Systematic meta-evaluation of ecosystem services generated by selected Baltic Sea ecosystem species and related valuation methods

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Introduction

The concept of natural capital was developed to designate potential and actual benefits that humans derive from ecological processes in the form of ecosystem services (ESS). Because of the widespread degradation of ecosystems and their associated services, international and Europe-wide sustainability policies have been established to regulate their use. Therefore, it has become crucial to understand the complex socio-ecological interactions associated with multiple human activities.

To this aim, a systematic review has been developed to:

a) categorize all ESS of the Baltic Sea provided by submerged vegetation, seagrass beds and mussel reefs and
b) identify and categorize all the pressures that impact the targeted habitats.

Methods and Materials

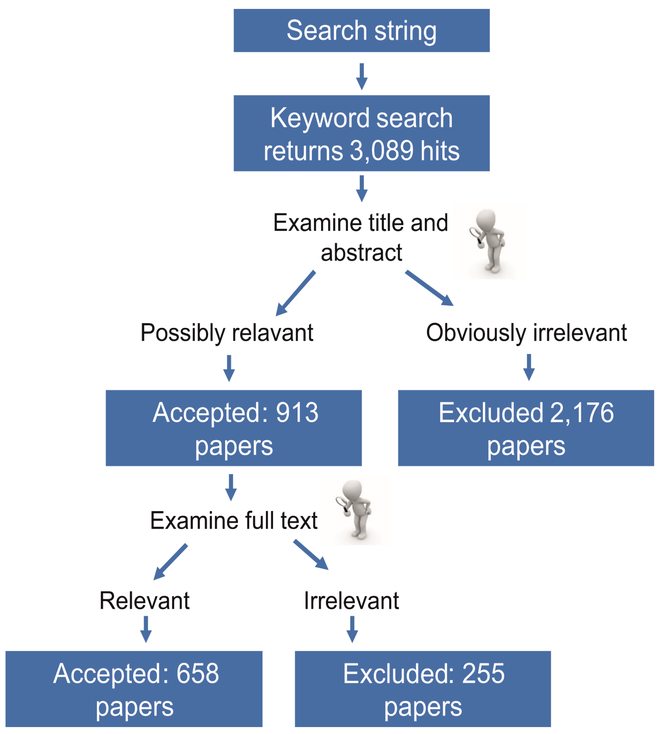

Figure 1. The workflow of the systematic review of the scientific papers.

ESS addressed in the 658 included full papers (**Figure 1**) were evaluated according to the Eco-GAME matrix (**Table 1**).

Table 1. Eco-GAME matrix.

Eco-GAME multi-dimensional systematic meta-evaluation of strength of science-policy interaction on ecosystem services and evaluation methods (development of Sajeva, 2016, Forum for the Future, 2017)					
Scoring system		Economic: adequacy to generate a price	Natural	Human	Social
			Adequacy to capture and transfer knowledge		
Visionary phase: future needs for ecosystem services and related methods					
Future vision/policy for human well-being: non-use values	**7**	Giving monetary values to future ecosystem services and impacs	Measuring future stocks of natural resources	Measuring human needs, well-being and related impacts of ecosystem services for future generations	Measuring future social well-being, needs and impacts
Definition of best practice through participation for achieving future goals	**6**				
Critical analysis of ecosystems services and methods of evaluation					
Current use of ecosystem services	**5**	Incorporation of values of ecosystem services and impacts into markets	Measuring current value of the stocks of resources	Ecosystem services evaluations able to evaluate human needs and included in individual choices	Incorporation of values of ecosystem services and impacts into policy-making
Evaluation of the impacts of scientific knowledge in relation to the use of the ecosystem services	**4**	Measuring impacts of ecosystem services use	Quantifying current environmental impacts and capitals	Quantifying impacts on human well-being	Quantifying social preferences or impacts
Quantitative assessment	**3**	Quantification of prices for ecosystem services	Quantifying current value of the stocks of resources	Quantifying current individual needs and preferences	Quantifying collective preferences or impacts (e.g. policies)
Qualitative understanding	**2**	Understanding possible quantification methods for ecosystem services	Understanding ecosystem services qualitative aspects	Understanding individual needs and preferences	Understanding collective preferences
Discovery	**1**	Discovery of possible ecosystem service	Discovery of natural resource	Awareness of individual benefits	Awareness of benefits for society
Knowledge gap: the method is unable to discover knowledge	**0**	Unawareness about ecosystem services	Lack of awareness of ecosystem service	Lack of awareness of possible individual uses	Lack of awareness of societal usefulness

Results

Macroalgae studies were most common around year 2000, however seagrass habitat studies have significantly increased during the last years (**Figure 2**).

ESS as raw material and provisioning habitat for other species were the most common services associated with macroalgae and seagrass habitats, while the most common ESS provided by the mussel beds was water quality enhancement (**Figure 3**).

All three targeted habitats showed that nutrients and toxins were the most common pressures affecting the habitats (**Figure 4**).

According to the Eco-GAME matrix evaluation, the natural system obtained the highest scores. The human, social and economic system was mostly scores as 0 or 1-2, which means that we have a big knowledge gap on how the ESS affect these systems (**Figure 5**).

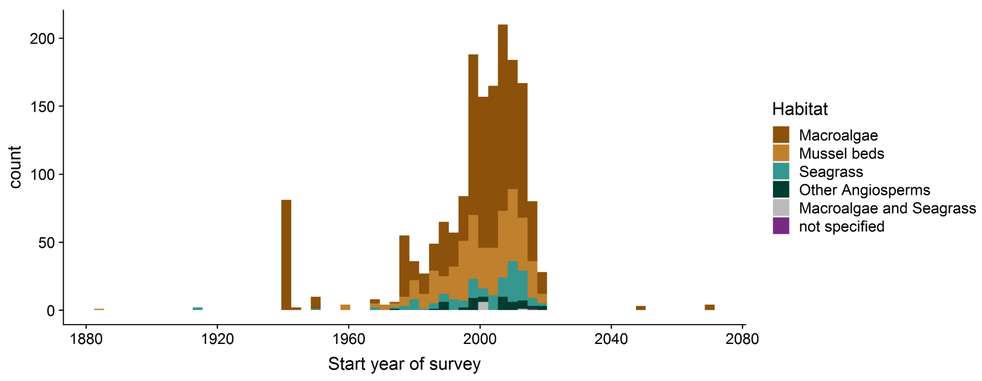

Figure 2. Targeted habitats on the timeline, according to accepted and examined ESS-related papers.

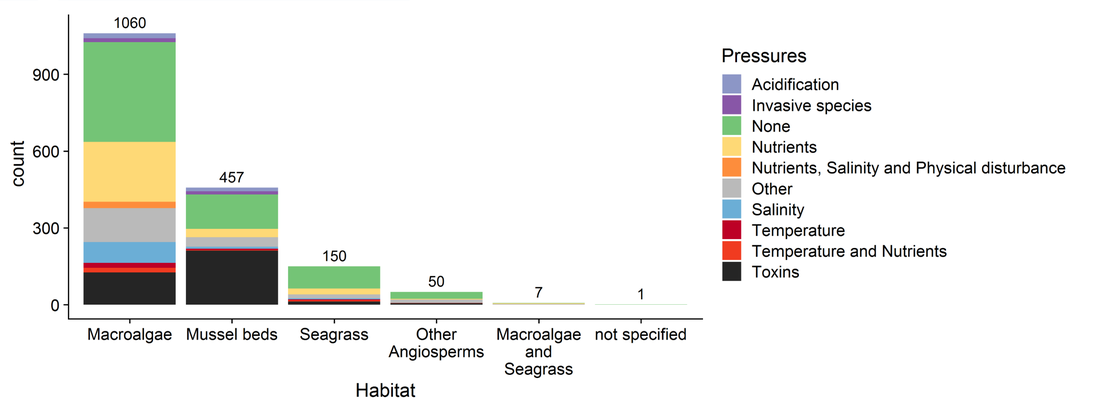

Figure 4. Targeted habitats on the timeline, according to accepted and examined ESS-related papers.

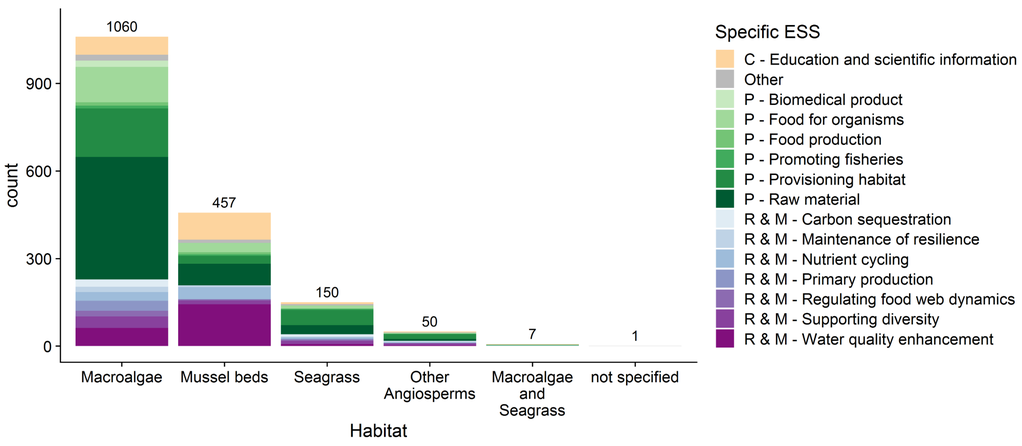

Figure 3. Most common ESS-services provided by the target habitats: macroalgae, seagrass beds and mussel beds. ESS were categorized as C – cultural, P – provisioning and R & M – regulating and maintaining.

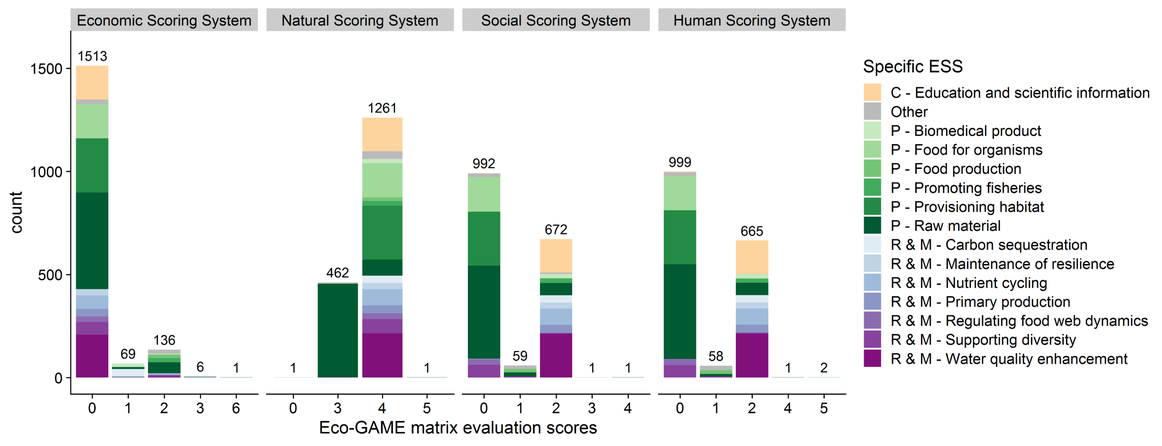

Figure 5. ESS evaluated according to the eco-GAME matrix economic, natural, social and human scoring systems. ESS were categorized as C – cultural, P – provisioning and R & M – regulating and maintaining.

Conclusions

We identified a huge knowledge gap in the quantification and mapping of the majority of ecosystem services as well as in the applicability of valuation methods. Connections of ecosystem services with economic, human or social systems are represented and studied rarely. Only a small fraction of the papers (13 papers from 658) provided information about existing monetary and non-monetary valuation methods. In order to make informed and sustainable decisions under European-wide sustainability policies, we need to fill those gaps.

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