SEAS4GES: Optimising tool selection when applying EBM approaches to ecological assessment

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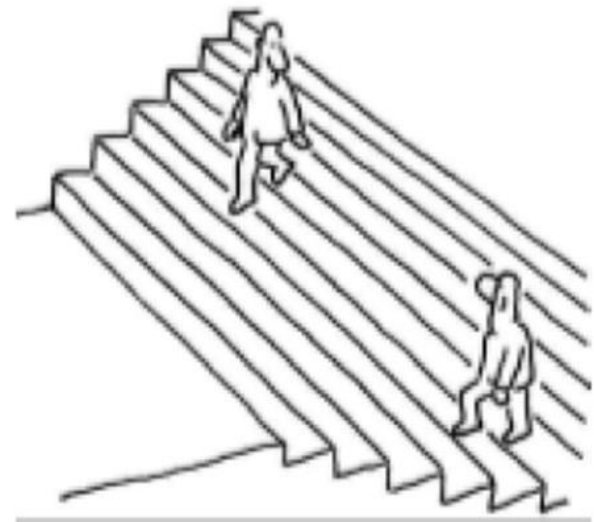* - corresponding author; steve.barnard@iecs.ltd

SEAS4GES (the Selection of Ecosystem-based ApproacheS 4 GES) is a decision support tool (DST) developed within the GES4SEAS project to assist in identifying optimal assessment methods when applying ecosystem-based approaches to support the assessment of Good Environmental Status (GES) under the EU's Marine Strategy Framework Directive (MSFD).

1. The importance of ecosystem-based management, EBM within the GES4SEAS project

What is ecosystem-based management?

- originally **developed by the UN Convention for Biological Diversity (CBD)** as the ecosystem approach, it was defined as '**a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way**' (CBD, 2004);
- it promotes an integrated approach to the management of human activities, that **considers the entire ecosystem, and recognises human society as being an integral component of such systems**;

- it is a spatial approach that acknowledges the connectivity of the ecological system, the **cumulative impacts that arise from (mainly) endogenous pressures, and the existence of multiple objectives** (after Smith et al., 2022);
- the **goal of EBM is to maintain ecosystems in a healthy, clean, productive and resilient condition**, so that they can **provide society with the goods and services** upon which it depends;
- application of an ecosystem-based approach (realised through effective EBM, practices) will help in achieving a **balance of the three objectives of the CBD: conservation; sustainable use; and the fair and equitable sharing of the benefits** arising out of the utilisation of genetic resources.

Whilst many tools or approaches may be used to implement EBM as part of GES assessments under the EU's MSFD, these tools encompass a range of strengths and weaknesses. Each specific application potentially presents a unique set of circumstances, both in terms of the user's needs and the availability of resources (such as types and qualities of input data, and user-skills) against which the value and suitability of each potential tool should be viewed. Consequently, it is not appropriate to attempt to define a single 'best' tool.

Not all users will view the suitability or performance of any given tool in the same way; depending on the user, and the specific circumstances of the tool's application, the same tool is unlikely to perform consistently well (or poorly) under all different application scenarios, and will therefore be seen as being more - or less - suitable in the eyes of the end-user (e.g. Papadopoulou et al., 2024).
It's all relative!

EBM requirements (after Franco et al., 2023)
i. tools or approaches to support the practical implementation of EBM **should be fit-for-purpose (i.e., they should address the needs of the user);**
ii. the **user should have those resources (data and skills) required by the tool**; and
iii. in order to be able to make full and correct use of its outputs, the **user should be aware of the tool's limitations, underlying assumptions, and potential barriers or impediments to its application**

To assist practitioners from the GES4SEAS project in addressing these three areas in a consistent way, the SEAS4GES DST was developed, specifically to address these by:

➤ **identifying** those **approaches and tools that better match the specific combinations of user requirements and available resources**; and
➤ providing **an information 'factsheet' for each tool** –presenting the user with a valuable synopsis of each tool and pointers to further reading.

Scope of EBM approaches and tools considered

Generic approaches	Tool ref
Conceptual models (generic)	1
Knowledge Graphs (generic)	3
EBM probabilistic models (generic)	4
Risk-based approaches: exposure-effect-hazard-vulnerability (generic)	5
Cumulative impact spatial mapping (e.g., Halpern et al., 2008) (generic)	6
Impact risk ranking through linkage-chain-frameworks (generic)	7
Single species models (e.g., life cycle, stock assessment) (generic)	8
Biogeochemical models (generic)	9
Ecosystem models (e.g., End2End) (generic)	11
Habitat suitability/species distribution models (spp. predictive distribution) (generic)	12
Natural capital accounting, ecosystem services valuation (generic)	13
Bioeconomic models, socioeconomic models (CBA), societal goods and benefits valuation (generic)	14
Spatial planning models and tools (e.g., GIS, VAPEM, related to use) (generic)	15
Systematic conservation planning tools (generic)	16
Simple assessment index (e.g., M-AMBI) (generic)	17
Descriptor or theme-specific combination of indices and models (e.g., HEAT, BEAT, CHASE) (generic)	18
Overarching assessment tools (e.g., NEAT, OHI) (generic)	19
Size spectrum models (generic)	20

| Specific tools	Tool ref
Conceptual models: MAMBO	1.1
Conceptual models: GES4HABs	1.2
Semi-quantitative mental models - Fuzzy Cognitive Mapping: Fuzzy Cognitive Modelling (FCM) with Mental Modeler	2.1
Knowledge Graphs (KG): EAD DAPSI(W)R(M) KG	3.1
Risk-based approaches: exposure-effect-hazard-vulnerability: Bow tie analysis	5.1
Cumulative impact spatial: CIMPAL - cumulative impact of invasive alien species	6.1
Cumulative impact spatial mapping: PlanWise4Blue	6.2
Impact risk ranking through linkage-chain-frameworks: SCAIRM	7.1
Impact risk ranking through linkage-chain-frameworks: ODEMM	7.2
Impact risk ranking through linkage-chain-frameworks: Aquacross	7.3
Impact risk ranking through linkage-chain-frameworks: ICES/Mission Atlantic variation	7.4
Biogeochemical models: DCPM box model, and biochemical models being used by OSPAR to consider eutrophication in the NE Atlantic	9.1
Food web models: Ecopath with Ecosim	10.1
Natural capital accounting, ecosystem services valuation: Ocean Accounts	13.1
Spatial planning models and tools: GIS	15.1
Systematic conservation planning tools: MARXAN family tools	16.1
Overarching assessment tools: NEAT	19.1

2. The SEAS4GES DST

Within the context of the GES4SEAS project, a brief review and collation of expert opinion identified a range of 35 tools or approaches (see table, right) used by practitioners as part of their part of GES assessments within an EBM framework, Franco et al., (2023). Subsequently, an online questionnaire was developed and used to collate information on each tool's products/outputs, and its requirements (in terms of data and expertise). More than 60 responses to this questionnaire (completed by 45 respondents) together provided profiles for these tools. Data from the questionnaire was collated, coded, and stored to a 'tool profiles database'.

Specifically, information was collected on each tool's outputs or products, and on each tools' requirements (the data and skills that must be provided by the user and/or their organisation, building a tool profile reflecting 13 specific areas:

- the particular elements or applications of EBM that the tool is able to address;
- whether there are particular aspects of marine management that the tool caters for;
- whether the tool is able to produce outputs relating to particular GES Descriptors;
- whether the tool is able to produce spatial outputs (e.g. maps) and, if so, at what scale(s);
- whether the tool is able to produce temporal outputs (e.g. future projections/forecasting) and, if so, at what scale(s);
- whether the tool provides a measure of the level of confidence in its outputs;
- whether the tool requires data with spatial and/or temporal components as quantitative, semi-quantitative, or qualitative metrics;

- whether the tool requires: (i) quantitative, (ii) semi-quantitative; or (iii) qualitative data for specific DAPSI(W)R(M) components – i.e. for Activities, Pressures, or State indicators (for Species, Habitats, Ecosystem Services, or Societal benefits);
- whether, where empirical data are not available, the tool is able to make use of expert judgement as an alternative source of data;
- what specific expertise is required (on the part of the user or their organisation) in order to use the tool; and
- whether the tool requires associated confidence/uncertainty information.

An interactive Excel-based DST (SEAS4GES) was produced (see, e.g., Franco et al., 2023) allowing a user to specify their particular assessment needs, and their ability to provide particular resource types (data/expertise), by providing standardised responses (Yes/No, or restricted picklists) to a series of detailed questions against 13 filters, each relating to one of the 13 areas considered when building the tool profiles database. The DST is split into two related sections:
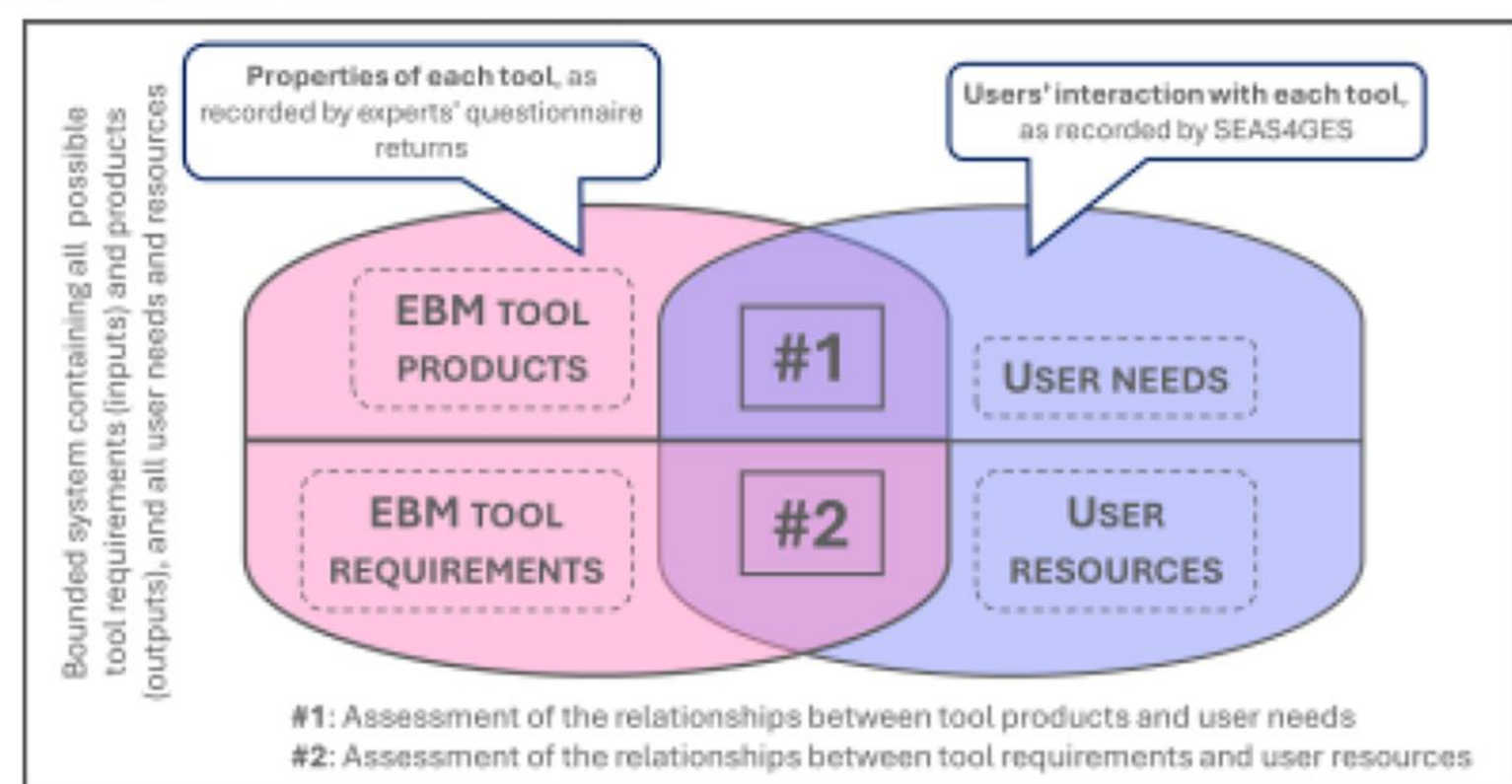
1. Filtering by user needs - what does the user want to do? This section of the tool contains six 'filters' which, together, outline the user's needs. The SEAS4GES tool takes the user's responses and compares them against the functionality of each of the range of 35 tools under consideration (as previously defined through the responses to the online survey questionnaire.

2. Filtering by available information and skills - what is the user able to provide? This section contains a further seven 'filters' which, together, outline the range and nature of data and skills that the user and their organisation are able to provide. Again, the SEAS4GES tool compares the user's responses against the requirements of each of the 35 possible tools under consideration.
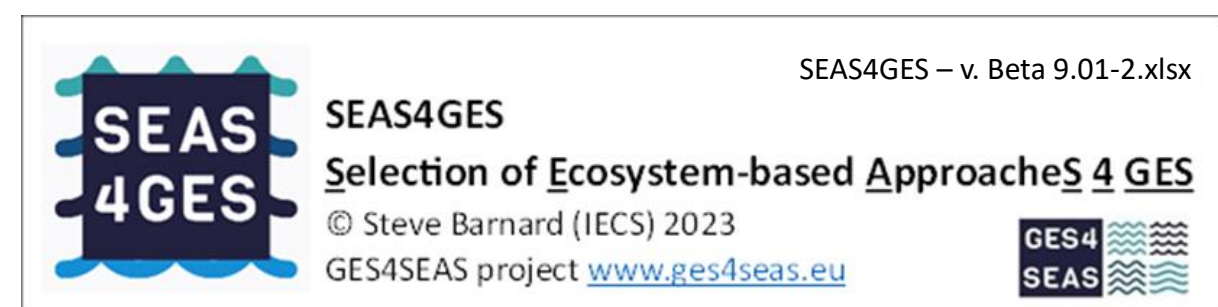
For each filter, two of four possible scenarios are considered: where the user has a specific need (which should ideally be met by a tool's capabilities); and where the tool has a particular requirement (which should ideally be satisfied by the user's resources) – see graphic, left.

The SEAS4GES tool assesses how many of the detailed options within each filter are satisfied by each of the 35 tools and expresses this as a series of percentage 'compliance' scores representing the extent to which the user's needs are satisfied by each approach, or the extent to which the user is able to satisfy the requirements of an approach.

SEAS4GES also includes factsheets for each tool, which outline the purpose and context of its use; the nature of its assessments (e.g. the EBM element(s) addressed; type(s) of assessment provided; range of inputs required (e.g. variable- and data-types, expertise and other resources), and strengths or weaknesses (including barriers for its practical implementation).

3. SEAS4GES outputs

Two main forms of output are produced by SEAS4GES - providing dynamic feedback on the implications of the user's selections across the 13 filters:

1. **a simple matrix showing percentage compliance scores for each approach against each of the 13 filters.** Across the matrix, higher values indicate where an approach represents a 'better' option given the assessment needs of the user or the ability of the user to satisfy the requirements of an approach. Conversely, lower scores indicate where an approach is less suitable. The cells of the matrix are colour-coded to aid interpretation.

SEAS4GES is intended to be used interactively/dynamically, with the user referring to the input data to identify why a particular tool is scoring high or low, e.g.:

- is it scoring high because it has few requirements and can therefore be used with less resources (data, expertise)?
- might it score low because some key data requirements are missing, or one particular set of needs can't be addressed?
- if it's possible to be creative, might improved resources (e.g. a new dataset, or shared expertise) result in a different tool being promoted, providing better operational options?

To help with these considerations and judgements, hyperlinks to factsheets for each of the tools (embedded in the spreadsheet as PDF 'objects') are also provided as part of the tool.

2. **a prioritised listing of the 35 tools, which is dynamically sorted using the average compliance score for each approach** so that the likely optimal approach(es) are always towards the top of the list, and the less appropriate approaches are towards the bottom. Any changes made to the user's responses are immediately reflected in the tool scores and ordering allowing 'what-if' scenarios to be assessed (e.g. seeing what the trade-offs might be if the user's requirements are altered, or if more resources (data or expertise) can be made available). Again, entries are colour-coded.

4. References cited:

- CBD, 2004. Secretariat of the Convention on Biological Diversity (2004) *The Ecosystem Approach, (CBD Guidelines) Montreal*: Secretariat of the Convention on Biological Diversity 50pp. https://www.cbd.int/doc/publications/ea-text-en.pdf
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- Smith C., Papadopoulou N., Elliott M., Franco A., Barnard S., Borja Á., Uyarra M.C. (2022) *Marine Strategy Framework Directive Terminology Definitions and Lists*. GES4SEAS Project. 29pp.

Link to GES4SEAS project website:

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