WP 4 (Task 4.1)	Deliverable D4.1/EVA section

MARBEFES Project

Title: Guide 1 - Ecological Value Assessment (EVA) *(Section of the Draft D4.1 report)*

Delivery date: Month 35 (Draft)

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Submission date

15 June 2025 (modified 17 October 2025)

MARBEFES project has received funding
from the European Union's Horizon Europe research and innovation
programme under Grant Agreement no 101060937 and
from UKRI under Grant Agreement no. 10048815

Document Version Control			
Version	**Date**	**Comment**	**Modified by**
1.0	28.03.2023	First draft	A. Franco, E. Amorim
2.0	18.04.2023	Document revised after comments by M. Elliott and D. Burdon	A. Franco, E. Amorim
2.1	09.06.2023	Guidance revised after comments received up to EVA workshop on 9 June 2023	A. Franco
2.2	24.07.2023	Guidance revised following discussions (incl. use hexagonal grid and revised algorithms for question scoring in Table 5, plus other minor amendments)	A. Franco
Final Draft	22.08.2023	Final revisions	A. Franco
FD.1.0	04.12.2023	Amendment/clarification to hexagon grid size	A. Franco
FD.1.1	12.01.2024	Amendment to confidence assessment to account for additional metrics of data availability (section 2.4, Tables 7 and 8 and Figure 2)	A. Franco
FD.1.2	16.01.2024	Clarification added to algorithm for AQ9 (step 5) in Table 5	A. Franco
FD.1.3	29.01.2024	'Intrinsic' value replaced by 'inherent' value	A. Franco
FD.1.4	14.02.2024	Details added on how to combine EV from ECs with different grid size into total EC (section 2.3)	A. Franco
FD.1.5	21.10.2024	Amended confidence score categorisation (section 2.4)	A. Franco
FD.1.6	27.11.2024	Changes to aggregation method for EV calculation (maximum instead of average; section 2.3, also incl. spatial grid cells aggregation) and classification of data availability for w_i estimate (Table 8 in section 2.4)	A. Franco
FD.1.7	05.02.2025	Change to confidence aggregation between ECs following changes in version dated 27.11.2024 (section 2.2.4)	A. Franco
FD.1.8	06.06.2025	Change to AQ selection procedure (with prioritisation of quantitative AQs over qualitative ones, if quantitative data are available) (section 2.2.3, with new decision system flow-chart (Figure 2.3) for AQ selection)	A. Franco
FD.2	10.06.2025	Confidence assessment updated following changes in AQ selection procedure (section 2.2.4, formula 1). Changes to spatial system, to include possible use of square grid cells and larger scale for habitat ECs (section 2.2.2.1, Table 2.2, Figure 2.2)	A. Franco
FD.3	17.10.2025	Decision system flow-chart for AQ selection (Figure 2.3) revised and parameters in the confidence assessment formula (section 2.2.4, formula 1) redefined for better clarity and consistency with latest method changes. Excel template for AQ and EV calculations (Phase 2) created.	A. Franco

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Title of the document: Ecological Value Assessment (EVA) Guidance

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2 Guide 1: ECOLOGICAL VALUE ASSESSMENT (EVA)

2.1. INTRODUCTION

This document provides a step-by-step guidance to apply the Ecological Value Assessment (EVA). The method and corresponding guidance were developed as part of the Horizon Europe project MARBEFES, within the work package (WP) and task outlined below:

> *WP4 Ecological, Social and Economic Valuation*
>
> ***Task4.1: Ecological and biodiversity valuation*** *(Lead:* ***IECS****; IO PAN, LW ERIC, APN, CEFAS, KU, TU, CNR, UC, FIHAC, CSIC, NBE). T4.1. will develop methods for the site-specific ecological valuation of the features of ecosystems using a created innovative typology of specific features provided by WP3 (e.g., naturalness, connectivity, pristineness, irreplaceability, rarity, vulnerability and redundancy of ecological functions). A matrix-based tool will be created using expert-judgement scoring of these characteristics in an area. The tool will indicate the means of illustrating and valuing these features within and between the BBT sites.*

The EVA guidance has undergone a series of revisions since its first design in March 2023, following the testing of the method by the BBTs and the consequent feedback received throughout the MARBEFES project (see Section 2.3). This document provides the resulting update (to June 2025) of the original guidance. As such, it delivers the ecological component of the WP4 milestone M39 ‘Draft methods on ecological, economic and socio-cultural valuation’ and will contribute to the final WP4 deliverable D4.1 ‘Handbook on Ecological, Economic and Socio-Cultural Biodiversity Valuation’ (due in August 2026).

The EVA method and guidance have been designed and formulated for general applicability to any marine area (including the BBT case study areas in MARBEFES). As the method allows some flexibility in its implementation (e.g., depending on data availability), additional specific guidelines were defined for its use within MARBEFES in order to standardise the approach implemented by the different BBTs as much as possible. Such additional guidelines are distinguished from the generic guidance provided in each of the methodological steps/sections.

2.1.1. Aims and structure

The aim of this document is to provide guidance on the methodological protocol to undertake Ecological Value assessment (hereafter EVA) in marine areas (the term ‘Ecological Valuation’, as used in the MARBEFES WP4 description, has been replaced by Ecological Value (EV) assessment to avoid misunderstandings about the (non-monetary) nature of this approach).

A brief outline of what the EVA entails is given as background in Section 2.1.2, as reviewed from the available literature on the approach. Additional details and definitions are provided in Appendix 2.1.

Section 2.2 provides the step-by-step guidance to undertake the EVA process. For each step, the rationale behind the proposed methodology is provided, along with the methodological guidelines (often given in tabular format) and additional specific guidelines for use by the BBTs in MARBEFES.

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Section 2.3 includes a preliminary overview of the method testing during the implementation by the BBTs, along with a list Questions & Answers is also included (Section 2.3.2) as developed throughout the testing process. These Q&As record the feedback and discussions about the method and provide justification to the subsequent method revisions that have been implemented iteratively.

2.1.2 What is Ecological Value assessment

The concept and methodology for the assessment of the Ecological Value of an area was first developed by Derous et al. (2007a, 2007b) and has since been adapted and applied in various case studies, including the Dutch and Belgian parts of the North Sea (Derous, 2007), the Isles of Scilly archipelago (Vanden Eede, 2007), the Polish EEZ in the Baltic Sea (Węsławski et al., 2009), the Basque continental shelf (Pascual et al., 2011), the Belgian coastline (Vanden Eede et al., 2014), and the Portuguese continental shelf (Gomes et al., 2018). This guidance document builds on this literature in applying the Ecological Value assessment.

It is of note that the literature above refers to this method as (Marine) Biological Valuation with the term Biological Value (BV) used to indicate the ecosystem property that is being assessed. To ensure clarity, the terms Ecological Value (EV) and Ecological Value assessment (EVA) are used in this guidance instead; although they are conceptually equivalent to the terms in the literature, they are preferred as they account for the wider applicability of the approach to ecosystem components, such as habitats, that are not solely biological. Although habitats were less represented in the previous uses of the method, which mostly used species as features for the assessment, it was considered important to include them in this guidance.

Ecological Value (EV) is the <u>inherent</u> value of the qualities of an ecosystem. It is a property of the ecosystem and its biodiversity that is <u>independent from any human association</u> (e.g., anthropogenic uses, pressures or social interests) and is measured in <u>non-monetary</u> terms (modified from Smith and Theberge 1986, Derous et al. 2007a, Gomes et al. 2018).

Ecological Value assessment (EVA) is the process of assigning ecological value <u>to an area</u> through the integration of the <u>inherent value of the ecosystem qualities within</u> (modified from Derous et al. 2007a, 2007b).

Key aspects of this approach are:

- Ecosystem qualities that do not reflect the inherent value of biodiversity (e.g., utilitarian/instrumental value related to the uses humans make of the environment) do not contribute to EV.
- EV is assessed separately for the multiple ecosystem components (ECs) characterising the ecosystem within the study area (e.g., species groups, habitats and habitat mosaics, ecosystem processes/functions) which are then integrated across ECs.
- EVA is a spatial assessment, i.e., the EV is assigned to spatial units (subzones) within a study area (the BBT in MARBEFES) and the EV of a subzone reflects the ecological value of that subzones relative to the other subzones in the study area.

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An ecosystem has many qualities, but not all of them necessarily reflect its inherent ecological value and therefore do not constitute suitable assessment criteria for Ecological Value (see Appendix 1 for further details). The assessment criteria that have been used for Ecological Value are defined as follows:

Rarity - this is the degree to which an area is characterized by unique, rare or distinct ecosystem components (landscapes, habitats, communities, species, ecological functions, geomorphological and/or hydrological characteristics) for which no alternatives exist (modified from Derous et al. 2007a, 2007b).

Aggregation-Fitness consequences:

- **Aggregation** - this represents any of (i) the degree to which an area is a site where most individuals of a species are aggregated for some part of the year; (ii) a site which most individuals use for some important function in their life history; or (iii) a site where some structural property or ecological process occurs with exceptionally high density (DFO 2004, Derous et al. 2007a, b).
- **Fitness consequences** - this represents the degree to which an area is a site where the activity(ies)/functions undertaken by the species there have fitness consequences, i.e., contribute significantly to the survival or reproduction of a species or population (DFO 2004).

As a measure of functional quality, the criterion 'Fitness consequences' partially overlaps with functional habitats identified under 'Aggregation'. Therefore, the merging of these two criteria into one (Aggregation-Fitness consequences) has been suggested, as undertaken in Derous et al. (2007b, and derived applications).

Biodiversity is also a key inherent property of an ecosystem, as advocated in the literature on Biological Valuation. However, this is not included in the assessment here as a standalone criterion, but rather attributes of biodiversity are used in the measurement of the metrics characterising the above-mentioned criteria (see Section 2.3 for details).

The operationalisation guidance of the EVA process is given in Section 2.2.

2.2. EVA PROTOCOL – a step-by-step guide

2.2.1 The EVA process

The EVA process can be separated into three main phases, with several steps in each phase:

Phase 1: Define the study system

This phase includes defining the spatial system (study area and its subdivision in spatial assessment units or subzones), and identifying the relevant ecosystem components, the data available for the assessment and the time over which they were determined.

Phase 2: Assess the EV

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EVA then involves answering a set of questions which characterise key qualities of the ecosystem relevant to EV. The questions are answered by calculating a set of metrics (using specific algorithms) separately for each ecosystem component (EC) in each subzone, and then integrating the results across metrics (questions) and ECs. The resulting EV is mapped across subzones in the BBT.

Phase 3: Assess Confidence

Different sources of uncertainty are considered and combined to determine the confidence in the EV assigned to a subzone. The resulting confidence is mapped across subzones in the study area.

Figure 2.1 gives the graphical conceptual model of the EVA process.

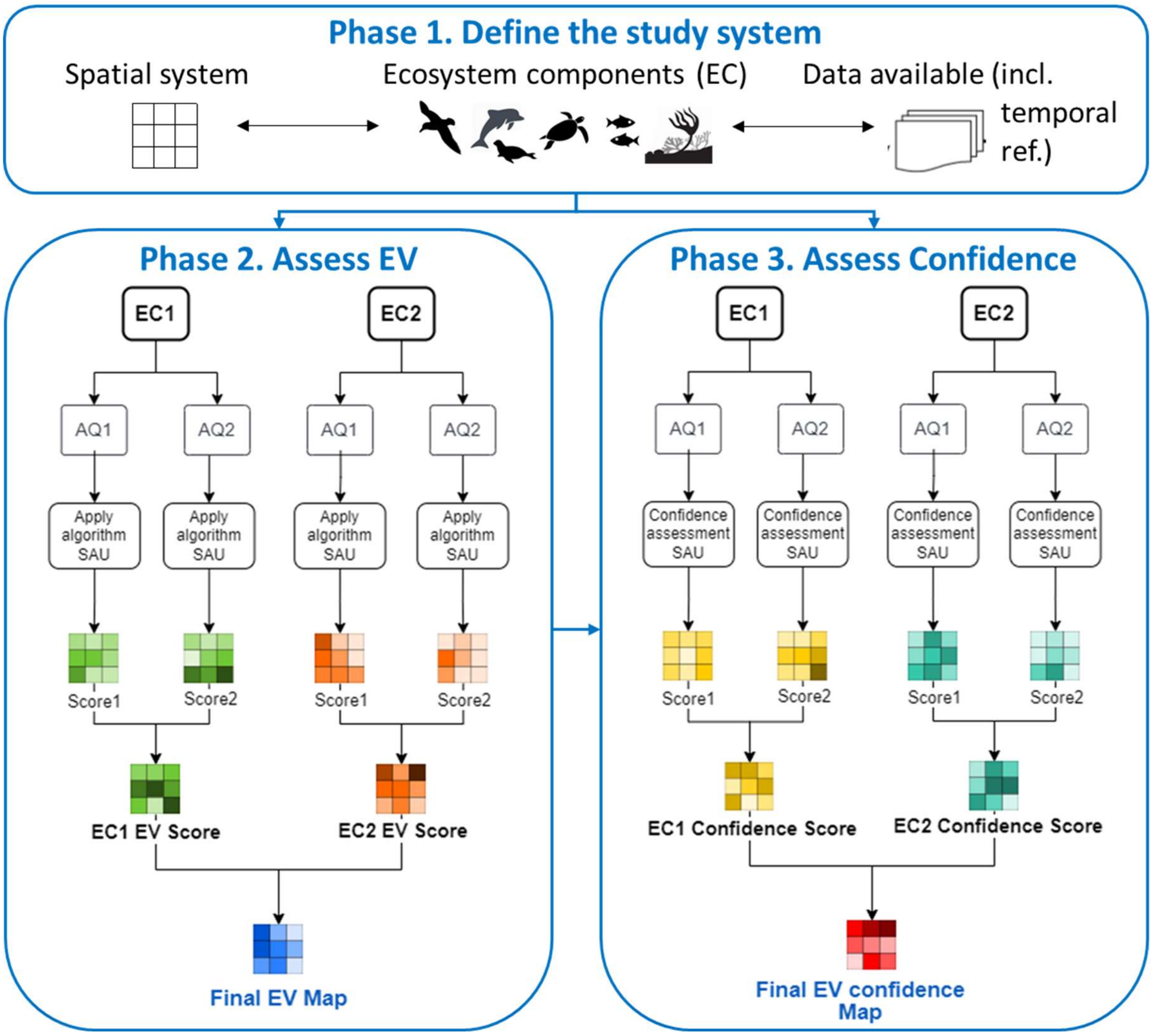

Figure 2.1. The EVA process (AQ = assessment question; SAU = spatial assessment unit or subzone; EV = ecological value).

Detailed guidance on each step of the process is given in the sections below.

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2.2.2 Define the study system (Phase 1)

2.2.2.1 Spatial system and Ecosystem Components

General principles

The EVA should be applied to as many components of the ecosystem as possible (both structural components and processes) (Derous et al. 2007a, 2007b) and all levels of biodiversity (from species to ecosystem level) should be assessed (if data are available).

The study area should be clearly delineated and divided into subzones that constitute the spatial assessment units. Given the nature of the EV, subzones should be identified based on their ecological and physical relevance to the ECs being considered in the assessment (hence the combination of spatial system and ECs in this section of the guidance). Practicality aspects should also be considered (e.g., data availability, spatial scale of sample data, size of the study area) to allow the comparison of the EV between defined subzones.

Derous et al. (2007a, 2007b) recommend the use of habitat classification schemes (e.g. EUNIS) or marine landscapes for zoning, which should incorporate bottom and pelagic habitat features. However, this might lead to high variability in the size between subzones, within and between different BBTs, depending on the variability in habitat distribution and in the habitat classifications used. Such variability may create issues in the standardisation of the assessment across zones and study areas.

Alternatively, a zoning approach using a regular raster grid to divide the study area into subzones (grid cells) may be used (Derous et al. 2007a, 2007b). The spatial resolution of the grid cells (i.e., the size of the subzones) may be variable depending on the EC under consideration, responding to ecologically meaningful reasoning (Pascual et al., 2011) as detailed below.

The selection of the resolution should take into consideration:

- The EC being assessed (smaller grid sizes should be chosen for benthic ecosystem components (habitats or species) which have no or low mobility, while larger grid sizes are more appropriate for highly mobile species such as fishes, birds and sea mammals).
- The compatibility of the selected grids, which, when combined, should align. This can be achieved by nesting smaller grids (e.g. defined for benthic ECs) within larger grids (e.g. defined for highly mobile ECs) and it is necessary to integrate the EV across ECs spatially, later in the process.
- Data availability (data poor areas/components might result into lower resolutions, to allow good coverage of the study area - however, too large grid cells could result in the loss of site-specific information).

Other types of spatial zonation, e.g., based on management spatial units (MPAs, ICES rectangles, etc.), or impact areas in the marine environment, should be avoided for the spatial assessment of EV as they introduce a human element in the assessment which is outside the scope of the EVA. However, these additional zones can be applied *a posteriori*, to compare the spatial distribution of EV (based on inherent value of biodiversity) with other spatially meaningful representations of the marine system

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(e.g., associated with other values that may be attributed to biodiversity). This comparison may be undertaken by aggregating or disaggregating the assessed subzones into these zones. The nature of this comparison is outside the scope of the EVA and will depend on specific interests (e.g., to validate the designation of conservation areas, identify areas of higher risk or concern where anthropogenic impacts may occur).

Additional spatial units may be defined and the spatial results of the assessment (in SAUs) may be spatially aggregated/disaggregated into these additional polygons through GIS. These additional units may be defined at the scale of management areas (ecoregion, governance scales, ICES zones, protection areas, etc.), depending on the specific interest within the study area (e.g., in order to compare the EV of protected/unprotected areas, or differently impacted areas within a marine area).

Method guidance

The use of a regular grid is the most commonly-applied zonation approach in the site-specific applications of EVA (as mentioned in Section 2.1.2). The scales applied in those studies have been taken into consideration for the provision of the guidance below (Tables 2.1 and 2.2).

Grid cells may be of a square or hexagonal shape. The use of hexagonal grids is recommended as, compared to square grids, they allow more flexibility and better spatial representation of marine biological components and information. They are also more suitable for the evaluation of different connectivity measures. Their projection and visualisation are also more precise and aesthetically pleasing, which is a criterion also valued in this project. Hexagonal meshes can be produced both in GIS software (ArcGis or QGis) and in R or Matlab. However, it is acknowledged that the use of square grids may be easier (e.g., to aggregate/re-scale data from grids of variable spatial resolution), and therefore the choice is left to the user, based on their GIS skills and level of expertise.

The list the Ecosystem Components (ECs) that can be for the assessment is given in Table 2.2. It is of note that the previous versions of the biological valuation approach only use species groups (defined through a combination of taxonomic and functional criteria, e.g., birds, marine mammals, demersal fish) as ECs, with the assessment questions mostly focusing on different aspects of the species diversity within these groups (this is also used as a proxy for functions; see Section 2.2.3). This emphasis may be due to the fact that most of the current monitoring programmes undertaken at the broader scale (hence with more chances to provide better coverage of a broad study area) focus on structural aspects of species biodiversity.

This EVA guidance also includes habitats as ECs to account for diversity at the higher level (biotopes, ecosystems). Where there is possible overlap (e.g., between macrobenthos and benthic habitats assessments), this has been considered in the formulation of the algorithms to answer the assessment questions (see Section 2.2.3).

Whether or not an EC is used for the assessment of a study area will depend on the relevance of an EC in the area (e.g., marine reptiles might not be a relevant EC if they do not occur in the area or the region) and on the availability and distribution of the evidence-base for the assessment.

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Additional guidelines for use in MARBEFES: In MARBEFES, the study area is synonymous to a specific BBT area. For standardisation of the EVA implementation across BBTs, the minimum requirement is that the EVA is undertaken using the benthic ECs - macrobenthos and benthic habitats, with EUNIS Level 3 classification used to identify habitat types. The use of a hexagonal grid is also required (see video tutorial on how to create hexagonal grids using QGIS at https://nc-marbefes.iopan.pl/nextcloud/s/retGAGYs97B6fRt).

Table 2.1. EVA guidance: Spatial system.

Spatial System
1. Identify the study area by delineating its boundaries in GIS.
2. Divide the area into subzones by applying a regular raster hexagonal (or square) grid. Grids of different resolution are defined for different ECs (see Table 2.2) and grids of finer resolution should be nested within those of coarser resolution. Each grid cell will constitute a subzone, i.e. the spatial unit for which the EV is calculated (for the relevant EC).
3. Any data-based evidence for the assessment is to be assigned to each cell within the grid. Monitoring data points/tracks are the most common type of data-based evidence, but spatial interpolation/extrapolation of these data (e.g., based on spatial or habitat suitability models) may also be used where appropriate to improve the spatial coverage of the grid cells in the study area. Expert judgment may also be used for this, where deemed appropriate. If expert judgment is used when/where data are not available, this must also apply to individual subzones distinguished by the grid cells. Where there is no evidence (of any nature) supporting the assessment in a subzone, no value (e.g., for a metric for an EC) is assigned to that subzone (hence resulting in s spatial gap in the mapped results).
4. Additional zonation can be applied by identifying natural zones (e.g., regions, depth biozones) or management zones (e.g., MPAs, impact areas). These zones will only be used *a posteriori*, i.e., EV is calculated for the grid as specified in point 2 above, and the subzones defined that grid can be aggregated into larger natural or management zones for other assessments.

Table 2.2. EVA guidance: Ecosystem Components.

Ecosystem Components		
EC type	**Ecosystem component (EC)**	**Subzone size (see Figure 2.2)**
Species group	Seabirds	3 km
	Marine mammals and/or Marine reptiles They can be assessed together or as separate ECs, depending on relevance and data availability)	3 km

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Ecosystem Components		
EC type	**Ecosystem component (EC)**	**Subzone size (see Figure 2.2)**
	Fish Likely differentiated into ECs for Demersal fish and Pelagic fish given different nature of the evidence base (e.g., different monitoring methods/programmes). Pelagic molluscs (e.g., squids) may be included in this EC as they are sampled in the same programmes.	3 km
	Zoobenthos Likely differentiated into ECs for Macrobenthos, Epibenthos, Hyperbenthos, Meiobenthos and possibly further between hard and soft substrata (where appropriate), given different nature of the evidence base (e.g., different monitoring methods/programmes).	250 m
	Phytobenthos Likely differentiated into ECs for Algae and Plants (seagrasses, saltmarsh) and further between hard and soft substrata (where appropriate), given different nature of the evidence base (e.g., different monitoring methods/programmes).	250 m
	Plankton Likely differentiated into ECs for Zooplankton and Phytoplankton	3 km
Habitats	Marine benthic habitats	250 m or 3 km*
	Marine pelagic habitats Possible differentiation based on vertical/depth zonation	3 km
* The grid cell size may vary depending on the scale at which the habitat types are defined and used in the assessment (e.g., for benthic habitats broadly defined, for example using EUNIS Level 3 habitat type classification, the use of the larger grid cell size is suggested to allow the habitat diversity within a grid cell to be adequately represented).		

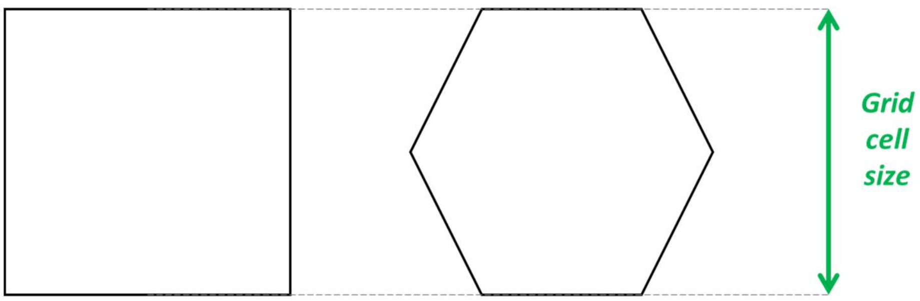

Figure 2.2. Subzone (grid cell) size measured for a square or a hexagonal grid cell.

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2.2.2.2 Evidence base

Type of evidence

The application of the EVA to case studies in the literature (see Section 2.1.2) mostly relies on the use of monitoring data available for the study area, and the EVA methodology used (assessment questions and associated algorithms) reflects this.

To allow wider applicability of the method also to case study areas (or ECs) for which data may be sparse or lacking, the methodology has been modified to include other data-derived evidence, for example interpolated or modelled maps that can be derived from the monitoring data or that can be obtained from publicly available data layers (e.g., EUNIS habitat maps, Copernicus oceanographic layers modelled from optical characteristics of the sea). Evidence based on expert judgment may also be used where data are lacking, as necessary and if appropriate. The type of evidence base used for the assessment will influence the confidence in the resulting EV (see Section 2.2.4).

Examples of typical data-based evidence (directly from monitoring or derived through modelling) are given in Table 2.3 for each of the ECs.

As data requirements for the assessment may also vary depending on the assessment questions (e.g., some require species presence/absence, other estimates of density), additional details on this are given in Section 2.2.3.

Additional guidelines for use in MARBEFES: The use of monitoring data should be prioritised over model-based evidence or expert judgement for the assessment in the BBT areas.

Table 2.3. EVA guidance: Examples of data-based evidence types for the different ECs.

Ecosystem components (EC)	Typical monitoring data sources	Model-based data
Seabirds	Boat/airplane-based systematic visual surveys (transect-base) Breeding colonies visual surveys (coastal)	Inter/extrapolation across transect area with Spatial Analysis
Marine mammals Marine reptiles	Boat/airplane-based systematic visual surveys (transect-base) Opportunistic sightings	Inter/extrapolation across transect area with Spatial Analysis
Demersal fish	Bottom/beam trawl surveys (tow line) from broad scale survey programmes (e.g., ICES DATRAS or eggs and larvae surveys) or localised / site specific surveys (which may also include visual or acoustic surveys)	Habitat suitability/species distribution models (some may be valid for species as a whole, e.g. sandeel; but note that most are developed for Essential Fish Habitats, hence they refer to a particular life stage/function rather

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Ecosystem components (EC)	Typical monitoring data sources	Model-based data
		than to the species as a whole)
Pelagic fish	Pelagic trawl surveys (tow line) from broad scale survey programmes (e.g., ICES DATRAS or eggs and larvae surveys) or localised / site specific surveys (which may also include acoustic surveys)	As for demersal fish
Epibenthos	Bottom/beam trawl surveys (tow line)	As for demersal fish (e.g., crustaceans)
Macro(zoo)benthos	Grab surveys, Coring (point data)	Habitat suitability models for individual species or communities (note that EUNIS habitat classification maps are often the result of community model predictions and can be used as proxy for macrobenthos, depending on which metric is to be measured)
Macro(phyto)benthos (incl. macroalgae and/or plants)	Quadrat surveys, visual census (based on transects/point or aerial photography).	
Meiobenthos	Grab surveys, Coring (point data)	
Zooplankton	Plankton nets (tow line), CPR	
Phytoplankton	Plankton nets (tow line), CPR, remote sensing (which may also include acoustic surveys) (where species ID and a measure of abundance can be obtained)	e.g., Chlorophyll-a (or other optic characteristics of the ocean) maps from remote sensing as possible proxy for total abundance.
Marine benthic habitats	Habitat maps, e.g. based on EUNIS broad scale habitat (Level 3) classification or biotopes (Level 4) (EUNIS, 2022)	
Marine pelagic habitats	Habitat maps, e.g. based on EUNIS broad scale habitat (Level 3) classification or biotopes (Level 4) (EUNIS, 2022)	

Spatial availability of the evidence

The evidence available in a study area (both from expert judgment and data-based) are likely to have variable coverage of the subzones. This could be shown, for example, as the percentage of subzones

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with evidence available for the assessment (for each EC), and, where monitoring data are used, the data availability may be measured as the number of data points (or observations) used in each subzone to calculate a metric in response to an assessment question. The latter (data availability) is one of the sources of uncertainty that is considered in the confidence assessment (see Section 2.2.4).

Spatial gaps may occur in subzones and for ECs for which there is no evidence available to support the assessment. As a result, these subzones may remain unassessed (for EV overall, or limited to a specific EC or to a specific question/metric for the EC) if there are no other alternatives sources of evidence for their assessment. However, spatial interpolation/extrapolation of the available data over the wider study area (e.g., based on spatial or habitat suitability models for certain types of data; see examples in Table 2.3) may be used to increase the spatial coverage of the assessment. In the absence of data, expert judgment may also be used, if deemed appropriate.

Whether an EVA is undertaken for a subzone, and, if so, what evidence is used and its availability, are elements that contribute to the confidence associated with the resulting EV (see Section 2.2.4).

Temporal reference of the evidence

The evidence available for an EC in a study area may also vary in terms of its temporal reference (time period covered, inter- or intra-annual frequency of the data collection, etc.). This should always be recorded for any type of evidence used in the assessment.

Datasets from multiple monitoring programmes and studies in multiple years can be combined to cover the full study area, as well as seasonal and interannual variabilities, assuring the availability of maximum information for each EC. However, when combining data from multiple sources, representativity and consistency (e.g., in the sampling regime, methods, seasonality) should be considered for the standardisation and harmonisation of the data into an integrated database, and for the comparability across subzones in the study area. Therefore, the EV of each subzone is a relative value given the data available at the time. Data from different time periods may have differences in methods, precision/accuracy and analysis and so the data may have to be harmonised to the lowest common denominator. As more (or better) evidence becomes available, the EVA for the study area may be revisited and refined.

The temporal coverage of the datasets should be limited to avoid using data with temporal trends and to avoid regime shifts caused by changing oceanographic conditions due to climate change (Pascual et al. 2011, DFO 2011). There is a suggestion in the literature that ecologically and biologically significant areas (EBSAs) are reassessed every 5 years (DFO 2011).

Additional guidelines for use in MARBEFES: A maximum of 10 years is suggested to define the time period for the data used in the EVA for the BBTs.

2.2.3 Assess EV (Phase 2)

General principles and approach

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The EVA is based on the assessment of the ecosystem in an area against criteria such as Rarity (R) and Aggregation-Fitness consequences (AF), as previously defined in Section 2.1.2.

To assess each criterion at different ecological organizational levels, a set of assessment questions should be addressed by examining all available data and the presence of certain processes and structures in the area. Table 2.4 provides examples of the possible topics on which these questions may focus, as mapped against the EVA criteria and the different biodiversity levels (species, community, habitat, etc). It should be noted that this is not an exhaustive list of topics, nor there is the requirement to answer all these questions, as practicality aspects (e.g., data availability) come into play when operationalising the EVA process. Specific categories of features to be identified within an ecosystem component (e.g., rare species, habitat-forming species or ecologically significant species) should be selected based on expert judgement, supported by the grey and published literature.

Each assessment question needs to be translated into a metric to be measured following a specific mathematical algorithm (for each ecosystem component), that will be applied at the subzone level allowing subzones to be quantitatively assessed relatively to each other (Figure 2.1). The algorithms can be developed for different types of data, such as densities or presence/absence for species components, and aim at assigning a standardised numeric value (score, typically between 1 and 5) to each metric for each question answered for each EC.

The numeric results thus obtained are then integrated first across all metrics/questions within each ecosystem component, so that an EC-specific EV is assessed at the subzone level and can be mapped across subzones in the study area (Figure 2.1). Average (Pascual et al. 2011) or sum (Derous 2007) has been typically used to aggregate the metric standardised score to obtain the EV map for each ecosystem component, with equal weight given to all assessment questions. After adding the scores Derous (2007) creates 5 classes from 1 to 5, based on the range of values to re-standardise the EV into the original 1-5 range.

The last step of the EVA process is the aggregation of the EC-specific EV values across ecosystem components and into an overall EV that can be mapped across subzones in the study area (Figure 2.1). Averaging is typically used for this step (Derous, 2007 and following method implementation in Section 1.2).

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Table 2.4. Assessment topics (leading to questions) related to the different structures and processes of biodiversity and coupled to the proposed EVA criteria (adapted from Derous, 2007). The asterisk identifies topics/questions that were indicated under the Rarity criterion in Derous (2007) and subsequent applications, but that were considered here more appropriate under the criterion 'Aggregation-fitness consequence'. This is because their main value derives from the function that they provide in supporting the ecosystem and its components (e.g., as a pivotal element of a food web, or forming a structured habitat that provide key support to other species) rather than for their rarity.

Organizational level of biodiversity		Criteria	
		Rarity	**Aggregation-Fitness consequences**
Structure	**Species/ Population level**	• High number of rare species • High abundance of rare species	• High percentage of a species population • High abundance of a certain species population • High counts of many species • High densities of species (otherwise restricted distribution in the study area • High abundance of focal species • Presence of habitats formed by keystone species (habitat forming species and ecological significant species)* • Presence of indicator species or indicator conditions* • High abundance of umbrella species* • Presence of ecological significant (keystone) species with controlling influence on other species present*
Structure	**Community level**	• Presence of distinctive/unique communities (with respect to species richness and abundance) • Presence of endemic species • Presence of unique biomes • High level of ecological heterogeneity	• High species richness • Presence of species living in symbiosis with each other • High total biomass
Structure	**Ecosystem level**	• Complex topography or seabed morphology • High substrate diversity • Subzone is outstanding example representing significant geological processes in the development of landforms • Presence of unique/distinctive ecosystems • Presence of unique/distinctive oceanographic features	• Presence of oceanographic features that cause species to aggregate (e.g., natural refugia?) • Subzone is critical for nutrient cycling*
Pro ces	**Species/ Population**	• Species retention (high/low)	• Existence of migration routes • Existence of refuge areas used in adverse

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Organizational level of biodiversity		Criteria	
		Rarity	Aggregation-Fitness consequences
	level		conditions • Existence of wintering/resting/feeding sites • Existence of key sites for reproduction (spawning/breeding) • Existence of key sites for recruitment (nursery/rearing)
	Community level		• Presence of species living in mutualism with each other • High natural productivity
	Ecosystem level	• Presence of unique distinctive oceanographic processes • Presence of upwelling areas	• Presence of oceanographic processes causing species to aggregate (e.g., nutrient retention, upwelling)

Method guidance

The approach described above is intended to be flexible, as it allows including a varying number of ecosystem components and assessment questions (depending on data availability for each component). However, in order to operationalise and standardise the approach operationalisation, a selected set of assessment questions (AQs), with associated metrics and algorithms, have been suggested (Table 2.5 and Table 2.6). A decision system flow-chart has also been designed (Figure 2.3) to support the user in the selection of the AQs relevant to their assessment.

The AQs have been proposed and algorithms for the AQ calculation and their selection formulated (modified from those applied in the literature on EVA) considering the following:

- The AQs and associated algorithms are designed to be applied separately to each of the ECs selected for the assessment and defined based either on species groups (taxonomic and traits-based) and habitats (see also Section 2.2.2.1). Species and habitats are cumulatively referred to as 'features' in this guidance. The original EVA protocol applied in the literature was operationalised only for species groups ECs (e.g. macrobenthos and birds in Vanden Eede et al., 2014), accounting for aspects of biodiversity at the species assemblage level. In this guidance, it has been extended to include habitat ECs as well, to improve the coverage at the community and ecosystem levels in the assessment. Where there is possible overlap in the assessments (e.g., between macrobenthos and benthic habitats), this has been considered in the formulation of the algorithms to answer the assessment questions in order to avoid double-counting (see footnotes in Table 2.5).
- AQs are provided which require either qualitative (e.g., presence/absence) or quantitative data (e.g., species density, habitat extent). A qualitative and a quantitative version of the

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same question (e.g. AQ1 and AQ2) has been defined for most questions. Where only presence/absence data are available for the species or habitat types characterising the EC, the user would only be able to measure the qualitative AQs. If quantitative data are available, the quantitative AQs should be prioritised (see Figure 2.3). In the latter case, a higher confidence will be associated with the EVA (as Data Reliability will increase; see Section 2.2.4).

- Unlike in the EVA protocols from the literature, the option is given here of using expert judgement to derive the metric values in the subzones of a study area where there are no data-based products (quantitative or qualitative) for an EC. This option is an alternative to not being able to undertake the EVA through a lack of data. Therefore, the user can decide whether the assessment (of a metric, for an EC, in a subzone) is possible and which evidence-base is most appropriate or available. Whichever option is taken, this should be recorded and the confidence assessment will take it into account (e.g., with higher confidence weight associated with metrics measured on data, compared to expert judgement; see Section 2.2.4).
- With regard to the questions on rare features (AQs #1-6), rarity has been defined at different spatial scales, from local to national and regional (the latter possibly including the international scale). Most of the algorithms applied for EVA in the literature accounted for rarity at the local scale (i.e., with reference to the occurrence of the species within the study area); this was probably as the EVA protocols were data-driven and data are more likely to be available for a specific study area as opposed to the wider regional or national waters covered by the study area. Consideration of rarity at the regional and national scale has been included in this guidance, with the option of using data (if available) or alternative evidence sources (see Table 2.6). It is emphasised that a species or habitat may be rare at one scale but not at another (e.g., a species may be rare in the study area, but not in the larger region where the study area occurs). The more scales that are considered in the assessment of rare features, then the higher the confidence associated with the EVA is likely to be (due to higher Data Reliability; see Section 2.2.4).

Despite the protocol adaptations mentioned in the points above, it is acknowledged that some aspects of biodiversity (e.g., genetic diversity, processes) are still not adequately represented in the AQs. However, considerations of practicality are also made, in that the proposed AQs have data requirements that most likely match the data that are collected and available from small and large scales monitoring programmes (e.g., for MSFD and other EU directive compliance), whereas other types of data (e.g., genetic biodiversity, process rates) may not yet be available consistently within an EC or at the spatial scale necessary for the EVA within the study area.

The final computed EV is essentially a multi-metric index and, as such, it has the flexibility of being easily adapted to the specific user's needs and capabilities. Where possible, it is aimed to standardise the set of possible questions assessed, but acknowledging that not all questions may be answered in all areas (this is captured by the confidence assessment; see Section 2.2.4)

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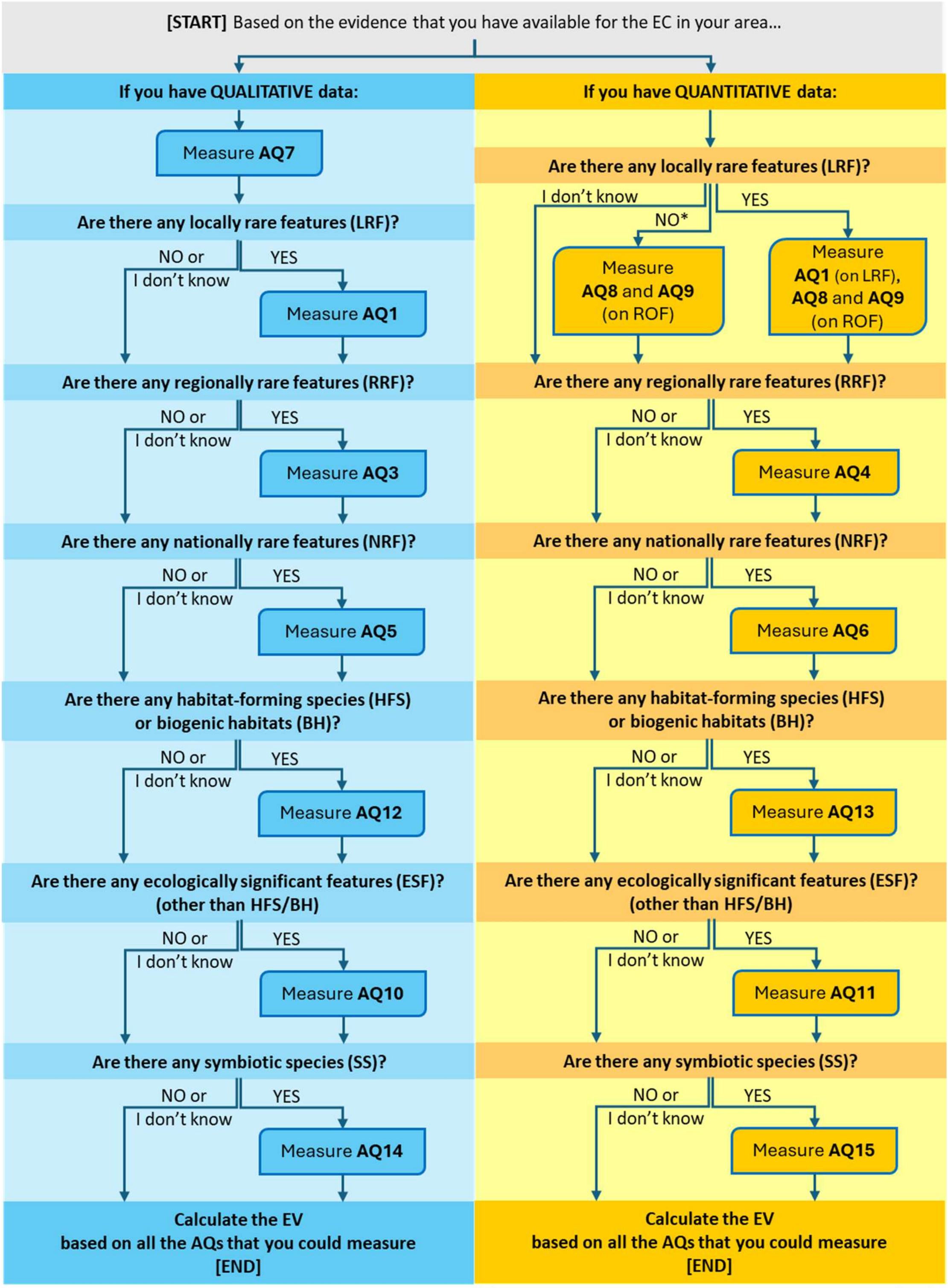
Additional guidelines for use in MARBEFES: As a minimum, BBTs should answer the question(s) accounting for rarity at the local scale (AQs #1 and #2), but, where possible, regional and national rare features should also be assessed (AQs #3-6).



**i.e., all features in the EC dataset are regularly occurring (ROF)*

Figure 2.3. Decision system flow-chart supporting the user in selecting the AQs to measure.

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Table 2.5. EVA guidance: Proposed assessment questions (draft) mapped against the EV criteria and with respective metrics and algorithms to be applied to answer the question. Data requirements are also indicated. Where reference to feature selection criteria is given, see Table 2.6 for guidance and evidence sources. Notes are given at the bottom of the table.

AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
1	Is the subzone characterized by the presence of many locally rare features?	R	All ECs	**LRF (qual) Locally rare features (species or habitats), qualitative**	1) Select LRF (see feature selection criteria) for the EC of interest. 2) Create 2 occurrence classes for the LRF in a subzone with value of 0 where it is absent and value of 5 where it is present. Leave blank where presence or absence cannot be ascertained (e.g., no evidence coverage for the LRF in a subzone). 3) Repeat steps 1 and 2 separately for each LRF in the BBT, then average the values across LRFs in every subzone. The resulting metric for this AQ will be a value between 0-5 (or blank where not assessed).	Spatial distribution (pres/abs) of species/habitats in the BBT area based on monitoring data (sample data/observations) or data-based model/spatial predictions allowing wider coverage of the BBT (e.g., spatial interpolation of data, maps from logistic regression model using relevant environmental predictors, EUNIS habitat maps). Where data-based evidence is not available, expert judgment may be used to assign class scores to subzones based on presence or absence of the species/habitat.	
2	Is the subzone characterized by high	R	All ECs	**LRF (quant)** Locally rare features (species or habitats),	1) Select LRF (see feature selection criteria) for the EC of interest. 2) If appropriate and needed, interpolate abundance data for the	Spatial distribution of the abundance of the feature (species/habitat) in the BBT area. Abundance of a feature in a subzone	(1)

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
	abundance of many locally rare features?			quantitative	feature to the chosen subzones. 3) Extract the abundance value (or proxy for it) for the LRF in each subzone (*LRF-abundance*). 4) Assign an *LRF-value* to each subzone by rescaling *LRF-abundance* to values between 0 and 5 using the following formula: *LRF-value = 5 * LRF-abundance / maximum LRF-abundance,* where *maximum LRF-abundance* is measured from the range of abundance values for the specific LRF (species or habitat) obtained across subzones in the BBT. Leave blank (no *LRF-value*) where the *LRF-value* cannot be ascertained (e.g., no *LRF-abundance* available in a subzone). 5) Repeat steps 1 to 4 separately for each LRF in the BBT, then average the values across LRFs in every subzone. The resulting metric for this AQ will be a value between 0-5 (or blank where	may be measured as density of the species, spatial extent/relative coverage of the habitat (provided the habitat base map is at higher spatial resolution than the grid identifying the subzones; if not, then the metric LRF (qual) is only used for habitats) or other suitable proxy (depending on evidence available). Feature abundance may be obtained from monitoring data (sample data/observations) or data-based model/spatial predictions allowing wider coverage of the BBT (e.g., spatial interpolation of data, maps from regression model using relevant environmental predictors, EUNIS habitat maps). Where data-based evidence is not available, expert judgment may be used to assign an LRF-value (between 0-5) to subzones representing species density or habitat extent (spatial coverage) within.	

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
					not assessed).		
3	Is the subzone characterized by the presence of many regionally rare features?	R	All ECs	**RRF (qual)** Regionally rare features (species or habitats), qualitative	The algorithm for AQ3 [RRF (qual)] is the same as for AQ1 [LRF (qual)], but applied to RRF instead of LRF.	Data requirements as for LRF (qual), but for RRF	
4	Is the subzone characterized by high abundance of many regionally rare features?	R	All ECs	**RRF (quant)** Regionally rare features (species or habitats), quantitative	The algorithm for AQ4 [RRF (quant)] is the same as for AQ2 [LRF (quant)], but applied to RRF instead of LRF.	Data requirements as for LRF (quant), but for RRF	(1)
5	Is the subzone characterized by the presence of many	R	All ECs	**NRF (qual)** Nationally rare features (species or habitats), qualitative	The algorithm for AQ5 [NRF (qual)] is the same as for AQ1 [LRF (qual)], but applied to NRF instead of LRF.	Data requirements as for LRF (qual), but for NRF	

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
	nationally rare features?						
6	Is the subzone characterized by high abundance of many nationally rare features?	R	All ECs	**NRF (quant)** Nationally rare features (species or habitats), quantitative	The algorithm for AQ6 [NRF (quant)] is the same as for AQ2 [LRF (quant)], but applied to NRF instead of LRF.	Data requirements as for LRF (quant), but for NRF	(1)
7	Is the number of features in the subzone high?	AF	All ECs	**FN (qual)** Feature (species or habitat) number, qualitative	1) Consider all species or habitats for the selected EC in the BBT. 2) Create 2 occurrence classes for each species/habitat in a subzone with value 0 where it is absent and value 5 where it is present. Leave blank where presence or absence cannot be ascertained (e.g., no evidence coverage in a subzone). 3) Average the values across the species/habitats within an EC for the subzone. The resulting metric for this AQ will be a value between 0-5 (or	Data requirements s for LRF (qual), but for all features relevant to the EC.	(2)

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
					blank where not assessed).		
8	Is the subzone characterized by high counts of many species?	AF	All ECs	**ROF1 (quant)** Regularly occurring features (species or habitats), quantitative	The algorithm for AQ8 [ROF1 (quant)] is the same as for AQ2 [LRF (quant)], but applied to ROF instead of LRF.	Data requirements as for LRF (quant), but for ROF.	(1)
9	Is the abundance of certain species very high in the subzone?	AF	All ECs	**ROF2 (quant)** Regularly occurring features (species or habitats), quantitative	1) Select ROF (see feature selection criteria) for the EC of interest. 2) Determine the mean abundance (or proxy for it) of the individual ROF for the whole study area (=X) 3) Calculate the mean abundance (or proxy for it) of the individual ROF in every subzone (=Xi). Leave blank where abundance cannot be ascertained. 4) Calculate the ratio Xi/X for the individual ROF in each subzone. 5) Determine the 5% subzones with the	Data requirements as for LRF (quant), but for ROF.	(1)

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
					highest ratio (across all subzones where data for the individual ROF exist, including those where the data say that the ROF is absent; these are also the 5% subzones with the highest abundance Xi). Calculate the percentage of the abundance (Xi) of the ROF that occurs in these 5% most important subzones (=Y) 6) Determine in how many subzones the individual ROF occurs (=Z, i.e. the number of subzones where Xi>0). 7) Calculate the ratio Y/Z which is the aggregation coefficient for the ROF. 8) Multiply the ratio Y/Z with the ratio Xi/X for the ROF (*ROF-unscaled*). Leave blank where the metric could not be calculated. 8) Assign a *ROF-value* to each subzone by rescaling *ROF-unscaled* to values between 0 and 5 using the following formula: *ROF-value = 5 * ROF-unscaled / maximum ROF-unscaled,*		

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
					Where *maximum ROF-unscaled* is measured from the range of *ROF-unscaled* values obtained across subzones in the BBT. Leave blank (no *ROF-value*) where the *ROF-value* cannot be ascertained. 10) Repeat steps 1 to 9 separately for each ROF in the BBT, then average the values across ROFs in every subzone. The resulting metric for this AQ will be a value between 0-5 (or blank where not assessed).		
10	Is the presence of ecologically significant features high in the subzone?	AF	All ECs	**ESF (qual)** Ecologically significant features (species or habitats), qualitative	The algorithm for AQ10 [ESF (qual)] is the same as for AQ1 [LRF (qual)], but applied to ESF instead of LRF.	Data requirements as for LRF (qual), but for ESFs; incl. maps of essential habitats (e.g., EFH based on occurrence) in the BBT.	(3)
11	Is the abundance of ecologically significant features high	AF	All ECs	**ESF (quant)** Ecologically significant features (species or habitats),	The algorithm for AQ11 [ESF (quant)] is the same as for AQ2 [LRF (quant)], but applied to ESF instead of LRF.	Data requirements as for LRF (quant), but for ESFs; incl. maps of essential habitats (e.g., EFH based on abundance) in the BBT	(1)

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
	in the subzone?			quantitative			
12	Is the presence of habitat-forming species (or species-formed habitats, i.e., biogenic habitats) high in the subzone?	AF	Benthic ECs only (e.g., Macrobenthos, Epibenthos, Algae, Plants, marine benthic habitats)	**HFS/BH (qual)** Habitat-forming species/biogenic habitats, qualitative	The algorithm for AQ12 [HFS/BH (qual)] is the same as for AQ1 [LRF (qual)], but applied to HFS/BH instead of LRF.	Data requirements as for LRF (qual), but for HFS/BH.	(4)
13	Is the abundance of habitat-forming species (or species-formed	AF	Benthic ECs only (e.g., Macrobenthos, Epibenthos, Algae, Plants, marine benthic habitats)	**HFS/BH (quant) Habitat-forming species/biogenic habitats, quantitative**	The algorithm for AQ13 [HFS/BH (quant)] is the same as for AQ2 [LRF (quant)], but applied to HFS/BH instead of LRF.	Data requirements as for LRF (quant), but for HFS/BH.	(1)

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AQ#	Assessment question (AQ)	EV criterion	EC	Metric name	Algorithm	Data required	Notes
	habitats, i.e., biogenic habitats) high in the subzone?						
14	Is the presence of mutualist or symbiotic species high in the subzone?	AF	All ECs (except for habitats)	**SS (qual)** Symbiotic species, qualitative	The algorithm for AQ14 [SS (qual)] is the same as for AQ1 [LRF (qual)], but applied to SS instead of LRF.	Data requirements as for LRF (qual), but for SS.	(4)
15	Is the abundance of symbiotic species high in the subzone?	AF	All ECs (except for habitats)	**SS (quant)** Symbiotic species, quantitative	The algorithm for AQ15 [SS (quant)] is the same as for AQ1 [LRF (qual)], but applied to SS instead of LRF.	Data requirements as for LRF (quant), but for SS.	

Notes: **(1)** Relative (or %) spatial coverage used as habitat-equivalent of the density for species. **(2)** This metric corresponds to the species richness question for species in EV assessment protocols applied in the literature. **(3)** To avoid double counting between ESF, HFS/BH and SS, if a species or habitat is selected in one of these metrics, then it should not contribute to the others. **(4)** The same feature may be identified in different ECs, as the habitat-forming species (e.g. *Sabellaria*, seagrasses) or the respective species-formed (biogenic) habitat type (e.g. Sabellaria reefs, seagrass beds). The choice of which EC to use in the assessment depends on data availability, and duplication across ECs should be avoided.

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Table 2.6. EVA guidance: protocols for the selection of specific features relevant to AQs in Table 2.5.

<table>
<tr><th colspan="5">Feature selection criteria</th></tr>
<tr><th>Type</th><th>Reference AQ#</th><th>Selection criterion</th><th>Evidence base</th><th>Note</th></tr>
<tr><td>Locally rare feature (LRF)</td><td>AQ1, AQ2</td><td>Species or habitat occurring in <5% of the subzones in the BBT</td><td>Spatial distribution (pres/abs) of species/habitats in the BBT area.</td><td rowspan="3">1. Area of occupancy (by a species or habitat) is used for identification of rare features
2. Percentage threshold for identifying rarity of a species/habitat (based on data) may be changed (increased) if justified by limited data coverage of the subzones. Expert judgement is to be applied for this choice.
3. A feature (species/habitat) may be rare at one scale but not at another.
4. The type of evidence base used for the selection affects the confidence associated with the assessment.</td></tr>
<tr><td>Regionally rare feature (RRF)</td><td>AQ3, AQ4</td><td>Species occurring in <2% of 50 x 50 km squares of each of three bathymetric zones (littoral, sublittoral, bathyal/abyssal) in the region / Habitat occurring in <2% of 50 x 50km squares in the region, OR
Species or habitat identified as regionally rare from accredited national/international lists, OR
based on expert judgement</td><td>Spatial distribution (pres/abs) of species/habitats in the regional waters; OR Accredited list of rare species/habitats in the region (e.g. from OSPAR, HELCOM); OR Expert judgement</td></tr>
<tr><td>Nationally rare feature (NRF)</td><td>AQ5, AQ6</td><td>Species occurring in <0.5% of 10 x 10 km squares within national waters / habitat type restricted to a limited number of locations in territorial waters, OR
Species or habitat identified as nationally rare from accredited national/international lists, OR
based on expert judgement</td><td>Spatial distribution (pres/abs) of species/habitats in the national waters; OR Accredited list of nationally rare species/habitats;
OR
Expert judgement</td></tr>
</table>

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Feature selection criteria				
Type	**Reference AQ#**	**Selection criterion**	**Evidence base**	**Note**
Regularly occurring feature (in the study area) (ROF)	AQ8, AQ9	Species/habitats occurring in >5% of the subzones for the study area (i.e. all species/habitat excluding locally rare ones)	Spatial distribution (pres/abs) of species/habitats in the BBT area	5. Complementary to locally rare species (AQ #1 and #2)
Ecologically significant feature (ESF)	AQ10, AQ11	Species or habitats which have a significant ecological role in supporting the ecosystem structure and functioning. E.g. keystone species; species which constitute important food sources of certain seabirds (e.g., *Mesopodopsis slabberi*, sandeels) or have a key/pivotal role in the food web (e.g., keystone, top predator); species which are important for recruitment of fish stocks (e.g., fish larvae); habitats which play a key function in supporting viable populations of certain species (e.g., areas or habitats identified as essential habitats for fish/shellfish nursery, spawning, feeding or other functions).	DEVOTES keystone catalogue; Species/habitat evidence for EBSAs in the region; Expert judgement, supported by the literature on the role of species and habitats in the region/ecosystem of interest.	6. There may be some overlap between ESF and HFS. ESF corresponding to HFS or biogenic habitats should be included in HFS metric instead, to avoid double counting. 7. Examples of ESF (from the literature) are given in Appendix 2. Work undertaken under MARBEFES WP3 may also contribute to identify ESF.

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Feature selection criteria				
Type	**Reference AQ#**	**Selection criterion**	**Evidence base**	**Note**
Habitat-forming species or biogenic habitat (HFS/BH)	AQ12, AQ13	These can be identified as the species with habitat forming role or as the respective biogenic habitat. Their distribution is indicative of habitats often supporting diverse biota and key functions (e.g., refuge from predators).	DEVOTES keystone catalogue; Species/habitat evidence for EBSAs in the region; Expert judgement, supported by the literature on the role of species and habitats in the region/ecosystem of interest.	8. The same feature may be identified in different ECs, as the habitat-forming species (e.g., *Sabellaria*, seagrasses) or the respective species-formed (biogenic) habitat type (e.g., *Sabellaria* reefs, seagrass beds). The choice of which EC to use in the assessment depends on data availability, and duplication across ECs should be avoided.
Symbiotic species (SS)	AQ14, AQ15	Species living in a symbiotic relationship with another species	Expert judgement, supported by the literature on the symbiotic interactions between species as relevant to the region/ecosystem of interest.	9. Where there is overlap between species or habitats identified as ESF, HFS/BH, SS, only include the species/habitat once to avoid double counting in the assessment.

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The AQs, metrics and algorithms in Table 2.5 are to be applied separately to the different ECs in each of the subzones in the study area. Where the assessment is not possible (e.g., due to insufficient data or knowledge for an EC in the area or in specific subzones of it), no AQ value will be attributed to the subzone.

The EC-specific values attributed to the different AQs in each subzone are to be aggregated by considering the maximum value across the calculated AQs to obtain the subzone-specific **EC-specific EV**. The **Total EV** is then obtained for each subzone by also considering the maximum value across the EC-specific EVs and the results are graphically represented by mapping on the grid for the study area. The overall aggregation procedure is illustrated in Figure 2.4.

An Excel spreadsheet where the gridded data for an EC can be uploaded and the AQs and EC-specific EV are calculated following the protocol described for Phase 2 above is provided at the following link:

MARBEFES_EVA-Phase2_template.xlsx

Unlike the use of the average as the aggregation method, which may dampen the variability of the resulting EVs across grid cells, the use of the maximum value as aggregation method allows higher value components of the biodiversity to be prioritised and represented. It is acknowledged that this may lead to different ECs and/or related AQs being responsible for the resulting Total EV in different grid cells. It is therefore emphasised the importance of also mapping the intermediate assessment results (maps of the EC-specific EVs and related AQs), as these will allow to ascertain the reason behind the value of total EV assigned to a grid cell (EC and AQ determining it).

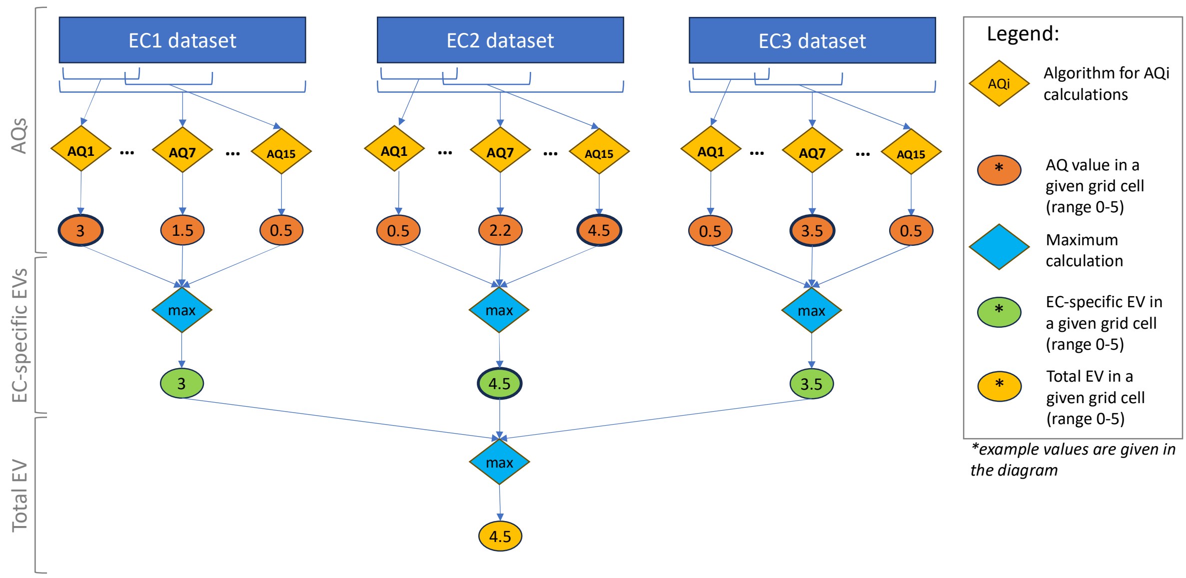

Figure 2.4. Aggregation procedure from individual AQ values (measured for a given EC) to the total EV (across all ECs assessed).

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When calculating the Total EV, it is acknowledged that the different EC-specific EVs might have different spatial reference, given that different ECs may be represented using subzones (grid cells) of different spatial resolution (see Section 2.2.2.1). If this is the case, the EC-specific EVs measured at the higher spatial resolution (i.e., using smaller grid cell size) should be aggregated at the lower resolution (i.e., at the scale of the larger grid cell size) to harmonise spatial scales and combine EVs across ECs. The overlap between smaller and larger grid cells may vary depending on the chosen cell shape (Figure 2.5). In any case, the aggregation of the EV values from the higher resolution grid (smaller cells) into the lower resolution grid (larger cells) should be undertaken using the maximum (i.e., the maximum EV across all small cells overlapping, partially or completely, with the larger cell should be used to represent the aggregated EV for the larger cell), in line with the aggregation method applied for the EV calculations.

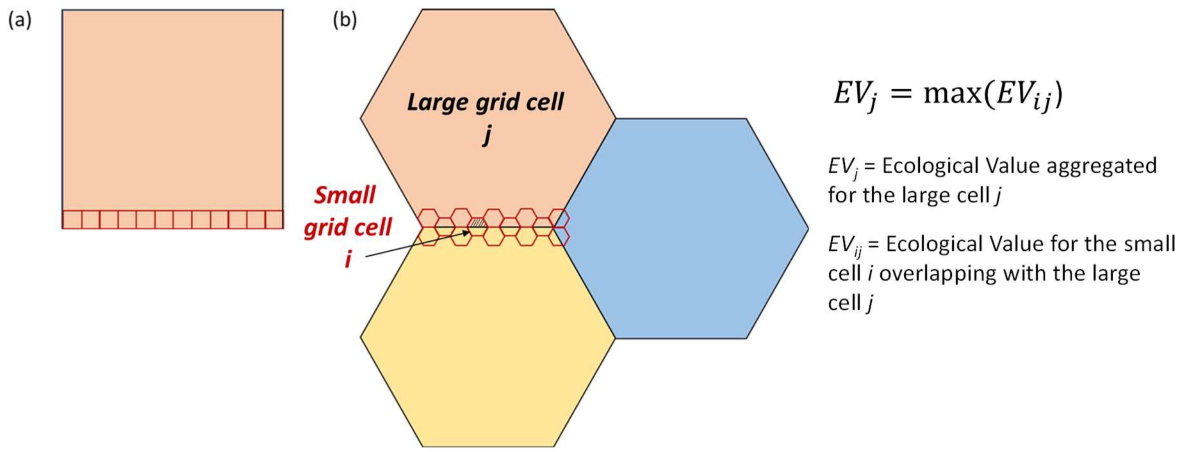

Figure 2.5. EVA guidance: Example of variable overlap between small and large hexagonal grid cells and EV aggregation formula (maximum).

The metrics calculated for each AQ assessed for each EC, as well as the derived EC-specific EV and Total EV are expressed as values ranging between 0-5. On mapping of these values, a 5-class scale may be used which distinguishes the following discrete categories: Very Low (VL, values 0-1), Low (L, values 1-2), Medium (M, values 2-3), High (H, values 3-4), Very High (VH, values 4-5).

A rescaling of the measure (presence/absence or abundance) relevant to each AQ is implied within the AQ algorithms (Table 2.5) to obtain standardised values within the 0-5 range and allow their aggregation into EC-specific EV and Total EV. The rescaling is based on the range of variability of such measure across subzones within an area, and therefore the resulting values (and the EV derived from them) express the relative ecological value of a subzone compared to the other subzones of the study area. This must be taken into account if comparing the results from different EVA implementations (study areas, e.g., BBTs in MARBEFES)), as e.g., a value of 5 assigned to an AQ for an EC in an area may have a different meaning, in absolute terms (e.g. as the abundance of the species being scored by the metric), for the same AQ and EC in another area (due to the different range of variability of the

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measure behind the score across the subzones in the area). In turn, the comparison of the EVA process between study areas (as opposed to the results) is not affected.

In order to make comparisons of EV values between study areas (e.g., BBTs in MARBEFES), the rescaling procedure in the algorithms would need to be modified to account for the wider variability of a metric across the multiple study areas rather than within the individual area. However, some of the factors affecting the assessment results at this wider scale might not reflect actual differences in the inherent ecological value between the ecosystems considered. For example, these could be due to variability in monitoring programmes (different sampling methods, regimes etc) affecting how the same measure for an AQ is obtained in different study areas, and therefore the comparability of the data. Biogeographic factors might also influence the EV assessment at the wider scale (between areas), e.g., latitudinal variability in the distribution of the species and habitats considered, natural variability in biodiversity between the regions where the areas occur, etc. The possible influence of these factors should be taken into consideration for the comparison of EV results across areas to avoid misinterpretations.

2.2.4 Assess Confidence (Phase 3)

Following the above calculations, it is important to give an indication of confidence in the produced results. This can be derived as a measure of uncertainty which is associated to the EV in the relevant literature through the assessment of data availability and reliability:

- Data availability (DAV) is determined by the number of (non-replicate) samples (or observations) of each ecosystem component taken (or made) in each subzone.
- Data reliability (REL) accounts for the number of AQs that could be answered for each subzone in relation to the maximum number of AQs answered (expressed as a ratio, or proportion).

Each of these uncertainty elements may be classified as Low (value 1), Medium (value 2) or High (value 3), based on the value range across the subzones in the study area and measured at the EC level (for DAV, the scores assigned to the different AQs are averaged to obtain a DAV for the EC). DAV and REL may be mapped separately or together (using a combination of colours and patterns to identify the combinations of the two variables). For example, Pascual et al. (2011) derived a map for 'reliability and sampling effort' to display the quality and amount of the data, respectively, to assess the information used for the EVA.

Given the modifications made to the original EVA protocol in this guidance (as in the above sections), the sources of uncertainty that may be associated with the estimated EV have been considered and updated (compared to the original method). These include the data availability and reliability components as per the original protocol applied in the literature (e.g., Pascual et al., 2011), with additional indicators of data availability being also added to account for distribution of mapped data and prediction. Additional sources of uncertainty are also taken into account, as specified in Table 2.7.

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The way in which these uncertainty sources influence the confidence in the resulting EVA is also indicated in Table 2.7.

Table 2.7. EVA guidance: Sources of uncertainty contributing to the confidence assessment.

Source of uncertainty	**What is assessed and its relationship with the confidence in the EVA**	**Where the uncertainty source is accounted for in the proposed confidence assessment**
(a) Assessment Reliability	How many of the AQs have been answered in the assessment of an EC in a subzone? Expressed as a proportion of the maximum number of AQs one may apply based on the AQ selection procedure in Figure 2.3. The higher is the proportion of AQs answered, the higher is the confidence associated with the EVA.	Equation 1
(b) Evidence Base for the assessment	Is the AQ (for an EC in a subzone) answered based on data or expert judgement? A higher confidence is associated with the use of data compared to expert judgement.	Weight scoring as per Table 2.8
(c) Data Use for the assessment	Where the assessment is based on data, is the metric to answer an AQ for an EC in a subzone derived directly from monitoring data or indirectly from model predictions? A higher confidence is associated with the use of monitoring data compared to model predictions. The latter may include for example habitat suitability models to extrapolate species occurrence or density based on environmental predictors, spatial interpolation models etc, which may be used to ensure full or better spatial coverage of the study area. This type of product (data-based modelled maps) may be generated by the assessor based on the monitoring data available in the BBT, or may be derived from pre-existing maps for the area (e.g., EUNIS habitat maps, Essential Fish Habitat maps, modelled oceanographic variable maps from Copernicus Marine Data sources).	Weight scoring as per Table 2.8
(d) Data Availability	Where the assessment is based on monitoring data, how many data (samples/observations) are available and have been used for the assessment of the AQ for an EC in a subzone? Where the assessment is based on modelled spatial distribution of data (e.g. EUNIS habitat maps, or	Weight scoring as per Table 2.8

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Source of uncertainty	**What is assessed and its relationship with the confidence in the EVA**	**Where the uncertainty source is accounted for in the proposed confidence assessment**
	indeed any other spatial predictions or interpolation of distribution of species for different ecosystem components), the data availability may be measured as % mapped area in a subzone. The higher the data availability supporting the assessment, the higher is the associated confidence.	
(e) Data Quality	Are the data used for the assessment qualitative (presence/absence) or quantitative (abundance, extent etc)? A higher confidence is associated with the use of quantitative data compared to qualitative ones.	Table 2.5 + Equation 1

The confidence assessment designed in this guidance takes into consideration the sources of uncertainty specified in Table 2.7, as well as the practicality of assessing them as part of the EVA process. It is acknowledged that the sources of uncertainty could be further detailed, and assumptions are made on how confidence is affected. For example, where expert judgment is applied (source (b) in Table 2.7), the confidence may vary depending for example on the range and type of expertise used to derive the judgment, and how this is obtained, which may affect bias and other pitfalls of this approach. Where the use of data-derived models and products is considered (source (c) in Table 2.7), a lower confidence is assumed on average to express the preferred direct use of monitoring data. However, it is acknowledged that the relative confidence of monitoring data and data-derived products is affected by a number of factors, such as for example whether the sampling method used is the most appropriate to estimate the metric under consideration, the model predictive ability, etc. (see for example a discussion of the different lines of evidence and the confidence assessment for Essential Fish Habitat maps in Franco et al., 2022).

We propose that the confidence associated with the EVA of each EC on each subzone is expressed as a single index, based on the equation below:

$$Confidence = \frac{1}{N}\sum_{i=1}^{N} AQ_i \, w_i \qquad \text{(Equation 1)}$$

where:

N is the maximum number of AQs that one may apply based on the AQ selection procedure in Figure 2.3. This varies depending on the EC and the type of data used: where the EC is made up of benthic species (e.g., macrozoobenthos), N is 7 with qualitative data used and 8 with quantitative

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data; where the EC is made up of non-benthic habitats (e.g., pelagic habitats), N is 5 with qualitative data and 6 with quantitative data; for all the other types of ECs (e.g., benthic habitats or non-benthic species such as fish, mammals, zooplankton), N is 6 with qualitative data and 7 with quantitative data;

AQ_i identifies the i^{th} Assessment Question, which in the equation is assigned a value of 1 if the AQ has been measured based on quantitative data, 0.7 if the AQ has been measured based on qualitative data, or 0 if the AQ has not been measured;

w_i is the coefficient assigned to the EC dataset used for the assessment of the AQ as identified in Table 2.8 and Figure 2.4 based on which evidence has been used to assess the EC, how the data have been used and their availability (sources b, c and d in Table 2.7). This is a value between 1 and 5.

As indicated in Table 2.7, the assessment reliability component of the confidence assessment (source (a) in Table 2.7), is included in the formulation of the confidence equation itself. By assigning 0 to non-answered AQs and dividing by the maximum number of available AQs that may be assessed in theory for an EC, the confidence score takes into account the proportion of questions answered. The data quality (source (e) in Table 2.7) is also incorporated in the AQi parameter of the confidence formula, whereby the value assigned to AQi, when measured, varies depending on the type of data used for the assessment (higher value for quantitative than for qualitative data).

The Confidence Index resulting from Equation 1 expresses the confidence associated with the assessment process that has led to the EC-specific EV resulting for a given subzone and ranges between 0 and 5. To express the confidence for the total EV integrating multiple ECs in a subzone, the confidence associated with the EC selected to represent the total EV in the subzone (i.e., the EC having the highest EV compared to the other ECs in that subzone) is to be used. Although not explicitly incorporated in the resulting overall confidence value, the number of ECs considered in the total EV assessment should also be considered to inform about the ecosystem representativity of the assessment (with higher representativity when the assessment was based on multiple ECs rather than an individual EC).

For mapping purposes, the confidence score may be classified on a 3-level scale as follows: Low confidence (score ≤1.67), Medium confidence (score >1.67 and ≤3.33) and High confidence (score >3.33 and ≤5). The confidence map (produced for each EC-specific assessment or for the EVA overall) provides a spatial product to be read in parallel with the respective EV maps.

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Table 2.8. EVA guidance: weight (w_i) to be assigned to answered AQs for each EC in each subzone in the confidence assessment (Equation 1).

Base for the assessment (b) & Data use (c)		**Data availability (d)***					
		Low	**Medium-low**	**Medium**	**Medium-High**	**High**	**Not known**
Expert judgment		**1**					
Data based	Indirect use of the data (model products)	1	1	2	3	3	3
	Direct use of monitoring data	1	2	3	4	5	-

*Note: The data availability in each subzone (for a given EC) is measured as the number of samples/observations available in the subzone where monitoring data are directly used for the assessment, or as the % mapped area in the subzone where interpolated or otherwise modelled spatial distribution maps are used as source data.
For the data availability categorisation (as low, medium-low etc), the range of the data availability measure is calculated across all the subzones in the BBT (Range=Min – Max) and it is divided in 5 classes. Where data availability is measured as % mapped area within a grid cell (e.g., from habitat model maps), the Min-Max range is fixed (0-100%) and the data availability is classified as follows: Low with % mapped area values ≤20%, Medium-low with values >20% and ≤40%, Medium with values >40% and ≤60%, Medium-high with values >60% and ≤80%, High with values >80%. Where data availability is measured as number of samples/observations (e.g., from species monitoring data), the Min-Max range is variable and the data distribution within this range might be skewed. Therefore, for these type of data availability measure, the 5 classes should be established using 20% inter-quantile ranges: Low with data availability values falling within the 1st/lowest 20% quantile (including ≤20% of data), Medium-low with values within the 2nd 20% quantile (>20% and ≤40% of data), Medium with values within the 3rd 20% quantile (>40% and ≤60% of data), Medium-high with values within the 4th 20% quantile (>60% and ≤80% of data), High with values within the 5th/uppermost 20% quantile (>80% of data).

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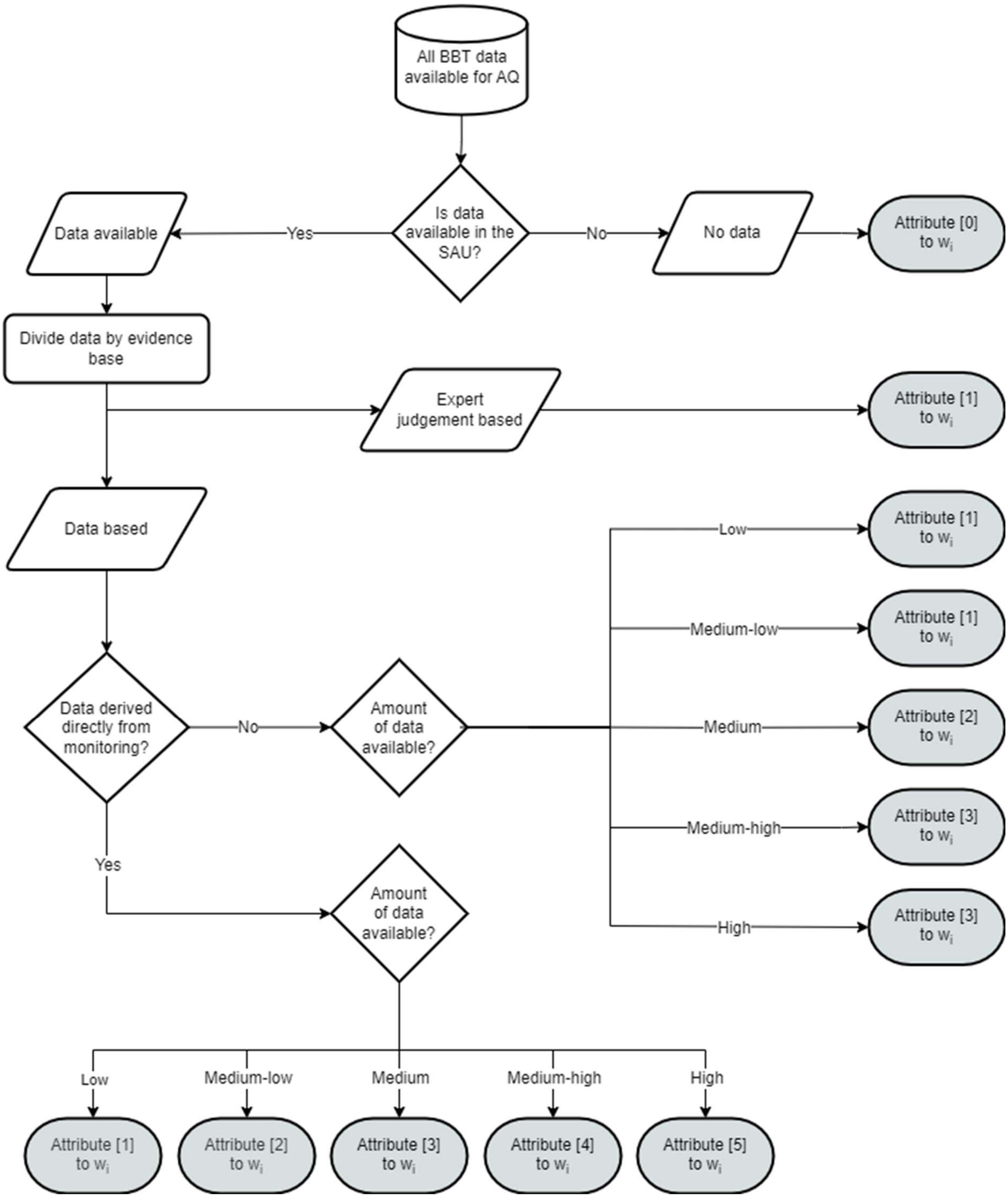

Figure 2.4. EVA guidance: Confidence weight (w_i) assessment for each AQ and EC in a subzone (SAU) based on criteria in Table 2.8.

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2.3. EVA TESTING in MARBEFES BBTs and PROTOCOL REVISIONS

This section provides an overview of the testing process undertaken in MARBEFES at the 12 BBT sites, which has led to revisions of the EVA protocol throughout the process (see Table 2.9 for a summary of the changes made since the original protocol was designed in March 2023). The feedback and main discussions about the method implementation have been summarised as a set of questions and answers (Q&A) which have been used to provide clarifications to the BBTs on the method use and to revise the protocol, if needed to improve its applicability, amend errors and reduce obstacles for its implementation.

Table 2.9. Summary of the versions of the EVA guidance produced following iterations in the method application and revision process, with indication of the main changes made.

Version date	Comment/Change made	Modified by
28.03.2023	First draft	A. Franco, E. Amorim
18.04.2023	Document revised after comments by M. Elliott and D. Burdon	A. Franco, E. Amorim
09.06.2023	Guidance revised after comments received up to EVA workshop on 9 June 2023	A. Franco
24.07.2023	Guidance revised following discussions (incl. use hexagonal grid and revised algorithms for question scoring in Table 2.5, plus other minor amendments)	A. Franco
22.08.2023	Final revisions	A. Franco
04.12.2023	Amendment/clarification to hexagon grid size	A. Franco
12.01.2024	Amendment to confidence assessment to account for additional metrics of data availability (section 2.2.4, Tables 2.7 and 2.8 and Figure 2.4)	A. Franco
16.01.2024	Clarification added to algorithm for AQ9 (step 5) in Table 2.5	A. Franco
29.01.2024	'Intrinsic' value replaced by 'inherent' value	A. Franco
14.02.2024	Details added on how to combine EV from ECs with different grid size into total EC (section 2.2.3)	A. Franco
21.10.2024	Amended confidence score categorisation (section 2.2.4, Table 2.8)	A. Franco
27.11.2024	Changes to aggregation method for EV calculation (maximum instead of average; section 2.2.3, also incl. spatial grid cells aggregation) and classification of data availability for w_i estimate (Table 2.8 in section 2.2.4)	A. Franco
05.02.2025	Change to confidence aggregation between ECs following changes in version dated 27.11.2024 (section 2.2.4)	A. Franco
06.06.2025	Change to AQ selection procedure (with prioritisation of quantitative AQs over qualitative ones, if quantitative data are available) (section 2.2.3, with new decision system flow-chart (Figure 2.3) for AQ selection)	A. Franco

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Version date	Comment/Change made	Modified by
10.06.2025	Confidence assessment updated following changes in AQ selection procedure (section 2.2.4, formula 1). Changes to spatial system, to include possible use of square grid cells and larger scale for habitat ECs (section 2.2.2.1, Table 2.2, Figure 2.2)	A. Franco
17.10.2025	Decision system flow-chart for AQ selection (Figure 2.3) revised and parameters in the confidence assessment formula (section 2.2.4, formula 1) redefined for better clarity and consistency with latest method changes. Excel template for AQ and EV calculations (Phase 2) created.	A. Franco

2.3.1 Considerations on the EVA protocol testing

The EVA was implemented at the 12 BBT areas in MARBEFES to test the method functionalities and identify possible areas for improvement. The implementation was undertaken between July 2023 and June 2025, although for most BBTs the bulk of the EVA implementation was completed by the summer-autumn 2024. The considerations below regard the implementation process and the exploration and discussion of the initial results obtained by the BBTs in July 2024 *(to be updated for the final deliverable D4.1 following further changes applied by the BBTs afterwards, e.g., to improve the EC or AQ coverage of the assessment or adjust the assessment following early protocol revision)*.

There was a variable degree of adherence by the BBTs to the full EVA protocol. This was not unexpected, given the flexibility of the EVA method, which allows the user to adjust the assessment based on their own interests and data availability (e.g., selection of ECs and AQs to include in the assessment). The 'gold standard' for the application of EVA to an area would be to include the full range of ECs relevant to that area and for which data are available to undertaken the assessment. Ideally, all the species or habitat assemblages in the area would be represented and all the quantitative AQs would be measured for the assessment using a wide variety of data sources (ideally combining monitoring data to increase accuracy and confidence with modelling data to increase spatial coverage and possibly future predictions). However, it is acknowledged that real-life constrains may apply to the assessment, e.g., due to limitations in the data availability for an area or the user level of skill to perform the assessment. For example, suitable/sufficient data may only be available to assess some ECs, and, in some cases, these may only qualitative data (presence/absence), thus limiting the assessment to the calculations of qualitative AQs only hence with inherent lower confidence associated. Operational constraints may also apply, for example due to time and resource limitations (as within MARBEFES) which may restrict the ability to source relevant data or to analyse them in all aspects. The flexibility of the EVA method allows its implementation even under these constraints, albeit this might happen at the expense of the representativity and accuracy of the results. Hence the importance of always undertaking the confidence assessment as an integral part of the EVA implementation.

Considering the operational constraints within MARBEFES, a minimum standard was set for the implementation of EVA by the BBTs, also to ensure consistency in the testing. This required that

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benthic ECs (macrobenthos and benthic habitats) were assessed as a minimum by the BBTs and that the assessment of benthic species groups prioritised the use of monitoring data over modelling ones (favouring higher confidence but likely at the expense of spatial coverage), while EUNIS habitat maps (based on Level 3 habitat classification) were used for the benthic habitats EC. Most BBTs conformed to this minimum requirement, although some went beyond it by also including additional ECs and data. For example: fish, zooplankton and phytoplankton data were also used in the Curonian lagoon and Lithuanian coast BBT5; fish (demersal and pelagic) cetaceans, seabirds and phytoplankton data were also used for the assessment in the Irish Sea BBT8; fish, waterbirds, phytoplankton, phytobenthos (seagrasses and saltmarshes) and macroalgae (intertidal and subtidal) data were also used in the southern Gulf of Biscay BBT9. In some cases, alternative or additional data sources were used as deemed more suitable for the assessment in a case study area (e.g., more detailed habitat types than EUNIS level 3m as obtained from filed surveys and local studies in the Gulf of Oristano BBT11 or in the Menorca channel BBT10; species abundance or biomass from spatially extrapolation or species distribution models for macrozoobenthos in the marine area of the Lithuanian BBT5 or in the Gulf of Biscay BBT9).

When considering the spatial system for the EVA implementation, most of the BBTs applied the 250 m hexagonal spatial grid as requested by the initial EVA protocol for the benthic ECs. However, the small spatial grid proved to be computationally demanding, especially in areas with a high habitat diversity and heterogeneity (e.g., Archipelago Sea BBT4), and in some areas a larger grid size was used (e.g., 3km in BBT5, 500 m in BBT10). In some cases, there was also a notable variability between the environments included in a BBT (also reflected by different data collection methods and availability) and the EVA was applied separately to them (e.g., lagoon or estuarine areas and the adjacent coastal marine area included in BBT5, BBT9 and BBT11). Consideration of this and of the results obtained for the assessment based on benthic habitat EC led to a revision of the recommendations on grid size (allowing higher flexibility in the choice, depending on the data used), as explained in the Q&A section below (Q (06/06/2025) and resulting in the protocol provided in Section 2.2.

There was also a marked variability in the set of AQs being included in the assessments in the different BBT areas (e.g., the benthic habitat EC assessment including from only AQ7 in BBT5 to all AQs relevant to this EC in BBT9). Often, this was due to limitations in the availability of relevant data (e.g., qualitative v. quantitative) or evidence (e.g., to identify rare species/habitats at different scales or ecologically significant species/habitats) time available to source/analyse the data), or in the ability to source them within the time allowed within the project task. However, in some cases, it was due to a misunderstanding of the protocol requirements. These were clarified with the BBTs and, where needed, the EVA protocol was amended to avoid them.

The considerations presented here only refer to the methodological aspects of the EVA implementation by the BBTs and do not address the interpretation of the specific results obtained by the BBTs. In fact, the Ecological Value (EV) calculated and mapped by the different BBTs cannot be directly compared. In addition to the variability in the protocol implementation between BBTs, the EV value calculated in an area is expressed in relative terms and this prevents comparability of results across different areas. In fact, although the EV resulting from the BBT implementations are expressed

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on a common standard scale (0-5), its calculation relies on intermediate steps requiring the averaging of values between species or habitats specific for the BBTs and rescaling the AQ intermediate values (to a 0-5 range) based on the maximum observed across grid cells in the case study area (BBT) being assessed. As a result, the maximum value of 5 for the standardised EV corresponds to the condition of maximum biodiversity observed within an area and its meaning (in terms of actual degree of biodiversity it represents) may change between BBTs. As mentioned in Section 2.2.3, the only way to compare the EV results between BBTs would be to disaggregate the EV value tracking the calculations back to the initial steps of the implementation of the AQ algorithms (separately for the individual ECs) and to define a different rescaling procedure which takes account of the variability of an AQ across multiple BBTs (rather than just within it). This was outside the remit of WP4 (and Task 4.1 in particular), which focused on testing the EVA methodology rather than analyse and interpret its results (the latter is left to the individual BBTs).

Exchanges and checks with the BBTs were maintained throughout the testing of EVA, to ensure that issues, possible errors (both in the protocol and in its use by the BBTs) and areas of improvement were identified in a timely manner, allowing the BBTs to correct their assessment accordingly, when possible. This flexibility in the implementation of the EVA protocol changes was more likely at the earlier stages of the implementation by the BBTs. As the process advanced, and more time were spent by the BBTs to obtain suitable results, revising the EVA implementation following protocol revisions became more difficult. While the BBTs have put great effort in amending their assessment following protocol changes up to the end of 2024, it is acknowledged that later protocol revisions (see Table 2.9) may not have been fully implemented by the BBT, nor they were required to do so. Nevertheless, the feedback obtained from the BBTs and the assessment of their experience in applying the EVA method has been invaluable to identify and correct possible weaknesses in the protocol and to improve the resulting protocol presented in Section 2.2.

2.3.2 Q&A

This section collates comments and questions, and the associated answers and clarifications about the EVA process developed in MARBEFES (WP4, Task 4.1). The Q&A are organised according to the phase of the EVA protocol they are relevant to (or in section 'Other' where of general relevance). The date of when the item was added (or last modified) is also indicated to provide temporal reference throughout the process of testing and revision of the EVA method.

2.3.2.1 Phase 1 – Define the study system

<u>*Spatial system*</u>

Q (11/07/2023): What is the **spatial scale of evaluation** - BBT limits only? Region? all EU area ? Difference is very important - rare, protected and important species in one place (e.g. *Fucus* in Poland) is a trivial and common species in Finland, and not taken in consideration in Lithuania as there is no habitat for this. The valuations separated by administrative/political borders are very difficult to compare - highest value in Baltic and highest value in Ireland will mean something completely different in terms of biodiversity

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A: There are two spatial scales to be considered in the EVA: one is the scale of the study area being assessed (defined by the BBT boundaries), the other the spatial scale at which the features (species and habitats) in the study area are characterised, e.g. in relation to their rarity. The questionnaire in EVA includes multiple questions for rarity which reflect the different scales at which rarity may be characterised (at local, within the study area; regional; or national). If in one BBT there is enough information to characterise the rarity of the species/habitats within on multiple scales (e.g. locally rare, nationally rare), there multiple questions can be answered and they will contribute to the final assessment. If there is no information available, e.g. on rarity at national or regional scale, then the BBT can assess local rarity based on the species/habitat distribution within the BBT (as per guidance). Only that question (on local rarity) will contribute to the final EV, although a lower confidence would likely be associated with that result as some the questions on regional/national rarity were not assessed.

As for the boundaries of the spatial scales for rarity, the local (BBT) and national scale are probably the easiest ones. For the regional scale, there will need to be clarity on which region the rarity assessment refers to.

Q (11/07/2023): **Grid for plankton** has resolution of 250 x 250 m. This is not consistent with wider grid (3 x 3 km resolution) for pelagic habitats. Patterns and dynamics for water column/plankton are more likely to occur at the wider spatial scale.

A: It is agreed that the grid scale for plankton should be changed from 250x250m to 3x3km. ***The EVA guidance document has been updated accordingly.***

Q (11/07/2023): Can the assessment be **applied to marine and coastal areas, also including estuaries**?

A: The 'ecological meaningfulness' of the zonation (gridding) is ensured by identifying different grid sizes as appropriate to the different ECs: larger grid cells (3x3km) for more mobile species or pelagic habitats, smaller grid cells (250x250m) for benthic species and habitats. This means that assessment can be applied to marine and coastal areas, including estuaries.

Q (11/07/2023): EVA requires for a study area (BBT) to be divided into **subzones that are meaningful from an ecological perspective**, as relevant to the ECs considered in the assessment. How are these identified?

A: Subzones may be identified for example through the biogeographic/habitat zonation of an area, or, as often applied in the literature, through the application of a regular spatial grid. The EVA protocol developed in MARBEFES adopts the latter approach for standardisation within and across BBTs. It is therefore emphasised that the terms 'subzone', 'spatial assessment unit (SAU)' and 'grid cell' are used interchangeably as synonyms in the proposed EVA protocol. The 'ecological meaningfulness' of the resulting zonation (gridding) is ensured by identifying different grid sizes as appropriate to the different ECs: larger grid cells (3x3km) for more mobile species or pelagic habitats, smaller grid cells (250x250m) for benthic species and habitats. The use of a regular grid defined independently from the habitat distribution also allows to use habitats as an EC to be assessed within each grid cell.

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Q (11/07/2023): Is there a potential issue with **grid cells crossing between different biological zones/habitats** (including for example coastal/estuarine boundaries), and how could this affect the assessment? (as the area within a grid cell is assessed as one spatial unit).

A: Whether this is an issue would depend on the EC taken into account, as, e.g. mobile species may distribute across multiple habitats/biozones and therefore the habitat boundary may be less relevant than for other ECs. The different scaling of the grid according to ECs takes this into account and therefore should allow mitigation of this potential issue.

Q (11/07/2023): We will be working with a **1km x 1km grid** as we consider the 250m grid too detailed for our BBT, particularly as most of the area is >50m (data comes from remote monitoring and spatial extrapolation)

A: I don't think it's an issue to adapt the grid to your specific case study if the proposed pre-defined grid scale is not suitable. I guess that, for comparability with the other BBTs, your 1x1km grid cell could be divided into 16 cells of 250x250m size (all with the same value as the bigger grid cell they fall within), but this can be done *a posteriori*, if comparison between BBTs is needed.

Q (11/07/2023): About the grid, could we work with **hexagonal grid** (better for marine areas) and with degrees as unit of measure?

As for using degrees, it will not be an issue as any measurement using degrees as units can always be transformed back into one using m/km.

As for using a hexagonal grid instead of a square one, it has been highlighted that hexagonal grids allow more flexibility and better spatial representation of marine biological components and information. They are also more suitable for the evaluation of different connectivity measures. But the most remarkable thing is that their projection and visualisation are more precise and aesthetically pleasing, which should be a criterion to be valued in this type of projects.

Some of the data that are used for EVA will probably feed into ARIES and then into the Natural Capital Physical Accounting, and it has been confirmed that ARIES can work with any grid type proposed. It is essential, however, that **all BBTs use the same type of grid**.

Following the comments above, it has been decided to ask **BBTs to use hexagonal grids** (of different size, depending on the ECs) instead of a square one (11/07/2023).

For those not familiar with hexagonal grids here is some advice (from Andrés Ospina-Alvarez at CSIC): *Both in GIS software (ArcGis or QGis) and in R or Matlab, hexagonal meshes can be produced in a simple way. In QGis, for example, it only involves two menus and three or four clicks, so there should be no problem in changing from square to hexagonal grids. [see video-tutorial on how to create hexagonal grids using QGis – file '*Makinga Hexbin Grid for a BBT*' in NextCloud at* https://nc-marbefes.iopan.pl/nextcloud/s/retGAGYs97B6fRt*)*

The EVA guidance document has been updated accordingly.

Q (04/12/2023): Regarding **grid size**, by 'Maximum width' do you mean twice the apothem of the hexagon or twice the radius of the circumscribed circle? The QGIS tool requests indicate the vertical distance from the centres, equal to twice the apothem?

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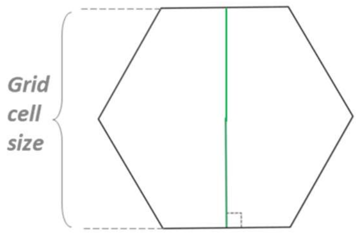
A: When the grid was changed from square to hexagonal, the grid cell size was changed from e.g. 3x3km square to 3km maximum width (meaning the diameter of the circumscribed circle) to keep the area of a grid cell closer to the one of the original square.

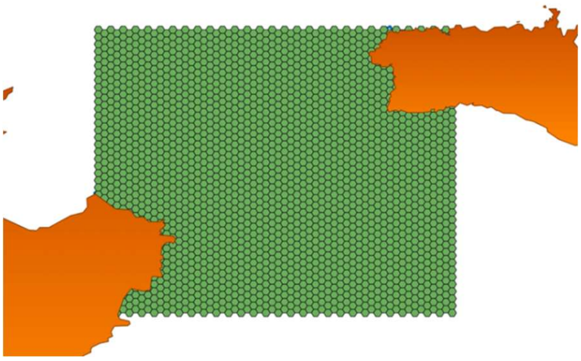
Using the indicated size as the length of the apothem (as in the figure below) would lead to a hexagon area which is 3.5 times bigger than the area of the original square (e.g., 31.2km^2 instead of 9km^2 using the 3km size). However, I have realised now that using the maximum width for the hexagon size, this would reduce the area to 65% of the original square (e.g., 5.85km^2 instead of 9km^2).

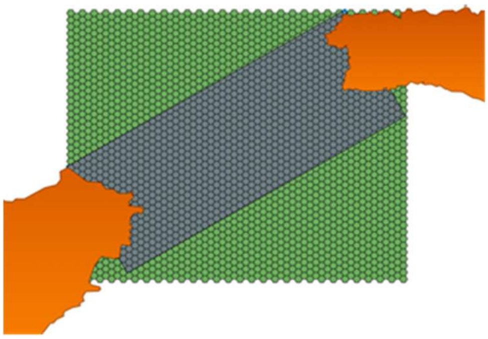
The best option would be to use the size indicated in the guidance as the measure of **twice the apothem (i.e. the vertical distance between two sides of the hexagon, through its** centre – see figure below). This would lead to an area which is 86% of the original square (e.g. using the size of 3km, hence apothem = 1.5km, the hexagon area would be 7.8km^2, compared to 9km^2 of the square 3x3km cell). ***The EVA guidance document has been updated accordingly.***



Q (04/12/2023): Using the **BBT boundary** as "Grid extent," the grid created does not completely fill the BBT extension, but there are holes on the sides of the layer (Figure 1). This also happens in the demo video (Figure 2). Can we expand the "grid extent" and then intersect?

A: Yes, you should create an expanded grid extent and then intersect as shown in the video (*https://nc-marbefes.iopan.pl/nextcloud/s/retGAGYs97B6fRt*) This way you will not have holes...





Q (04/12/2023; updated 12/01/2024): Using the **WGS 84 (4326) projection** to define hexagons, it is necessary, as shown in the demo video, to use values in degrees to **specify grid size** (as horizontal and vertical spacings – see screenshot below). In this way, hexagonal polygons with non-uniform metric dimensions will be generated. In this case we can't really insert the length of 2x apothem (e.g., 3 km) into horizontal and vertical spacing, only degrees allowed, UNLESS we swap to pseudo-Mercator projection, which allows m/km input. My question is in this case should we stick to the original

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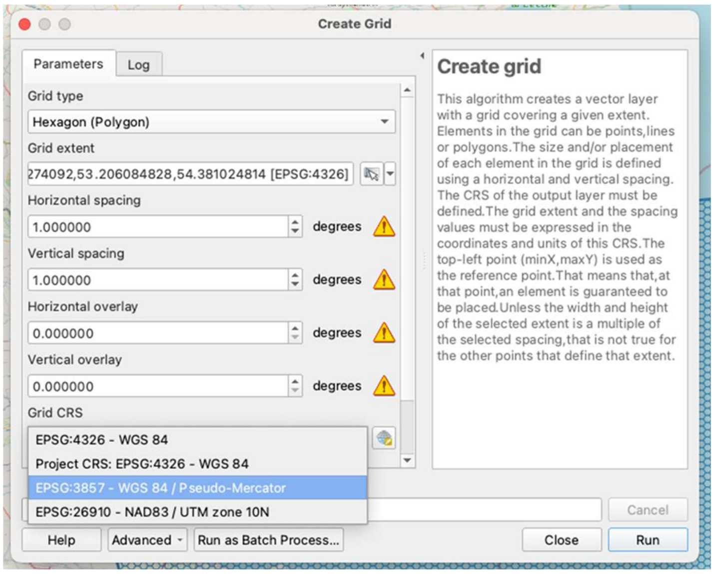
projection (and recalculate the degrees to relevant area etc.) or do we have some other possibility of entering selected m/km distances?



A: Two conversion methods can be used, as per advice provided by Willem Boone at VLIZ (below). We recommend to **use the second option** where possible. Note that the text below refers to the example of a 3km grid size; this value should be adjusted to the actual grid size required for the specific ecosystem component.

1) *The most straightforward method would indeed be to calculate how the defined distance in meters at a certain BBT can be converted to lat/lon degrees* [e.g., using online calculators as http://www.csgnetwork.com/degreelenllavcalc.html]. *In principle, latitude axis, 3km will always correspond to 0.027° Lat (considering a spherical geodetic datum i.e., the world is a perfect sphere). For longitude there is a larger difference as longitudes come closer together towards the NorthPole, so their distance in meters becomes smaller. See example.*

Specific Latitude	Length Of A Degree Of Latitude In Meters	Length Of A Degree Of Longitude In Meters	Lat degrees corresporning to 3km	Lon degrees responding to 3km
30	110852	96486	0.0271	0.0311
40	111034	85393	0.0270	0.0351
50	111229	71695	0.0270	0.0418
60	111412	55799	0.0269	0.0538
70	111561	38186	0.0269	0.0786
80	111659	19393	0.0269	0.1547

Concluding on this, using this conversion method will result in errors especially in longitude axis. If the BBT has a wide north-south range or is located higher up north, it is not recommended since the error will increase.

2) *An alternative method could be:*
   a. *Chose a local CRS with metric system (e.g. zone in* https://epsg.io/32600 *->codes 32601-32660 , for Belgium that would be EPSG32631N). *Using WGS 84 / Pseudo-Mercator is not a good option as it is a global metric CRS and local errors will be larger.*

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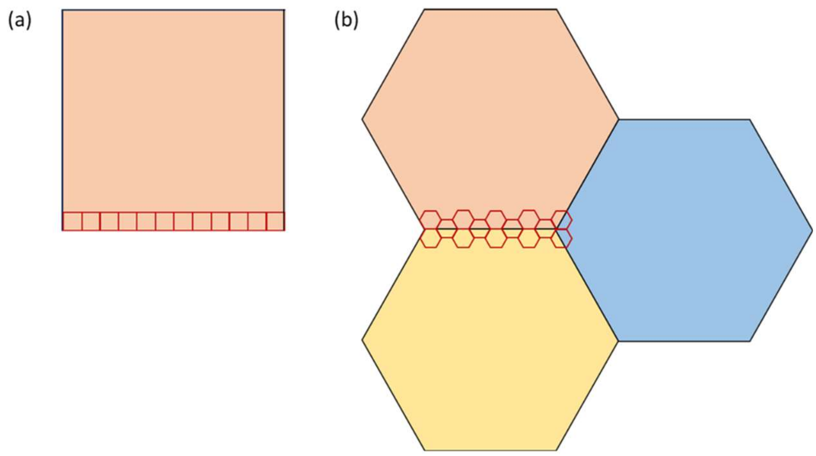
b. *Create the BBT grid in QGIS using this metric CRS, use 3000m as spacing.*
c. Reproject *the resulting shapefile/gpkg to WGS84 - EPSG4326.*

Q (14/02/2024): The assessment of an overall EV will require results to be combined across ECs. Different ECs may have different grid size (250 m v. 3 km), so how should the **EVs from different ECs assessed at different spatial resolution be combined**?

A: EC-specific EV values obtained at the higher resolution (250m grid size) should be aggregated at the lower resolution grid scale (3km grid size) before they can be combined with the EV values for the ECs assessed at the lower resolution. This rescaling would consist in averaging the EV values across all the small grid cells contained in a larger grid cell to obtain the resulting EV value for the larger grid cell.

While 144 (12 x 12) smaller (250 m) square cells would have fitted exactly within a larger (3 km) square cells (see figure (a) below), this is not the case when using hexagonal grids (figure (b) below). The area of the larger cell is still 144 times the area of the smaller cell, but some cells on the border may be partially included in different larger cells.



There are different methods that could be used to aggregate EV values from smaller cells into an EV value at the larger cell scale. Advice was sought from GIS experts (*) and it was agreed that the best option for the MARBEFES EVA approach is to use a weighted average, where the weights are determined by the proportion of the area of each small cell that overlaps with the large cell. Compared to other methods, this approach provides a more accurate representation of the EV values across different scales. It is acknowledged that it requires additional computations (including the determination of the overlapping areas and their respective proportions) compared to a simple overlap method, but these should be easily undertaken in GIS. ***The EVA guidance document has been updated accordingly.***

(*) Thank you to Andrés Ospina-Alvarez (CSIC), Giorgio Massaro (CNR) and Marta Pascual (BC3) for the advice provided.

Q (06/06/2025): **Final considerations on the spatial grid system** after seeing experience and results of implementation of EVA in the BBTS areas

A: These considerations regard both the shape and size of the grid cells.

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Shape of grid cells: The guidance to the BBTs was changed from using square to hexagonal grid cells following considerations as per Q (11/07/2023) above. After seeing the proposed approach implemented by the BBTS and receiving the feedback on use and challenges, it is clear that both grid shapes have their pros and cons. Square grid cells may be considered not as good as hexagonal cells to represent marine components and their connectivity, but are easier to use and to re-scale (e.g., when EV results obtained at different grid spatial resolution are to be rescaled for aggregation into a common grid). As such, they are more likely to be implemented even by users with basic GIS skills/experience. As a result, **the guidance has been modified (for general use)** to recommend the use of hexagonal grid cells, but also allow the use of square grid cells instead so as to remove a possible obstacle in the EVA implementation.

Size of grid cells: The size of grid cells determines the spatial resolution of the assessment within a study area and it may change depending on the EC considered and the type of evidence used to inform its assessment (e.g., to account for the spatial resolution and representativity of the sample data). For the assessment of benthic ECs, a smaller grid size (250 m) was suggested compared to that one used for most of the other ECs (3 km) considering the spatial resolution and representativity of typical benthic samples; e.g., in the worst-case scenario where the assessment of a grid cell area is based solely on the benthic community from one benthic grab sample, it would be unlikely for those data to represent the benthic features over a 3km-wide area hence the choice of a smaller grid size). However, after seeing the method implemented by the BBTs, it became clear that the same might not apply when benthic habitats are the EC being assessed. In this case, the EVA considers the diversity of habitats (based on presence and/or extent) within a grid cell, and therefore it is implied that such habitats are defined/identified (hence mapped) at a higher spatial resolution than the one of the grid cell. This may not be the case if the habitat types are identified in broader ecological terms (e.g., EUNIS Level 3 habitat types, as used by the BBTs), which may also reflect on the inability to differentiate them at lower spatial scales hence to assess their diversity within a smaller grid cell area (resulting in the homogeneous coverage of the grid cell area by the individual broad scale habitat). This was evident from the BBT's EVA results based on EUNIS Level 3 habitats, often showing a homogeneous low EV due to the presence on one individual habitat type within most of the 250 m grid cell in the study area, which higher levels only detected where the grid cells overlapped with the borders between the different broad scale habitats. The same assessment undertaken using 3 km grid cells (e.g., as tested in the Irish Sea BBT8) showed that a larger grid cell size allowed to better capture the diversity of habitat types defined by the EUNIS Level 3 classification. Taking this into consideration, **the guidance has been modified (for general use)** to allow some flexibility in the grid cell size and to allow the user to make a judgment call about the most suited spatial resolution depending on the scale at which the habitat types are defined and used in the assessment.

Ecosystem components (ECs)

Q (11/07/2023): What is the **limit of habitats and domains** we are dealing - benthos? pelagial? both? Valuation shall be set separately for seabed and water column as both domains are independent to a high degree - ecological valuation of seabed will not match this for pelagial in the same area

A: Benthic and water column habitats can be considered as separate components (as are, for example planktonic and benthic species), to be assessed separately in the EVA, if there is enough data (e.g. habitat maps for the two domains within coverage of the BBT). This means that you will have an EV for benthic habitats and an EV for pelagic habitats (as well as EV for the other species groups components, i.e. fish, marine mammals, seabirds etc). As you say, the resulting EV maps for the

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different components might not match and show different distribution of the EC-specific EV within the BBT. The overall EV will combine these EC-specific EVs.

Q (11/07/2023): What are the **organism categories we are going to value** - selected taxa (as I have proposed Crustacea, Polychaeta, Mollusca, Echinodermata, fish, macrophytes) again selection of taxa will set the value - e.g. all sea mammals and seabirds are rare and protected in many countries and their presence will outweigh all other organisms

A: In the guidance there is a list of the possible Ecosystem Components that can be used, but it doesn't mean that all are to be assessed in each BBT. The choice of the ecosystem components (organism categories for species) one BBT should consider for the EVA is up to the BBT, as it depends on the evidence that is available to undertake the assessment in that BBT. For example, some BBTs may have sufficient evidence (data or expert knowledge) to undertake an assessment (by answering as many questions as possible) based on birds, fish and benthic infauna, others may only be able to consider birds, and might have data for benthic infauna only including anellids). As regards the granularity of how EC are defined, there is some suggestion in the guidance (e.g. demersal and pelagic fish fauna, or benthic infauna and epifauna may be assessed separately if there is enough evidence to allow it). However, I would recommend not to resolve EC at a too high taxonomic level (differentiating polychaetes, molluscs etc). I would suggest to use taxonomic/functional groupings that are commonly applied (e.g., in MSFD assessments), as suggested in the guidance.

As for the risk of one quality of one EC outweighing the others, this is unlikely in the EVA as multiple qualities (assessed with different questions/metrics) for multiple ECs are combined in the final EV. In your example, the metric associated with the rarity of seabirds is only one among many other qualities that can potentially contribute to the final EV. Also note that the questions about rarity assess the diversity of e.g., rare species (at a given spatial scale) within each subzone of the BBT, but the metric is expressed as a relative score which depends on the diversity measured across the whole BBT. For example, if the range of nationally rare species in the BBT (across its subzones) is between 0-6 for fish and 0-22 for birds, a subzone with 6 rare fish and one with 22 rare seabirds will both have score 5 for that metric, and they will both contribute equally to the calculation of EV (first within the specific EC, then across all ECs).

Q (04/12/2023): In which EC or where do the data related to **microplastics** or anthropogenic impacts go?

A: NOT HERE! Ecosystem Components are just for BIOLOGICAL DATA. NOT ANTHROPOGENIC DATA.

Q (04/12/2023): We have information about the **microplastic** distribution along the BBT beaches. Do they fall under the EVA?

A: NO, that information is not for EVA

Q (12/12/2023): There is an ecosystem component for seabirds, but a big part of the coastal ecosystem in a BBT may also be **waterbirds** (incl. wintering). Is this OK to create an EC for birds from coastal wetlands etc.?

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A: Yes, you can create a separate layer for waterbirds. As these are generally recoded from coastal surveys (while roosting or feeding in intertidal areas), the range of this dataset will only cover the coastal cells of your BBT and the other cells will be blank (no data). You would then include EV-waterbirds and EV-seabirds separately with the other EC in the final EV (but EV-waterbirds will only contribute to the total EV in the coastal grid cells).

Q (15/12/2023): Have we agreed finally on the taxonomic level of evaluation - which taxa to consider? If one will focus on fishes and other on meiofauna we will travel to nowhere, of course habitats will be different in all sites (still in one EU classification). I have suggested to have common and the same for all BBT set of taxa for biological valuation, namely:

1) seabirds - species

2) sea mammals - species

3) fishes - species

4) crustaceans benthic and pelagic - species

5) Molluscs - benthic and pelagic - species

6) macrophytes (both algae and vascular) - species

7) Polychaeta - family level

8) Echinodermata- species

A: The full list of ecosystem components is in the guidance. BBTs should assess as many as possible, but not all of them will be assessed by all BBTs and we don't expect the BBTs to include all the same set of components, as it depends on the data they have. Some may only have data on fish and macrobenthos, others on macrobenthos and seabirds, so their EVA will be dependent on the EC they are able to include. As the EVA is based on the aggregation of ecological value at different levels (from individual metrics for each component, to EV across metrics for the whole component, to total EV across components), the final EV can be disaggregated to make ad-hoc comparisons if needed (e.g., for the same EC used by some BBTs), but with the caveat that the EV in different BBTs may have different meaning (as the standardisation of EV scores is based on the range of variability of the metrics in the individual BBT).

Even when the same EC is assessed by different BBTs (species groups or EUNIS habitats), we don't expect the identity of the species (or the habitats) included will be always the same across BBTs, due to biogeographical differences in the distribution of species and variable morpho-ecological characteristics of the different BBT areas. E.g., some BBTs might only have sedimentary/soft bottom habitats, while others might also have hard substrata. It will be all right, as long as the habitat classification system used by the different BBTs is the same (EUNIS 2022, broad scale habitat (Level 2) as minimum, biotopes (Level 4) where possible).

As regards the taxonomic level used to distinguish the EC, the EC are identified at a high taxonomic level groups (as indicated in the guidance), which may be combined with some functional grouping also considering that the data behind the different groups may be collected with different monitoring methods and therefore might not be comparable (e.g. demersal and pelagic fish could be assessed as separate EC). I would not suggest to split the EC taxonomically to finer levels; e.g., I would assess polychaetes, molluscs, echinoderms, and crustaceans altogether as part of the macrobenthic community; this could be distinguished between intertidal and subtidal communities, if the data exist

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in the BBT, as the sampling method may differ. Where epibenthic invertebrates (including larger crustaceans) are also sampled (with methods other than grabs/cores, eg epibenthic dredges/trawls) these could be included as a separate EC (as the data from epibenthic dredge would not be comparable with those from grabs or cores).

Q (15/12/2023): How can one use "macrobenthos" as a measure of biodiversity, without defining the species identity?

A: When I say that macrobenthos is the EC assessed, I mean that the metrics for EVA will be assessed on this community, but, of course, they require data for the individual species to measure the biodiversity metrics for the community (depending on the metric, all the macrobenthic species in the community may be considered in the measure of biodiversity, or only subsets of them, e.g. according to their rarity at different geographical scales, or their functional/ecological importance). The EVA requires both data on presence/absence and abundance/density, although, in the absence of the latter, a 'simplified' version of the EVA can be applied (only based on the metrics requiring p/a), although this reduces the confidence in the results.

Q (15/12/2023): Of course you may use the trawl, grab, core, traps etc for information of biodiversity, as long as what we need is presence/absence - species list, the qualitative, not quantitative information.

A: Even if only presence/absence (not just presence) data are used, I would be careful in combining data from different survey methods, as different survey methods may have for example different selectivity and this might affect the data comparability (especially for records of absence). For example, if trawl and grab data are combined to qualitatively characterise the macrobenthic community (no abundance), a mollusc species might be present in subzone 'A' where grab samples have been taken (hence a value of '1' in the dataset), but it might not be present in the samples collected with trawling in subzone 'B'. This doesn't necessarily mean that that mollusc is absent from subzone 'B', as trawling wouldn't have effectively sampled that part of the macrobentic community, and therefore its absence from the trawl sample in subzone ‘B’ cannot be taken as indicative of absence from the subzone (i.e., with a value of '0' in the combined dataset). The two datasets should be treated separately (e.g. trawling data for epibenthic community, grab data for microbenthic community) and the data for the species effectively sampled by each of these methods should be considered as representative of the two communities.

Evidence base

Q (04/09/2023): What to do if there are **spatial gaps in the evidence base** for an EC? (i.e., it only covers part of the BBT)

A: The evidence (data, data products, expert judgments) available for an EC may only cover part of the BBT for different reasons. The EC may potentially occur only in parts of the BBT that are suitable (e.g., salt marsh in intertidal areas only) and therefore the data for that EC only cover those suitable areas (these can be identified e.g., using depth zones). In other cases, the partial spatial coverage of the BBT may be associated with limited evidence availability, e.g., where the monitoring of an EC was only undertaken in a part of the BBT (e.g., an area of interest) but the EC may potentially be distributed in other areas of the BBT which were not monitored. In this latter case, where possible, modelling could

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be undertaken to extrapolate the monitoring results on the EC to the wider BBT area (e.g., using seabed characteristics and benthic data from monitoring to predict the distribution of benthic species or communities/habitats over the wider BBT area; or other species distribution models to predict habitat suitability of fish, marine mammals, seabird species). However, this may not be possible and the monitoring data (with spatial gaps) are directly used for the EVA.

In all these cases, the EVA assessment for the EC (and the rarity calculation in the specific; see also Q&A under 'Assessment criteria and questions') can only be applied to the areas of the BBT for which data are available, thus excluding any gap areas (n/a) from the calculations. The EC-specific results can then be combined in different ways, e.g., by calculating and mapping EV across the whole BBT using the ECs with widespread evidence and then 'zooming-in' to a specific area of the BBT (e.g., the intertidal zone, estuaries or the area where localised monitoring was undertaken), where additional relevant ECs can be added to the total EV assessment.

Q (04/12/2023): In case we are certain that a species cannot live in a specific area (e.g., *Patella ferruginea* cannot be found in the infralittoral zone), should we assign the **value "blank" or zero** to the subzone?

A: See also question above. The value should be BLANK (n/a) as zero is only used to characterise absence of a species from areas where it may occur (hence intertidal species should be marked as blanks in the subtidal parts of the BBT area, and, similarly, species associated with hard substrata should be marked as blank on sedimentary substrata, and vice versa).

Q (12/12/2023): Large mobile species such as whales or turtles - should we include **strandings**? What's often reported by volunteers is a dead animal.

A: I would not include strandings as they are not indicative of the actual spatial distribution of the species in the marine environment and their record in a (coastal) grid cell may be misleading.

Q (12/12/2023): We know that migrating species could be anywhere in the BBT and we just "happen" to catch them during a survey in a particular subzone/hexagon. In that case, that hexagon will have a higher EV than the neighbouring hexagon, where the species technically could have been just before, but hasn't been recorded. Consequently, that "empty" hexagon will have low EV despite being within the species wider occurrence area. In that case, can **species distribution models** "fill in" the gaps or should they not be combined in one EC with actual observations?

A: There are two aspects to this question:

1. There is a difference between 'zero data' (i.e. where a survey took place, but the species was not recorded) and 'no data' (i.e. where there was no survey, so we don't know whether the species occurs or not there). The former would be recorded as a zero in the dataset, and therefore it would probably contribute to lower the EV for that grid cell (subzone/hexagon), compared to others where the survey produced a positive record of the species. The latter ('no data', i.e. blanks in the dataset) would not contribute in any way to the final EV in the grid cell, which will be the mean of the EV of the ecological components for which data exist in that subzone/hexagon cell (e.g. in one grid cell the final EV may be the results of benthos + mammals + fish, while the EV in the next grid cell may only result from the assessment of benthos + fish, if there are no data on mammals for it; maps of EC-specific EV would allow you to see where the gaps are and therefore where each EC contributes to the final EV).

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2. Any survey is limited in the spatial coverage it can achieve, so there will likely be 'empty' subzones that are not covered by a survey, but it doesn't mean that the species or habitat doesn't occur there. Species distribution models can certainly be used to extrapolate the survey results and make predictions where there was no survey, thus improving spatial coverage (and reducing gaps). You can combine both sources for an EC (e.g., if you have predictive model maps for some species and only survey data for other species of the same EC), but make sure that zero data (observed or predicted absence) and no data (no observation or prediction, e.g. where the grid cell falls outside the survey area or model validity range) are reported correctly (as per point above). Also make sure you keep track of where you have used model results and where you have used survey data, as this will affect confidence calculations (phase 3).

Q (12/12/2023): The BBT may cover a pretty large area with **various sources of data**. For instance, ecosystem component "mammals" can comprise aerial surveys monitoring data for cetaceans, but for pinnipeds - only opportunistic sightings. In that case, is it OK to combine cetaceans and pinnipeds together as one EC?

A: As the two methods are very different (and also probably the time reference for the data, e.g. dates of the aerial survey vs. years over which opportunistic sightings have been recorded), the data are not really comparable. I would not integrate the data into the same dataset on which the EV is calculated for marine mammals. However, if you think both datasets provide valuable information (especially if the sightings integrate long term evidence), you could treat them as two separate sub-EC. That is, you could calculate EV separately for cetaceans and for pinnipeds (I would expect the latter would only have values>0 where sightings were recorded and blanks (not zero) elsewhere, as no sighting does not mean absence). Then you could include the EV-cetaceans and EV-pinnipeds (as sub-EC for mammals) in the final calculation of the total EV across all ECs.

Q (24/01/2024): Should we use preferably **monitoring data or data-derived evidence** (predictive models/spatial interpolations)?

A: At this stage, we suggest that the assessment prioritises monitoring data over modelled ones (for species EC), if possible (i.e., use the best data you have). The former have higher confidence, albeit with possible lower spatial coverage (hence more gaps in the grid) compared to model predictions. However, rather than thinking of these as alternative sources of evidence for the EVA, they could complement each other. The model predictions could be used to fill the gaps resulting from the EVA based on monitoring data alone, if needed (e.g., if monitoring data are too patchy, there are too many gaps with no assessment in the grid).

In the grid cells where both type of data are available, the direct use of monitoring data should be prioritised (higher confidence) over models for the EV assessment. However, the model data could inform the assessment in those grid cells for which no monitoring data are available. The confidence would be lower, but having an EV assessed, even at lower confidence, would be better than having no assessment at all.

This could mean double effort, as the assessment would have to be done twice on the same EC, on both monitoring data and model predictions (where these exist), but it would provide a more complete assessment of a BBT. As a starting point, I would suggest to concentrate on the assessment with the monitoring data, and, based on the EV results (for each EC and overall), then one can see whether there is the need to fill the gaps.

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Q (24/01/2024): Can monitoring data on **bird breeding colonies** be used for the assessment of the EC-Birds?

A: Data on breeding birds are generally recorded for species of seabirds only where their breeding colonies occur along the coast, and as number of breeding pairs or other variables representing the use/importance of that breeding colony for the species. These data are not representative of the distribution of the bird species as a whole, but only of a specific habitat they use for a key aspect of their life cycle (breeding). Where there are no data on breeding colonies it might be inferred that there are no breeding colonies for a species (=absence/0), but not that there are no birds of that species at all.

These data might not be suitable to calculate some metrics/AQs, e.g., those based on the frequency of occurrence of a species (as rare of regularly occurring), as these data could only inform rarity of breeding colonies not of the bird species as a whole. However, one of the aspects accounted by some metrics in EVA (AQ10 and AQ11) is the presence of aggregations identifying areas playing important functions (e.g., breeding grounds). In these terms, the distribution of breeding colonies would provide evidence on the distribution of an ecologically significant habitat for birds, more than on the distribution of bird species themselves, and this certainly is relevant to the ecological value of an area (increased where these functional habitats occur or are found with higher abundance of breeding pairs). The EVA undertaken based on the data on seabird breeding colonies could be based only these specific metrics/AQs only. Other data (e.g., at sea transect-based survey data) could be used to provide a more complete assessment of the bird species (other AQs also calculated).

Therefore, the EC-bird assessment could have multiple aspects (sub-components) assessed separately (where the different types of data are available): one based on the distribution of seabird species (e.g., from transect surveys at sea); another one based on the distribution of seabird breeding area (based on breeding colonies data and considering coastal grid cells only); and one on waterbirds (e.g., based on intertidal bird surveys and considering coastal grid cells only). EV could be calculated for each of these components (likely with gaps in the grid), and then combined to obtain the EV for the Birds EC.

Q (24/01/2024): Can **sightings** (e.g., of marine mammals or turtles) be used for the assessment of the relevant ECs?

A: Sighting data (e.g. for mammals or turtles) are obtained from opportunistic observations. Data are recorded only where a sighting of a species was made. Where there are no records of the species, its absence cannot be inferred, as we don't know the distribution of effort (observations), so those grid cells are blanks (no data). The resulting dataset would only include cells with values >0 and blanks. Therefore, as sighting data have no absences/zeros recorded, they cannot provide a complete picture of the species distribution in the marine area.

In addition, even the frequency of sightings in an area over the years may not be a reliable proxy for abundance of the species. As there is no information on the distribution of the effort, we cannot tell whether a higher frequency of records is the result of an actual higher occurrence of the species in an area (hence likely higher ecological value) or it is due to a higher number of people/observers visiting that area over the years, which would increase the chances of mammals/turtles being spotted compared to areas that are visited less frequently. If the latter, the higher EV calculated from sighting data might not necessarily correspond to an actual higher ecological value, just a higher effort.

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Based on the above, I would consider this type of data unsuitable for the EVA assessment of the related ECs. *More advice is needed from people who normally work and have better knowledge of this type of data.*

Q (03/07/2024): For assessing EVA on macrobenthos we are going to interpolate abundance of all species

A: I suggest that, in the first instance, you use your original sampling data to do the macrobenthic assessment. This will likely lead to many gaps (blanks in the dataset and in the resulting maps) for those subzones not covered by the monitoring, but, where assessed, the EV would have a higher confidence as it is based on monitoring data rather than on modelled interpolations. This would probably be quicker, so that you could give Marta the mapped results to proceed with the physical accounts in AIRES. If you have more time, then you can complete the interpolations for all species in the assemblage, and calculate the AQs and EVs based on the interpolated data and use the results to fill the gaps. This would have the advantage of a wider spatial coverage of subzones in your BBT, but at a cost for confidence (as assessment on modelled data has lower confidence that that one based on the source monitoring data). You will have to take this into consideration when calculating and mapping your confidence during Phase 3 of EVA.

Other

Q (22/08/2023): My question is if you already have or if **you will provide a data sheet for the EVA related data** with the organism groups and algorithms etc included? And would you like to receive the data as an excel sheet or in some other format? We have many data sources where the output varies, so I will likely not be able to calculate all values in ArcGIS, but will need to visually inspect some sources and fill in data by hand.

A: The choice of the specific organism groups that each BBT will consider (amongst those indicated in the EVA guidance on Table 3) is down to the BBT, as it will have to match data availability in the case study. We are not going to provide any spreadsheet for the data, as the source data may be of different type (occurrence, species abundance, habitat extent, or other indicators for them) and may be derived directly from monitoring (point data, transects etc) or from data-derived products (e.g., existing maps of species or habitat distribution from models), or even from expert judgment. Each BBT is free to choose the best format for the source dataset, as long as it allows its spatialisation in the assessment (hexagonal) grid(s), which each BBT has to create for their case study area and for the ecological components they use. The tabular form of the spatialised/processed dataset is expected to be a matrix where each row is one of the hexagonal grid cells that have been identified for an ecosystem component in the BBT area, and each column is a variable (indicator of presence/absence and/or abundance, extent, as derived from the original evidence) for each feature of an EC (species in each species group, or habitat types from the EUNIS habitat map). If you have to combine data from multiple outputs (e.g. from monitoring of different areas of the BBT or in different years), or use expert judgment to manually allocate data to the grid cells, it's fine. I only advise that you keep track of all the choices you make in data selection and treatment as this may affect the confidence (Phase 3 of EVA).

As for the algorithms to calculate the metrics for EVA (Phase 2), these are specified in Table 5 of the EVA guidance, with Table 6 providing additional information on the criteria for the selection of the

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subset of species or habitats for an EC that are relevant to the calculation of the different metrics (are features, ecologically significant ones, etc).

As WP4.1, we are providing the guidance to the BBTs, but it is up to each BBT (in WP2) to collect, prepare and analyse the data and undertake EVA. Year 2 of the project is dedicated to this, although we have suggested to phase this application so that all BBTs are working on the same phase of the EVA and, if there are any issues, we can sort them out together and to the benefit of all BBTs before the next phase is implemented. We are suggesting that the BBTs should implement the first phase of data collection, preparation and mapping (using the hexagonal grids relevant to EVA) between now and the end of the year (December 2023). During this period (and for the rest of the EVA implementation by BBTs), we can support the BBTs if they have any questions or doubts or difficulties by providing advice or specific help and then make the other BBTs aware of the solutions, and revise the EVA guidance accordingly, if needed.

2.3.2.2 Phase 2 – Assess EV

Assessment criteria and questions

Q (11/07/2023): Can there be an issue with **double-counting** where the same species may be considered in different questions to represent similar functional characteristics (e.g. habitat forming species and ecological significant species)?

It is important to carefully define the features (species or habitats) to be considered in different AQs to avoid double-counting. Where specific features are selected to answer a question, one should make sure they are not selected for another question for the same reason (i.e. based on the same quality). For example, if a species is selected to answer the AQs about habitat forming species, that species should not be selected in the AQs on ecological significant species if the reason for attributing ecological significance to the species is associated with its habitat forming capability (but the species could be selected if there is another quality that determines its ecological significance). Similarly, double-counting might occur across ECs when the AQs on habitat forming species or biogenic habitats are answered (AQ12, AQ13). If those AQs are answered for the EC-benthic habitats considering a specific biogenic habitat (e.g. mussel beds), then the species forming that habitat (e.g. mussels) should not be considered to answer the same AQ for the EC-benthos.

Q (04/09/2023): We have undertaken the EVA on salt marsh and seagrass ECs so far. There is an issue regarding how local rarity is calculated. These **ECs only occur in estuaries and coastal parts of our BBT**, while there is large part of the BBT (sea area) where these ECs do not (and cannot) occur. Calculating local rarity based on the 5% occurrence threshold across the whole BBT (as per current guidance) would always lead to salt marsh and seagrass species being locally rare, even if they were distributed over all the estuarine and coastline (i.e., the areas where they can occur). Therefore, we have divided our BBT into two sub-areas (estuaries & coast, and the rest of the sea area) where we undertake EVA separately considering the ECs relevant to the specific sub-area.

A: We agree that rarity should be calculated comparing the actual distribution of the EC with its potential area of distribution (within a BBT for local rarity, at wider scales for the other types of rarity; see Table 6 of the EVA guidance). Therefore, salt marsh and seagrass ECs (and their rarity) can only be assessed considering intertidal or/and shallow subtidal estuarine and coastal marine sub-areas of the BBT. As it has been suggested, the BBT area may be divided into sub-areas (e.g. based on depth zones)

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in which EVA is undertaken separately considering only the ECs relevant to each sub-area. The results will be spatially complementary, and may be combined into a single final map of EV (albeit with the caveat that the EV values in different parts of the BBT may result from different combinations of ECs).

A similar approach applies to any cases when the evidence for an EC only covers part of the BBT, for the reasons described above or where monitoring of an EC was only undertaken in a part of the BBT (even if the EC may potentially be distributed in other areas of the BBT which were not monitored). Where possible, modelling could be undertaken to extrapolate the monitoring results on the EC to the wider BBT area (e.g., using seabed characteristics and benthic data from monitoring to predict the distribution of benthic species or communities/habitats over the wider BBT area; or other species distribution models to predict habitat suitability of fish, marine mammals, seabird species, etc). Where this is not possible and the localised monitoring data are directly used for the EVA, the EVA assessment in general for this EC, and the rarity calculation in the specific, can only be applied to the areas of the BBT for which data are available, this excluding any gap areas (n/a) from the calculations. The EC-specific results can then be combined in different ways, e.g., by calculating and mapping EV across the whole BBT using the ECs with widespread evidence and then 'zooming-in' to a specific area of the BBT, where additional ECs (from the localised monitoring) can be added to the total EV assessment.

Q (06/02/2025): *[following changes in AQ/EV aggregation method] In lieu of phytoplankton community data from any monitoring in the BBT, we used remote sensing data to give chlorophyll-a concentration as a proxy for phytoplankton biomass. Our assumption was that we could only answer AQs 7, 8 and 9 using these data because we have no species resolution. However, that means that AQ7 would be essentially the presence/absence of phytoplankton biomass and a subzone with any concentration of Chl-a would get a 5. This would be ok per se but now in the new way of calculating the EC-specific EV using the maximum, it means that the presence/absence of chl-a will completely override the more quantitative measures of where ecological value may vary with respect to increased phytoplankton biomass*

A: The qualitative AQs are likely to be scored higher than their respective quantitative AQ, as they only need to reflect the presence of any individual of the species (max. score 5), not the variability in their abundance (with max. score 5 only achieved with maximum abundance for the species in the data). There is the risk that, even if quantitative AQs are measured, they would be frequently 'overpowered' by the qualitative ones in generating the final EV (even if it's just one qualitative AQ v. multiple quantitative AQs), following the change in the method for aggregating EC-specific EV results into a total EV (see 'Q (30/10/2024): Wouldn't averaging EV scores homogenise the results across the map?), now using maximum value for aggregation. Taking this into consideration, the protocol for selecting AQs for the assessment has been revised to allow prioritising the quantitative AQ over the correspondent qualitative AQ, when quantitative data area available to measure it. A decision system flow-chart has been designed and ***added in the EVA guidance (June 2025***) to support the user in the selection of AQs for the assessment. As an assessment based on quantitative data (hence AQs) is considered to have higher confidence than a qualitative one, the confidence assessment in the protocol has been modified accordingly.

Metrics calculations (algorithms) & aggregation

Q (11/07/2023): The **scoring method applied to the AQ metrics** was discussed at the EVA workshop on 9 June 2023, specifically how to assign classes ranging from 1 to 5 based on quantitative data.

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A: The earlier protocol included measure of continuous variables (abundance etc) and their classification into 5 discrete classes to which an integer value of 1 to 5 is assigned. Further calculations (averaging etc) were then undertaken on these class values, effectively treating the discrete classes as numbers. The results were then re-classified again into 5 classes. After discussions on how to improve this scoring method, the following changes have been made to the protocol. The continuous variables (abundance etc) measured to answer an AQ are rescaled into a 0-5 range, without classification (i.e. keeping them as continuous variables but on a common 0-5 scale). Scale starting with 0 gives better representation of absence and zero-abundance (classed as 1 before). The rescaled variables can be equally combined without the potential issue of treating discrete class values as continuous variables and having to re-classify them again afterwards. Classification of the values into 5 discrete classes is taken out of the algorithm, and is only added at the end, on mapping the results: the EV results will also be values ranging 0-5, and one can map them as continuous variable or group them into 5 classes from very low (0-1 values) to very high (4-5 values). ***The EVA guidance document has been updated accordingly.***

Q (04/12/2023): Will you provide a data sheet/**template** for the EVA related data with the organism groups and with formulas for the calculation of the algorithms etc included?
A: The choice of the specific organism groups that each BBT will consider (amongst those indicated in the EVA guidance on Table 3) is down to the BBT, as it will have to match data availability in the case study. We are not going to provide any spreadsheet/template for the data, as the source data may be of different type (presence, abundance, or other indicator for it) and may be derived directly from monitoring (point data, transects etc) or from data-derived products (e.g., existing maps of species distribution from models), or even from expert judgment. Each BBT is free to choose the best format for the source dataset, as long as it allows its spatialisation in the assessment grid(s) (which each BBT has to create for their case study area and for the ecological components they use).

The tabular form of the spatialised/processed dataset would essentially be a data matrix (e.g. an Excel spreadsheet) where each row is one of the hexagonal grid cells that have been identified for an ecosystem component in the BBT area, and each column is a variable (indicator of presence/absence and/or abundance, as derived from the original evidence) for each feature of an EC (species in each species group, or habitat types from the EUNIS habitat map). If you have to combine data from multiple outputs, or use expert judgment to manually allocate data to the grid cells, it's fine. I only advise that you keep track of all the choices you make in the data selection and treatment as this may affect the confidence (Phase 3 of EVA). You may create separate data matrices for each EC, and add columns with the calculations of the algorithms for the different questions.

We haven't provided a template with the formulas for the metrics calculation as these can be derived from the algorithm steps in Table 5 of the EVA guidance (Phase 2), with Table 6 also providing additional information on the criteria for the selection of the subset of species or habitat for an EC as relevant to the different questions. The formula a BBT will apply will depend on which species/habitats are selected from the data to answer a specific question (and their location as a column in the data matrix) and the BBT may choose to create separate formulas for each step of an algorithm (hence the calculation of a metric is undertaken over multiple columns) or to combine the steps in a single formula showing the scored result. It's up to the BBT to find the way that suits them most.

Q (04/12/2023): In **AQ#9**, Algorithm Column, point 5: What does it mean "Calculate the percentage of the abundance of the ROF that occurs in these 5% most important subzones (=Y)"

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A: Once you have identified the top 5% subzones with the highest abundance ratio for a ROF species (e.g. if you have 200 subzones where you have data and have calculated the abundance ratio Xi/X, these would be the 10 subzones with the highest value), you sum the abundance of the ROF recorded in each of these top 5% grid cells (ΣXi across top 5% cells) and divide it by the total abundance of the ROF in the BBT (ΣXi across all grid cells). Multiply the resulting number by 100 and you obtain the required percentage Y (but you may also calculate it as a proportion, i.e. without multiplying it by 100, as long as you do this for all cells – the result would not change once you rescale the final ROF-value). ***The EVA guidance document has been updated (with clarification on this aspect) accordingly.***

Q (29/01/2024): **Regional and National features**: Answering AQ1 and AQ2 concerning the local features is not an issue, but we are not too sure on how to apply the regional and national features. Specifically, how do we apply the 50 x 50km and 10 x10km search on the hexagonal grids? It's probably something easy to define in the code but we are not sure on how to approach this.

A: The 50x50km and 10x10km grids that can be used to identify which features are regionally or nationally rare are independent from the hexagonal grids. You would map the species/habitat distribution at the regional or national scale using the 10 or 50 km grids to see whether the species can be classified as rare at that scale (based on the criteria in Table 6 of the EVA guidance). The species/habitats distribution within the BBT then are to be mapped using the relevant hexagonal grid, and those that have been identified as regionally or nationally rare will be used for the calculations of AQ3 – AQ6.

If there are no data that allow to map the wider distribution of the features over the region or national marine area to assess their rarity at that scale, then other sources providing that classification can be used (e.g., if there are lists of nationally/regionally rare species or habitats in the literature) or, alternatively, expert judgment. If no information or expert judgment on either or both national and regional rarity is available, then the question based on those specific features can be skipped.

Q (29/01/2024): **Number of features and count of species:** For the **AQ7 and AQ8**, could you clarify the difference between these two questions.

A: AQ7 is calculated taking into account the presence/absence distribution of ALL the features (species or habitats) for the EC (including both rare and frequently occurring ones) for which data are available in the BBT.

AQ8 is calculated taking into account only the regularly occurring features (ROFs) in the BBT (hence excluding the locally rare species or habitats) and it needs quantitative data for them (abundance or proxy for it).

Q (29/01/2024): **Mutualistic or symbiotic species:** Is there a centralized list for specific species that we should test or is this BBT/region/dataset specific? For bird species or some benthic species this is more likely to be well documented, but for phytoplankton and zooplankton this is not so easy to identify. We were just wondering what the agreement was around this.

A: There is no centralized list of symbiotic species, it's up to each BBT to identify them from the species pool they have in their area. However, having a centralized list shared between all BBTs is a good idea. *As a starting point, a shared Excel worksheet ('EVA_Features classification.xlsx') has been added in Next Cloud for BBTs to list the symbiotic species they have identified, as well as the ecologically*

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significant features and the habitat forming species (or biogenic habitats) to be identified for the purpose of the EVA. This way, the information can be exchanged between BBTs.

Q (05/07/2024): **AQs that one should be able to answer as a minimum?**

A: The AQs that you will be able to answer for a given EC (an assemblage of species or of habitats) depend on the EC and the data you have available:

1. AQ7 is the AQ that you should be able to measure in any case for the EC that you are assessing as: (i) it is based on qualitative information (presence/absence), so you should be able to measure it whether you have qualitative or quantitative data; (ii) it considers all the species or habitats present in the assemblage being assessed, and does not require any additional knowledge or ability to identify specific features of interest within that assemblage (LRF, RRF, ESF etc).
2. Whether you can assess the other AQs depends on your ability of identifying features of interest (LRF, RRF, NRF, ROF, ESF, HFS/BH, SS) in the assemblage you are assessing. This will be influenced by the knowledge that you have available and the data that you have (e.g., you might have no knowledge of species being identified as rare in the wider region where your study area occurs, nor data to assess this spatially (as per the RRF criterion in Table 6 of the EVA guidance), so you could not assess either AQ3 or AQ4; you might have a dataset that only includes main/common species, and based on this there might not be LRF in it, so you could not assess AQ1 or AQ2 as the feature of interest is not present in your dataset).
3. If you only have qualitative data (presence/absence), then the other AQs that you may be able to assess (depending on the factors described above) include AQ1, AQ3, AQ5, AQ10, AQ11 and AQ13 for any EC, as well as AQ15 for species EC only.
4. If you have quantitative data, a general rule is that, if you can measure the quantitative version of a specific AQ in one subzone (e.g. AQ2, AQ4, AQ11), then you should be able to also measure the qualitative version of the same AQ in that subzone (e.g. AQ1, AQ3, AQ10) as well as AQ7.
5. If you have quantitative data and you can measure AQ2 (LRF), then you should also be able to measure AQ8 and AQ9 as these AQs focus on ROF, which are all the other species or habitats in your assemblage (other than LRF) and require quantitative data. If you are unable to establish which features in your assemblage are LRF, then you would also be unable to identify which features are ROF and therefore could not measure either AQ1/2 or AQ8/9. However, if you are able to assess the features in your assemblage for local rarity and you can establish that none of those in your data is LRF (see example given in point 2), then you would be able to say that all features in your dataset are ROF and therefore you should be able to apply AQs 8 and 9 (provided that you have quantitative data).

Q (05/07/2024): **Number of subzones assessed per AQ:** Can the number of subzones assessed for a given EC be different between AQs?

A: The possible cases are these:

1. You have abundance data for X subzones (sbz) (excluding blanks): in this case you should be able to answer multiple AQs (AQ7 as a minimum, plus others depending on whether you can identify LRF, RRF, NRF, ESF etc. in your data), including both quantitative and qualitative AQs (as if you have abundance, then you will be able also to know presence/absence). No matter

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which AQs you answer, the number of subzones assessed for them should always be X (with variable number of zeros).

2. You only have presence data for Y sbz (excluding blanks): in this case you should be able to answer multiple AQs (AQ7 as a minimum, plus others depending on whether you can identify LRF, RRF, NRF, ESF etc. in your data), but only amongst those requiring qualitative data (hence no AQ2, AQ4, AQ6, AQ8-9, AQ11, AQ13, AQ15). No matter which qualitative AQs you answer, the number of subzones assessed for them should always be Y (with variable number of zeros).
3. You have abundance data for X sbz, but also presence/absence data that cover additional Y sbz: in this case you should be able to answer multiple AQs (AQ7 as a minimum, plus others depending on whether you can identify LRF, RRF, NRF, ESF etc. in your data). You should be able to answer the qualitative AQs in all the sbz where you have data (of any type), while you will be able to answer the quantitative AQs only in the sbz where you have abundance data (subzones with only presence/absence data will have blanks for the quantitative AQs). In this case, it is reasonable to expect a difference in the number of subzones between AQs, in that, all the quantitative AQs that you assess will only have measures (incl. 0) in X sbz, while all the qualitative AQs that you assess will have measures (incl. 0) in X+Y sbz.

Q (06/07/2025): Clarification about **AQ standardisation/scaling** – should an AQ value be expected to cover the full 0-5 range across the grid cells assessed in an area?

A: Although the AQ values may theoretically vary on between 0 and 5, the full range is represented by the values across the grid cells, as the theoretical maximum diversity might not be realised in any of these areas. To clarify, see example below:

Say, you are calculating AQ7 for benthic habitats and in your BBT you have 9 habitats. Each habitat is assigned 0 or 5 in a subzone depending on its absence or presence. You will only have AQ7 observed max=5 if you have all 9 habitats occurring in one subzone/grid cell, but this might not happen and it might be that the highest habitat diversity you get in any subzone in your BBT is 6 habitats, which would lead to AQ7 observed max = 3.33 [=(5+5+5+5+5+5+0+0+0)/9]. Therefore, the observed max for the AQ may be lower than the theoretical max (5).

Q (30/10/2024): Wouldn't **averaging EV scores** homogenise the results across the map?

A: The aggregation of values (AQs into EC-specific EV and EC-specific EV into Total EV) in the EVA method is currently done by averaging the values (first across AQs and then across ECs). It has been commented that averaging might 'homogenise' the results across the maps, and this seems a valid point also by looking at the EV maps resulting from the work done in the BBTs. Based on this, the aggregation method has changed, whereby the <u>maximum value</u> is used (across AQs to derive the EC-specific EV, and across ECs to derive the total EV) instead of the average***. The EVA protocol has been changed accordingly***. It is highlighted that <u>this change in method has consequences for the way AQs are selected for the assessment and also for how the confidence is represented</u>. These parts of the protocol have been changed accordingly, as also highlighted in the relevant questions reported here (see sections on 'Assessment criteria and questions' and 'Phase 3 - Confidence').

<u>Other</u>

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Q (11/07/2023): Each EC is currently given equal weight in the calculation of the final EV. Can alternative **weighting options for the ECs** be explored, e.g., to also account for different conservation or other type of human value assigned to different ECs?

A: Each EC is given equal weight in the calculation of the final EV because the assessment measures the intrinsic ecological value, and all ECs are considered equally important to support the ecosystem and its functioning. Giving different weights to the ECs, e.g. based on the different conservation or other type of human value assigned to different ECs, would lead to a different type of assessment, considering that the key principle of EVA is to assess the intrinsic ecological value of an ecosystem, independently from human interactions/uses, hence solely from an eco-centric perspective. Identifying which ECs are more important (hence bring more weight) from a purely ecological point of view would require philosophical discussions and expert input. The work in Tasks 4.2 and 4.3 may also help in defining different weights from a more anthropo-centric perspective (e.g. based on good and benefits to society and economic value). At the EVA workshop on 9 June 2023 it was agreed that the EVA giving equal weighting to the ECs should be prioritised for the baseline application in the BBTs, but discussions about alternative weightings may be undertaken throughout the project and the results applied as additional implementations, where appropriate. The Analytical Hierarchical Process (AHP) methodology was suggested to derive different weights from an expert judgment perspective; this involves collecting information from local experts and performing repeated pairwise judgments to produce consistent relative weightings.

Q (11/07/2023): Can **EVs be compared between different BBTs** across Europe?

A: No. The metrics (and resulting EVs) are expressed as a relative score which depends on the diversity measured across the subzones (grid cells) in the individual BBT. For example, if the range of nationally rare seabird species in one BBT (across its subzones) is between 0-6 and 0-22 in another BBT, a subzone with 6 rare seabirds in the first BBT and one with 22 rare seabirds in the second BBT will both score 5 for that metric, and they will both contribute equally to the calculation of EV.

In order for the EV results to be comparable between BBTs, a different re-scaling procedure for the AQs would be needed. This would involve applying the algorithms to obtain the EV scores using the variability range (min-max) of each metric (AQ) ACROSS all the BBTs (instead of WITHIN a BBT, as done in current protocol), ensuring that the final EV is comparable between them. However, there are factors of variability at the wider geographical scale that may influence the variability of the metrics and therefore of the resulting EV across BBTs but that might not necessarily reflect a change in intrinsic value of the ecosystem (e.g., naturally low diversity areas/regions, effects of biogeography). These should be taken into account.

2.3.2.3 Phase 3 – Confidence

Q (12/01/2024): Available mapped data (e.g., EUNIS habitat maps or indeed any other spatial predictions of distribution of species for different ecosystem components) may have incomplete coverage of an area, and therefore **% of mapped area** may be <100% in some subzones/grid cells. This **may also account for data availability** and therefore affect the confidence assessment. However, currently, data availability is only measured as number of samples/observations available in the subzone (Table 8 of the EVA guidance), and only for data directly derived from monitoring. How can the aspect of data availability represented by % area mapped/covered by the data be included in the confidence assessment.

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A: The % of area covered by the data (monitored or predicted by a spatial model) is certainly an important aspect of data availability for certain types of data (e.g. EUNIS maps for the habitat EC). ***The EVA guidance document has been updated accordingly (with changes to the protocol for confidence assessment in the text, Tables 7 and 8 and Figure 3)***

Q (30/10/2024): Amendments to the **classification of data availability for monitoring data** (to define wi)

A: Where monitoring data are used to inform the EVA, data availability is measured as number of samples or observations used for the AQ calculations in a grid cell and it is classified by dividing its range (min-max across all grid cells) into 5 equally-sized classes. The EVA implementation undertaken MARBEFES (e.g., in the North Sea BBT7) has shown that the range of number of samples used to inform the EV calculations may be very wide (e.g., up to around 1000 samples in some cells for BBT7) and a skewed distribution is not uncommon (e.g., only very few cells would have data availability close to the maximum, and most of cells would be closer to the minimum). As a result, the current method for classifying data availability across their range (using fixed/equal-sized classes dividing the range) would lead to most of the grid cells in the area having low data availability, leading to low-confidence grid cells dominating the map (as a reflection of the skewed distribution of the data availability across grid cells). Taking this into consideration, the approach for classifying data availability within their range has been changed, whereby the data availability range is to be divided into **20% quantiles** (hence accounting for the distribution of data within the range) to derive the five classes. ***The EVA guidance document has been updated accordingly.***

An illustration of the problem and the protocol change applied is given in the figures below:

Proposed changes to EVA protocol

2. Phase 3 - Confidence:

Step: classification of data availability (to define w_i)

Problem: data availability may vary widely across grid cells and distribution may be right skewed *(example: # of samples in the grid cells ranges 3 to 500, but only one grid cell has 500 samples, and most grid cells have <5 samples)*. Classifying the data availability (from low to high, 5 classes) by dividing the min-max range into 5 equally-sized classes may lead to confidence map with most cells with low confidence.

Solution: use 20% quantiles to divide the min-max range

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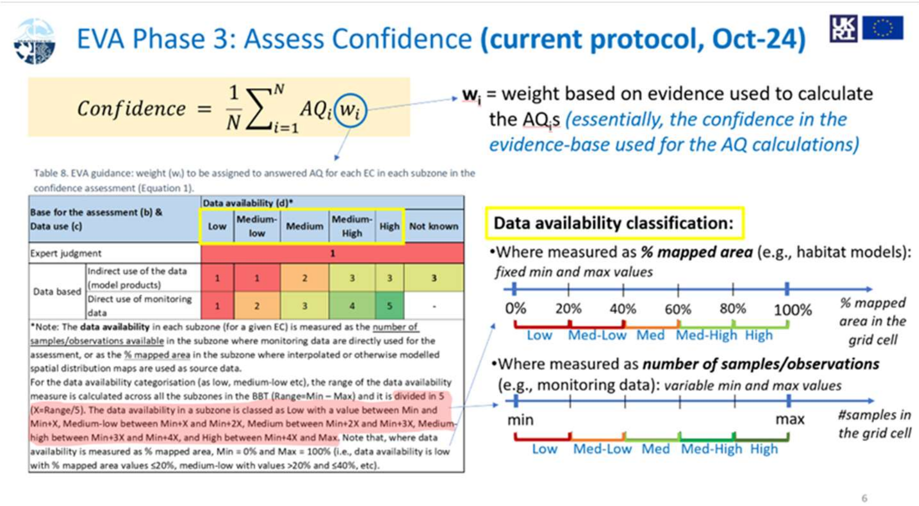
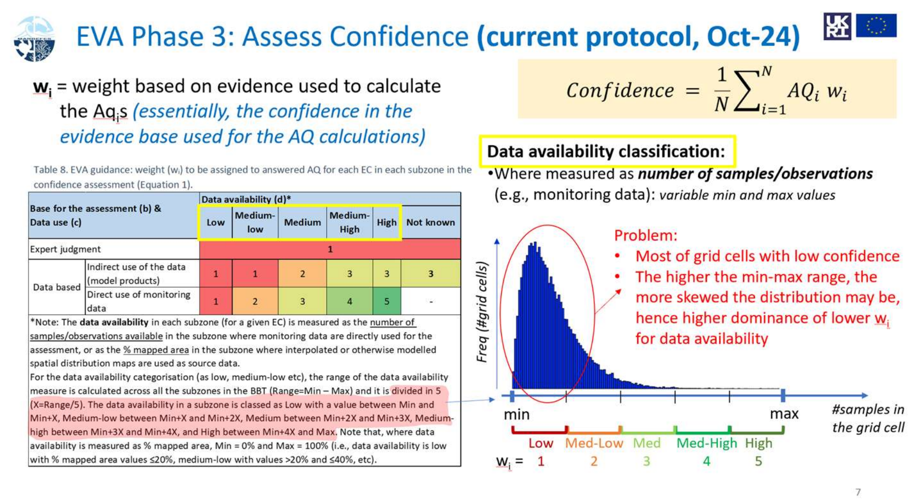


Table 8. EVA guidance: weight (w_i) to be assigned to answered AQ for each EC in each subzone in the confidence assessment (Equation 1).

Base for the assessment (b) & Data use (c)		Data availability (d)* Low	Medium-low	Medium	Medium-High	High	Not known
Expert judgment		1					
Data based	Indirect use of the data (model products)	1	1	2	3	3	3
	Direct use of monitoring data	1	2	3	4	5	-

*Note: The **data availability** in each subzone (for a given EC) is measured as the number of samples/observations available in the subzone where monitoring data are directly used for the assessment, or as the % mapped area in the subzone where interpolated or otherwise modelled spatial distribution maps are used as source data.
For the data availability categorisation (as low, medium-low etc), the range of the data availability measure is calculated across all the subzones in the BBT (Range=Min – Max) and it is divided in 5 (X=Range/5). The data availability in a subzone is classed as Low with a value between Min and Min+X, Medium-low between Min+X and Min+2X, Medium between Min+2X and Min+3X, Medium-high between Min+3X and Min+4X, and High between Min+4X and Max. Note that, where data availability is measured as % mapped area, Min = 0% and Max = 100% (i.e., data availability is low with % mapped area values ≤20%, medium-low with values >20% and ≤40%, etc).



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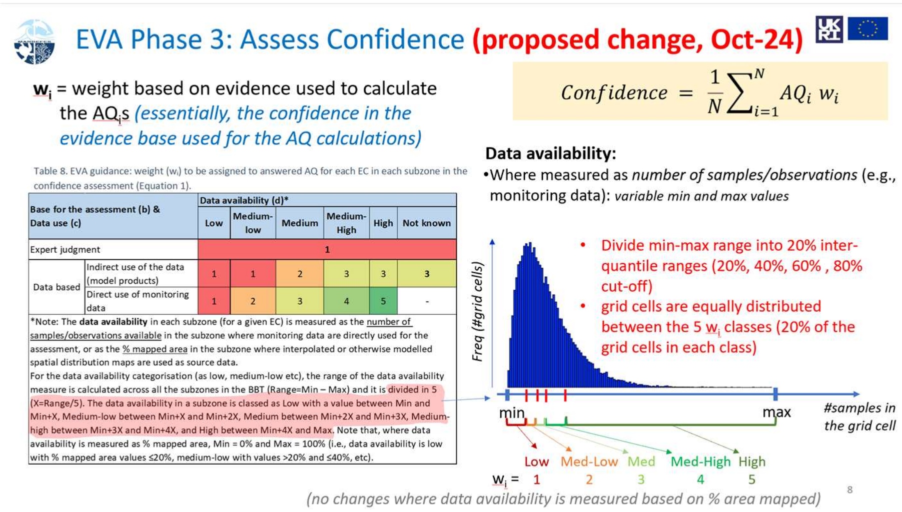

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Q (30/10/2024): *[following changes in AQ/EV aggregation method]* I have one question though about calculating final confidence scores - not exactly sure how to approach it (is it using confidence scores

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from the EC that had the highest EV in the subzone, or is the highest confidence score from whichever EC had the highest confidence in the subzone?) I'm assuming it's the first one, but please let me know if that's correct and I'll amend accordingly.

A: Following the change in the method for aggregating EC-specific EV results into a total EV (see 'Q (30/10/2024): Wouldn't averaging EV scores homogenise the results across the map?), the way confidence values are transferred between result representation was adjusted as follows. To express the confidence for the total EV integrating multiple ECs in a subzone, the confidence associated with the EC selected to represent the total EV in the subzone (i.e., the EC having the highest EV compared to the other ECs in that subzone) is to be used. Therefore, the answer to the question above is that the first option is more appropriate to give the confidence associated with the actual EV in the cell/subzone. ***The EVA guidance document has been updated accordingly.***

Other

Q (11/07/2023): **Additional work on biological valuation** in the Baltic was done by Węslawski et al. (2009)

A: ***This has been added to the EVA guidance.***

Q (11/07/2023): **Interaction of EVA with other WPs** in MARBEFES

A: Once the EVA tool has been tested and implemented in the BBTs, it might be possible to incorporate information resulting from WP3 into the EVA to enhance the tool (e.g., incorporating outputs from the ecological models and data from innovative monitoring methods to inform the assessment). This would also be an opportunity to explore incorporating more functional aspects into the tool. EVA tool features may also be considered in WP6, when addressing upscaling, relevance to other areas, and potentially other challenges.

Q (11/07/2023): The proposed **EVA approach is only one of many approaches** that can be used to assess the ecological value of an ecosystem. Can BBTs apply other approaches?

A: It is fine that there are other approaches, but, for standardisation, the same EVA protocol should be applied across BBTs, as a minimum. Should the BBTs want to implement alternative approaches, they are free to do it in addition to the standardised approach. If so, circulating the information on the pros and cons of different approaches would be good.

Q (27/11/2023): A **phased implementation of the EVA protocol by the BBTs** has been agreed, with meetings and discussions at the end of each assessment phase.

A: The timeline for the phased implementation of the EVA protocol by the BBTs within Year 2 of the project is as follows:

- Phase 1: the BBT defines the study system by mapping the BBT area and the spatial grids for the relevant ECs; identifies, gathers and maps (on the selected grids) the relevant evidence for the assessment; prepares the data (e.g., where they need to be aggregated or

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standardised from multiple surveys if needed); identifies which subset of species or habitats are relevant to the different questions of the assessment (based on Table 6 of the guidance); extracts the values for each grid cell (e.g., as average of the data points within a cell) into the data matrix that will be used to calculate the metrics during Phase 2. The data matrix will have rows = grid cells in the BBT, columns = variable (indicator of presence/absence and/or abundance, as derived from the original evidence) for each feature of an EC (species in each species group, or habitat types from the EUNIS habitat map). Timeline: Month 13-16/17 (September 2023 to December 2023/ January 2024)

- Phase 2: the BBT applies the algorithm for the calculation of the different metrics (see Table 6 of the EVA guidance) to the data matrix to obtain the resulting score values for each question; combines the scores across questions for each EC into the EC-specific EV; combines the scores across EC into the total EV; maps the resulting scores back into the BBT grid. Timeline: Month 17-20/21 (January to April/May 2024).
- Phase 3: the BBT calculates the confidence criteria and overall score and maps the results into the BBT grid. Month 21-24 (May to August 2024).

Please note that we are not asking for the BBTs to provide any output for each phase. The timeline above is there just to help the BBTs to organise their work for the implementation of the EVA protocol, and so that all BBTs are working on the same phase. This way, if a BBT has an issue during one phase, the solution can be shared as it could also help other BBTs who are at the same stage of the EVA implementation. We plan to organise a meeting with the BBTs at the end of each phase to discuss the challenges faced by different groups and find solutions to overcome similar issues, thus progressing to the next phase. We will provide support to individual BBTs during each phase, e.g. to check or review intermediate outputs and spreadsheets and help overcome possible issues, where needed.

Q (21/10/2024): I have created a few slides (below) summarising the guidance on the EVA confidence assessment, and also including a couple of mock-up examples of how the confidence score is calculated.

A: .

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EVA Phase 3: Assess Confidence

A **CONFIDENCE SCORE** is associated to each EV result, considering multiple sources of uncertainty:

$$Confidence = \frac{1}{N}\sum_{i=1}^{N} AQ_i\, w_i$$

AQ_i = 1 if the AQ_i has been answered, 0 if not

N = max. number of AQs defined for the EC (13 for habitat-based ECs, 15 for species-based ECs)

w_i = weight based on evidence used; see Table 8

As a result, confidence score varies between 0 and 5

Table 8. EVA guidance: weight (w_i) to be assigned to answered AQ for each EC in each subzone in the confidence assessment (Equation 1).

Base for the assessment (b) & Data use (c)		Data availability (d)*					
		Low	Medium-low	Medium	Medium-High	High	Not known
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EVA Phase 3: Assess Confidence

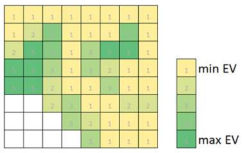
Example (mock-up): Benthic habitats EC

$$Confidence = \frac{1}{N}\sum_{i=1}^{N} AQ_i\, w_i$$

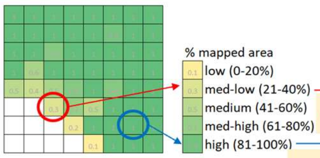
(value ranging 0-5)

EV map:

EV calculated based on AQ1, AQ2, AQ7, AQ8, AQ9, AQ12, AQ13



- Data source: EUNIS habitat map
- Data availability:



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Expert judgment		1					
Data based	Indirect use of the data (model products)	1	1	2	3	3	3
	Direct use of monitoring data	1	2	3	4	5	-

$$Confidence = \frac{1}{13}(1+1+0+0+0+0+1+1+1+0+0+1+1) * 1 = \mathbf{0.54}$$

$$Confidence = \frac{1}{13}(\overset{AQ1}{1}+\overset{AQ2}{1}+\overset{AQ3}{0}+\overset{AQ4}{0}+\overset{AQ5}{0}+\overset{AQ6}{0}+\overset{AQ7}{1}+\overset{AQ8}{1}+\overset{AQ9}{1}+\overset{AQ10}{0}+\overset{AQ11}{0}+\overset{AQ12}{1}+\overset{AQ13}{1}) * 3 = \mathbf{1.62}$$

13 AQs for benthic habitats EC

w=3 for all AQs as the same data have been used

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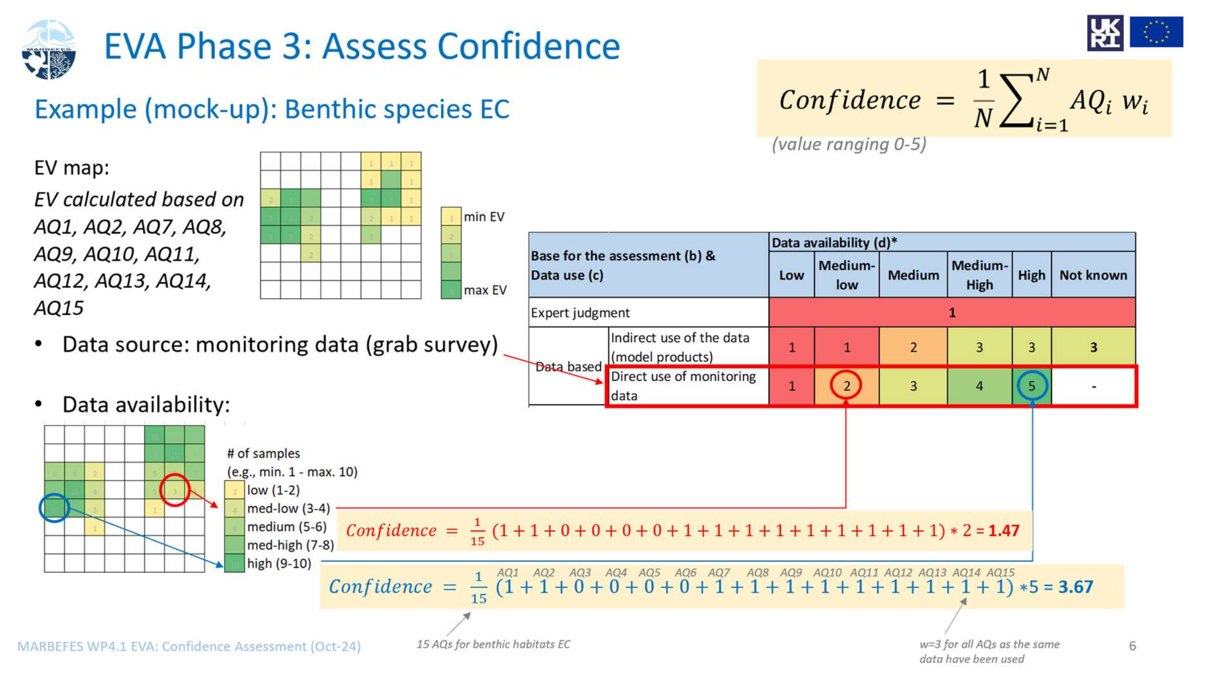

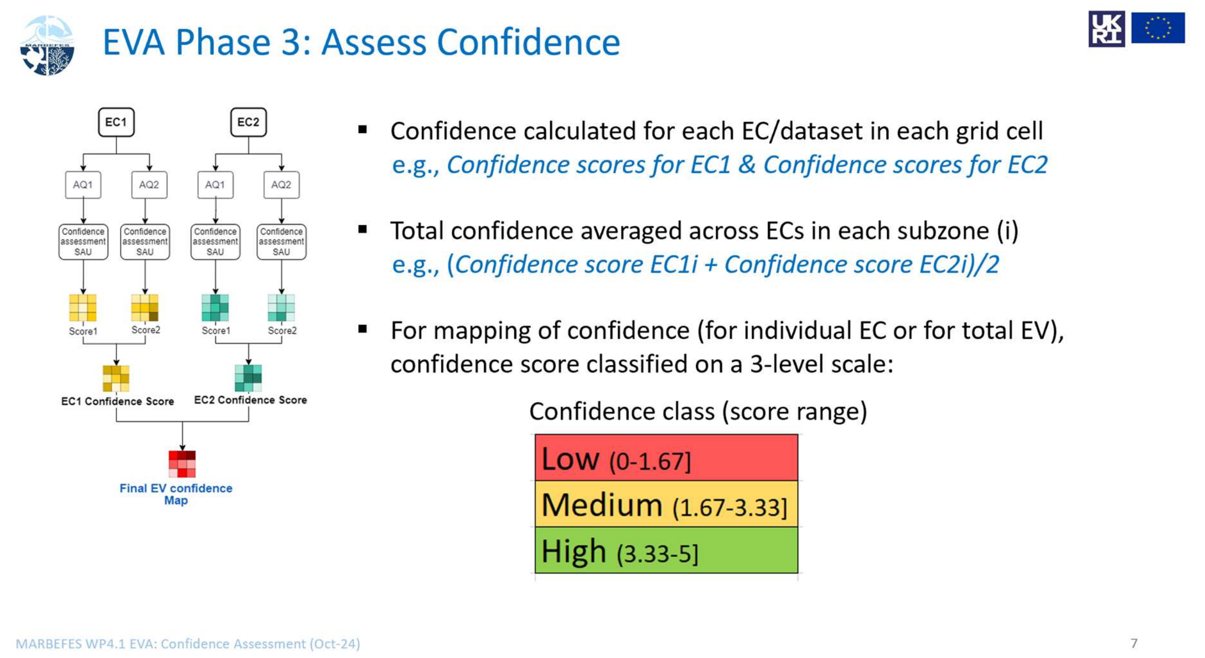

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Note: additional references are cited and given in Appendix 1.

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Guide 1: EVA - APPENDIX 1 – Ecological value and the properties of an ecosystem

This appendix provides definitions and background discussion on the following topics (numbered according to the section of the appendix):

1. **Ecological value and Ecological valuation**;
2. **Ecosystem properties relevant to Ecological valuation;**
3. **Other ecosystem properties;**
4. **Additional terms**.

For each of these sections, definitions of concepts are given, with additional information and considerations provided as resulting from the critical review of the available literature relevant to ecological valuation. Where it was deemed necessary (e.g., for better clarity), definitions of some terms given in the literature have been revised. In this case, the definition is referred to as 'modified from' the relevant literature.

1. Ecological value and Ecological valuation

Definitions of Ecological value and Ecological valuation are given below (in bold) as per literature on this topic.

Synonyms and additional information to clarify the concepts defined are also provided.

ECOLOGICAL VALUE

The intrinsic value of the qualities of an ecosystem, regardless of its anthropogenic use or social interests. It is a property of the ecosystem/biodiversity, and is measured in non-monetary terms or even metaphysical ways (modified from Smith and Theberge 1986, Derous et al. 2007a).

Synonyms: biological value, ecological value, intrinsic value, inherent value (of nature/biodiversity).

Additional information: Ecosystem qualities is the attribute valued, covering all levels of biodiversity, from genetic diversity to ecosystem processes. Ecological value is the inherent value of such qualities hence it is a property of biodiversity that does not depend on or is related to human use (non-utilitarian perspective).

Note that an ecosystem may also have qualities that do not reflect an inherent value of biodiversity, but rather have their value attributed in relation to human use, interactions or associations with the environment. For example, where an ecosystem is valued for its ability to provide goods and benefits to human society (this will be investigated in detail in Tasks 4.2- 4.3 of MARBEFES WP4), or where a conservation value is assigned to an ecosystem or its components due to their sensitivity to anthropogenic disturbance. These ecosystem qualities reflecting non-inherent values ARE NOT part of the ecological value as defined here and in the literature (Derous et al. 2007a, b, and derived applications). It is of note however that, although the conservation value is not an inherent value *per*

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se, ecosystem components which have a conservation value may also have an inherent ecological value.

ECOLOGICAL VALUATION

The process of assigning ecological value to an area through the integration of the intrinsic value of the ecosystem qualities within the area (modified from Derous et al. 2007a, 2007b).

Synonyms: biological valuation.

Additional information: Ecological valuation is a spatial/geographical non-monetary assessment which integrates the inherent value of ecosystem qualities measured across multiple ecosystem components (e.g., habitats, species, ecosystem processes/functions) characterising a geographic area of interest (case study area). The combination of ecosystem components within an area contributes to its ecological valuation against a set of criteria assessing their ecosystem qualities (e.g., rarity, fitness consequences – see Section 2 of this appendix).

It is a tool able to highlight subzones that have particularly high ecological or biological significance and to provide a greater-than-usual degree of risk aversion in spatial planning activities in these subzones (Derous et al. 2007b). It does not consider management criteria and quantitative conservation targets (Derous et al. 2007a).

The case study area is divided into spatial assessment units (called 'subzones' in Derous et al. 2007a, 2007b), which can be identified through a regular spatial grid or other ecologically meaningful spatial subdivision. Note that the spatial scale/resolution of the subdivisions may differ depending on the ecological feature assessed individually (e.g., coarser resolution for highly mobile species), before integration is undertaken across ecosystem components (through the overlapping of the related subzones) for the overall ecological value. An ecological value is assigned to each subzone in relative terms, i.e., relative to the other subzones in the case study area.

The ecological valuation process as originally developed in Derous et al. (2007a, 2007b) is graphically summarised in Figure A1.

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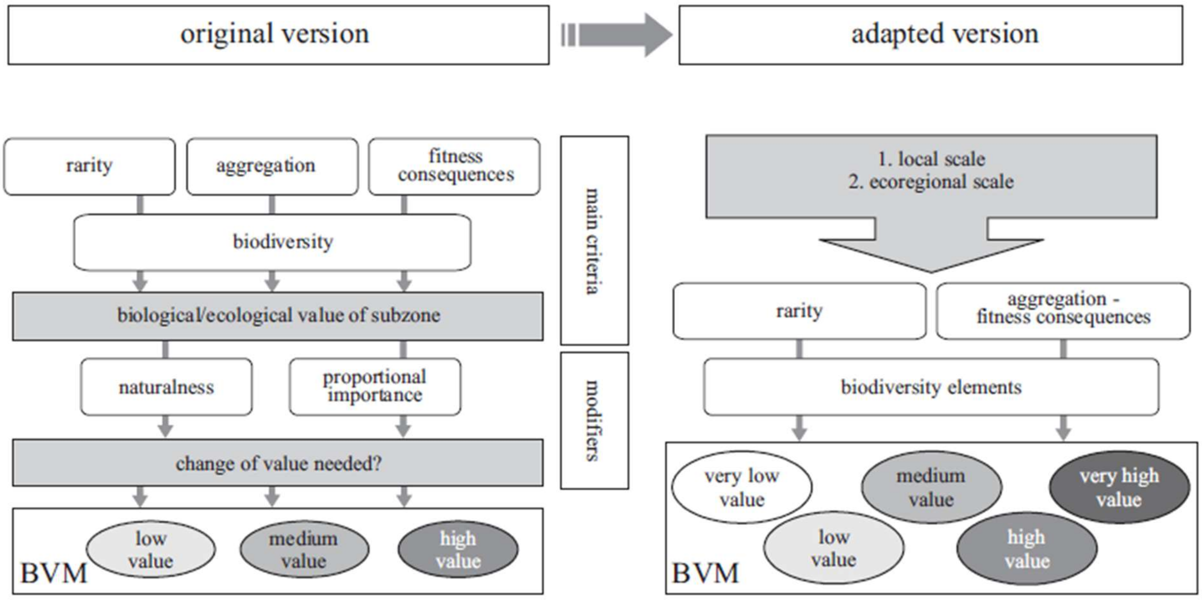

Figure A1. Adaptation of the concept for marine biological valuation, from original version (Derous et al. 2007a) to adapted version (Derous et al. 2007b). BVM= biological valuation map. From: Derous et al. (2007b).

2. Ecosystem properties relevant to Ecological valuation

A list of properties that are relevant to the ecological valuation of an ecosystem (i.e., properties of the ecosystem which have an inherent ecological value) is provided in this section, with definitions of the terms and additional information.

BIODIVERSITY

Synonym: Biological diversity

All aspects of variability within the living world, including diversity within and between individuals, populations, species, communities, and ecosystems (Convention on Biological Diversity Article 2, United Nations 1992)

Attributes of biodiversity include structures and processes existing on different organisational levels (viz. genes, species, population, community and ecosystem) (Zacharias and Roff 2000; see Figure A2).

Surrogate measures for biodiversity have been implicitly included in some form in previous ecological valuation approaches (e.g. Derous et al. 2007a, 2007b), albeit not as a stand-alone valuation criterion but rather as the attribute being measured under other valuation criteria.

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The components of marine biodiversity:

GENETIC		SPECIES/ POPULATION		COMMUNITY		ECOSYSTEM	
Structure	Process	Structure	Process	Structure	Process	Structure	Process
Structure	Mutation	Structure	Migration	Structure	Succession	Watermass	Currents
Genotypes	Differentiat.	Abundance	Dispersion	S.Diversity	Predation	Temp	Tides
Fitness	Drift	Distribut	Retention	S. Richness	Competit.	Salinity	Disturban.
Haplotype D	Flow	Focal Spp	Mig/ Drift	S. Evenness	Parasitism	Properties	Gyres
Stocks	Nat. Select	Keystone	Growth	Abundance	Mutualism	Boundaries	Retention
	Inbreeding	Ind. Cond.	Reprod.	Represent.	Disease	Depth/Pres	P-B couple
	Mating	Ind. Comp.	Recruit	Distinctive	Production	Light	Entrain.
	Dir. Select	Umbrella		Biomes	Decomp.	Stratificat.	B-G cycles
	Stab. select	Phenotypes		Biocoenos.		Topograph	Seasonal.
	Dis. select	Fragments		S-A relns.		Substrate	Product.
	Micro. Evol.	Meta-pops		Transitions		Represent.	H-A equil.
	Erosion			Fun.groups		Distinctive	H-L equil.
	Speciation			Heterog.		Anomalies	Turbulence
	Macro. Evol			Endemism		Exposure	Mixing
				Alt. S.Stats		Patchiness	Upwelling
				Symbioses		Nutrients	Divergence
				Biomass		Dis. Gases	Ecol.Integ.
						Anoxia	Erosion
							Desiccation

Adapted from Zacharias and Roff (2000)

Figure A2. The attributes of marine biodiversity. Source: http://www.coastalwiki.org/wiki/Biodiversity_as_a_marine_valuation_concept (Note: number of habitats/biotopes and their extent, could be added under Community or Ecosystem-Structure)

Biodiversity can be measured at different levels of biological organisation from the cell to the ecosystem. The most common measures of species diversity are species richness or diversity indices (for different ecosystem components, i.e., species groups). Similarly, habitat diversity could be measured using the extent of different habitat types (i.e. a mosaic) in the area. In turn, some levels of biodiversity (e.g., genetic) may have very fragmentary data, thus preventing their inclusion as candidates/suitable criteria for ecological valuation. Community or assemblage biodiversity is usually termed diversity; a community may be taken to imply interrelationships between species whereas an assemblage does not make that assumption (Gray and Elliott, 2009).

The practice of reducing biodiversity to a single index or a few dimensions is seen as unjustified by some authors (Derous et al., 2007a) but, despite this, is universally used, especially in quality assessments (Gray and Elliott, 2009). Assessing biodiversity only on one level (e.g., species richness) can be misleading (not representative of the biodiversity on other levels) (Derous et al. 2007a) and usually requires to be accompanied by an evenness index, thereby increasing the value of information statistics such as the Shannon-Wiener H’ index (Gray and Elliott, 2009).

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This argument highlights that biodiversity (syn. species richness), a structural characteristic, alone is not sufficient for ecological valuation and needs to be used in combination with other criteria that represent other ecosystem qualities of an area (e.g., rarity for uniqueness and aggregation or fitness consequence for the functioning of those species).

There is an increasing importance of an understanding of functioning instead of only using structural characteristics. As such, a proxy for functional diversity could be a diversity index created using functional guilds (trophic, ecological, etc) instead of only the taxonomic identity of species (i.e., based on species number or total abundance within each guild similar to using abundance within each species for species diversity/richness). Thrush et al. (2021) details many functional diversity indices, including the ability to compute them in R, and their main features.

However, including functional diversity indices might lead to double counting if other criteria included in the ecological valuation provide an assessment of functional diversity (e.g., aggregation and fitness consequence). Therefore, care must be taken when selecting criteria for the ecological valuation. Alternatively, if the overlap between different potential criteria is only partial (because they measure functional diversity in different ways, or attest for different types of functions), weighting could be introduced to reduce the overall contribution of such criteria in the final assessment.

RARITY

Synonym: Uniqueness, Distinctiveness

As a property/quality of an ecosystem component (e.g., habitats, landscapes, species, communities, ecological functions, geomorphological and/or hydrological characteristics), it qualifies being unique (the one and only, without equal, unparalleled, for which no alternatives exist), distinct (remarkable, unusual) or rare (scarce, occurring seldom, not widely distributed, having a low density, uncommon).

As a criterion for ecological valuation, rarity is the degree to which an area is characterized by unique, rare or distinct ecosystem components (landscapes/habitats/communities/species/ecological functions/geomorphological and/or hydrological characteristics) for which no alternatives exist (modified from Derous et al. 2007a, 2007b).

Rarity is one of the first-order (main) criteria for ecological valuation in Derous et al. (2007a, 2007b and derived applications).

Additional information:

An ecosystem component may be naturally rare (e.g., naturally present in small numbers or extent), or it may be so as a consequence of anthropogenic impacts (e.g. numbers depressed or extend reduced due to human actions). Natural rarity may be due to the species being at the edge of its distribution and/or outside its optimal environmental conditions; climate change migrations may increase or decrease the rarity of a species. Derous et al. (2007a) suggest to include both types in the assessment. A species recently introduced to an area by natural or anthropogenic means will also be rare.

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The assessment of rarity of an ecosystem component is scale-dependent (e.g., national, regional, global), which affects data requirements and how this criterion is measured. This can be according to international lists of rare species, habitats or communities on a local, regional or global scale; data on population size at national or regional scale; trends, area of occupancy (as a proxy for number and location of rare/unique/distinctive features in the study area) (Derous et al. 2007a, 2007b). It is therefore essential to first define the scale at which the rarity of an ecosystem component is assessed and then select the appropriate method and data accordingly. Examples of criteria to ascertain the rarity of species and habitats at different spatial scales are given in Table A1. It should be noted that a component might be nationally rare or scarce (e.g., because the component occurs in the area of interest at the edge of its range), but not necessarily regionally or globally rare or scarce.

However, a definition of rarity also has to accommodate the condition that a species may naturally not be abundant irrespective of whether its preferred conditions are prevalent, such as species with predominantly solitary individuals (e.g. echiurids). Also, note that rarity may relate to time as well as space in that species may be rare apart from breeding aggregations during the year (e.g. spider crabs). The SACFOR scale (superabundant, abundant, common, frequent, occasional, rare) is commonly used to describe such spatial and temporal patterns (Gray and Elliott, 2009).

Table A1. Examples of criteria to define the rarity of species and habitats at different spatial scales (from Derous et al. 2007a, based on UK designations and criteria).

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Rare species	**Regionally rare** (sessile or of restricted mobility) **species** = species occurring in less than 2% of the 50 × 50 km UTM grid squares of the following bathymetric zones in the region (e.g. North East Atlantic): littoral/sublittoral/bathyal, abyssal	Connor et al. (2002) (only applicable to sessile species; no guidelines available for mobile species); Connor et al. (2004); Lieberknecht et al. (2004a,b)
	Nationally rare species = species occurring in less than 0.5% of the 10 km × 10 km squares within the study area	Sanderson (1996a,1996b); Connor et al. (2004); Lieberknecht et al. (2004a,b)
	Nationally scarce species = species occurring in less than 3.5% of the 10 km x 10 km squares within the study area	
	Nationally rare species = species found in fewer than x km squares in territorial waters	Hiscock et al. (2003); Department for Environment, Food and Rural Affairs (2002)
Rare habitats	**Regionally rare habitat** = habitat type occurring in less than 2% of the 50 x 50 km UTM grid squares of the following bathymetric zones in the region (e.g. North East Atlantic): littoral/sublittoral/bathyal, abyssal	Connor et al. (2002)
	Nationally rare habitat = habitat type restricted to a limited number of locations in territorial waters	Department for Environment, Food and Rural Affairs (2002)

The scale at which rarity is defined for the ecosystem components may be different from the one at which the ecological valuation is being undertaken. The temporal aspect of rarity also needs to be defined under the methodology as something can now be rare whereas previously it was common (i.e., nearly extinct species) and conversely, species introduced to an area will be rare until they become established.

Amongst the ecosystem components and qualities that can be considered for the assessment of rarity, Derous et al. (2007a, 2007b) include: rare species, keystone species, umbrella species, endemic species, distinctive/unique biomes or communities, complex/diverse topography or seabed morphology, ecological heterogeneity, distinctive/unique ecosystems, critical processes (e.g., nutrient cycling, retention), unique/distinctive oceanographic features (with respect to temperature, salinity, stratification, anoxia, natural boundaries etc) or causing species to aggregate (e.g., natural refugia), unique/distinctive oceanographic processes (e.g., unique tidal systems, gyres, entrainment, natural

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erosion and deposition, other natural disturbance). However, some of these components (habitat-forming species, keystone species) are also considered for the assessment of fitness consequences, and therefore these should be excluded from rarity to avoid double counting.

According to these authors, accidental recordings or vagrants (termed stragglers or adventitious species in the ichthyological literature) should not be considered for the ecological valuation as they are not inherent to the ecosystem or community under consideration and hence do not contribute to the inherent biological value of the study area. However, recent entrants such as non-indigenous species should be included as they may eventually become established.

FITNESS CONSEQUENCES (or FUNCTION)

As a property/quality of an ecosystem component, it qualifies its ability to make a vital contribution to the fitness (i.e., increased survival or reproduction) of the population or species present (DFO 2004, in Derous et al. 2007a). Hence, fitness-to-survive has become a central concept in determining anthropogenic stress in an area.

As a criterion for ecological valuation, it represents the degree to which an area is a site where the activity(ies)/functions undertaken by the species there have fitness consequences, i.e., contribute significantly to the survival or reproduction of a species or population (DFO 2004). This degree may be measured by the abundance/density of the relevant ecosystem components providing such functions. For example, if the component is at species level, we are looking at the number of / presence of habitat forming species / keystone species etc. This may represent optimal habitat and environmental conditions for a species.

Fitness consequence is one of the first-order (main) criteria for ecological valuation in Derous et al. (2007a), although in later applications this criterion has been combined with the one of Aggregation (into the criterion FITNESS CONSEQUENCE and AGGREGATION) due to the potential overlap between them (Derous et al. 2007b, and derived applications).

Additional information:

In broader terms, this property can be qualified as the ability of an ecosystem component (e.g., whether species or habitat) to provide a key FUNCTION which contributes to the fitness of others (e.g., survival or reproduction of the populations/species, or a specific structural property or ecological process). However, there is the potential for confusion in combining the fitness of the individual or population (to survive) and the fitness of the environment to support those species or populations. This relates to the stress-subsidy continuum in that optimal environmental conditions for one species will create a subsidy (benefit) whereas the same conditions will reduce the fitness of another species (stress) (Elliott and Quintino, 2019).

Fitness consequence accounts for the FUNCTIONAL qualities of the ecosystem components that, through their presence or aggregation (metric), provide value to an area. For example, areas with high diversity of genetic stocks of a species (require genetic data), where individuals stop for a certain amount of time to rest or feed, or where structural habitats or keystone species are present that enhance survival and reproduction of species (e.g., refuge function) (Derous, 2007). Indicators (of the

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consequences of environmental fitness) may include habitat-forming species (ecoengineers)/biogenic habitats, keystone species, EFH (e.g., for nursery function).

To measure this functional property, there is the need to (i) first, define the function(s) of interest (e.g., habitat formation, keystone role), then (ii) define/identify the relevant ecological components (species, habitats, populations, etc) providing that function (e.g., habitat forming benthic species, keystone species) and (iii) define the metric to measure this criterion for an area (e.g. presence of habitat forming benthic species, total number of …).

It is highlighted that, when operationalising this property as a criterion for ecological valuation, there may be some overlap with other criteria (see above and below), which may depend on which ecosystem components are selected for the assessment. In particular, functional diversity based on traits analysis may be synonymous with fitness as a species suited to its own habitat, modifying its habitat and being in optimal environmental conditions. Therefore, the ecological valuation process should make allowance for this possibility so that double counting is avoided.

AGGREGATIONS

As a property/quality of an ecosystem component, it qualifies specifically species which individuals occur at high density on a temporary (e.g., in a particular season) or permanent basis. Such aggregations may be associated to the performance of key life cycle functions (e.g., wintering, resting, feeding, spawning, breeding, nursery, rearing area or migration routes). In some cases, aggregations may involve specific life stages (e.g., aggregations of juveniles of the species in nursery areas) for which the survival or fitness is enhanced by the function performed. In this sense, this property largely overlaps with fitness consequences.

As a criterion for ecological valuation, it represents the degree to which an area is a site where most individuals of a species are aggregated for some part of the year; or a site which most individuals use for some important function in their life history; or a site where some particular structural property or ecological process occurs to create exceptionally high density (DFO 2004, Derous et al. 2007a, 2007b).

One of the first-order (main) criteria for biological valuation in Derous et al. (2007a), although in later applications this criterion has been combined with the one on Fitness consequence, as mentioned before. This may be the result of aggregation merely showing that a species is in its optimal environmental conditions.

Additional information:

Criterion especially important for highly mobile species (e.g., birds, marine mammals, fish). The distribution of Essential Fish Habitat (EFH) may be an example of the application of this criterion (see EFH definition in Section 4 of this appendix).

The assessment is undertaken for subzones within the study area and the connectivity within the study area can be highlighted by clusters of subzones with similar aggregation value.

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As aggregations of mobile species may be temporary (e.g., seasonal), this may set the temporal scale for the criterion. However, it is of note that different seasons or different temporal scales may be relate only to different species, depending on their life history (e.g., for some spawning aggregations may occur in the winter, for others in the spring, for others they may occur over multiple seasons). As the criterion for ecological valuation is likely to integrate multiple components, the temporal scales integrated in the assessment need to be made explicit. The degree to which an area is a site of aggregation may be determined based on the density of one species or the number of aggregating species, which might be weighed by their respective density and/or duration of the aggregation in the year.

The definition in Derous et al. (2007a, 2007b) includes the degree to which an area acts as a site where some structural property or ecological process is exceptionally prevalent. This likely refers to aggregations of components or environmental characteristics (e.g., habitats) other than species, but which may lead to associated aggregations of species (e.g., species associated to that habitat to benefit from its structural property or the ecological process occurring in it).

NATURALNESS

Synonym: pristineness.

The characterization of an area with emphasis on its native/indigenous species (number of native/endemic species as opposed to alien, introduced or cultured species).

The characterization of an area based on the degree to which an area is currently (though not inherently) in a pristine condition and characterised by native species (i.e., absence of perturbation by human activities and number of native/endemic species as opposed to the presence of alien, introduced or cultured species (Derous et al. 2007a)).

This has been included as a second-order (modifying) criterion for biological valuation in Derous et al. (2007a), but it was not taken any further in the development of the ecological valuation protocols and in subsequent applications.

The criterion is assessed by comparison to appropriate pristine areas or reference sites, or with baseline levels or reference conditions. Alternatively, proxies for the degree of naturalness can be used, e.g., information on the presence of native and absence of introduced species in the study area. While the presence or abundance of native species may provide an added value to the ecological value of an ecosystem, considering the absence of introduced species or the comparison with pristine/reference conditions (which are often defined according to the absence of anthropogenic pressures, e.g. sensu Water Framework Directive) implicitly account for the interaction with anthropogenic factors which is outside of the scope of ecological valuation.

IRREPLACEABILITY

Referred to habitats: Habitats which would be technically very difficult (or take a very significant amount of time) to restore, recreate or replace once destroyed, taking into account their age, uniqueness, species diversity or rarity (NPFF Glossary, UK Government 2021). They include for example sand dunes and salt marsh.

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If an ecosystem component is irreplaceable, it is often because it is either rare, the richness is high, it possesses a functional quality that is unique for fitness or for aggregation. These are qualities that are already included in other Ecological Valuation criteria (e.g., rarity, fitness consequences/aggregations) and therefore irreplaceability should/would not be included as an additional criterion in Ecological Valuation to avoid double counting.

ENDEMISM

It refers to the confinement of a habitat or species to a territory of variable extent (e.g., present within a localised area). For the study of endemicity, the exclusive geographical distribution of the habitat or species is assessed.

This quality is considered the same as Naturalness (endemic or native species) and therefore endemism is not included as an additional criterion in Ecological Valuation to avoid double counting.

PROPORTIONAL IMPORTANCE

The definition is scale-dependent (Derous et al. 2007a and references therein):

Global importance: proportion of the global extent of a feature (habitat/seascape) or proportion of the global population of a species occurring in a certain subarea within the study area.

Regional importance: proportion of the regional (e.g., NE Atlantic region) extent of a feature (habitat/seascape) or proportion of the regional population of a species occurring in a certain subarea within the study area. For example, supporting 1% of the international seabird population confers international importance.

National importance: proportion of the national extent of a feature (habitat/ seascape) or proportion of the national population of a species occurring in a certain subarea within territorial waters. For example, supporting 1% of the national seabird population confers national importance.

The assessment of this quality requires data on the extent of marine features or population data of individual species. Thresholds for the term ‘high proportion’ are very scale-dependent and should therefore be set for every case study separately (Derous et al. 2007a). However, as indicated above, there are agreed national and international standards for this attribute in the case of seabirds and wading birds.

This is one of the second-order (modifying) criteria for biological valuation in Derous et al. (2007a), but it was not taken any further in the development of the ecological valuation protocols and in subsequent applications. It has been suggested that this property is inherently included in the assessment when the scale of the assessment is defined.

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3. Other ecosystem properties

Other properties for which an ecosystem and its biodiversity may be valued, but that are not commonly used for ecological valuation as their value is ascribed in relation to human association (e.g., in response to a pressure).

SENSITIVITY

Sensitivity, in the context of environmental change, is the "susceptibility of a defined component of the system to harm, resulting from exposure to stressors" (Cinner et al., 2013).

The likelihood of change when a pressure (which could be chemical, physical, hydrological or biological) is applied to a species or habitat. It is a function of the ability of the habitat or species to tolerate or resist change (resistance or tolerance) and the rate (or time taken) for it to recover from impact (resilience or recovery) (Tillin & Tyler-Walters, 2014).

The intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery (Tyler-Walters & Hiscock 2005).

Sensitivity (as well as other qualities as vulnerability, fragility etc.) can only be considered in relation to a particular pressure or stressor. If the stressor is a natural environmental characteristic then it should be included whereas if an anthropogenic stressor then not so. As such, it is not considered a property with inherent ecological value and, as such, is not considered as a suitable ecological valuation criterion.

VULNERABILITY

A measure of the degree of exposure of a receptor to a pressure to which it is sensitive (based on Hiscock et al., 1999, Oakwood Environmental Ltd., 2002). (Definition used in Marine Evidence based Sensitivity Assessment (MarESA), https://www.marlin.ac.uk/sensitivity/sensitivity_rationale)

See comments above (in relation to sensitivity).

FRAGILITY

Synonyms: attribute associated to being delicate, in a weakened state, tenuous.

A characteristic of a species or habitat identifying its ability to be broken easily.

This can be seen as a particular case of sensitivity (specifically to physical disturbance) hence the considerations above for sensitivity apply here. Fragility and vulnerability will contribute to a species or community being rare and therefore are implicitly included in the ecological value assessment through the criterion of rarity.

CONNECTIVITY

'Ecological connectivity' is the unimpeded movement of species and the flow of natural processes that sustain life on Earth (CMS, 2020).

The flow of materials, energy, and/or organisms, genes, etc. across space (e.g. among habitat patches or regions of interests). Specifically, ecological connectivity can include propagule dispersal, adult

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movement, species migrations, species interactions, and ontogenetic linkages, with the associated flows of energy and matter (Beger et al., 2022).

Connectivity is a dynamic ecological (flow) process that emphasises the inter-dependence of different areas (e.g. habitats, patches) which underpins the persistence of populations, species, communities, and ecosystems in an area. As such, it has a pivotal role in conservation strategies (see for example IUCN guidelines for conserving connectivity; Hilty et al., 2020), although its operationalisation is still limited in spatial conservation planning (Beger et al., 2022). See also connectivity as a network criterion in the design of MPA networks (below).

MPA NETWORK COHERENCE CRITERIA

REPRESENTATIVITY, ADEQUACY, VIABILITY, CONNECTIVITY and REPLICATION are used as criteria for the designation and assessment of the coherence of MPA networks: (the definitions below are derived from HELCOM MPA designation guidance[1] and are in line with those in the UK MCZ Ecological Network Guidance[2], as based on guidance agreed by the OSPAR Commission[3])

- Representativity is captured by a network when the network consists of areas representing the different biogeographical subdivisions of the sea, which in turn reflect the full range of ecosystems, including the biotic and habitat diversity of those marine ecosystems.
- Adequate and viable sites indicate that all sites within a network should have size and protection sufficient to ensure the ecological viability and integrity of the feature(s) for which they were selected.
- Connectivity in the design of a network allows for linkages whereby protected sites benefit from larval and/or species exchanges, and functional linkages from other network sites.
- Replication of ecological features (species, habitats and ecological processes) requires that more than one site shall contain examples of a given feature in the given biogeographic area.

These do not represent the ecological value of a study area *per se*, but in relation to the network of MPAs, i.e., a management measure. As such, these are not considered as suitable ecological valuation criteria.

4. Additional terms

Additional terminology that may be used or related to ecological value assessment is reported below. Please note that this is not an exhaustive list. The terms are provided in alphabetical order.

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[1] https://helcom.fi/wp-content/uploads/2022/08/HELCOM-MPA-designation-guidelines.pdf
[2] https://data.jncc.gov.uk/data/94f961af-0bfc-4787-92d7-0c3bcf0fd083/MCZ-Ecological-Network-Guidance-2010.pdf
[3] http://www.ospar.org/content/content.asp?menu=00700302210000_000000_000000

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ECOSYSTEM-BASED MANAGEMENT

The comprehensive integrated management of human activities based upon the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of goods and services and maintenance of ecosystem integrity (ICES 2003). The main underlying philosophy is *Ecosystem Based Management* and the *Ecosystem Based Approach* – as first developed by the UN Convention for Biological Diversity, this is defined as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. As such, its application will help to reach a balance of these three objectives of the Convention. It is based on applying appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. Furthermore, it recognizes that humans, with their cultural diversity, are an integral component of ecosystems.

ESSENTIAL FISH HABITAT (EFH)

"...those waters and substrata necessary to fish for spawning, breeding, feeding, or growth to maturity" (U.S. Magnuson-Stevens Fishery Conservation and Management Act 1976).

Additional information: The EFH definition has been operationalised as the habitat performing a specific function (e.g., nursery, refugia, spawning) for key life stages (e.g., juveniles) or processes (e.g., spawning) of fish/shellfish species, and that supports aggregations (higher densities) of the associated individuals/life stages of the species (hence having an 'added value' compared to other habitats where the species/life stages occur). The degree by which a site provides the EFH function can be measured for example based on the probability of occurrence of aggregations of the relevant species/life stage (Franco et al., 2022).

Habitat is intended in its wider meaning, including habitat types, the combination of environmental and biotic conditions in an area.

EXPOSURE

The action of a pressure on an ecosystem component, with regard to the extent, magnitude and duration of the pressure (Robinson et al., 2008). (Definition used in Marine Evidence based Sensitivity Assessment (MarESA), https://www.marlin.ac.uk/sensitivity/sensitivity_rationale).

PRESSURE

The mechanism through which a human activity has direct or indirect effects on any part of the ecosystem. The nature of the pressure is determined by activity type, intensity and distribution (Robinson et al., 2008). (Definition used in Marine Evidence based Sensitivity Assessment (MarESA), https://www.marlin.ac.uk/sensitivity/sensitivity_rationale).

RESILIENCE

Synonym: Recoverability.

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The degree to which an ecosystem or a part/component of it is able to recover from disturbance without major persistent change (Orians, 1974).

The ability of a receptor to recover from disturbance or stress (Holling 1973). (Definition used in Marine Evidence based Sensitivity Assessment (MarESA), https://www.marlin.ac.uk/sensitivity/sensitivity_rationale).

Recovery may be partial or complete with the difference between regarded as hysteresis (Elliott et al., 2007; Tett et al., 2013). However, the move towards another state may be regarded as a tipping point and in which the system will not regain its original form even if the stressor is removed.

RESISTANCE

Synonym: Intolerance.

Resistance characteristics indicate whether a receptor can absorb disturbance or stress without changing character (Holling 1973). (Definition used in Marine Evidence based Sensitivity Assessment (MarESA), https://www.marlin.ac.uk/sensitivity/sensitivity_rationale). The shift from an unimpacted state to an impacted one along a trajectory of degradation will be regarded as a threshold.

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MARBEFES project has received funding from the European Union's Horizon Europe research and innovation programme under

Grant Agreement no 101060937

Guide 1: EVA - APPENDIX 2 – Ecological Significant Species examples

Examples of Ecological Significant Species included in the literature applying EVA are provided below. Please note that this is not an exhaustive list.

Examples of Ecological Significant Species	Geographical area (Reference)
<u>Macrobenthos</u> *Protodorvillea kefersteini, Pisione remota, Asbjornsenia pygmaea, Magelona johnstoni, Urothoe pulchella, Fabulina fabula, Abra alba, Galathowenia oculata, Lumbrinerides amoureuxi, Euchone rubrocincta, Lysidice unicornis, Sternaspis scutata, Heteromastus filiformis, Psammogammarus caecus* <u>Birds</u> *Puffinus mauretanicus, Calonectris diomedea, Morus bassanus, Larus michahellis* <u>Demersal Fish</u> *Abralia (Asteroteuthis) veranyi, Alloteuthis, Illex coindetii, Loligo vulgaris, Sepiolidae, Todaropsis eblanae, Engraulis encrasicolus, Sardina pilchardus* <u>Marine Mammals and Sea Turtles</u> *Balaenoptera acutorostrata, Phocoena phocoena, Caretta caretta*	Portuguese coast (Gomes et al, 2018)
<u>Macroalgae Soft-substratum</u> *Bostrychia scorpioides, Caulacanthus ustulatus, Gelidium pusillum, Laminariales, Lyngbya sp., Porphyra umbilicalis, Ulothrix sp.* <u>Macroalgae Hard-substratum</u> *Ceramium ciliatum, Ceramium rubrum, Ceramium sp., Chondrus crispus, Cladophora sp., Dictyota dichotoma, Pelvetia canaliculata, Peyssonnelia squamaria, Porphyra leucosticta* <u>Macrobenthos Soft-substratum</u> *Aphrodita aculeata, Branchiostoma lanceolatum, Cerastoderma glaucum, Cerastoderma sp., Chamelea gallina, Chamelea striatula, Chartella papyracea, Echinocyamus pusillus, Mactra stultorum, Nucula hanleyi, Nucula nitidosa, Nucula nucleus, Nucula sp.,Nucula sulfata, Nucula turgida, Pomatoceros lamarcki, Pomatoceros triqueter, Pontocrates altamarinus, Ruditapes decussatus, Sabella pavonina, Sabella spallanzanii Sabellaria spinulosa, Sabellidae, Sabellides octocirrata, Serpula concharum, Serpula lobiancoi, Serpulidae, Spisula*	Basque continental shelf (Bay of Biscay) (Pas-cual et al., 2011)

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Examples of Ecological Significant Species	Geographical area (Reference)
elliptica, Spisula sp., Spisula subtruncata, Tellina (Moerella) donacina, Tellina compressa, Tellina fabula, Tellina pseudopusilla, Tellina pygmaea, Tellina serrata, Tellina sp., Veneridae, Venerupis aurea, Venerupis senegalensis, Venerupis sp., Venus casina	
<u>Plants</u> *Zostera marina* <u>Hyperbenthos</u> *Astrorhiza limícola, Halyphysema tumanowiczii, Hippolyte varians, Palaemon serratus, Pandalus propinquus* <u>Epibenthos (hard substrata)</u> *Alcyonium digitatum, Alcyonium glomeratum, Alcyonium species, Asterias rubens, Asterina gibbosa, Astropecten irregulares, Crossaster papposus, Echinus esculentus, Henricia oculata, Hinia incrassata, Marthasterias glacialis, Monodonta lineata, Psammechinus miliaris*	Isles of Scilly archipelago, UK (Vanden Eede, 2007)
<u>Macrobenthos</u> *Abra alba; Asterias rubens; Bathyporeia pilosa; Bathyporeia sarsi; Eumida sanguínea; Eurydice affinis; Eurydice pulchra; Mysella bidentata; Nephtys hombergii; Pariambus typicus; Scolelepis squamata; Tellina fabula* <u>Birds</u> *Arenaria interpres; Larus argentatus; Larus fuscus; Sterna albifrons; Sterna hirundo; Thalasseus sandvicensis*	Belgian coast (Vanden Eede et al, 2014)
<u>Macrobenthos</u> *Abra alba; Spisula subtruncata*	Dutch coast (Derous, 2007)

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