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Selecting ecosystem indicators for fisheries targeting highly migratory species: An EU project to advance the operationalization of the EAFM in ICCAT and IOTC

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Selecting ecosystem indicators for fisheries targeting highly migratory species: An EU project to advance the operationalization of the EAFM in ICCAT and IOTC

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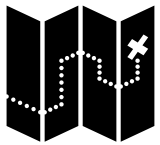
SUMMARY

Several international legal agreements and guidelines have set the minimum standards and key principles to guide the implementation of an ecosystem approach to fisheries management (EAFM). However, the implementation of an EAFM in tuna Regional Fisheries Management Organizations (RFMOs) has been patchy and lack a long-term plan, vision and guidance on how to operationalize it. The Specific Contract N^0 2 “selecting ecosystem indicators for fisheries targeting highly migratory species-” (SC02 project) under the Framework Contract - EASME/EMFF/2016/008 provisions of Scientific Advice for Fisheries Beyond EU Waters- addresses several scientific challenges and provides insights to support the implementation of an EAFM through collaboration and consultation with the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the Indian Ocean Tuna Commission (IOTC). Specifically, this project first highlights properties of success and best practices from other regions of the world in operationalizing the ecosystem approach that potentially could be transferred to ICCAT and IOTC. Second, it delivered a list of potential ecosystem indicators of relevance to tuna RFMOs (ICCAT and IOTC) that are suitable to track the impacts of fisheries targeting tuna and tuna-like species on the broader pelagic ecosystem. Third, it designed a general framework based on a rule-based decision tree to provide guidance on how reference points could be set and used for diverse types of ecosystem indicators. Fourth, it proposed candidate ecoregions within the Atlantic and Indian Oceans which could be used to guide region-based ecosystem plans, assessments and research to ultimately provide better ecosystem-based advice to inform fisheries management. Fifth, it developed two pilot ecosystem plans for two case study regions, the tropical ecoregion within the ICCAT convention area, and the temperate ecoregion within the IOTC convention area. At this stage, these pilot ecosystem plans aim to create awareness about the need for ecosystem planning, start a discussion about the elements that need to be part of a planning process, and initiate a discussion in ICCAT and IOTC about the potential needs of ecosystem plans and their function. Finally, this project provided recommendations to foster the potential development, use, and implementation of ecosystem plans in ICCAT and IOTC.

The SC02 project in a nutshell

Here a "road map" for implementing the EAFM for highly migratory fish species



The EAFM process in 4 steps:	What the SC02 project has achieved?	What else needs to be done?
What are our objectives? What is our strategy? Who do we need to engage? **STEP 1 Ecosystem planning**	• Identified **best practices and lessons** around the world that could be transferred to tuna RFMOs • Put forward a proposal of **pelagic ecoregion** within the Atlantic and Indian oceans to guide ecosystem planning, research, assessments and ecosystem-based advice • Created **pilot ecosystem plans** (tropical ecoregion in ICCAT, temperate ecoregion in IOTC) • Pilot ecosystem plans include a **vision**, an **ecosystem overview**, **conceptual ecosystem models**, a **skeleton on an ecosystem status assessment** and **strategy for communication**	• **Disseminate the pilot ecosystem plans** in ICCAT and IOTC (Commission and Scientific Committees) • Add **additional elements** to the pilot ecosystem plans (ecosystem risk assessments, interactions with other processes, socio-economic implications, financial implications) • Create an **engagement strategy** (establish a ecosystem plan team, appoint ecosystem point contact coordinators, develop EAFM materials for widespread use)
Do we have the science to understand the main ecosystem processes, the threats, status and trends of major ecosystem components? **STEP 2 Ecosystem status assessments**	• Delivered a **proposal of ecosystem indicators** of relevante to tuna RFMOs that are suitable to track the impacts on marine ecosystems of fisheries targeting tuna and tuna-like species, with **their strengths** and **weaknesses** • Provided the **skeleton of a ecosystem status assessment** • Created **guidelines on** how **reference points** can be set for different types of ecosystem indicators	• **Improve the reporting** of spatially-explicit basic fisheries statistics • **Better use regional and national observer programs** to develop ecosystem indicators • Improve our **understanding of ecosystem processes** (fish diet, trophic studies, impacts of climate change, mapping of habitats of ecological significance, mapping fishing footprint) • Support the development of **multi-species, community and end-to-end ecosystem models**
What are our priorities? **STEP 3 Ecosystem risk assessments**	• **No covered** in the SC02 objectives, yet provided the basis for a future ecosystem risk assessments	• Vulnerability **habitat risk** assessment • Vulnerability **climate risk** assessment • **Social** vulnerability **risk** assessment • **Economic** vulnerability **risk** assessment • Comprehensive **ecosystem risk** assessment
What are our options? What is our advice? **STEP 4 Incorporating ecosystem considerations into fisheries management**	• Created a basic **framework** to **link better ecosystem science with fisheries management**	• Development of tools for **visualization and assessments of trade-offs** • **MSE** for harvest strategies that address trade-offs that incorporate ecosystem considerations (fleet interactions, bycatch, habitat, climate)

Background and objectives

There is **political need** to operationalize an Ecosystem Approach to Fisheries Management (EAFM). Its operationalization has been slow and patchy in tuna Regional Fisheries Management Organizations (tuna RFMOs).

There are some **practical impediments to the operationalization of an ecosystem approach** for highly migratory and oceanic tuna-and tuna like species, including:

1. Scarcity of ecosystem indicators (and associated reference points) to track the impacts of relevant fisheries on ecosystems, as most ecosystem indicators have been developed for coastal and demersal fisheries.
2. Lack of defined ecoregions in marine pelagic ecosystems to guide ecosystem research, ecosystem planning and the operationalization of an EAFM in general.
3. Lack of pre-agreed vision, operational objectives, and ecosystem plans to ensure ecosystem and socio-economic considerations are accounted for in fishery management advice and decision making.

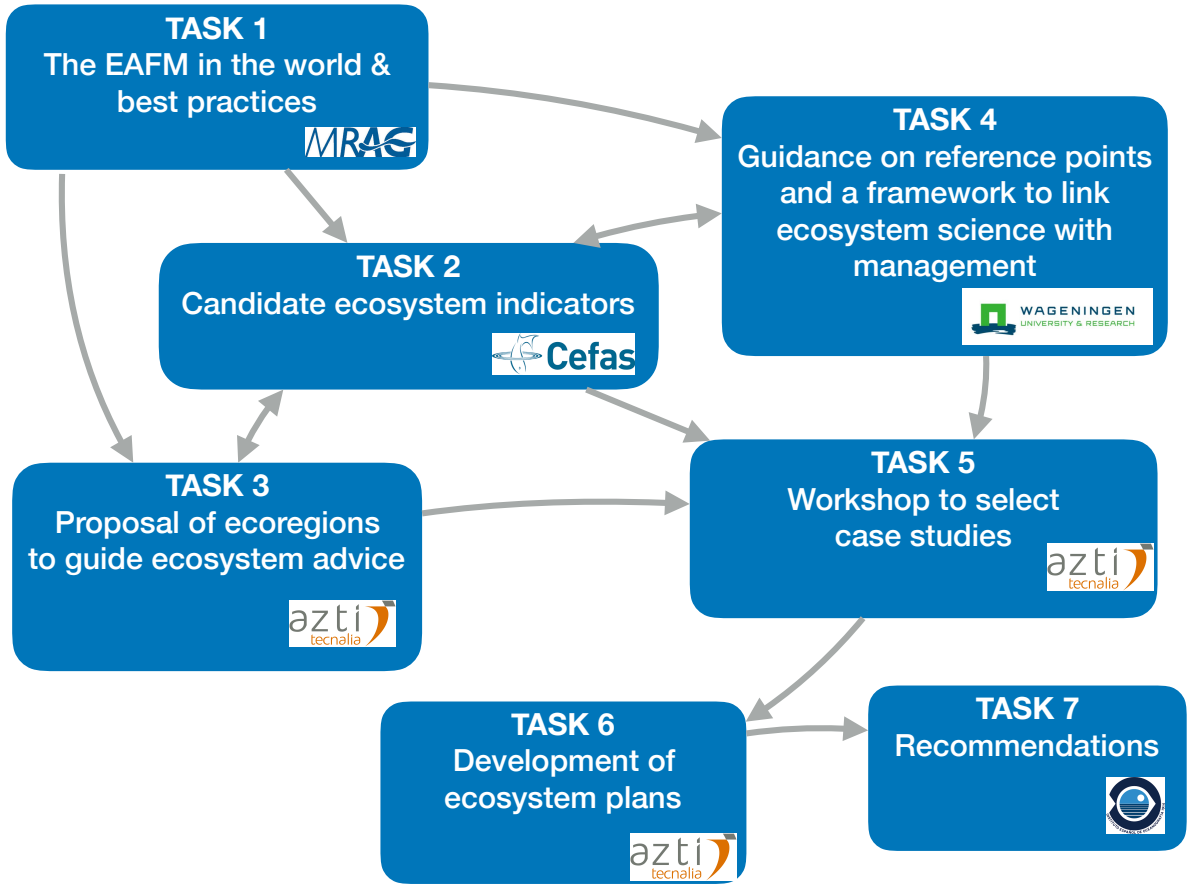
The **Specific Contract Nº 2 under the Framework Contract - EASME/EMFF/2016/008 provisions of Scientific Advice for Fisheries Beyond EU Waters-** addresses several scientific challenges and provides solutions that shall support the implementation of an EAFM through collaboration and consultation with the International Commission for the Conservation of Atlantic Tunas (ICCAT) and Indian Ocean Tuna Commission (IOTC).

The **main purpose** of Specific Contract Nº 2 is to provide the Directorate-General for Maritime Affairs and Fisheries (DG MARE) with:

- A list of ecosystem indicators (and guidance for associated reference points) to monitor impacts of fisheries targeting highly migratory and oceanic tuna-and tuna like species. These indicators cover all ecological components of an EAFM, including target species, bycatch and threatened species, foodweb and trophic relationships, and habitats of ecological significance.
- Candidate ecoregions with meaningful ecological boundaries for highly migratory tuna-and tuna like species and their fisheries in order to facilitate the operationalization of an EAFM in marine pelagic ecosystems in ICCAT and IOTC.
- Two pilot ecosystem plans, using two ecoregions as case studies, one within the ICCAT convention area and one within the IOTC convention area. These ecosystem plans have the main purpose of facilitating the link between ecosystem information and science and fisheries management.
- Recommendations to better link ecosystem science and fisheries management to foster the implementation of an EAFM in ICCAT and IOTC.

Background and objectives

Seven tasks were carried out and briefly summarized in this abridged version of the Final Report.



TASK 1

The ecosystem approach to fisheries management in the world

Task 1 reviewed how different areas of the world are implementing an EAFM with the objective of identifying elements of success, best practices and lessons that potentially could be transferred to tuna RFMOs.

Three areas of the world were chosen in which **ecosystem science and advice has been used to influence fisheries management decisions**. These places are at different stages of implementing an EAFM, which allows us to highlight best practices and effective approaches from different states of the EAFM implementation process. Specifically, the areas examined were:

The **North Pacific Fishery Management Council** (NPFMC) in the United States established to manage groundfish, salmon, crab and scallop fisheries.

The **Commission for the Conservation of Antarctic Marine Living Resources** (CCAMLR) established to manage exploitation of Antarctic marine living resources.

The **Northwest Atlantic Fisheries Management Organization** (NAFO) established to manage groundfish, shrimp and pelagic redfish fisheries.

We also reviewed and learnt from relevant projects and programs that have **worked extensively on the development and use of a wide range of ecosystem indicators** to monitor the impact of fisheries and climate on the status of marine ecosystems around the world and inform the EAFM. These programs are:

EU Project ECAPRHA "An ecosystem approach to regional habitat assessments" which addresses gaps in the development of biodiversity (pelagic, benthic and foodwebs) indicators for the OSPAR Regions.

IndiSeas
"Indicators for the Seas" is a scientific program which evaluates the effects of fishing on the health status of marine ecosystems.

EU DEVOTES Project
"DEVelopment OF innovative Tools for understanding marine biodiversity and assessing good Environmental Status" aimed at improving understanding of human activities and variations due to climate change on marine biodiversity.

The EU MSFD
"Marine Strategy Framework Directive" which enshrines in a legislative framework the ecosystem approach to managing human activities having an impact on the marine environment, integrating the concepts of environmental protection and sustainable use.

TASK 1

The ecosystem approach to fisheries management in the world

From the different reviewed areas and programs, properties **for success** (and failures) as well as **best practices** and **lessons** were identified that have fostered and are facilitating the implementation of an EAFM in these regions.

These are summarized below:

Properties of success

1. Clear implementation framework
2. Transparent and trusted participatory and consultative process
3. Well-articulated needs and vision
4. Mechanisms for setting ecosystem objectives and priorities
5. Flexible and adaptive process
6. Fluid and strategic communication

Best scientific practices

1. Adoption of area-based assessment units or ecoregions to guide ecosystem assessments and plans
2. Monitoring of selected ecosystem indicators to track the impacts of pressures (fishing and climate) on the state of the ecosystems
3. Analysis of trade-offs
4. Assessment of cumulative impacts of fishing
5. Development of multispecies, ecosystem and climate models
6. Quantification of ecosystem production and thresholds
7. Development of ecosystem risk assessments
8. Establishment of plans for bycatch reduction, protections of habitats and monitoring food web dynamics
9. Development of tools, such as specific software, to visualize indicators and integrate information in support of ecosystem assessments

Lessons learnt

1. Ecosystem focused fisheries management can be done without full knowledge of the ecosystem but making use of integrating all available knowledge is crucial
2. Get to know well the annual management cycle to identify opportunities to incorporate ecosystem science into
3. Be flexible and adaptive in the process of selecting a small number of key ecosystem indicators and start the process with a pilot case study
4. Stakeholders need to be involved in the development of ecosystem products from the beginning
5. Development of ecosystem indicators and assessments that are area-based can be the catalyst for stronger regional collaboration
7. Effort to develop standardize guidelines for data collections and estimation of indicators (to override data confidentiality issues) leads to stronger outputs, higher participation and more regional collaborations

TASK 2 A proposal of ecosystem indicators and their data requirements

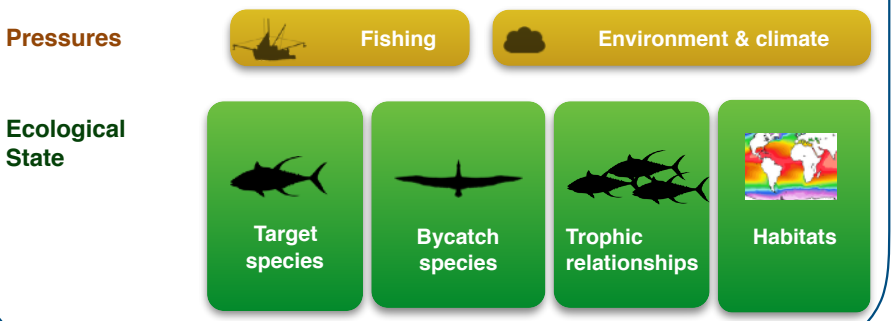
Task 2 delivered a list of potential ecosystem indicators of relevance to tuna RFMOs (ICCAT and IOTC) that are suitable to track the impacts on marine ecosystems of fisheries targeting tuna and tuna-like species. This task has not developed indicators but conducted a review of those indicators currently in operation in the reviewed case studies under Task 1. The development of a complete indicator suite will take many years and require specific development work to build bespoke indicators for particular issues of concern.

The selection and proposal of candidate indicators were done in three major steps:

Step 1

An initial list of more than **200 ecosystem indicators** was extracted from all the reviewed case studies in Task 1 that **aimed at monitoring the broader and cumulative impacts of fisheries on the state of the ecosystem**. All the indicators were cataloged into broad categories, those tracking pressures and those tracking changes in the state of ecosystem components.

Framework for cataloguing ecosystem indicators:



Step 2

Filtering criteria were applied to all the indicators with specific questions in mind to identify those that were more relevant to tuna-and tuna-like species and their fisheries. This filtering resulted in a **subset of 36 indicators.**

Step 3

These 36 indicators were then evaluated in great detail using an objective framework to test their quality. The **Queirós Indicator Quality (IQ) Evaluation Criteria** were used to rank the indicators given their strength and weaknesses relative to key attributes that define an indicator, its use and applicability.

INDICATOR QUALITY CRITERIA OF QUEIROS ET AL 2016

	Scores
IQ1. Scientific basis	0 -1
IQ2. Ecosystem relevance	0 -1
IQ3. Responsiveness to pressure	0 -1
IQ4. Possibility to set targets	0 -1
IQ5. Precautionary capacity / early warning	0 -1
IQ6. Quality of sampling methods	0 -1
IQ7. Cost-effective	0 -1
IQ8. Existing /ongoing data	0 -1
Maximum score:	8

TASK 2

A proposal of ecosystem indicators and their data requirements

Candidate ecosystem indicators

INDICATOR NAME	SCORE (max = 8)	IQ1 Scientific Basis	IQ2 Ecosystem Relevance	IQ3 Responsiveness	IQ4 Targets?	IQ5 Early-warning	IQ6 Concrete	IQ7 Cost-effective	IQ8 Data available	Ecological component
Group Spawning Stock Biomass relative to a reference level (e.g. Bmsy or proxies)	8	1	1	1	1	1	1	1	1	target species
Group Fishing mortality relative to a reference level (e.g. Fmsy or proxies)	8	1	1	1	1	1	1	1	1	target species
Single species biomass/abundance/catch rate indicators	7.5	1	1	1	1	1	1	1	0.5	target and non-target species
Total catch (total, by guild)	7	1	1	1	0.5	1	1	1	0.5	target and non-target species
Mean Trophic Level Indicators (model derived)	7	1	1	1	1	1	1	0.5	0.5	trophic relationships
Community size based indicators (mean length, 95th percentile of the length distribution, Proportion of fish larger than the mean size of first sexual maturation) (model based)	7	1	1	1	1	1	1	0.5	0.5	target and non-target species/trophic relationships
Size spectra (total, by guild/community) (model based)	7	1	1	1	1	1	1	0.5	0.5	trophic relationships
Frequency of bycatch and total number of interactions	6.5	1	1	0.5	1	1	1	0.5	0.5	non-target vulnerable species
Population level mortality (non target species)	6.5	1	1	1	1	1	1	0	0.5	non-target species
Community size based indicators (mean length, 95th percentile of the length distribution, Proportion of fish larger than the mean size of first sexual maturation) (catch based)	6.5	1	1	0.5	1	0.5	1	1	0.5	target and non-target species
Mean Trophic Level Indicators (catch)	6.5	1	1	1	1	0.5	0.5	1	0.5	trophic relationships
Predation mortality from multispecies models	6.5	1	1	1	0.5	1	1	0.5	0.5	trophic relationships
Distributional range (including extent, centre of gravity, pattern within range and pattern along environmental gradients)	6	1	1	0.5	0	1	1	1	0.5	target and non-target species
Proportion of non-declining exploited species	6	1	0.5	1	1	0.5	1	0.5	0.5	target and non-target species
Recovery in the Population Abundance of Sensitive Fish Species	6	1	0.5	1	1	0.5	1	0.5	0.5	target and non-target species
Single Species Spawning Stock Biomass relative to reference level (e.g. Bmsy or proxies)	6	1	0	1	1	1	1	0.5	0.5	target and non-target species
Single species fishing mortality relative to a reference level (e.g. Fmsy or proxies)	6	1	0	1	1	1	1	0.5	0.5	target and non-target species
Single species size based indicators (mean length, 95th percentile of the length distribution, Proportion of fish larger than the mean size of first sexual maturation)	6	1	0	0.5	1	1	1	1	0.5	target and non-target species
Zooplankton biomass and/or abundance	6	1	1	0	1	1	1	0.5	0.5	pelagic habitats/trophic relationships
Primary production	6	1	1	0	1	1	1	0.5	0.5	pelagic habitats/trophic relationships
Biomass indicators (total, guild/community) including fish, marine mammals and seabirds	5.5	1	0.5	1	1	1	1	0	0	target and non-target species/trophic relationships
Mean maximum length of fish and elasmobranchs (catch data)	5.5	1	0.5	1	0.5	0	1	1	0.5	target and non-target species
Mean maximum length of fish and elasmobranchs (model derived)	5.5	1	1	1	0.5	0	1	0.5	0.5	target and non-target species
Single species catch (Length-frequency; Catch sex and maturity composition)	5.5	1	0	0.5	0.5	1	1	1	0.5	target and non-target species
Proportion of predatory fish or "Large Species Indicator" (model derived)	5	1	0.5	1	0.5	0.5	0	1	0.5	target and non-target species
Proportion of predatory fish or "Large Species Indicator" (catch data)	5	1	0.5	1	0.5	0.5	0	1	0.5	target and non-target species
Fish condition (length-weight residuals) for main commercial species	5	1	1	0.5	0	0	1	1	0.5	target and non-target species/trophic relationships
Single species age-based indicators	5	1	0	0.5	0.5	1	1	0.5	0.5	target and non-target species
Zooplankton biomass and size structure	5	1	1	0	1	1	1	0	0	pelagic habitats/trophic relationships
Abundance-Biomass Comparison (ABC) curves	4.5	1	1	1	0	1	0.5	0	0	target and non-target species
Species diversity indices (Shannon/Simpson/Evenness/Richness) (model derived)	4.5	1	1	0	0.5	0	1	0.5	0.5	target and non-target species
Ichthyoplankton abundance indices	4.5	1	1	0	0.5	1	1	0	0	target and non-target species
Species size at first sexual maturation	4	1	0	0	0.5	1	1	0.5	0	target and non-target species
Species diversity indices (Shannon/Simpson/Evenness/Richness) (catch data)	3.5	1	0.5	0	0.5	0	0	1	0.5	target and non-target species
Discard survival	2.5	0	1	0	1	0	0.5	0	0	non-target vulnerable species
Population genetic structure (single species)	0	0	0	0	0	0	0	0	0	target and non-target species

Ranked candidate ecosystem indicators

After applying the **Queirós Indicator Quality (IQ) Evaluation Criteria** and scoring all the 36 indicators relative to their attributes, **the proposed indicators are ranked in order of priority for development given their qualities**. This list of ranked indicators can guide decisions on how to allocate efforts to develop key indicators specific to highly migratory tuna and tuna-like species, their fisheries and data availability. **A score of 8 indicates the highest priority for development.**

Data requirements and recommendations

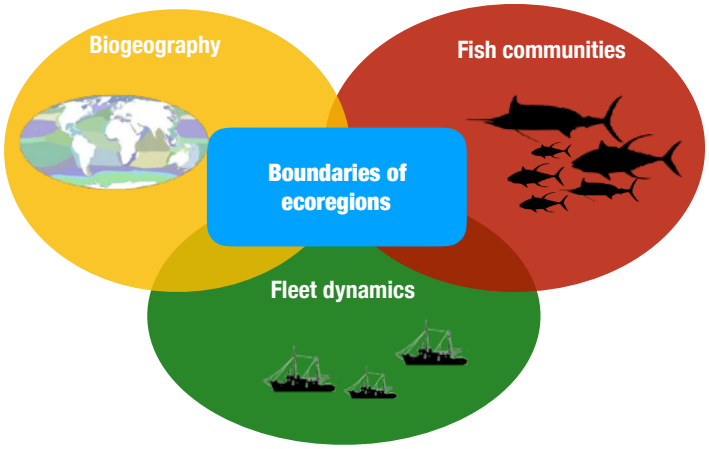
This task also reviewed the datasets that are currently held by ICCAT and IOTC as well as other potential external sources of data outside these tuna RFMOs in order to assist with the evaluation and scoring of the indicators.

- A large number of the indicators reviewed are not currently calculable in ICCAT and IOTC due to lack of scientific surveys.
- Indicators prioritized here should be developed and tested using data available from the tuna RFMOs and external non-traditional data sources.
- Indicators based on non-traditional data sources should be developed through specific projects involving scientists from tuna RFMOs and academics.
- End-to-end ecosystem models, which are currently not well developed in ICCAT and IOTC, should be further developed to support the development of model-based indicators.
- Data collected in the observing programs, which are currently underexploited in ICCAT and IOTC to estimate ecosystem indicator, should be further tested to develop ecosystem indicators.

TASK 3 A proposal of ecoregions to guide ecosystem advice

The definition of EAFM specifies that it is area-based and its operationalization requires selecting spatial units that are ecologically and biologically meaningful. **This task proposed candidate ecoregions within the Atlantic and Indian Oceans** which could be used to guide region-based ecosystem plans, assessments and research to ultimately provide ecosystem management advice on a regional basis.

The ecoregions proposed were based on three pillars of information:



The following criteria was used to inform the boundaries of the ecoregions:

1. Boundaries demarcate areas with identifiable oceanographic features
2. Boundaries demarcate the core distribution of a range of species or communities
3. Boundaries appropriately demarcate areas with identifiable fisheries/fleets

1. Biogeography

- Existing biogeographic classifications for marine pelagic ecosystems were reviewed and their potential relevance for the management and conservation of HMS was evaluated.
- Of the six biogeographic classifications reviewed, the **Spalding Pelagic Provinces of the World (PPOW)** had the most qualities to inform the choice of ecologically meaningful spatial units for the management and conservation of highly migratory tuna and tuna like species.

2. Fish communities

- The spatial distribution of catches of tuna and tuna-like species in the Atlantic and Indian Ocean were examined, and their spatial partitioning into communities and degree of overlap with the Spalding PPOW biogeographic classification were analyzed.
- Despite tunas and billfishes having a very broad tolerance for a wide range of environmental conditions, **they form unique communities, which are associated with specific pelagic provinces with specific environmental conditions**.
- The most subtropical and temperate provinces were characterized mostly by a single or double species dominance, and the most tropical provinces were characterized by multispecies dominance.
- The environmental conditions captured by the Spalding PPOW might be controlling to some extent the spatial distribution and co-occurrence of tuna and billfish communities in these oceans.

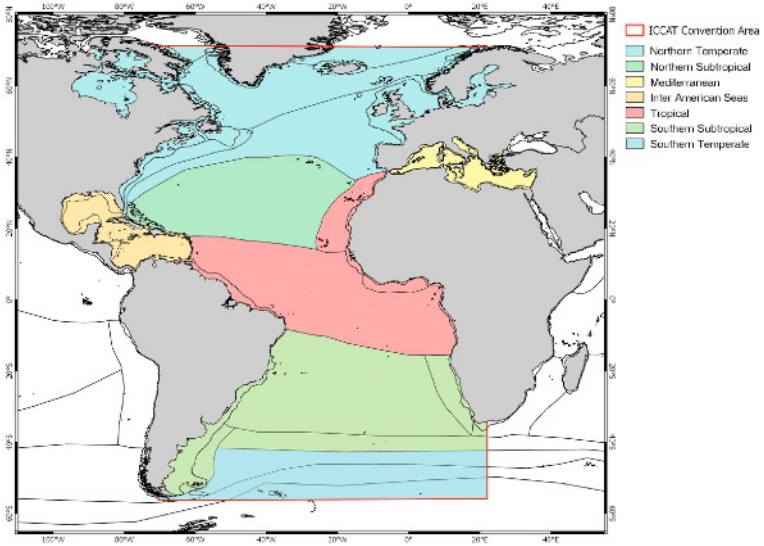
3. Fleet dynamics

- The spatial dimensions of the main fleets and fisheries targeting tuna and tuna-like species in the two oceans was also examined, including their overlap with the PPOW biogeographic classification.
- Purse seine fleets mainly operate in the tropical provinces targeting principally tropical tuna species, while longline fisheries operate throughout the entire Atlantic and Indian Oceans targeting a larger number of species.

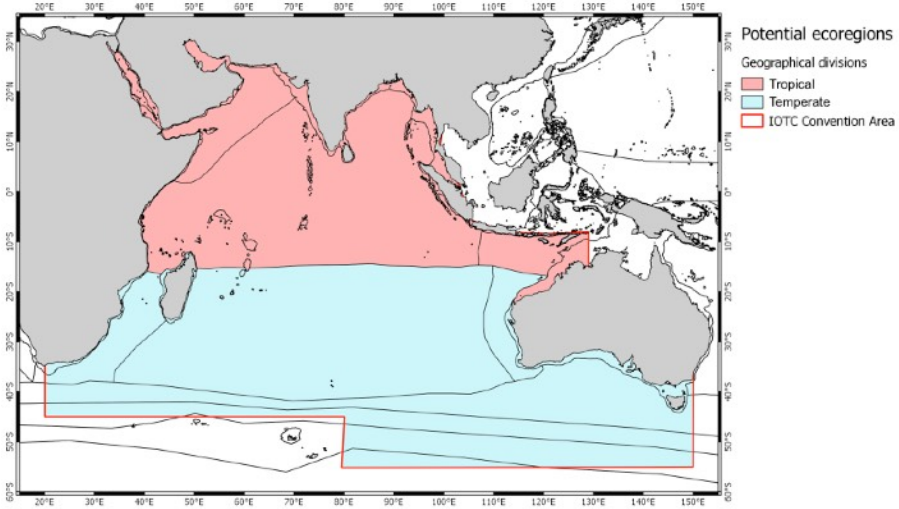
TASK 3 A proposal of ecoregions to guide ecosystem advice

Based on the three aforementioned pillars of information, **seven candidate ecoregions were proposed in the Atlantic Ocean** (and adjacent seas) and **two candidate ecoregions in the Indian Ocean**. Each ecoregion is characterized by greater similarity in biogeographic and oceanographic characteristics, in tuna and billfish communities and the type of fishing fleets exploiting them.

Candidate ecoregion in the Atlantic Ocean



Candidate ecoregions in the Pacific Ocean



Main outcomes and future directions

- The proposed ecoregions **make sense ecologically**, and also account for the spatial patterns and dynamics of the main ICCAT and IOTC species and their fisheries.
- They represent **a solid starting point to support ecosystem planning and development of regional ecosystem assessments**. Ultimately an ecoregion can be used to guide management advice that encompasses multiple species and stocks which inhabit a common and geographically defined area.
- The boundaries between ecoregions should be seen and treated with flexibility, recognizing that marine ecosystems are dynamic. The borders of the proposed ecoregions could also be adjusted to account for additional policy objectives, if the end users, here ICCAT and IOTC, deem it important.
- The delineation of ecoregions (the number of them as well as their boundaries) should be seen as an **iterative and consultative process**. Hopefully it will **encourage discussions and debates about the need for regional classification** for the application of the EAFM in ICCAT and IOTC.

Task 4

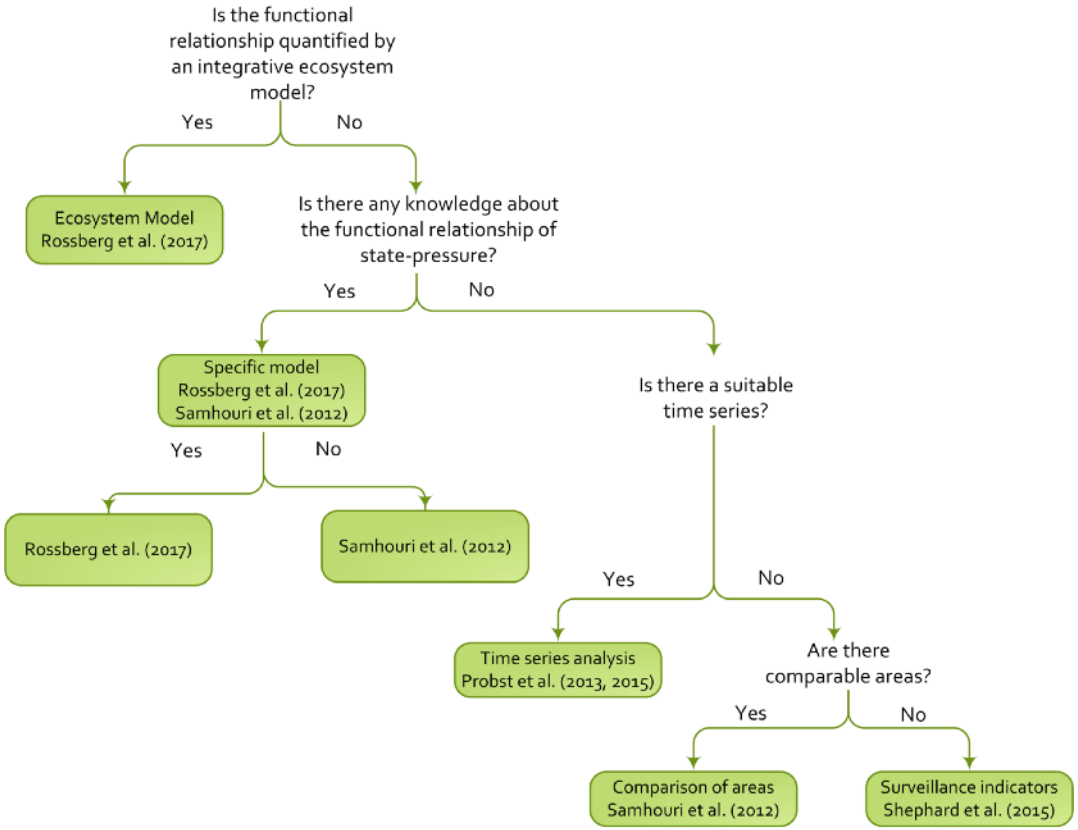
Guidance to choose reference points and a framework to link ecosystem science and fisheries management

Determining reference points in ecological indicators to assess ecosystem state is a complex task for a variety of reasons, mainly the lack of data and long time series, and the poor knowledge of the ecosystem response to environmental and human pressures. This difficulty is reflected by the limited work available addressing the problem of determining reference points for use in resource management. **Task 4 has designed a general framework based on a rule-based decision tree to provide guidance on how reference points can be set** and used for diverse types of ecosystem indicators, so they can be better used in management decisions.

Guidelines to set reference points for ecosystem indicators

- The proposed decision-tree framework was based on several projects (The EU project DEVOTES and Ocean Health Index Program) and three published studies that have developed practical protocols to use the available data and functional relationships in place to define reference points.
- The proposed decision-tree framework describes three broad approaches to define reference points with their respective strengths and weaknesses.
- The three broad approaches for setting reference points are:
    - based on functional relationship
    - based on time series analysis
    - based on spatial comparisons
- Their application depend on model reliability, data availability and quality, length of time series, etc.

Decision-tree to guide the setting of reference points for ecosystem indicators



Task 4

Guidance to choose reference points and a framework to link ecosystem science and fisheries management

The use of ecosystem indicators to assess the state of marine ecosystems and its communication to policymakers for management purposes also remains a challenging task. **This task also proposed a framework with different tools and products to better integrate and visualize multiple ecosystem indicators to establish the ecosystem context within which management decisions can take place.** Communication strategies, ecosystem products and visualization tools used to better linked ecosystem information and science into fisheries management were reviewed in four different institutions or programs. The institutions and project reviews were the NPFMC in the United States, CCAMLR, the ocean health index program, and EU project DEVOTES. These were used to inform a strategic framework, composed of three main elements, that potentially could be used in ICCAT and IOTC to better integrate and communicate ecosystem science into fisheries managements.

Two alternative framework to integrate and communicate ecosystem information and science are presented, each of them including three elements which aggregate ecosystem information at different levels to fit different purposes and reach different end users.

The **first element** entails developing an **"ecosystem status assessment"** which provides detailed information on all the indicators used to monitor the pressures and assess the state of the different ecosystem components. Each indicator would come with a detailed description including how it is calculated, data sources and data requirements, a description and interpretation of its trends and current state capturing the uncertainty of the indicators, factors causing the observed trends and a final section with its implications and link to fisheries management.

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The **second element** entails developing an **"ecosystem report card"** where top ecosystem indicators derived from the ecosystem status assessment are presented in a highly visual manner. It includes a very brief but thoroughly selected number of ecological, pressure and socio-economic indicators, which are updated and presented annual to stakeholders.

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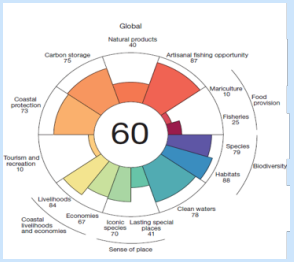
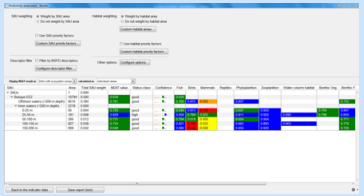
Ocean health index graphical tool

or

NEAT graphical tool in DEVOTES project



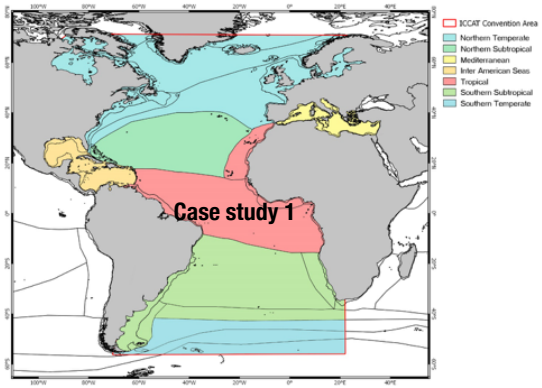


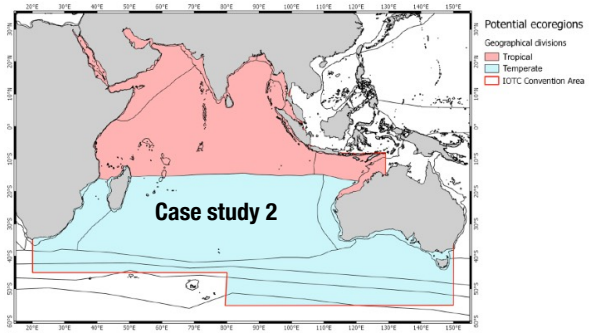
The **third element** entails developing a **"highly integrated visual tool"** that summarizes the information of all the ecosystem indicators into a single or few numerical values. Both the ocean health index program and the DEVOTES project have developed graphical and analytical tools to integrate multiple indicators of state and pressures into few numerical values and graphical outputs to facilitate their communication.

Task 5

January 2018 Mid-term Workshop

A midterm workshop between DG MARE, EASME and scientists of the Consortium was organized in January 2018. During this workshop **two case study regions were selected, one in the Atlantic Ocean and one in the Indian ocean**, for the the development of pilot ecosystem plans.





Tropical Ecoregion of the Atlantic Ocean

•Three Spalding's biogeographic provinces were combined to form the Tropical Ecoregion, including the Guinea Current Province, the Equatorial Atlantic Current Province, and the Canary Current Province.

•The Tropical Ecoregion is characterized by several areas of coastal upwelling along the African coast, with increased biological productivity, and rich fishing grounds. It also features the seasonal equatorial upwelling (July – September).

•The species primarily targeted are tropical tuna species – skipjack, yellowfin, and bigeye tunas, and secondarily swordfish, but other billfishes, bony fishes and sharks are also caught as bycatch and retained for their commercial value.

•Industrial purse seiners, followed by industrial longliners are the main fisheries targeting tuna and tuna-like species in the Tropical Ecoregion.There are also artisanal baitboat and gillnets fisheries operating in the region.

Temperate Ecoregion of the Indian Ocean

• Several Spalding's biogeographic provinces were combined to form the Temperate Ecoregion including the Indian Ocean Gyre, Agulhas current, and Leeuwin Current provinces as well as some areas of the subtropical Convergence, Subantarctic and Antarctic Polar Front provinces.

•It is characterized by a subtropical gyre, which is in an oligotrophic area. It represents a transitional area between the tropical waters in the north and the temperate and Antarctic waters in the south.

•The species primarily targeted are albacore tuna and swordfish, followed by yellowfin and bigeye tunas at the northern edges of the region. These species are primarily targeted by industrial longline fleets. Blue shark and shortfin mako are also important bycatch fish species which are also retained by longline fleets. There are also artisanal gillnets fisheries operating in the region off the southeastern African continent.

•Southern bluefin tuna also occupies the most southern waters of the temperate ecoregion, but it is managed by CCSBT.

TASK 6 Development of pilot ecosystem plans

Task 6 developed pilot ecosystem plans for two case study regions: the Tropical Ecoregion in ICCAT and the Temperate Ecoregion in IOTC. The main purpose of the pilot ecosystem plans is to facilitate the implementation and operationalization of the EAFM in ICCAT and IOTC and prescribe how fisheries will be managed from an ecosystem perspective. At this stage, the pilot ecosystem plans seek to **create awareness** about the need for ecosystem planning, **initiate discussion** about what elements need to be part of a planning process, and intent to be the foundation for future **participatory and consultative ecosystem plans** in the ICCAT and IOTC Convention Areas.

Main purposes and benefits of an ecosystem plan

Consultation

Strategic

Trade-offs

Communicate

- Creates a **transparent process** and could help the Commission set ecosystem goals and management responses
- Provides a framework for **strategic planning** to guide and prioritize fishery and ecosystem research, modelling and monitoring needs
- **Integrates information and knowledge** from different fisheries operating in a region and their impacts on the ecosystem
- **Provides a framework to identify key ecosystem components in the region,** their interconnectedness, and importance for specific management questions
- **Provides a framework to document current and best practices** in the region as well as short-term expectations and impediments hindering the operationalization of EAFM in the region
- Can help the Commission to understand **cumulative effects & trade-offs**
- Serves as a **communication tool** to better link ecosystem science and policy and as a dialogue forum for managers, scientist and stakeholders

Each of the pilot ecosystem plans include the following main **core elements** which have been developed individually for each ecoregion:

TASK 6

Development of pilot ecosystem plans

Strategic vision and goals

•An ecosystem plan needs a vision, goals, and objectives. A vision in line with the ecosystem approach to fisheries should be a long-term statement of the aspirations of the Commission of what the future would look like if management is successful.

•**Ideally a strategic vision and high-level goals should be agreed by the Commission**. ICCAT and IOTC have not yet adopted ecosystem plans with formal ecosystem goals and objectives.

•The ecosystem plan includes **examples of vision statements** from other organizations which can be used to guide the Commission when developing its own.

•A vision statement should encapsulate key principles of the ecosystem approach such as the sustainable use of fish resources, conservation of biodiversity, and maintenance of resilient ecosystems.

NORTH PACIFIC Fishery Management Council

An example -

The North Pacific Fisheries Management Council (USA) adopted in 2014 an ecosystem policy that expressed the Council's intent to continue moving towards EBFMm including a value statement, vision statement, implementation strategy and ecosystem goals

Vision statement

"The Council envisions sustainable fisheries that provide benefits for harvesters, processors, recreational and subsistence users, and fishing communities, which (1) are maintained by healthy, productive, biodiverse, resilient marine ecosystems that support a range of services; (2) support robust populations of marine species at all trophic levels, including marine mammals and seabirds; and (3) are managed using a precautionary, transparent, and inclusive process that allows for analyses of tradeoffs, accounts for changing conditions, and mitigates threats."

MID-ATLANTIC FISHERY MANAGEMENT COUNCIL

An example -

The Mid-Atlantic Fisheries Management Council (USA) approved its first strategic plan, including its vision, mission, core values and strategic goals

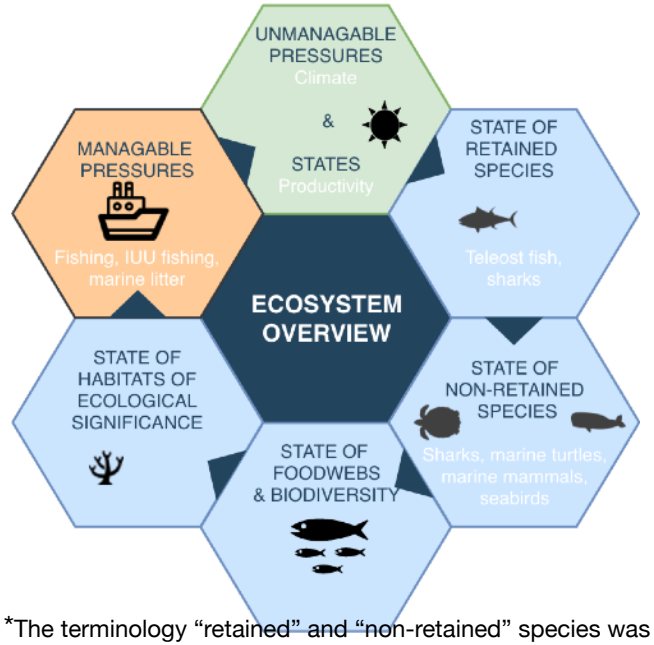
Vision statement

"Healthy and productive marine ecosystems supporting thriving, sustainable marine fisheries that provide the greatest overall benefit to stakeholders."

TASK 6

Development of pilot ecosystem plans

Main ecosystem components described in the ecosystem overview:



Ecosystem overview - *a tool that synthesizes ecosystem information for the Commission*

•The ecosystem overviews developed **integrate and synthesize current knowledge of main pressures and drivers that contribute to the state**, and changes in the state, of the different ecosystem components in the ecoregions.

•It identifies how different ecosystem components interact and relate to each other, **highlighting those emergent issues that need to be monitored** and those research gaps that need to be addressed to have a complete view of the system.

•A distinction is made between **pressures** that can be controlled by ICCAT/IOTC management and those that cannot. The most important manageable pressures are commercial fishing and the dumping of marine litter debris. The changing oceanographic conditions and climate are the most important unmanageable pressures.

•The ecosystem overview also describes **the state** of the following ecosystem components:

- **State of retained species***: describes the state of the main commercial fish species, tunas, billfishes and sharks as well as the small tunas and other bony fish species caught and retained by ICCAT fisheries because of their commercial value. Each fishery preferentially targets and retains a set of species but may also catch other fish species, that although not primarily targeted, are also retained for commercial reasons.
- ***State of non-retained species*:*** describes the state of the main species (fish and non-fish) incidentally caught by ICCAT fisheries and non-retained either because of their low commercial value or the non-retention measures in place. This also includes some shark species, sea turtles, seabirds, and marine mammals.
- ***State of foodweb and biodiversity:*** *describes the* state of knowledge of the main trophic relationships and the potential impacts of the fishing activity on the structure and functioning of marine ecosystems.
- ***State of habitats of ecological significance:*** *describes the* state of knowledge on habitats of ecological significance (e.g. spawning grounds, migration corridors, productive areas for feeding) for the species interacting with ICCAT fisheries and how these fisheries might be impacting them.
- ***State of productivity:*** describes the state of productivity and main spatio-temporal patterns.

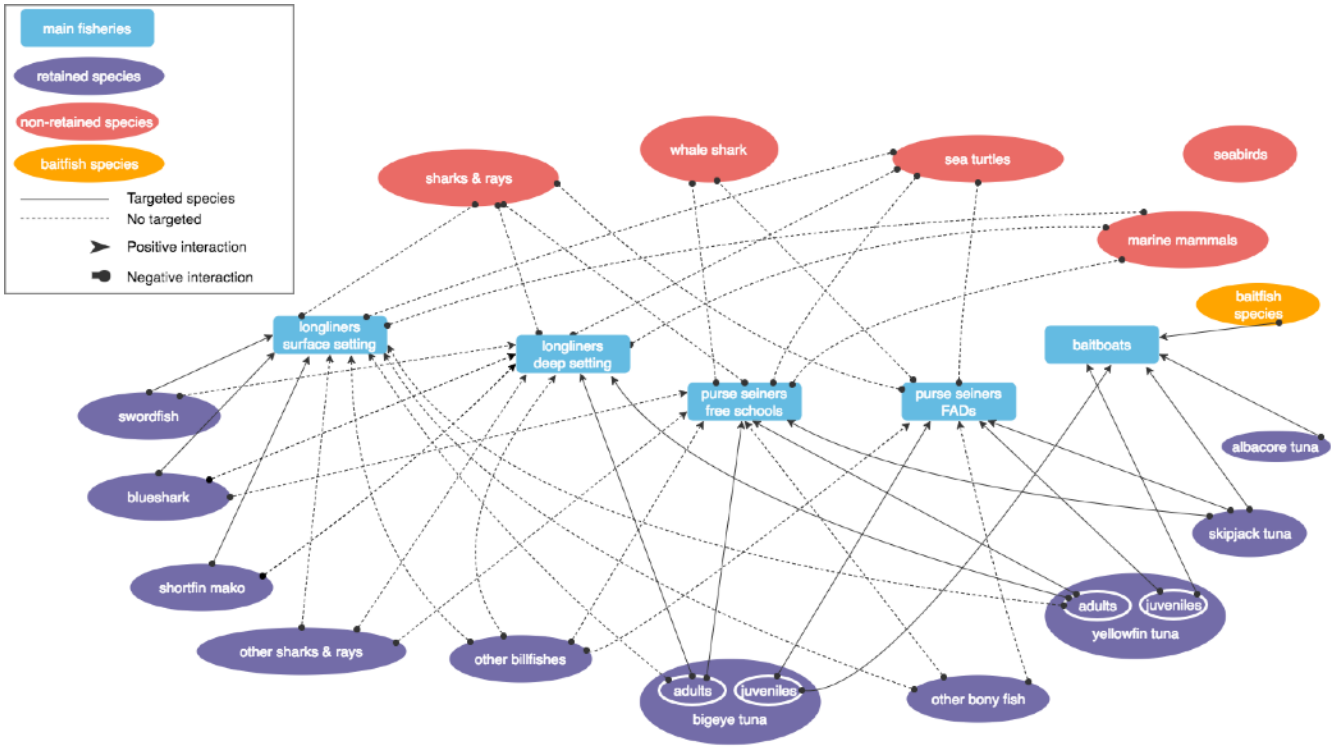
*The terminology "retained" and "non-retained" species was used in this report as it is the preferred terminology used by the ICCAT and IOTC Scientific Community. Within the EU fisheries context, the "retained species" terminology would correspond to "wanted species" and "non-retained species" to "unwanted species"

TASK 6

Development of pilot ecosystem plans

Conceptual ecosystem models - *a tool that enables visualization of those relevant ecosystem components and their interconnection*

- It is important to identify **key interactions between the different ecosystem components** to ensure a more holistic and integrative view of how the different pressures may be affecting species and the structure and functions of the ecosystem they rely.
- Conceptual models help to identify **a manageable number of issues that may require monitoring** or need to be researched separately or jointly, and ensure that no critical components are missed.
- Several conceptual ecosystem models have been developed at different scales of detail (at the ecosystem and fishery level) based on the information gathered in the ecosystem overview.

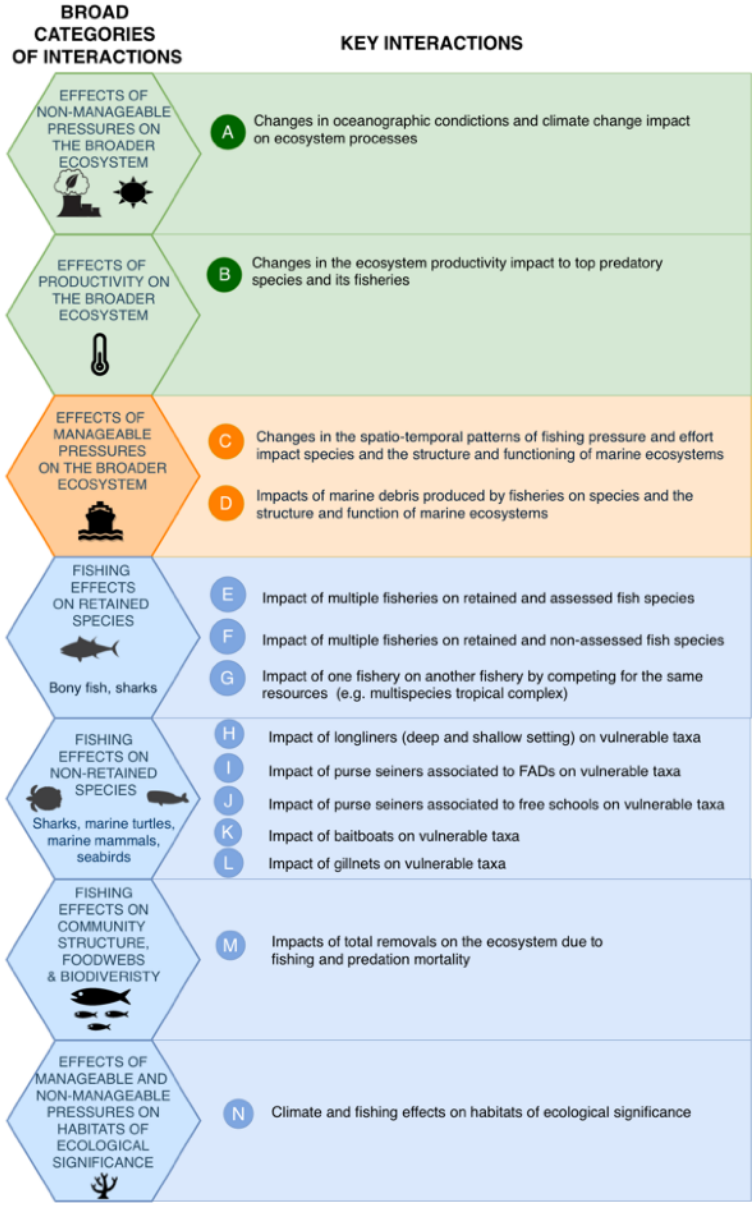


An example of a conceptual model - *illustrating the main fisheries operating in the Tropical Atlantic ecoregion and their interactions with species.*

TASK 6

Development of pilot ecosystem plans

*Example of **key ecosystem interactions** to be monitored in the Tropical Atlantic ecoregion*



Skeleton of an indicator-based ecosystem assessment

•A general framework was designed to list all the relevant ecosystem interactions in each of the ecoregions that need to be monitored and assessed by the ICCAT/IOTC Commissions in order to avoid undesired ecosystem states.

•For each ecosystem interaction, the following elements were elaborated:

Objectives

Indicators

Risks

•potential **management objectives** to track the state of each relevant interaction

•a **list of ecosystem indicators** to asses the state of the interaction. Potential data sources to use to estimate the indicators were also identified and data gaps and research needs were discussed.

•a description of the **potential risks** of not monitoring the interactions

•a **synopsis of what the Commission is doing** to monitor (and potentially address the potential risks) for each of the interactions. We also identify actions that the Commission may need to initiate to monitor and address the potential risks associated with the interactions.

TASK 6

Development of pilot ecosystem plans

Communication strategy

- The pilot ecosystem plans need to be shared and communicated to **different audiences** including the Scientific Committees and the ICCAT/IOTC Commissions.
- A communication strategy is proposed for sharing the plans in a logical and strategic way.

Target audience	Communication method (how & where)	Key messages	Timing
Scientists	Presentation of ecosystem plan to ecosystem working groups and the Scientific Committees	Consultative, revision, request feedback	Annual meetings 2019
Scientists and managers	Dialogue meetings between scientists and managers	Consultative, revision, request feedback	Annual meetings 2019
Commission	Presentation of ecosystem plans to the ICCAT/IOTC Commission meeting	-Inform the purpose and implications of plan -Seek a request from the Commission to develop a formal plan	Annual meetings 2019

The aforementioned core elements are considered to be the first step towards the development of formal ecosystem plans in ICCAT and IOTC. At present, the current state and formulation of elements included in the ecosystem plans should be seen as preliminary as they are still under development and need to be openly discussed with the Scientific Committees and the ICCAT and IOTC Commissions.

TASK 7 Recommendations to strengthen the EAFM in ICCAT and IOTC:

What are our objectives?
What is our strategy?
Who do we need to engage?

STEP 1
Ecosystem planning

The Consortium proposes a list of actions, research activities and capacity building activities **to foster the development, use and implementation of ecosystem plans in ICCAT and IOTC:**

- The pilot Ecosystem Plans should be **presented, discussed and reviewed by the ICCAT Sub-Committee on Ecosystems (SUBECO) and IOTC Working Party of Ecosystems Bycatch (WPEB) and their Scientific Committees (SC)** to evaluate its usefulness and promote further steps.
- The **regionalization of ecosystem plans**, including its potential benefits and drawbacks, need to be further discussed and reviewed by the SUBECO and WPEB and their SC.
- ICCAT/IOTC Commissions need to **agree on an ecosystem vision, goals, and objectives** for the pilot Ecosystem Plans (or any ecosystem plan). The Commission should request that the SCs develop a formalized Ecosystem Plan(s).
- Future versions of an ecosystem plan should incorporate an **ecosystem risk assessment**, which will become a cornerstone of the plans. An ecosystem risk assessment will determine the degree of importance of each of the interactions and issues identified in the pilot ecosystem plans. It will help prioritize the main issues and research actions that need to take place to avoid unwanted risk through appropriate management actions to the Commission.
- The ICCAT SUBECO and IOTC WPEB should **continue the development of ecosystem assessments** (and ecosystem report cards). The on-going assessments in ICCAT and IOTC can benefit from the current ecosystem plan and vice versa and both efforts should be coordinated. The pilot ecosystem plan identifies and proposes candidate indicators that can inform the development of ecosystem assessments in ICCAT and IOTC.
- An **Ecosystem Plan Team** should be created in ICCAT and IOTC to oversee the development of the ecosystem plan(s) and provide recommendations and guidance to the SC and the Commission.
- An **EAFM engagement strategy and standardized EAFM road map materials** for widespread use should be developed to communicate the importance of ecosystem planning and ecosystem assessments to the Commission.
- Future versions of an ecosystem plan should identify **how the ecosystem plan interacts with other Commission processes** as well as other SC activities and research programs.
- Future version of an ecosystem plan should consider including a section on **skills and capabilities** to support the implementation of the plan, as well as identify continuous financial support to ensure its implementation.
- Future versions of an ecosystem plan should consider including **socio-economic and governance aspects of fisheries** in the region covered by the plan. Until the socio-economic and governance considerations are addressed properly, an ecosystem plan will only be partially guiding the operationalisation of EAFM in the covered region.
- An **Ecosystem Plan Coordinator/Analyst** at the ICCAT and IOTC Secretariat would facilitate the development of many of the activities proposed here.

TASK 7 Recommendations to strengthen the EAFM in ICCAT and IOTC:

Do we have the science to understand the main ecosystem processes, the threats, status and trends of major ecosystem components?

STEP 2
Ecosystem status assessments

The Consortium proposes a list of actions, research activities and capacity building activities **to advance the understanding of ecosystem processes:**

- ICCAT/IOTC should ensure compliance, and enhance the **minimum requirements, in the collection of basic fisheries statistics** (catch, effort and size data) which should be spatially explicit for a larger number of ICCAT/IOTC species and other species interacting with ICCAT/IOTC fisheries (whether retained and non-retained by the fisheries).
- ICCAT/IOTC should explore the potential of using **data derived from the observer programs** to develop some of the ecosystem indicators proposed, as well as support joint collaborative analysis among CPCs to share confidential data
- Many of the proposed indicators rely on data collected by the observer programs and on the level of coverage of these programs. ICCAT/IOTC should increase further and progressively the **level of observer coverage** in all fisheries to improve the representativeness of data collected in these programs.
- ICCAT/IOTC should create a **revised list of fish and non-fish species** (not included in the ICCAT mandate) interacting with ICCAT/IOTC fisheries and a prioritise list for monitoring purposes.
- ICCAT, contrary to IOTC, does not require monitoring the number of interactions between ICCAT fisheries and marine mammals anymore. ICCAT should consider making the **collection of marine mammal interactions** and mortalities mandatory.
- ICCAT/IOTC should monitor closely the type of species and quantities interacting with **baitboat/gillnet fisheries** and promote the development of observer programs in these fisheries.
- ICCAT/IOTC should promote and support the development and use of a suite of **modelling techniques (from multispecies models, size-based community models, end-to-end ecosystem models, bioenergetic models)** to increase our existing knowledge of the impacts of fisheries and the environment on the structure and functioning of marine ecosystem
- ICCAT/IOTC should promote and support studies of **fish diet, feeding ecology and food habits** to support the development of ecosystem models and better understand trophic interactions and foodweb dynamics in marine ecosystems.
- ICCAT/IOTC should make a **better use of existing external databases** to monitor fishing activity at finer spatio-temporal scales.
- ICCAT/IOTC should set a **habitat research agenda** and continue supporting habitat studies and mapping of habitats of ecological significance for ICCAT/IOTC species and other vulnerable taxa.
- ICCAT/IOTC should promote and support assessments of the **impacts of climate change** on ICCAT/IOTC species (impacts on distribution, abundance phenology, etc.) and evaluate the socio-economic implications of these impacts for national economies and food security in order to inform mitigation and adaptation strategies to climate change.

TASK 7 Recommendations to strengthen the EAFM in ICCAT and IOTC:

What are our priorities?

STEP 3
Ecosystem risk assessments

The Consortium proposes a list of actions, research activities and capacity building activities **to prioritize vulnerabilities and risks of ecosystems and its components:**

- ICCAT/IOTC should focus on identifying and monitoring closely those fish and non-fish species most vulnerable to ICCAT/IOTC fisheries identified in the ecological risk assessments. **Monitoring of priority species should be done by fisheries and by area**, since the impacts of ICCAT /IOTC fisheries on species vary by fishery and region.
- While ICCAT/IOTC has conducted several ecological risk assessments for some gears and taxonomic groups, there are still missing for others. **Some ecological risk assessments are missing** for (1) the impacts of gillnet fisheries on all major taxonomic groups, (2) impacts of pole and line fisheries on all major taxonomic groups, (3) impacts of all gear groups on marine mammals (in the case of ICCAT), (4) impacts of purse seine (in the case of ICCAT) and gillnet fisheries on shark species. It is pivotal that the ecological risk assessments are spatially explicit.
- ICCAT/IOTC should conduct a **vulnerability climate risk assessment** to identify those ICCAT/IOTC fish species potentially most-vulnerable to climate change
- ICCAT/IOTC should conduct **habitat risk assessments** to identify those areas known to serve as important ecological functions for multiple species groups
- ICCAT/IOTC should also conduct a **more systematic and integrative ecosystem risk assessment** to identify and prioritize those pressing issues arising from the assessments of the different ecosystem components (issues for the different fisheries, bycatch species, climate interactions, etc). An ecosystem risk assessment aims to quantify the risk of each ecosystem interactions (interaction between fisheries, species and climate) based on two sources of information, their probability of occurrence as well as the level of impact on the current ecosystem state. Defining these interactions and their relative importance and risk in the system, can provide both Commissions with a tool to prioritize potential issues, make choices between different risks and trade-offs or take actions to avoid unwanted risk.

TASK 7 Recommendations to strengthen the EAFM in ICCAT and IOTC:

What are our options? What is our advice?

STEP 4
Incorporating ecosystem considerations into fisheries management

The Consortium proposes a list of actions and research activities **to address trade-offs within the ecosystem and incorporate ecosystem considerations into management advice:**

- ICCAT/IOTC should **continue supporting the development of ecosystem assessments** currently being undertaken by the ICCAT Sub-Committee on Ecosystems and IOTC Working Party in Ecosystem and Bycatch. The purpose of ecosystem assessment is to monitor climate, environmental, and fishing effects on the state of the different ecosystem components and flag issues to the Commission. This EU project provides guidelines and proposes candidate indicators for the development of such ecosystem assessments and aims to contribute to ICCAT/IOTC process and efforts in this direction. It is also important to stress that these **ecosystem assessments should be conducted by area**, since fisheries, species, and environmental conditions differ across regions within the ICCAT/IOTC convention area, and therefore the issues emergent in each area might require different management responses.
- ICCAT/IOTC should support the **development of analytical EAFM tools that enable the visualisation and assessment of trade-offs** within the ecosystem. These include ecosystem modelling tools, visualisation tools (ecosystem report cards) and decision support tools.
- ICCAT/IOTC should support the **development of Management Strategy Evaluation analysis for harvest strategies that assess trade-offs and explore harvest control rules that incorporate ecosystem considerations** (e.g. climate impacts, bycatch impacts) to test robust ecosystem level strategies.
- ICCAT/IOTC should continue supporting further research and testing of **more efficient mitigation methods to reduce bycatch** on vulnerable taxa (e.g. shark deterrent measures, hook pods to minimize seabird interactions, biodegradable FADs, etc..). In addition, improve the knowledge of post-release mortality of vulnerable and non-retained species.
- ICCAT/IOTC should support the establishment of **protocols for data collection and monitoring of the lost fishing gear** of its fleets, promote preventive measures such as the use of technology to track gear position for their retrieval and reduce gear loss, disincentivize the abandonment and discarding of fishing gear at sea, and establish port reception facilities for recycling unwanted gears.

Full report can be accessed in:

https://publications.europa.eu/en/publication-detail/-/publication/152d6214-6faa-11e9-9f05-01aa75ed71a1/language-en/format-PDF/source-95975627

Juan-Jordá M.J., H. Murua, P. Apostolaki, C. Lynam, A. Perez Rodriguez, J.C Baez Barrionuevo, F. Abascal, R. Coelho, S. Todorovic, N. Billet, M. Uyarra, E. Andonegi, J. Lopez. 2019. Selecting ecosystem indicators for fisheries targeting highly migratory species. Final Report. European Commission. Specific Contract No. 2 EASME/EMFF/2015/1.3.2.3/02/SI2.744915 under Framework Contract No. EASME/EMFF/2016/008. 633pp.