Task 3.1.3 Developing the ecosystem service approach in the ESA framework

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List of abbreviations

BSAP	HELCOM Baltic Sea Action Plan
BSPI	Baltic Sea Pressure Index
DI	Direct Driver-Impact method or assessing the relationships between human activities and marine ecosystem services
DPSI	Indirect Driver-Pressure-State-Impact method for assessing the relationships between human activities and marine ecosystem services
ESA	Economic and Social Analysis
HELCOM	Baltic Marine Environment Protection Commission - Helsinki Commission
HOLAS	HELCOM holistic assessment
MSFD	Marine Strategy Framework Directive
	For assessing the relationships between human activities and marine ecosystem services

1. Introduction

This work task aimed to develop an approach for analysing the relationship between the use of marine waters and ecosystem services in the Baltic Sea. The approach aimed to examine how different activities were dependent on and to what extent they use ecosystem services. The linkage was explored using quantitative data were possible and using expert judgment when quantitative data is lacking. The purpose was to develop a method that can be used for regional ecosystem analysis as well as national analysis. Sweden was used for a case study for the development of the method. The developed method was customised to the Baltic Sea pressure index (BSPI) which made it possible to produce results for the Baltic Sea area given data from BSPI.

This chapter includes a general description of the developed methods (section 2) and presents the classification of human activities and pressures that link to ecosystem services (section 3). The methodology for assessing the relationships between human activities and ecosystem services is described in section 4. Section 5 presents results from a case study for the Swedish coastline, and the final section discusses areas for future development.

2. Method

The central goal was to examine how different activities impact and are dependent on (to what extent they use) ecosystem services. The linkages are explored using quantitative data where possible and expert judgements when quantitative data are lacking. Basically, the DPSIR (***Driver – Pressure – State change – Impact – Response***) approach was followed. For the purposes of this work, the first four letters "DPSI" are of most interest. Here, D represents Drivers (focusing on secondary drivers as human activities rather than primary such as population growth and increased consumption)), P stands for the Pressures from human activities (acting on the ecosystem), S stands for State (as the changes imposed by pressures on ecosystem components) and finally, I stands for Impact on ecosystem services (Atkins *et al.* 2011). Note that this report uses activities and drivers (D) as synonyms.

3. Lists of human activities, pressures and ecosystem services

For the linking of ecosystem services to human activities, we have used the activities listed in Annex III of the Marine Strategy Framework Directive (MSFD) which have deemed relevant for the Baltic Sea region (HELCOM 2017; Table 1), and the Swedish national tool to support marine spatial planning; Symphony [1]. The human activities (drivers) that give rise to pressures on ecosystems are defined and listed somewhat differently in MSFD Annex III and in Symphony. The pressures used in Symphony are linked directly to human activities.

With regard to ecosystem services, a number of different classification systems exist that categorize ecosystem services.For the purposes of the current work, we have used the list of ecosystem services presented in Bryhn *et al.* (2015), who have earlier assessed the status and pressures of Swedish marine ecosystem services, see table 1.

[1] Symphony is a tool that allows us to assess the cumulative environmental impact from different plan options in the marine spatial planning (SP) process. Cumulative environmental impact refers to the combined pressure from all kinds of different human activities on the marine ecosystems. The cumulative impact is eventually what determines the health of ecosystems.

Table 1. The ecosystem services and their status (poor, moderate and good) as assessed by Bryhn et al. (2015) for different parts of the Swedish marine economic zone is presented below (Table 3). The letters preceding each ecosystem services indicate their grouping. In this respect, S stands for Supporting, R stands for Regulating, P stands for Provisioning and C stands for Cultural ecosystem services.(from Bryhn et al. 2015).

Ecosystem service	Kattegat and Skagerrak	Baltic Proper	Gulf of Bothnia
S1: Biogeochemical cycling	Moderate	Moderate	Moderate
S2: Primary production	Moderate	Moderate	Good
S3: Food web dynamics	Poor	Poor	Poor
S4: Biodiversity	Moderate	Moderate	Moderate
S5: Habitat	Poor	Poor	Good
S6: Resilience	Moderate	Moderate	Moderate
R1: Climate and atmospheric regulation	Moderate	Moderate	Moderate
R2: Sediment retention	Moderate	Moderate	Good
R3: Regulation of eutrophication	Moderate	Moderate	Good
R4: Biological regulation	Moderate	Moderate	Good
R5: Regulation of toxic substances	Moderate	Moderate	Moderate
P1: Food	Poor	Poor	Poor
P2: Raw material	Poor	Moderate	Good
P3: Genetic resources	Good	Good	Good
P4: Chemical resources	Good	Good	Good
P5: Ornamental resources	Good	Good	Good
P6: Energy	Good	Good	Good
C1: Recreation	Moderate	Moderate	Moderate
C2: Aesthetic values	Moderate	Moderate	Moderate
C3: Science and education	Good	Good	Good
C4: Cultural heritage	Moderate	Moderate	Moderate
C5: Inspiration	Good	Good	Good
C6: Natural heritage	Moderate	Moderate	Moderate

4. Establishing relationships between activities and ecosystem services

For assessing the relationships between human activities and marine ecosystem services, we have developed two types of methods: the direct (DI) method and the indirect (DPSI) method which will be described below. The direct/DI-method goes straight from human activities to estimating their impact on ecosystem services using an expert evaluation. This method uses the activities/pressures from Annex III in the Marine Strategy Framework Directive (Table 1) with the addition of a number of background drivers (caused by part human activities) such as eutrophication, toxic compounds and variables related to climate change. The indirect/DPSI-method, in turn, makes use of existing knowledge on links between activities/pressures to ecosystem components and is developed further from there onto assessing relationships between ecosystem components and ecosystem services.

4.1 The direct/DI-method

The direct (Driver-Impact, DI) method is dependent on expert judgment for assessing the links between human activities and ecosystem services. The method is a further development of the one used in a previous assessment of marine ecosystem services in Sweden (Bryhn *et al.* 2015), but comprises more activities and a more refined assessment scale. The estimated level of (negative) impact of each activity on each ecosystem service is evaluated and is given a score on a scale of 0–5, where 5 represents the highest impact and 0 no impact (see Table 2). In the current work, this was applied as a consensus assessment between the four scientists from SLU Aqua authoring this report. When estimating the scores, the table was appraised from two perspectives: row by row, i.e. assessing each human activity at a time (in rows) in relation to all ecosystem services (in columns), and assessing each ecosystem service (in columns) in relation to all human activities (in rows). This was done in order to focus on evaluating the relative strength of impact for each cell in comparison to all other cells, and so that all ecosystem services and human activities are included in the same evaluation. This means that a pressure which is strong, but very local, e.g. pressure from aquaculture in Sweden (very restricted activity geographically), is given a relatively low score, whereas an activity which has a weaker impact, but is geographically extended, e.g. noise from shipping traffic, receives a relatively high score.

Table 2. Score sheet for Direct/DI-assessment human activities' impact on ecosystem services. For each cell, the expert group made an assessment (0–5, where 5 is the highest) depending on the intensity/strength of the pressure and its geographical extent. More detailed arguments for the reasoning within this evaluation are provided in Bryhn et al. (2015).

Activity	S1 BCC	S2 PP	S3 FWD	S4 BDIV	S5 HAB	S6 RSIL	R1 CA	R2 SRET	R3 EUT	R4 BIOL	R5 TOX	P1 FOOD	P2 RAW	P3 GEN	P4 CHE	P5 ORN	P6 ENRG	C1 RECR	C2 AEST	C3 SCIED	C4 CULH	C5 INSP	C6 NATH
Land claim	1	1	1	1	2	1	0	1	1	0	1	1	0	0	0	0	0	1	1	0	1	0	1
Restructuring of seabed morph	3	1	1	2	2	2	0	1	1	1	2	3	1	0	0	0	0	1	3	0	1	1	3
Extraction of minerals	1	1	1	1	1	1	0	1	1	1	1	1	2	0	0	0	0	1	2	0	1	1	2
Renewable energy generation	0	1	1	1	2	1	0	1	0	0	0	0	0	0	0	0	0	1	3	0	2	1	3
Nuclear power	1	1	1	1	1	1	0	1	0	0	1	1	1	1	0	0	0	1	1	0	1	1	2
Transmission (cables)	1	0	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
Fish and shellfish harvesting (prof.)	3	3	5	5	5	4	0	5	3	4	3	5	3	4	1	1	1	3	1	1	3	1	5
Hunting and collecting	0	0	1	3	1	1	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	1	1
Aquaculture	2	1	1	1	2	1	0	0	2	1	1	0	0	2	0	0	0	1	1	0	1	0	1
Agriculture	4	4	3	2	2	3	2	1	4	3	1	3	1	1	0	0	0	3	2	1	1	1	1
Forestry	4	4	2	2	2	2	2	1	3	2	1	2	1	0	0	0	0	2	2	1	0	1	3
Transport — infrastructure	1	1	1	2	3	1	1	1	2	2	1	2	1	0	0	0	0	2	3	0	1	1	2
Transport — shipping	1	1	1	2	2	2	1	2	2	2	2	1	1	1	0	0	0	3	3	0	2	1	2
Urban uses	1	1	1	1	3	1	1	1	2	1	1	2	1	0	0	0	0	1	2	0	2	1	2
Industrial uses	2	3	2	2	2	2	1	1	1	1	2	3	1	1	0	0	0	2	3	0	2	1	3
Waste treatment and disposal	3	4	3	2	2	2	0	1	3	3	4	4	2	1	0	0	0	3	2	0	0	1	2
Tourism and leisure infrastructure	1	1	1	1	3	1	0	2	1	1	1	2	1	0	0	0	0	1	2	0	1	1	2
Tourism and leisure activities	1	3	2	2	3	2	1	2	2	2	2	2	1	0	0	0	0	2	1	0	1	1	1
Fish and shellfish harvesting (recr.)	1	2	3	3	1	2	0	1	2	2	1	3	2	3	1	1	1	2	1	0	1	1	4
Security/defence, Military operations	0	0	0	0	1	0	0	1	0	0	1	1	0	0	0	0	0	1	1	1	1	2	1
Scientific and educational activities	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eutrophication	5	4	4	4	5	5	2	2	5	4	1	3	2	1	0	0	0	5	3	1	1	2	4
Toxic pollution	1	0	2	2	1	2	0	0	0	2	4	5	3	1	0	0	0	3	1	0	1	2	2
Climate change CO2	4	2	2	2	2	3	3	0	1	2	1	1	1	1	0	0	0	1	1	0	0	1	1
Climate change Temperature	3	4	3	2	4	3	5	2	1	2	1	2	2	1	0	0	0	1	1	0	1	1	1
Climate change Salinity	3	2	3	5	5	3	1	2	1	2	1	2	1	2	1	1	0	1	1	0	2	1	2

The direct evaluation process considered the initially available scores from Bryhn *et al.* (2015), present at three levels (0, 1 and 2) for those activities and ecosystem services that were included there. These scores were first translated into six levels, 0–5, in such a way that former 0's could become 0–1, former 1's could become 2–3 and former 2's could become 4–5. Then, scores for links between activities and ecosystem services missing in Bryhn *et al*. (2015) were estimated with the existing evaluations in mind. Initially, all four experts conducted separate evaluations and after this they got together to motivate the individually given scores and to compare arguments on which score would be most justified. Within this process, the descriptions of ecosystem services and the indicators for their assessment given in Bryhn *et al.* (2015) played a substantial role in underpinning the arguments used when deciding on the final scores.

4.2 The indirect/DPSI-method

The indirect (Driver-Pressure-State-Impact) method utilizes existing information on the links between pressures and ecosystem components before assessing impacts on ecosystem services. The approach is shown here with example from the spatial modelling framework Symphony, which is used as a maritime spatial planning tool in Sweden (see Andersen and Kallenbach 2016). The applied approach is similar to that of the Baltic Sea Pressure Index (BSPI), which assesses the cumulative impact of pressures from human activities in the Baltic Sea (HELCOM 2017). The assessment of impacts on ecosystem services is made by adding conversion factors for each ecosystem component, which estimate to what extent it contributes to each ecosystem service. The impact on ecosystem services is assessed based on the underlying "sensitivity scores" (which estimate the likely sensitivity of each ecosystem component to each pressure), or alternatively based on the "impact sums" (which estimate the likely impact from each pressure on each ecosystem component after also accounting for the spatial distribution of all pressures and ecosystem components and their overlap in the assessed area), which are both derived from Symphony (in this case).

Basing the assessment on the sensitivity scores provides an assessment of the sensitivity of an ecosystem service to a certain pressure, without acknowledging the spatial extent of the pressure. However, basing the assessment on the impact sums instead, conveys the potential continuing impact on that ecosystem services in the sea today, at the scale of assessment. The indirect method also relies on expert opinions and contains more steps as compared to the direct method, but is expected to be more robust, transparent and adaptive in the long run. When comparing the results from the Direct/DI-method and the Indirect/DPSI-method, not only do the methods differ (and hence their robustness and transparency), but some activities from the MSFD list (Table 1) have not been considered in Symphony and are thereby also not included in the Indirect/DPSI-method. These missing activities are:

- Fish and shellfish harvesting (recreational)
- Tourism and leisure infrastructure (including marinas)
- Nuclear power (uptake and discharge of cooling water)
- Agriculture
- Forestry
- Research, survey and educational activities
- Climate change (induced lowered salinity)

The indirect/DPSI-method: Ecosystem components versus ecosystem services – motivations for scores

This section presents the motivations for scores given as expert evaluations on the contribution of each ecosystem component to ecosystem services as applied in the indirect method. The assessment was made by the authors of this report. When estimating the scores, it was looked at the tables from both of two perspectives: row by row, i.e. ecosystem components (in rows) in relation to all ecosystem services (in columns), and column by column, ecosystem services (in columns) in relation to all ecosystem components (in rows), see Table 1 annex 1. It should be noted that for this evaluation of ecosystem components to ecosystem services, the assessment has not considered the spatial extent of the ecosystem component, but a point view has been used assuming that the ecosystem component is present. This is because the extent is already considered in the first step, which estimated the link between activity/pressures and ecosystem components. Additionally it should be noted that for the assessment of Supporting ecosystem services, S, the scores 0–4 have been used, whereas for the ecosystem services R (regulating), P (provisional) and C (cultural), scores 0–2 have been used. This approach was used in order to avoid overestimation of ecosystem components that have a role in more than one group, assuming that the supporting services are the "base" and recognizing that other services are also dependent on the supporting services but that these do not have to be counted again in those groups.

Results from the indirect/DPSI-method based on Symphony sensitivity scores

The assessment where links between activities/pressures and ecosystem components are quantified by **sensitivity scores** emphasizes the influence from intense pressures (even in cases where they do not have a broad geographical extent). The results thus indicate highest sensitivity from commercial fishing (catch), activities causing habitats loss and disturbance (such as dredging, dumping and shipping) but also background levels of nutrients, toxic compounds and climate change (Table 7). Considering ecosystem services, the highest scores are obtained for supporting services in general, genetic resources and many cultural ecosystem services (Table 3).

Table 3. First results based on the indirect/DPSI-method using sensitivity scores to evaluate the impact of activities/pressures on ecosystem services.

Second run: This uses the raw "own expert" scores from our table of ecosystem components versus ecosystem services	S1 Biochemical cycling	S2 Primary production	S3 Food web dynamics	S4 Biodiversity	S5 Habitat	S6 Resilience	R1 Climate and atmospheric regulation	R2 Sediment retention	R3 Regulation of eutrophication	R4 Biological regulation	R5 Regulation of toxic substances	P1 Food	P2 Raw material	P3 Genetic resources	P4 Chemical resources	P5 Ornamental resources	P6 Energy	C1 Recreation	C2 Aesthetic values	C3 Science and education	C4 Cultural heritage	C5 Inspiration	C6 Natural heritage
Birdhunt	0,6	0	1,8	2	0,6	1,2	0	0	0	0	0	0	0	1,2	0	0,4	0	1,2	1,2	1,2	1	1,2	0,6
Catch Gillnet	23	3,4	51	38	17	40	2,4	3,6	12	8,6	12	13	4,8	22	2,7	3	4,7	30	26	29	20	24	16
Catch Pelagic trawl	7,4	0	23	13	3,6	18	0	0	7,6	5	8,6	10	3,2	7,4	1,8	0	3,6	14	10	11	9,6	9,2	7,4
Catch Bottom trawl	30	8,8	42	29	22	36	6,4	7,2	17	9,2	14	16	8	20	3	2,4	4,8	15	11	17	10	10	8,4
Turbidity Bottom trawl	26	12	33	29	23	28	7,2	8,2	14	9	11	11	6,2	16	3,4	3,4	4,6	10	9,4	12	8	9	7,4
Turbidity Dredging	26	12	33	29	23	28	7,2	8,2	14	9	11	11	6,2	16	3,4	3,4	4,6	10	9,4	12	8	9	7,4
Turbidity Shipping	26	12	33	29	23	28	7,2	8,2	14	9	11	11	6,2	16	3,4	3,4	4,6	10	9,4	12	8	9	7,4
Turbidity Mining	26	12	33	29	23	28	7,2	8,2	14	9	11	11	6,2	16	3,4	3,4	4,6	10	9,4	12	8	9	7,4
Abrasion Bottomtrawl	34	10	40	34	31	35	7,6	12	16	9	11	12	8,2	22	3,4	4,2	3,8	9,8	11	15	6,4	9,2	7,8
Habitatloss Dumping	40	14	48	43	38	40	9,6	15	20	13	17	16	9,2	25	4,6	6,2	6,4	14	13	17	10	12	9,4
Habitatloss Fishfarm	26	9,2	30	28	25	25	7	11	13	8,2	11	9,4	6,6	17	2,8	4,2	3,4	6,8	7,4	10	5,6	6,6	5,4
Habitatloss Musselfarming	26	9,2	30	28	25	25	7	11	13	8,2	11	9,4	6,6	17	2,8	4,2	3,4	6,8	7,4	10	5,6	6,6	5,4
Abrasion Dredging	44	16	50	46	42	43	11	16	22	14	17	17	11	27	4,6	6,6	6,6	13	12	17	9,6	11	9,2
Habitatloss Coastal Exploitation	19	13	26	23	18	24	7,4	6,6	11	8	9	8,4	5	12	2,8	3,2	4,4	10	8,2	9	8,2	7,8	6,4
Infrastructure	11	4,6	13	11	11	12	3	4,2	5,4	3,5	4,3	4	2,6	7	1	1,4	1,5	2,6	3	4,1	2	2,6	2,6
Habitat Loss Mining	26	9	33	33	28	29	6	8,6	11	8,8	9,4	9,6	5	18	2,2	5,2	4	11	12	13	7,9	10	7,9
Noise 125Hz Shipping	11	2,6	19	15	8	14	1,8	2	5	2,8	4,4	4,8	2,6	9,3	1	1,6	1,6	9,4	8,2	9,8	6,9	7,6	4,9
Noise 125Hz Wavepower	11	2,6	19	15	8	14	1,8	2	5	2,8	4,4	4,8	2,6	9,3	1	1,6	1,6	9,4	8,2	9,8	6,9	7,6	4,9
Noise 125Hz Windpower	11	2,6	19	15	8	14	1,8	2	5	2,8	4,4	4,8	2,6	9,3	1	1,6	1,6	9,4	8,2	9,8	6,9	7,6	4,9
Noise 2000Hz Shipping	4,8	0	13	9,7	2,6	9,9	0	0	1	0,5	1,1	1,2	0,8	6	0,4	0,8	0,5	9,4	9	9,1	5,8	7,8	4,8
Boating Noise	4,8	0	13	9,7	2,6	9,9	0	0	1	0,5	1,1	1,2	0,8	6	0,4	0,8	0,5	9,4	9	9,1	5,8	7,8	4,8
Explosion PM	23	9,6	22	19	19	18	6,4	6,8	9,6	4	5,8	6,2	6,4	13	1,4	2,6	2	4	3,6	6,8	2,8	2,8	2,4
Explosion SPL	15	0	43	28	5,8	35	0	0	10	6,6	12	13	4	16	3	0,4	4,8	29	24	27	20	22	15
Oilspill 2knots Shipping	15	6	31	26	10	24	3,2	2	6,8	4,4	6,6	7	3,2	15	2	3	3	18	16	17	14	15	10
Oilspill 2knots Wrecktif	23	8	35	31	21	30	5	6,4	11	8,6	10	11	4,2	17	3	4,2	4,2	15	14	16	11	13	9,4
Tox Metal Background	17	5,2	28	22	14	23	3,9	5,1	8,7	6	8,1	7,4	3,7	13	1,7	2	2,7	12	11	13	8,5	10	7,4
Tox Metal Fiberbanks	17	5,2	28	22	14	23	3,9	5,1	8,7	6	8,1	7,4	3,7	13	1,7	2	2,7	12	11	13	8,5	10	7,4
Tox Metal Mercurydump	17	5,2	28	22	14	23	3,9	5,1	8,7	6	8,1	7,4	3,7	13	1,7	2	2,7	12	11	13	8,5	10	7,4
Tox Metal Military	17	5,2	28	22	14	23	3,9	5,1	8,7	6	8,1	7,4	3,7	13	1,7	2	2,7	12	11	13	8,5	10	7,4
Tox Mine Risk	17	5,2	28	22	14	23	3,9	5,1	8,7	6	8,1	7,4	3,7	13	1,7	2	2,7	12	11	13	8,5	10	7,4
Tox Munition	23	6,4	39	30	18	31	4,4	5,6	13	7,8	12	13	6,6	18	3	2,6	4,6	17	14	17	13	14	9,7
Tox Synthetic Background	19	6,2	32	25	15	26	4,4	5,4	8,7	5,4	8	6,7	3,9	15	2	2,3	2,9	15	14	16	9,8	13	8,9
Tox Synthetic Harbor	19	6,2	32	25	15	26	4,4	5,4	8,7	5,4	8	6,7	3,9	15	2	2,3	2,9	15	14	16	9,8	13	8,9
Tox Synthetic Industry	29	8,9	43	34	22	35	6	6,8	13	7	10	10	6,7	21	2,9	3,4	4,1	19	17	21	13	16	11
Tox Synthetic Treatmentplants	29	8,9	43	34	22	35	6	6,8	13	7	10	10	6,7	21	2,9	3,4	4,1	19	17	21	13	16	11
Boating Pollution	29	8,9	43	34	22	35	6	6,8	13	7	10	10	6,7	21	2,9	3,4	4,1	19	17	21	13	16	11
Nitrogen Background	24	11	32	27	21	28	7,2	8,2	12	7,6	9,6	8,6	5,8	17	2,6	3	3,8	11	10	13	7,7	9,2	7,3
Nitrogen Fishfarming	24	11	32	27	21	28	7,2	8,2	12	7,6	9,6	8,6	5,8	17	2,6	3	3,8	11	10	13	7,7	9,2	7,3
Phosphorous Background	8,7	3	15	12	8	14	2	2,6	3,8	3,4	4	3,8	1,2	7,1	0,8	1,4	1,2	7,6	7,2	7,6	4,5	6	4,5
Anoxia Background	42	13	55	48	39	47	9,2	13	20	13	17	17	9,4	29	4,2	6,8	6,2	19	17	22	14	15	12
Pathogens Fish farm	1,7	0,4	5,1	4	1,1	3,5	0,2	0	1,2	1,9	1,3	2,1	0,1	1,5	0,1	0	0,3	2,6	2,2	2,5	2	2,3	1,4
Pathogens Treatmentplants	3,5	0,8	7,1	4,8	1,8	5,8	0,5	0,2	0,6	0,4	0,4	0,4	0,3	3	0,3	0,1	0,3	4,9	5	5,1	2,7	3,9	2,7
EMF	0,8	0	2,4	1,8	0,6	2,2	0	0	0,6	1	1	1,4	0	0,8	0	0	0,2	1,4	1	1,4	1,2	1	0,8
TempIncrease Summer 2050	24	6,8	33	27	19	27	5,2	7	14	7,6	11	12	6,6	17	3,4	3	4	10	9,4	12	8,3	9,2	7,3
TempIncrease Winter 2050	24	6,8	33	27	19	27	5,2	7	14	7,6	11	12	6,6	17	3,4	3	4	10	9,4	12	8,3	9,2	7,3
OA 2050	25	7,2	34	28	22	28	5	7,2	13	8,2	11	12	6,1	17	3,5	3,6	4,2	11	11	13	8,4	9,7	7,8
Avoidance Windpower	1,8	0	5,4	6	1,8	3,6	0	0	0	0	0	0	0	3,6	0	1,2	0	3,6	3,6	3,6	3	3,6	1,8
Microplastics	21	7	31	24	16	25	4,7	5,1	11	5,9	9,1	9,6	6	15	2,8	2,3	3,7	11	9,9	13	8,5	9,5	7,2
Macroplastics	8,7	4	16	14	6,8	12	2,2	2	2,5	1,7	1,9	1,4	1,1	7,6	0,9	1,8	1,1	8,7	8,8	8,8	5,8	8,2	5
Ghostnet	33	7,8	55	42	25	44	5,6	7	14	9	11	13	6,6	26	2,8	3,8	3,8	26	24	29	17	21	14

Results from the indirect/DPSI-method based on Symphony impact sums (results will be updated)

The indirect/DPSI evaluation of impacts from activities/pressures on ecosystem services based on impact sums emphasizes activities which are present over larger areas as it also takes the geographical extent into account (while the sensitivity of the ecosystem component to the pressure may get relatively lower influence in comparison to when sensitivity scores are used). Based on these results, the highest impact is seen from shipping (noise, oil spills) and from environmental background pressures such as anoxia, nutrients, toxic compounds and climate change (Table 4). However, with regard to the high scores for shipping, this may be an exaggeration due to relatively large areas considered to be affected by this activity. For example, especially noise from shipping is probably not as disastrous as this table suggests for many ecosystem components and thereby ecosystem services. Similarly, this method seems to miss the effects of small boats, whose effects are widely distributed and can be at least as damaging to the environment as effects from larger ships. We also mentioned above a number of activities that are missing from Symphony in comparison with MSFD and thereby also from the Indirect/DPSI-evaluation conducted for this report. Considering results for ecosystem services, similar to the results based on sensitivity scores, the supporting services in general, genetic resources and many cultural ecosystem services seem to score high. The results presented here are based on interim assessment results from Symphony regarding impact sums, and should be viewed as a demonstration of the method rather than as a final impact assessment. For a more accurate estimation, the assessments should be done separately for the Gulf of Bothnia, the Baltic Proper and for Kattegat/Skagerrak, since the relative importance of human activities could be different in these basins, as well as the distribution of ecosystem components.

Table 4. First results based on the indirect/DPSI-method using impact sums to evaluate the impact of activities/pressures on ecosystem services.

	S1 Biochemical cycling	S2 Primary production	S3 Food web dynamics	S4 Biodiversity	S5 Habitat	S6 Resilience	R1 Climate and atmospheric	R2 Sediment retention	R3 Regulation of eutrophication	R4 Biological regulation	R5 Regulation of toxic substances	P1 Food	P2 Raw material	P3 Genetic resources	P4 Chemical resources	P5 Ornamental resources	P6 Energy	C1 Recreation	C2 Aesthetic values	C3 Science and education	C4 Cultural heritage	C5 Inspiration	C6 Natural heritage
Abrasion Bottomtrawl	0,6	0,0	1,0	0,6	0,4	0,8	0,1	0,2	0,3	0,2	0,3	0,3	0,2	0,5	0,0	0,0	0,1	0,4	0,3	0,5	0,2	0,3	0,2
Abrasion Dredging	1,1	0,1	1,2	1,5	1,5	1,1	0,1	0,7	0,4	0,4	0,4	0,4	0,0	0,7	0,1	0,4	0,0	0,1	0,2	0,4	0,1	0,4	0,4
Anoxia Background	10,9	3,0	13,8	12,3	9,9	11,1	2,2	3,1	5,0	3,1	4,1	4,3	2,6	7,5	1,1	1,7	1,6	4,7	4,2	5,8	3,6	3,9	2,7
Avoidance Windpower	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Birdhunt	0,1	0,0	0,4	0,4	0,1	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,1	0,0	0,2	0,2	0,2	0,2	0,2	0,1
Boating Noise	0,1	0,0	0,3	0,2	0,1	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,2	0,2	0,2	0,1	0,2	0,1
Boating Pollution	0,5	0,2	0,8	0,7	0,5	0,7	0,1	0,2	0,2	0,1	0,2	0,1	0,1	0,4	0,1	0,1	0,1	0,4	0,4	0,4	0,3	0,4	0,2
Catch Bottom trawl	0,6	0,0	1,2	0,6	0,3	1,0	0,1	0,1	0,4	0,3	0,4	0,4	0,1	0,5	0,1	0,0	0,2	0,5	0,4	0,6	0,4	0,4	0,3
Catch Gillnet	1,0	0,1	2,0	1,7	0,9	1,6	0,0	0,3	0,4	0,4	0,4	0,4	0,1	0,9	0,1	0,2	0,1	1,0	1,0	1,1	0,7	1,0	0,6
Catch Pelagic trawl	0,1	0,0	0,2	0,1	0,0	0,2	0,0	0,0	0,1	0,0	0,1	0,1	0,1	0,1	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1
EMF	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Explosion PM	1,0	0,3	0,9	0,7	0,7	0,7	0,2	0,2	0,4	0,1	0,2	0,3	0,3	0,6	0,0	0,1	0,1	0,1	0,1	0,3	0,1	0,1	0,1
Explosion SPL	0,1	0,0	0,2	0,1	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,1	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1
Habitat Loss Mining	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Habitatloss Coastal Exploitation	0,7	0,6	1,1	1,1	0,7	0,9	0,3	0,3	0,4	0,4	0,3	0,4	0,1	0,5	0,1	0,1	0,1	0,5	0,5	0,4	0,4	0,4	0,3
Habitatloss Dumping	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0

Habitatloss Fishfarm	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Habitatloss Musselfarming	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Inrastructure	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Nitrogen Background	7,2	2,9	9,8	8,5	6,3	8,3	1,9	2,1	3,3	2,1	2,4	2,4	1,7	5,0	0,8	0,9	1,1	3,6	3,6	4,1	2,5	3,2	2,3
Nitrogen Fishfarming	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Noise 125Hz Shipping	3,2	0,7	5,9	5,2	2,1	4,6	0,5	0,5	1,2	0,8	1,3	1,5	0,7	2,9	0,3	0,5	0,4	3,3	3,0	3,6	2,7	2,9	1,8
Noise 125Hz Wavepower	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Noise 125Hz Windpower	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Noise 2000Hz Shipping	0,2	0,0	0,4	0,3	0,1	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,3	0,3	0,3	0,2	0,3	0,2
OA 2050	9,7	3,3	13,3	11,4	8,4	10,6	2,2	2,7	5,2	3,4	4,2	4,5	2,7	6,5	1,5	1,4	1,8	4,6	4,3	5,3	3,6	4,0	3,0
Oilspill 2knots Shipping	4,0	1,4	8,3	7,3	2,2	6,8	0,7	0,4	1,6	1,1	1,8	1,9	0,9	4,0	0,6	0,6	0,7	4,9	4,6	5,2	4,1	4,5	2,9
Oilspill 2knots Wreck	0,1	0,0	0,1	0,2	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1
Phosphorous Background	6,0	2,4	8,3	6,9	4,9	7,0	1,5	1,5	2,6	1,5	1,8	1,9	1,5	4,3	0,6	0,7	0,7	3,0	3,0	3,6	2,1	2,6	2,0
TempIncrease Winter 2050	8,8	2,9	11,8	10,2	7,2	9,8	2,1	2,5	5,0	3,1	4,0	4,4	2,8	6,2	1,6	1,2	1,5	3,3	3,4	4,3	3,0	3,3	2,6
Tox Metal Background	2,4	0,8	3,8	3,0	1,7	2,9	0,6	0,6	1,4	0,9	1,2	1,1	0,7	1,8	0,3	0,2	0,4	1,5	1,3	1,7	1,2	1,3	0,9
Tox Metal Fiberbanks	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Tox Metal Mercurydump	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Tox Metal Military	0,3	0,1	0,5	0,4	0,2	0,4	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,2	0,0	0,0	0,1	0,2	0,2	0,2	0,2	0,2	0,1
Tox Mine Risk	0,4	0,1	0,6	0,5	0,2	0,5	0,1	0,1	0,2	0,1	0,1	0,1	0,1	0,3	0,0	0,0	0,1	0,3	0,3	0,3	0,2	0,3	0,2
Tox Munition	0,3	0,0	0,6	0,4	0,2	0,5	0,0	0,0	0,2	0,1	0,3	0,3	0,1	0,2	0,1	0,0	0,1	0,3	0,2	0,3	0,2	0,2	0,2
Tox Synthetic Background	4,5	1,5	7,4	5,8	3,1	5,7	1,0	1,1	1,9	1,2	1,7	1,4	1,0	3,4	0,5	0,5	0,7	3,4	3,2	3,8	2,3	3,1	2,0
Tox Synthetic Harbor	0,5	0,3	0,7	0,7	0,5	0,6	0,2	0,2	0,2	0,1	0,2	0,1	0,1	0,4	0,1	0,1	0,1	0,3	0,3	0,3	0,2	0,3	0,2
Tox Synthetic Industry	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Tox Synthetic Treatmentplants	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Turbidity Bottom trawl	0,4	0,1	0,6	0,5	0,2	0,6	0,1	0,1	0,2	0,2	0,3	0,3	0,1	0,3	0,1	0,0	0,1	0,2	0,1	0,3	0,2	0,2	0,1
Turbidity Dredging	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Turbidity Mining	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Turbidity Shipping	0,2	0,1	0,2	0,2	0,2	0,2	0,0	0,1	0,1	0,1	0,1	0,1	0,0	0,1	0,0	0,0	0,0	0,1	0,1	0,1	0,1	0,1	0,1

Indirect/DPSI-method based on Baltic Sea Impact Index

In order to assess the possibilities to do similar analyses at the scale of the entire Baltic Sea, the evaluation was also made in relation to the ecosystem components used in Baltic Sea Impact Index, in addition to the list from Symphony presented above. A table proposing conversion factors for estimating the contribution of ecosystem components to ecosystem services based on the Baltic Sea Impact Index list of Ecosystem components is presented in Annex 1.

5. The dependency of human activities on ecosystem services

For further analyses of relationships between human activities and ecosystem services, we also investigated dependencies from the other way round, i.e. asked the question: "what is the dependency of various human activities on the marine ecosystem services"? This has tentatively been done before for Swedish conditions by HaV (2012), but assessing fewer activities and using only the scores 0 and 1. Within the current work, the activities listed in Annex III in the Marine Strategy Framework Directive and deemed relevant for the Baltic Sea region were given scores based on their evaluated dependency on each ecosystem service at a scale within a range of 0–4, where 4 is the highest degree of dependence. The score was set for each activity - ecosystem service combination, assessing the same ecosystem services as presented above and in alignment with Bryhn *et al*. (2015). The assessment was made by expert judgement by the authors of this report, using the same procedure as in the assessments of impacts on ecosystem services described above. Thus, the table was looked at from both of two perspectives: row by row, i.e. human activities (in rows) in relation to ecosystem services (in columns), and column by column, ecosystem services (in columns) in relation to human activities (in rows). However, the focus of the assessment was on ”ecosystem capital", rather than abiotic services and flows. In the evaluation, the recommendations by Ivarsson *et al*. (2017) were also considered. The steps suggested by these authors are presented in Fig. 7, and include separate evaluations of the dependency of the quantity and the dependency of the quality of the ecosystem service in question. Subsequently, these are weighted together to the assigned scores.

The resulting scores to assess the dependency of various human activities on ecosystem services can be seen in Table 5. Commercial and recreational fisheries as well as hunting and collecting of species are very dependent on certain supporting, regulating and provisioning marine ecosystem services, according to this assessment, whereas various tourism-related activities are very dependent on cultural marine ecosystem services. Other activities such as shipping, agriculture, forestry, transmission (cables), in turn, have very low dependency on marine ecosystem services, i.e. they can be expected to take place regardless of the quantity and quality of the ecosystem services. Looking from the perspective of ecosystem services, it can also be seen that the quantity and quality of some marine ecosystem services are potentially significant for many human activities, whereas other ecosystem services are so for only a few activities.

Table 5. Estimated dependency of human activities on ecosystem services, range of 0–4, where 4 is the highest degree of dependence, according to expert judgement, considering suggested assessment steps by Ivarsson et al. (2017).

Activity	S1 BCC	S2 PP	S3 FWD	S4 BDIV	S5 HAB	S6 RSIL	R1 CA	R2 SRET	R3 EUT	R4 BIOL	R5 TOX	P1 FOOD	P2 RAW	P3 GEN	P4 CHE	P5 ORN	P6 ENRG	C1 RECR	C2 AEST	C3 SCIED	C4 CULH	C5 INSP	C6 NATH
Land claim	1	1	0	0	0	0	1	4	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0
Restructuring of seabed morph	1	1	0	0	0	0	0	4	1	0	2	0	0	0	0	0	0	1	0	1	0	0	0
Extraction of minerals	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Renewable energy generation	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Nuclear power	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Transmission (cables)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0
Fish and shellfish harvesting (prof.)	1	3	4	4	4	2	1	1	4	4	2	4	2	1	1	0	1	0	0	2	1	1	1
Hunting and collecting	1	2	3	2	3	2	1	0	2	2	1	4	1	0	0	1	0	2	0	1	1	1	1
Aquaculture	1	0	1	1	1	1	0	0	1	1	2	2	1	1	0	0	0	0	0	2	1	0	0
Agriculture	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Forestry	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Transport — infrastructure	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0
Transport — shipping	1	0	0	0	0	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	1	0	0
Urban uses	1	0	0	0	0	0	2	0	1	1	1	1	0	0	0	0	1	1	1	1	2	0	1
Industrial uses	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	0
Waste treatment and disposal	1	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	1	0	0	0
Tourism and leisure infrastructure	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	4	4	1	4	4	4
Tourism and leisure activities	1	2	1	2	2	1	1	0	2	0	1	1	0	0	0	1	0	4	4	0	4	4	4
Fish and shellfish harvesting (recr.)	1	3	3	4	3	2	1	0	1	1	1	2	0	0	0	1	0	4	2	1	2	4	4
Security/defence, Military operations	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0
Scientific and educational activities	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	4	1	2	1

Example of how the results of the assessments done above can be used

As an example, applying the results from the exercises above data from the direct/DI-method were first used to illustrate the relationship between Swedish activities at sea and marine ecosystem services for a few central activities. To indicate each dependency and negative impact of each activity on marine ecosystem services, respectively, tallied total scores may be used. The tentative results are shown in Fig. 1 and demonstrate the relationship between the activities and ecosystem services. The impact of activities on ecosystem services is indicated on the y-axis and the dependency of activities on ecosystem services on the x-axis. The economic performance of the activities is indicated by the size of the bubble, based on economic data for value added derived using the NACE codes for each activity according to Statistic Sweden. Using the results, the ecosystem service analysis can be used for a cost of degradation study which focuses on ecosystem services. The results show which activities have the most significant impact on each ecosystem service and which activities have the biggest dependence on that ecosystem service. Therefore, the results can be used to show not only which activities carry the biggest cost from a specific ecosystem service status being less than good, but also which activities are supposedly creating those cost. This will in turn create a bridge between the use of marine waters and the cost of degradation.

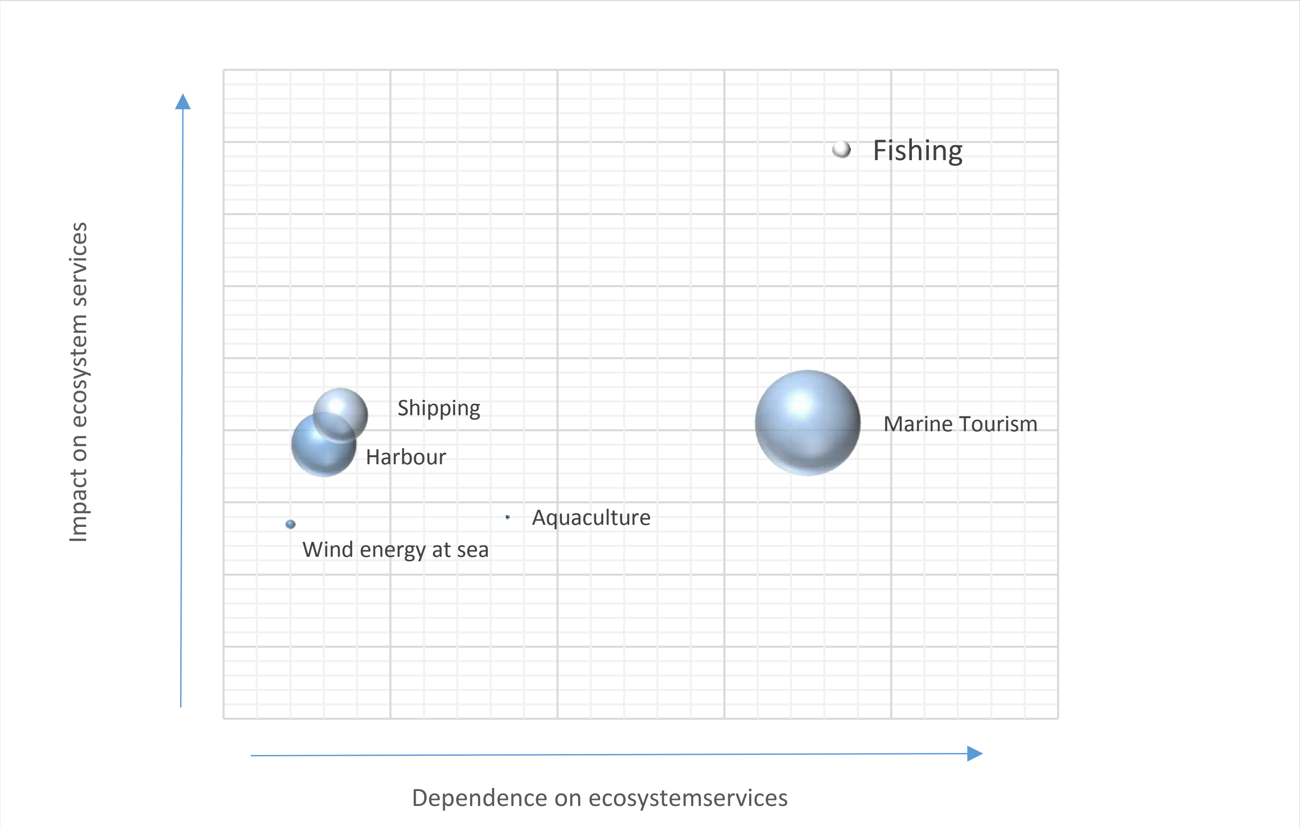

Figure 1. Tentative results for the dependency of human marine activities on ecosystem services (x-axis) and their impact on ecosystem services (y-axis). The size of the bubbles represents their value added. The total value of all the sectors represented in the diagram is 1.5 % of the Swedish Gross Domestic Product.

6. Looking forward

The study have resulted in two different methods which both have their merits, but which are to be used in different situation. However we see the indirect method (DIPS) as having the most potential.

Indirect method

The method makes use of existing data from tools like Symphony or the Baltic sea pressure index to analyse the pressure on ecosystem service as well as where ecosystem services exist and to what extent. This opens an avenue of useful analysis that could be dynamic and/ or spatial, placing specific ecosystem service on a map. The result from that kind of analysis can be especially useful in marine spatial planning in accordance with the marine spatial directive, as well for social-and economic analysis in the marine strategy frame work directive. The results from this study should be seen as a first step in the direction of making that kind of analysis possible. In taking the next step there are some knowledge gaps that need to be addressed:

- Further develop analyses of ecosystem services on/ by the coast. There is data lacking for that area. The area is also interesting since many activities which create welfare for society take place on the coast.
- Better understanding on how to integrate cultural ecosystem services in the analysis, both for use value like recreation but also non-use value like existence value, bequest value
- Further develop the understanding of activities dependence of ecosystem services.
- How to include activities such as agriculture, industry and marine tourism (boating) which are now excluded.

There also need to be a more data and knowledge about the relationship in the link between activities, pressures and ecosystem service. However, this is seen as a general gap and not specific for this method, but rather in all areas of development of policy related to the marine environment.

Direct method

As for the direct method, it is to be used in cases where there is a lack of data. The method supports expert judgment of relationship between ecosystem services and structured and make it possible to go from qualitative analyse to quantitative scores. The result is highly dependent on the experts that make the judgment. How to assemble a group that can present the best results hasn´t been explored within the study, but is an area that can be developed further in order to increase the quality of the results.

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Annex 1

Table 1. Scores received when estimating the contribution of different ecosystem components (Symphony list) on ecosystem services.

Ecosystem components versus ecosystem services Symphony	S1 Biochemical cycling	S2 Primary production	S3 Food web dynamics	S4 Biodiversity	S5 Habitat	S6 Resilience	R1 Climate and atmospheric regulation	R2 Sediment retention	R3 Regulation of eutrophication	R4 Biological regulation	R5 Regulation of toxic substances	P1 Food	P2 Raw material	P3 Genetic resources	P4 Chemical resources	P5 Ornamental resources	P6 Energy	C1 Recreation	C2 Aesthetic values	C3 Science and education	C4 Cultural heritage	C5 Inspiration	C6 Natural heritage
Angiosperms	3	4	4	4	4	4	2	2	2	1	1	0	1	2	0	0	1	2	2	1	1	1	1
Artificial Reefs Total	3	2	3	4	4	0	1	1	1	1	1	0	0	1	0	1	1	2	1	1	1	1	0
Birds Coastal	1	0	3	4	4	2	0	0	0	0	0	0	0	2	0	1	0	2	2	2	2	2	1
Cod	1	0	4	2	0	4	0	0	2	2	2	2	0	1	1	0	1	2	1	2	2	2	1
Deep Reef	3	0	3	4	4	3	0	1	1	1	1	1	0	2	1	1	0	0	2	1	0	1	1
Eel Migration	1	0	1	2	0	2	0	0	0	0	1	1	0	1	0	0	0	1	1	2	2	1	1
Grey Seals	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Haploops Reef	3	0	3	4	4	3	0	2	1	1	1	1	0	2	0	1	0	0	0	1	0	1	1
Harbour Seals	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Hardbottom Aphotic	3	0	3	2	2	2	0	0	1	0	0	1	1	2	0	0	0	0	0	1	0	0	0
Hardbottom Deep	3	0	3	2	2	2	0	0	1	0	0	1	1	2	0	0	0	0	0	1	0	0	0
Hardbottom Photic	4	4	4	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
Herring	1	0	3	2	0	2	0	0	2	1	2	2	2	1	1	0	1	2	1	1	2	1	1
Mussel Reefs Total	3	0	3	4	4	4	1	2	2	2	2	2	1	2	1	1	1	2	2	1	1	1	1
Plankton Community	4	4	4	4	1	3	2	0	2	1	1	1	1	2	1	0	1	0	0	1	1	1	1
Porpoise Baltic	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Porpoise Baltic Reproduction	1	0	2	1	4	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	1	1
Porpoise Belt Reproduction	1	0	2	1	4	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	1	1
Porpoise Beltsea	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Porpoise North Reproduction	1	0	2	1	4	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	1	1
Porpoise Northsea	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Ringed Seals	1	0	3	2	0	2	0	0	0	0	0	0	0	1	0	0	0	2	2	2	1	2	1
Rivermouth Fish	1	0	4	4	4	2	0	0	1	2	1	2	0	1	0	0	0	2	2	2	2	2	1
Seabird Winter Coastal	1	0	3	3	4	2	0	0	0	0	0	0	0	2	0	1	0	2	2	2	2	2	1
Seabird Winter Offshore	1	0	3	3	4	2	0	0	0	0	0	0	0	2	0	0	0	2	2	2	1	2	1
Softbottom Aphotic	3	0	3	2	2	2	1	2	2	1	2	1	1	2	0	0	0	0	0	1	0	0	0
Softbottom Deep	3	0	3	2	2	2	1	2	2	1	2	1	1	2	0	0	0	0	0	1	0	0	0
Softbottom Photic	4	4	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
Spawning Cod	1	0	4	2	4	4	0	0	1	1	2	2	0	1	0	0	1	2	1	2	1	1	1
Spawning Fish	1	0	3	1	4	3	0	0	1	2	1	2	0	1	0	0	0	2	1	1	1	1	1
Sprat	1	0	3	1	0	2	0	0	2	0	2	2	2	1	1	0	1	1	1	1	1	1	1
Transportbottom Aphotic	3	0	3	2	2	2	0	0	1	0	0	1	1	2	0	0	0	0	0	1	0	0	0
Transportbottom Deep	3	0	3	2	2	2	0	0	1	0	0	1	1	2	0	0	0	0	0	1	0	0	0
Transportbottom Photic	4	3	3	4	4	4	2	1	1	1	1	1	1	2	0	1	0	1	1	1	1	1	1
Vendace	1	0	3	2	0	2	0	0	2	0	2	2	0	1	0	0	1	2	1	1	2	1	1

Table 2. Scores received when estimating the contribution of different ecosystem components (Baltic Sea Impact Index list, HELCOM 2017) on ecosystem services.

ECOSYSTEM COMP (HOLAS II)	*S1 Biochem. cycl.*	*S2 Prim. Prod.*	*S3 Food web dyn.*	*S4 Biodiversity*	*S5 Habitat*	*S6 Resilience*	*R1 Climate/atm.reg.*	*R2 Sed. retention*	*R3 Reg. of eutr.*	*R4 Biol. reg.*	*R5 Reg. of tox. sub.*	*P1 Food*	*P2 Raw material*	*P3 Gen. res.*	*P4 Chem. res.*	*P5 Orn. res.*	*P6 Energy*	*C1 Recreation*	*C2 Aesthetic values*	*C3 Sci. and edu.*	*C4 Cultural heritage*	*C5 Inspiration*	*C6 Natural heritage*
01. Productive surface waters	***4***	***4***	***4***	***4***	***1***	***3***	***2***	***0***	***2***	***1***	***1***	***1***	***1***	***2***	***1***	***0***	***1***	***0***	***0***	***1***	***1***	***1***	***1***
02. Oxygenated deep waters	***3***	***0***	***3***	***3***	***2***	***2***	***1***	***2***	***2***	***1***	***2***	***1***	***1***	***2***	***0***	***0***	***0***	***0***	***0***	***1***	***0***	***1***	***0***

03. Infralittoral hard bottom	4	4	4	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
04. Infralittoral sand	4	4	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
05. Infralittoral mud	4	4	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
06. Infralittoral mixed	4	4	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
07. Circalittoral hard bottom	4	3	4	4	4	3	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
08. Circalittoral sand	4	3	4	4	4	3	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
09. Circalittoral mud	4	3	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
10. Circalittoral mixed	4	3	4	4	4	4	2	2	2	1	2	1	1	2	1	1	1	1	1	1	1	1	1
11. Furcellaria lumbricalis	4	4	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1
12. Zostera marina	4	4	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
13. Charophytes	4	4	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
14. Mytilus edulis	3	0	3	4	4	4	1	2	2	2	2	2	1	2	1	1	1	2	2	1	1	1	1
15. Fucus sp.	4	4	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	1	1	1	1
16. Sandbanks (1110)	3	3	3	4	4	3	2	2	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1
17. Estuaries (1130)	3	3	3	4	4	4	2	2	2	2	2	1	1	2	1	1	1	2	2	2	1	1	2
18. Mudflats and sandflats (1140)	3	3	3	4	4	3	2	2	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1
19. Coastal lagoons (1150)	3	3	3	4	4	4	2	2	2	2	2	1	1	2	1	1	1	2	2	2	1	1	2
20. Large shallow inlets and bays (1160)	3	3	3	4	4	4	2	2	2	2	2	1	1	2	1	1	1	2	2	2	1	1	2
21. Reefs (1170)	3	3	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	2	1	1	1
21. Submarine structures made by leaking gas (1180)	3	3	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	1	1	2	1	1	1
22. Baltic Esker Islands (UW parts, 1610)	3	3	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	2	1	1	2
24. Bor. Baltic islets and small islands (UW parts, 1620)	3	3	3	4	4	4	2	2	2	1	1	1	1	2	1	1	1	2	2	2	1	1	2
25. Cod abundance	1	0	4	2	0	4	0	0	2	2	2	2	0	1	1	0	1	2	1	2	2	2	1
26. Cod spawning area	1	0	3	2	4	4	0	0	1	1	2	2	0	1	0	0	1	2	1	2	1	1	1
27. Herring abundance	1	0	3	2	0	2	0	0	2	1	2	2	2	1	1	0	1	2	1	1	2	1	1

28. Sprat abundance	***1***	***0***	***3***	***1***	***0***	***2***	***0***	***0***	***2***	***0***	***2***	***2***	***2***	***1***	***1***	***0***	***1***	***1***	***1***	***1***	***1***	***1***	***1***
29. Distribution of demersal spawning flounder	***1***	***0***	***3***	***1***	***4***	***3***	***0***	***0***	***1***	***1***	***1***	***2***	***0***	***1***	***0***	***0***	***0***	***2***	***1***	***1***	***2***	***1***	***1***
30. Abundance of pelagic spawning flounder	***1***	***0***	***3***	***1***	***4***	***3***	***0***	***0***	***1***	***1***	***1***	***2***	***0***	***1***	***0***	***0***	***0***	***2***	***1***	***1***	***2***	***1***	***1***
31. Recruitment areas of perch	***1***	***0***	***3***	***1***	***4***	***3***	***0***	***0***	***2***	***2***	***2***	***2***	***0***	***1***	***0***	***0***	***0***	***2***	***1***	***1***	***2***	***1***	***1***
32. Recruitment areas of pikeperch	***1***	***0***	***3***	***1***	***4***	***3***	***0***	***0***	***2***	***2***	***2***	***2***	***0***	***1***	***0***	***0***	***0***	***2***	***1***	***1***	***2***	***1***	***1***
33. Recruitment areas of roach	***1***	***0***	***3***	***1***	***4***	***3***	***0***	***0***	***1***	***1***	***1***	***1***	***0***	***1***	***0***	***0***	***0***	***0***	***1***	***1***	***2***	***1***	***1***
34. Wintering seabirds	***1***	***0***	***3***	***3***	***4***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***2***	***0***	***1***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
35. Breeding seabird colonies	***1***	***0***	***3***	***4***	***4***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***2***	***0***	***1***	***0***	***2***	***2***	***2***	***2***	***2***	***1***
36. Migration routes for birds	***0***	***0***	***3***	***3***	***4***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
37. Grey seal abundance	***1***	***0***	***3***	***2***	***0***	***2***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
38. Grey seal haulouts	***1***	***0***	***2***	***2***	***4***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
39. Harbour seal abundance	***1***	***0***	***3***	***2***	***0***	***2***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
40. Harbour seal haulouts	***1***	***0***	***2***	***2***	***4***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
41. Ringed seal distribution	***1***	***0***	***3***	***2***	***0***	***2***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***
42. Distribution of harbour porpoise	***1***	***0***	***3***	***2***	***0***	***2***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***1***	***0***	***0***	***0***	***2***	***2***	***2***	***1***	***2***	***1***