential
Latvia	0*	0*	0*
Lithuania	0*	0*	0*
Poland	0*	0*	0*
Sweden	1.6	0.535	12
Russia ^a	no data	no data	no data
TOTAL	79	14	256

Source: Scientific, Technical and Economic Committee for Fisheries (STECF) (2016a), except Sweden: SwAM (2017).

* Only or mainly produce freshwater aquaculture and marked as 0 in STECF national data tables

^a STECF does not report on Russia.

Tourism and leisure

The coastal and marine tourism and leisure sector covers a wide range of sub-sectors including accommodation, food and drinks, and leisure activities such as boating and fishing. In many cases, it is difficult to separate the extent of the coastal and marine tourism from tourism that is not dependent on the marine and coastal environment, as the activities are not limited only to those which take place in the sea, but also includes those at the coast alongside the sea. However, marine tourism and recreation are dependent on the state of the sea, which is not true for all tourist activities taking place along the coast. In our analysis, we describe coastal tourism accommodation, available from statistics, (Table 4) and supplement these data with values of coastal and marine recreation in the Baltic Sea (Table 5).

The coastal tourist accommodation figures (value added and employment in Table 4) are available for all countries except Russia. Eurostat defines coastal areas as “municipalities bordering the sea or having half of their territory within 10 km from the coastline.” Eurostat provides statistics on the number of nights spent at tourist accommodation establishments in the coastal area, as well as the number of nights spent at tourist accommodation establishments

nationally. This enables calculating the share of nights spent at coastal areas of the total nights (coastal/total) (Table 4). Eurostat also provides the total value added at factor cost and employment statistics for accommodation. However, in order to better represent tourism related to the sea, the national value added and employment figures are multiplied with the share of coastal accommodation. For example, in Finland 38% of the value added and employment in the national tourism accommodation is attributed to the coastal areas.

It should be noted that as value added and employment data related to *tourist* accommodation is only reported by Lithuania and Sweden, we have used the value added and employment data related to accommodation, which is reported by all the EU countries. These indicator values are of similar magnitude for Lithuania and Sweden. Furthermore, for countries bordering more than one sea area (Germany and Denmark), the figures include all coastlines, as the Baltic Sea coastline is not differentiated from other sea coastlines. Figures for Russia are not available since the data source is Eurostat.

The total value added at factor cost from accommodation for coastal tourism for the Baltic Sea was €4,797 million in 2015 compared to the € 5,261 million in 2016. Total number of persons employed in this sector is 176,000 persons in 2015 and 161,000 persons in 2016. (Table 4). Socioeconomic indicators and their data year vary in the national use of marine waters analyses of the marine related tourism and leisure activities (Table 5).

Table 4. Socio-economic indicators related to tourism accommodation (data from the years 2015 and 2016)

Country	Share of the number of nights spent at tourist accommodation establishments in coastal areas of the national total number of nights spent (coastal/total) ^a		Annual value added at factor cost from coastal tourism accommodation sector (million €) ^b		Number of persons employed in coastal tourism accommodation ^b	
Data year	2015	2016	2015	2016	2015	2016
Estonia	79 %	79 %	79	89	5,159	5,341
Finland	38 %	38 %	156	168	4,526	4,205
Denmark ^c	91 %	91 %	771	821	16,013	15,367
Germany ^c	18 %	18 %	2,345	2565	97,668	90,356
Latvia	83 %	84 %	63	66	5,377	5,373
Lithuania	24 %	24 %	16	23	1,795	1,526
Poland	25 %	24 %	246	276	16,457	13,168
Sweden	62 %	63 %	1,121	1 253	29,326	25,658
Russia	no data	no data	no data	no data	no data	no data
TOTAL			4,797	5261	176,321	160,994

Sources: ^a Eurostat (2016e and 2017e: tour_occ_nin2c) and ^b Eurostat (2016d and 2017d: sbs_na_sca_r2)

^a Figures are derived from calculating the percentage of nights spent at tourist accommodation establishments in coastal areas of the national total number of nights spent at tourist accommodations (tour_occ_nin2c). Related NACE code: 55.1; I55.1; 55.2; 55.3: Hotels; holiday and other short-stay accommodation; camping grounds, recreational vehicle parks and trailer parks.

^b Figures are derived from applying the share of nights spent at tourist accommodation establishments in coastal areas to national annual value added at factor cost and number of persons employed figures (sbs_na_sca_r2). Related NACE code: 50,I55.1 Accommodation.

^c Includes coastal accommodation in both the Baltic Sea and North Sea.

^d Eurostat does not report on Russia.

Table 5. Socio-economic indicators related to marine related tourism and leisure activities according to the data call. The data year is shown in brackets.

Country	NACE code	Value added (million EUR)	Employment	Other quantitative data
Denmark ¹	NACE codes are not specified ²	Gross value added – 1,100 ³ (2014)	Employed persons – 39,800 (2014)	
Finland	I55.2, I55.3, I56.1, G47.11, N79.1, R93.29 ⁴	Gross value added – 284 (2014)	Working days – 7,250 (2014)	
Germany	NACE codes are not specified	Gross value added – 2,000 (2013)		
Latvia	No NACE codes (expenditure data are used) ⁵	Turnover (based on Expenditure) – 97.6 (2016); VA at factor costs – 23.4 (2016).	Employed persons – 3,625 (2016); Employment in FTE – 2,431 (2016).	Past trend (data for 2011-2016): changes in (1) No of accommodation establishments in coastal area – decrease by 22%; (2) persons served in accommodation establishments in coastal area – increase by 21%; (3) nights spent in accommodation establishments in coastal area – increase by 11%; (4) No of nights in leisure trips to coastal area by foreign tourists – increase by 89%.

Country	NACE code	Value added (million EUR)	Employment	Other quantitative data
Poland	Not specified ⁶	Revenues from activity – 53.9 (2016)	Employed persons – 1,177 (2016)	Average annual gross wages and salaries (EUR) – 8552.4 (2016)
Sweden ⁷	I55.10, I55.20, I55.30, I56.10 (partly – 1 km from coastline)	Gross value added – 2171.4 (2014)	Employment in FTE – 41,924 (2014)	

¹ The provided data include national data for all sea regions (not only Baltic).

² The estimates are based on consumption related to coastal tourism, excluding commercial stays. The four biggest cities are also excluded (Copenhagen, Odense, Aalborg and Aarhus).

³ Calculated using European Central Bank exchange rate for 04.04.2018: 1 EUR = 7.4499 DKK. Original data – 8.7 billion DKK.

⁴ Coastal tourism includes values (employment, value added) from seven coastal counties: Ahvenanmaa, Kymenlaakso, Pohjanmaa, Pohjois-Pohjanmaa, Satakunta, Uusimaa and Varsinais-Suomi.

⁵ Expenditure (data) on leisure trips is used, assumed as turnover of all "related" sectors, thus no need to know NACE codes. A list of sectors (with codes) is used for specific calculations (e.g. to calculate Turnover-VA and Turnover-Employment ratios). Here the list of sectors includes I55, I56, N79, R90, R91, R93. The expenditure for leisure trips to coastal counties and cities is calculated (the list is specified). The capital city (Riga) is not included.

⁶ Various tourism-related economic activities according to the Statistical yearbook of maritime economy (NACE codes are not specified). Data of the entities in coastal regions (e.g. Pomorskie, Warmińsko-Mazurskie and Zachodniopomorskie) are accounted in the estimates.

⁷ The provided data include national data for all sea regions (not only Baltic).

Recreation

In order to complement the statistics of coastal tourism, we have used estimates of the benefits from recreational visits to the Baltic Sea marine and coastal areas. These estimates (Table 6) were derived from a Baltic Sea wide travel cost study on the value of recreation (Czajkowski *et al.* 2015). The annual consumer surplus measures the total value of recreation visits made to the Baltic Sea and its coast during a year. The table also reports the average number of recreational trips to the Baltic Sea per person based on people's responses in the travel cost survey.

The total annual benefits of the Baltic Sea recreation visits in 2010 were €15 billion. The highest estimated values originate from Germany (€5.1 billion) and Sweden (€4.4 billion), while the lowest estimated values were found in Latvia (€110 million) and Estonia (€150 million). The average number of annual recreational visits per person was highest in Sweden (6.4 trips) and Denmark (6 trips), while the lowest average was found in Russia (0.5 trips) and Poland (1.1 trips).

Table 6. Consumer surplus from marine and coastal recreation and average number of annual recreational trips to the Baltic Sea (data from the year 2010)

Country	Annual value of Baltic Sea recreation visits (million €)	Average number of annual recreational visits to the Baltic Sea per person
Denmark	720	6.0
Estonia	150	1.8
Finland	1,040	4.0
Germany	5,140	1.2
Latvia	110	2.6
Lithuania	190	1.7
Poland	2,070	1.1
Russia	940	0.5
Sweden	4,430	6.4
TOTAL	14,790	

Source: Czajkowski *et al.* (2015)

Renewable energy generation

Offshore wind energy is a sub-sector of the renewable energy production sector which takes place in the sea.

Offshore wind energy refers to the development and construction of wind farms in marine waters and the conversion of wind energy into electricity (EC 2013). It is a new industry that is considered to have much potential for growth.

For offshore wind energy, non-monetary figures can be used to describe the sector as there are no other socio-economic indicators available. The capacity and number of existing offshore wind turbines can be used to show the current situation, while the number of offshore wind turbines approved or under construction and their capacity illustrate future development. In Table 7, the first two columns include those offshore wind turbines that generate power. The last two columns depict the number and capacity of those wind turbines that have been approved or are under construction. In addition to these, there are dozens of proposed windfarm areas, some for which an application has been submitted. For example, according to the data, there are no existing offshore wind turbines in Poland, but 40 have been proposed.

While the data have been accepted by the countries, the year the data originates from is not clear and may differ between countries. This makes especially the figures on the planned wind turbines rather uncertain.

Table 7. Socio-economic indicators related to off-shore wind energy

Country	Number of existing offshore wind turbines	Capacity of existing offshore wind power (megawatts)	Number of offshore wind turbines approved or under construction	Capacity of offshore wind turbines approved or under construction (megawatts)
Estonia	0	0	no data	no data
Finland	7	32	1	3
Denmark	341	885	20	80
Germany	102	339	160	735
Latvia	0	0	no data	no data
Lithuania	0	0	no data	no data
Poland	0	0	no data	no data
Sweden	81	182	349	1,853-2,069
Russia	no data	no data	no data	no data
TOTAL	531	1438	530	2671-2887

Source: HELCOM

Marine transport

Marine transport can be divided into transport infrastructure and shipping, which includes both shipping of passengers and freight. These two sectors are interrelated as shipping utilises transport infrastructure. Transport infrastructure includes ports, as well as activities done in relation to ports, such as dredging, cargo handling, and the construction of water projects. The shipping transport can be seen to cover shipbuilding and repair industry. Some data are available for all coastal countries, and some only for the EU member states.

Transport infrastructure

There are no monetary data available for evaluating transport infrastructure (ports). In many countries, port authorities are public bodies and economic statistics are not available for this sector. For the regional analysis, we utilise non-monetary data to describe the sector, including the gross weight of goods handled in all ports and passengers embarked and disembarked in all ports (Table 8). Table 9 shows the value added and employment figures for this sector in the national level analyses.

Table 8. Socio-economic indicators related to marine transport infrastructure

Country	Annual gross weight of goods handled in all ports (thousand tonnes)		Annual number of passengers embarked and disembarked in all ports (thousand passengers)	
	2014 ^{a)}	2015 ^{b)}	2014 ^{c)}	2015 ^{d)}
Estonia	43,578	34,965	13,654	14,164
Finland	105,537	99,962	18,487	18,884
Denmark	74,956	74,956	23,599	23,599
Germany	52,994	52,994	11,478	11,478
Latvia	71,836	67,811	862	661
Lithuania	41,105	43,128	280	286
Poland	68,744	69,530	2,224	2,421
Sweden	166,857	169,685	26,218	26,239
Russia	no data		no data	
TOTAL	625,607	613,031	96,820	97,071

^{a)}Eurostat (2016b) (mar_mg_aa_cwh), except Denmark: Statistics Denmark (2017) and Germany: Federal Statistical Office of Germany (2017a). NACE code unspecified.

^{b)}Eurostat (2017b) (mar_mg_aa_cwh), except Denmark: Statistics Denmark (2017) and Germany: Federal Statistical Office of Germany (2017a). NACE code unspecified. Sweden covers only (Baltic Sea).

^{c)}Eurostat (2016a) (mar_pa_aa), except Denmark: Statistics Denmark (2017) and Germany: Federal Statistical Office of Germany (2017b). NACE code unspecified.

^{d)}Eurostat (2017a) (mar_pa_aa), except Denmark: Statistics Denmark (2017) and Germany: Federal Statistical Office of Germany (2017b). NACE code unspecified.

Table 9. Additional socio-economic indicators from the data call related to marine transport infrastructure. Denmark, Finland and Germany do not use this sector in their national use of marine waters analysis.

Country	NACE code	Value added (million EUR)	Employment
Latvia	H52.10, H52.22, H52.24, H52.29 (partly for all sectors) ¹	Value added at factor costs – 4.46 (2016)	Employed persons – 143 (2016); Employment in FTE – 125 (2016).
Poland	H52.10, H52.22, H52.24, L68.20, L68.322	Revenues from activity – 1869.1 (2016)	Employed persons – 10142 (2016)
Sweden ³	H52.22, H52.24, H52.29 (partly) ⁴	Gross value added – 818.65 (2014)	Employment in FTE – 7497 (2014)

¹ The included sectors: cargo storage and warehousing (H52.10); activities supporting water transport (H52.22); cargo handling (H52.24) and other transportation support activities (H52.29). Input-output table from national statistical accounts is used as source for estimating intermediate consumption - production of the specified sectors which is consumed by the marine shipping. The proportion (amount of the intermediate consumption) is applied to calculate VA and Employment in the specified sectors, which is related to (serves) the marine shipping.

² The included sectors: cargo handling (H52.24); cargo storage and warehousing (H52.10); activities supporting water transport (H52.22); rental and operating of own or leased real estate (L68.20); real estate management at request (L68.32). Data regarding seaports' authorities and cargo handling and storage in seaports were used (from the statistical yearbook of maritime economy).

³ The provided data include national data for all sea regions (not only Baltic).

⁴ The included sectors: activities supporting water transport (H52.22), cargo handling (H52.24) and other transportation support activities (H52.29). Micro-economic data were used to estimate the marine-related shares of activities of these sectors.

Shipping

The socio-economic indicators for the shipping transport sector include both the value added at factor cost from and the number of people employed by the sea and coastal freight and passenger transport (Table 10). The total value added for the region from freight transport is around €4.5 billion and from passenger transport around €2 billion. In 2011, there were an estimated 42 million international ferry passengers in the Baltic Sea (HELCOM 2015). Around 25% of the shipping in the Baltic Sea takes place under the flag of one of the Baltic Sea coastal countries, according to HELCOM data from the automatic identification system for vessels (AIS).

It should be noted, however, that for Germany and Denmark, these figures relate to all ports and shipping transport, not just the Baltic Sea related ports or shipping transport. No figures for Russia are available for the indicators coming from Eurostat. Also, many countries do not report shipping statistics when the data "allow for statistical units to be identified" (EU 2009), e.g. when there are too few actors to protect anonymity of the data. In this case, data has been marked as "confidential" by countries. Together, these issues affect the regional totals.

Table 10. Socio-economic indicators related to marine shipping

^a Source: Eurostat (2016c) (sbs_na_1a_se_r2). Related NACE codes: 50.1 Sea and coastal passenger water transport, 50.2 Sea and coastal freight water transport.

^b Includes shipping transport both the Baltic Sea and North Sea.

^c Eurostat does not report on Russia.

Country	Annual value added at factor cost from sea and coastal freight water transport (million €)		Number of people employed annually by sea and coastal freight water transport activities		Annual value added at factor cost from sea and coastal passenger water transport (million €)		Number of people employed annually in sea and coastal passenger water transport	
Data year	2014 ^a	2015 ^b	2014 ^a	2015 ^b	2014 ^a	2015 ^b	2014 ^a	2015
Estonia	confidential	confidential	confidential	confidential	11.7	39	670	707
Finland	403	426	3,502	2,923	27.8	316	5,739	5,781
Latvia	12	10	197	198	confidential	confidential	606	400
Lithuania	30	39	1,333	confidential	confidential	confidential	confidential	confidential
Poland	100	113	1,403	1,400	27.3	16	734	670
Sweden	287	413	3,847	3,833	333.2	404	8,519	8,247
Russia ^c	no data	no data	no data	no data	no data	no data	no data	no data
Denmark ^b	<i>confidential</i>	<i>3,441</i>	<i>no data</i>	<i>not available</i>	<i>517.3</i>	<i>811</i>	<i>5,635</i>	<i>5,720</i>
Germany ^b	<i>3,641</i>	<i>4,120</i>	<i>14,027</i>	<i>13,924</i>	<i>1069</i>	<i>932</i>	<i>2,848</i>	<i>3,048</i>
TOTAL	4,473	4,442	24,309	22,278	1,986.3	1,586	24,751	24,573

Chapter 4. What is at stake? Cost of degradation analysis

What is cost of degradation?

Cost of degradation means the change in citizens' well-being from the deterioration of the marine environment. Degradation causes many adverse effects that affect human well-being directly or indirectly, including:

- Increased water turbidity, more frequent blue-green algal blooms and oxygen deficiency in bottom waters
- Reduction and changes in fish stocks
- Contamination of fish and seafood
- Increased litter on the beach and in the sea
- Loss of marine biodiversity

Noticeable effects of degradation are decreased possibilities for marine and coastal recreation, reduction in the quality and quantity of food and other products available from the sea, adverse effects on human health, and reduced biodiversity, ecosystem health and marine resources for the enjoyment of current and future generations.

Degradation of the marine environment reduces the ecosystem's ability to produce goods and services, which in turn affects human well-being. As the aim of marine policies is to achieve good environmental status (GES), meaning that seas are clean, healthy and productive, cost of degradation can be assessed based on the benefits forgone or damages resulting from not achieving good environmental status (GES) of the marine environment. Thus, cost of degradation measures the change in people's well-being for moving from the current or baseline status of the marine environment to the good environmental status (Figure 4).

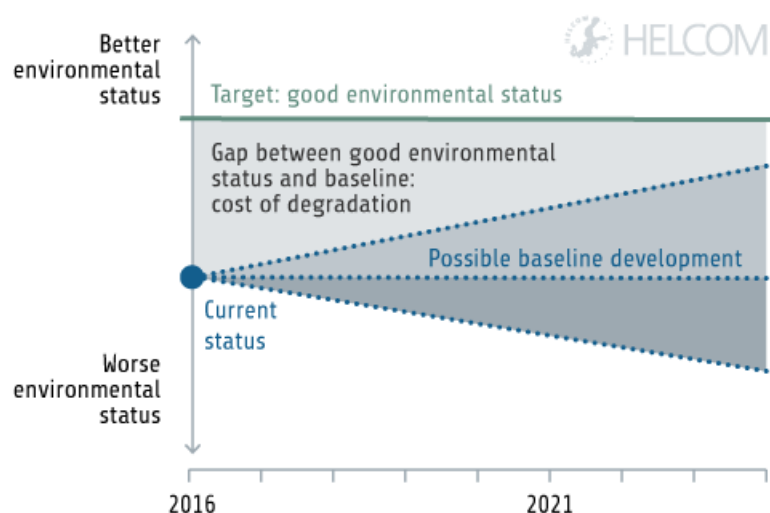


Figure 4. Illustration of the cost of degradation concept. Cost of degradation results from the difference between the current/baseline environmental status and the good environmental status.

There are three general approaches to assess cost of degradation (WG ESA 2010):

- 1) Ecosystem service approach
 - a) Define good environmental status (GES) and the baseline (= the development of environmental status given business as usual) and their difference in terms of ecosystem services
 - b) Describe the consequences to human well-being
- 2) Thematic approach
 - a) Identify degradation themes (e.g. marine litter, eutrophication)
 - b) Define the present state and the target state (e.g. GES boundary or threshold value for an indicator) and their difference
 - c) Describe the consequences for human well-being
- 3) Cost-based approach
 - a) Assess the costs of measures currently implemented to prevent degradation of the marine environment

The ecosystem service approach is the most ambitious of these, followed by the thematic approach and the cost-based approach. All approaches call for some kind of valuation to assess the consequences to human well-being, but the ecosystem service and thematic approaches involve valuing the benefits forgone if the state does not improve, while the cost-based approach focuses on the costs of improvement measures. Thus, the cost-based

approach does not measure the actual well-being lost due to marine degradation, but rather the funds that are used to improve the state of the sea at present. Cost-based approaches could be used as proxies for the cost of degradation when the thematic or the ecosystem services approach cannot be applied. Monetary estimates of the damage or maintenance costs to measure environmental degradation could be derived from the framework of the System of Environmental-Economic Accounting (UN 2003, 2012, Schroer 2007), e.g. the environmental protection expenditure account (EPEA) and statistics on the environmental goods and services sector (EGSS).

The main difference between the ecosystem and thematic approach is in the focus of valuation. The ecosystem service approach focuses on describing and valuing the difference in ecosystem service provision between the baseline and GES. In the thematic approach, the cost of degradation is assessed in terms of degradation themes (i.e. environmental problems), and there is no need to value ecosystem services. Another major difference is in how the gap is defined. In the ecosystem approach, one examines the gap, or difference, between the baseline and GES at the target year. In the thematic approach, the gap is the difference between the present and target conditions (i.e. GES). A combination of the ecosystem and thematic approaches is also possible, depending on the available knowledge. The consequences to human well-being in both the ecosystem and thematic approach can be presented in monetary terms, when possible, but also described quantitatively or qualitatively.

Table 11 presents approaches used in the national cost of degradation analysis according to the data call. From the three general approaches recommended for the cost of degradation analysis, Denmark, Poland and Sweden have used a combination of the thematic and ecosystem services approaches, while other countries have used the thematic approach only (Finland, Germany and Latvia). For countries using the combined approach, the cost of degradation is analysed for relevant themes of the marine environment according to the thematic approach, and the results are complemented with qualitative, quantitative or monetary assessments in relation to the marine ecosystem services (for instance, monetary estimates for recreational ecosystem service is provided in Denmark and Poland, degradation of all ecosystem services is assessed in Sweden based on quantitative assessment approach). This diversity limits possibilities to use the national data as a source for the regional cost of degradation estimates.

Table 11. National approaches used for the cost of degradation analysis of the marine environment.

	Thematic approach	Ecosystem services (ES) approach	Cost-based approach
Denmark	Monetary assessment for the identified degradation theme ^[1]	Monetary assessment for recreational ES ^[2]	
Finland	Joint monetary assessment for all degradation themes ^[3]		
Germany	Qualitative analysis ^[4] for the identified degradation themes	Qualitative description for recreational ES	
Latvia	Monetary assessment for selected degradation themes ^[5]		
Poland	Qualitative analysis for the identified degradation theme ^[6]	Monetary assessment for recreational ES	
Sweden	Monetary assessment for selected degradation themes ^[7]	Quantitative (non-monetary) assessment for all ES	

^[1] Only for eutrophication is the degradation noted, and the cost of this degradation estimated. It is noted that the estimate reflects partial costs of degradation, because the study used for the assessment does not provide a reliable enough estimate. With the use of a single study, the hypothetical nature of the used valuation method carries uncertainties for the results. Further valuation studies are needed for estimating a comprehensive value for the cost of degradation.

^[3] One monetary estimate is provided for all identified degradation themes that were covered in one contingent valuation study and the used method does not allow for estimating separate values for each theme.

^[4] Qualitative analysis of the cost of degradation is conducted for now and a research project is planned for the assessment in the future. All themes, where the degradation assessment has been done, are covered in the cost of degradation analysis. These themes include introduction of non-indigenous species, eutrophication, contaminants in the marine environment and marine litter.

^[5] The assessed degradation themes include marine biodiversity, introduction of non-indigenous species, eutrophication and marine litter. Concerning commercial fish stocks qualitative analysis is conducted.

^[6] The theme, where the degradation assessment has been done and, hence, the cost of degradation is analysed, include commercial fish stocks.

^[7] The assessed degradation themes include marine biodiversity (partly), commercial fish stocks and eutrophication.

4.1 VALUING THE CONSEQUENCES TO CITIZENS' WELL-BEING

In the ecosystem service and thematic approaches, the economic (monetary) assessment of the cost of degradation requires valuing how changes in the marine environment impact human well-being. In many cases, the value of environmental changes cannot be observed from markets or market prices, and thus environmental valuation methods have been developed for this kind of analysis. The aim of these methods is to estimate the effects of environmental changes on human welfare in terms of citizens' willingness to pay for these changes. The willingness to pay represents the benefits associated with the environmental change. Environmental valuation methods estimate either use values, non-use values or both. Use values are related to the (direct or indirect) use of the environment. One example of these are recreation values. Non-use (or existence) values are values people hold even though they might not use the environmental resource at all. They are associated with preserving the ecosystem and its species in good health, and giving others in current or future generations the opportunity to enjoy the environment.

There are, in general, two types of valuation methods: stated preference and revealed preference methods (see Champ *et al.* 2017). Stated preference methods are based on carefully constructed surveys that ask people's willingness to pay for well-defined changes in the environment (Bateman *et al.* 2002). These methods are the only ones that can capture both use and non-use values. Revealed preference methods are based on observing people's behaviour to determine environmental values (Bockstael and McConnel 2007). They are able to estimate use values related to the environment, for example recreation values. In addition to these two, the benefit (or value) transfer method is becoming more and more common in policy analysis (Johnston *et al.* 2015). It entails using existing research results to assess environmental values in locations for which value estimates are not available.

Some may criticise the methods used to assess cost of degradation. Value transfer is considered to produce less reliable estimates than original valuation studies. Criticism can also be directed at survey-based stated preference methods used to estimate the cost of degradation from eutrophication. The most common issues mentioned include biases in hypothetical responses, no effect of the size of the environmental change on values, and differences in value estimates between different value measures (e.g. Hausman 2012). These criticisms have largely been answered in Carson (2012). Proponents have argued that survey-based valuation studies are a practical alternative in cases where values cannot be based on market behaviour and prices, which is the case for many features of the Baltic Sea environment. Thus, comprehensive estimates of the cost of degradation caused by eutrophication cannot be obtained without using stated preference methods.⁷

⁷ Denmark has expressed a hesitation to using stated preference methods and the value transfer method to assess the cost of degradation.

4.2 APPROACH FOR ASSESSING THE REGIONAL COST OF DEGRADATION

The following approach has been developed for assessing the cost of degradation in the Baltic Sea region for HELCOM HOLAS II.

General

- Use mainly the thematic approach, combined with the ecosystem service approach
- Examine the cost of degradation separately for each descriptor of good environmental status (grouping overlapping descriptors when appropriate) and ecosystem service
- Use the baseline and target scenarios specified in the existing valuation studies. Discuss how well these scenarios correspond to achieving good environmental status (as in HELCOM BSAP/EU MSFD) to evaluate the reliability of the estimates
- Assess the cost of degradation in monetary terms if possible (if economic valuation studies are available), and if not, quantitatively or qualitatively

Data and studies

- Include both stated and revealed preference valuation studies
- Use international valuation studies to ensure comparability across countries
- Use studies covering all coastal countries when possible
- Use value transfer across countries to obtain regional estimates when there are no studies covering the entire Baltic Sea area

Evaluation

- Assess how well the studies are suited for the assessment (e.g. scenarios and environmental change, geographical coverage, time frame)

Ecosystem services

- Present additional information on ecosystem services when available (illustrations, graphs, maps, qualitative assessments)

The assessment of cost of degradation is based on economic valuation studies that value the benefits of improving the state of the Baltic Sea. If the state does not improve, these benefits are lost, and thus they can be interpreted as the cost of degradation. The valuation studies estimate people's willingness to pay for a specific environmental change, either using surveys (stated preference studies) or by observing people's behaviour (revealed preference studies).

The valuation studies have been identified based on several extensive literature reviews conducted in the Baltic Sea area in the recent years (Söderqvist and Hasselström 2008, Turner *et al.* 2010, COWI 2010, Ahtiainen and Öhman 2014, Hasler *et al.* 2016). Results of these valuation studies are reported either in journal articles or project reports. In an ideal case, the regional assessment of the cost of degradation would rely on international valuation studies that covered all nine coastal countries, valued the environmental change in the entire Baltic Sea and presented national level benefit estimates. This would allow for both national and regional estimates of the cost of degradation.

The cost of degradation estimates are presented in Chapters 3, 4.1 and 5.6 in the 'State of the Baltic Sea' report (HELCOM 2018).

Available regional estimates

Studies on the cost of degradation that cover the entire Baltic Sea marine area and all nine coastal countries are available only for eutrophication (thematic approach) and recreation (ecosystem service approach) (see Table 9). The cost of degradation estimate for eutrophication comes from a stated preference valuation study conducted in 2011 (Ahtiainen *et al.* 2014). The cost of degradation estimate for recreation is based on a revealed preference valuation study conducted in 2010 (Czajkowski *et al.* 2015). These Baltic-wide studies are used to provide regional estimates of the cost of degradation in this report. For other themes or ecosystem services, there are no valuation studies that would cover all Baltic Sea countries. The cost of degradation estimates with regard to recreation are presented in Chapter 3, and with regard to eutrophication in Chapter 4.1 of the 'State of the Baltic Sea' report (HELCOM 2018).

When there are no regional estimates: value transfer

Regional cost of degradation estimates are readily available only for eutrophication and recreation, as these have been examined in Baltic-wide studies. Assessing the cost of degradation related to other descriptors and ecosystem services for the entire Baltic Sea region requires value transfer. Value transfer means using existing value estimates to infer values in other, previously unstudied sites. In the case of the Baltic Sea, this implies transferring the cost of degradation estimates across countries. An example of the value transfer approach is presented for biodiversity and food webs (see Table 12).

Table 12. Details of the studies that are used to assess cost of degradation.

Regional estimates are available							
Descriptor/ ecosystem service	Focus of valuation	Study year	Area	Countries	Original value estimates	Source	In the 'State of the Baltic Sea' report (HELCOM 2018)
Eutrophication	Reducing the effects of eutrophication	2011	Entire Baltic Sea	All 9 coastal countries	WTP, €/person Denmark: 32 Estonia: 24 Finland: 42 Germany: 25 Latvia: 6 Lithuania: 9 Poland: 12 Russia: 9 Sweden: 76	Ahtiainen <i>et al.</i> (2014)	Yes, Ch4.1
Recreation	Improving (perceived) environmental quality by one unit	2010	Entire Baltic Sea	All 9 coastal countries	Total value, million € Denmark: 54 Estonia: 12 Finland: 84 Germany: 411 Latvia: 9 Lithuania: 18 Poland: 167 Russia: 171 Sweden: 336	Czajkowski <i>et al.</i> (2015)	Yes, Ch3, Box 3.3
No regional estimates: value transfer							
Descriptor	Focus of valuation	Study year	Area	Countries	Original value estimates	Source	In the 'State of the Baltic Sea' report (HELCOM 2018)
Biodiversity and foodweb	Increasing the amount of healthy perennial vegetation and size of fish stocks	2011	Finnish- Swedish archipelago, Lithuanian coast	Finland, Lithuania, Sweden	WTP, €/household Healthy vegetation Finland: 105 Lithuania: 44 Sweden: 209 Fish stocks Finland: 81 Lithuania: 35 Sweden: 169	Kosenius and Ollikainen (2015)	Yes, Ch5.6, Box 5.6.1

The value transfer approach entails transferring mean willingness to pay (WTP) from one or several countries of the Baltic Sea to the other countries (where estimates are not available), adjusting for differences in price levels, currencies, and income. The country where the cost of degradation estimate originates from is called the *study country*, and the country where the estimate is transferred to is called the *policy country*.

When transferring, original cost of degradation estimates (from the study country) need to be adjusted to express the value estimates in the same year, currency and price level, and to account for the effect of income level on the cost of degradation estimates (see information box below on value transfer). The value estimates are first adjusted to year 2015 using country-specific consumer price indices (CPIs). Then they are converted to common currency (euro) using purchasing power parity (PPP) adjusted exchange rates, which allow cross-country comparisons by eliminating price level differences. The estimates are also adjusted for income differences across countries, assuming that the willingness to pay is a constant share of income (income elasticity of WTP is one). This is done by multiplying the primary estimate with the ratio between the gross domestic product (GDP) per capita in each country and the GDP per capita in the study country. These are all standard adjustments in international value transfers.

When value estimates are available from several countries, i.e. there are several possible study countries, the study country needs to be chosen. The choice of the appropriate study country should be based on the similarity between the study and the policy country, as this correspondence is crucial for the reliability of the value transfer. A practical approach is to base the choice on the average income level of the countries, and transfer value estimates between countries with similar income levels.

All value transfers rely on strong assumptions. Here it is assumed that the cost of degradation estimated in one (or few) countries can be used to assess the cost of degradation in other countries with small adjustments in price levels and income. This is not necessarily the case, as additional factors, such as differences in cultural issues, attitudes and use of the Baltic Sea may cause further divergence between the estimates across countries. These factors have been observed to have a significant effect on WTP in empirical valuation studies. Adjustments for these differences are not yet standard practice in value transfers, and information on which to base the adjustment factors is not readily available, and thus they are not performed.

Value transfer is used in Chapter 5.6 of the 'State of the Baltic Sea' report (HELCOM 2018). The related text describes the approach, and the visualization of the results clearly separates between the estimates that are based on original valuation studies and those based on value transfer.⁸

⁸ Denmark has expressed a hesitation to using the value transfer method to assess the cost of degradation.

Value transfer approach

Cost of degradation estimates (i.e. estimates of mean willingness to pay) are transferred from one or several countries of the Baltic Sea (*study countries*) to the other countries (*policy countries*), adjusting for inflation and differences in price levels, currencies and income. Adjustments are needed to express the value estimates in the same year, currency and price level, and to account for the effect of income level on the cost of degradation estimates. Additional adjustments may be necessary to change household values to individual ones, and to express one-time estimates in annual values.

$$CoD_{policy\ country} = CoD_{study\ country} * CPI\ factor * PPP\ factor * GDP\ factor$$

$$Consumer\ price\ index\ adjustment\ (CPI)\ factor = \frac{CPI_{2015}}{CPI_{study\ year}}$$

$$Purchasing\ power\ parity\ adjustment\ (PPP)\ factor = \frac{1}{PPP_{study\ country}}$$

$$Gross\ domestic\ product\ adjustment\ (GDP)\ factor = \frac{GDP\ per\ capita_{policy\ country}}{GDP\ per\ capita_{study\ country}}$$

Data sources:

CPI data: OECD (2016). Consumer prices – all items. Accessed 29.6.2016.

PPP data: Eurostat (2016). Purchasing power parities (PPPs), price level indices and real expenditures for ESA 2010 aggregates [prc_ppp_ind]. Updated 16.6.2016, accessed 21.6.2016. Except Russia: OECD (2016). Purchasing Power Parities for GDP and related indicators. Accessed 21.6.2016.

GDP data: Eurostat (2016). Main GDP aggregates per capita [nama_10_pc]. Updated 16.6.2016, accessed 21.6.2016. Except Russia: OECD (2016). Gross domestic product (GDP). Accessed 21.6.2016.

4.3 RESULTS OF THE COST OF DEGRADATION ANALYSIS

The following sections present examples of regional analysis of the cost of degradation. The values reflect the losses in citizens' well-being of not achieving a good environmental status of the marine environment. As the estimates cover only a limited number of degradation themes and ecosystem services, the analysis does not provide a complete overview of the regional cost of degradation for the Baltic Sea area. However, the estimates represent the best currently available information for the regional cost of degradation analysis.

Eutrophication

The cost of degradation from eutrophication was assessed based on the benefits forgone if the Baltic Sea does not reach the good environmental status with regard to eutrophication. An international stated preference contingent valuation study (Ahtiainen *et al.* 2014) elicited citizens' willingness to pay (WTP) for achieving good eutrophication status in the Baltic Sea (good status was said to be achieved in all other sub-basins except for the northern Baltic Proper). The study was conducted in each of the nine coastal countries in 2011. The willingness to pay represents the benefits of reaching GES. If GES is not reached, these benefits are lost, meaning that the benefits can be interpreted as the cost of degradation.

The study captured a variety of eutrophication effects, including water clarity, blue-green algal blooms, underwater meadows, fish species composition and oxygen deficiency in the sea bottom. The change in eutrophication was described using all of these effects.

The study has appropriate geographical coverage as it has been conducted in all nine coastal countries and considers a change in the condition of the entire Baltic Sea. The baseline and target state are projected by marine models. The target state corresponds closely to that of achieving good environmental status of the sea, as the study states that GES is reached in all other sub-basins except the northern Baltic Proper. The time frame is somewhat longer than in current policies, as it is set to year 2050 in the study. Reaching GES earlier than 2050 might bring about even greater benefits, as people generally place more value on goods and services they obtain sooner.

Table 13 presents the country-specific estimates of the cost of degradation from eutrophication per person and for the national adult population. The value estimates are expressed in 2015 euros, and the national estimates are calculated by multiplying the mean willingness to pay per person with the adult population in 2015 to express the total cost of degradation in the country in question. The results indicate that each year, 3.8 - 4.4 billion euros are lost in citizens' welfare in the Baltic Sea region due to eutrophication.

Table 13. Cost of degradation from eutrophication

Country	Cost of degradation (€/person/year, 2015 euros) ¹	Population (18-80 years old in 2015)	Cost of degradation (M€/year, 2015 euros)
Denmark	29 – 37	4.28	125 – 158
Estonia	21 – 30	1,011	21 – 31
Finland	42 – 46	4,151	176 – 189
Germany	25 – 28	64,164	1,572 – 1,781
Latvia	5 – 6	1,553	8 – 9
Lithuania	9 – 10	2,267	19 – 22
Poland	12 – 13	29,789	368 – 383
Russia	11 – 12	90,787	1,028 – 1,129
Sweden	60 – 92	7,316	440 – 674
Total		205, 318	3,760 – 4,380

Source: Ahtiainen *et al.* (2014)

1 The range for the cost of degradation estimates comes from the 95% confidence intervals for the value estimates reported in the original study.

Population data from Eurostat, except Russia: Russian Federation Federal State Statistics Service. Russian population includes the population who is over 15 years old in Western Russia, i.e. Central, Southern, North Western, Ural and Volga federal districts.

All value estimates are primary (no value transfers).

Value estimates in PPP adjusted 2015 euros.

Recreation

The cost of degradation estimates for recreation are based on a revealed preference travel cost study with the data collected using a survey in all nine coastal countries in 2010 (Czajkowski *et al.* 2015). The study estimated the change in the value of Baltic Sea recreation from a one-step change in the (perceived) environmental status of the Baltic Sea. This was based on the predicted change in the expected number of trips to the Baltic Sea when the perceived environmental conditions change in general. Thus, the resulting estimates represent the change in citizens' recreational values from the perceived deterioration of the Baltic Sea marine environment.

The study covers all coastal countries and considers recreation in the entire Baltic Sea. It is difficult to assess how well the environmental change in the study corresponds to achieving GES, as it is based on the respondents' perception of a one-step change in the environmental status of the Baltic Sea. The responses were measured on a Likert scale from 1 ("very bad") to 5 ("very good"). The average perceived environmental status was "rather good" in Germany and "neither bad nor good" in the remaining eight countries. Thus, a one-step change means in most cases an improvement from "neither bad nor good" to "rather good". How well these perceptions correspond to the actual current status and the good environmental status is unclear, but nevertheless, the value estimates can be used as a proxy for the cost of degradation related to recreation.

Table 14 presents the cost of degradation estimates related to recreation. The value estimates are expressed in 2015 euros. The national cost of degradation estimates are calculated using the change in the number of recreation trips to the Baltic Sea per year and the value (consumer surplus) per trip in the country in question. The results suggest that the value of coastal and marine recreation in the Baltic Sea could increase by 1 - 2 billion annually if the environmental conditions improved.

Table 14. Cost of degradation related to recreation.

Country	Cost of degradation (M€/year, 2015 euros) ¹
Denmark	51 – 70
Estonia	11 – 16
Finland	76 – 109
Germany	384 – 544
Latvia	9 – 11
Lithuania	14 – 22
Poland	151 – 232
Russia	30 – 736
Sweden	297 – 415
Total	1,024 – 2,155

Source: Czajkowski *et al.* (2014)

¹ The range for the cost of degradation estimates comes from the 95% confidence intervals for the value estimates reported in the original study.

All value estimates are primary (no value transfers).

Value estimates in PPP adjusted 2015 euros.

Biodiversity and food webs: healthy perennial vegetation and fish stocks

The valuation study for biodiversity and food webs valued the benefits of increasing the amount of healthy perennial vegetation (such as underwater meadows) and the size of fish stocks in the Finnish-Swedish archipelago and the Lithuanian coast (Kosenius and Ollikainen 2015). The discrete choice experiment study was conducted in Sweden, Finland and Lithuania in 2011. Thus, primary cost of degradation estimates are available for these three countries, and these estimates have been transferred to the other six coastal countries to produce a regional estimate of the cost of degradation.

Kosenius and Ollikainen (2015) present their estimates as one-time payments per household in 2011. Thus, the estimates were first converted to 2015 euros and expressed in annual values per person assuming the payment would be made for the next 10 years. These value estimates were then transferred to the six remaining countries correcting for PPP and using the GDP per capita ratio between the countries. The Finnish value estimate was transferred to Denmark and Germany, and the Lithuanian estimate to Estonia, Latvia, Poland and Russia (see Table 15). The choice of which estimates to transfer and where was made based on average income levels.

The results suggest that citizens' welfare would increase 1.8 – 2.6 billion euros annually, if the state of the perennial vegetation and fish stocks improved. It is worth noting that there is more uncertainty about these estimates compared to the estimates for eutrophication and recreation, as some of the values are based on benefit transfer.

Table 15. Cost of degradation related to perennial vegetation and fish stocks. Note that estimates for Finland, Lithuania and Sweden are based on original valuation studies and data collection, and estimates for the six other countries are based on value transfer from Finland (Denmark and Germany) and Lithuania (Estonia, Latvia, Poland and Russia)

Country	Cost of degradation (€/person/year, 2015 euros) ¹	Population (18-80 years old) in 2015	Cost of degradation (M€/year, 2015 euros)
Estimates based on original data			
Finland ^a	10–13	4,151	42–54
Lithuania ^a	4–6	2,267	9–14
Sweden ^a	18–26	7,316	132–190
Estimates based on value transfer			
Denmark ^b	10–14	4,280	43–60
Estonia ^b	3–5	1,011	3–5
Germany ^b	13–18	64,164	834–1,155
Latvia ^b	3–5	1,553	5–8
Poland ^b	4–6	29,789	119–179
Russia ^b	7–11	90,787	636–999
Total		205,318	1,822–2,663

Source: Kosenius and Ollikainen (2015)

Population data from Eurostat, except Russia: Russian Federation Federal State Statistics Service. Russian population includes the population who is over 15 years old in Western Russia, i.e. Central, Southern, North Western, Ural and Volga federal districts.

¹ The range for the cost of degradation estimates comes from the 95% confidence intervals for the value estimates reported in the original study.

a Estimate based on original study and data,

b Estimate based on value transfer.

Value estimates are in PPP adjusted 2015 euros.

Chapter 5. Discussion

The framework and results of the regional economic and social analysis of the use of marine waters and cost of degradation presented in this report illustrate, from one perspective, the contribution the Baltic Sea marine environment makes to the society in terms of well-being of current and future generations and national and regional economies. The development work on the economic and social analyses has aimed to produce analysis tools that could be used in the national analyses and reporting, but also applied to the regional context. The work has prioritized approaches and methods that are able to provide regional analyses with the existing data sets.

A clear conclusion from the work is that data availability limits the analyses in practice. Not all marine uses can be characterized with existing statistics and economic indicators. Data issues are also evident for the cost of degradation analysis, as value estimates are available only for few degradation themes and good environmental status descriptors. Additionally, existing information guides the selection of approaches for the analyses. This section discusses the analyses, their limitations and knowledge gaps, and future work.

5.1 POSSIBILITIES AND LIMITATIONS OF THE USE OF MARINE WATERS ANALYSIS

The economic and social analysis of the use of marine waters has identified key uses of the sea, utilising mainly existing statistical information to measure the contribution the marine sectors and activities make to the national economies and the entire Baltic Sea region. The same approach (marine water accounts) was applied by many of the Baltic Sea region countries in the 2012 MSFD initial assessment. The marine water accounts approach is complemented with estimates on the economic value of Baltic Sea recreation, in line with the ecosystem service approach for the use of marine waters analysis.

The advantage of the marine water accounts approach is that the economic sectors and their activities can relatively easily be linked to the list of activities used in the HOLAS II assessment. Moreover, the data are derived from the existing system of national accounts, allowing for comparisons across countries, and the indicators used in this report are similar to the indicators used to measure blue economy and blue growth (EC, 2016).

The indicators in the present results cannot typically be compared between sectors. On exception is employment, as the total employment indicator is available for many of the sectors. For value added, the indicators 'gross value added' and 'value added at factor costs' are similar, but not the same, and thus not completely comparable. However, they are comparable between tourist accommodation and shipping (passenger and freight). Further, the 'value added at factor costs' of fish and shellfish harvesting and aquaculture could be compared for those countries for which data are available.

Also, comparisons can be made between countries for the data available within a sector, as the indicators for one sector are harmonised across countries. Such comparisons can indicate which nations engage in the activities and the extent of the activities (e.g. aquaculture, shipping infrastructure and wind energy). For some sectors the indicators are not confined to activities that take place within the national waters or specific sea basins, but they rather take place throughout the Baltic Sea. This is clear, for example, with shipping, but also for fish and shellfish landings, which describe the value of fish landed by each country's national fleet within the Baltic Sea. Thus, the estimates describe the economic impact of the activity for a specific country, but do not link it to the specific sub-basins of the Baltic Sea.

There are some additional limitations to the use of marine water accounts approach. First, the effect of the status of the sea on the economic performance of the analysed sectors is not described or measured. Second, the use of the sea as a sink for pollutants is still hard to trace from national statistics. Third, the present System of National Accounting (SNA) excludes uses of the environment that are non-consumptive and/or are hard or impossible to measure using market prices. For example, statistics for the tourism sector are presented through statistics related to tourist accommodation, but these do not include or describe appropriately marine and coastal recreation. To overcome this, the approach employed in this report is to supplement the existing statistical indicators with

indicators found from scientific literature that measure economic benefits derived from recreation. Fourth, the existing System of Environmental-Economic Accounting and its compulsory accounts (i.e. Environmental Protection and Expenditure account, Environmental Goods and Services account, Environmental Taxes account and/or Air Emissions account) have not been used to analyse the environmental impacts of the marine sectors or the monetary transactions by the sectors in responding to the management of the marine resources.

Available data

Availability of data has limited the analysis in many ways. For many of the sectors, only one main sectoral activity has been included due to the availability of data. Related activities, such as dredging that is related to shipping infrastructure and has a significant environmental impact, are not included in the analysis due to the lack of data. Monetary indicators, or indicators of employment have not been available for all sectors. For example, shipping infrastructure is characterized by number of ports and port traffic indicators, and the offshore wind energy sector by the number and capacity of wind turbines.

A shortcoming with the existing statistical information is that it only provides proxies for the economic value of the marine environment as it measures economic impact (value added and employment) rather than economic values per se. Another major issue is that the analysis does not give any insights into the sustainability of the use of marine waters. With improved information about the links between the activities, pressures, state and economic values, it could in the future be possible to show how the economic value from the activities changes depending on the state of the Baltic Sea. A holistic economic and social analysis, in support of the ecosystem approach, would identify a balance between the economic and environmental impacts.

Recommendations on how to improve the usability of statistics and indicators for use of marine waters analysis

The analysis of the use of marine waters has revealed several shortcomings and limitations in the indicators and data available for the marine water accounts approach. The following list includes suggestions on how to improve the coherence and validity of the statistics for the regional analysis.

1) *Working across nations and statistical organisations to harmonise data and terminology*

Harmonized data and terminology across countries and statistics are needed to obtain comparable information across countries for the entire marine region. For example, for employment indicators, 'total employees' used in STECF is equivalent to the 'number of persons' employed in Eurostat Structural Business Statistics (SBS) (EC 2016b). Furthermore, there are organisations collecting cross-country data which would be useful to use, e.g. recreational fishing data gathered by ICES. However, we have left out these indicators due to differing survey designs used by the various countries in collecting the data. The ICES report discusses the need for improved reliability of data reported (ICES 2015).

2) Disaggregation of national statistics between regional seas

National data related to marine uses and activities needs to be reported separately for each regional sea. In the Baltic Sea region, this is an issue for Denmark and Germany which have coastlines also on the North Sea. In many cases, these countries report aggregate statistics on marine uses without separating between the seas.

3) Differentiating between inland/freshwater and marine activities in national statistics

For some marine activities, data are not broken down according to whether they take place in the marine environment or inland/freshwater environment. This type of aggregation can lead to an overestimation of the economic benefits originating from the use of marine waters, and makes it challenging to include data on these activities. This is relevant to statistics on marine aquaculture, which for some reason include freshwater aquaculture in some countries; freight and passenger water transport, which also includes transport on great lakes; as well as the definition of coastal tourism. It also applies to the following sectors which have not been covered in this report, but are relevant to the use of marine waters: extraction of crude petroleum and natural gas and support activities, and mining. This disaggregation has been overlooked in previous reports of blue economy and growth, e.g. (EC 2013; EC 2014a).

In addition, in Eurostat, coastal areas are currently defined as “municipalities (LAU-2) bordering the sea or having half of their territory within 10km from the coastline.” However, all tourism and accommodation activities taking place in this territory cannot be considered marine related. Thus, a more refined definition of the coastline should be agreed upon.

4) Encouraging all Baltic Sea region countries to report the data

Presenting comparable information across countries requires that all countries report the data to authorities that make review reports. In the Baltic Sea region, lack of data is a problem especially in the case of Russia, which is not subject to the reporting requirements of Eurostat or EU.

5) Utilising the existing environmental economic accounts

More systematic use of environmental economic accounts, as well as water and ecosystems services accounts would support several EU policies and Regional Seas Conventions, but national governments and intergovernmental institutions themselves need further guidance on how to utilise the relevant knowledge available from existing statistics and environmental economic accounts related to water and marine issues. At the same time there is a need to develop the existing environmental accounts and accounts in the pipeline (water and experimental ecosystem accounts).

5.2 POSSIBILITIES AND LIMITATIONS OF THE COST OF DEGRADATION ANALYSIS

The cost of degradation analysis has examined losses in welfare due to the deterioration of the Baltic Sea marine environment, and presented estimates for a selected descriptors of good environmental status (eutrophication, biodiversity and food webs) and an ecosystem service (recreation). The cost of degradation estimates can be used to illustrate what is at stake if the state of the Baltic Sea does not improve.

It should be noted that the cost of degradation estimates should be used separately – summing them together to provide an estimate of the “total” cost of degradation could lead to double-counting. This is because the estimates originate from separate studies which may have some overlap in the valued ecosystem components of the marine ecosystem. In addition, two different approaches are used to assess the cost of degradation (thematic and ecosystem service approach) which also overlap in terms of valued ecosystem components.

The estimates for eutrophication and recreation presented here are applicable to both regional and national level analysis, as both studies have been conducted in all Baltic Sea countries. The situation is different for other themes and ecosystem services, for which there are no cost of degradation estimates from every country, and value transfer is recommended to obtain a regional estimate. An example of value transfer is presented for assessing the cost of degradation from biodiversity and food webs.

National cost of degradation analysis would preferably rely on national studies, as value estimates from original valuation studies are considered more reliable than transferred results. The problem with this approach is that it is questionable whether national values, originating from studies employing different methods, definitions and analyses, can be summed together to produce a regional estimate of the cost of degradation. Thus, for regional analysis of these themes and ecosystem services, value transfer is needed in order to have comparable results across countries and to enable summing the national estimates to obtain an aggregate cost of degradation estimate for the entire Baltic Sea region. Another option is to conduct new international valuation studies for selected descriptors/ecosystem services in all coastal countries, showing the economic value of marine protection to provide holistic and ecologically and economically sound marine management and policies.

Uncertainties

There is some uncertainty in the cost of degradation estimates. One source of uncertainty is that the baseline and target scenarios and the study areas specified in the valuation studies do not fully correspond to those of marine policies, e.g. HELCOM Baltic Sea Action Plan or EU Marine Strategy Framework Directive. Even though these differences in the scenarios and areas could be identified, there are no simple approaches to correct the estimates for these differences.

There are also uncertainties associated with each of the methods used for estimating cost of degradation. Value transfer is seen to result in higher uncertainty to the estimates, compared to original valuation studies. Criticism can also be directed to survey-based stated preference methods used to estimate the cost of degradation from eutrophication. The most common issues mentioned include biases in hypothetical responses, no effect of the size of the environmental change on values, and differences in value estimates between different value measures (e.g. Hausman 2012). A discussion to meet these criticism is provided for example by Carson (2012). Proponents have argued that survey-based valuation studies are a practical alternative in cases where values cannot be based on market behaviour and prices, which is the case for many features of the Baltic Sea environment. Thus, comprehensive estimates of the cost of degradation caused by eutrophication cannot be obtained without using stated preference methods.

5.3 APPLICABILITY OF THE ECOSYSTEM SERVICES APPROACH

The *ecosystem services approach* would allow for a holistic analysis of the socio-ecological linkages between the Baltic Sea countries, their economies and citizens, and the sea. Applying the ecosystem services approach in the use of marine waters and cost of degradation analyses would require identifying marine and coastal ecosystem services and their contribution to human welfare. Current knowledge is, however, insufficient to fully apply the ecosystem services approach to the regional use of marine waters and cost of degradation analyses. We have been able to employ the ecosystem service approach exclusively for marine and coastal recreation, as there was a recent multi-country study focusing on recreational use and values in the Baltic Sea area (Czajkowski *et al.* 2015).

In many cases, the existing information on economic values is not in a format that supports the ecosystem services approach. This is especially true for the use of marine waters analysis, where existing statistics provide information on the economic and social impacts of marine uses to the national economy and businesses as outlined in the marine water accounts approach. An alternative approach for the use of marine waters analysis would be to identify and define economic indicators for the ecosystem services provided by the sea. This ecosystem services approach would describe the linkages between the marine ecosystem and economic sectors more thoroughly, but is difficult to apply due to the current lack of data. The shortcomings of the system of national accounting are known and there have been several initiatives to extend the accounting system to consider the environment. The System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA-EEA) is an integrated statistical framework for organising biophysical data, measuring ecosystem services, tracking changes in ecosystem assets and linking this information to economic and other human activities. The EU Biodiversity Strategy expects Member States to map and assess the state of the ecosystems and their services, assess the economic value of the services and integrate them into accounting systems (EC 2014b). The knowledge innovation project on an integrated system of natural capital and ecosystem services accounting in the EU (KIP-INCA) is building marine ecosystem accounting (EC 2016a). Thus, it seems likely that in the future, marine ecosystems and marine ecosystem services will be assessed and valued in a coherent manner, making estimates available for the use of marine water analysis.

Full application of the ecosystem services approach in the cost of degradation analysis is likewise impossible. There are two obvious knowledge gaps: 1) descriptions of the baseline and good environmental status of the Baltic Sea in terms of ecosystem services, and 2) economic valuation studies that estimate the effect on human well-being from the change in the provision of ecosystem services in the baseline and good status. First steps towards this kind of analysis have been taken in the form of reviews and case studies (Söderqvist and Hasselström 2008, Ahtiainen and Öhman 2014 and Hasler *et al.* 2016), but a comprehensive examination would be required to fully apply the ecosystem services approach in the regional cost of degradation analysis. This necessitates additional valuation studies that focus on marine and coastal ecosystem services, preferably international ones that produce comparable information across the Baltic Sea region.

5.4 SUGGESTIONS FOR FURTHER WORK

The conceptual framework developed for the economic and social analyses in HOLAS II, as presented in this report, together with the data collated to support regional scale analyses, pave way for further analyses and work, e.g. on the cost-effectiveness and cost-benefit analyses of the programmes of measures (MSFD Article 13). For example, the approach and results of the cost of degradation analysis could be used in cost-benefit analysis as the estimate of the economic benefits of achieving the good environmental status (Börger *et al.* 2016). Besides the requirements of the MSFD, there are clear connection points to maritime spatial planning and the development of blue growth indicators. Similarly, the economic and social analyses to support the MSFD can benefit from the increasing interest in and resources for the development of the experimental ecosystem accounts ⁹ that might lead to better data collection and statistics beneficial for the economic analyses of marine protections as well.

From a holistic perspective, economic and social analyses would ideally show linkages and feedbacks between the use of marine waters analysis (describing the contribution marine sectors and activities make to the economy) and the cost of degradation analysis (identifying the economic benefits forgone if the good environmental status of the marine environment is not achieved). This would provide a more holistic view on the links and feedbacks between the Baltic Sea marine environment and societies around it. The first steps towards such integrated analysis have been taken in the HELCOM SPICE project¹⁰ in 2017, which studied whether integration of the economic indicators of the use of marine waters analysis with the Baltic Sea Pressure and Impact Index is possible. An analysis showing how the state of the Baltic Sea affects the economic performance of the different sectors and activities would be a worthy extension of the planned further work.

The approach applied in HELCOM HOLAS II is adaptable for updating the results with reasonable effort when new information and research findings become available. Potential additional sources for new information are ongoing regional research projects and new statistical information. Moreover, the development of environmental economic accounts and marine ecosystem accounts may, in the future provide regionally coherent data and framework for economic and social analyses.

⁹ <https://seea.un.org/events/forum-experts-seea-experimental-ecosystem-accounting>

¹⁰ SPICE: HELCOM coordinated project implemented in 2017, co-financed by the EU.

References

- Ahtiainen, H., J. Artell, M. Czajkowski, and many (2014): Benefits of meeting nutrient reduction targets for the Baltic Sea – a contingent valuation study in the nine coastal states. *Journal of Environmental Economics and Policy* 3:278-305. URL: <http://dx.doi.org/10.1080/21606544.2014.901923>
- Ahtiainen, H. & M. Öhman (2014): Ecosystem Services in the Baltic Sea. Valuation of Marine and Coastal Ecosystem Services in the Baltic Sea. Nordic Council of Ministers. TemaNord 2014:563. Copenhagen, Denmark. URL: <http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A767673&dswid=-3377>
- Bateman, I. J., R.T. Carson, B. Day, M. Hanemann, N. Hanley, T. Hett ,... & G. Loomes (2002): Economic valuation with stated preference techniques. Edward Elgar Publishing.
- Bockstael, N. E. & K. E. McConnell (2007): Environmental and Resource Valuation with Revealed Preferences. A Theoretical Guide to Empirical Models. Springer Netherlands.
- Börger, T., S. Broszeit, H. Ahtiainen, J.P. Atkins, D. Burdon, T. Luisetti, A. Murillas, S. Oinonen, L. Paltriguera, L. Roberts, M.C: Uyarra & M.C. Austen (2016):. Assessing Costs and Benefits of Measures to Achieve Good Environmental Status in European Regional Seas: Challenges, Opportunities, and Lessons Learnt. *Frontiers in Marine Science* 3, 192.
- Carson, R. T. (2012): Contingent Valuation: A Practical Alternative When Prices Aren't Available. *Journal of Economic Perspectives* 26:27-42.
- Champ, P. A., K. Boyle & T.C. Brown (eds.) (2017): A primer on nonmarket valuation. 2nd edition. Springer Netherlands.
- COWI (2010): Scoping Study on the Requirements for Economic Assessment in the Marine Strategy Framework Directive. Final report, June 2010. European Commission DG Environment.URL: http://www.dredging.org/documents/ceda/downloads/2010-12-cowi_final_report_scoping_study_2010-esa-2011.pdf
- Czajkowski, M., H. Ahtiainen, J. Artell, W, and many (2015). Valuing the commons: An international study on the recreational benefits of the Baltic Sea. *Journal of Environmental Management*, 156, 209-217. URL: <http://dx.doi.org/10.1016/j.jenvman.2015.03.038>
- EEA (2015). State of Europe's seas. EEA Report No 2/2015, European Environment Agency. URL: <http://www.eea.europa.eu/publications/state-of-europes-seas>
- EC (2013) (European Commission): Study on Blue Growth, Maritime Policy and the EU Strategy for the Baltic Sea Region. MARE/2012/07, EUNETMAR. URL: <https://webgate.ec.europa.eu/maritimeforum/en/node/3550>

EC (2014a) (European Commission): A Sustainable Blue Growth Agenda for the Baltic Sea Region. Brussels, 16.5.2014.

SWD (2014) 167 final. URL: https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/body/swd-2014-167_en.pdf.pdf

EC (2014b) (European Commission): Mapping and Assessment of Ecosystems and their Services. Indicators for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. 2nd Report – Final. February 2014. URL: http://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf Accessed on 20.02.2017

EC (2016a) (European Commission): Report on phase 1 of the knowledge innovation project on an integrated system of natural capital and ecosystem services accounting in the EU (KIP-INCA Phase 1 report). 15.09.2016. URL: http://ec.europa.eu/environment/nature/capital_accounting/pdf/KIP_INCA_final_report_phase-1.pdf Accessed 20.02.2017.

EC (2016b) (European Commission): Study on the Establishment of a Framework for the Processing and Analysing Maritime Economic Data in Europe, Draft Final Report. December 2016. CONTRACT NO EASME/EMFF/2014/1.3.1.13/SI2.718095

EU (2009): Regulation (EC) No 223/2009 of the European Parliament and the Council on European statistics and on the transmission of data subject to statistical confidentiality to the Statistical Office of the European Communities. Official Journal of the European Union L 87, Vol 52, 31 March 2009.

Eurostat (2016a): Passengers embarked and disembarked in all ports by direction - annual data (mar_pa_aa). Maritime transport database. Last update: 24.3.2017. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_pa_aa&lang=en

Eurostat (2016b): Country level - gross weight of goods handled in all ports (mar_mg_aa_cwh). Maritime transport database. Last update: 14.03.2017. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=mar_mg_aa_cwh&lang=en

Eurostat (2016c): Annual detailed enterprise statistics for services (NACE Rev. 2 H-N and S95) (sbs_na_1a_se_r2). Structural Business Statistics (SBS) database. Last update: 16.6.2017. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_1a_se_r2&lang=en

Eurostat (2016d): Annual enterprise statistics for special aggregates of activities (NACE Rev. 2) (sbs_na_sca_r2). Structural Business Statistics (SBS) database. Last update: 16.6.2017. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_sca_r2&lang=en

Eurostat (2016e): Nights spent at tourist accommodation establishments by coastal and non-coastal area and by NUTS 2 regions (tour_occ_nin2c). Tourism database. Last update: 13.6.2017. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tour_occ_nin2c&lang=en

Eurostat (2017): Structural business statistics (sbs). Reference Metadata in Euro SDMX Metadata Structure (ESMS). URL: http://ec.europa.eu/eurostat/cache/metadata/en/sbs_esms.htm#unit_measure1476799874543

Eurostat (2017a): Passengers embarked and disembarked in all ports by direction - annual data (mar_pa_aa). Maritime transport database. Last update: 16.10.2017

Eurostat (2017b): Country level - gross weight of goods handled in all ports (mar_mg_aa_cwh). Maritime transport database. Last update: 13.12.2017.

Eurostat (2017c): Annual enterprise statistics for special aggregates of activities (NACE Rev. 2) (sbs_na_sca_r2). Structural Business Statistics (SBS) database. Last update: 11.12.2017. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_sca_r2&lang=en

Eurostat (2017d): Annual detailed enterprise statistics for services (NACE Rev. 2 H-N and S95) (sbs_na_1a_se_r2). Structural Business Statistics (SBS) database. Last update: 11.12..2017. http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=sbs_na_1a_se_r2&lang=en

Eurostat (2017e): Nights spent at tourist accommodation establishments by coastal and non-coastal area and by NUTS 2 regions (tour_occ_nin2c). Tourism database. URL: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=tour_occ_nin2c&lang=en

Federal Statistical Office of Germany (Destatis) (2017a): Annual gross weight of goods handled in all ports in 2014.

Federal Statistical Office of Germany (Destatis) (2017b): Annual number of passengers embarked and disembarked in all ports in 2014.

Hasler, B., H. Ahtiainen, L. Hasselström, A.-S., Heiskanen, Å. Soutukorva. & L. Martinsen 2016): Marine Ecosystem Services. Marine ecosystem services in Nordic marine waters and the Baltic Sea – possibilities for valuation. Nordic Council of Ministers. TemaNord 2016:501. Copenhagen, Denmark. URL: <http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A920382&dswid=-5557>

Hausman, J. (2012): Contingent Valuation: From Dubious to Hopeless. Journal of Economic Perspectives 26(4): 43-56.

HELCOM (2015): Baltic Sea Sewage Port Reception Facilities HELCOM Overview 2014.

HELCOM (2018): State of the Baltic Sea – Second HELCOM holistic assessment 2011-2016. Available at: <http://www.helcom.fi/baltic-sea-trends/holistic-assessments/state-of-the-baltic-sea-2018/reports-and-materials/>

ICES (2015): Report of the Working Group on Recreational Fisheries Surveys (WGRFS). ICES WGRFS REPORT 2015. 1–5 June 2015, Sukarrieta, Spain. ICES CM 2015\SSGIEOM:10. 111 pp. URL: http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/SSGIEOM/2015/WGRFS_2015.pdf

Johnston, R.J., J. Rolfe, R. Rosenberger & R. Brouwer (Eds.) (2015): Benefit Transfer of Environmental and Resource Values. A Guide for Researchers and Practitioners. Springer Netherlands.

Kosenius, A-K. & M. Ollikainen (2015): Ecosystem benefits from coastal habitats – A three-country choice experiment. Marine Policy 58:15-27.

Pendleton, L. H. (Ed.) (2009): The Economic and Market Value of America's Coasts and Estuaries: What's at Stake? Restore America's Estuaries, Arlington, USA.

Schroer, K. (2007): On monetary valuation of environmental degradation in the framework of the System of Environmental-Economic Accounting Discussion paper. By Federal Statistical Office Germany Environmental-Economic Accounting (EEA).

STECF (2014) (Scientific, Technical and Economic Committee for Fisheries): The economic performance of the EU aquaculture sector (STECF 14-18). Publications Office of the European Union, Luxembourg, EUR 27033 EN, JRC 93169, 451 pp. URL: https://stecf.jrc.ec.europa.eu/documents/43805/839433/2014-11_STECF+14-18+-+EU+Aquaculture+sector_JRCxxx.pdf

STECF (2015) (Scientific, Technical and Economic Committee for Fisheries): The 2015 Annual Economic Report on the EU Fishing Fleet (STECF-15-07). Publications Office of the European Union, Luxembourg, EUR 27428 EN, JRC 97371 URL: https://stecf.jrc.ec.europa.eu/documents/43805/1034590/2015-07_STECF+15-07+-+AER+2015_JRCxxx.pdf

STECF (2016a) (Scientific, Technical and Economic Committee for Fisheries): Economic Report of the EU Aquaculture Sector (EWG-16-12); Publications Office of the European Union, Luxembourg. URL: https://stecf.jrc.ec.europa.eu/documents/43805/1491449/_2016-10_STECF+16-19+-+EU+Aquaculture_JRCxxx.pdf

STECF (2016b) (Scientific, Technical and Economic Committee for Fisheries): The 2016 Annual Economic Report on the EU Fishing Fleet (STECF 16-11); Publications Office of the European Union, Luxembourg. Doi:10.2788/842673. URL: https://stecf.jrc.ec.europa.eu/documents/43805/1481615/2016-07_STECF+16-11+-+AER+2016_JRC103591.pdf

STECF (2017): (Scientific, Technical and Economic Committee for Fisheries) - The 2017 Annual Economic Report on the EU Fishing Fleet (STECF-17-12). Publications Office of the European Union, Luxembourg, 2017, ISBN 978-92-79-73426-7, doi:10.2760/36154, PUBSY No. JRC107883 URL: <https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/2017-annual-economic-report-eu-fishing-fleet-stecf-17-12>

Statistics Denmark (2017): SKIB101: Call of vessels, passengers and throughput of goods in traffic ports by seaport and unit.

SwAM (2017): (Swedish Agency for Water and Marine Management) *Ekonomisk statistik om sektorer som är beroende av havet -- Underlag till inledande bedömning 2018 inom havsmiljöförordningen* (in Swedish). Havs- och vattenmyndigheten 2017: 16. ISBN: 978-91-87967-64-1

Söderqvist, T. & L. Hasselström (2008): The economic value of ecosystem services provided by the Baltic Sea and Skagerrak. The Swedish Environmental Protection Agency Report 5874. Stockholm, Sweden. URL: <https://www.naturvardsverket.se/Documents/publikationer/978-91-620-5874-6.pdf>

Turner, R.K., D. Hadley, T. Luisetti, T., V.W.Y. Lam & W.W.L. Cheung (2010): An introduction to socio-economic assessment within a Marine Strategy Framework. Department for Environment, Food and Rural Affairs (Defra). London, UK. URL: [https://tethys.pnnl.gov/sites/default/files/publications/Socio-Economic Assessment with Marine Strategy Framework.pdf](https://tethys.pnnl.gov/sites/default/files/publications/Socio-Economic%20Assessment%20with%20Marine%20Strategy%20Framework.pdf)

UN (2003) (United Nations): Handbook of National Accounting. Integrated Environmental and Economic Accounting 2003. <https://unstats.un.org/unsd/envaccounting/seea2003.pdf>

UN (2012) (United Nations): System of Environmental-Economic Accounting 2012, Central Framework. [https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA CF Final en.pdf](https://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf)

WG ESA (2010): (Working Group on Economic and Social Assessment) Economic and social analysis for the initial assessment for the Marine Strategy Framework Directive: a guidance document. European Commission, 21 December 2010. URL: http://www.dredging.org/documents/ceda/downloads/2010-12-final_report_wg_esa_guidance_document_no_1.pdf