Consultation Report: Support to develop the MSC ecosystem component – ecosystem impacts indicators, and best practice review

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Marine Stewardship Council

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Support to develop the MSC Ecosystem Component – Ecosystem Impacts Indicators, and Best Practice Review

Contract report

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This report utilizes data from publicly accessible sources or accessible through scientific projects and collaborations, and is not providing and exhaustive and complete picture of the field. Data quality is subject to the original data sources.

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1 Introduction

This document details the main activities undertaken between 28th of October and 13th of November 2019 regarding the collaboration between the Marine Stewardship Council and Dr. Marta Coll Montón, supporting activities on the Ecosystem Component of MSC evaluation, specifically on the Ecosystem Impacts Indicators and the Best Practice review.

As agreed with MCS, Dr. Coll undertook the following activities the Terms of Reference:

1. Determine a set of indicators/methodologies that have been peer reviewed and assessed as reliable for monitoring and mitigating fisheries impact on the wider ecosystem:
    a. Literature review to determine a list of indicators/ methodologies that are either peer reviewed and/or in use by management agencies/industry.
2. Based on the outcome of Objective 1, determine:
    a. Options for how those indicators could be adapted to ensure effective precautionary assessments of fisheries under the MSC programme.
    b. Provide a detailed account of how those indicators differentiate from each other in terms of resource intensity (information, time, expert knowledge, etc.).

The deliverables established in the ToR were:

1. Description and justification of the methodology and scope of literature to be covered in the review.
2. Report outlining the analyses and results used to determine conclusions which should include:

    a. List of currently available indicators, the results must detail characteristics of these indicators in the form of a table that include (but is not limited to) 1) information aboutspatial resolution; 2) evidence of current and successful use by RFMOs, fishing authorities/researchers and/or industry; 3) an account of their applicability to data richand data poor scenarios; 4) taxa or objective the indicators aiming to monitor.

    b. Summary of the indicators' characteristics, in narrative and in a summary table, which should detail at least: 1) whether they are qualitative or quantitative, 2) if they are used mostly on data-rich or poor scenarios, 3) the regions where they have been used, 4) fisheries/resources that have been assessed with these indicators, 5) costs andhuman resources required. The consultant can expand the list of characteristics if s/heconsiders it is necessary

    c. Emphasis should be placed in identifying and characterizing a qualitative data- limited alternative and it should be contrasted with the characteristics of the current MSC risk-based approach for ecosystem impacts (SICA).

    d. An identification of commonalties across these indicators (i.e. what are they assessing? are they mostly qualitative or quantitative in nature? what type of models do they require? etc.).

e. A detailed description of the mechanisms that allow to evaluate the indicators' performance/robustness (e.g. model fitness, minimum spatial resolution, etc.). This deliverable should answer the question: "how can we evaluate the quality and reliability of ecosystem indicators in fisheries management?" These results will be used to informMSC's requirements for information/models at a later stage in the project.

The deliverables are presented in this report. Due to de findings of the first part of the study,the review of indicators was organized using an operational concept instead of a list of available indicators in the literature. The operational concept proposes an indicator framework that is organised in several operational objections and lists several candidate indicators, which can be replaced by more suitable or alternative indicators according to regional/local management needs (Section 4 of the report).

2 Description and justification of the methodology and scope of literature

The work to be developed under this contract started with two parallel activities: 1) a reviewof MSC background information about evaluation guidelines and the Ecosystem Component,and 2) a review of available initiative regarding indicators that could be of interest for MSC Ecosystem Component evaluation.

Regarding the review of MSC background, three documents were mainly used:

- MSC 2018. Working towards MSC certification: A practical guide for fisheries improving to sustainability. 221 pages
- MSC 2014. MSC Fisheries Certification Requirements and Guidance. Version 2.0,1stOctober 2014. 528 pp.
- MSC 2018. MSC Fisheries Certification Process. Version 2.1, 31st August 2018.

Regarding the review of indicators' initiatives, several peer-review papers and project initiatives were reviewed, with special emphasis on state-of-the-art initiatives and benchmarkpublications. Some of the most relevant ones are:

- ***Indicators of the Seas*** (IndiSeas, http://www.indiseas.org/,): Indiseas was a bottom-up scientific program which evaluated the effects of fishing on the health status of marine ecosystems. A panel of indicators was provided, characterizing the ecological and biodiversity status of exploited resources, their environment, and the human dimension offisheries. IndiSeas run from 2010 to 2018 and several peer-review publications were produced, both based on survey-based, catch-based and model-based datasets (e.g., Bundy et al., 2012; Coll et al., 2016; Fu et al., 2019a; Fu et al., 2019b; Shin et al., 2012; Shinet al., 2018; Shin and Shannon, 2010).
- ***Marine Strategy Framework Directive*** of the European Commission (MSFD, https://ec.europa.eu/environment/marine/eu-coast-and-marine-policy/marine-strategy- framework-directive/index_en.htm) and the International Council for the Exploration of the Sea (ICES). The MSFD was adopted in 2008 with the aim to achieve Good EnvironmentalStatus (GES) of the EU's marine waters by 2020 and to protect marine resources with economic and social importance. The MSFC is the first EU legislative instrument related tothe protection of marine biodiversity, as it contains the explicit regulatory objective that "biodiversity is maintained by 2020", as the cornerstone for achieving GES (e.g., EU, 2008;Piroddi et al., 2015; Smith et al., 2016).
- ***Common Fisheries Policy*** of the European Commission (CFP, https://ec.europa.eu/fisheries/cfp_en). The CFP sets rules for managing European fishing fleets and for conserving fish stocks. The CFP aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable and that they provide a sourceof healthy food for EU citizens (EU, 2016).

- ***Regional policies such as the General Fisheries Commission for the Mediterranean*** *(GFCM, http://www.fao.org/gfcm/en/)* ***and the UNEP-MAP EcAp framework*** *(http://web.unep.org/unepmap/),* which aim of identifying common principles in relation to the achievement of sustainable use of marine resources and ecosystems in the Mediterranean Sea (including both EU and non-EU waters) (GFCM, 2012, 2019).
- ***Lenfest Project Benchmarks for Ecosystem Assessment(https://www.lenfestocean.org/en/research-projects/benchmarks-for-ecosystem- assessment),*** led by Dr. Beth Fulton and Dr. Keith Sainsbury under the Lenfest OceanProgram. The project aims at developing practical indicators for ecosystem structure andfunction, along with guidelines for applying those indicators in a variety of ecosystems andmanagement contexts (Fulton and Sainsbury, 2019).

During the review, relevant literature was searched, and especially benchmark peer review publications on ecological indicators applied to monitoring and mitigating fisheries impact onthe wider ecosystem.

3 Analyses and results

3.1 Critical analysis of the ecosystem component of principle 2 of the msc

Firstly, the revision of MSC documentation enabled me to get familiar with key elements of the Ecosystem Component in Principle 2 of MSC evaluation and conduct a critical assessment.

Principle 2 states that 'fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends'. There are five components in Principle 2, which are considered to cover the range of potential ecosystem elements that may be impacted by a fishery: primary species, secondary species, ETP species,habitats and ecosystems.

The Ecosystems Component is descried in IP 2.5.1 (Ecosystem Outcome), 2.5.2 (Ecosystem Management Strategy) and 2.5.3 (Ecosystem Information).

Regarding the Ecosystem Outcome (2.5.1), the scoring is based to evaluate the Ecosystem Status. The first results of the critical review of the procedure to score this IP was the realization that only very general information is provided about the data to be used for the evaluation of ecosystem outcomes. The guidelines seemed too general to provide clear **operational objectives**, which are necessary to establish **specific indicators** to rigorously evaluate the ecosystem status with a clear aim and **standardized framework**. The guidelineswere also unclear on how to incorporate the **regional management context** into account andexisting frameworks. The regional context on where the ecosystem is located and which management bodies (national and regional) operate is necessary to the evaluation of the ecosystem. This context can facilitate the identification and access of available data, the identification of legal and management rules established and even the specific indicators thatare currently used to evaluate ecosystem components by regional bodies. These observationsare in line with what is being highlighted in the Benchmarks for Ecosystem Assessment led byDr. Beth Fulton and Dr. Keith Sainsbury (Fulton and Sainsbury, 2019) and findings of the IndiSeas international initiative (Shin et al., 2012).

Another outcome of the critical analysis was the realization that the scoring issue of Ecosystem Status (SG60, SG80 and SG100) seemed to be biased towards the evaluation of a good ecosystem status or towards no impact of the fisheries. This is so because the three scores are described to evaluate a positive outcome: "unlikely/highly unlikely to disrupt underlying ecosystem structure and function to a point where there would be a serious or irreversible harm". This motivates a recommendation to establish an **unbiased score system** where the evaluation can also score that there is a "likely" probability to disrupt the ecosystem following the **Precautionary Principle (EC, 2000)**, if information to prove otherwiseis not available.

Regarding Ecosystem Management Strategy (2.5.2), the scoring is set to evaluate the Ecosystem Strategy in Place. The outcome of the critical review of the procedure to score thisIP was the realization that only general information is provided about the data to be used forthe evaluation of this element. The ecosystem management strategy in place likely depend on **national and regional management bodies and policies**, and as such, identifying **the management context** of the evaluation is needed before the scoring. In addition, the scoringin place (SG60, SG80 and SG100)

seemed to be biased towards the evaluation of a measuresbeing set to manage the ecosystem. This is so because the scores do not provide the option to score a negative outcome of the evaluation (e.g. “there is no measures in place”). Therefore, there is a need to establish an **unbiased score** option following the Precautionary Principle.

Regarding Ecosystem Information (2.5.3), the scoring is based to evaluate the information quality, investigation of UoA impacts, understanding of component functions, information relevance and monitoring. According to the MSC standards, the desirable situation is that thefishery management system is capable of adapting management to environmental changes as well as managing the effect of the fishery on the ecosystem, in addition to including the capability to monitor changes in environmental change on productivity and the importance of climate change. Overall, the same challenges on this IP were found as in the previous ones,mainly in terms of too general guidelines to assess data available under the good practice andcertification checks and biases score options.

Overall, this first part of the study pointed out to **the need to establish a MSC Ecosystems Evaluation Standardized Framework (MSC EESF), with MSC Operational Objectives (MSC OO) that can be applied and adapted within a meaningful regional context to establish specific indicators and assess them against unbiased scores andlocal expertise.**

3.2 Review of indicators to be used under the Ecosystem component of MSC

The review of indicators available to assess the impacts of fishing on marine ecosystems as awhole or specific components evidenced that there has been a sustained increase of indicators, reviews and applications, especially in the last decades.

Full projects and programs have been developed at the international and regional level, suchas IndiSeas (Shin and Shannon, 2010) or the Ocean Health Index project (Halpern et al., 2012).Current efforts are being put to identify robust indicators (e.g.,Fu et al., 2019a; Fu et al., 2019b; Fulton et al., 2005; Shin et al., 2018) and apply them to meaningful local and regionalmanagement contexts (e.g., Fulton and Sainsbury, 2019; Gislason et al., 2000; Juan Jorda et al., 2018; Lockerbie et al., 2017a; Lockerbie et al., 2016; Lockerbie et al., 2017b; Sainsbury andSumaila, 2003).

Indicators can be obtained from several data sources: surveys independent from fisheries, from landings or catch data, from stock assessments and other models such as ecosystem models, and from Local Ecological Knowledge (LEK) or any combination of the above (e.g., Christensen et al., 2014; Coll et al., 2016; Coll and Steenbeek, 2017; Fu et al., 2019a; Fu et al.,2019b; Pauly et al., 1998; Piroddi et al., 2015; Rochet and Trenkel, 2003; Shin et al., 2010; Shinet al., 2018; Shin and Shannon, 2010).

A large variety of Indicators have been proposed and used to capture different components of marine ecosystems and fisheries impacts, such as changes in key targeted species and its prey and predators (in abundance, biomass, distribution, size, etc.), the impact on vulnerable components of the ecosystem (such as species at risk, vulnerable species or essential habitats)and the loss of biodiversity due to the loss of some of these components, and changes in theoverall structure and functioning of the ecosystem (such as those documenting changes in trophic interactions, energy

flows and the loss of productivity) (e.g., Coll et al., 2016; Coll andSteenbeek, 2017; Gascuel et al., 2016; Rochet and Trenkel, 2003; Rochet M.-J. et al., 2009; Shannon et al., 2014; Shin et al., 2012). Indicators have been classified as to inform about thestate of the ecosystem, the pressures on them, or the responses (Butchart et al., 2010; Tittensor et al., 2014).

From these benchmark studies, initiatives and applications, several important lessons have been learned. They can be very relevant for the MSC Ecosystems evaluation and the use of indicators:

1. **A set of indicators is needed**: not one single indicator seems to be enough to capture theecosystem effects of fishing, therefore there is a need to select a suit of indicators coming from different methods, using different data associated with different uncertainty and spatial-temporal coverage, and capturing different ecosystem components and compartments.
2. **A local/regional evaluation of indicators is necessary**: indicators used to assess the ecosystem impact of fishing need to be sensitive, responsible and specific to fishing impacts. Indicators may vary due to ecological features of the ecosystem, productivity changes, historical fisheries patterns and fisheries strategies (targeting lower or higher trophic levels). Therefore, indicators should be tested in the particular ecosystem before they are used for monitoring and management purposes.
3. **The regional context where the indicators will be applied is important**: Ecological indicators are resource intensive. Regional fisheries bodies and other management bodies hold important information that can be used to calculate and evaluate indicators and facilitate their regular update and communication. In addition, regional bodies may have selected (or may be in process to select) specific management objectives that can help adapt ecological indicators and make them easily to communicate to the management and policy context of specific case studies. Therefore, the selection of indicators should be performed in collaboration with and with participation from the regional management and policy stakeholders.
4. **Local expertise is needed to interpret indicators patterns:** The involvement of local expertise to correctly interpret results from ecological indicators has been identified as a key element of the evaluation process. Changes in the hisotorical exploitation patterns, the exploitation status of the ecosystem and specific fisheries strategies impact ecological indicators in ways that make the general application of indicators difficult. Local expertise has been proven very useful to avoid misinterpretation of indicators' patterns.
5. **Reference points are needed to evaluate indicators:** Understanding how indicators change with time and space, and how they should change to indicate good environmental status, is a challenge. Reference points are "conventional values of an indicator, either model based or empirical, which represents a state of species, communities or ecosystems, and whose characteristics are considered to be useful for the management of the fisheries with respect, for example, to an acceptable level of biological or ecological risk or a desired level of catch. The values may be key fishing mortality rates (F), total mortality rates (Z), exploitation rates (E), biomass

levels, catch rates and related fishing effort or other set of empirical indicators that are related to the maximum potential of a stock, a community or an ecosystem and that produce the highest sustainable catches and economic viability of fisheries while maintaining and conserving ecological and biodiversity targets. In terms of their use, reference points can be classified as Target, Threshold or Limit reference points. They are important to enable the evaluation of an ecosystem against specific criteria to assess the Ecosystem status and should be established with the involvement of scientists, managers, fishers and local/regional practitioners and management bodies prior to Ecosystems evaluation.

4 Overall recommendations to MSC

Overall, from the critical review of the MSC Ecosystems Status guidelines and indicators (section 2 above) and the lessons learned from available work done with ecological indicatorsto assess the ecosystem impacts of fishing (section 3 above), the following main recommendation to MSC are formulated to advance the evaluation of the Ecosystems Statuscomponent:

First recommendation: Establishment of the MSC Ecosystems Evaluation General Framework(MSC EEGF) with selected Operational Objectives (MSC OO) and candidate indicators that encompass different levels of data needs, applicability, uncertainty, and resource intensity. The MSC EEGF and MSC OO should be common to all Ecosystems evaluations.

A first attempt to define a general indicator's framework containing three MSC OO and a setof candidate indicators to evaluate Ecosystems Status is provided in this report (see accompanying Tables to the report, Table 1 and Table 2). An overview of this proposal is summarized below:

Operational Objective A. Level of exploitation by fisheries allows populations of key predators and prey (if fished) to be within biological safe limits. This OO includes 6 candidateindicators:

1. Catch of key predators and prey species
2. Fishing mortality of key predators and prey
3. Biomass indices of key predators and prey
4. Ratio between catch and biomass index (catch/biomass ratio) of key predators and prey
5. Spatial distribution of the population of key predators and prey
6. Length distribution of the population of key predators and prey in the catch

Operational Objective B. Level of exploitation by fisheries allows maintaining or recover biodiversity levels. This OO includes 4 indicators:

1. Proportion of exploited species with declining biomass in the population (DEB)
2. Biomass of IUCN species at risk
3. Mean intrinsic vulnerability index of the fish landed catch (MIVI)
4. Proportion of discards in the fishery

Operational Objective C. Level of exploitation by fisheries allows maintaining the ecosystem structure and functioning traits. This OO includes 4 indicators:

1. Proportion of Large Fish in the catch (LFc) and in the surveyed (exploited) community (LFsc)

2. Proportion of predatory fish in the catch (and in the community)

3. Mean Trophic Level of the catch (TLc) and of the surveyed (exploited) community (TLsc)

4. Primary Production Required to sustain the catch in comparison with the primary production available (PPR%)

Table 1 in the Annex of this report contains a short description and definition of each indicator, proposed targets for its evaluation, examples of policies and initiatives where the indicator has been considered, suggestions for the implementation of the indicator and a listof alternative indicators, and key scientific references and websites.

Table 2 in the Annex of this report provides further specific information per indicator. It includes information about the dependency of the indicator to fisheries data, the spatial resolution frequently used, the nature of the indictor (qualitative or quantitative), information about the resources needed in terms of (a) time to calculate (from low to high, considering that normal evaluation processes may last a maximum of 18 months and that availability of data may be different for different case studies, (b) expertise to assess (from low to high, considering the expertise needed by the evaluator to property interpret the indicator's results in terms of Ecosystem Evaluation), and (c) funding to calculate (from low to high, considering the overall funding needed to collect, integrate and calculate the indicator). The table also includes main advantages and limitations identified from theliterature review and a qualitative evaluation of the uncertainty that input data can bring to the indicator (from low to high, considering that input data can have sometimes different quality depending on the case study).

Second recommendation: Adapt the proposed general indicator' framework in meaningful regional contexts taking into account the ecological, legal and management context of each region. It is advisable that this is perform with assistance or involvement of the Regional Fisheries Management Organizations and other national and regional management and policy bodies. The candidate indicators can be then selected to fit the regional contexts.

Third recommendation: Test the selected indicators per region in specific and well known case studies that allow MSC to learn from the process and improve the MSC EEGF applicationprocedure and selection of indicators within the regional context. Specific case studies couldbe located in different regional seas and incorporate local expertise to evaluate the Ecosystems Component status.

Forth recommendation: Several ongoing initiatives seem to follow a similar philosophy and strategy to what is proposed in this study. This is for example the case of the Benchmarks for Ecosystem

Assessment by Lenfest Ocean Program, the Integrated Ecosystem Assessments byNOAA (NOAA, 2019) or previous work developed under IndiSeas project and its follow ups.

To develop the proposed MSS EEGF, MSC OO and apply the general indicator's framework intandem with these initiatives seems a rational way to proceed.

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	GES included				*Species included*			*Regions*			*Monitoring*		
Indicator	**GES general objective**	**EcAP EOs**	**MSFD descriptors**	**State or stressor**	**Biodiversity components**	**Species included**	**Commercial stock included**	**Common or candidate Indicators**	**Sub-regions**	**GSAs**	**Prospective for monitoring**	**Data requirements**	**Minimum sampling**
Operational objective 3.1 Level of exploitation by commercial fisheries allows populations to be within biological safe limits													
3.1.1 Total Official Landings (TOL) and Total Catch (TC)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3	D1, D3	stressor	- exploited populations - exploited communities - ecosystem	-Priority species (I-II-III) -Vulnerable species	assessed species all	TOL: **common** TC: candidate	TOL: all TC: some (12-48 stocks regularly per sub-region)	TOL: all TC: some (12-48 stocks regularly per GSA)	TOL: already available from the GFCM. TC: to be available after implementation of the GFCM-DCRF (and if by-catch and IUU information is also available)	catch-based data by-catch of vulnerable species and IUU catches	Annual (could be seasonal)
3.1.2 Fishing mortality (F)	-Sustainable fishing	EO3	D3	stressor	- exploited populations	-Priority species (I)	assessed species	**common**	all (5-7 stocks regularly per sub-region)	all (5-7 stocks regularly per GSA)	Already available from the GFCM for exploited species with valid formal assessments (priority species of Group I).	catch-based data and assessments	Annual (could be seasonal)
3.1.3 Biomass index (B)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3, EO4	D1, D3, D4	state	- exploited populations - exploited communities	-Priority species (I) -Priority species (II-III) if survey data are available	assessed and surveyed species	candidate	some (5-7 stocks regularly per sub-region)	some (5-7 stocks regularly per GSA)	Will be available from the GFCM after implementation of the GFCM-DCRF for commercial and non-commercial species derived from surveys at sea.	survey-based data	Annual
3.1.4 Ratio between Catch and Biomass index (C/B)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3	D1, D3	stressor	- exploited populations - exploited communities	-Priority species (I) -Priority species (II-III) if survey data are available	assessed species	candidate	some (5-7 stocks regularly per sub-region)	some (5-7 stocks regularly per GSA)	Will be available from the GFCM after implementation of the GFCM-DCRF for commercial species.	catch-based and survey-based	Annual
3.1.5. Proportion of the stocks sustainably fished (SS)	-Sustainable fishing	EO3	D3	state	- exploited populations	-Priority species (I)	assessed species	**common**	all	all	Already available from the GFCM for exploited species with valid formal assessments (priority species of group I).	catch-based data	Annual (could be seasonal)
Operational objective 3.2. The reproductive capacity of stocks is maintained													
3.2.1. Mean Length of the population in the catch (mL) and in the surveyed exploited community (mLsc)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3, EO4	D1, D3, D4	stressor	- exploited populations - exploited communities (-ecosystem)	-Priority species (I-II-III) (-Vulnerable species if specimens are measured (either from the catch or from surveys))	assessed and surveyed species	candidate	mL: all mLs: some	mL: all mLs: some	Will be available fter implementation of the GFCM-DCRF including commercial and non-commercial species.	mL: catch-based data; mLsc: survey-based data (and by-catch of vulnerable species)	Annual (could be seasonal)
3.2.2 Spawning Stock Biomass (SSB)	-Sustainable fishing	EO3, EO4	D3, D4	state	- exploited populations	-Priority species (I)	assessed species	**common**	all (5-7 stocks regularly per sub-region)	all (5-7 stocks regularly per GSA)	Already available since regularly monitored by GFCM (priority species of Group I).	catch-based data and assessments	Annual (could be seasonal)
Operational objective 3.3. The impact of fishing activities in the ecosystem is low													
3.3.1. Mean Trophic Level of the catch (TLc and MTI) and of the surveyed exploited community (TLsc)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3, EO4	D1, D3, D4	state	- exploited populations - exploited communities (-ecosystem)	-Priority species (I-II-III) (-Vulnerable species if specimens are measured (either from the catch or from surveys))	assessed and surveyed species	candidate	TLc: all TLsc: some (12-48 stocks regularly per sub-region)	TLc: all TLsc: some (12-48 stocks regularly per GSA)	Will be available in the future after implementation of the GFCM-DCRF.	TLc & MTI: catch-based data;TLsc: survey-based data (and by-catch of vulnerable species)	Annual
3.3.2. Proportion of Large Fish in the catch (LFc) and in the surveyed exploited community (LFsc)	-Sustainable fishing -Conservation of biodiversity	EO1, EO3, EO4	D1, D3, D4	state	- exploited populations - exploited communities (-ecosystem)	-Priority species (I-II-III) (-Vulnerable species if specimens are measured (either from the catch or from surveys))	assessed and surveyed species	candidate	LFc: all LFsc: some (12-48 stocks regularly per sub-region)	TLc: all TLsc: some (12-48 stocks regularly per GSA)	Will be available after implementation of the GFCM-DCRF for commercial species (and non-commercial if surveys data are available).	LFc: catch-based data; LFsc: survey-based data (and by-catch of vulnerable species)	Annual
3.3.3. Proportion of all exploited species with DEclining Biomass in the population (DEB)	-Sustainable fishing -Conservation of biodiversity	EO3, EO4	D3, D4	stressor	- exploited populations - exploited communities	-Priority species (I) -Priority species (II-III) if survey data are available	surveyed exploited species	candidate	some (12-48 stocks regularly per sub-region)	some (12-48 stocks regularly per GSA)	Will be available after implementation of the GFCM-DCRF for commercial species.	survey-based data	Annual

Operational objectives and indicators:

A. Level of exploitation by fisheries allows populations of key predators and

1. Catch of key predators and prey species
2. Fishing mortality of key predators and prey
3. Biomass indices of key predators and prey
4. Ratio between catch and biomass index (catch/biomass ratio) of key p
5. Spatial distribution of the population of key predators and prey
6. Length distribution of the population of key predators and prey in the

B. Level of exploitation by fisheries allows maintaining or recover biodivers

1. Proportion of exploited species with DEclining Biomass in the populati
2. Biomass of IUCN species at risk
3. Mean intrinsic vulnerability index of the fish landed catch
4. Proportion of discards in the fishery

C. Level of exploitation by fisheries allows maintaining the ecosystem struc

1. Proportion of Large Fish in the catch (LFc) and in the surveyed (exploit
2. Proportion of predatory fish in the catch (and in the community)
3. Mean Trophic Level of the catch (TLc) and of the surveyed (exploited)
4. Primary Production Required to sustain the catch in comparison with

Operational objective	Proposed Indicator	Short description and definition of indicator	Proposed Targets	Examples of policies/initiatives where the indicators are considered	Suggestions for implementation and similar indicators to consider	Key reference of the indicator	Website of indicator
1. 1. Level of exploitation by fisheries allows populations of key predators and prey (if fished) to be within biological safe limits	***1.1 Catch of key predators and prey species***	Short description: Total catch of key predators and prey species does not exceed the Maximum Sustainable Yield (MSY) and the by-catch is reduced. *Definition: The total catch is the quantity of fish which is retained by the fishing gear during fishing operations. This should ideally include landings by commercial fleet, recreational fishing, by catch and IUU estimates. The Maximum Sustainable Yield is the theoretical maximum catch that can be extracted from a stock. Due to difficulties to calculate MSY, this should be a limit. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Long-Term High Yields -Catch < MSY -Negative trend of bycatch Pressure -Reduction of IUU catch -Minimization of discarding and by-catch	CFP-EU MSFD-EU FAO regional bodies (GFCM) NOAA-USA ICCAT (proposed phase)	The identiication of predators and prey should be done with regional experts. Predators and prey of main commercial species are the main candidates. If keystone indicator analyses available, keystone species could also be targeted.	Modified from Coll et al. 2016	www.indiseas.org
	1.2 Fishing mortality of key predators and prey	Short description: Fishing mortality in the stock of predators and preys does not exceed the level that allows MSY (F≤ F_{MSY}). *Definition: The Maximum Sustainable Yield is, theoretically, the maximum yield that can be obtained from a species, and it is associated with a maximum fishing mortality (F_{MSY}). When F is higher than F_{MSY} the yield decreases. F_{MSY} is consider as a limit due to the consequences of overestimating F. Only available if the stock has been assessed. Fishing mortality (F) reflects all deaths in the stock that are due to fishing per year (not only what is actually landed). It is usually expressed as a rate ranging from 0 (for no fishing) to high values (1.0 or more). This indicator is linked with sustainable fishing.*	Pressure -F_{MSY} -$F_{0.1}$ a proxy of F_{MSY} (more precautionary)	CFP-EU MSFD-EU FAO regional bodies (GFCM) NOAA-USA, ICCAT (proposed phase)	The main limitation of this indicator is that a formal evaluation of the stocks is needed to find Fmsy. X Alternative indicators: As a proxy, the Catch / Biomass indicator can be used (see Indicator 1.4).	Modified from Gascuel et al. 2016	
	1.3 Biomass indices of key predators and prey	Short description: Stable or increasing biomass indices (relative or absolute), with absolute value at or above biomass that produces MSY. *Definition: Biomass indices can be calculated when scientific surveys (trawling, acoustics, etc.) are available. Different targets can be used, such as acceptable stock size, safe biological limits, historical level of Catch per unit of effort (CPUE), Trend of CPUE increasing per year, Historical level of standardized index of abundance form scientific surveys. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Positive trend -Biomass at MSY (Bmsy) (when MSY available)	CFP-EU MSFD-EU IndiSeas project NOAA-USA	If regional data is not available for many species, Local Ecological Knowledge (LEK) can be used	Modified from Gascuel et al. 2016, Fulton et al. 2005	
	1.4 Ratio between catch and biomass index (catch/biomass ratio) of key predators and prey	Short description: The catch/biomass ratio allows to recover the stock or to maintain it at a level where it can produce the MSY. *Description: The catch/biomass ratio should entail a low risk of collapse of the species, and a high probability of recovery of the stock. If the species is at risk, it should entail a low time frame of recovery. This indicator is linked with sustainable fishing.*	Pressure - Negative trend	CFP-EU MSFD-EU IndiSeas project	If regional data is not available for many species, qualitative data can be used Alternative indicators: This indicator is a proxy for fishin gmortality (see Indicator 1.2).	Coll et al. 2016; Shin et al. 2018	www.indiseas.org
	1.5 Spatial distribution of key predators and preypopulations	Short description: The spatial distribution of the population of key predators and preys is maintained or increases *Definition: It is important to know the spatial distribution of species: Species with wider distributions are less vulnerable to fishing. However, regional data is not always available. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State - Positive trend	CFP-EC MSFD-EU NOAA-USA	If regional data is not available for many species, global databases or LEK can be used. Alternative indicators: Distribution of vulnerable species.		
	1.6. Length distribution of the population of key predators and prey in the catch	Short description: The mean size of predators and preys in the catch (Lt) is larger than the mean size at first maturity (Lm) *Definition: May reflect the extent of undesirable genetic effects of exploitation. To calculate this indicator, the mean size at first maturity is needed by species in the catch, in addition to the size of species in the catch. It can also be used to compare it with the minimum conservation size (for example, to protect juveniles with minimum sizes). The length distribution of the population in the catch will be available only for those target species with monitoring programs dedicated to collect length distribution data. This indicator is linked with sustainable fishing.*	State - Lt > Lm - Positive trend	CFP-EU MSFD-EU ICCAT (proposed phase)	Alternative indicators: Weight distribution of the population in the catch, or mean life span (Coll and Steenbeek 2017)		
	2.1. Proportion of exploited species with	Short description: The proportion of species with declining biomass in the population is reduced with time	State -Negative trend	IndiSeas project ICCAT (proposed phase)	If biomass data from surveys is not available, LEK data can be used to inform this indicator in a qualitative way.	Lynam et al. 2010; Kleisner et al. 2015	www.indiseas.org

2. Level of exploitation by fisheries allows maintaining or recover biodiversity levels	***DEclining Biomass in the population (DEB)***	*Description: This indicator is based on biomass and it will be only calculated when time series of survey biomass of* ***retained species*** *is available. It includes commercial target and non-target species. This indicator is linked with sustainable fishing and conservation of biodiversity.*					
	2.2. Biomass of IUCN species at risk	Short description: Stable or increasing biomass indices (relative or absolute), with absolute value at or above biomass that ensures population success, of IUCN species at risk *Definition: Biomass indices can be calculated when scientific surveys (trawling, acoustics, transects, counts, etc.) are available. Different targets can be used, such as acceptable stock size, safe biological limits, Historical level of standardized index of abundance form scientific surveys.. IUCN cathegories may include CR, EN, VU, NT. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Positive trend -Biomass at MSY (Bmsy)	CFP-EU MSFD-EU IndiSeas project IUCN framework	If regional data is not available for many species, LEK knowledge can be used Alternative indicators: Biomass of endemic species, Biomass/abundance of sentinel species.	Butchart et al. 2010, Maynou et al. 2011	
	2.3. Mean Intrinsic Vulnerability index of the (fish) landed catch	Short description: Stable or increase contribution of vulnerable species in the catch *Definition: The Mean Intrinsic vulnerability index of the catch is calculated with catch data by species and their species vulnerability index. By defaul, FishBase provides general values per fish and invertebrate species. The index provides a tool for fisheries management and conservation. Globally it has been described a decline with time, probably as a result of overexploitation of the more vulnerable species.*	State -Positive trend	IndiSeas project Sea Around Us project	If local IVI values are not available, they can be obtained from FishBase and SealifeBase	Cheung et al. 2017.	www.seaaroundus.org/ www.indiseas.org
	2.4. Proportion of discards in the fishery	Short description: The proportion of discards in the fishery is reduced with time *Definition: Discards are the portion of a catch of fish which is not retained on board during commercial fishing operations and is returned, most often dead or dying, to the sea. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Negative trend	CFP-EU MSFD-EU IndiSeas project	Alternative indicator: proportion of IUU in the fisheries (Pauly and Zeller 2016)	Coll et al. 2016; Gascuel et al. 2016	www.indiseas.org
3. Level of exploitation by fisheries allows maintaining the ecosystem structure and functioning traits	***3.1. Proportion of Large Fish in the catch (LFc) and in the surveyed (exploited) community (LFsc)***	Short description: The proportion of large fish is maintained or increases with time *Definition: TThe large fish indicator (LF) reflects the size structure of the fish assemblage, which is assumed to be primarily affected by size-selective exploitation but is mediated by species composition as well as the fishing-induced reduction of life expectancy of each exploited species. The LF = WLargeFish / Wtotal, where WLargeFish is the weight of fish greater than a chosen length (cm) and Wtotal is the total weight of all fish in the catch or survey. It includes commercial target and not target species if calculated from the catch, in addition to non-commercial species when calculated from surveys. The definition of Large fish fish should be specifically defined according established criteria. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Positive trend	MSFD-EU IndiSeas project	More feasible using catch data than biomass data from surveys. The definition of what is a large fish has to be regionally established Alternative indicators: Mean fish length in the catch or surveyed community, Mean maximum life span in the catch or surveyed fish species. Also similar to the proportion of predatory fish in the catch and surveyed community (Indicator 3.2) (Shannon et al. 2014; Gascuel et al. 2016)	Coll et al. 2016; Gascuel et al. 2016	www.indiseas.org
	3.2. Proportion of predatory fish in the catch (and in the surveyed exploited community)	Short description: The proportion of predatory fish in the population is maintained or increases with time *Definition: This indicator is similar to 3.1 and uses time series of total catch and catch of predatory species. This indicator can be calculated from biomass surveys if data is available. The definition of predatory fish should be specifically defined according established criteria. This indicator is linked with sustainable fishing and conservation of biodiversity.*	State -Positive trend	MSFD-EU IndiSeas project	More feasible using catch data than biomass data from surveys Alternative indicators: Mean fish length in the catch or surveyed community, Mean maximum life span of surveyed fish species (Coll and Steenbeek 2017)	Coll et al. 2016	www.indiseas.org
	3.3. Mean Trophic Level of the catch (TLc) and of the surveyed (exploited) community (TLsc)	Short description: The Mean Trophic Level does not decrease with time *Definition: These indicators are being used by the CBD and other programs. To calculate these indicators, time series of catch per species or biomass (tones) and trophic level of the species (in the catch or in the surveys) are needed. In addition, the Marine Trophic Index (MTI), which is the TLc with a threshold of trophic levels 3.25) can be also derived from TLc. The trophic level per species can be obtained from FishBase, SeaLifeBase, or regional datasets and ecosystem models. These indicators include commercial target and not target species if calculated from the catch, in addition to non-commercial species when calculated from surveys. These indicators are linked with sustainable fishing and conservation of biodiversity.*	State -Positive trend	MSFD-EU, CBD, IndiSeas, OSPAR, SeaAroundUs project ICCAT (proposed phase)	More feasible using catch data than biomass data from surveys Alternative indicators: MTI (Marine Trophic Index, Pauly and Watson 2005; Gascuel et al. 2016)	Christensen 1996; Pauly et al. 1998; Butchard et al. 2010; Shannon et al. 2014	www.seaaroundus.org/ www.indiseas.org
		Short description: The Primary Production Required to sustain the Catch does not exceed unsustainable levels	State	Sea Around Us project			www.seaaroundus.org/

	3.4. Primary Production Required to sustain the catch in comparison with the primary production available (PPR%)	*Definition: The Primary Production Required to Sustain the catch (PPR) calculated the units of primary productivity needed to obtained the catches reported in a specific area, and enables the quantification of the fishing pressure on ecosystem scale, taking into account the primary productivity of the area and the fishing strategy used (through the trophic level indicator).*	PPR% < PPR%sust		Alternative indicators: Loss in Production Index (Lindex) and Probability of Sustainable Fishing (Libralato et al. 2006; Coll et al. 2008; Mora et al. 2009)	Pauly and Christensen 1995	

Operational objective	Indicator name	Species included	General objective	Biodiversity components	Data requirements	Main data needed	Fisheries dependency	Spatial resolution	Nature of the indicator	Resource intensity: time to calculate	Resource intensity: expertise to assess	Resource intensity: funding to calculate	Main advantages	Main limitations	Input uncertainty
1. Level of exploitation by commercial fisheries allows populations to be within biological safe limits	***1.1. Catch of key predators and prey species***	Commercial, by-catch species Non-comm species	Sustainable fishing Conservation of biodiversity	exploited populations exploited communities	medium to low	catch statistics, LEK	Yes	1D (temporal)	Quantitative (can be qualitative)	medium	low	medium	widely available	can provide confounding signals of fishng and climate	medium to high
	1.2 Fishing mortality of key predators and prey	Commercial, by-catch species Non-comm. species	Sustainable fishing	exploited populations exploited communities	high	catch statistics, stock assessments, biomass survey assessments, ecosystem models	Partially	1D (temporal)	Quantitative	high	medium	high	highly responsive to fishing	resource intensive	high
	1.3. Biomass indices of key predators and prey	Commercial, by-catch species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited populations exploited communities	high	stock assements, biomass survey assessment, ecosystem models, LEK	No	1D (temporal)	Quantitative (can be qualitative)	high	medium	high	easy to communicate	resource intensive	medium to high
	1.4 Ratio between catch and biomass index (catch/biomass ratio) of key predators and prey	Commercial, by-catch species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited populations exploited communities	medium to high	catch statistics, stock assessments, biomass survey assessments, ecosystem models	Partially	1D (temporal)	Quantitative	high	medium	high	highly responsive to fishing, easy to communicate	resource intensive	medium to high
	1.5 Spatial distribution of key predators and prey populations	Commercial, by-catch species Non-comm. species	Conservation of biodiversity	exploited populations exploited communities	medium to high	biomass survey assessments, ecosystem models, LEK	No	2D (spatial-temporal)	Quantitative (can be qualitative)	medium	high	high	easy to communicate	resource intensive	medium to high
	1.6. Length distribution of the population of key predators and prey in the catch	Commercial, by-catch species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited populations exploited communities	high	catch statistics, catch surveys	Yes	1D (temporal)	Quantitative	high	high	high	indicator of size traits	found to be responsive to cliamte change, resource intensive	medium to high
2. Level of exploitation by fisheries allows maintaining or recover biodiversity levels	***2.1. Proportion of exploited species with DEclining Biomass in the population (DEB)***	Commercial, by-catch species	Sustainable fishing	exploited populations exploited communities	high	biomass survey assessment	No	1D (temporal)	Quantitative	high	medium	high	highly sensitive to fishing	resource intensive	medium to high
	2.2. Biomass of IUCN at risk species	Vulnerable species Commercial, by-catch species	Conservation of biodiversity	nonexploited populations exploited communities	medium (biomass) to high (models)	biomass survey assessment, ecosystem models, LEK	No	1D	Quantitative (can be qualitative)	medium	medium	high	easy to communicate	resource intensive	medium to high
	2.3. Mean Intrinsic Vulnerability index of the (fish) landed catch	Commercial, by-catch species Vulnerable species	Sustainable fishing Conservation of biodiversity	exploited populations exploited communities	medium (catch) to high (models)	catch statistics, vunerability indices from online databases or local studies, ecosystem models	Partially	1D (temporal)	Quantitative	medium	low	medium	easy to calculate	difficult to communicate, values of the IVI needed	high
	2.4. Proportion of discards in the fishery	By-catch species Vulnerable species	Sustainable fishing	exploited communities	medium to high	catch statistics, LEK	Yes	1D (temporal)	Quantitative (can be qualitative)	high	low	high	easy to communicate	resource intensive	high
3. Level of exploitation by fisheries allows maintaining the ecosystem structure and functioning traits	***3.1. Proportion of Large Fish in the catch (LFc) and in the surveyed (exploited) community (LFsc)***	Commercial, by-catch species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited communities ecosystem	medium (catch) - high (biomass, models)	catch statistics, stock assessments, biomass survey assessment, ecosystem models	No (biomass) - Yes (catch)	1D	Quantitative	high	medium	medium	easy to communicate, highly responsive to fishing	standardization of the Large Fish definition needed	medium to high
	3.2. Proportion of predatory fish in the catch (and in the community)	Commercial, by-catch species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited communities ecosystem	medium (catch) - high (biomass, models)	catch statistics, biomass survey assessment, ecosystem models	No (biomass) - Yes (catch)	1D (temporal)	Quantitative	high	low	medium	easy to communicate, highly responsive to fishing	standardization of the predatory definition needed	medium to high
	3.3. Mean Trophic Level of the catch (TLc) and of the surveyed (exploited) community (TLsc)	Commercial species Non-comm. species	Sustainable fishing Conservation of biodiversity	exploited communities ecosystem	medium (catch) - high (biomass, models)	catch statistics, biomass assessment, ecosystem models, trophic levels from online databases or local studies	No (biomass) - Yes (catch)	1D (temporal)	Quantitative	medium	low	medium	easy to communicate, popular	found to change response with strategy of fishing (e.g. HTL towards ecosystem overfishing), TL values estimates needed	high
	3.4. Primary Production Required to sustain the catch in comparison with the primary production available (PPR%)	Commercial, by-catch species	Sustainable fishing	exploited communities ecosystem	medium (catch) - high (models)	catch statistics, ecosystem models	Yes	1D (temporal)	Quantitative	high	high	high	considers both the strategy of the fishery and the traits	difficult to communicate	high