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INTEGRATED ANALYSIS OF IMAP INDICATOR INTERLINKAGES AND THE ROLE OF COMMERCIAL FISHERIES IN ACHIEVING GOOD ENVIRONMENTAL STATUS IN THE MEDITERRANEAN

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List of acronyms

CBD: Convention on Biological Diversity
CI: Common Indicator
COP: The Conference of the Parties
EcAp: Ecosystem Approach
EO: Ecological Objective
EU: European Union
FAO: Food and Agriculture Organization of the United Nations
FishEBM MED: Fisheries and Ecosystem Based Management for the Blue Economy of the Mediterranean project
GES: Good Environmental Status
GFCM: General Fisheries Commission for the Mediterranean
IAS: Invasive Alien Species
IMAP: Integrated Monitoring and Assessment Programme under Barcelona Convention
Med QSR: The Mediterranean Quality Status Report
MSFD: Marine Strategy Framework Directive
NIS: Non-indigenous species
SPA/BD: Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean
SPA/RAC: Specially Protected Areas Regional Activity Centre
UNEP MAP: Mediterranean Action Plan of the UN Programme for Environment

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Ana Štrbenac, Mag. Biol. (Ecology), M.Sc. in Management of Protected Areas, is an international nature conservation expert with extensive knowledge and experience in strategic planning for regional organizations (e.g. SPA/RAC, MedPAN), management planning for protected areas (including Natura 2000 sites), and the practical application and assessment of nature conservation legislation and policies. She has conducted biodiversity status assessments, with a focus on the Barcelona Convention's IMAP–GES assessments, and has been actively involved in regional, EU, and international cooperation.

Ana Štrbenac began her career in Croatian governmental and expert institutions for nature conservation, where she played a key role in building the national conservation framework, notably as Acting Director and head of the Expertise Division of the former State Institute for Nature Protection. She also represented Croatia in several international and regional nature conservation agreements, including serving as Chair of ACCOBAMS, and contributed to the Croatia's accession to the EU..

Ana Štrbenac now works as a consultant through her company, Stenella consulting Ltd (www.stenella-consulting.hr). She has advised numerous international and national organizations, including UNEP/MAP (SPA/RAC and PAP/RAC), GIZ, ACCOBAMS, IUCN, WWF, EUSAIR, MedPAN, MedWet, BirdLife, OceanCare, and Croatian ministries for nature conservation, fisheries, and rural development.

Among her key international projects are the assessment of the status of cetaceans for the 2023 Mediterranean Quality Status Report (Med QSR), a comparative analysis of GES assessments under the MSFD and IMAP, initial national IMAP–GES assessments for Albania and Montenegro, application of the NEAT methodology for IMAP–GES assessments in the Adriatic, contributions to the development of the Post-2020 SAP BIO, the updated MedPAN Strategy 2026–2030, and various other evaluations, including assessments of both the original and Post-2020 SAP BIO, as well as analyses of different aspects of the Common Fisheries Policy, particularly bycatch issue.

Executive summary

The Mediterranean Sea is a biodiversity hotspot facing growing environmental pressures, particularly from marine litter and fisheries-related impacts. As a semi-enclosed basin supporting diverse ecosystems and long-standing fishing traditions, its ecological balance is increasingly at risk. Integrated monitoring and assessment are critical for maintaining the region's environmental health and sustainable resource use.

This study aims to identify and analyse relationships among key indicators under the Integrated Monitoring and Assessment Programme (IMAP), notably those related to pollution, eutrophication, marine litter, biodiversity, non-indigenous species, coastal ecosystems, and fisheries. The work is conducted in collaboration with the SPA/RAC and the GFCM Secretariat and supports the implementation of the Ecosystem Approach (EcAp) under the Barcelona Convention.

The methodology combines desk-based literature review—including IMAP reports, Med QSRs, and GFCM data—with expert consultations. The findings will inform recommendations for more integrated and effective monitoring of ecological interactions, ultimately supporting the achievement of Good Environmental Status (GES) in the Mediterranean.

1 INTRODUCTION

The marine environment is a highly complex living system, where various components are strongly interlinked and interdependent. This perspective is reflected in the so-called Ecosystem Approach (EcAp), a strategy for the integrated management of natural resources that accounts for the intricate relationships between biodiversity, humans, and ecological processes. It emphasizes the sustainable use of ecosystems while maintaining their structure, functions, and productivity. This approach recognizes that ecosystems are dynamic and interconnected, requiring adaptive management based on scientific knowledge and stakeholder involvement. This understanding is particularly relevant for coastal and marine environments, where the fluid nature of water maintains ecological connectivity.

The Ecosystem Approach has been promoted by the Convention on Biological Diversity (CBD) (Decision IG. V/6, COP , Nairobi, Kenya., May 2000) and subsequently adopted by the Contracting Parties to the Barcelona Convention, which decided in 2008 to gradually apply the Ecosystem Approach to the management of human activities that may affect the Mediterranean marine and coastal environment in order to promote sustainable development (Decision IG.17/6, COP 15, Almería, Spain, January 2008). Thus, the EcAp has become the overarching principle of UNEP/MAP and is applied through an agreed-upon implementation roadmap. This roadmap was formally adopted in 2012 during the 17th Meeting of the Contracting Parties to the Barcelona Convention (COP 17) through Decision IG.20/4. This process begins with the definition of an ecological vision for the Mediterranean: "A healthy Mediterranean with marine and coastal ecosystems that are productive and biologically diverse for the benefit of present and future generations." The overarching goal of implementing the Ecosystem Approach is to achieve and maintain Good Environmental Status (GES) of the Mediterranean Sea and coasts. Eleven Ecological Objectives have been defined to support GES, reflecting common priorities for the management of the Mediterranean's marine and coastal environments (Table 1).

A vital component of the Ecosystem Approach is the monitoring and assessment of the marine and coastal environment. Accordingly, in 2016, the Contracting Parties adopted the Integrated Monitoring and Assessment Programme (IMAP) (Decision IG.22/7, COP 19, Athens, Greece, February 2016), with the objective of conducting regional assessments on the status of the Mediterranean Sea and coast. IMAP establishes a comprehensive framework for integrated monitoring and assessment of biodiversity and fisheries, pollution and marine litter, as well as coastal and hydrographic conditions. Furthermore, IMAP is based on above mentioned eleven Ecological Objectives and associated 23 regionally agreed common indicators and four candidate indicators, for which scientific knowledge and data collection continue to advance in support of regional monitoring and assessment.

The Contracting Parties have been developing IMAP-based national monitoring programmes to implement these objectives at the national level. In doing so, they conduct monitoring for each common indicator, generating data and information at national level that support regional-level assessments of whether the Good Environmental Status (GES) related to specific Ecological Objectives (EOs) is being met. Based on these individual EO assessments, an integrated assessment of the state of the Mediterranean Sea and coast is conducted and reflected in the Quality Status Reports (Med QSRs), which are issued regularly. So far, two such reports have been published: Med QSR 2017 and Med QSR 2023.

Regarding the EO3 - Harvest of commercially exploited fish and shellfish specifically, a significant work has been carried out by GFCM, particularly for Common Indicators 7, 8 and 9, which is already reflected in preparation of Med QSR 2023, but also in GFCM's biennial State of Mediterranean and Black Seas Fisheries reports (SoMFI). Ongoing work is being carried out on other relevant Common Indicators. Particularly for CI 12 - Bycatch of vulnerable and non-target species (EO1 and EO3), GFCM developed a standardized protocol "Monitoring incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection" (FAO, 2019) and is developing a regional bycatch Database.

Besides the GES assessment under the Barcelona Convention, the European Union has established in 2008 a GES assessment framework under the Marine Strategy Framework Directive. According to this framework, the GES of the environment is also described and examined through 11 Descriptors (equivalent to Ecological Objectives under EcAp/IMAP) and associated criteria (equivalent to Common Indicators). This system is mandatory for EU Member States. It should be emphasized that both GES assessment systems are largely harmonized; however, some methodological differences remain, as explained in more detail for EO1 and EO2 in the 2021 Comparative Analysis undertaken regarding IMAP and the European Commission's GES Decision 2017/848/EU on Biodiversity and NIS (UNEP/MAP, 2021c).

One of the key elements of GES is the set of parameters related to fisheries. IMAP's Ecological Objective 3—Harvest of commercially exploited fish and shellfish—comprises six Common Indicators, ranging from spawning fish biomass to bycatch of vulnerable and non-target species (Table 1).

This report is produced under the FishEBM MED project (2023–2026), which supports ecosystem-based fisheries management in the Mediterranean. It contributes to Output 3.2 by analysing interlinkages between IMAP indicators, with the aim of enhancing integrated monitoring systems and supporting evidence-based decision-making for sustainable marine resource management.

Table 1. Ecological Objectives and their related Common Indicators and Candidate Indicators.

Ecological Objective	IMAP indicators
EO 1 Biodiversity	
Biological diversity is maintained or enhanced. The quality and occurrence of coastal and marine habitats and the distribution and abundance of coastal and marine species are in line with prevailing physiographic, hydrographic, geographic and climatic conditions.	**Common Indicator 1**: Habitat distributional range (EO1) to also consider habitat extent as a relevant attribute (EO1 related to Benthic and Pelagic Habitats)
	Common Indicator 2: Condition of the habitat's typical species and communities (EO1) (EO1 related to Benthic and Pelagic Habitats)
	Common Indicator 3: Species distributional range (EO1 related to marine mammals, seabirds, marine reptiles)
	Common Indicator 4: Population abundance of selected species (EO1, related to marine mammals, seabirds, marine reptiles)
	Common indicator 5: Population demographic characteristics (EO1, e.g., body size or age class structure, sex ratio, fecundity rates, survival/mortality rates related to marine mammals, seabirds, marine reptiles)
EO 2 Non-indigenous species	
Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem	**Common Indicator 6**: Trends in abundance, temporal occurrence, and spatial distribution of non-indigenous species, particularly invasive, non-indigenous species, notably in risk areas (EO2, in relation to the main vectors and pathways of spreading of such species)
EO 3 Harvest of commercially exploited fish and shellfish	
Populations of selected commercially exploited fish and shellfish are within biologically safe limits, exhibiting a population age and size distribution that is indicative of a healthy stock	**Common Indicator 7**: Spawning stock Biomass (EO3)
	Common Indicator 8: Total landings (EO3)
	Common Indicator 9: Fishing Mortality (EO3)
	Common Indicator 10: Fishing effort (EO3)
	Common Indicator 11: Catch per unit of effort (CPUE) or landing per unit of effort (LPUE) as a proxy (EO3)
	Common Indicator 12: Bycatch of vulnerable and non-target species (EO1 and EO3)
EO 4 Marine food webs	
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	*Eight indicators under EO4 are currently under development with the support of the online Biodiversity Working Group on Marine Food Webs. This proposal was endorsed during the CORMON Biodiversity and Fisheries meeting held in April 2025. Final approval is expected upon the adoption of the revised version of IMAP. GES and associated targets will be developed during the upcoming working group meetings, with a view to submitting them to the next CORMON Biodiversity and Fisheries meetings.* • *Biomass or abundance of species or trophic groups (4.1.1.)* • *Average of Mean Trophic Level from biomass and/or catches of species or trophic groups (4.1.2.)* • *Biodiversity indices (4.1.3.)* • *Pelagic/Demersal ratio (4.2.1.)* • *NIS/Demersal ratio (4.2.2.)* • *Zooplankton/phytoplankton (4.2.3.)* • *Size distribution of trophic groups (4.2.4.)* • *Production of Megafauna (**Megafauna variables from EO5) (4.2.5.)*
EO 5 Eutrophication	
Human-induced eutrophication is prevented, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful	**Common Indicator 13**: Concentration of key nutrients in water column
	Common Indicator 14: Chlorophyll-a concentration in water column

algal blooms and oxygen deficiency in bottom waters.	
EO 6 Sea-floor integrity	
Sea-floor integrity is maintained, especially in priority benthic habitats	*Two EO6 indicators were endorsed during the CORMON Biodiversity and Fisheries meeting in April 2025. Final approval is expected upon the adoption of the revised version of IMAP. GES and associated targets will be developed during the upcoming working group meetings, with a view to submitting them to the next CORMON Biodiversity and Fisheries meetings* • *Extent of physical loss of natural habitat* • *Extent of adverse effects on benthic habitat (this may comprise several indicators which address specific pressures)*
EO 7 Alteration of hydrographical conditions	
Alteration of hydrographic conditions does not adversely affect coastal and marine ecosystems.	**Common Indicator 15**: Location and extent of the habitats impacted directly by hydrographic alterations to also feed the assessment of EO1 on habitat extent
EO 8 Coastal ecosystems and landscapes	
The natural dynamics of coastal areas are maintained and coastal ecosystems and landscapes are preserved	**Common Indicator 16**: Length of coastline subject to physical disturbance due to the influence of human-made structures
	Candidate Indicator 25: Land use change
EO9 Pollution	
Contaminants cause no significant impact on coastal and marine ecosystems and human health	**Common Indicator 17**: Concentration of key harmful contaminants measured in the relevant matrix (related to biota, sediment, seawater)
	Common Indicator 18: Level of pollution effects of key contaminants where a cause-and-effect relationship has been established
	Common Indicator 19: Occurrence, origin (where possible), extent of acute pollution events (e.g., slicks from oil, oil products and hazardous substances), and their impact on biota affected by this pollution
	Common Indicator 20: Actual levels of contaminants that have been detected and number of contaminants which have exceeded maximum regulatory levels in commonly consumed seafood
	Common Indicator 21: Percentage of intestinal enterococci concentration measurements within established standards
EO10 Marine Litter	
Marine and coastal litter do not adversely affect coastal and marine environment	**Common Indicator 22**: Trends in the amount of litter washed ashore and/or deposited on coastlines
	Common Indicator 23: Trends in the amount of litter in the water column including microplastics and on the seafloor
	Candidate Indicator 24: Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles
EO11 Energy including underwater noise	
Noise from human activities cause no significant impact on marine and coastal ecosystems	**Candidate Indicator 26**: Proportion of days and geographical distribution where loud, low, and mid-frequency impulsive sounds exceed levels that are likely to entail significant impact on marine animals
	Candidate Indicator 27: Levels of continuous low frequency sounds with the use of models as appropriate

Source: UNEP/MAP, 2023

2 INTERRELATIONS BETWEEN RELEVANT IMAP ECOLOGICAL OBJECTIVES AND COMMON INDICATORS

2.1 Interrelations between all indicators

The overall assessment of the GES of the marine environment is envisioned as an integrated effort, incorporating an evaluation of key ecosystem state elements as well as the intensity and effects of pressures from human activities. **Table 2** provides an overview of the state- oriented (state being a state of marine environment – biodiversity) and/or pressure-oriented nature of the Ecological Objectives. It should be noted here that the EU MSFD system overcome this dual nature of some Ecological Objectives, by addressing the state of pelagic habitats, fish and cephalopods in the scope of Descriptor 1 – Biodiversity (equivalent to EO1) (UNEP/MAP, 2021c).

Table 2. Overview of the (predominantly) state and pressure-oriented IMAP's Ecological Objectives

Ecological Objective (EO)	State-oriented	Pressure-oriented	Remark
EO1 – Biodiversity	X		
EO2 – Non-indigenous species		X	
EO3 – Harvest of commercially exploited fish and shellfish	X partly	X	EO3 is partly state-oriented (indicating state of certain fish and invertebrates' populations): spawning stock biomass (CI7). Fish mortality (CI9) and Bycatch (CI12) may to smaller extent contribute to understanding state of fish and invertebrates, as well as certain vulnerable species populations, such as marine turtles.
EO4 – Marine food webs	X		Common Indicators have not yet been officially approved, but they are in final stages of adoption. See **Table 1**
EO5 – Eutrophication	X partly	X	EO5 is to a small part state-oriented. Namely, through concentration of chlorophyl, it informs about the state of plankton (pelagic habitats) (CI14).
EO6 - Seafloor integrity	X		Common Indicators have not yet been officially approved, but they are in final stages of adoption. See **Table 1**
EO7 - Alteration of hydrological conditions	X		
EO8 - Coastal ecosystems and landscapes		X	
EO9 - Pollution		X	
EO10 – Marine litter		X	
EO11 - Energy, including underwater noise		X	Common Indicators have not yet been developed.

In practice (e.g. Med QSR assessment), each EO is assessed as a functional unit of the marine ecosystem, which in turn enables the evaluation of the overall GES achievement with application of appropriate aggregation approaches. For a comprehensive integrated GES assessment, it is essential to understand the interrelationships between different IMAP Ecological Objectives and their Common Indicators.

A more detailed proposal for an integrated GES assessment was presented at the Regional Meeting on IMAP Implementation in 2018 (UNEP MED WG. 450/3) and endorsed at the 7th Meeting of the Ecosystem Approach Coordination Group of UNEP/MAP in 2019 (UNEP MED WG. 467/7), including an indicative outlook on the interrelations between the Ecological Objectives, drawing on best practices from the EU MSFD implementation (European Commission, 2017), as presented in Table 3. As displayed in this Table, EO1 – Biodiversity, as the main state-oriented Ecological Objective, is the only linked to most of other EOs, with particularly significant interrelations with EO2, EO3, EO4, EO5, EO6, and EO7.

Table 3. Indicative interrelations between Ecological Objectives.

	EO1	EO2	EO3	EO4	EO5	EO6	EO7	EO8	EO9	EO10	EO11
EO1											
EO2											
EO3											
EO4											
EO5											
EO6											
EO7											
EO8											
EO9											
EO10											
EO11											

	No relation
	Limited relations

	Significant relations
	Extended relations

Extracted from the UNEP/MAP, 2019 (Table 4).

Furthermore, a possible framework has been proposed to facilitate an integrated GES assessment, considering the relationships among certain IMAP Ecological Objectives (EOs) and their Common Indicators (CIs) (Table 4). This proposal explains the interrelations between pressure-oriented and state-oriented EOs, along with their relevant associated CIs, in the context of impacts on state of biodiversity. The EOS and associated CIs, which were not identified at that time, nor in a mature stage of development, were not addressed.

For example, fishing efforts and yields (EO3 – CI8, CI10, and CI11) impact the state of fisheries (EO3 – CI7) as well as EO1 Common Indicators. This interaction is expressed through fish mortality (EO3 – CI9) and bycatch (EO3 – CI12). However, while this approach describes the impact of pressures on biodiversity, it does not explain the synergistic interrelations between pressure-oriented EOs and pressure-oriented/impact Common Indicators themselves—for instance, the interrelationship between EO3 and EO2 or EO5 (one of the concrete examples: invasive alien species can also affect fish stocks, spawning biomass, etc.).

Table 4. A possible framework for integrated GES assessment

ASSESSMENT OF GOOD ENVIRONMENTAL STATUS (GES)					Assessment of pressures				
					EO 2	EO 3	EO 5	EO 9	E0 10
					Nis	Extraction of wild species	Eutrophication	Contamination	Marine Litter
					Common Indicators of pressure				
					CI 6	CI 8, CI 10, CI 11	CI 3	CI 17, CI 19	CI 22, CI 23
Assessment of state	EO 1, EO 3	Species (birds, turtles, fish etc.)	State indClators	CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 9, CI 12	?	CI 18, CI 20-21	CI 24
	EO 1, EO 3	Pelagic Habitats		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	CI 18, CI 20-21	CI 24
	EO 1, EO 3	benthic habitats		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	CI 18, CI 20-21	CI 24
	EO 1, 2, 3, 4	ecosystems		CI 1 to 5, CI7, CI9	CI 3-5, C I7	CI 7, CI 9, CI 12	CI 14	?	?

In orange – EOs representing pressures (P); IMAP Common Indicators in yellow concern impacts (I) and ecosystem elements in grey cells concern state. Some EOs are repeated, as they are applicable to several ecosystem elements (species groups, pelagic and benthic habitats). EOs for which Common Indicators were not developed at the time (EO 4, 6 and 11) are not considered in this table, as well as EO 7 and EO 8. Cells marked with '?' indicate situations where an impact from the pressure is possible without any possible assessment.
Extracted from the UNEP/MAP, 2019 (Table 5).

Given the complexity of the marine environment, with numerous interrelations, synergies, and cumulative impacts, it is essential to acknowledge and understand the interactions between different pressures as key components of GES.

Based on the proposal of qualitative interrelations between most of the EOs (notably EO1, EO2, EO5, EO7, EO8, EO9 and EO10, EO3 was not included), elaborated in the framework of the two initial IMAP GES assessments developed in the scope of the GEF Adriatic project for Albania and Montenegro, a general description of nature of interrelations between majority of EOs, with some concrete examples, is provided in Annex 1. It appears that most interrelations between Ecological Objectives can be explained, at least descriptively. However, explaining the interrelations between some Ecological Objectives remains challenging, notably those between EO2 on one side and EO5, EO8, and EO9 on the other.

2.2 Interrelations between IMAP indicators and fisheries

An attempt was made to develop a more detailed qualitative analysis of EO3 and its associated Ecological Objectives and associated Common Indicators interrelations, including those EOs and associated indicators which are in the final stages of development (EO4 and EO6). Interrelations between pressure-oriented EOs and their Cis were of particular interest, as they may help in understanding synergistic interrelations. Most interrelations between EO3 and other EOs can be characterized as likely impacts coming from different pressures (including fisheries efforts) to the state of fish, shellfish and other related invertebrates (CI7 and CI9) (Table 5 and Table 6). However, many of

the interrelations express synergistic effects of different pressure-oriented indicators, contributing to a higher intensity of particular pressures. For example, spread of NIS/IAS (EO2 – CI6), such as Caulerpa and tropical fish, may affect fish habitats, but also create a competition for a common food source. Microplastic (EO10 – CI23) have already been recorded to accumulate in invertebrates and fish, affecting both state of fish and fishing effort. There is also a specific interrelation which can be characterized as primarily trophic. For example, some fish and invertebrate's species represent food for vulnerable species such as seabirds, marine turtles and marine mammals. Any fluctuation in fish stock biomass may affect the populations of these vulnerable species and their trophic interrelations (EO3 – EO, EO4, EO6 interrelations).

Although this analysis did not include Candidate Indicators under EO11 – Energy, including underwater noise, it is worth mentioning the possible interrelations with this objective. This research is still in its early stages in the Mediterranean, but it is important to note that some studies already suggest anthropogenic underwater noise may impact some invertebrate species (shellfish) and fish, (FAO/GFCM and OceanCare, 2021).

It should be noted that there is still a knowledge gap regarding the measurement of EO4 indicators (UNEP/MAP, 2024), which also hinders an adequate understanding of their interrelations with other EO3 Common indicators.

Table 5. Qualitative overview of the interrelations between Ecological Objectives and associated Common indicators in the Mediterranean Sea:
EO3 – Harvest of commercially exploited fish and shellfish and EO1 – Biodiversity, EO2 – Non-indigenous species, EO4 – Marine food webs, EO5 – Eutrophication, EO6 – Seafloor integrity, EO7- Alteration of hydrographical conditions, EO8 - Coastal ecosystems and landscapes, EO9 - Pollution, EO10 – Marine litter. Note: EO4 and EO6 Common indicators have not yet been officially adopted, but they are in the final stages of development.

	EO1	**EO2**	**EO3**	***EO4***	**EO5**	***EO6***	**EO7**	**EO8**	**EO9**	**EO10**
E03	• **Impact of bycatch on state of certain vulnerable species** (marine turtles, dolphins, seabirds) may affect/have; CI3, CI4 and CI5 with CI12 interrelated. •**Understanding statue of demersal and benthic fish and invertebrates could help explain the status of certain vulnerable species** (see also EO4 and EO6). For example, reduced fish and invertebrate	• **Spread of some NIS may cause degradation of habitats, both pelagic and benthic (**e.g. *Caulerpa* algae); affecting directly state of fish and invertebrates, and subsequently fisheries and more indirectly bycatch CI6 with CI7 - CI12 interrelated. •**IAS can be competitors to local populations and may impact fish and invertebrates,** and subsequently fisheries**.** al fish	• **Impacts of fishery on state of fish and invertebrate**; CI8, CI10, CI11, CI12 with CI7 and CI9 interrelated. • **Impact of fishery on bycatch of non-targeted and vulnerable species.** Less fishing efforts means less likelihood of bycatch (link to CI12 – CI3-CI5 interrelated.	• **Impact of fishery on biomass, abundance, trophodynamics (cascading effect) and diversity of all trophic groups.** For example, bottom trawling has detrimental effects (alone or in combination with effects of climate change) (Agnetta et al, 2022, Agnetta et al, 2024): CI8, CI10, CI11, CI12 with CI 4.1.1., 4.1.2, 4.1.3 interrelated. **Impacts of fishery on healthy proportion of selected group of species in marine food web.** For example, detrimental impact of bottom fisheries (often in	•**Impact of extensive nutrients and chlorophyl concentration disbalance** (such as harmful algal blooms – HAB) **on state of fish stocks, invertebrates,** and. **subsequently impacts on fisheries;** CI13, CI14 with CI7 – CI12 interrelated. • **Overfishing may contribute to and promote eutrophication related events, such as algal blooms** (Eriksson for European Parliament, 2011); CI8, CI10, CI11 with	• **Impact of bottom fishing efforts to sea-floor integrity.** Same as with impacts on benthic habitats (EO1 – CI1, CI2); CI10 with proposed EO6 indicators (extent of physical loss of natural habitat and extent of adverse effects of benthic habitats) • **Understanding status of demersal and benthic fish, invertebrates could contribute to assessment of sea-bed integrity** (UNEP/MAP, 2025b): CI7 and CI9 with	•**Impacts of hydrography alternation to benthic habitats important for fish and invertebrates** (e.g. changed fluctuation may lead to changed sedimentation rate). These impacts may **subsequently impact fisheries;** CI15 with CI7 – CI12 interrelated. •**Impact to primary production and pelagic habitats** (e.g. through turbidity in water column**),** which may **impact fish,**	•**Impact of coastal development to benthic habitats important for fish, invertebrates and subsequently on fisheries**; CI15 with CI7 – CI12 interrelated.	•**Impact on invertebrates and fish**, and **subsequently. on fisheries - toxicological effects of harmful chemicals and microbial pathogens;** CI17, CI18, CI20, CI21 with CI7 – CI12 interrelated. •**Impact of acute pollution events on fish, Invertebrate, subsequent. on fisheries;** CI19 with CI7 – CI12 interrelated.	• **Contribution of fisheries to amount, concentration of marine litter in marine environment - discarded fishing gear (ghost nets) and similar tools;** CI22 with CI8, CI10 and CI11 interrelated. •**Impact of marine litter on fish and fisheries**, for example through entanglement and ingestion: CI22 with CI7 – CI12 interrelations •**Impact of microplastic on fish,**

	populations, may particularly affect certain vulnerable species, such as dolphins, seabirds, and marine turtles.; CI3 – CI5 with CII7 and CI9 interrelated. • **Impact of fishing effort on benthic habitats,** particularly through dredging, bottom-trawling etc (see also EO4 and EO6); CI0 with CI1 and CI2 interrelated. • **Impact of fishing effort on pelagic habitats.** This interrelation is more difficult to examine (see EO4), but there is evidence of such interrelation;	populations.; CI6 with CI7 - CI12 interrelated. •**Some NIS my transmit disease and impact fish, invertebrates and subsequently fisheries.** For example, American lobster impacts the European lobster – (Katsanevakis et al, 2018); CI6 with CI7. CI12 interrelated.		combination with eutrophication) to pelagic/ demersal ratio (UNEP/MAP, 2025a), but also possible impact to other related parameters: CI CI8, CI10, CI11 and CI12 with 4.2.1, 4.2., 4.2.3, 4.2.4 and 4.2.5, interrelated. • **Understanding trophic interrelations could help explain status of fish and invertebrate species;** CI 4.1.1., 4.1.2, 4.1.3, with CI7 and CI9 interrelations: 4.2.1. with CI7 and CI9 interrelations, probably also 4.2.2. – 4.2.5. with CI7 and CI9, but this needs to be supported by science-based evidence. **Note:** There is still a significant knowledge gap	CI14 interrelated. **Note**: Impacts of eutrophication are particularly relevant for semi-enclosed bays	proposed EO6 indicators interrelated.	**invertebrates**, **subsequently fisheries**; CI15 with CI7 – CI12 interrelated. •**Increase in temperature and salinity (to the most part related to climate change) may affect composition of fish and invertebrates** subsequently fisheries; CI15 with CI7 – CI12 interrelated. **Note:** In relation to the points mentioned above, strong linkages between EO7 with EO1, EO4 and EO6 should also be highlighted.			**invertebrates**, **and subsequently fisheries**. Microplastic accumulates in animals and enters food-webs; CI23 with CI7 – CI12 interrelated.

	CI0 with CI1 and CI2 interrelated.			which leads to many uncertainties in the measurement of EO4 indicators, as well as the assessment of interrelations with other EOs and CIs (UNEP/MAP, 2024).						

Table 6. Summary of interrelations between EO3 and EO1, EO2, EO4, EO5, EO6, EO7, EO8, EO9 and EO10 and associated Common Indicators

(Note: visual display of the results from the Table 5). EO4 and EO6 CIs have not yet been officially adopted, but they are in the final stages of development. For the purpose of this table, EO4 candidate indicators will be marked as 4.1.1. – 4.1.3 and 4.2.1. – 4.2.5. (UNEP/MAP, 2025a). For EO6 they will simply be called 6.1 and 6.2.

Ecological Objectives with Common Indictors		EO1					EO2	EO3**				EO4								EO5		EO6		EO7	EO8	EO9					EO10	
		CI 1	CI 2	CI 3	CI 4	CI 5	CI 6	CI 8	CI 10	CI 11	CI 12	4.1.1	4.1.2	4.1.3	4.2.1	4.2.2	4.2.3	4.2.4	4.2.5	CI13	CI 14*	6.1.	6.2.	CI 15	CI 16	CI 17	CI 18	CI 19	CI20	CI 21	CI 22	CI 23
EO 3	CI7						D													D	D			D	D	D	D	D	D	D	D	D
	CI8			#	#	#															B										B	
	CI9						D													D	D			D	D	D	D	D	D	D	D	D
	CI10			#	#	#															B										B	
	CI11			#	#	#															B										B	
	CI12																															

In green – state oriented Ecological Objectives (predominantly) and state-oriented Common indicators, in orange pre-dominantly pressure-oriented Ecological Objectives and pressure-oriented Common Indicators, in red – interrelation expressing impacts of pressures to the state of marine biodiversity (including commercial fish and invertebrates), in grey – interrelations expressing synergistical effects of different pressure-oriented indicators, in blue – interrelations expressing co-relations between state of different component of biodiversity; mostly tackling availability of food provision for certain targeted species, yellow – still not sufficiently understood nature of interrelations.

*CI14 to the most part indicated state of plankton (pelagic habitats) via concentration of chlorophyl, which is essentially expression of the state of marine biodiversity. However, if the concentration of plankton is higher (such as through algal blooms), it is expression of pressures. Hence, for this analysis only, CI14 is viewed as pressure-oriented one.

**CI7 and CI9 are not specifically indicated in this column, because there is no relevant interrelations between them. It was to accentuate the impacts expressed through other EO3 Common indicators on the state of fish stocks.

#Common Indicators expressing different aspects of fishing efforts and yields have impact on state of species, but results of these impacts are more clearly expressed in the state of spawning stocks (CI7) and fish mortality (CI9).

B – Pressure-oriented indicators work both ways – e.g. harmful algal blooms can impact fish stocks and invertebrates, and subsequently fishery. On the other hand, overfishing may contribute to/promote harmful algal blooms. Fisheries can also contribute to amount/concentration of marine litter in the marine environment, while marine litter may impact fish and invertebrates, and subsequently fisheries.

D – Direct (or more direct) impacts of pressures (such as invasive alien species and eutrophication) are seen in state of fish biomass and mortality, which subsequently/indirectly affects fishery.

3 CONCLUSIONS AND RECOMMENDATIONS

- The interrelations between different EcAp/IMAP Ecological Objectives and associated Common Indicators are complex but understanding them is essential for a comprehensive overall GES assessment.

- Significant efforts have been done so to elaborate IMAP's EO3 Common Indicators, led by GFCM in collaboration with SPA/RAC.

- An attempt was made to analyse in a qualitive manner interrelations between EO3 and its Common Indicators with other IMAP's Ecological objectives and their indicators, including both those adopted and those in the final stages of development (EO1, EO2, EO4, EO5. EO6, EO7, EO8, EO9 and EO10). The focus was not only to understand pressure- state interrelations (for example already expressed through EO3 – CI12 on bycatch of vulnerable species), but also on understanding synergistic effects of various pressures.

- Most interrelations between EO3 and other EOs indicate their synergistical effects. One of concrete examples are connections between EO3 Common Indicators and NIS/IAS (EO2 – CI6), as well as microplastics (EO10 – CI23). In this context, fisheries and fish resources may be significantly affected by IAS, which degrade their habitats and compete with native species. Accumulation of microplastic in fish stocks, may harm both fish and fisheries.

- Some interactions are trophic, such as fish and invertebrates serving as food for vulnerable species (EO3 with EO1, EO4 and EO6).

- While EO11 – Energy, including underwater noise Candidate Indicators were not analysed, studies suggest potential links with this EO.

- The findings of this qualitative analysis could contribute to the further elaboration of the EO3 Common Indicators (including their quantifications), as well as assist in refining an overall integrated GES assessment. More specifically it can:

    - Assist in further defining thresholds for Common Indicators.
    - Facilitate the linking and operationalization of monitoring efforts. For example, as explained in *FAO, 2019* fishing observations could be a good opportunity for collection of data and a rough estimate of quality and quantity of marine litter brought by fishing operations. Further examples could be explored.
    - Contribute to refining the methodological approach for overall integrated/aggregated GES assessment.

REFERENCES

1. Agnetta D, Badalamenti F, Colloca F, Cossarini G, Fiorentino F, Garofalo G, Patti B, Pipitone C, Russo T, Solidoro C and Libralato S (2022). Interactive effects of fishing effort reduction and climate change in a central Mediterranean fishing area: Insights from bio-economic indices derived from a dynamic food-web model. *Front. Mar. Sci*. 9:909164. doi: 10.3389/fmars.2022.909164

2. Agnetta D, Badalamenti F, Sweeting CJ, D'Anna G, Libralato S, Pipitone C. (2024) Erosion of fish trophic position: an indirect effect of fishing on food webs elucidated by stable isotopes. *Phil. Trans. R. Soc. B* 379: 20230167. https://doi.org/10.1098/rstb.2023.0167.

3. European Parliament (Committee on Fisheries) (2011). Does overfishing promote algal blossoms. A report prepared by B.K Eriksson.

4. Food and Agriculture Organization (FAO). (2019). *Monitoring the incidental catch of vulnerable species in Mediterranean and Black Sea fisheries: Methodology for data collection*. FAO Fisheries and Aquaculture Technical Paper No. 640. Rome, FAO. https://www.fao.org/3/ca4991en/ca4991en.pdf

5. FAO – GFCM in cooperation with OceanCare (2021). Study on the potential effects of underwater noise on demersal fisheries in the fisheries restricted area of Jabuka/Pomo Pit in the Adriatic Sea. An expert study is prepared with the support of the Federal Food Safety and Veterinary Office of Switzerland (FSVO) of the Federal Council of Switzerland

6. Katsanevakis S., Rilov G. and Edelist D. (2018). Impacts of marine invasive alien species on European fisheries and aquaculture - plague or boon? pp. 125- 132 In CIESM Monograph SO [F Briand Ed.] Engaging marine scientists and fishers to share knowledge and perceptions- Early lessons. CIESM Publisher, Monaco and Paris, 218 p.

7. UNEP/MAP (2025a). Development of the EcAp Ecological Objective 4 on Marine food webs under the Barcelona Convention. Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries (Athens, 2025). UNEP/MED WG. 606.4

8. UNEP/MAP (2025b). Development of the EcAp Ecological Objective 6 on Sea-floor integrity under the Barcelona Convention. Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries (Athens, 2025). UNEP/MED WG. 606/03

9. UNEP/MAP (2024). Desk review on the available information on marine food webs in the Mediterranean. Meeting of the Ecosystem Approach Correspondence Group on Monitoring (CORMON) Biodiversity and Fisheries (Athens, 2024). UNEP/MED WG. 592/Inf3

10. UNEP/MAP (2023). 2023 Mediterranean Quality Status Report. Document presented at the 10th Meeting of the Ecosystem Approach Coordination Group (Istanbul, 2023). UNEP/MED WG.567/Inf.3

11. UNEP/MAP-PAP/RAC-SPA/RAC and MTE (2021a). Towards an Integrated Marine Good Environmental Status (GES) Assessment for Albania. Assessment of the marine environment and the sustainability of the ecosystem values. By (alphabet order): Edlira Baraj, Giuseppe Civitarese, Zamir Dedej, Carlos Guitart, Rezart Kapedani, Vedrana Kovačević, Milica Mandić, Marina Marković, Robert Precali, Elson Salihaj, Ivan Sekovski, Ana Štrbenac, Anis Zarrouk. Eds: PAP/RAC, GEF Adriatic project. pp 92 + Annex

12. UNEP/MAP-PAP/RAC-SPA/RAC and MESPU (2021b). Towards an Integrated Marine Good Environmental Status (GES) Assessment for Montenegro. Assessment of the marine environment and the sustainability of the ecosystem values. By (alphabet order): Željka Čurović, Dragana Drakulović, Mirko Đurović, Carlos Guitart, Aleksandra Ivanović, Christos Ioakemidis, Darinka Joksimović, Vesna Mačić, Milica Mandić, Marina Marković, Branka Pestorić, Slavica, Petović, Robert Precali, Darko Saveljić, Ivana Stojanović, Ivan Sekovski, Ana Štrbenac, Danijela Šuković, Anis Zarrouk. Eds: PAP/RAC, GEF Adriatic project. Pp 110 + Annex

13. UNEP/MAP (2021c). Comparative Analysis undertaken with regard to IMAP and the European Commission GES Decision 2017/848/EU for Biodiversity and NIS. Document presented at the 15th Meeting of the SPA/BD National Focal Points. UNEP/MED WG.502/Inf.10

14. UNEP/MAP (2019). Cross-Cutting Issues and Common Challenges: The Methodological Approach for Mapping the Interrelations between Sectors, Activities, Pressures, Impacts and State of Marine Environment for EO5 and EO9. Document presented at the 7th meeting of the Ecosystem Approach Coordination Group of the UNEP/MAP (Athens). UNEP MED WG.467/7

15. UNEP/MAP (2018). Progress Report on the implementation of Decision IG.22/7 on the Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) Document presented at the Regional Meeting on IMAP Implementation: Best Practices, Gaps and Common Challenges (Italy). UNEP MED WG. 450/3

Annex 1.

Qualitative overview of the interrelations between Ecological Objectives EO1 – Biodiversity, EO2 – Non-indigenous species, EO5 – Eutrophication, EO7- Alteration of hydrographical conditions, EO8 - Coastal ecosystems and landscapes, EO9 - Pollution, EO10 – Marine litter

	EO1	EO2	EO5	EO7	EO8	EO9	EO10
E01	-	**NIS** may cause: • Habitat degradation and destruction, • Decline of certain species, e.g. through spread of diseases	**Eutrophication** may: • Significantly impact habitats via nutrient and organic matter enrichment in coastal zone (e.g. harmful algal blossoms – HAB) and subsequent hypoxic conditions in certain benthic areas • Impact whole food web (and fisheries in particular). Both types of impacts are particularly relevant for semi-enclosed bays	**Hydrographic alterations** may: • Impact benthic habitats via altered sedimentation rates. Currents and other types of water movement directly influence sedimentation rates. • Affect primary production and pelagic habitats via turbidity • Impact species composition due to increase in Temperature or salinity. • Altered conditions such as (increase of temperature) may also facilitate spread of diseases – which may significantly affect survival of some species	**Tourism-driven urbanisation and construction in coastal area** may cause: • Benthic habitats destruction • Destruction of habitats important for certain species, such as monk-seal habitats, as sea turtles nesting sites etc	**Pollution** may cause: • Degradation and destruction of habitats. including its species in all its forms. • Toxicological effects of harmful chemicals and microbial pathogens accumulated in invertebrates can affect vertebrates from individual specimen to entire communities. Economically commercial species may be impacted too (relation t fisheries).	**Marine litter** may particularly: • Affect certain species. Most evident cases relate to entanglement of marine turtles and marine mammals in fishing gear, as well as suffocation through ingestion of plastic. • Microplastics is Very problematic, entering food-webs and accumulating In shellfish and fish. • Benthic habitats can also be severely impacted via physical damage by litter, such as to corals
EO2		-	Currently unknown	• Increasing sea temperature can favour the introduction of NIS and facilitate the	Currently unknown	Currently unknown	• Floating litter could be a favourable vector for

				spread of thermophilic species. • Change in currents in certain environmental conditions can favour the inflow of NIS from southern - eastern parts of Mediterranean Sea.			transmission of organisms to distant places and it can cause transportation of NIS to new locations
EO5	-	-	-	• Local (small scale) and mesoscale coastal currents can extend the eutrophication. • Information on hydrographic conditions (e.g., temperature, salinity, and density) are particularly relevant for eutrophication assessment. it is advisable that the monitoring of parameters belonging to these two EOs takes place at the same stations at the same time.	• Urbanised areas in coastal zone are sources of nutrient enrichment in near-shore marine areas, in particular in the absence of the appropriate wastewater treatment.	• Eutrophication sources could be also related to other sources of pollution (e.g., chemical pollution and microbial pathogens) through Wastewater Treatment Plant outflows.	
EO7	-	-	-	-	• Physical changes of the coastline may affect near-shore hydrographic conditions.	• Pollution/contaminants from both diffuse or point sources can be redistributed or transported throughout the environment by hydrographic processes. • Contaminants remain in the water column and especially in the sediment, from which they can be re-suspended depending on the currents, waves, turbulence, and other environmental features.	• Hydrographic conditions, in particular currents have significant impacts on accumulation, transport and distribution of marine litter.
EO8	-	-	-	-	-	• Coastal construction, such as ports and similar, may be sources of marine contamination	• There is a strong link between urban areas and marine litter depositions

EO9	-	-	-	-	-	-	• Chemical plasticizers and other known persistent substances can leach from marine litter (both macro and micro-litter items).
EO10	-	-	-	-	-	-	-

This table is prepared building on results from the initial GEF assessments for Albania and Montenegro - GEF Adriatic project: UNEP/MAP-PAP/RAC-SPA/RAC and MESPU (2021a and 2021b)

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