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Agenda Item 7: Status of implementation of the Ecosystem Approach (EcAp) Roadmap

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Appendix A: Proposal of Common Indicators of the EcAp Ecological Objective 4 on Marine Food Webs under the Barcelona Convention.

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Proposal of Common Indicators of the EcAp Ecological Objective 4 on Marine Food Webs under the Barcelona Convention.

1. Introduction:

1. The Contracting Parties (CPs) to the Barcelona Convention agreed to implement the Ecosystem Approach (EcAp) process. In their 19th COP (Athens 2016), the CPs adopted the Integrated Monitoring and Assessment Programme of the Mediterranean Sea (IMAP) (Decision IG.22/7). However, regarding the Biodiversity component, the current IMAP did not yet cover the development (i.e., proposals of indicators, Good Environmental Status (GES) description and related targets) of the ecological objective 4 (EO4) on marine food webs. The EO4 deals with: "Alterations to components of marine food webs caused by resource extraction or human-induced environmental changes do not have long-term adverse effects on food web dynamics and related viability".

2. As a first step towards the development of EO4 on food webs, SPA/RAC has initiated a desk review study to inventory data sources, best practices, and methodologies for monitoring and assessing marine food webs in the Mediterranean (UNEP/MED WG. 592/Inf.3). The desk review consists of the following sections: scientific publications; existing and potential data sources; methodologies for monitoring and assessment (under the MSFD and other Regional Sea Conventions, such as OSPAR, HELCOM); relevant ongoing/concluded initiatives/projects at regional, sub-regional, or national levels; regional/national institutions and key experts working on monitoring and assessment of food webs in the Mediterranean; knowledge gaps. This review was presented during the first meeting of the Biodiversity Online Working Group (BWG) for Marine Food Webs on 4 December 2024 where IMAP gave other keynote presentations: an overview of the indicators used in the Marine Strategy Framework Directive on marine food webs Descriptor 4 (D4) Italian project led by ISPRA and a summary of scientific knowledge and methodological applications related to indicators of marine food webs in the Mediterranean showed by other scientists.

3. Following the first meeting of the BWG on Marine Food Webs, a multidisciplinary group of voluntary experts was established. Its role is to provide technical expertise, strategic advice, and practical recommendations to enhance the development of IMAP common indicators for Ecological Objective 4. A coordinator was designated to deliver backstopping services to both the Biodiversity Working Group and the voluntary experts' group and to facilitate their work. The BWG for Marine Food Webs is supported by the Italian Working Group under the Marine Strategy Framework Directive (MSFD).

4. The main purpose of the BWG is to facilitate the contribution of the country scientists to the process of finalization of the EO4 through the application of the following key points:

- Scoping the most relevant approaches to develop IMAP common indicators for the Ecological Objective 4 on Marine Food Webs under the Barcelona Convention.
- Establish common indicators to assess marine food webs in alignment with existing frameworks such as the Marine Strategy Framework Directive (MSFD) and regional conventions like OSPAR and HELCOM.
- Define targets and criteria for assessing the Good Environmental Status (GES) of marine food webs.
- Identify data gaps regarding marine food webs in the Mediterranean.
- Propose innovative approaches to improve monitoring and assessment based on best practices and methodologies.
- Harmonize data collection processes at national and regional levels to ensure their integration into Mediterranean environmental assessments (e.g., MED QSR).
- Develop guidelines for collecting, interpreting, and using food web data.

5. The Biodiversity Online Working Group met online on December 4, 2024, and February 20, 2025, while the voluntary expert groups met online on February 3, 2025. These meetings and discussions led to the following considerations and recommendations.

2. Outcomes of the Biodiversity Online Working Group for Marine Food Webs

6. The BWG stated that multiple pressures impact food webs and affect their dynamics in complex ways. Therefore, it is challenging to link changes in indicators to pressures. Fishing pollution, eutrophication, climate change and non-indigenous species affect multiple levels of the food web simultaneously in ways that are specific to a given ecosystem and have only recently been investigated. With the current knowledge-base, it is impossible to construct a single general indicator to assess the impacts of these pressures. On the other hand, several indicators are adopted to assess the impact of specific pressures whose effects are better known, for instance fisheries impacts on the food web. One of the most used indicators is the Mean Trophic Level (MTL), which originally assessed the average trophic level of a marine system from the trophic position of harvested species in the food web (Pauly et al. 1998) and tends to decrease with increasing fishing impact. MTL is currently used in ecosystem modelling to investigate the effects of fishing based on the trophic position of species (Agnetta et al. 2024) coming from both catches and biomass at sea. In addition, Gascuel et al. (2005) suggested the Trophic Spectrum of total consumer biomass as an indicator of trophic structure in a fisheries context. To characterise food webs and their status in general, authors suggested a single indicator based on feeding guild assessment (Thompson et al. 2020) as well as a set of operational indicators (Tam et al. 2017, Machado et al. 2021) also using outputs of Ecological Network Analysis (Safi et al. 2019) to propose food web indicators.

7. To build indicators and GES, the BWG identified key research gaps. The gaps included uncertainties regarding top predator production, limited data on highly dynamic plankton communities and processes, inadequacy of size-based indicators, poor reliability of abundance trends, lack of data on feeding habits, and long-term data time series in general, need for adopting operational ecosystem-based indicators versus single species-focused ones. Long-term effects of global change, impacts of invasive alien species, nutrient changes, habitat loss, and baseline data deficiencies further challenge food web assessment. Additional gaps encompass limited trophic level estimations, especially for non-fish organisms, lack of data on invertebrates and non-indigenous species, temporal and spatial coverage limitations, not uniform and consistent sampling strategies and frequencies, and uncertainties in assessing the impact of future changes on food web structure and function.

8. Nevertheless, various ecological analyses, such as those using biomass and gut contents or stable isotope-based ones (Berto et al. 2024), from linear mixing to Bayesian ones, help assess the feeding habits of several consumers and features of food webs and establish the trophic position of marine species. Analysis of these data and their integration into more complex models (McCormack et al. 2019) such as OSMOSE, ATLANTIS and ECOPATH represent a way forward to exploring scenarios of food web changes in relation to disturbances with notable Mediterranean case studies like Coll & Libralato (2012), Piroddi et al. (2015) and Agnetta et al. (2022). An intermediate level of complexity in such analysis is represented by the cumulative trophic spectra suggested by Link et al. (2015, 2024), which also offers valuable insights.

9. Based on the experience of the BWG and the desk review, it has been confirmed that there is an extreme heterogeneity of approaches for studying marine food webs in the Mediterranean. The topic has been extensively explored in the last few decades, with reference to single species, trophic guilds, or the analysis of whole food webs using indicators or modelling. Various methodologies are used for monitoring and assessing marine food webs, which is crucial for understanding ecosystem health and fulfilling objectives outlined in the Barcelona Convention. Each method has its advantages and limitations, emphasising the importance of combining approaches to study marine food webs and assess their ecological status comprehensively.

10. The BWG reviewed advancements in the application of food web indicators in the European context. The MSFD sets out objectives for achieving and maintaining good environmental status in the marine environment, including D4 focusing on food webs. According to the decision EU 2017/848, laying down criteria and methodological standards on good environmental status, for D.4-Food Webs, trophic guilds are selected under criteria elements which meet the following conditions:(a) include at least three trophic guilds; (b) two should be non-fish trophic guilds; (c) at least one should be a primary producer trophic guild; (d)

preferably represent at least the top, middle and bottom of the food chain. Primary and secondary criteria are adopted, including indicators for the diversity of the guild (D4C1), the balance in abundance and biomass within the guild (D4C2), size distribution within the guild (D4C3) and productivity of the guild (D4C4). In contrast, assessment results are not independent from the different criteria. Other indicators have been identified for D4 of the MSFD, such as the performance (production) of key predator species, the biomass of large fish, and abundance trends of selected groups and species (European Commission 2010/477/EU). However, these indicators are intended as surveillance indicators and, in many cases, are not directly related to a specific pressure.

11. Development of indicators usable for food webs (such as D4) poses challenges due to the complexity of marine ecosystems, leading to improved ecological models and discussions around indicator selection and operationalization. In the Baltic Sea region, HELCOM has established an expert group on food webs (EG FOODWEB) within its biodiversity working group (WG BioDiv) to develop quantitative, indicator-based assessments supporting MSFD objectives. The expert group contributed to the 2016-2021 HELCOM Holistic Assessment (HOLAS 3). Besides data-based indicators, such as “Seasonal succession of functional phytoplankton groups” and Integrated Trend Analysis on food webs, they also presented a methodology for assessing MSFD indicators associated to the criteria D4C2 and D4C4 using the Ecopath with Ecosim model (EwE). However, a quantitative evaluation of the Baltic Sea's food web status remains challenging due to a lack of harmonized data and regionally agreed-upon indicators, as noted in the HOLAS 3 assessment. OSPAR, as Regional Sea Convention, conducts thematic assessments in the context of MSFD regional implementation, including food webs assessment, with common indicators like changes in phytoplankton and zooplankton communities, size composition in fish communities, change in average trophic level of marine predators, and proportion of large fish. OSPAR has initiated pilot assessments in various assessment areas using Ecological Network Analysis, feeding guild assessments, and trophic level changes of marine consumers. Several further research projects and initiatives exist in Europe concerning assessing and monitoring marine food webs (OSPAR ICG COBAM 2012, Preciado et al. 2023). However, the Mediterranean region appears to be less active in leading such projects than other regions. Food web studies focusing on indicator development are relatively recent and less developed, in the Mediterranean despite the production of several scientific papers on Mediterranean case studies. At present, significant gaps exist in data collection, reliable indicators, and setting thresholds, hindering the establishment of common targets and harmonized monitoring initiatives.

12. Considering all this information, the BWG suggests adopting a stepwise approach to implement EO4, from basic to complex methods and indicators. Biomass, abundance, diet, and trophic levels of marine species, as well as commercial catches of fisheries and fishing activities, are primary variables that can be used to start estimates of useful and common indicators. These variables and parameters are immediately available for all CPs on open-source websites (for example, GFCM, FishBase, FishStatJ, Global Fishing Watch), although the information is mainly related to fish species and suffers variable degrees of aggregation and may be referred to different geographic domains. Moreover, marine inshore ecosystems are generally not adequately included in these datasets.

13. In light of these considerations, the BWG proposes to adopt the following operational objectives and indicators (Table 1). Instead, GES and targets will be discussed at the next meetings of the Working Group as soon as other progress from EU experience (MSFD, OSPAR, HELCOM) or other pilot assessments allow a proposal to be made.

Table. 1. Proposal of operational objectives and indicators for the Ecological Objective 4 on Marine Food Webs under the Barcelona Convention

Operational objective	**Indicator**
4.1 Diversity of ecosystem and dynamics across all trophic groups can ensure long-term biomass-abundance of the species	4.1.1 Biomass or abundance of species/genera/taxa or trophic groups
	4.1.2 Average of Mean Trophic Level of species/genera/taxa or trophic groups from biomass and/or catches
	4.1.3 Biodiversity indices
4.2 Proportion of selected group of species is balanced as in healthy food webs	4.2.1 Pelagic/Demersal ratio
	4.2.2 NIS/Demersal ratio
	4.2.3 Zooplankton/phytoplankton ratio
	4.2.4 Size distribution of trophic groups
	4.2.5 Production of Megafauna (*Megafauna variables from EO5)

14. Trends and/or comparisons across spatial scales of the food web indicators proposed (Table.1) can be performed at least at regional or subregional level, depending on the availability of three groups of data (A, B, C). A) Biomass (i.e. Kg/km2), abundance (i.e. Number of individuals/km2) and size (i.e. total length of body) of species can be obtained for example for many demersal species from MEDITS data and GFCM stock assessment reporting datasets. B) commercial catches of target species and production of fisheries can be obtained for example by using FAO data (FishstatJ). C) Trophic level of species can be obtained from large dataset such as Fishbase and Lifebase. Indicators belonging to objective 4.1 are useful for a first evaluation of potential anthropogenic impact on the structure of food webs as a whole system by specifically looking at simple data such as biomass or abundance of species groups (indicator 4.1.1), trophodynamics (indicator 4.1.2) and diversity such as alpha and beta indices (indicator 4.1.3). Indicators belonging to operational objective 4.2 focus on some food web compartments to have more specific evidence of potential anthropogenic impacts such as detrimental effect of bottom fisheries and/or eutrophication (indicator 4.2.1), increase of non-indigenous species (indicator 4.2.2), changes in net primary production affecting the base of food webs (indicator 4.2.3 and 4.2.4), depletion of large megafaunal organisms (indicator 4.2.5)

15. The BWG proposed to (i) complete the list of experts, laboratories, institutions and organisations involved in the work on EO4 established in the desk study and (ii) update and complete the lists of marine food web projects carried out at the national and regional level that could contribute to the development of EO4. To this end, the SPA/RAC has prepared and sent a questionnaire to the Contracting Countries to collect the necessary information. In addition, it is important to (iii) exchange experiences with other working groups on food webs in the context of the MSFD, HELCOM and OSPAR.

16. 11 countries and partners were represented in the BWG for marine food web. SPA/RAC will invite the Contracting Parties who have not yet appointed members to the BWG of experts to do so as soon as possible to allow to take advantage of the diversity of skills and expertise across the region.

17. Given the importance of monitoring marine food webs, especially considering multifactorial disturbances on the Mediterranean ecosystem, SPA/RAC will continue to develop IMAP Ecological Objective 4 on marine

food webs, drawing on the results of the desk review study as provided for in the SPA/RAC work program for 2024-2025 and the new achievements the WG will have. WG and SPA/RAC have planned to have other two meetings in 2025 after the CORMON meeting. At least one of these will be organized to have representative participation of Spain and Croatia for D4, to identify data gaps regarding food webs in the Mediterranean and innovative approaches to improve monitoring and assessment based on best practices and methodologies. Moreover, it was proposed to share a database between the country representatives and the SPA-RAC to collect information on the availability of field samples relevant for the development of food web indicators at regional level.

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