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Background

HELCOM MetDev WP2 on economic and social analyses (ESA) work with conceptional and operational relationships between the marine environment and human welfare. It works to further develop regional methods and results for economic and social analyses to support the holistic assessment of the marine environment by addressing some of the shortcomings and development needs identified in previous regional ESA work. The HOLAS III assessment will constitute the first-time ecosystem accounting included in a HELCOM assessment. As a consequence, the application for HOLAS III will be limited to topics where sufficient information is available.

This document outlines the progress on assessment of the marine ecosystem accounting approach for HOLAS III. The document was prepared as a joint effort by MetDev and BLUES projects as they complement each other in analyses related to ecosystem services and accounting.

Action requested

The Meeting is invited to consider and endorse the approach for assessing marine ecosystem accounting for the HOLAS III assessment to be submitted to HOD 61-2021 for approval.

Marine Ecosystem Accounting

Ecosystem accounting is a structured compilation of consistent and comparable information on ecosystems and ecosystem services in the framework of national accounting, such as spatial data, statistics and indicators. As a way of organising stocks and flows within the environment, it is aligned with existing statistical standards that measure society and the economy. However, it uses environmental data as a foundation to relate flows from the environment (ecosystem goods and services) to social circumstances (or values) and economic activity. Marine ecosystem accounting focuses on coastal and marine ecosystems and ecosystem services (Dvarskas, 2019) to inform and enable decision making about the marine environment by providing a combination of information and datasets in a specific format (Fenichel et al. 2020). Ecosystem accounting applies a common framework and structure in order to provide comparable and consistent information to the System of National Accounts (SNA). In this accounting process, statistics and indicators on social, environmental, and economic domains related to marine environments are used. According to the UN System of Environmental Economic Accounts Ecosystem Accounts (UN, 2021) there are several benefits from ecosystem accounting, such as i) guidance for coherence and standardization, ii) combination of information and data sets in a consistent format, iii) information to analyse environment, iv) assessment of policy options and v) support the implementation of management decisions. The European Union has also enacted legislation to provide a legal framework for the collection of comparable data, consistent with the SEEA EA, from EU Member States (Regulation (EU) 691/2011).

As part of the economic and social analyses of the marine environment, HELCOM MetDev and BLUES projects aim to 1) describe a general approach for ecosystem accounting applicable for the marine environment and 2) apply the framework to the Baltic Sea and provide illustrations of marine ecosystem accounting for specific ecosystem components. Ecosystem accounting provides an additional perspective for linking flows within a socio-ecological system (e.g., the complex flows and feedbacks between environment, society, and the economy).

The work outlined in this document builds on the international UN ecosystem accounting framework and available spatial data on ecosystem assets and has actively engaged with HELCOM EN ESA to utilize its topical expertise and reginal experience.

The work of MetDev and BLUES complement each other in analyses related to ecosystem services and accounting. BLUES provides a general description of the framework for ecosystem accounting that can be applied in the Baltic Sea region. MetDev provides examples and illustrations of applying ecosystem accounting around the world and in the Baltic Sea.

Progress and potential synergies with other processes

As ecosystem accounting has been developed for the terrestrial space, coastal and marine accounts require a more nuanced approach. To learn from international examples and address complexities related to accounting within the marine space, the project had several meetings with the Global Ocean Accounts Partnership (GOAP). The GOAP Secretariat is developing guidance for accounting within coastal and marine environments and seeks to build capacity globally through providing a forum for the growing global community of practice. This includes providing technical assistance and capacity building and there are no resourcing or binding commitments expected of members. The GOAP currently assists in the development of ocean accounts in 15 countries.

In total six meetings were held in 2021, consisting of discussions such as the benefits of marine ecosystem accounting and the potential for pilot studies in the Baltic region. Discussions also included how ecosystem accounts aligned with existing HELCOM commitments and mandates, and how they further aligned with the aims of MetDev. A representative from Global Ocean Accounts Partnership presented the ecosystem accounting concept to EN ESA expert group and BLUES project partners in April.

In addition, MetDev participated to the European Commission working group on Mapping and Assessment of Ecosystem and their Services (MAES) monthly meetings, to learn from their experience on ecosystem service valuation and mapping.

Approach for Marine Ecosystem Accounting

Natural capital accounting

Marine ecosystems provide a wide range of good and services ('ecosystem services') that support human activities, and by extension the livelihoods of communities. This is especially true across the Baltic, where the Baltic Sea supports sectors such as fishing, shipping, ports, and related infrastructure. These activities depend on ecosystems, which could be considered the natural wealth (or 'capital') of the countries bordering the sea. Framing marine ecosystems lends to the use of accounting frameworks, which can be used to trace the relationships and dependencies from marine ecosystems to society and the economy.

The United Nations System of Environmental-Economic Accounting—Ecosystem Accounting (SEEA EA) is a spatially-explicit and integrated statistical framework that provides concepts and principles for measuring and organizing information on the extent and conditions of ecosystem assets, ecosystem services (ES) and their value, value of ecosystem assets, as well as their links to economic and other activities (UN 2021). The following description of ecosystem accounting and accounts is based on the recent report on the UN SEEA EA framework (UN 2021).

A central concept in ecosystem accounting are 'ecosystem' assets, which are defined as "contiguous spaces of a specific ecosystem type characterized by a distinct set of biotic and abiotic components and their interactions" (UN 2021). The definition of ecosystem assets is a statistical representation of the general definition of ecosystems from the UN Convention on Biological Diversity (e.g., *Zostera marina*, charophyte). Ecosystem assets are spatially defined and represent ecosystems that can be mapped, should be exhaustive and mutually exclusive.

Each asset is classified to an ecosystem type, which has a distinct set of abiotic and biotic components. The UN SEEA-EA framework (UN 2021) for ecosystem types is based on the IUCN Global Ecosystem Typology (Keith et al. 2020). It classifies ecosystem types into four realms: terrestrial, freshwater, marine and subterranean, with transitional realms indicating areas that are at the interface between two or more realms. Ecosystem types can be classified further based on biomes and ecosystem functional groups.

The outputs from ecosystem accounting are typically presented in tables with data by ecosystem types, or on maps which show individual ecosystem assets and ecosystem types. An ecosystem accounting area defines the area the account covers, and which ecosystem assets are included in the accounting. It can be based on e.g., national borders, administrative areas or environmental, policy or analytical considerations, such as marine protected areas.

The UN SEEA-EA (2021) is built on five core accounts: 1) physical accounts of ecosystem extent, 2) physical accounts of ecosystem condition, 3) physical accounts of ecosystem services, 4) monetary accounts of ecosystem services, and 5) monetary accounts of ecosystem assets. Extent, condition, and ecosystem asset accounts are stock accounts (and changes in stocks), while the two ecosystem service accounts are flow accounts. Stock accounts measure units at a specific point in time, for example, as total area or volume. Flow accounts measures units per unit of time, for example, as cubic meters per year. The accounts are connected to each other as presented in Figure 1.

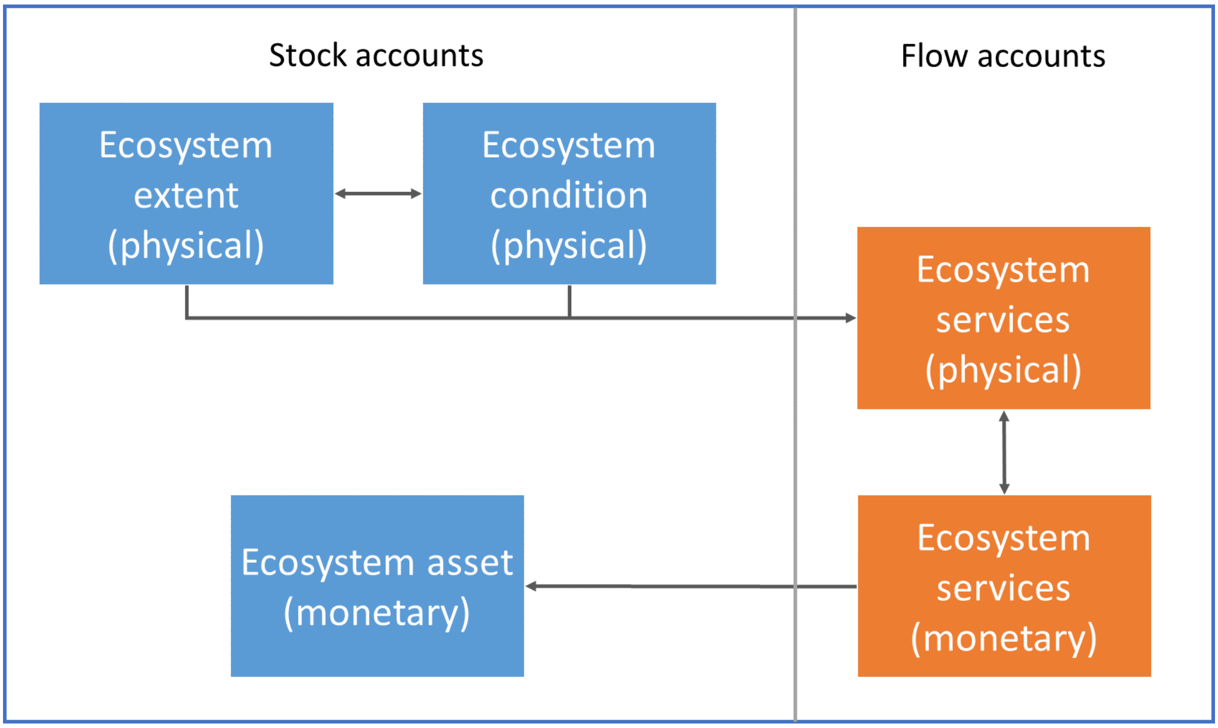

Figure 1. Ecosystem accounts and their connections (Source: UN 2021).

Ecosystem extent and condition accounts

The ecosystem extent and condition accounts record ecosystem characteristics and extent existing environmental-economic accounting by including a spatial component.

Ecosystem extent accounts describe the spatial area of ecosystem types (i.e., ecosystem assets) and the changes of ecosystems over time. Extent accounts record the area of all ecosystem assets of the same ecosystem type within an accounting area. Extent accounts include information on the opening and closing extent, and additions and reductions in extent (e.g., in hectares or km^2). Extent is measured for a specific accounting period, normally a year, and thus opening is the extent at the beginning and closing at the end of the year. The extent account records changes in ecosystem types (ecosystem conversions), which result in changes in the provision of ES. Presentation of extent accounts on maps is common. Extent accounts may be complemented with economic data on ownership and management or activities for each ecosystem type.

Ecosystem condition accounts describe the quality of the ecosystem in terms of its abiotic and biotic characteristics, and is assessed based on ecosystem composition, structure, and function. Condition can be defined in comparison to a reference condition, such as good environmental status. Biodiversity is integral for ecosystem condition, affecting composition, structure, and function. Ecosystem condition affects the provision of ecosystem services, but the link can take varying forms. Condition accounts include information on variables and indicators for ecosystem condition, which can be aggregated to produce overall measures of ecosystem condition. The variables and indicators are biophysical, quantitative and reflect changes over time. The difference between variables and indicators is that indicators are set against reference levels. Measurement units vary across variables, and can be, for example, % of area, number of species or tons/ha. Indicators are generally presented on a scale of 0-1, and reference levels are presented for each indicator. Aggregate ecosystem indices combine information on several indicators using a specific aggregation approach, potentially applying weighting. Similar to extent accounts, condition accounts include opening and closing conditions and change for a specific time period, normally a year. Examples of condition variables for marine areas are water clarity, chlorophyll-a concentration, oxygen concentration, species richness and habitat diversity.

Ecosystem service accounts

Ecosystem services (ES) are described both in physical and monetary terms. The ES, supplied by ecosystem assets, are contributions of ecosystems to the benefits that are (directly, indirectly or passively) used in human activities. Benefits are the outputs or resulting provision of ES used and enjoyed by people. ES are often categorized into provisioning, regulating, maintenance and cultural services (Haines-Young & Potschin 2012). All provisioning and cultural ES are final services. Regulating ES can be either final or intermediate services and maintenance ES are intermediate services. Physical ecosystem services accounts describe the supply and use of ES by ecosystem assets, while monetary ecosystem services accounts provide estimates of the value of ES in monetary terms.

Physical accounts

The aim of *physical ES accounts* is to record the flows of ES over an accounting period in physical units (e.g., litres, kilograms), focusing on both the supply of ES (structure, processes, and functions) and the use of ES. The accounts measure the total flow of ES over a specific accounting period, where total flow is assessed against a baseline level, usually zero supply of ES. For regulating and maintenance services the baseline can also be based be on the minimum supply level of ES.

The *ES supply account* includes information of selected (intermediate and final) ES in quantitative units for different ecosystem types, and the *ES use account* on the use of these ES by economic units (final ES) or ecosystem types (intermediate ES). The economic units can represent industries, government, and households, as well as use by non-residents (“exports”). Same unit of measurement should be used for supply and use of specific ES, as it is important that the supply of ES is equal to their use during the accounting period. Units of measurement depend on the ES, data availability and measurement method (e.g., tons, cubit meters or number of visits). Both supply and use accounts can be presented on maps to provide information on ES hotspots.

Monetary accounts

Monetary ES accounts capture the monetary value of flows of ES over an accounting period based on their exchange value. Exchange value reflects the value at which goods, services or assets are or could be exchanged for cash and are normally based on market prices. When market prices do not exist, exchange values can be estimated based on the costs of providing the ES or other approaches that approximate prices or exchange values. Useful approaches include residual value and resource rent, hedonic pricing, averting behaviour, travel cost, replacement cost, avoided damage cost and simulated exchange value (SEV) methods.

Monetary ES accounts are structured the same way as physical accounts into supply (by ecosystem type) and use (by economic unit or ecosystem type) parts and should be consistent to the physical accounts. In some cases, ES provide inputs to the production of goods and services already included in national accounts (SNA benefits), such as pollination and biomass provisioning services, and monetary valuation involves separating the ecosystem contribution to the value of those goods and services. In other cases, ES contribute to benefits to economic units not included in national accounts e.g., air filtration, and valuation seeks to estimate the prices, costs or lost benefits related to the ES provision.

Monetary accounts of ecosystem assets

Monetary ecosystem asset accounts provide information on the monetary values of stocks of assets for the beginning and end of each accounting period in net present values, as well as on stock changes. The aim is to value individual ecosystem assets and their changes. The value of an ecosystem asset is calculated based on the net present value of the future returns of each ES supplied by that asset, considering the links across services and assets. Each ES is valued individually, and they are aggregated to obtain the total monetary value of an asset. This requires that ES are attributable to individual ecosystem assets. If that is not possible, value of ES can be aggregated to estimate the total value of (all) ecosystem assets. Calculation of the net present value requires defining the discount rate as well as the life of the asset (e.g., the accounting period the asset is expected to generate ES).

The monetary asset accounts report values by ecosystem type for five asset changes: ecosystem enhancement, degradation, conversions, other changes in volume and revaluations resulting from price changes. The opening and closing values are based on the monetary value of flows of ES from the monetary ES accounts and compiled first. In addition, information on the specific asset changes is needed.

For ecosystem enhancement and degradation, change in net present value is assessed and compared to the change in the condition of the ecosystem type recorded in the condition account. Ecosystem enhancement is the increase in value from improvement in ecosystem condition of the asset over the accounting period, measured as an increase in the net present value of future returns of ES from the asset. It includes the effect of restoration, rehabilitation, and reclamation activities. Ecosystem degradation is the opposite of enhancement, representing the degradation in value from decline in the condition of the asset over the accounting period, resulting e.g., from pollution and extraction and harvesting of natural resources.

For ecosystem conversions, ecosystem extent accounts are relevant. Conversions refer to persistent changes in ecosystem structure, composition and function that result in different provision of ES and future returns. They should be recorded in physical term to extent accounts. In monetary terms, decreases should be recorded for the ecosystem type the area has been converted from and increases for the type of the area has been converted to. The future returns do not necessarily offset each other.

Other changes and revaluations are based on specific information on those changes. Other changes include catastrophic losses (such as earthquakes, fires, cyclone) and reappraisals from changes in the expected future returns due to re-evaluation of the condition of ecosystem assets or demand for ES. Revaluations result solely from changes in unit prices of ES, while changes in the quantity of quality of future flows of ES should be included in the other categories.

Marine ecosystem accounting experiences around the world

There is a growing number of pilot marine ecosystem accounts around the world, with at least thirty countries supporting ongoing projects. While few have published reports, Australia does have available outputs. In addition, Finland has ongoing projects focusing on marine ecosystem accounting and sustainability assessment.

Proof of concept: Australia

Australia's ocean natural capital is managed predominantly through a network of commonwealth, state, and territory-managed marine parks, covering 3.3 million km^2. The overarching objective of all marine parks are healthy and resilient ecosystems which enhance Australia's wellbeing. To understand the contribution of ocean ecosystems within marine parks, the Department of Energy and Environment commissioned ocean accounts for Geographe Bay Marine Park, Western Australia (IDEEA-Group, 2020). The pilot focused on the extent and condition of **seagrass** ecosystems, which form the largest continuous beds within Australia. It further extended analyses to the ecosystem services provided to economic activities (fishing, whale watching) and local communities (recreational activities), and potential pressures by human activities on environmental assets.

The resulting accounts were aimed to inform risk assessments, prioritise monitoring and intervention activities, evaluate zoning and present a supporting narrative for the contribution of environmental assets within the marine park.

- Ecosystems in Geographe Marine Park contributed approximately AUD316,000 in 2019 to the gross operating surplus of the local economy through whale watching (AUD254,000) and commercial fishing (AUD62,000).
- Recreational fishers took more than 12,000 fishing trips in 2018, which is valued at over AUD2.2 million (consumer surplus).
- Seagrass meadows in Geographe Marine Park were estimated to store approximately 6.2 million tonnes of carbon in soil, and each year sequester approximately a further 27,569 tonnes (net).

Proof of concept: Finland

There have been several past and ongoing projects applying the ecosystem accounting framework to marine areas in Finland.

MERIAVAIN project (2018-2021) applied an accounting framework to value selected ecosystem services from marine habitats, such as carbon sequestration, ferromanganese deposits, common reed and recreation. The project report on valuing ES is forthcoming.

MAREA project (From Marine Ecosystem Accounting to Integrated Governance for Sustainable Planning of Marine and Coastal Areas, 2020-2022) aims to test new concepts of ecosystem services mapping, environmental accounting and sustainability assessment and apply these concepts in a decision support geoportal in two pilot areas: Finland-Estonia in the Gulf of Finland and Estonia-Latvia in the Gulf of Riga.

ENVECOPACK project (Developing pilot accounts for marine, freshwater and urban ecosystems and packaging materials, 2021-2023) develops pilot marine ecosystem accounts with cultural and provisioning services for fishing.

ESTAT-EEA project (Towards ecosystem accounting based on innovations and insights on natural capital knowledge, 2017-2018) supported the Knowledge Innovation Project (KIP INCA) at EU level by testing the System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA EEA) framework in Finland. Project highlighted the national capacity to perform ecosystem accounting, and showed gaps and possibilities in data and knowledge.

Illustration of Marine Ecosystem Accounting Approach in the Baltic Sea

According to the above-mentioned accounting structure and the framework provided by UN SEEA EA, the following five steps could be applied in principle in the Baltic Sea marine ecosystem accounting process:

1. Identification of priority policy needs and available data,
2. Preparation of ecosystem extent accounts: Spatial distribution of ecosystem components (assets) and how it changes over time. This activity includes preparation of a broad data inventory for ecosystem assets,
3. Preparation of ecosystem condition accounts: Assessing quality of the Baltic Sea ecosystem and its assets using several variables (e.g., ecosystem functions) and indicators (e.g., HELCOM Core Indicators),
4. Preparation of physical ecosystem services accounts,
5. Preparation of monetary ecosystem service and ecosystem asset accounts.

Pilot Example: Common eelgrass (*Zostera Marina*, Seagrass)

Identification of priority policy needs and available data

Zostera marina (common eelgrass) was selected as the pilot example of regional scale ecosystem accounting in the Baltic Sea region due to data availability. *Z. marina* is present from Kattegat to the Archipelago Sea, however the macrophyte is far more abundant in the southern Baltic Sea. According to HELCOM Red List (2013), *Z. marina* is under pressure from eutrophication, epidemics, water traffic, construction (sand extraction) and fishing (bottom trawling). Additionally, it is a relatively well studied marine species in the ecosystem services literature.

Ecosystem extent account

Extent accounts include the spatial area of ecosystem assets and their changes over time are used in the periodic balance sheets. In the *Z. marina* example, available data only allows to analyse the spatial extent of the asset in the Baltic Sea in 2018.

What is available?

HELCOM Maps and Data Service (MADS) hosts a GIS layer for the presence of *Z. marina* in the Baltic Sea. This layer is a raster with 5km^2 spatial resolution based on data submitted by Contracting Parties gathered from national mapping and monitoring campaigns, or from scientific research. However, most of the submitted data are point locations for *Z. marina* presence that have then been rescaled to the 5km^2 raster. This leads to a significant overestimation of *Z. marina*. Baltic *Z. marina* coverage is estimated to be a minimum of 1222 km^2 with a speculated maximum above 2000 km^2 (Boström et al., 2014), while the unaltered MADS layer estimates 21000 km^2.

How can this be improved?

Filtering using other data layers can significantly improve the accuracy of our estimation. The most direct correction is to limit the depth where *Z. marina* can be indicated. For an initial test, *Z. marina* was limited to maximum 10m depth using a 250-meter square resolution bathymetry layer. This resulted in a calculated area of 11150 km^2. However, better data does exist to further improve this filter. For this purpose, it is planned to use the next version of the broad-scale seabed habitat and bathymetry maps for Europe produced by EMODnet Seabed Habitats project during HOLAS III. There is also a strong relationship between water clarity (secchi depth) and the maximum depth of *Z. marina,* as illustrated in Danish waters (Krause-Jensen et al. 2011). This relationship can be applied to the depth filter using the HELCOM water clarity core indicator during HOLAS III with updated datasets. This would allow for varying depth limits to be applied to different coastal areas.

Without attempting the more demanding depth filter, *Z. marina* distribution can still be improved using broadscale habitat data layers from MADS. If *Z. marina* distribution is limited to e.g., infralittoral sand, the calculated area is only 3475 km^2. However, this filter does eliminate some known *Z. marina* beds, possibly as a result of poor resolution within the broadscale habitat map layer.

How can this be improved in the future?

- New high resolution spatial data layers for habitat forming species and benthic habitats
- Enhanced monitoring effort in Baltic Sea scale
- Identification of data rich pilot areas in the Baltic Sea

Conclusions

The ecosystem extent account for *Z. marina* is coarse and challenging, but can be made to approximate estimates from literature, particularly if there are strong responses to HOLAS III data requests. For the purposes of a pilot example, the data appear sufficient.

Ecosystem condition account

Ecosystem condition accounts cover relevant biotic and abiotic characteristics of the ecosystem that affect the provision of ecosystem services. However, the relevant characteristics will vary by the ecosystem service being evaluated. *Z. marina* provides numerous ecosystem services that can be assessed in an accounting framework. Currently, a few are reviewed below but it is likely that more will be added before project completion.

Carbon storage

The characteristics relevant to assessing ecosystem condition have been studied both in the Baltic Sea (Röhr et al. 2016) and globally (Röhr et al. 2018). The most significant ecosystem characteristics for carbon storage in the Baltic Sea region are physical sediment characteristics: sediment density, degree of sorting, mud content (Kattegat only). While biotic characteristics (shoot density, below ground biomass, *Z. marina* organic carbon contribution) are relatively minor factors for predicting carbon sequestration. Therefore, in terms of ecosystem condition accounts, the physical sediment characteristics are more valuable to estimating *Z. marina* carbon storage than accounts tracking *Z. marina* characteristics.

Carbon sequestration

Variation in carbon sequestration rates is less systematically evaluated and suffer somewhat from the stochastic nature of erosion events and strong landscape effects (Chen et al. 2007, Dahl et al. 2018, Dahl et al. 2020). However, generally lower energy environments (less wind and wave energy, more energy dissipation from depth or vegetation) will exhibit higher sequestration rates. Producing relevant ecosystem condition accounts may not yet be possible given current scientific knowledge.

Conclusions

Relevant condition accounts for the ESs of *Z. marina* cannot be prepared at present due to lack of data and scientific knowledge on physical and biotic ecosystem characteristics. The accounting process can function without these accounts but cannot show variation in ES supply or values.

Physical ecosystem service accounts

Physical ecosystem service accounts track the annual flow of services provided by a unit of the ecosystem of interest. Currently, a few are reviewed below but more will be added before project completion.

Carbon storage

Regional estimates of carbon held in the upper meter of sediment are available and can be applied to *Z. marina* extent accounts to estimate current carbon stocks held by *Z. marina* habitats (23 Mg h^{-1} Baltic average, 195 Mg h^{-1} Kattegat-Skagerrak average; Röhr et al. 2018). Further intra-regional variability would require relevant condition accounts.

Carbon sequestration

Regional estimates of carbon sequestration are available for the Baltic Sea region and can be applied to *Z. marina* extent accounts to estimate carbon sequestration rates in *Z. marina* habitats (0.0084 – 0.052 Mg h^{-1} y^{-1} Baltic Sea main basin, 0.213 – 0.491 Mg h^{-1} y^{-1} Danish straights; (Röhr et al. 2016, Jankowska et al. 2016).

Conclusions

Preparation of physical ES accounts are possible for many ecosystem services, although the quality will vary based on available data. For the purposes of a pilot example, they appear sufficient.

Monetary ecosystem service and ecosystem asset accounts

Monetary ecosystem service accounts provide monetary valuations for each tracked ecosystem service, while ecosystem asset accounts provide a combined monetary valuation of an ecosystem for all tracked ecosystem services. The HELCOM MetDev project is working in partnership with HELCOM BLUES to generate monetary ecosystem service accounts which can then be used to generate ecosystem asset accounts. Work is ongoing in BLUES to develop these accounts (BLUES activity 1.3).

Conclusions

Preparation of monetary ES accounts are possible for many ecosystem components (e.g., *Z. marina* habitat) although quality will vary due to available data quality. Further, the quality and completeness of these accounts are dependent on ecosystem extent, ecosystem condition and ES physical accounts.

Data requirement to apply accounting framework in HOLAS III

Due to available data, this exercise reflects a preliminary application of the marine ecosystem accounting framework in the Baltic Sea. High-quality responses to HOLAS III data requests are critically important for applying the accounting framework at the regional scale in the Baltic Sea.

Data resolution is low (5km^2) in most of the ecosystem asset layers in HELCOM MADS. International accounting experiences indicate that benthic habitats and habitat forming species are the assets most commonly used, thus the most efficient way of improving ecosystem accounting in the Baltic Sea would likely be increasing the effort to collect and collate observation data on the distribution of habitat forming species and benthic habitats.

In addition, in order to analyse changes in asset distribution over time, monitoring needs to take place at a high enough frequency to indicate change. In order to complete a more detailed condition account, more detailed information is needed on the variation in the condition of *Z. marina* and its impacts on the supply of ecosystem services.

Although the aim for the purpouses of HOLAS III is to implement test accounting a the Baltic Sea scale, marine ecosystem accounting can be applied more accurately in smaller and data rich areas. Thus, pilot study areas with high data availability should be identified in the Baltic Sea to provide more accurate and comprehensive results.

Expected HELCOM MetDev outputs by end of 2021

- Development of a regional approach aligned with the System of Environmental-Economic Accounting (SEEA) framework, although modified to meet the needs of HELCOM member states,
- Data inventory of a diverse array of available data for the ecosystem assets,
- Initial test of SEEA framework and ocean accounting in the Baltic Region by using other ecosystem assets,
- Identification of ecosystem asset- ecosystem condition- ecosystem service relationships by using the pilot ecosystem assets,
- Aligning with the international frameworks and community of practice.

Use in HOLAS III and presentation of results

Outputs of MetDev Activity B can be used in HOLAS III process by:

- Scaling of SEEA marine ecosystem accounting framework to the whole Baltic region,
- Using the developed ecosystem accounting framework, and analysing the improved integration of land sea interactions,
- Integration of HELCOM Map and Data Services and Marine Ecosystem Accounting data inventory,
- Distribution of ecosystem assets in countries' territorial waters in order to understand the changes in ecosystem assets and services for national accounts,
- Providing added value and synergies to other ongoing assessments.

HELCOM MetDev Work Plan

Table 2 outlines the tasks and progress of MetDev's work on marine ecosystem accounting.

Table 2: Summary of progress and timeline for tasks in WP2

Task	Work ongoing	Planned schedule for task	Collaboration with HELCOM BLUES project
Review of existing literature on ecosystem service valuation studies and marine ecosystem accounting	Done	Q1/21	x
Application of ecosystem service supply maps in marine ecosystem accounting framework	Done	Q3/21	
Preparation of a framework for Marine Ecosystem Accounting in the Baltic Sea region	Done	Q3/21	x
Marine ecosystem accounting pilot application for selected ecosystem assets in the Baltic Sea Region	x	Q2/21 – Q4/21	x

Conclusion

In summary, a pilot illustration of marine ecosystem accounting is possible to perform in the Baltic Sea. However, the lack of time series data and inability to observe changes in ecosystem asset accounts prevent the performing of a complete marine ecosystem accounting exercise. In addition, lack of high-resolution data on ecosystem assets such as habitat forming species and benthic habitats limited the results on ecosystem extent and condition accounts. As was mentioned, significant data requirements, especially on ES monetary values and spatially explicit data are the main challenges to perform a complete accounting.

It is worth noting that valuation in the context of ecosystem accounting does not provide a comprehensive value of ecosystems, as values based on exchange value do not reflect willingness to pay or consumer surplus, which are theoretically correct measures of ecosystem contribution to human well-being and often used in environmental economics, e.g., in environmental cost-benefit analyses.

Application of accounting in a small-scale pilot areas can provide more accurate results. Generally, only a limited number of ES provided by specific ecosystem assets can be covered in an accounting process. Therefore, further work in the Baltic Sea region can focus on small-scale but data-rich areas for ecosystem accounting implementation.

References

Boström, C., Baden, S., Bockelmann, A.-C., Dromph, K., Fredriksen, S., Gustafsson, C., Krause-Jensen, D., Möller, T., Nielsen, S.L., Olesen, B., Olsen, J., Pihl, L. and Rinde, E. (2014), Distribution, structure and function of Nordic eelgrass (Zostera marina) ecosystems: implications for coastal management and conservation. Aquatic Conserv: Mar. Freshw. Ecosyst., 24: 410-434. https://doi.org/10.1002/aqc.2424

Chen, L. D., Gong, J., Fu, B. J., Huang, Z. L., Huang, Y. L., andGui, L. D.: Effect of land use conversion on soil organic carbonsequestration in the loess hilly area, loess plateau of China, Ecol.Res., 22, 641–648, 2007.

CICES, Common classification of ecosystem services, Website: https://cices.eu/

Cole SG and Moksnes P-O (2016) Valuing Multiple Eelgrass Ecosystem Services in Sweden: Fish Production and Uptake of Carbon and Nitrogen. Front. Mar. Sci. 2:121. doi: 10.3389/fmars.2015.00121

Dahl, M., Asplund, M.E., Björk, M. et al. The influence of hydrodynamic exposure on carbon storage and nutrient retention in eelgrass (Zostera marina L.) meadows on the Swedish Skagerrak coast. Sci Rep 10, 13666 (2020). https://doi.org/10.1038/s41598-020-70403-5

Dahl, M., Infantes, E., Clevesjö, R., Linderholm, H.W., Björk, M. and Gullström, M. (2018), Increased current flow enhances the risk of organic carbon loss from Zostera marina sediments: Insights from a flume experiment. Limnol Oceanogr, 63: 2793-2805. https://doi.org/10.1002/lno.11009

Dvarskas, A. Experimental ecosystem accounting for coastal and marine areas: A pilot application of the SEEA-EEA in Long Island coastal bays, Marine Policy, Volume 100, 2019, Pages 141-151, ISSN 0308-597X, https://doi.org/10.1016/j.marpol.2018.11.017.

Fenichel, E.P., et al., Modifying national accounts for sustainable ocean development. Nature Sustainability, 2020. 3(11): p. 889-895.

GOAP, 2019, Pilot Study Report on Ocean Accounting in Thailand, Global Dialogue on Ocean Accounting November 2019, https://www.unescap.org/sites/default/files/1.3.A.4_Thailand_GOAP_12-15Nov20199.pdf

Haines-Young, R. and Potschin, M. (2013): Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012. EEA Framework Contract No EEA/IEA/09/003

HELCOM, 2013, HELCOM Red List of Baltic Sea species in danger of becoming extinct. Balt. Sea Environ. Proc. No. 140.

IDEEA-Group, Synthesis report, Ocean accounting pilot for Geographe Marine Park. 2020, Institute for the Development of Environmental-Economic Accounting: Victoria, Australia.

Jankowska, E., Michel, L. N., Zaborska, A., and Włodarska-Kowalczuk, M. (2016), Sediment carbon sink in low-density temperate eelgrass meadows (Baltic Sea), J. Geophys. Res. Biogeosci., 121, 2918– 2934, doi:10.1002/2016JG003424.

Keith, D.A., Ferrer-Paris, J.R., Nicholson, E. and Kingsford, R.T. (eds.) (2020). The IUCN Global, https://portals.iucn.org/library/sites/library/files/documents/2020-037-En.pdf

Ecosystem Typology 2.0: Descriptive profiles for biomes and ecosystem functional groups. Gland,

Switzerland: IUCN.

Krause-Jensen D, Sagert S, Schubert H, Boström C. Empirical relationships linking distribution and abundance of marine vegetation to eutrophication. Ecological Indicators. 2008;8:515–529.

Krause-Jensen D, Carstensen J, Nielsen SL, Dalsgaard T, Christensen PB, Fossing H, Rasmussen MB (2011) Sea bottom characteristics affect depth limits of eelgrass Zostera marina. Mar Ecol Prog Ser 425:91-102. https://doi.org/10.3354/meps09026

Röhr, M. E., Boström, C., Canal-Vergés, P., and Holmer, M.: Blue carbon stocks in Baltic Sea eelgrass (Zostera marina) meadows, Biogeosciences, 13, 6139–6153, https://doi.org/10.5194/bg-13-6139-2016, 2016.

Röhr, M. E., Holmer, M., Baum, J. K., Björk, M., Boyer, K., Chin, D., et al. (2018). Blue carbon storage capacity of temperate eelgrass (Zostera marina) meadows. Global Biogeochemical Cycles, 32, 1457– 1475. https://doi.org/10.1029/2018GB005941

United Nations. 2021. System of Environmental-Economic Accounting—Ecosystem Accounting:

SEEA-EA, Final Draft. Prepared by the Committee of Experts on Environmental-Economic Accounting. Version 5 February 2021. Available at: https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

United Nations, 2014. "System of Environmental-Economic Accounting 2012," World Bank Publications, The World Bank, number 23959, July.