**Annex 1**

The Nested Environmental status Assessment Tool - NEAT

The NEAT tool is a further development of the HOLAS tool. It is a structured, hierarchical tool for making marine status assessments (Berg et al., 2017; Borja et al., 2016), and freely available at www.devotes-project.eu/neat. NEAT was developed to assess biodiversity status of marine waters under the MSFD and has been used to assess different ecosystem components and geographical areas (Nemati et al., 2017; Borja et al., 2019; Pavlidou et al. 2019; Kazanidis et al., 2020; Borga et al., 2021). NEAT uses a combination of high-level integration of habitats and spatial units and an averaging approach, allowing for specification on structural and spatial levels, applicable to any geographical scale. As explained here-below, the use of NEAT is not limited to the assessment of biodiversity but can be used for assessment of pollution impact. The analysis provides an overall assessment for each case study area and a separate assessment for each of the ecosystem components included in the assessment. The final value has an associated uncertainty value, which is the probability of being determinative in a certain class status (GES - nonGES) (Uusitalo et al., 2016). Essentially, the ﬁnal assessment value is calculated as a weighted average. The weighting factors are based on the respective surface of the areas and are combined with the respective monitoring data for the indicator/chemical contaminant in question. No special rules are applied but the tool design allows assigning diﬀerent aggregation rules at the various steps in the calculation of the overall assessment value. In order to assess the uncertainty in the ﬁnal assessment value, the standard error/ standard deviation of every observed indicator value is used (Borja et al., 2016). Therefore, the standard deviation values as obtained from the monitoring data play a major role in the uncertainty associated with the final assessment result. This emphasizes the importance of the standard deviation for the accuracy and evaluation of the final assessment result.

During the EU funded MEDCIS project ([www.medcis.eu](http://www.medcis.eu)) it was shown that: (i) it is possible to integrate data from different sources, spatial and temporal scales and from different ecosystem components into a unique value; (ii) this integration has permitted to undertake a real Ecosystem Based Management ( EBM) assessment; (iii) despite the integration there is not a loss in tracking the problems that should be addressed at the indicator, ecosystem component, descriptor or smaller spatial levels; (iv) this track of the problems is clearly related with the pressures identified and the pressure index used to validate the assessment undertaken using NEAT; (v) the assessment demonstrates also the temporal changes due to the management measures taken, showing the recovery of the system in respect to the time needed for each ecosystem component and area; and (vi) all of these findings and conclusions could be very useful for managers, policy makers and scientists when deciding the method to use in assessing and communicating the environmental status under the MSFD.

As the objective was to apply an integrative method to assess the environmental status of the study area under the MSFD framework, NEAT was applied (Borja et al., 2016); a free software is available at www.devotes-project.eu/neat. NEAT has been used to assess different ecosystem components and geographical areas (Uusitalo et al., 2016; Nemati et al., 2017, 2018).

The main elements and principles of NEAT application are:

* + - * **NEAT Indicators**: they constitute the basis of the assessment. NEAT integrates an indicator catalogue (Teixeira et al., 2016) as a source for choosing predefined indicators for the biodiversity assessment. However, the tool is not limited to those indicators; it allows the addition of as many indicators as required, not only related to biodiversity, but any kind of indicator, specific to each assessment performed (e.g. eutrophication, organic pollution, etc.). In practice these refer to the parameters/elements of the criteria that are subject of assessment (i.e. IMAP Common Indicators or MSFD Criteria) and can be either synthetic biological metrics/indices (i.e. Eutrophication Index E.I., BENTIX, AMBI) or individual parameter values (i.e. nutrients, chlorophyll-a, chemical contaminants concentrations). Under ‘Indicators’ the actual monitoring data reported by the CPs of the Barcelona Convention need to be introduced for preparing 2023 MED QSR assessments. Thresholds and boundary values correspond to the parameters (‘Indicators’) used.
* **Habitats***:* Some examples are pelagic, benthic, rocky, ice habitats and may include sub- categories in a hierarchical order.
* **Ecosystem Components**: Examples are phytoplankton, microbes, mussel, sediments.
* **Weighting and hierarchies**: the central principle in the NEAT method is a hierarchical, nested structure of spatial assessment units (SAUs) and habitats. Thus, it avoids the dominance of certain indicators or habitats or SAUs by using a proper weighting procedure, which considers what information is available for different real spatial scales. The weighting factors are based on the respective surface of the areas and are combined with the respective monitoring data for the indicator in question. In addition, each indicator is related to a specific ecosystem component, which exists in a certain habitat, and information has been collected for a specific area or SAU (e.g. North Adriatic Sea (NAS)). Thus, no bias is introduced into the assessment by the choice of the indicators.
* **Aggregation**: In order to aggregate monitoring data, they are all normalized into a scale of 0 to 1, independently of their original scale. Specific boundaries of the indicators (e.g. boundary between moderate and good status) are also normalized. By default, aggregation is done across all indicators assessed within concerned SAU, either by ‘Ecosystem Component’ or by ‘Habitat’. For example, the method can be used to aggregate all indicators of a specific SAU and show the status divided among the different ecosystem components of that SAU in line with the aggregation and integration rules as defined in the documents of UNEP/MAP (2021). The first level of the spatial aggregation of the ‘Indicators’ data is not shown by default.
* **Integration** is done spatially across all the SAUs used with a weighting factor related to the SAU surface area in line with the aggregation and integration rules as defined in the documents of UNEP/MAP (2021).
* **NEAT value**: the outcomes of the aggregation are visualized into a number (NEAT value) and a colour, which corresponds to the status (i.e. high, good, moderate, poor and bad). This NEAT value is obtained for the whole assessed area but can be visualized in different forms. For example, it is possible to visualize how the information from the different ecosystem components (e.g. fish, phytoplankton, etc.) has contributed to the assessment, or how the information available to the different areas contributes to the overall assessment.
* **Confidence**: each NEAT value is accompanied by its quantitative estimate of the confidence of the result. This estimate is performed using the standard deviation (entered at the same time as the indicator value/monitoring data), and performance of Monte Carlo simulations, as a mean to understand how this error propagates throughout the assessment.

The NEAT tool is primarily designed for assessing biodiversity status and works well with other MSFD descriptors of either state or pressure/impact, especially when these are linked to one type of pressure/impact. The way the tool makes the aggregation of data theorizes that all ‘Indicators’ data introduced for a specific habitat or ecosystem component have the same type of impact on the ecosystem, hence they are related (for example nutrients and chlorophyll-a are interrelated for the eutrophication EO5 status; beach litter data and floating microplastics are both related to a common pressure and interrelated for assessing the EO10 status). For chemical contaminants status, the above assumption is not true. Pollution from one chemical compound is not necessarily related to another. Therefore, for assessing the chemical status of an area it is important to get also a detailed picture per contaminant (i.e. first level spatial aggregation of the Indicators data inserted in the tool).

An example of using NEAT for the assessment of the chemical status i.e. for EO9/CI 17 in the Adriatic Sea, is described as follows: ‘Indicators’ (e.g. PAHs, Cd) are measured in one or more ‘Ecosystem Components’ (e.g. mussels, sediments, waters, phytoplankton). ‘Ecosystem Components’ are assigned to specific ‘Habitats’, i.e. pelagic habitat includes waters and phytoplankton; benthic habitat includes mussels and sediments. NEAT then aggregates all the Indicators normalized values (PAHs and Cd) per SAU on either the Habitat level (all data in pelagic, all data in benthic) or on the Ecosystem Component level (all data in: mussels, sediments, waters, phytoplankton). An assessment classification (high, good, bad, etc.) is then obtained for all the nested SAUs of an area, for the chemical status of the pelagic and benthic habitats separately (Habitat level) or for the chemical status of the mussels, sediments, water, phytoplankton separately (Ecosystem Component level). In this way the information on the first level of aggregation of indicators per SAU is lost. It is not transparent which of the Indicator (contaminant measured) PAHs or Cd is responsible for the obtained chemical status, and this may mislead managers and policy makers in the designing and implementation of measures.

For the transparent assessment of different IMAP CIs, there is a need to provide adjustments in the NEAT software, regarding the use and meaning of ‘Indicators’, ‘Habitats’ and ‘Ecosystem Components’.

Example of adjustment for IMAP EO9/CI 17 is provided here-below:

* *NEAT Indicators*: These refer to 5 chemical compounds that constitute mandatory contaminants of IMAP CI17 (Cd, Hg, Pb, Σ16PAHs, Σ7PCBs).
* *Habitats:* In the absence of integrated assessment of IMAP EO9/CI 17 and CI 1, and given the data available for contaminants were measured in the two mandatory matrices of sediment and biota, two ‘habitats’ are used, sediments and biota. Assessment results are aggregated for each of them separately to get the status of EO9 /CI 17 in sediments and in biota separately for all SAUs. Alternatively, under ‘Habitats’ it is possible to use the various chemical contaminants (Cd, Hg, Pb, ΣPAHs, ΣPCBs) and get an overall assessment status (for both matrices together) for each of the contaminants.
* *Ecosystem Components*: Instead of using ecosystem categories, the Ecological Objective 9 (EO9) is used as ecosystem component, and the ‘Indicators’ are listed again as subcategories of EO9 in a hierarchical structure. In this way an aggregated assessment status result on the EO9 level can be achieved and at the same time the assessment result on each of the ‘Indicators’- chemical compounds.