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Transition towards an ecosystem approach to fisheries in the Mediterranean Sea

Lessons learned through selected case studies

Cover illustration: Designed by Catherine Perry. ***Image:*** Purse seine small-scale fishers in Lebanon © Claudia Amico.
Map: Hand-drawn map of the Mediterranean, Europe, Africa and Middle East ©Naeblys.

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Transition towards an ecosystem approach to fisheries in the Mediterranean Sea

Lessons learned through selected case studies

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Preparation of this document

Responding to the issues faced by global fisheries in the past decades, FAO Members adopted the Code of Conduct for Responsible Fisheries (CCRF) and a series of practical guidelines to improve the sustainability of fisheries. In particular, the ecosystem approach to fisheries (EAF) was adopted by the FAO Technical Consultation on Ecosystem-based management (Reykjavik, 2002) and since then has been promoted by FAO as the appropriate approach for the sustainable development and management of fisheries in the framework of the FAO CCRF. Experience in putting the EAF principles and tools into practice has been gained on several occasions, either through direct support from FAO or other national/international initiatives. These experiences led to varying levels of success and changes in fisheries management practices. This document was prepared with a view to contribute to a global effort by the FAO to identify lessons and good practices for EAF implementation. Case studies were commissioned from experts from different areas of the Mediterranean Sea, who prepared and submitted their first drafts prior to the technical workshop "Transition towards an ecosystem approach to fisheries in the Mediterranean Sea: lessons learned through selected case studies" (online, 9–10 December 2020) organized and funded by the FAO Fisheries and Aquaculture Division and the FAO Mediterranean Fisheries Management Support Projects (AdriaMed, CopeMed II, EastMed and MedSudMed). All case studies were reviewed by the editors and updated by authors after the workshop. The final chapter on emerging lessons from the comparative analysis of case studies were drafted by the editors and revised and updated by all authors of case studies. Copy-editing, formatting and layout were provided by Evan Jeffries and Catherine Perry (Swim2Birds Ltd., UK). The cover was designed by Catherine Perry, hand-drawn map ©Naeblys and image ©Claudia Amico.

Abstract

FAO has promoted the ecosystem approach to fisheries (EAF) as an appropriate framework for the sustainable development and management of fisheries worldwide. With a view to contribute to the identification of lessons and good practices for EAF implementation, this publication documents 10 case studies that attempted to put into practice some of the key principles and tools of the approach in the Mediterranean Sea. The case studies were selected to cover a broad range of contexts including small-scale and industrial fisheries operating at local, national and sub-regional scales. It was not within the scope of the publication to evaluate the level of implementation of the ecosystem approach. A specific tool for monitoring implementation is proposed and exemplified. Case studies were analysed with a view to draw preliminary lessons regarding the enabling factors that facilitated the progress made as well as the challenges faced in the transition towards EAF-based management systems. Attention is drawn to key enabling conditions such as favourable policies, legislation and regulatory frameworks, the existence of regional mechanisms for cooperation, favourable market dynamics and social processes, and the relatively low complexity of the fishery systems analysed. A set of factors emerged that contributed to progress during implementation, such as the clear definition of fishing rights, the enhancement of mechanisms for compliance, scientific monitoring and adaptation of management measures, as well as the explicit consideration of biological and socioeconomic aspects in management actions. Further progress in the transition towards sustainable management systems is hampered by external and internal factors. External factors are related, for instance, to environmental changes, the poor regulation and control of competing sectors, consumer behaviour and the governance environment. Issues such as stakeholder representation, knowledge gaps and the availability of sustainable sources of funding are among common internal factors. The authors also discuss how slow progress in the implementation of management plans can generate discredit with the institutions and add additional challenges for any future initiatives to engage stakeholders in participatory management. The case-based results and lessons of how the ecosystem approach to fisheries was considered, developed and implemented in the fisheries discussed in this publication not only contribute to the documentation of current practices in the Mediterranean but may also guide future attempts to further develop the field.

Contents

Abbreviations and acronyms

AASTMT	Arab Academy for Science, Technology and Maritime Transport
AKD	Mediterranean Conservation Society
APAL	Coastal Protection and Management Agency
APIP	Ports and Port Installations Agency
AVFA	Agricultural Extension and Training Agency
B_{MSY}	biomass at maximum sustainable yield
CBD	Convention on Biological Diversity
CCRF	FAO Code of Conduct for Responsible Fisheries
CFP	Common Fisheries Policy
CL	carapace length
CNR	National Research Council
COFI	FAO Committee on Fisheries
COVID-19	Coronavirus disease 2019
CPC	Cooperative non-contracting party
CPUE	catch per unit of effort
CRDA	Commissariat of Agriculture Development in the Medenine region
CSIC	Spanish National Research Council
DCRF	Data Collection Reference Framework
DC-MAP	European Union data collection multi-annual programme
DFA	Department of Fisheries and Aquaculture
DFW-MoA	Directorate of Fisheries and Wildlife (DFW) of the Ministry of Agriculture
DGPAq	General Directorate of Fisheries and Aquaculture
DGPMM	Direcció General Pesca and Medi Marí
DG-Fisheries	Directorate General of Fisheries and Aquaculture
DPS	deep-water rose shrimp
EAF	ecosystem approach to fisheries
EAF-BL	ecosystem approach to fisheries baseline report
EC	European Community
EC DGMARE	Directorate-General for Maritime Affairs and Fisheries of the European Commission
EMFF	European Maritime and Fisheries Fund
EEAA	Egyptian Environmental Affairs Agency
EEZ	exclusive economic zone
EFH	essential fish habitat
ENSO	El Niño Southern Oscillation
FAD	fish aggregating device
FAO	Food and Agriculture Organization of the United Nations

FAO EastMed	FAO Regional project "Scientific and Institutional Cooperation to Support Responsible Fisheries in the Eastern Mediterranean"
FAO CopeMed	FAO Regional project "Coordination to Support Fisheries Management in the Western and Central Mediterranean"
FAO MedSudMed	FAO Regional project "Assessment and Monitoring of the Fishery Resources and the Ecosystems in the Straits of Sicily"
FLOUCA	Fish Landings Operational Utility for Catch/Effort Assessment
FMP	fisheries management plan
$F_{0.1}$	fishing mortality rate at which the marginal yield-per-recruit is only 10 percent marginal yield-per-recruit on an unexploited stock
F_{curr}	current level of fishing mortality
F_{MSY}	fishing mortality at maximum sustainable yield
FRA	fisheries restricted area
GFCM	General Fisheries Commission for the Mediterranean
GAFRD	General Authority for Fish Resources Development
GDP	gross domestic product
GIPP	Interprofessional Group of Fishery Products
GSA	GFCM Geographical Sub-Areas
GPS	global positioning system
GT	gross tonnage
HKE	hake
ICATMAR	Catalan Institute for Ocean Governance Research
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
ICM-CSIC	Institut de Ciències del Mar
IMEDEA	Mediterranean Institute for Advanced Studies
IMT EAF	Implementation Monitoring Tool
INSTM	National Institute of Marine Sciences and Technologies
IUCN	International Union for Conservation of Nature
IUU	illegal, unreported and unregulated (fishing)
LOA	length overall
LRP	limit reference point
LPUE	landing per unit effort
MAP	multiannual management plan
MCRS	minimum conservation reference size
MCS	monitoring, control and surveillance
MEDAC	Mediterranean Advisory Council
MEDITS	international bottom trawl survey in the Mediterranean
MFA	full-time vessels in the Maltese dolphinfish fishery
MFB	part-time vessels in the Maltese dolphinfish fishery
MoU	memorandum of understanding
MoAF	Turkey's Ministry of Agriculture and Forestry
MPA	marine protected area
MBRC	Marine Biology Research Centre
MSC	Marine Stewardship Council

MSFD	Marine Strategy Framework Directive
MSY	maximum sustainable yield
MUT	red mullet
NFZ	no-fishing zone
NMG	National Marine Guard
NGO	non-governmental organization
NIS	non-indigenous species
NIOF	National Institute of Oceanography and Fisheries
NTZ	no-take zone
OECD	Organization for Economic Co-operation and Development
OT	outcome target
PO	producer organization
PSF	purse seine fishery
R/V	research vessel
RFMO	Regional Fisheries Management Organization
RBMS	results-based management systems
RPOA-SSF	Regional Plan of Action for Small-Scale Fisheries in the Mediterranean and the Black Sea
SSB	spawning stock biomass
SAC	GFCM Scientific Advisory Committee
SC	Survey Commission
SEPA	Special Environmental Protection Area
SOFIA	State of World Fisheries and Aquaculture
SoS	Strait of Sicily
SSF	small-scale fisheries
SST	sea surface temperature
STECF	Scientific, Technical and Economic Committee for Fisheries
TAC	total allowable catch
TL	total length
TMCC	Technical Monitoring and Consultation Committee
TND	Tunisian dinars
TRP	target reference point
TURF	territorial use rights for fisheries
UIB	University of the Balearic Islands
UN	United Nations
USD	United States dollar
UTAP	Tunisian Union of Agriculture and Fisheries
VME	vulnerable marine ecosystem
VMS	vessel monitoring system
WG	working group
WWF	World Wide Fund for Nature

Chapter 1: Introduction

INTRODUCTION

International efforts to address the sustainability of the world's fisheries have intensified in recent decades amidst increasing awareness of the poor status of global fish stocks: indeed, one of the targets of Sustainable Development Goal 14 was to end overfishing by 2020 and implement science-based fisheries management plans to restore fish stocks to sustainable levels of production. But in spite of these efforts, a considerable share of global fisheries still suffer from weak management, justifying earlier concerns of a worldwide expansion of fisheries mismanagement (Hannesson, 1996). Nevertheless, although the status of fisheries management remains a matter of concern in some regions, successes have been achieved in many parts of the world and there is an increasing level of understanding of the factors behind sustainable fisheries (Beddington *et al.*, 2007; Hilborn *et al.*, 2020).

According to data reported to FAO, global fishery production has reached a ceiling of about 90 million tonnes and has remained relatively stable at that level for more than three decades (FAO, 2020a). Also according to the latest FAO SOFIA assessment (FAO, 2020a), the global proportion of assessed stocks in a state of overfishing reached 34 percent in 2017, without any signs of reversion in the trend, observed since the 1970s, of increasing numbers of stocks considered biologically unsustainable. Notwithstanding the progress made in certain regions to recover previously overfished stocks and to maintain fisheries within sustainable levels of exploitation (Hilborn *et al.*, 2020), in many other areas, in particular in developing countries, progress towards more sustainable levels of exploitation has been slow (Ye and Gutiérrez, 2017; Duarte *et al.*, 2020). Responding to the issues faced by global fisheries in the past decades, FAO members adopted the Code of Conduct for Responsible Fisheries (CCRF) and a series of voluntary guidelines to improve fisheries sustainability. In particular, the ecosystem approach to fisheries (EAF) was adopted by the FAO Technical Consultation on Ecosystem-based management (Reykjavik, 2002) and since then has been promoted by FAO as the appropriate approach for the sustainable development and management of fisheries in the framework of the FAO CCRF (FAO, 2003). The 2021 COFI Declaration for Sustainable Fisheries and Aquaculture (FAO, 2021) reiterates the importance of the ecosystem approach as an effective framework for integrating conservation and sustainable use objectives in fisheries management.

The purpose of an EAF is to plan, develop and manage a fishery's socioecological dynamics in a way that addresses the multiplicity of needs of society, without jeopardizing the options of future generations to benefit from a full range of goods and services provided by marine ecosystems (FAO, 2003). The overall objective of the EAF is to address the multiple needs of societies, but at the same time ensure the health of the ecosystem as well as long-term human wellbeing. In effect, it is intended to

reinforce the ecological and human dimensions in fisheries management (Garcia and Cochrane, 2005; De Young, Charles and Hjort, 2008). The EAF does not contradict or replace conventional fisheries management, but it seeks to improve its application and reinforce aspects such as participation and inclusivity in management systems, the best use of scientific and local knowledge, the interaction with other sectors, and its ecological relevance, in order to contribute to sustainable development (FAO, 2009).

There have been several attempts to put the EAF principles and tools into practice, which have met with varying levels of success (Pitcher *et al.*, 2009; Trochta *et al.*, 2018; Aly *et al.*, 2019; Ünal *et al.*, 2019; Nader *et al.*, 2020; Defeo and Vasconcellos, 2020). Learning from these experiences will be instrumental to guide future efforts to promote good practices for the sustainable use of marine capture fisheries.

In this publication, we document initiatives to manage fisheries according to EAF principles in the Mediterranean Sea, based on selected case studies representative of the types of fisheries in the region. The case studies are analysed and compared to draw some preliminary lessons on the factors that facilitated or hampered the progress achieved so far, and the challenges to overcome to strengthen the implementation of the approach in the future.

CASE STUDIES IN THE MEDITERRANEAN SEA

The Mediterranean Sea has sustained important fisheries activities since ancient times. Industrial, semi-industrial and small-scale fisheries coexist in the region, with the small-scale fisheries sector being the most prominent. The sector contributes significantly to food security and nutrition, economic growth, rural development and cultural wealth while providing valuable employment opportunities to several hundred thousand people in the region (FAO, 2020b). In contrast to other areas in the northern hemisphere, the Mediterranean Sea in general lacks large mono-specific stocks, and the fisheries rely on a variety of demersal and pelagic resources. In addition, due to the geographic configuration of this semi-enclosed sea and the overall absence of EEZs, many resources are shared among fleets from different countries, demanding strong regional cooperation for their rational management.

In the Mediterranean Sea, fisheries production declined from the mid-1990s to 2015 and has shown a slightly increasing trend since then. Reported landings in 2019 were about 800 000 tonnes (Figure 1). Fisheries in the region are subjected to many stressors, chief of which is the high level of overfishing that affects about 75 percent of the assessed stocks, according to the GFCM's report *The State of Mediterranean and Black Sea Fisheries* 2020 (FAO, 2020b). The same report acknowledges a slight decrease in the percentage of overfished stocks in recent years, down from 88 percent in 2014. Although the trend of increasing levels of overfishing has been reversed, the level of exploitation is in general unsustainable. The sustainability of fisheries in the region is additionally affected by important drivers of environmental change, including increased levels of pollution, habitat degradation, introductions of alien species and the impacts of climate change (Hidalgo *et al.*, 2018; FAO, 2020b).

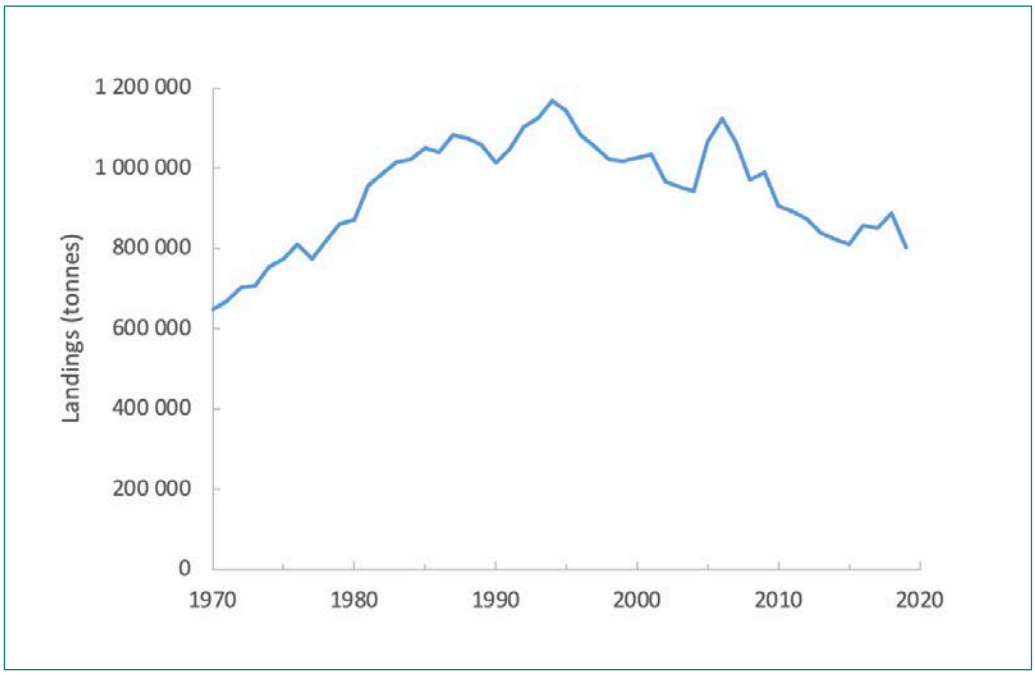

Figure 1. Total reported landings in the Mediterranean Sea, 1970–2019.
Source: FAO-GFCM.

In spite of the critical overall situation and the challenges faced by fisheries in the Mediterranean Sea, there are several ongoing initiatives to improve fisheries management in the region in line with the principles of EAF, although many do not make explicit reference to the concept. The case studies presented in this report were identified in two different ways. First, there is a group of case studies that were supported by the FAO Mediterranean Fisheries Management Support Projects. They include small-scale and industrial fisheries in Turkey, Lebanon, Egypt and Tunisia that followed the management planning steps promoted by FAO (FAO, 2012). Second, there are case studies that were selected for their recognized attempts to adjust or develop management systems in accordance with EAF principles such as enhancing stakeholder participation in the management process, strong reliance on the best available knowledge to inform decisions, the adoption of precautionary and adaptive management systems for dealing with uncertainties, and the prioritization of both ecological and human wellbeing issues and objectives in management decisions. Case studies were selected through literature review and consultation with experts, and include fisheries that were formally recognized for the progress made by means of regional awards and ecological certification. The final 10 case studies (Table 1; Figure 2) were selected so as to cover a broad range of contexts, including spatial scales (local/national/regional), resources (e.g. small pelagics, multi-species, demersal), types of fisheries (small-scale and industrial), and geographical and socioeconomic settings. Nine case studies address single fisheries, while the case study by Costantini *et al.* (this volume) covers a set of small-scale fisheries undergoing a process of capacity development for co-management. Finally, the chapter by Bernardon *et al.* (this volume) demonstrates the use of a tool for monitoring progress in EAF implementation, using information obtained from the case studies supported by FAO.

Table 1. Case studies analysed in this report.

Fishery	El Bibane lagoon*	Purse seine Lebanon*	Demersal fisheries Egypt*	SSF Gökova Bay*	Striped venus clam	Dolphinfish Malta	Transparent gobids Ballearic	Sand eel Catalonia	Demersal fisheries Strait of Sicily
Chapter	Jarboui, Djabou and Bernardon (this volume)	Nader *et al.* (this volume)	El Haweet and Megahed (this volume)	Ünal, Tiraşin and Tosunoğlu (this volume)	Luchetti *et al.* (this volume)	Laspina and Said (this volume)	Morales-Nin, Moragues and Grau (this volume)	Rodon *et al.* (this volume)	Jarboui, Ceriola and Fiorentino (this volume)
Main target species	Multispecies, including coastal demersal fish and shrimps	Small pelagics, including round sardinella *Sardinellas aurita*	Multispecies, including shrimps, common cuttlefish, bluecrab and demersal fish species	Multispecies, including demersal and small pelagic fish species, crustaceans and cephalopods	Striped venus clam, *Chamelea gallina*	Dolphinfish, *Coryphaena hippurus*	Pelagic gobies, mainly *Alphia minuta*	Sand eel, *Gymnammodytes cicerelus* and *G.semisquamatus*	Multispecies, including deep-water rose shrimp, European hake, and red mullet
Country(ies)/ locality	Tunisia	Lebanon	Egypt	Turkey	Italy	Malta	Spain (Catalonia)	Spain (Catalonia)	Italy, Malta, Tunisia and Libya
Area	Southern Mediterranean	Eastern Mediterranean	Eastern Mediterranean	Eastern Mediterranean	Adriatic Sea	Central Mediterranean	Western Mediterranean	Western Mediterranean	Central Mediterranean
Habitat	Coastal lagoon	Pelagic	Demersal	Demersal/ Pelagic	Benthic	Pelagic	Sandy or hard bottom	Sandy bottom	Demersal
Sectors	Small-scale	Small-scale	Industrial and small-scale	Small-scale	Industrial	Small-scale	Small-scale	Small-scale	Industrial
Main fishing gears	Bordigue (trap), gillnet, longline	Purse seine and lampara nets	Botton-trawling	Trammel nets, bottom set gillnets and longlines	Hydraulic dredges	Surrounding nets and FADs	Boat-seine	Boat-seine (sonsera)	Bottom-trawling
Number vessels	122	108	1006	100	601	130	55	26	467
Number fishers directly employed	~150	369	4280	200	1500	300	530	75	~2500
Landings (t)	200	2458	13185	21	19000	318	40	394	13000
Economic value (million Euros)	<0.5	3.3	41	0.1	51.4	1.4	~1.0	2.7	NA
Main markets	Domestic	Domestic	Domestic	Domestic	Domestic and international	Domestic	Domestic	Domestic	Domestic and international
Organization	Private, families	Families, syndicates and cooperatives	Fishermen's Association	Fisheries cooperatives	Fisheries consortium	Families, individual boat owners, fishing cooperatives	Fishing guilds (cooperative)	Fishing guilds (cooperative)	Fishing cooperatives and syndicates in participating countries
Governance mode	Private concession and government	Centralized with the Ministry of Agriculture	Centralized with GAFRD	Centralized with DG Fisheries	Co-management	Centralized with the Department of Fisheries and Aquaculture	Co-management	Co-management	Centralized with national authorities and under a GFCM regional management plan

*Case studies supported by FAO Fisheries Mediterranean Management Support Projects.

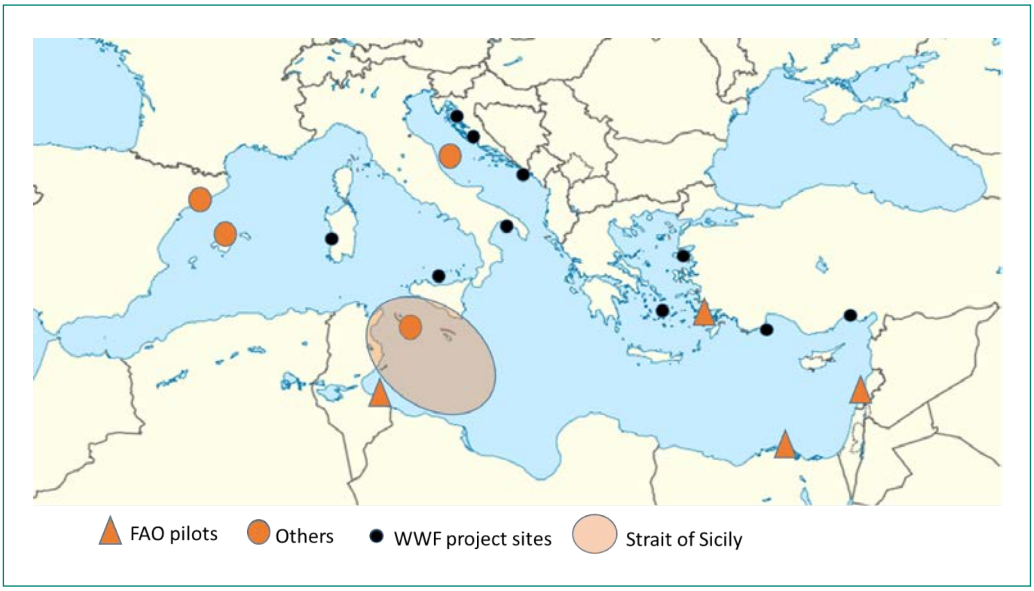

Figure 2. Location of case studies covered in this report (see Table 1 for details). The black dots represent the location of fisheries analysed in the case study by Costantini *et al.* (this volume).
Source: map from NordNordWest/Wikipedia (//commons.wikimedia.org/wiki/File:Mediterranean_Sea_location_map.svg), modified by authors.

Case studies were analysed with a view to drawing preliminary lessons regarding the factors that hampered or facilitated progress to adjust fisheries management systems according to EAF principles, as well as the challenges faced in the transition towards EAF-based management systems. Considering that the case studies followed different paths towards the implementation of EAF principles, their joint analysis required a general framework that differed from the phased approach on which the FAO guidelines are based (FAO, 2003; FAO, 2012). In fact, the changes observed in some of the fisheries responded dynamically to socioeconomic aspects and to the problems that were affecting fishery sustainability, within a changing institutional context. Following Defeo and Vasconcellos (2020), the analysis took into consideration the theory of change proposed by Moore *et al.* (2014) for the transformation of socioecological systems towards sustainability. The resulting analytical framework and guiding questions are described in Table 2. To facilitate the analysis of lessons learned, the preparation of the case studies followed a general template guided by these questions. Case studies supported by FAO additionally analysed the experience with the implementation of each of the EAF planning steps (FAO, 2012): i) initiation and scope; ii) identification of assets, issues and their priority; iii) development of management systems; and iv) implementation, monitoring and performance review. These case studies document and discuss the factors that favoured or blocked the implementation of each of these planning steps, and provide suggestions both for stakeholders in relevant cases and for actors who will adopt similar approaches in the future.

Table 2. Elements and questions that guided the analysis of the case studies (adapted from Defeo and Vasconcellos, 2020). The terminology is consistent with FAO (2012).

Elements of analysis	Guiding questions
Triggering factors and enabling conditions	• What were the factors that triggered a change in the governance system towards an EAF (e.g. resource overfishing, policies, markets, projects, etc.)? • What were the key institutions, organizations and processes that facilitated the change?
Management processes and results	• Does the management framework comprehensively address the issues of human and ecological wellbeing? • Is there a fit between the scope of fisheries management and the scale of the fishery socio-ecological system? • How were the changes in the management system institutionalized (e.g. legislation, management plan)? • Were the management measures effectively implemented? What were the results and their indicators? • Is there monitoring, control and surveillance of the measures taken? • How do the main stakeholders participate in the management system?
Barriers and challenges	• What were the internal and external factors that hampered the governance and 'ability to achieve' of the management system? (External factors are here considered as processes operating at scales that are beyond the boundaries of the fishery socioecological system and/or processes out of the scope of the fisheries management authorities.) • How did the system react to these factors? • What are the main challenges to the implementation of EAF-like management systems?

The emerging lessons from the comparison of the case studies were first presented and discussed during the online workshop 'Transition towards an ecosystem approach to fisheries in the Mediterranean Sea: lessons learned through selected case studies', 9–10 December 2020, organized by the FAO Fisheries Division in collaboration with the FAO Mediterranean Fisheries Management Support Projects. The final version of the emerging lessons was prepared after the workshop following a review of the case studies by the authors.

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Chapter 2: Ecosystem approach to the demersal fishery of the Mediterranean coast of Egypt: lessons learnt and the way forward

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1. STUDY AREA

The Mediterranean coast of Egypt extends for about 950km from Rafah in the east (Sinai Egyptian-Palestine border) to Sallum in the west (Egyptian-Libyan border), one of the longest Mediterranean coastlines in North Africa. It is identified by the General Fisheries Commission for the Mediterranean (GFCM) as sub-area 26 (GSA 26) Southern Levant Sea. Six coastal lagoons are connected to the coast – Maruit, Edku, Burollus, Manzala, Port Fouad and Bardawil – as shown in Figure 1. The continental shelf is wide off the eastern coast and the Nile Delta in the middle, with a flat and mostly muddy or sandy seabed, in contrast to the narrow western region where the substrate is sandy and rocky.

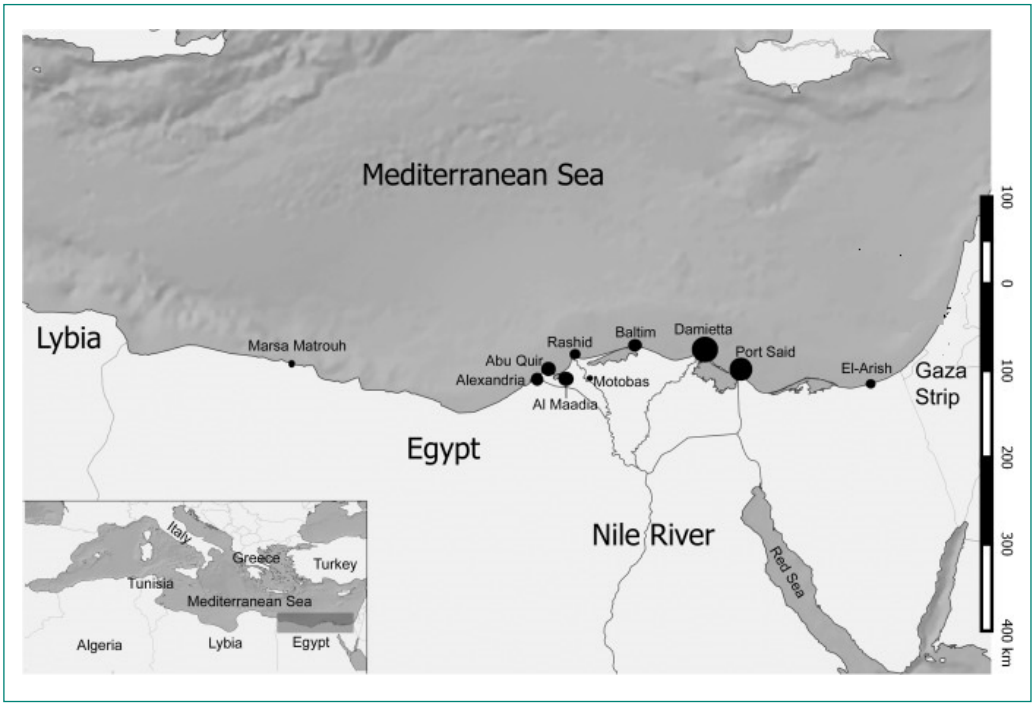

Figure 1. Map of the Egyptian Mediterranean coast, showing the main fishing ground and the main fishing ports. Source: modified after Mehanna (2007).

2. FISHERIES CONTEXT

According to the General Authority for Fish Resources Development (GAFRD) of Egypt's Ministry of Agriculture, in 2018 the licensed motorized fleet on the Mediterranean Sea coast comprised of 3 158 vessels equipped with inboard engines of 50-1 000 horse power, with an additional 959 non-motorized boats (most using outboard motors). About 15 000 fishers are licensed for fishing in the Mediterranean Sea – some fishers licensed for the Red Sea or inland water also occasionally work in the Mediterranean Sea.

The registered fishing fleet targeting demersal species includes three types of vessels, and they use different fishing gears.

1. ***Trawlers*** (1 006 vessels) are the main fishing vessels which target demersal species. The Egyptian fishing fleet is dominated both in terms of technical characteristics and activity by trawlers using otter trawl gear. In addition, an unknown number of vessels registered to use hooks and lines also illegally use bottom trawls. Trawlers from 12 m to 33 m length overall (LOA) are approved to fish in any area along the coast, regardless of their registered port. They operate on the muddy and sandy flat bottom at depths ranging from 15 m to 900 m, and up to 75 km offshore. While Egyptian fishing legislation prohibits fishing within 3 miles of the shoreline, some illegal activities nevertheless take place. Fishing trips usually last from 1 to 20 days, and the number of crew employed ranges from 5 to 12 per vessel.

2. ***Polyvalent vessels*** (1 911 vessels) are registered to fish with hooks and lines or static nets (trammel and gill nets). These boats range in LOA from 12 m to 19 m, and work in shallow fishing grounds to depths of 150 m. Fishing trips usually last from 1 to 6 days, and the number of crew employed ranges from 5 to 10 per vessel depending on the fishing method and gear utilized. Various fish species are targeted depending on their seasonal abundance.

3. ***Artisanal vessels*** (around 1 000 vessels) are of <12m LOA and use static fishing gears (gill or trammel nets and handlines) to target various species according to seasonal abundance. They work in inshore areas, particularly around rocks or seagrass. Fishing trips usually take one or two days, with two to four fishers per vessel.

Fishing operations mostly take place along the continental shelf off the Nile Delta, extending to the eastern side of Port Said but rarely west of Alexandria (limited trawling grounds are available), while artisanal fishers exploit inshore areas. The main fishing ports along the Egyptian Mediterranean coast are Matrouh, Alexandria (Anfoshi and Abu Qir), Maadia, Rashid, Borg El-Burullus (Baltim), Damietta (Izbet El-Borg), Port Said and Arish, while various other landing sites are scattered along the coast.

Commercial fishing fleet numbers have been largely stable for the last 20 years as a result of a decree from the fishery authority, but engine power has been increasing. The fishing industry is constantly evolving as new technology is developed and new markets open.

Recreational fishing is widespread along the Egyptian Mediterranean coast, but there is no information about fishing effort or catch so the impact of this activity is unknown. Only 3 141 people have been licensed by GFARD for recreational fishing, but many others fish without licences.

In view of the trawler fleet's importance and its potential impacts on other fleet segments, the bottom-trawling fishery has been the focus of attention of the current management regime in Egypt, and the main target of the management planning process described in the present article.

Resource exploitation

Throughout the year, trawlers mainly target shrimps (*Penaeus spp., Metapenaeus spp., Marsupenaeus spp., Parapenaeus spp. and Aristaeomorpha spp.*), common cuttlefish (*Sepia officinalis*), blue crab (*Portunus pelagicus*) and some fish species like *Mullus spp*., *Saurida undosquamis* and Sparidae family species. Many other commercial species are regarded as bycatch. Discards are mainly composed of small-sized fish (including commercial species) and species with no commercial value, including some invertebrates (Alsayes *et al*., 2010; Ragheb *et al.*, 2019). Trammel nets are used to target various demersal species depending on seasonal abundance (Aly *et al*., 2019).

Stock status

The number of stock assessments for demersal species conducted in Egypt has increased in the past 10 years, with most being undertaken by the National Institute of Oceanography and Fisheries (NIOF) and some university participants. Although the assessments do not entirely cover the Egyptian Mediterranean coast, almost all of them show a state of overexploitation (Mehanna, 2009; Eid, 2015; Mahmoud *et al.*, 2015; El-Haweet and Abdelwakil, 2018). Most of the assessments recommend reducing fishing mortality by 30 to 45 percent, with suggested management measures including reducing the number of fishing boats, improving trawl selectivity by increasing net mesh sizes, identifying and protecting nursery and spawning areas, banning trawlers from working within a minimum distance from the coast, and introducing closed areas or seasons (FAO EastMed, 2014).

The bottom trawl fishery in Egyptian Mediterranean waters is a multispecies one. The high marketability of small fish for local consumption encourages the targeting of the immature portion of some stocks. Consequently, shallow areas (within the three-mile coastal limit or at depths of less than 50 m) are frequently trawled with small mesh sizes, which contributes to overfishing (Tudela, 2004). Trawled shrimp has the highest discard ratios, ranging from 3:1 to 15:1, and the level of bycatch varies in relation to target species (Alsayes *et al.*, 2009). The impacts of discards can go far beyond single-species demographic effects. The discarded biomass can, for instance, alter ecosystem structure by favouring scavengers (Tudela, 2004.). However, the consequences of the fishing-driven increase in food supply stemming from discards have seldom been addressed by specific studies.

Trawling also harms seagrass, both through sediment suspension and by directly damaging the vegetal mass – the most dramatic impacts have been on *Posidonia* beds.

3. MANAGEMENT CONTEXT

Traditional fisheries management – focused on target species and based exclusively on scientific advice – was applied for many years in Egypt. Management measures were based on scientific studies of specific fishers at particular times presented to the governmental fisheries authority committee, which would then declare annual resolutions for managing each fishery by area. More recently, a management plan was established which considered economic and social issues alongside the biological ones affecting fisheries development: in other words, it was one which took an ecosystem approach to fisheries (EAF) as a management system. Accordingly, the management

system was modified through stakeholder participation in order to establish a management plan with clear objectives for each fishing ground along the country.

The main objectives set were to recover fish stocks, maintain fisher income, and conserve the ecosystem. Selected management scenarios were simulated by employing an operating model consisting of three components: the population, fleet and observation models. Operational objectives were clear, measurable and directly linked to one or more of the high-level objectives. Indicators and associated measures to monitor performance against each operational objective were identified. An effective set of management arrangements designed to generate good levels of performance for all operational objectives were selected. The management plan was made official with the agreement of the stakeholders.

The timeline for the EAF management plan was as follows:

- ***February 2016:*** coordination meeting followed by the first stakeholder meeting. The second and third stakeholder meetings were organized in April and July, to discuss the base line report.
- ***September and December 2016:*** fourth and fifth stakeholder meetings held to discuss the management plan.
- ***January to June 2017:*** formulation of the plan completed, followed by stakeholder revision and approval.
- ***November 2017:*** management plan adopted by Minister of Agriculture.
- ***April 2018:*** advisory committee established with different stakeholder representatives, to monitor and follow up the implementation of the plan.
- ***2019:*** management measures issued by special decrees from GAFRD.

Triggering factors that led to the changes in the management system

Change is critical for any administration that wants to optimize its performance. Factors influencing the changes in the present plan included:

- Failure of the traditional management methods to improve fishing activities.
- Deterioration of fish stocks due to ineffective management measures.
- Growing knowledge of fishery managers regarding the multidisciplinary nature of the fishery sector.
- Variation of fishing operations and developments in technology used along the coast.
- Deviation of some fishers from licensed activities.
- Modification in the governance system that controlled the sector.
- Liberalization of the country's traditional economic system.
- Knowledge exchange and effective communication with other Mediterranean countries through the FAO EastMed project and the GFCM.
- Globalization and its impact on developing countries.

Key institutions and stakeholders involved

The changes in management system reflect a new development model, where stakeholder involvement is believed to lead to more realistic and effective policies and plans, as well as improving their implementation through greater knowledge and broader experiences. Various stakeholders have participated in the development of the management plan for Egypt's Mediterranean coast demersal fishery. These include:

1. The General Authority for Fish Resources Development (GAFRD), Ministry of Agriculture, which is responsible for the development and management of Egypt's fishery resources.

2. The National Institute of Oceanography and Fisheries (NIOF), which carries out the majority of fisheries research in Egypt and is the main scientific consultant for the government.

3. The Arab Academy for Science, Technology and Maritime Transport (AASTMT), acting as a representative of various Egyptian universities studying fisheries science.

4. The Coastal Guard, Ministry of Defence.

5. The Egyptian Environmental Affairs Agency (EEAA), which is responsible for marine conservation.

6. The Fishers' Association (Co-operative Union of Aquatic Resources), which is elected by local fisher cooperatives; some fishers also participated on an individual basis.

Factors that enabled the changes

Although the fishing industry is often resistant to change, discussion of change management concepts provides a new opportunity to reduce or eliminate barriers to change and facilitate fishery development. Change management has the potential to facilitate greater cross-sector collaboration and increase sustainable utilization of ecosystem resources. Most change that has occurred in the management process can be considered evolutionary, occurring continuously and gradually over a period. Various factors enhanced the EAF implementation process:

- A multi-stakeholder governance structure was established, ensuring that government, private sector and civil society were equally represented.
- The resistance of some stakeholders to the change process was effectively handled.
- There was a focus on the science behind the changes.
- Dialogue between different stakeholders was sustained.
- Development of the fishery sector was supported by national policymakers.
- Greater transparency between fisheries authorities and stakeholders was pursued.

Factors that hindered the changes

As stated above, the fishing industry can be resistant and slow to change. Change to established processes and systems may be seen as a threat because it forces fishers to face an unknown future, as well as being a threat to their financial wellbeing, and –especially in developing countries – a threat to their food security (Eayrs *et al*., 2014). Changes are often considered uncontrollable and unpredictable, and fishers raised a number of concerns about the new management plan:

- Risk of job losses
- Risk of smaller catches due to restrictive measures
- Risk of competition from other fisheries – e.g. recreational
- Poor communication and engagement from some sectors (tourist and petroleum) could interfere with planned changes
- Poor oversight from the weak control and observation system along the Egyptian coast.

4. ACHIEVEMENTS AND LIMITATIONS OF THE NEW MANAGEMENT PLAN

The previous management system for the study area was run by the government, had inadequate management and enforcement, and led to ecological unbalance; while the EAF system has clear objectives and integrates management measures with co-management principles. In the current plan, achievements have included:

- ✓ Broader stakeholder participation, with fishers involved throughout the process (instead of only the head of the Co-operative Union, as on the previous committee).
- ✓ Management decisions that are based on the best available knowledge.
- ✓ Compatible management measures with penalties for noncompliance.
- ✓ Improved human well-being and equity in fisheries communities, with different fishery types represented and social status also considered.
- ✓ A special logbook-style form for periodically recording landings, with possible suspension of vessel licences in cases of nonfulfillment.
- ✓ In cooperation with the EEAA, the first ever brochure was designed to help fishers avoid catching endangered species.
- ✓ New management measures have been introduced, such as:
  - A minimum landing size for target species for different fisheries in the area (NIOF estimates suitable length for important commercial target species).
  - A new mesh shape for trawl codends using a T90 design instead of diamond mesh in order to enhance net selectivity.
  - A maximum of 20 days at sea per month for trawlers, to reduce effort.
  - Specific measures (e.g. monitoring, licensing) for recreational fishers to be accelerated by authorities.

Successes on the ground

Setting up an effective and equitable EAF management process led to some ground-breaking outcomes in the region:

- The management plan for the demersal fishery of Egypt's Mediterranean coast had a clear objective and timetable, agreed by stakeholders.
- Most stakeholders accepted the management plan and EAF system, supporting the implementation of its action plan.
- Cooperation with the Ministry of Supply and Internal Trade was arranged to monitor fish markets in line with the new measures and confiscate threatened species, such as sea turtles and some shark species.
- The social and cultural profiles of target markets were considered in the strategic plan for the deep-sea red shrimp trawl fishery.
- Bio-economic management strategy evaluations of demersal trawl fisheries were applied for the present plan, and selected management scenarios were simulated. Overall results indicated that effort reductions and/or gear selectivity improvements (as in the present management measures) would be beneficial for both stock and fisheries.
- Experience gained in formulating the current EAF management plan has encouraged the fisheries authority to apply the same principles in other parts of Egypt (e.g. Lake Nasser).

Challenges to implementation

Each fishery management plan outlines the measures that will be used to regulate the fishery. A strategic plan lays the ground for improving fisheries activities where needed, but some strategic plans fail due to difficulties during the implementation phase. In the present plan, key challenges include:

- A lack of observers at landing sites is always an obstacle, since observers often provide the most reliable data on catch and fishing effort. Observer data (such as bycatch, catch composition, protected species interactions, and gear configuration) are critical to the success of the plans, particularly when it comes to compliance with rules that had been missed in the previous system.
- There is a lack of funding for training on advanced technology and general awareness activities for fishers.
- The Egyptian fleet has no vessel monitoring system (VMS), so it is impractical to link landed species to certain fishing grounds or definite geographic areas.
- Fishers' Associations have little influence on individual fishers.
- Older fishers have less trust and understanding of how the management plan will help them in their work.
- Most fishers have weak economic status and poor social protection, and some act illegally.
- Universities and research centres have limited interest in linking their scientific research with the requirements of the management plan.
- Fishers have to share their grounds with other activities that have particular importance for the national economy, like tourism and oil exploration.

Conclusion

The ecosystem approach is promoted as a fishery sustainability solution. However, its implementation is often seen as being overly complex and difficult. Fishery stakeholders on the Egyptian Mediterranean coast realized the importance of the EAF management plan for changing the traditional management system by relying on participatory management and considering the views of all stakeholders, to formulate a balance between scientific recommendations and economic and social aspects. However, some fishers consider that change is uncontrollable and unpredictable.

Nevertheless, the limited available data demonstrated that, under the historic exploitation pattern, the economic viability of the fleet would be threatened, particularly with higher fuel prices, so stakeholders recognized that the responsibility to develop an improved management framework was shared between them all.

The present management plan is based on clear objectives and an integration of management measures with co-management principles. Although some achievements have resulted from the present plan, there are still some challenges in its implementation that need more funding, effort and cooperation from all fishery stakeholders.

Experience in formulating an EAF management plan for the demersal fishery in the Mediterranean Sea has encouraged the Egyptian fisheries authority to try to do the same in other areas. Understanding the biggest challenges to strategy implementation will help to avoid the most common difficulties, and better set up future plans for success.

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Chapter 3: Italian striped venus clam fisheries management: an ecosystem approach to fisheries-like system for the Mediterranean mollusc sector

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1. INTRODUCTION

The use of hydraulic dredging for the catch of striped venus clam (*Chamelea gallina* L., 1758; FAO Code SVE) has a long history in the Adriatic Sea, and its management has been through several stages of development in the last 40 years. In the early 1970s the transition from a hand-operated dredge to a hydraulic dredge resulted in an immediate increase in fishery yields (80,000-100,000 metric tonnes per year), followed by a progressive decline due to overexploitation and poor management (Carlucci *et al*., 2015). As a result, considerable effort has been made in the last two decades to move from poorly or weakly managed fisheries to a well-structured co-management system, with the goal of improving sustainability (Lucchetti *et al*., 2014).

The process towards co-management of the clam fishery began in 1995, when the National Authority (Ministry of Agriculture and Forestry) established the Consortia for Molluscs Management (Co. Ge. Mo.; Spagnolo, 2007), involving them in the decision-making processes and entrusting them with the management of the fishery, under a national governing framework. The Consortia, with the support of a scientific body, have adopted a management system based on effective and more restrictive measures over time. Collaboration with scientists is a crucial factor behind the development of nationally endorsed management plans. At present, the striped venus clam fisheries along the Italian coasts represent a successful example of how to manage a sedentary target species. Modern clam fishery management is still strongly based on fishing activity, and the technical measures set by the Consortia are mainly driven by the state of the resource and market demand; however, more attention has recently been paid to the entire ecosystem (Lucchetti and Sala, 2012; Morello *et al*., 2005). Above all, this is because the operators have finally understood that good environmental status strongly and positively influences the state of the resource: the nutrients and the granulometry of the sediments influence the areas suitable for the clam and its growth, the physical parameters of water can influence local or massive die-off phenomena, and chemicals, contaminants or pathogens can affect the health of the waters. This approach, that takes major ecosystem components and services – both structural and functional – into account in managing fisheries, makes the striped venus clam management representative of an EAF-like system. Many of the EAF principles and objectives have been satisfied at this point thanks to Consortia management criteria, which include a maximum acceptable fishing level, maintaining the reproductive capacity of target resources, impact minimization, improving research capacity, and certification.

2. FISHERIES CONTEXT

The striped venus clam – known in Italy as '*vongola*' and locally as '*cappola*', '*lupino*' and '*cocciola*' – is a bivalve of the Veneridae family. It is distributed throughout the Mediterranean, with commercial densities present mainly in the western Adriatic, the Marmara Sea (Turkey), and southern Spain (Andalusia, Catalonia and mainly the Gulf of Cádiz), and to a lesser extent on the Albanian (southeastern Adriatic) and Moroccan coasts of the Alboran Sea. Italy, Turkey and Spain are the main countries involved in the venus clam fishery.

In Italy the striped venus clam is particularly abundant along the central and northern Adriatic coast, although noteworthy quantities are also caught in the south Adriatic and central-southern Tyrrhenian Sea. *C. gallina* is one of the most important edible bivalve molluscs and it is mainly found in fine well-sorted coastal sand biocenosis, described by Péres and Picard (1964) at depths between 2 m and 12 m (Morello *et al*., 2006).

Clams are harvested with hydraulic dredges which operate within a narrow strip between 0.3 and 2 nautical miles (nm) from shore, although high densities for commercial use are normally concentrated within 1 nm of the shore. The gear consists of a metal cage 2.5-3 m wide mounted on two skid-sledge runners that help it slide on the seabed and prevent the cage from digging into the sediment. A sharp metal blade fitted on the lower part in front of the cage protrudes a few centimetres under the sledge runners (4-6 cm for the 'vongolara' dredger), which removes the top part of the sediment. A hose connects a centrifugal water pump to nozzles placed at the dredge mouth and inside the cage; nozzles eject pressurized water towards the sea bottom to dislodge the marine organisms living in sediment and facilitate their capture. The vessel moves backwards during towing and, at the end of the tow, the cage is hauled on board at the bow and its contents are tipped into a collecting box. Selection is carried out either on the seabed by the dredge itself, or on board using a vibrating sieve, which consists of multiple grids. The dredge catch is processed on board and sorted mechanically into different commercial classes by the vibrating sieve, while discard (small clams) and other species without commercial interest are thrown directly back into the sea.

Fisheries employing hydraulic dredges are active along about 1 400 km of coastline over a total length of about 8 000 km of Italian coasts. There are 635 vessels in the fleet of hydraulic dredges harvesting the striped venus clam, 34 of which mainly target the razor clam Ensis minor and only occasionally the venus clam. The 601 most productive vessels are concentrated along the Adriatic coasts, mainly in the Marche (31 percent) and Veneto (23 percent) regions (Figure 1). Overall production in 2018 and 2019 was around 19 000 tonnes per year, representing 11 percent in weight and 6 percent in revenue (around EUR 51.4 million) of all fisheries production in Italy. The fleet of hydraulic dredgers is currently uniform in terms of technology and dimensions (average LOA 15.5 m, average tonnage 9.98 GT, average engine power 150 kw). The total number of crew members on board is estimated at around 1 500, which is equivalent to an average crew of two operators per vessel (Italian National Management Plan for hydraulic dredges, 2019).

The first hydraulic dredges in Italy entered service in the Adriatic Sea in the early 1970s, and within a few years had exceeded the traditional hand-operated dredges because their catches and economic returns were much higher. In 1974 there were 383 hydraulic dredges (of which 240 were modified traditional dredges) along the entire Italian Adriatic coast, with annual landings reaching 100 000 thousand tonnes (Froglia, 1989a). Ten years later dredges had increased in number to 607 in the same area. Dredges peaked at 778 in 1993, and then the fleet started decreasing. This increased fishing effort (in terms of number of vessels) and catch efficiency via technical innovations, led to intense exploitation, with a risk of over-exploitation (Carlucci *et al*., 2015).

In the early 2000s, ecological, environmental, institutional and socioeconomic issues all threatened the sustainable management of fishing with hydraulic dredges. The entry into force of Regulation (EC) 1967/2006, which banned hydraulic dredging within 0.3 miles of the coast, resulted in a significant reduction of the exploitable areas (the previous legislation forbade the use of hydraulic dredges in areas with a depth less than 3 m; Ministry Decree 22/12/2000); although the potential fishing grounds were affected differently by the new technical measures depending on the nature of the coastal area concerned and on the spatial distribution of the species. The reduced exploited areas were significant: for example, for the most productive regions of Marche and Veneto, the fishing areas were reduced by 35.3 percent and 56.3 percent respectively.

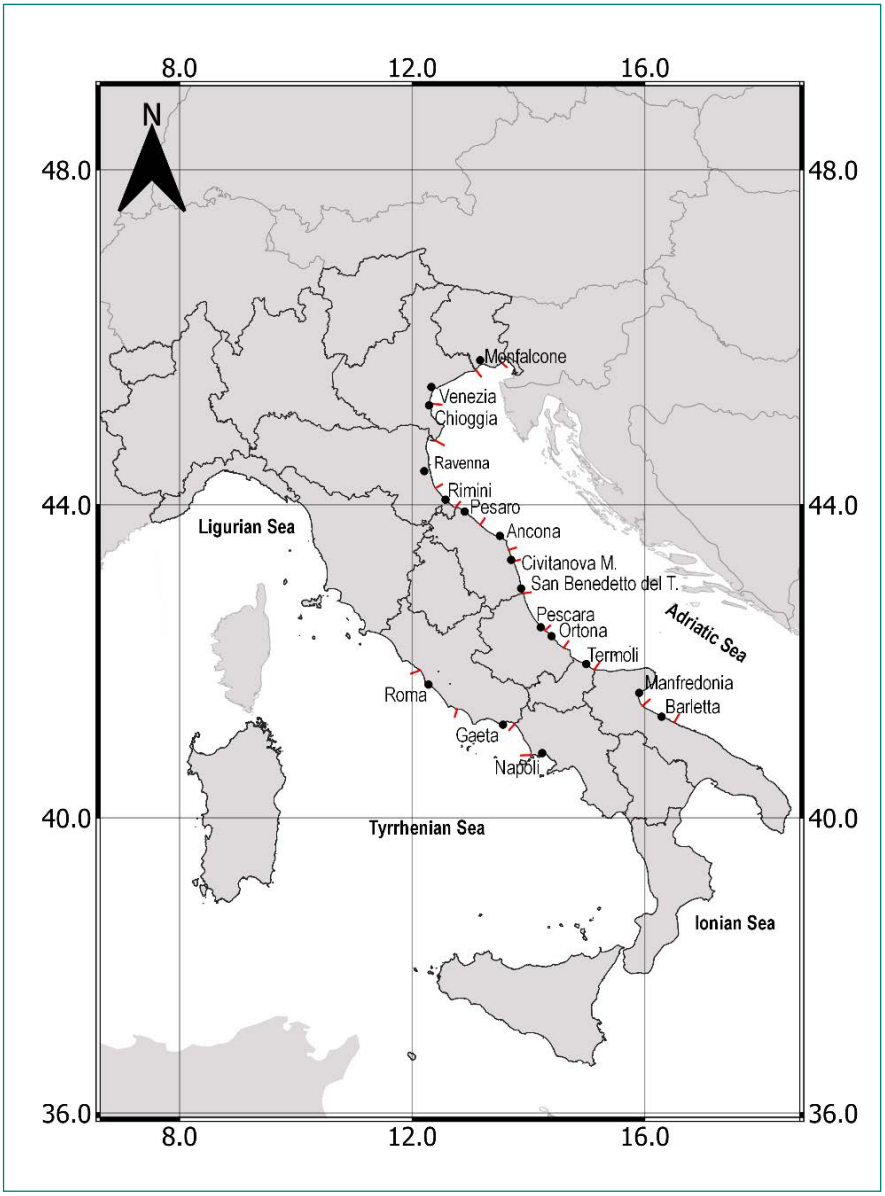

Figure 1. Map of Italy indicating all the Maritime Districts scattered along the Italian coasts (black dots), and also representing the extent of their waters of jurisdiction (red bars).
Source: www.istat.it.

The reduction of the total fishing area at the national level was around 526.3 km² – this was of a total 1 108 km² before the implementation of the Regulation, equal to a reduction of 52.5 percent.

Several other factors influence the extent of clam fishing grounds. Water quality directly affects the biology of bivalve molluscs, since they are filter-feeding organisms – and hence it also affects the fisheries that depend on them. Any deterioration in water quality due to the presence of pollutants of bacterial and viral origin, heavy metals, algal biotoxins etc. can have negative consequences for the clam fishery and market, because of the possible declassification of the production areas (Regulation (EC) 854/2004). Poor water quality is a cause of concern for product safety and therefore for public health, and leads to fishing closures and the suspension of the sale and consumption of clams. The presence of pollutants is an ecological and biological threat for the environment with direct negative implications for the entire fishing sector. Furthermore, in some areas (particularly inshore areas affected by river inputs) the lack of effective and regular checks on the quality of coastal waters has recently led to the imposition of restrictions on some otherwise potentially productive fishing areas. This water classification is an issue typical of some Tyrrhenian areas, as is the case of the Salerno, Naples and Gaeta districts.

Biotic and abiotic factors such as temperature, nutrients, particulate organic matter, the nature of the sediments, currents and river inflows strongly influence the settlement of larval stages, the growth and the densities of clams, as well as other fossorial species. In the presence of high densities (> 500 individuals m²), phenomena such as increased natural mortality as well as a reduced growth rate and slowing down of recruitment have been demonstrated (Carlucci *et al*., 2015). It is therefore quite common for this species to experience massive mortality events, determined by natural factors including anoxia on the seabed (especially in the late summer inshore areas), massive inflows of fresh water from rivers, sudden changes of water temperature due to storms etc. – these have, on several occasions, led to critical periods for the fishing industry. In recent years there have been mass mortality events both on a small scale and over large areas, and in some cases they have affected the entire Adriatic basin. These events are a key critical issue for the sector, as they also involve long periods of forced inactivity. In the last three years (2018–2020) the coastal area of the Veneto and Emilia Romagna regions have faced a meteo-marine event of exceptional flow, with exceptional high water in Venice (up to +187 cm above sea level) supported by intense sirocco winds (gusts at about 100 km/h) and intense sea storms that have upset the shoreline and the beach areas behind. As a direct effect of the sea storms, large quantities of *C. gallina* were moved to the beach; as an indirect effect, in the following weeks natural banks of *C. gallina* were covered by debris and muddy sediments poured into the sea by the rivers, leading to a decrease in biomass ≥ 20 mm equal to 40–50 percent in the period 2016–2020.

Waters transported by the rivers into the sea affect the biogeochemistry of sediments and coastal seabed sediment characteristics. Sometimes sediments suddenly change from sandy to muddy, making them less favourable for the settlement and survival of clams. By reducing the optimal habitats for their survival, these factors reduce the area of distribution and the density of clams. It would appear, however, that the clam has a remarkable capacity for recovery following stressful conditions and its reproductive biology appears naturally predisposed to react to phenomena of sudden mass deaths with subsequent intense recruitment (Froglia, 1989b).

Other problems that hinder fishing are mainly due to the presence of urban centres, as is the case in the districts with a strong seaside tourism industry (e.g. the Rimini district), and to the various anthropogenic infrastructures existing along the coast.

Sometimes the fishing grounds are further reduced by the presence of other activities and facilities:

- In the Ravenna district a large area is allocated for military use.
- In the Pescara district the Torre del Cerrano marine protected area has recently been established.
- Along the coastline there are periodic beach replenishments and other port engineering activities (e.g. creation of underwater dams at the Lido of Venezia and Pellestrina, the Mo.S.E project etc.) that over time permanently and constantly reduce areas traditionally used as fishing grounds, or modify the sediments.
- Several mussel farming facilities (for *Mytilus galloprovincialis*) and submerged artificial reefs that overlap the fishing areas are present along the coast.
- In addition, the coastal area is a fishing ground that must be shared with small-scale fisheries (mainly fixed nets and pots), further limiting the range of activity of hydraulic dredges, especially at particular times of the year.

Moreover, Italy is the largest European producer, and the second largest in the world, of Manila clams (*Ruditapes philippinarum*): these are both cultivated in shellfish farming facilities and harvested in the northern Adriatic Sea (Turolla, 2008). This product competes on a market level with the striped venus clam, causing some Maritime Compartments to suffer.

Finally, market demand is one of the most important drivers in the venus clam fishery, driving daily or weekly quotas, sizes etc. Catches – and hence landings – vary according to market demand, and do not reflect the real biomass present in the fishing area. While the Consortia (made up of vessel owners and fishers) are responsible for the management of the fishing activities (days per week, hours per day, closed areas and periods etc.; see section 3), the Producer Organizations (PO) are responsible for the commercial management. The PO are made up of fishing companies that associate with the aim of managing commercial operations – and, for this reason, they also drive fishing activities directly or indirectly, based on market requests and prices. The product is sold mainly fresh while a small fraction is intended to be processed. Only 30 percent to 40 percent of the production is sold in Italy in the fish markets and through wholesalers, while the major market demand is led by export to foreign countries (especially Spain).

3. Management context

When taking the abovementioned factors into account, it is clear why adaptive management has been considered as a key factor for the sustainable exploitation of venus clams, embodying the EAF principles, operational objectives and measures. The hydraulic dredging fishery was the first in Italy to be controlled through a system of licences, whose number had been set at the national level to keep the fleet and the fishing effort nearly unchanged. European, national and regional management plans led to a reduction of Adriatic fishing capacity from 665 vessels in 1998 to 588 vessels in 2002 (this number has subsequently remained almost unchanged). Therefore, at a national level, the drop in annual landings from around 100 000 tonnes in the early 1980s to the present (around 19 000 tonnes), can be explained by the reduced fishing effort and the increasingly restrictive management measures implemented over the years, rather than reflecting the real status of the resource at sea (Italian National Management Plan for hydraulic dredges, 2019).

However, chronic fishing pressure over the last 30 years and other factors led to a reduction in mean clam sizes. Concurrently, in the last 10 years, a reduction of about an order of magnitude in the nutrient inputs that feed the Adriatic food chain has been recorded, making this basin a less nutrient-rich sea than in the past (Totti *et al.*, 2019; Grilli *et al.*, 2020).

3.1 Legal framework

The main current legislations which regulate clam fishing activity are:

- Regulation (EC) 1967/2006 that bans the use of hydraulic dredges within 0.3 nautical miles of the coast.
- Regulation (European Union) 2019/1241 of the European Parliament and of the Council fixed that the maximum breadth of dredges shall be 3 m (the same measure was already set by the Regulation (EC) 1967/2006).
- Regulation (EC) 1380/2013 establishes that for the species for which scientific evidence demonstrates high survival rates, which include the striped venus clam, the landing obligation is not applicable.
- The DM 27/12/2016 'National Discard Management Plan for clam stocks (*Chamelea gallina*)', which transposed the European Union Regulation 2376/2016, setting the new Minimum Conservation Reference Size (MCRS) for C. *gallina* at 22 mm by way of derogation to the previous 25 (Annex III to Regulation (EC) No 1967/2006) until 31/12/2019, and setting the new daily quota at 400 kg instead of 600 kg.
- The Commission Delegated Regulation (European Union) 2020/2237 of 13 August 2020, preceded by the Commission Delegated Regulation (European Union) 2020/3 and Regulation (EC) 2019/124, sets in Article 2 the MCRS at 22 mm (until 31/12/2022).
- DM 22/12/2000 established the following characteristics for hydraulic dredges: i) maximum cage width 3 m, ii) maximum water pressure from the nozzles 1.8 bar, and iii) maximum gear weight 600 kg. The dredge on vessels targeting clams is also subject to the following limitations: the distance between the metal rods on the lower part of the cage must not be less than 12 mm. Instead of the rods, a metal grid with square mesh not less than 17 mm/side or rectangular mesh with sides of 12 mm and 25 mm respectively are allowed, or a perforated sheet of metal with holes with a diameter of not less than 21 mm and a full/empty ratio of less than ½. Once hauled, the contents of the cage are turned out into the collection box then separated with sieves that have grids with the same characteristics as the cage described above.
- DM 22/12/2000 established two months of fishing closures between April and October.

3.2 Fisheries management and measures

Over a period of about 50 years, the management of *C. gallin*a fisheries has undergone several evolutionary phases and only recently moved towards an EAF-like system, following the example of the most responsive fishery management systems internationally. During the first 20 years the management was a top-down system, where the authority (the Ministry) was the only agent designated in decision-making processes.

The management measures were based only on fishing effort control and a few and weak technical restrictions: a high daily quota and sporadic fishing closures, with no limit on the number of fishing licences. None of the measures undertaken at that time were based on scientific studies or biological and economic analysis, but only on commercial and traditional rules. Despite an initial rapid increase in fleet size and economic revenues, this centralized system of lax management measures led in a few years to a socio-economic decline in the clam fishery sector, as well as a sharp decline in the stock.

These conditions were the backdrop for the transition from a micro-management to a co-management system represented by three independent agents, in line with modern international results-based management systems (RBMS): (i) an 'authority' defining specific, measurable and achievable objectives (outcome targets, OTs) for the utilization of fisheries resources, (ii) an 'operator' taking responsibility for achieving these OTs and providing documentation that allows (iii) independent auditors (scientific support) to evaluate the achievement of the OTs (Nolde Nielsen *et al.*, 2015; Santiago *et al.*, 2015). In light of this, in 1996 the Italian government (the 'authority' of the management system) launched a first clam management programme, introducing a series of measures to contain fishing effort by delegating management responsibility directly to industries and fishers (the 'operator'). Bivalves fishing management was, therefore, entrusted to the Bivalve Molluscs Management Consortia, established pursuant to Ministerial Decree (M.D.) 44/1995 and 515/1998 and recognized by the Ministry of Agriculture and Forestry. The operational procedures and the prerogatives of the Consortia were defined by the M.D. of 22 December 2000 that amended the M.D. of 21 July 1998.

The framework and the general rules are decided at the central level by the Directorate General for Fisheries and Aquaculture, while the Consortia can regulate activities within the waters of jurisdiction adopting more restrictive measures within the boundaries set by national and European Union legislation. In this way, bivalve mollusc management is actually based on territorial fishing rights, similar to those that exist in other Member States (TURF, territorial use rights for fishing). Territorial fishing rights, which provide for the full transfer of responsibility to the holders of these rights, is an appropriate and more easily applicable management system in cases where a few species with sedentary habits are targeted (in this case *C. gallina* is the only species with commercial interest). Each fishing district operates and has fishing rights exclusively in its own territory (maritime district). Therefore, there is no competition between the parties who hold territorial rights and those who practise fishing outside the borders.

The principle that inspired this management system, introduced in the 1990s by national policies similarly to the EAF principles, was to ensure a balance between the fishing effort exerted in relation to the exploitable areas and the size of the stock. This management system, which is based on measures taken directly by the Consortia, was also adopted to increase the added value of the fished product (only what is required by the market is caught) without overexploiting the resource.

The different Consortia, in relation with local specificities, have adopted different management measures to safeguard resources and maintain good social and economic conditions. The Consortia have the power to suggest alternative technical measures to the authority, taking as a reference the limits imposed by the general rules. Current fisheries management has therefore turned into a bottom-up approach, or rather one of co-management. Moreover, the Consortia are responsible for the checks on the conformity of the gear used by affiliated boats (dimension of the dredge, water pressure on the nozzles, space between the rods or diameter of holes of the vibrating sieve etc.), and they can also monitor the fishing areas exploited by the boats (through a GPS device installed in each vessel) to plan shifts in fishing areas. Finally, the Consortia can carry out operations for moving or sowing the product from more productive areas to areas that have already been exploited. At present, the most effective measures implemented are as follows:

- ***Daily quota and fishing days***

The daily quota per vessel lowered over the years from 2 500 kg in 1986, to 600 kg in 1989, to 400 kg in 2017 (M.D. 27/12/2016). Consortia respond to market demand by collecting only the quantities requested by the market, harvesting lower quantities than the maximum allowed. This means they do not saturate the market, and it keeps prices higher. The maximum number of 4 fishing days per week allowed by law can be further reduced depending on market demand and resource availability.

- ***Technical and voluntary fishing closures***

Beyond the two compulsory months of fishing closure (set by the authority) the majority of Consortia adopt additional periods of voluntary fishing closure, related to resource availability, natural fluctuations of the stock, and mass mortality events.

- ***Gear selectivity***

Some Consortia, thanks to scientific support, have studied and introduced a series of changes to the dredges to reduce their impact, by changing the position of the nozzles and increasing the flow of water inside the dredge so as to better expel the sand and juvenile specimens. Having considered that a large proportion of the clams caught are thrown back into the sea after the sieving process on board, some Consortia have introduced rubber-coated sieves, in order to reduce the damage suffered by clams from passing through the sieve. This indicates that fishers are careful about safeguarding the resource (especially the younger part), as well as the benthic habitat on which the clams live and grow.

- ***Fishing effort monitoring***

The vessels authorized to harvest clams adopted a GPS system to monitor and record vessel position at sea as well as the fishing effort.

- ***Monitoring of the resource at Consortium level***

The constant monitoring of the resource carried out autonomously by each Consortium with the support of a scientific body plays a role in assessing the spatial distribution and the abundance of both the commercial and undersized parts of the resource. This monitoring is preparatory for seeding, rotation and repopulation activities, which are the most important technical measures undertaken by most of the Consortia in relation to preserving the stock as well as fishing activities.

- ***Commercial policies***

The innovative commercial policies introduced by the Consortia are of vital importance to make the fisheries profitable, even when the resource is not abundant. The opening of new commercial outlets, new export destinations, and local product promotions through events and fairs are all strategies demonstrated by some Adriatic Consortia. In recent years, some Consortia have started to enhance product value through eco-labelling, and some are now certified by the Marine Stewardship Council (MSC).

- ***Inter-district management***

The unique inter-district management of two Consortia (Chioggia and Venice) of the Veneto region is the most interesting, forward-looking management method in the entire Italian fishing industry. All members of both Consortia share further common management measures (beyond those in the National Management Plans), which has resulted in (i) the establishment of an important PO – 'Bivalvia Veneto' – that drives the commercial management and hence also influences fishing activities, (ii) a fruitful cooperation through which companies are able to better overcome critical situations (e.g. mass mortality events, resource scarcity), and (iii) a rotation of the fishing grounds over a larger area, allowing better spatial planning and better management of the resource.

Each Consortium must rely on the technical/scientific opinion of a reference research body (the 'auditor', chosen by the Consortium itself) for the constant monitoring of the resource, and on the basis of which results it adopts *ad hoc* management measures.

A standardized survey to assess clam biomass is carried out annually at national level by all the Consortia, with the scientific support of a research institute; this survey involves samplings on equidistant transects and perpendicular to the coast, with stations at different distances from the shoreline. The results gained are crucial to evaluate the status of the clam stocks in each maritime district and to identify possible further management measures to be applied. This monitoring activity is part of the National Work Plan for Halieutics Data Collection (PNLRDA) under the European Union Data Collection Framework (DCF), Council Regulation (EC) 199/2008. By linking biological and socioeconomic aspects, the scientific bodies have defined average values for the density of bivalves, both as a threshold value below which fishing is not to be permitted (< 5 g/m^2), and an optimal value to be pursued to obtain optimal fishing revenue.

Every year each Consortium draws up a report indicating the daily, monthly and annual landings of clams, the fishing effort exerted (total monthly fishing days), the months of closure of fishing (both compulsory and optional), as well as a preventive plan that sets out in detail the actions to be taken for the following year. Every five years, based on the information gathered through i) the constant monitoring of the resource at a local level, ii) the standardized survey at a national level, and iii) the annual report drawn up by the Consortia, the scientific body evaluates the measures taken by the Consortium and expresses its favourable or unfavourable opinion on how the resource was managed over those years, sometimes suggesting additional *ad hoc* management measures to be implemented. Based on the opinion of the scientific body, the Ministry evaluates the renewal of the assignment of the management of bivalve mollusc fishing to the Consortia.

All the measures so far implemented aim to make the management system increasingly sustainable at social and ecological level: this is evidence of how things are moving towards an EAF-like system. In fact, many of the EAF principles have been satisfied – for example the maximum acceptable fishing level (i.e. daily quota), impact minimization (i.e. spatial and temporal closure of fishing grounds and rotation of the fishing areas), rebuilding of resources (i.e. seeding and repopulation activities), and decentralization and participation in decision-making process (i.e. co-management and TURFs). The main operational objectives and measures undertaken in line with EAF were improving the management system (transition from a micro- to a co-management system) and ecosystem well-being (i.e. reduction of fishing effort and daily quota), improving the decision-making framework (i.e. participatory mechanisms), maintaining the reproductive capacity of target resources (i.e. introduction of the MCRS), monitoring and indicators (i.e. creation of programmes to constantly monitor the status of the resource and reference points), improving research capacity (i.e. increasing collaboration with research bodies), management planning (two management plans are in force) and certification (i.e. MSC certification for clam management in the Veneto region).

4. ACHIEVEMENTS AND LIMITATIONS

4.1. Adoption of management plans and technical measures

The management of the clam fishery is quite complex: at the end of each year, each Consortium, with the support of a scientific body, must present a local plan which summarizes the management measures undertaken, the fishing closures implemented, the quantities caught, the vessels operating, and any other useful information. In the same document, the Consortium also reports the measures planned for the following year. In association with local management plans, national management plans are periodically produced, which give strategic guidelines and define mandatory management measures for all Consortia. Over the last 10 years, the experience gained in 20 years of clam fishery management by the Consortia, with scientific support, led to the development of three national management plans: the two Italian management plans for hydraulic dredges of 2014 and 2019, and the 2016 discard management plan for clam stocks (M.D. 27/12/2016). These management plans are ultimately evaluated by the Scientific, Technical and Economic Committee for Fisheries (STECF) of the European Commission. The management plans aimed to provide the most suitable technical measures, described above, for adoption by Consortia to guarantee the conservation of the resource and fishing activities over time, in line with an EAF-like system.

In summary, the management plans stressed the importance of some particular management measures: decreasing daily quota per vessel, abolition of tolerance limits for clams below the MCRS (from 10 percent to null), temporary (technical and voluntary) and spatial (seeding, rotation and repopulation) fishing closures, and the creation of designated areas for transferring undersized specimens collected during fishing operations (restocking areas). As a direct result, the fishing effort over time and space has decreased since the time spent fishing at sea and the areas dredged have been reduced, with the vessels reaching the daily quota more quickly. This also implies that the costs of the fishing day have been reduced as the fuel consumption is lower, increasing income.

Moreover, economic benefits have increased thanks to the existing connection between Consortia and POs which maintains high product prices and defines additional periods of fishing closure. Periods of voluntary fishing closure do not necessarily reflect the status of the resource at sea, but they are strongly influenced by market demands.

Nevertheless, the identification of restocking areas did not find the same success on a national scale. A recent study conducted in the Adriatic (Sala *et al*., 2017) on the selectivity of vibrating sieves made it possible to verify that with the legal sieves (hole diameter of the perforated sieve equal to 21 mm) the undersized proportion of clams (below 22 mm) retained on board is scarce, so that any seeding action would be uneconomical and barely useful. This explains why, so far, restocking areas have been poorly used for reallocating undersized clams – although there have been successful exceptions in some Consortia.

An important technical innovation introduced by the national discard plan is focused on fishing effort control through the implementation of a system to monitor and record vessel position at sea (GPS). The systems adopted have some common basic characteristics, including that of operating independently from the fishers to ensure that they are always active during fishing operations (activation occurs when the vessel's engines are switched on), transmitting data (vessel number/ European Union number/ other identification code, date, time and GPS position in geographical coordinates) to the receiving station every 60 to 120 seconds; the system also records any entrance into a prohibited area at a speed compatible with fishing activities, keeping track of it in the database. The system also allows constant monitoring of the fishing effort applied in the areas of reference, and the planning of harvesting activities through a fishing-grounds rotation.

The process that led to the development of the management measures, both at regional and national level, involved a strong collaboration between Consortia and the scientific bodies of reference. The production of the scientific documentation and the fishing data has been useful in preparing Consortia for participation in technical, scientific and decision-making process panels, at both national and international level – for example in the case of the waiver of 22 mm for the MCRS.

OP Bivalvia Veneto and Co.Ge.Vo. of Chioggia and Venice have become the first Italian fishery – and the first in the Mediterranean basin – to achieve MSC certification. The fishery has been certified as sustainable and well managed following an assessment by independent certifier DNV-GL (Det Norske Veritas group, Norway). This certification is in line with many of the EAF principles, and guarantees a higher economic value for the product, preferential market channels (e.g. Swiss Big Organised Distribution), and the possibility of selling the product frozen.

4.2. Fisheries statistics

There has been a reduction in landings from more than 35 000 tonnes in the early 2000s to the present 18–20 000 tonnes, while the number of vessels has remained almost unchanged in the same period (Figure 2). Indeed, this is the only Italian fishing sector in which the number of active boats has not decreased in the last 20 years.

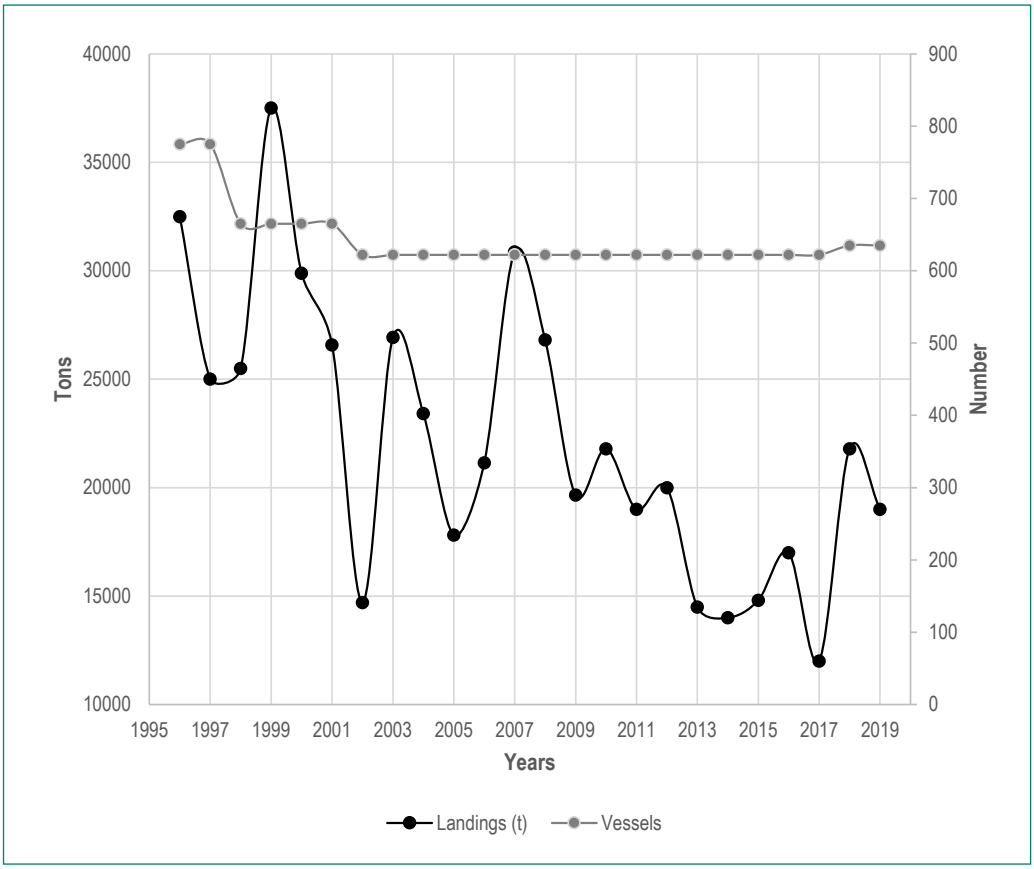

Figure 2. Total landings (tonnes) and number of vessels targeting venus clams over the period 1996–2019.

However, as already explained, the data on commercial landings is not indicative of the state of the resource, since the quantities landed are established periodically based on market requests. The entry into force of Regulation EC 1967/2006 and the more restrictive measures set in the recent national management plans have undoubtedly directed the clam fishery towards a more sustainable management approach which also considers the effects on the ecosystem (the area within 0.3 miles from the coast is forbidden for hydraulic dredges). The socioeconomic indicators reveal an increase of nearly 100 employees in the sector (from 1 430 to 1 520) in the last two decades, while the revenues have decreased from a mean annual value of EUR 69.9 million to EUR 48.6 million. Looking in more detail, a clear collapse took place with the entry into force of the Regulation EC 1967/2006, which effectively halved the potentially exploitable areas. Moreover, competition on the market from other species of clams, such as the cultivated Manila clam (*Ruditapes philippinarum*), meant that the quantity of product landed has been progressively reduced, because the market for clams was already saturated.

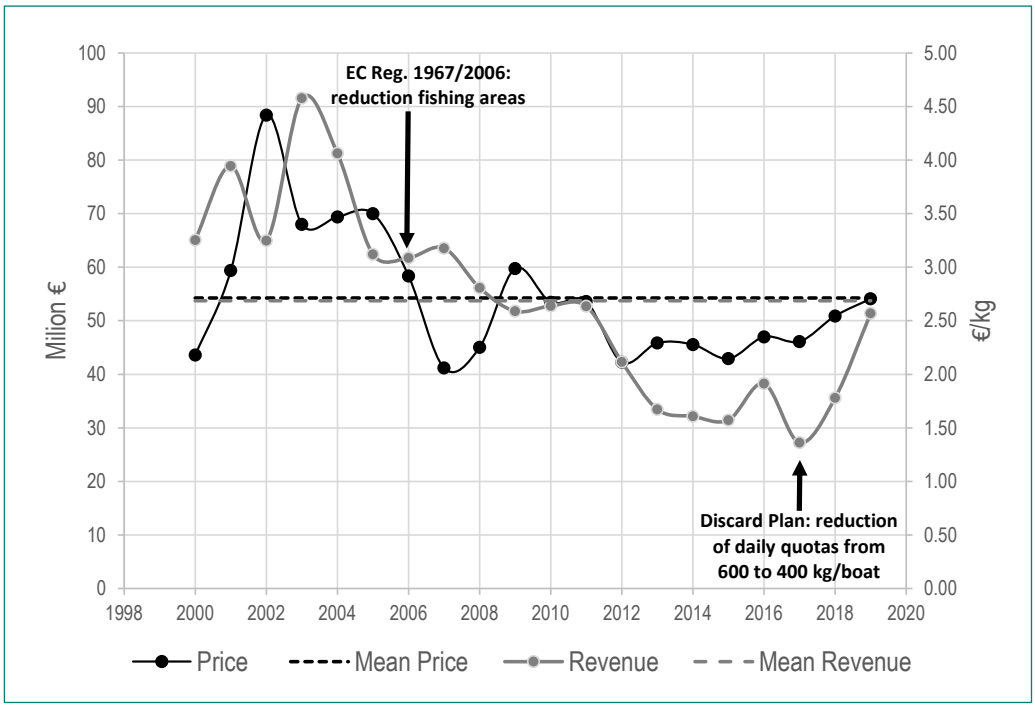

Figure 3. Trends of revenues (expressed in ten millions of euros) of the clam hydraulic dredge sector and price (expressed in euros per kg) of the venus clam in the period 2000–2019.

In the last 10 years, the improved fishery and commercial management has stabilized the situation; a decrease of revenues was observed in 2017, mainly due to reduction of the fishing quantities from 600 kg to 400 kg established by the national discard plan in 2016 (Ministerial Decree 27/12/2016). However, in general the hydraulic dredge fishing sector has over a few years been able to adapt to the situation created with the entry into force of new rules. The sector reacted without reducing the number of boats and increasing, albeit with small variations, the price per kilo of the clam (from EUR 2.11/kg in 2012 to EUR 2.71 in 2019; Figure 3), thanks to the measures taken by the POs and Consortia. The main socio-economic indicators therefore show that the hydraulic dredge fishing sector has found a new balance in 5-6 years, despite the multiple restrictions adopted for a more sustainable and responsive fishery, in line with the EAF-principles.

4.3. Exploitation rate of the resource

The constant monitoring of the resource (both at national and local level) allowed the Consortia to apply different management measures based on the results gained. Current reference points, established in the Italian national management plans for hydraulic dredges of 2014, have been used as a precautionary approach; therefore 5 g/m^2 has been used as the limit reference point (LRP) and 10 g/m^2 as the target reference point (TRP). When clam density falls below 10 g/m^2, management Consortia activate measures aimed at reducing fishing in areas identified as experiencing problems. Having reached these limits, the Consortia react by closing fishing activities until clam density rises above these reference points. While those areas are kept closed, others where the values exceed the TRP can be opened for fishing. In this way, the rotation of the fishing grounds (together with seeding activities) is one of the most powerful tools adopted to safeguard the abundance of the resource without reaching critical levels.

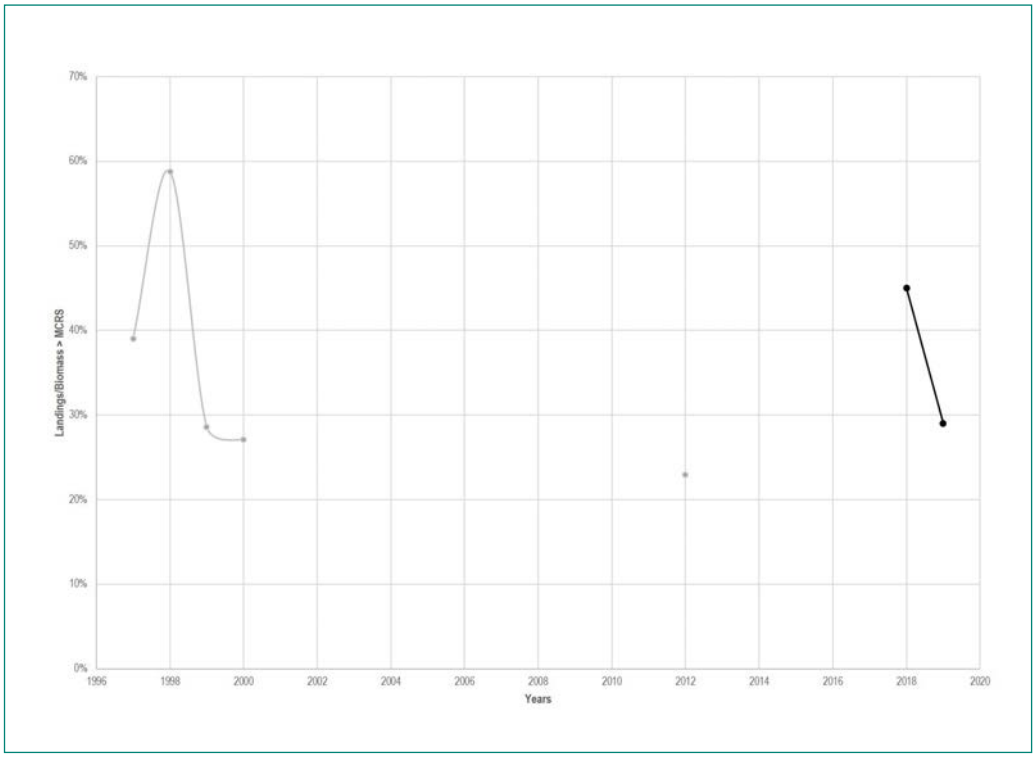

Figure 4. Exploitation rate expressed in landing/biomass (obtained from surveys) harvested by hydraulic dredges targeting venus clams in three different periods (1997–2000, 2012 and 2018–2019) in the Marche Region. Unfortunately, the lack of surveys between 2001 and 2011 and between 2012 and 2017, as well as reliable landing values before 2005, make it difficult to ascertain clear trends between densities observed during the surveys and the landings produced over the years. Grey line represents MCRS set at 25 mm and black line MCRS set at 22 mm: for the years 2018–2019 the two lines completely overlap.

Considering the biomass of clams estimated from the available surveys (some of them were carried out back in 1990) and the monthly landings, it was possible to produce an exploitation graph (Marche Region case study; Figure 4), where the ratio between clams removed by fishing activity (landings) and the total fraction of commercial clams present at sea (estimated by survey) is shown. Considering the MRCS of 25 mm (revised to 22 mm in 2017), it is possible to estimate that the rate of exploitation in 2012 was quite similar to that observed at the end of the 1990s. However, in 2018 the exploitation rate was high due to the crisis faced by the sector in 2017 and 2018 caused by the natural fluctuations of the population at sea, whereas in 2019 it dropped steeply due to the recovery of the resource assessed in the survey in that year.

When the MRCS of 22 mm is considered, the exploitation rate overlaps with the one calculated for the ex-MCRS of 25 mm. Independently from the MCRS considered, the exploitation rate shows fluctuations strictly related to the biomass present at sea. Nevertheless, the density data (± SE; g/m^2 ≥ 25 mm), always higher than the TRP in the last three years (22.9±2.8 g/m^2, 2017; 20.8±1.3 g/m^2, 2018; 63.9±2.6 g/m^2, 2019) (CAMEL Project, 2018–2020) and similar to that observed at the end of the 1990s, suggests that the population is in an overall good status. This is in contrast to what was observed in 2012, where half of the Marche Region area presented lower density values between 4–7 g/m^2 (Prioli *et al.*, 2012).

Recently, further scientific studies promoted by Consortia and the Italian Ministry have been conducted on the selectivity of the dredge and the vibrating sieve and the survival of clams returned to the sea, to improve knowledge of the gear and its efficiency. CNR-IRBIM (Italy) recently carried out a study to assess the selectivity of the dredge during fishing. The results show a 50 percent retention length (L50) of around 19 mm. About 60 percent of the clams caught were below the previous MCRS of 25 mm. The study explains that to land only the legal sizes of clams, an additional size selection process carried out on board the fishing vessels by the sorting sieves is therefore necessary. Indeed, Sala *et al*. 2017 demonstrate that the selectivity of the vibrating sieves has the result that the undersized fraction of clams retained on board is not relevant. In parallel, a new study on the survival of clams monitored post fishing operations reveals that *C. gallina* specimens returned to the sea (after vibrating sieve selection) have a very high survival rate (>90 percent both in laboratory and natural conditions) and can contribute to restocking natural populations.

4.4. Benthic impact

The venus clam fisheries management was not directly built following the EAF principles, but the management framework and the strategies adopted to achieve sustainable development in fisheries properly meet the EAF criteria. Similarly, the management measures have been set mainly to sustainably exploit the target species (*C. gallina*), but the reduction of fishing effort also contributes to the maintenance of environmental conditions and to the preservation of the benthic communities living associated with *C. gallina*.

In the last 20 years, several research projects were undertaken to study the chemical-physical impact on the bottom due to hydraulic dredge activities. Sidescan sonar records (Lucchetti and Sala, 2012) showed evidence of considerable physical disturbance in the surveyed area, with numerous tracks crisscrossing the area, which remained traceable for 2 to 3 months. Furrows had an average height of 10 cm and a width of 3 m, equivalent to the dredge width.

From an EAF perspective, it is in the producers' interest to maintain the ecological integrity and functioning of the ecosystems where the clams live. The ecological situation of the environment is the basic condition for maintaining and increasing the production of the species. This is why scientists started to focus their attention on reducing the impact on benthic communities, since operating on the seabed inevitably causes a physical disturbance to the bottom, destabilizing and modifying the conditions of the sediment and resulting in a decrease in habitat complexity, with consequences for benthic communities. However, the biological communities present in the fishing areas are the typical ones that live in low-depth and high-energy environments. Vatova (1949) found similar communities in the studied area at that time. These communities are already naturally subject to constant environmental stress due to exceptional phenomena (in particular, significant wave movements and strong currents), and for this reason they demonstrate a rapid recovery (resilience). But the areas of the shoreline affected by clam fishing activities are not chronically disturbed as management planning differentiates harvesting activities by area, closing areas in rotation or reducing fishing effort. The rotations of fishing areas (typical of clam management) enable long rest periods that allow the macrobenthic community to recover for periods of 2 to 6 months up to a maximum of 8 to 9 months. These resting periods for the production areas allow the macrobenthonic community to recover over a 3 to 6-month period, as indicated by Pranovi and Giovanardi (1994) and Vasapollo *et al*., (2020), or over about 2 months for areas with predominantly

sandy characteristics used for commercial fishing (Pranovi *et al*.,1998). The ecological effects and the recovery of the benthic community after the action of hydraulic dredge gear can therefore be equated to the recovery that takes place following natural disturbances. No species are caught that present problems related to conservation or which are protected.

A biological indicator of impact exerted by hydraulic dredges fishing for the venus clam on benthic communities was identified in the bivalve mollusc Abra alba (Morello *et al*., 2005), whose abundance was negatively correlated with fishing intensity. Moreover, an increased scavenger abundance in fished areas as a result of increased food availability has been also reported. Nevertheless, there are no recent available data for which comparisons between exploited habitats before and after the implementation of EAF-like management measures can be made. Therefore, a future challenge to be achieved is to assess if and how indicators have changed in response to the adopted measures. A study performed along the Veneto coast in 2019 highlights no relevant disturbance due to fishing activities on benthic communities and assemblages, with only 5 percent of other species by-caught (bivalves, gastropods, crustaceans, Ophiuridea), present in the same way (in weight and in number) both in exploited grounds and in non-fished areas. The presence of the marine polychaete worm *Owenia fusiformis* in fishing grounds does confirm (as seen in other sites) that some ecological change exists, but more investigation is needed.

4.5. External stressors and limitations

In general, no factors or internal dynamics influence the management of the Consortia as almost all the fishing boats are registered with the Consortia, and thus respect the same measures. Despite all the management measures foreseen by the management plan being aimed – ideally – to guarantee a good conservation status for the resource and for the fishing activities, other external factors and variables (as described above) create a varied national panorama. In fact, the different percentage of areas suitable for fishing the striped venus clam, as well as the different numbers of vessels enrolled in each Consortium and the different environmental conditions, contribute to a diversified productivity at local scale.

Unpredictable external stressors such as the natural fluctuations of the stock or mass mortality events have sometimes caused a significant reduction of the available resource, leading to an interruption of the fishing activity for several consecutive months until the resource has recovered. Moreover, the water quality can change due to intense rainfall, river runoff, discharges at sea and pollution. The quality of the waters (chemical and biological parameters) is constantly monitored through a monthly monitoring programme conducted by the local health authority, which, in the event of contamination, bans fishing activity to guarantee the health of consumers. These conditions of inactivity have been a major threat to Consortia subsistence, as they are often forced to stop fishing.

Attempts to overcome these issues are reflected in examples of good cooperation between Consortia themselves, beyond the compartmental level. This is the case for some northern Consortia, which adopted supra-compartmental cooperation to overcome management difficulties of neighbouring Consortia. For example, in Monfalcone district, where clam productivity is very low, seeding activities to repopulate the local stocks have been performed by the neighbouring Consortia of Chioggia and Venezia. Another example is connected with the smooth clam (*Callista chione*) fishery operated in Friuli and Veneto, where the shifting of activity between smooth and venus clam of all three Consortia is managed according to the availability of the two resources.

Some difficulties in management with other fishing sectors (mainly mussel farms and small-scale fisheries) have always occurred. Mussel longlines have their own exclusive maritime state property, which is set beyond 1.5 nm, where dredges generally do not operate. There are some conflicts with set nets and pots fishermen, since cooperation and collaboration are scarce, but the planned rotation of fishing areas operated by clam dredgers overcomes this difficulty, at least on a seasonal scale.

5. CONCLUSION

The successful management of the clam sector is based on the progressive decentralization of decision-making, ending up with a co-management regime where 'territorial use rights,' or TURF, has been introduced. A number of interesting observations can be made of this experience. They can be summarized as follows:

- The sedentary character of the target resource, which is distributed in specific areas easily identified in each maritime district, facilitates the management of the resource through TURF.
- The territorial exclusive rights make it easier to control the fishing effort and the areas exploited by the vessels registered in each Consortium.
- A winning key element of the co-management approach has been to delegate the management responsibility directly to industries and fishers (within the general boundaries set by the authority, i.e. the Ministry). A command-and-control approach would never have been appropriate. Becoming active parts of the managing system, industries and fishers gained awareness of the necessity of developing a management plan which takes into consideration more than just the economic and productive aspects.
- The participatory approach also makes compliance with the rules more effective, because these are established in agreement with the operators in the sector.
- Homogeneity of the fishery segment is another important point, because it allows the implementation of the rules on a large scale and not only on compartmental level.
- The development of the technical measures and their improvement after a long period of application are vital for the sustainable exploitation of the resource and for all the socioeconomic aspects of the fishing sector.
- The connection between Consortia and Producers' Organizations, which allows a rational collection of the clams to assure product quality while maintaining a high market price (without exceeding demand), is a key element that has increased the employment and income of workers involved in the industry.
- A fishing activity increasingly managed and coordinated through scientific support is also a crucial pillar.

The positive attitude of the Consortia has been another key aspect for the implementation of the management measures developed over the years. So far, different Consortia have adopted management measures to safeguard resources and maintain good ecological, social and economic sustainability, certifying a transition strategy comparable to EAF. There is evidence that the results of the studies and monitoring performed in cooperation with research bodies have increased interest and provided a positive stimulus in the fishing sector, as is proven by the participation of Consortia in research projects for personnel training, improvement of product quality and environmental protection.

Clam fishery management experience highlights that where fishing activities are carried out in close cooperation with a scientific institute, the state of the resource is improved, and hence so are fishing activities. Obviously, the positive results play a key role in facilitating the acceptance of increasingly restrictive management measures by the Consortia. Twenty years of experience with co-management led to an eco-sustainable and responsive fishery based on an adaptive management system, also to be promoted for the coming years.

In conclusion, the management of venus clam mainly aims to guarantee human as well as ecological well-being; this management has improved slowly in the last 20 to 30 years (management plans, co-management, adaptive management, considering socio-economic and environmental factors, restocking areas), approaching step by step the same principles on which the EAF is based.

At present, the striped venus clam fisheries management along the Italian coasts, which is entrusted to Consortia, represents a successful example of managing sedentary target species such as bivalve molluscs.

Future challenges, in view of an EAF, need to improve two critical aspects: statistics and indicators. As regards the first, there is a necessity i) to collect accurate fishery data, and ii) to carry out a constant scientific monitoring programme (at least on an annual scale) for each compartment. Accurate fishery statistics are not easily available, and show some heterogeneities at compartmental level. Scientific surveys had long interruptions in the past, due to the lack of funding. These two kinds of data are of extreme importance to assess the trend of the exploitation rate of the resource on temporal and spatial scales. Furthermore, studies on physical, biological and ecological impacts are constantly in progress for the definition of benthic impact indicators, but more investigations are needed.

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Chapter 4: Is the ecosystem approach to fisheries management an effective tool for small-scale fisheries? The case of the purse seine fisheries in Lebanon

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1. INTRODUCTION

The Food and Agriculture Organization of the United Nations (FAO) launched the 'Scientific and Institutional Cooperation to Support Responsible Fisheries in the Eastern Mediterranean' (EastMed) project in 2009 to support regional cooperation and to further develop the multidisciplinary expertise necessary to formulate appropriate management measures. One of the goals pursued by the project has been to mainstream the ecosystem approach to fisheries (EAF) in the participating countries to ensure rational, responsible and participative fisheries management (Nader *et al.*, 2020; www.faoeastmed.org).

In this context, and on the request of the Directorate of Fisheries and Wildlife (DFW) of the Ministry of Agriculture (MoA), the FAO-EastMed project supported a pilot case study in 2016 on the implementation of the EAF in the purse seine fishery in Lebanon. The pilot study was carried out with the support of the DFW-MoA and was executed in collaboration with the Marine and Coastal Resources Programme of the Institute of Environment, University of Balamand (MCR-IoE-UoB). The aim of the pilot study was to guide the DFW-MoA in the development of coordinated and participative fisheries management plans following the EAF principles and tools (FAO, 2012).

This paper describes the process of development of the management plan for small-scale purse seine fisheries, and discusses the main lessons learned from the implementation of the EAF in Lebanon.

1.1 Fisheries in Lebanon

Lebanese fisheries are artisanal or small-scale in nature, with the majority of boats motorized and below 12 m in length (Sacchi and Dimech, 2011; Pinello and Majdalani, 2018). It is a family-based activity where the owners of the vessels are directly involved in fishing operations. Fishing occurs at an average depth of 50 m, and does not usually take place further than 3 nautical miles from the coastline (Figure 1): this exerts pressure on the marine resources in shallow areas of Lebanese waters (Majdalani, 2004; Nader *et al.*, 2014).

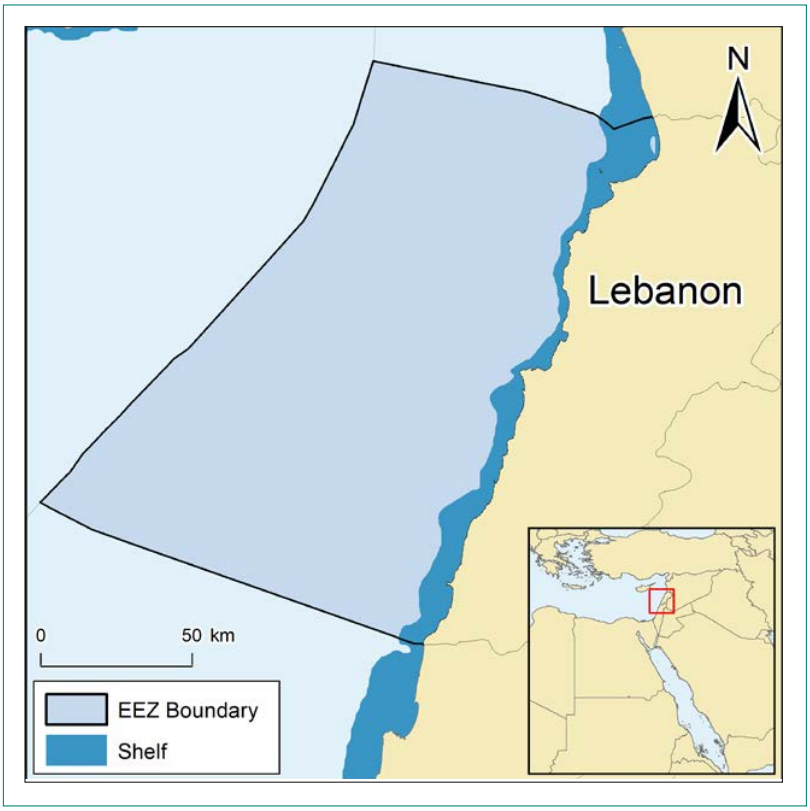

Figure 1. The Exclusive Economic Zone (EEZ) and continental shelf of Lebanon.
Source: Nader *et al.*, 2014.

According to the DFW-MoA, the number of licensed fishing vessels in 2020 was 1 544 (Table 1), operating from 44 fishing harbours and landing sites. Most of the fleet has very simple safety gear (mainly oars), and vessels are rarely fitted with Global Positioning Systems (GPS) or life vests. Furthermore, few vessels are equipped with echo sounders to detect fish. The most common gears used are fixed nets, longlines, purse seines and lampara nets (Pinello and Majdalani, 2018). The estimated total landings in 2020 were 2 877 tonnes (DFW-MoA; personal communication).

Table 1. Total catch and total PSF catch from 2014–2020.
Source: DFW-MoA, 2021.

Year	Total licensed fleet	Total licensed purse seiners	Total catch (tonnes)	Total purse seine catch (tonnes)	Total sardine and anchovy catch (tonnes)	percent purse seine catch of total catch	percent sardine and anchovy of total catch
2014	-	-	2 936	-	-	-	-
2015	2 005	65	3 653	896.5	621.65	25 percent	17 percent
2016	1 962	61	4 275.5	1 791.5	1 630.55	42 percent	38 percent
2017	2 193	87	3 535.8	1 543.5	1 345.8	44 percent	38 percent
2018	2 143	100	3 100	893	852.8	29 percent	28 percent
2019	2 084	91	3 185	1 196	990.4	38 percent	31 percent
2020	1 544	51	2 877	916	708	32 percent	25 percent

1.2 Purse seine fisheries in Lebanon

The purse seine fishery in Lebanon (PSF) is managed according to the 2010 Ministerial Decision No. 346/1 (Table 2; Nader *et al*., 2020), which sets the annual fishing season from 16 April until 31 December (Nader *et al*., 2020). Purse seiners use floating lamps to attract target species, and avoid fishing during the full moon phase when the light of the moon lessens the efficiency of the artificial lights. Purse seiners tend to have the largest horsepower and longest average boat length in the Lebanese fishing fleet, and they are typically the newest vessels in terms of age (Pinello and Dimech, 2013). The catch is usually sold fresh on local markets, especially through auctions, without any post-harvesting operations (packaging, processing etc.). The main auctions are located in the largest cities like Tripoli-North, Dora-Mount Lebanon, Karantina-Beirut, Saida and Sarafand-South (Nader *et al*., 2020).

Table 2. Management measures for the purse seine fishery in Lebanon.
Source: Nader *et al*., 2020.

Management measures	Description	Effectiveness
Required documents	• Boat registration deed • Navigation licence • Fishing licence • Fishers' ID	The major fishing ports are under the control of the Lebanese Army where fixed points are positioned
Spatial restrictions (e.g. closed areas, MPAs, etc.)	• Forbidden in depths of more than 25 fathoms (45.7 m)* • Fishing activities are allowed beyond 500 m from coastline*	Fishing is allowed beyond 500 m from shoreline. Deep water is a major challenge as continental shelf is narrow
Temporal restrictions (e.g. closed seasons)	• Closed season: from 1 January to 15 April* • Forbidden to fish during the day*	Fishers requested a reconsideration of the closed season
Gear restrictions (e.g. forbidden gears, limits to mesh size etc.)	• Net cannot be higher than 25 fathoms (45.7 m)* • Mesh: >20 mm for non-migratory species. No minimum limit for migratory species, including sardines, according to Law 2775 of 1929. Sardine nets' minimum mesh size of 6 mm is specified in Decision No. 43/1 of 1999. • A maximum of four light holders can be used (500 W each)* • Forbidden to use generators*	Large mesh purse seines do not catch targeted species
Minimum fish size	• 15 cm (Decision No. 15/1 of 2004)	Sardines in Lebanon are commercialized and appreciated when they are small. Large sardines are not attractive to consumers
Participatory restrictions (e.g. licensing, TURFs etc.)	• No limits for numbers of fishing licences	
Limits to fishing capacity (e.g. maximum number of vessels, fleet reduction etc.)	• No limits for boat size and engine power	
Others	• Potential capture of protected and vulnerable species (whales, dolphins, marine turtles, sharks and rays, monk seals)	Accidental bycatch

*According to the 2010 Ministerial Decision No. 346/1.

According to the Mediterranean (GFCM) Data Collection Reference Framework (DCRF), the length class of purse seine vessels is predominantly (68 percent) S-02 (6–12 m), with the rest falling under S-03 (12–24 m). The purse seine and the lampara fishing gears are classified under 'Surrounding Nets' with the codes PS and LA respectively (GFCM, 2014). For the purpose of this manuscript, both gears are considered part of the PSF. This fishery is operated from several harbours along the coast (Figure 2), with the main catch composed of sardines and anchovies (Table 2; DFW-MoA, personal communication).

Figure 2. Main fishing harbours with purse seine fisheries in Lebanon.
Source: MCR-IoE-UoB, 2021.

Bariche *et al.* (2006) and Bariche *et al.* (2007) studied the diversity of fish species caught by purse seiners, and concluded that this fishery mainly targets juveniles. More specifically, Bariche *et al.* (2006) reported that at least 32 species were identified, with 11 making up most of the catch (primarily *Engraulis encrasicolus*, *Sardina pilchardus*, *Sardinella aurita* and *Scomber japonicus*). As for Bariche *et al.* (2007), it was concluded that the families most represented in terms of abundance were the Clupeidae (49.28 percent), the Engraulidae (41.69 percent) and the Scombridae (7.01 percent). Regarding biomass, these families represented 56.76, 22.04 and 9.72 percent respectively.

The socioeconomic aspects of the PSF were mainly reported in Pinello and Dimech (2013) and Pinello *et al.* (2020). Pinello and Dimech (2013) showed that the purse seine fishery employed 403 fishers and landed an estimated 2 112 tonnes for a total revenue of USD 2.9 million with a relatively high catch per unit effort (CPUE) (206.6 kg/day). On average, the vessels generated an overall turnover of USD 49 000 per vessel, while the average salary per fisher was USD 2 210. Furthermore, Pinello *et al.* (2020) revealed that the PSF employed 369 fishers in 2016 and landed an estimated 2 458 tonnes for a value of USD 3.287 million with a relatively high landing per unit effort (LPUE) (Boat segment 6–12m = 168 kg/day; Boat segment 6–24m = 305 kg/day). On average, the vessels generated an overall turnover of USD 54 900 per vessel, while the average salary per fisher was USD 3 946 (Pinello *et al.*, 2020). The difference in the total reported purse seine catches between the DFW-MoA (Table 1) and Pinnello *et al.* (2020) for the year 2016 is mainly due to the fact that the latter was based on a multivariate sampling survey specifically targeting the purse seine segment, while the DFW-MoA values were obtained from the catch/effort monitoring system (FLOUCA Web utility) of the whole fleet (DFW-MoA, personal communication).

Studies targeting small pelagics on regional and national scales are of great importance as their stocks might be shared and exploited by several countries (EastMed, 2019; El Khoury *et al.*, 2020). Within this context, several biological studies and stock assessments of commercial fish species were conducted over the past few years, including small pelagics in Lebanese waters. In order to fill data gaps and better manage the sector, the DFW-MoA, in collaboration with the FAO-EastMed project, is supporting the National Centre for Marine Sciences-National Council for Scientific Reasearch (NCMS-NCSR) in assessing the stocks of four commercial species, *Sardinella aurita, Pagellus erythrinus, Lithognathus mormyrus* and *Pagellus acarne*. Two stock assessments for *Sardinella aurita* using landing data from Tyre (Sour), Saida, Beirut, Tripoli and Aabdeh fishing harbours (Figure 2) were carried out by the NCMS-NCSR and validated by the GFCM for Lebanon for the years 2016 and 2017. Results, although preliminary, indicate high levels of exploitation of the species in Lebanese waters. At present the stock of *Sardinella aurita* is undergoing a benchmark assessment under the GFCM that will take into account the available data from Eastern Mediterranean countries and new information coming from stock boundary studies to assess the status of the species in the different fishing grounds, including in Lebanon. New values are expected to be published in the near future (EastMed 2019; Lteif *et al.*, 2020; www.fao.org/gfcm/data/safs).

Investigations of sardine and anchovy off the Lebanese coast have revealed specificities and differences when compared to their counterparts in other parts of the Mediterranean basin. It is believed that these differences might be related to topography and oceanographic barriers, or to the existence of sub-stocks (Jemaa *et al.*, 2015a, 2015b). Such hypotheses are currently being tested through a multi-disciplinary research programme coordinated by the EastMed project and jointly carried out by research institutes from Lebanon, Egypt, Palestine, Turkey, Cyprus and Italy (EastMed, 2019).

2. MANAGEMENT CONTEXT

2.1 Fisheries management framework

Within the MoA, the DFW is responsible for the management of fisheries at national level. The first fisheries law No. 1104, entitled 'The determination of the coastal zone scope and penalties related to the infringement of fishing rules' was promulgated on 14/11/1921 during the French mandate over Lebanon, followed by Law No. 2775 ('Monitoring of coastal marine fishing') that was passed in 1929. Since then, several laws, decrees and decisions related directly to fisheries have been issued to address shortcomings in the legal framework governing the national fisheries sector. In the absence of integrating plans and laws related to several sectors exploiting resources in the Lebanese coastal zone, overlapping mandates and conflicting uses are negatively affecting the management of marine ecosystems, including marine biological resources. With the support of the FAO and GFCM, the MoA formulated a new draft fisheries and aquaculture law to replace Law No. 2775 of 1929. This draft law takes into consideration the new challenges as well as the new scientific references and benchmarks for the sustainable management of marine resources and the wellbeing of fisher communities. It is a framework law aiming to cover most developments in the fisheries and aquaculture sectors, and it is in line with current international legal instruments (Lelli, 2017). The draft law is presently being reviewed by the appropriate authorities for subsequent adoption (MoE/UNEP/GEF, 2016 a; Nader *et al.*, 2020). Outdated legislation, inefficient policy management, scarce financial resources and chronic neglect of the sector by central government have resulted in weak fishery and aquaculture sectors and a decline in the wellbeing of fisher communities (Lelli, 2017). To improve the situation, several initiatives and valuation studies were launched during the past decade related to catch and effort, stock assessments, and the socioeconomic status of target groups.

Previously, Lebanon lacked the national data series for fisheries that are crucial for any management initiative and decision-making. Until 2014, fishery data were reported sporadically, as no monitoring system was in place and catch-reporting from fishers – when it even occurred – tended to be underestimated (Lelli, 2017; Nader *et al.*, 2014). However, efforts at many levels over the past two decades have resulted in the FAO-EastMed project and the MoA launching the national catch/effort monitoring system using the Fish Landings Operational Utility for Catch/Effort Assessment (FLOUCA) Web utility in 2014. FLOUCA Web reported that the purse seine fishery represented more than 20 percent of the total national catch in 2014 and 2015 (Nader *et al.*, 2020). FLOUCA Web data for commercial fish species has proven to be an important basis for the implementation of management initiatives such as the EAF.

The catch/effort monitoring system is constantly being updated by the DFW-MoA with the support of the FAO to accommodate new techniques and perspectives in the fisheries sector (DFW-MoA, personal communication). The FAO-EastMed project is also collaborating with the NCMS-NCSR and DFW-MoA to monitor different parameters (morphometry, otolith shape analysis, genetic markers, environmental information and fisheries data) of some flagship species including *Sardinella aurita*, in line with the DCRF issued by the GFCM (Lelli, 2017; EastMed, 2019). This will provide a clearer analysis of the status of targeted species in the Eastern Mediterranean, as well as the scientific basis for the sustainable management of fisheries resources (NCMS-NCSR, personal communication).

Given the difficulties experienced in Lebanon and at global level in sustainably managing fisheries, the EAF approach that addresses both ecological and socioeconomic challenges is considered as one of the best paths to provide solutions to all concerned. The concept takes a holistic approach to the management of fisheries and marine resources from an ecosystem perspective (FAO, 2012). Its overall purpose is to plan, develop and manage fisheries to meet the multiple needs of society without jeopardizing the chance for future generations to benefit from the full range of goods and services (including non-fisheries benefits) provided by marine ecosystems (FAO, 2003). Accordingly, the FAO suggested to the MoA the idea of implementing the EAF approach to develop a management plan for the small pelagic fishery in Lebanon through a bottom-up process.

2.2 Triggering factors leading to changes in the management system

In addition to the legal constraints governing the fisheries sector (section 2.1), Lebanese marine resources are under severe anthropogenic pressures that are negatively affecting harvestable marine resources and the wellbeing/livelihoods of fisher communities. These may be summarized as follows:

- ***Pollution and degradation of habitats:*** The Lebanese coastline hosts more than 70 percent of the country's human population, with the highest concentration in cities like Beirut and the surrounding Mount Lebanon region (MoE/UNEP/GEF, 2016a). Such high population density is leading to extreme artificialization and privatization on the coast. In addition, the coastal population increases significantly during the summer tourist season (MoE/UNEP/UNDP, 2013; Kanbar, 2015). Moreover, the main economic sectors are also located on this thin strip, resulting in large land-based sources of pollution (municipal effluents and solid waste, industrial effluents, agricultural runoff, oil pollution, noise and visual pollution etc.) (MoE/UNEP/GEF, 2016b). There is a near-total absence of solid and wastewater management in the country: wastewater is released untreated into rivers, valleys and coastal waters while solid waste is disposed of mostly in unsanitary coastal landfills and valleys. In addition, high rates of coastal artificialization have resulted in the destruction of productive shallow-water habitats including spawning and nursery grounds. All these factors contribute to habitat degradation and exert remarkable pressure on marine resources and ecosystems (Kanbar, 2015; MoE/UNEP/GEF, 2019). This is exacerbated by insufficient information and documentation on the status of resources that are essential for proper management (Nader *et al.*, 2020).

- ***Fishing practices and status of the stocks:*** High fishing pressure may lead to low stock levels and contribute to impaired recruitment, therefore severely influencing the livelihood of the dependent communities (FAO, 2018a). Stock assessments for round sardinella (*Sardinella aurita*) in Lebanese waters revealed that the stock status is still uncertain and requires further investigation (FAO, 2018a). Meanwhile Sacchi and Dimech (2011) in their assessment of the fishing gears in Lebanon stated that there is neither a limitation on mesh size nor a maximum length authorized for the PSF. Nets with small meshes result in the excessive fishing of juveniles (0 age-class) of several species (Bariche *et al.*, 2006). These fishing practices are not sustainable and may have great negative impact on recruitment rates and food webs in particular and marine species in general (Nader *et al.*, 2020).
- ***Non-indigenous species (NIS):*** Most NIS in Lebanon have been either introduced directly by people (i.e. through aquaculture and the aquarium industry), accidentally by fouling and ballast water from ships, or allowed passage by human actions (Nader *et al.*, 2012; Otero *et al.*, 2013) like the opening of the Suez Canal. Due to its geographical location in proximity to the Suez Canal, the Lebanese coast is one of the first arrival grounds for NIS species of Indo-Pacific origins. To date, a total of 215 marine NIS have been listed in Lebanon (SPA/RAC-UN Environment/MAP, 2018b), and more are constantly being identified. The enlargement of the Suez Canal and the increase in shipping volume throughout the region coupled with changing climatic variables are expected to boost the rate of arrivals of aliens into the Eastern Mediterranean (El Khoury *et al.*, 2020; Rotter *et al.*, 2020). NIS are usually recorded after a relatively long period of their migration (Otero *et al.*, 2013; Bitar *et al.*, 2017; Rotter *et al.*, 2020) and they have become a familiar sight, at least in the East Levantine corner of the Mediterranean (Boustany *et al.*, 2015; SPA/RAC-UN Environment/MAP, 2018 a, 2018 b). NIS have drastically affected certain species populations, pushing away native species of commercial value by occupying their habitats and competing for existing resources (SPA/RAC-UN Environment/MAP, 2018b).

3. MANAGEMENT PLANNING PROCESS

3.1 Key institutions and stakeholders involved

The fisheries sector in Lebanon falls under the responsibility of the DFW-MoA. Fishing licences are issued on a yearly basis, while the Ministry of Public Works and Transport (MoPWT) is in charge of the fishing boat registry (Nader *et al.*, 2020). Stakeholders involved in the development and implementation of the current EAF management plan are divided according to their respective role and mandate:

- Primary stakeholders: DFW-MoA, MoPWT, fisher syndicates and fisher cooperatives, private-sector commercial entities engaged in the sector
- Secondary stakeholders: FAO, Ministry of the Environment (MoE), Ministry of Defence (MoD), Ministry of Interior and Municipalities (MoI), Ministry of Labour (MOL), NCMS-NCSR
- Tertiary stakeholders: academic institutions, research centres, non-governmental organizations (NGOs)

3.2 Rationale for selecting the purse seine fishery (PSF)

In 2016, the FAO-EastMed project in partnership with the MoA collaborated with the MCR-IoE-UoB to implement a pilot case study in Lebanon which applied the EAF approach. This EAF-based initiative aimed to assist managers and stakeholders in making more informed decisions on the sustainable use of resources in light of priorities and recommended actions jointly identified by the main stakeholders in the fishery. The plan was designed in line with the FAO Code of Conduct of Responsible Fisheries, following the principles of the EAF and the FAO-EAF Toolbox (FAO, 2003; FAO, 2012). The EAF team was comprised of representatives from the DFW-MoA, FAO-Lebanon, FAO-EastMed and from the MCR-IoE-UoB.

The PSF was selected for the following reasons:

- Purse seiners catch large quantities of fish (Pinello and Dimech, 2013, Pinello *et al*., 2020).
- This gear is very efficient, with high CPUE and LPUE (Pinello and Dimech, 2013, Pinello *et al*., 2020).
- The fleet has a limited number of fishing vessels, meaning communication and meetings with purse seine fishers are practical and efficient.
- Fisher communities in Lebanon would be greatly affected if the sardine fishery collapsed.
- A whole economic sector that depends on fishing activities (e.g. carpenters, fishing gear suppliers, fishmongers and restaurants) would also be negatively impacted, which would threaten the wellbeing and food security of the Lebanese population.

3.3 Mechanisms for developing the EAF-PSF management plan

A synthesis of available information coupled with the active participation and commitment of different stakeholders formed the basis of the entire initiative. An extensive background search of available documents and information reinforced by a series of stakeholder consultation workshops provided the pillars for drafting the management plan. A draft EAF baseline report (EAF-BL) on the status of the purse seine fishery in Lebanon was produced. It included an analysis of all available information on the socioeconomic, environmental and institutional aspects of the fishery that were considered relevant for the development of the management plan (Nader *et al*., 2020).

A first general stakeholder meeting (15 March 2016) was held to introduce the project and the EAF concept to key stakeholders (section 2.2) and to initiate the first set of discussions regarding the management of the purse seine fishery. For subsequent meetings, a selected number of individuals were delegated by their respective sectors to represent fisher cooperatives and syndicates, fishmongers, fishing gear traders, ministries, academic institutions, research centres and NGOs.

The EAF-BL was then presented in the second stakeholder meeting (18 May 2016), where relevant inputs were recorded and duly incorporated to finalize the EAF-BL.

A third stakeholder meeting (28 July 2016) identified issues affecting the sustainability of the fishery in relation to ecological wellbeing, social and economic wellbeing, and governance aspects. This workshop also assessed the risks associated with each issue.

The fourth stakeholder meeting (17 November 2016) gathered elements for the development of management systems for the high-priority issues identified in the third stakeholder meeting.

Finally, the draft management plan was presented by stakeholders at a general meeting (29 September 2017) to be subsequently approved officially by the MoA.

3.4 The management plan

The management plan was developed based on the EAF Toolbox and addressed high-risk issues (Annex 2; FAO, 2005; FAO, 2012), while medium- and low-risk issues were left to be addressed in the future. The high-risk issues associated with the purse seine fishery in Lebanon were structured into the three main EAF thematic areas – ecological wellbeing (six high-risk issues), social and economic wellbeing (seven high-risk issues), and ability to achieve (three high-risk issues) – among which attendees were divided. For each high-risk issue, the management plan identified the following elements: operational objectives, indicators, performance measures, data requirements, current management practices, and future management measures (examples in Tables 3, 4 and 5). Partners, timeframes and costs in the management plan are only indicative. Detailed responsibilities, budgets and timelines depend on when the actions are implemented. These actions can either be addressed individually or as part of a comprehensive approach.

Table 3. Example of a high-priority issue for the ecological wellbeing of the purse seine fishery in Lebanon.

High-risk issue	Operational objectives	Indicators	Performance measure	Recommended future management practices	Financial cost *	Time frame**	Main partners
Uncertainties regarding the stock status of target species. Preliminary assessment of sardine indicates stock is in overexploitation	To enhance stock assessments of species of interest, especially sardine and anchovy	Current fishing mortality (F) and exploitation status	Fishing mortality and reference points for the species of interest estimated and validated by the GFCM	• Continue biological data collection to improve the population dynamics of the stock. • Fill data gaps, including age structure of the stock. • Continue the collection of catch and effort data • Update stock assessments with new data. • Test other data-limited approaches for stock assessment and management advice, including through the integration of local fisher knowledge.	Low	Medium	• FAO-EastMed • DFW-MoA • NCMS-NCSR • Cooperatives and syndicates • GFCM • Other research institutes

*Low (USD 0-25 000); medium (USD 25 000-75 000); high (≥ USD 75 000).
**Short (1–2 years); medium (3–5 years).

Table 4. Example of a high-priority issue for the social and economic wellbeing of the purse seine fishery in Lebanon.

High-risk issue	Operational objectives	Indicators	Performance measure	Recommended future management practices	Financial cost	Time frame	Main partners
High-risk issue Conflicts between fisheries organizations and public administration	To improve the relationship between fisheries administration and fisheries cooperatives and syndicates through effective participatory management of the purse seine fishery	Number of complaints received; community satisfaction with MoA	Increase in community satisfaction with the way the fishery is managed	• Establish a regular forum to discuss the problems and demands of the sector (fishery advisory committee). • Consider the revision of norms regulating the fishery, based on identified demands from communities and the best available knowledge (see point 3.1).	Low	Short	• DFW-MoA • Cooperatives and syndicates

Table 5. Example of a high-priority issue affecting the ability of the fishery to achieve its objectives.

High-risk issue	Operational objectives	Indicators	Performance measure	Recommended future management practices	Financial cost *	Time frame**	Main partners
Shortcomings in the current legislations regulating the purse seine fishery	To update the existing regulations based on best available knowledge and taking into account international obligations and regional specificities	Ministerial decisions concerning the regulation of the purse seine fishery	Regulations applied to the purse seine fishery revised based on sustainability criteria and according to the best available knowledge	• Revise the current regulatory framework of the purse seine fishery based on the results of a comprehensive evaluation of options concerning: a) limits to fishing licences based on sustainability criteria; b) quota for sardine catches; c) allowable distance to fish from the coast increased from 6 nm to 12 nm; d) mesh sizes of nets; e) minimum size of fish landed; f) extent of fishing season, including area-specific fishing seasons (e.g. start fishing on 1 March and stop fishing in June/July in the north); g) lighting and electrical power used to attract fish; i) protection of spawning areas; and j) species to be caught to be limited to sardines and anchovy only. • Consider the adoption of science-based grace periods for new regulations.	High	Short	• DFW-MoA • Ministry of Public Works & Transport • Lebanese Army / ISF • Cooperatives and syndicates

3.5 Achievements and limitations

Positive changes and progress have been driven by the initiatives and receptiveness of the DFW-MoA, the support of FAO-Lebanon and the FAO-GFCM, the launch of the FAO-EastMed project, and the participation of academic institutions (e.g. the MCR-IoE-UoB) and research centres (e.g. NCMS-NCSR). One of the main drivers was the DFW-MoA's adoption of the EAF concept as a key approach to sustainably develop the sector. Overall, achievements can be summarized as follows:

- The participatory approach of the EAF provided stakeholders (fishers, scientific bodies, commercial entities) with an equal opportunity to communicate directly with the DFW-MoA, related public authorities and the scientific community, in order to share their problems and challenges, decide on priorities, and attempt to find solutions in a professional setting.
- Exhaustive discussions between fishers, administrators and scientists reduced misconceptions about the state of the fishery, clarified the intentions of public authorities regulating the sector, and brought the main stakeholders together in pursuit of shared goals.
- The EAF participatory approach further enhanced the personal relationships between DFW-MoA rangers and the fishers, leading to better data collection on landings and other aspects related to the sector.
- The EAF participatory approach showed fishers that the process gives equal weight to their wellbeing along with stock management and conservation. This led the fisher community to support and agree to actively participate in the implementation of the management plan.
- The need emerged for data to support the better design and implementation of the management plan. Therefore, the actual catch/effort monitoring programme and the FLOUCA Web utility were evaluated within the context of the PSF, and efforts were made to reduce potential estimation errors, allowing the continuous improvement of the system.
- The EAF-PSF management plan provided useful experience in using FLOUCA Web data sets and in identifying data gaps, both of which are essential for developing EAF-PSF-style management plans for other fisheries.
- The development of the EAF-PSF management plan built the capacity of the DFW-MoA, the MCR-IoE-UoB, FAO-Lebanon and the FAO-EastMed project teams in particular and other stakeholders in general in terms of drafting management plans according to the EAF approach.
- The development of the EAF-PSF management plan proved that the EAF approach can be implemented, and it has paved the way to develop similar management plans for other fisheries.

During the process of developing the EAF-PSF management plan, certain challenges were faced and addressed:

- Difficulties were encountered during background searches for the EAF-PSF management plan, as few references were available. This was overcome by using all publications and available data related to PSF at national and regional levels and by consulting fisheries experts.
- Catch/effort data series at national level were very recent and did not represent the trends of the PSF sector over longer periods of time. The FLOUCA Web data formed the backbone for the Clupeidae landings that were used to describe the fishery. From this perspective, the FLOUCA Web national data was adopted for management purposes.

- The available datasets of some fishers are in hard copy format (mainly auction bills) and require tremendous time and effort to be digitized. The EAF team could not benefit from these, even though they may have provided valuable information on the purse seine fishery in Lebanon.

Although several private and public institutions and independent experts have collaborated with the DFW-MoA to develop management plans and strategies and to carry out related scientific assessments (Nader *et al.*, 2020), several limitations that will hinder the implementation of the EAF-PSF management plan were nonetheless identified:

- Chronic stalemate in endorsing and activating plans and strategies at political level.
- Integration of concerned public authorities and the private sector in the process.
- Difficulty in implementing applicable fisheries laws.
- Recurrent political, security and economic crises.
- Integration of the EAF-PSF actions in the yearly programmes of concerned public authorities to meet objectives.
- Delay in the endorsement of the new fisheries and aquaculture draft law.
- Sustainable funding for the implementation of all actions detailed in the EAF-PSF management plan (i.e. replacement of fishing gears, fisher social safety nets, and research activities).
- Unknown status of fish stocks of commercial species targeted by the EAF-PSF management plan.
- Sustainability of stock assessments and data collection for other identified actions over the lifetime of the EAF-PSF management plan.
- Minimal awareness of fishers about sustainable fisheries and fish stock maintenance.
- Fishers may be unwilling to participate in implementing the proposed EAF-PSF management plan actions in the absence of incentives.

CONCLUSION

The EAF-PSF management plan for Lebanon's purse seine fisheries has not been endorsed by the MoA to date due to the delay in the ongoing biological and stock assessment studies of the targeted species (DFW-MoA personal communication). Once finalized, these assessments will create the strong scientific basis needed for supporting managerial decisions at the level of the Ministry.

This management plan reflects the current understanding of the fishery and associated exploited resources. The participatory approach involving a wide range of stakeholders provided a holistic perspective for the management of the fishery. Within this context, several factors contributed to the successful development of the current EAF-PSF management plan, mainly:

- The availability of data, albeit not sufficient, on PSF species through FLOUCA Web.
- The public-private partnership that saw close collaboration between a public institution (the DFW-MoA) and a private academic institution (the MCR-IoE-UoB) supported by the regional and national offices of a renowned international United Nations agency, the FAO (FAO-Lebanon and the FAO-EastMed project).
- The proposition and active participation of DFW-MoA in developing the EAF-PSF management plan.
- The financial and technical support of both the FAO-EastMed project and FAO-Lebanon.
- The active contribution of the PSF fishers in Lebanon in all phases of the project.

- The positive participation of other public authorities and stakeholders concerned with fisheries and marine conservation sectors.

Once implemented, the EAF-PSF management plan must be revised and improved based on advances in knowledge and the experience gained from ongoing management practices. A full review of the plan is highly recommended five years after the date of implementation, given the fact that it may be endorsed but not executed until years afterwards.

Lastly, and in line with the principles of participatory fisheries management embedded in the Code of Conduct for Responsible Fisheries and the Ecosystem Approach to Fisheries, a specific 'Fisheries Advisory Task Force' should be established to function as a consultative body during the implementation of the EAF-PSF management plan, and to propose the development of new plans based on the EAF approach for other fisheries.

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ANNEX 2. LESSONS LEARNED FROM THE PRACTICAL IMPLEMENTATION OF THE EAF PLANNING PROCESS ACCORDING TO FAO GUIDELINES

Steps	Activity (what was done)	Comments and observations about this step	Cases where it went wrong, and why	Cases where it went well, and why
1. Initiation and scope	• Background search • Stakeholder analysis • First stakeholder meetings (March 2016) • Elaboration and consolidation of EAF Baseline Report (EAF-BL) • Second stakeholder meeting to review the Baseline Report (18 May 2016)	• The objective of the EAF-BL is to complete the EAF planning phase by defining the scope of the case study based on available information in addition to identifying gaps in order to ensure success of the EAF plan. • The EAF-BL is a document that outlines the available information on the PSF that can assist with the rest of the EAF management planning process.	• During background searches for the PSF, few references addressed this topic in Lebanon. • Catch/effort data at national level were very recent and did not fully represent the real figures of the PSF sector and related resources. • Available datasets with certain fishers are scattered and in hard copy format.	• EAF-BL documented all relevant information about the fishery, the species and geographical areas, the socioeconomic profile of the fishery and the institutional arrangement for its management. • Several drafts were shared between the EAF team and changes were added based on the comments obtained. • Fruitful consecutive workshops. • Exceptional cooperation and collaboration between the EAF team (DFW-MoA, MCR-IoE-UoB and FAO-EastMed).
2. Identification of assets, issues and their priority	• Issue identification and prioritization workshop (July 2016)	• Results obtained from this workshop formed the corner stone of the EAF-PSF management plan.	N/A	• Good participation from stakeholders due to direct contact from the MoA, FAO and MCR-IoE-UoB team. • The workshop was divided into two sessions. • The lists of predefined issues were thoroughly discussed in each working group and amended according to the input of the participants. • Issues were then ranked in Session 2 based on the EAF Toolbox.
3. Development of management systems	• Third stakeholder meeting to discuss operational objectives and indicators and methodologies for evaluation of management measures (November 2016) • Prepare the workshop reports • Preparation of fishery management plan and action plan for capacity development by the EAF project team (EAF-PSF management plan) • Translation of workshop reports, Baseline Report and management plan into Arabic (100 pages).	• The plan is the key document that sets a framework for the long-term sustainable management of marine fisheries resources of Lebanon based on EAF principles. • It is a strategic document highlighting issues and opportunities raised by related stakeholders that need to be addressed to enhance the environmental and social situation of fisher communities.	N/A	• Good participation from stakeholders due to direct contact from the MoA, FAO and MCR-IoE-UoB team. • The EAF-PSF management plan adopted the FAO method detailed in the EAF Toolbox (FAO, 2012). • The EAF-PSF management plan provides guidance to decision-makers, fisher cooperatives and fishers themselves at the level of ecological wellbeing, social and economic wellbeing and governance. • It facilitates cooperation and communication among different beneficiaries of fisheries resources and among all stakeholders.
4. Implementation, monitoring and performance review	The management plan has not yet been endorsed by the MoA.	N/A	N/A	N/A

Chapter 5: Implementation of the ecosystem approach to fisheries in the management of the dolphinfish fishery in Malta

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1. INTRODUCTION

1.1 Overview of an ecosystem approach to fisheries

According to FAO, 'an ecosystem approach to fisheries strives to balance diverse societal objectives, by taking account of the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries' (FAO, 2003). The fisheries sector plays an essential role in global efforts to tackle both malnutrition and hunger. This sector supplies both marine and freshwater aquatic products, which are highly nutritious and rich in essential fatty acids, proteins, vitamins and minerals. On an international scale, the fisheries sector provides approximately 3 billion people with 20 percent of the average per capita intake of animal protein, reflecting the sector's global importance (FAO, 2020a).

However, global fish stocks constantly face challenges, such as overfishing. Overfishing occurs either due to a lack of willingness to establish sustainability principles for fisheries management such as maximum sustainable yield, or due to the use of inadequate tools to manage fisheries (Degnbol *et al*., 2006).

The inadequate or late implementation of fisheries management degrades fisheries in both biological and socioeconomic terms, with the primary consequences being issues of food security and employment, and – in more extreme cases – poverty in fisher communities. Moreover, in many cases fisheries management tends to be developed as a response to a crisis, and established through quick-fix solutions, predominantly biological ones. But if these solutions are perceived as panaceas without addressing the complexity of a fishery and the bigger picture of the ecosystem – including human relations and markets – management failures are likely to ensue (Finkbeiner *et al*., 2017[1]).

As a breakaway from the traditional, conventional mode of managing fisheries the ecosystem approach to fisheries (EAF) is increasingly being presented as a more holistic approach to fisheries governance. In principle, this type of management acknowledges both the ecosystem and the stakeholders who – whether or not they are actively involved in fishing activity – depend on associated ecosystem services (FAO, 2020a) (Figure 1).

[1] www.researchgate.net/publication/319684483_Reconstructing_overfishing_Moving_beyond_Malthus_for_effective_and_equitable_solutions

Figure 1. Ecosystem approach to fisheries management: this type of approach takes into consideration all the ecosystem factors that directly affect or are affected by the fisheries sector.
Source: NOAA, n.d.

The move towards an integrated approach to fisheries management began in the 1960s, when the US Stratton Commission recommended a systematic move away from a single-sector approach. In the 1980s, the new approach was considered during the evolution to single-species Total Allowable Catches introduced by the European Union. The sustainability concept gained more importance after the Rio Summit in 1992, where a direct link between environmental protection and fisheries was established. Following on, the need for an EAF was recognized at several international fora including the World Summit for Sustainable Development (2002), which proposed maintaining and restoring fish stocks to ensure that maximum sustainable yield is not exceeded (FAO, 2003). Since then, EAF has started making inroads into official texts, including in European Union fisheries and environment policy. In fact, after the European Union treaty was revised, environmental protection requirements were integrated into all fisheries plans included in discussions of European Union fisheries policy (Ramirez-Monsalve *et al*., 2015).

This broader scope to fisheries management reflects two drivers: i) natural factors, as fisheries form part of a whole ecosystem and trophic food chains, and ii) social elements which incorporate the economy, markets and other human relations. It is important

to understand that consumption patterns and trends that drive demand for fish have a direct impact on fisheries – but in most developing and developed countries, fisheries sectors have been managed traditionally, resulting in a situation where marine habitats have been degraded by intensive abrasive activities such as bottom trawling.

The move to an EAF has also been motivated by the following factors:

1) An increased awareness of the importance of the fishery resource's interactions with the ecosystem.

2) The necessity for a set of societal objectives, as well as objectives for the marine ecosystem and the fishery resource, within a sustainable development context.

3) The underperformance of traditional management approaches, as is seen in numerous world fisheries.

4) New evidence provided through scientific research, which underlines both knowledge and uncertainties regarding the ecosystem's functional value to humans. (FAO, 2003)

The Maltese fisheries sector is of a typical Mediterranean artisanal nature. It practises seasonal fishing activities in multi-gear and multi-species fisheries, making it highly diverse. The fleet is composed of around 850 full-time and part-time vessels, which engage in various fisheries through the year. Most of the fish caught is sold locally, with some species (tuna and shrimps) being exported to other lucrative markets. Although only comprising 2 percent of the national GDP, the Maltese fisheries sector provides a number of positive externalities, including post-harvest value chains and indirect economic benefits to the tourism sector thanks to the attraction of fishing ports. The dolphinfish fishery, for example, is popular due to its use of traditional gear known as '*kannizzatti*', which appears on many tourist postcards.

This fishery, for one of Malta's most sought-after species, exploits a shared stock, targeted by various countries across the Mediterranean – as a result, it is considered as a GFCM priority species. Studies indicate that dolphinfish is normally targeted when it is around 2 to 8 months old, which raises important questions about the stock status and sustainability, and how these affect the socioeconomic conditions of fisher communities (European Commission, 2008). An ecosystem-based approach towards this fishery was therefore adopted, with its first aim being to carry out a holistic assessment through data collection and stakeholder consultation. The results helped the government to devise efficient and effective management measures for the fishery.

1.2 Fisheries context

1.2.1 The dolphinfish (Coryphaena hippurus, Linnaeus, 1758) fishery

In Malta (Figures 2 and 3), the dolphinfish – locally known as '*lampuka*' – is of great economic importance to the fishing industry, with the fishery having its origins as early as the 1960s. It is captured using anchored fish aggregating devices (FADs) and surrounding nets. FADs are permanent or temporary floating objects, consisting of material such as palms, that are designed to attract the dolphinfish (FAO, 2020b). These FADs are generally marked with floats and buoys, and placed in multiple locations all around the island (Figure 4). The species is considered as highly migratory, and is known to exhibit heightened responses to thermal alterations in the environment, such as changes in spawning areas, behaviour, and larval growth. Ospina-Alvarez *et al.* (2019) state that adult dolphinfish migrate from the Mediterranean Sea to warmer Atlantic regions in winter, and return to spawn in spring.

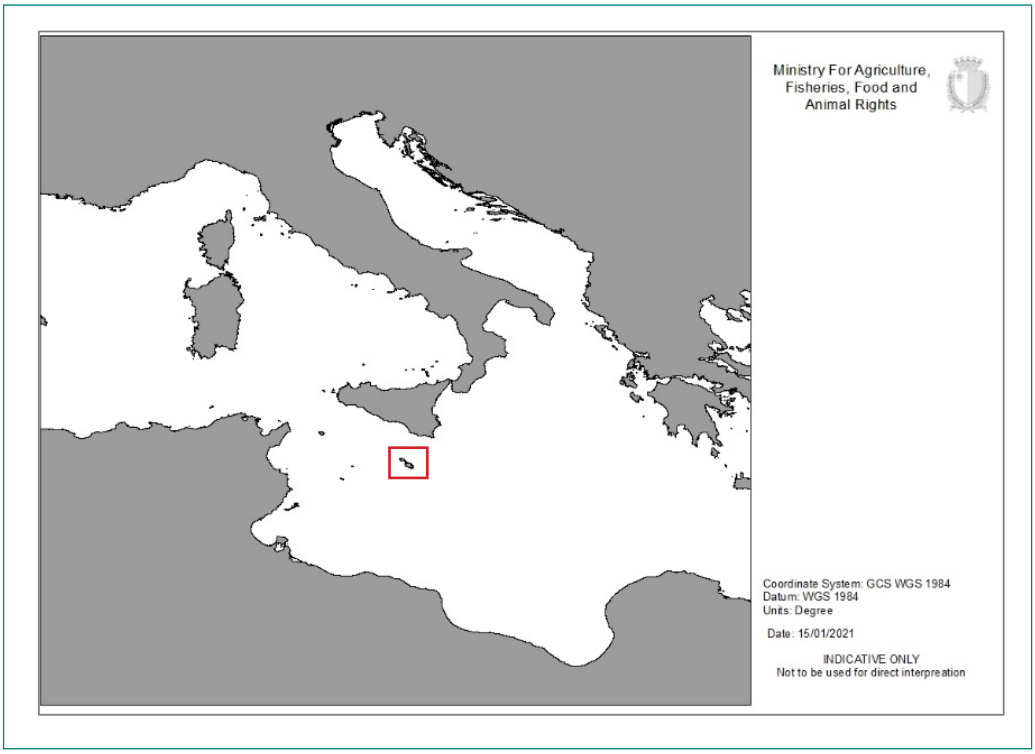

Figure 2. Map of the Mediterranean highlighting the location of Malta.

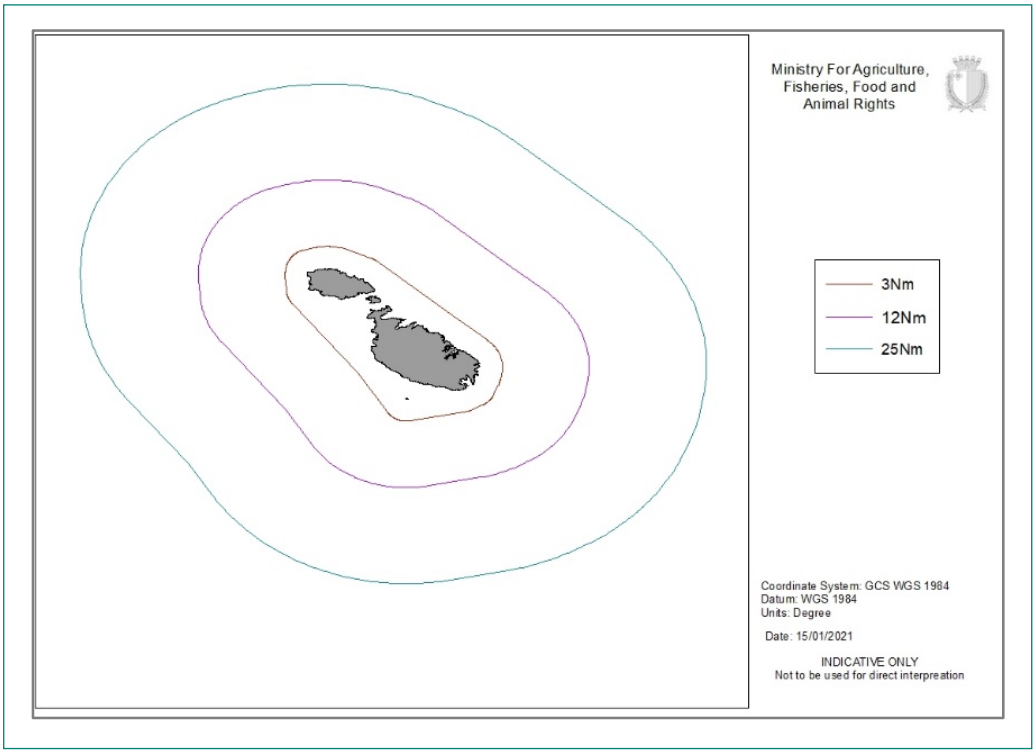

Figure 3. Malta.

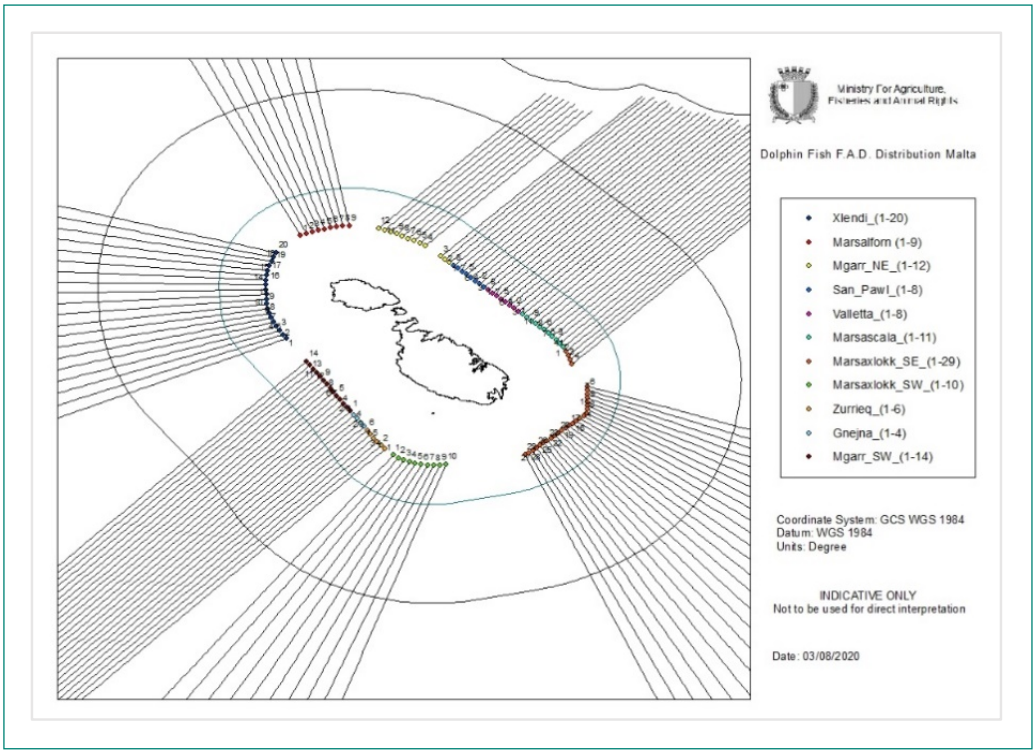

Figure 3. The lines represent the MFAD fisheries course lines. Every MFAD is labelled with a number which is then allocated to dolphinfish fishers.

Fishing for *lampuki* in Malta started around the 1960s. Fishing vessels were traditionally operated by family members, with the coordination and hard work needed to haul and retrieve the net requiring both focus and dedication. Nowadays, crews also include foreign labour, as – according to local fishers – the sons and daughters of the vessel owners are becoming less interested in joining the sector. Vessel owners fish either on a full-time or part-time basis: it is not always possible to sustain an income from the fishing sector. A maximum of 130 vessels each year, employing approximately 300 fishers, are allowed to fish for this species, in accordance with paragraph 2 of Article 27 of Council Regulation 1967/2006. Each vessel is given the right to deploy FADs in a specific zone off the Maltese coast. These zones, known as FAD course lines (in Maltese, '*rimja*'), encircle the entire coast like a rose, and collectively form 11 sea districts corresponding to different fishing ports (Figure 4). Each *rimja* – separated by 0.5 nautical miles (nm) inshore and up to 4 nm offshore – gives individual fishers exclusive rights to deploy and moor FADs within a specified area. The rights are granted on an annual basis by the government through a lottery process, which has been in place since the 1960s. Around June, vessel owners apply to have a *rimja* in a particular district. Following the lottery, they are permitted to deploy FADs and fish in a given *rimja*, using a surrounding net to harvest dolphinfish during the season – this starts on 15 August and continues until the end of December. The lottery system gives fishers an equal chance to select thee course lines of their choice. It is interesting to note that this bottom-up arrangement for fleet space allocation has been practised since the 1960s, and when Malta joined the European Union the measure was incorporated in the European Union Mediterranean Regulation EC 1967/2006 Article 27, 'Fishing Measures in Maltese Waters'. The direct adoption of pre-existing traditional arrangements into European Union policies gave them a more solid and formalized status, and ensured more compliance across the country.

A fisher or a company can own more than one vessel, and is thus able to claim more than one *rimja* per season. Priority is given to fishers who would have fished the year before, as this ensures that the *rimja* which is assigned is actually used. This measure was introduced as a deterrent to fishers who claim a *rimja* then do not take part in the fishery. The number of vessels operating varies annually, depending on how many fishers apply, and not all 130 FAD lines are taken every year. On average, 73 percent of the vessels engaged in FAD fisheries are between 6 and 10 metres in length, of which 54 percent are between 6 and 7 metres.

The number of full-time (MFA) and part-time (MFB) vessels authorized to take part in the dolphinfish fishery varied between 2015 and 2020 (Figure 5). The highest numbers were in 2019 and 2020, with 122 fishers registered in both years. The lowest was in 2018, when only 109 vessels were involved.

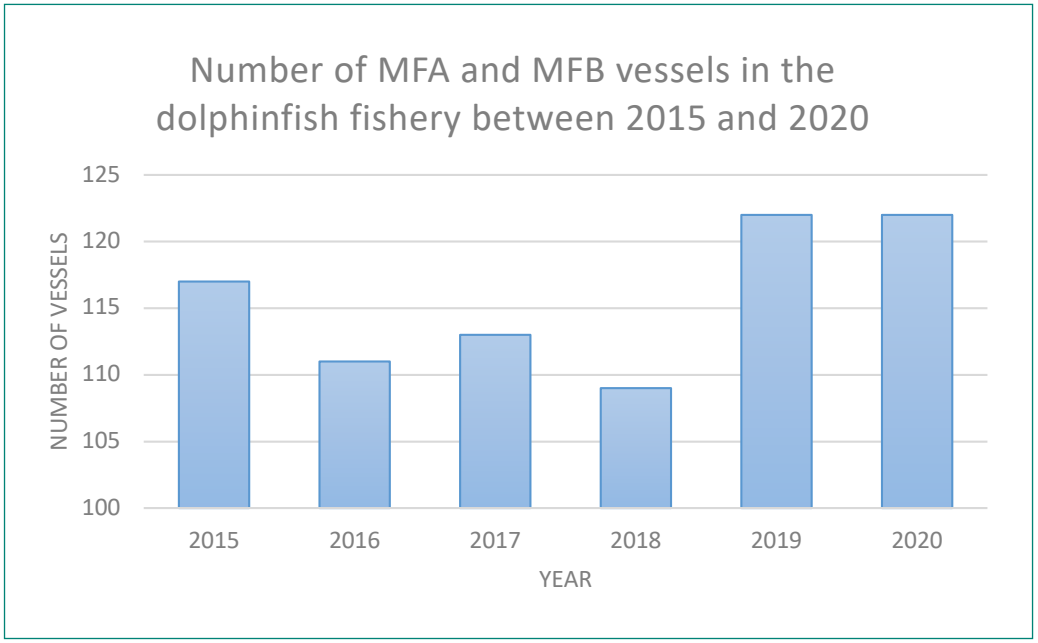

Figure 5. Number of MFA and MFB vessels in the dolphinfish fishery between 2015 and 2020.

Each vessel deploys a number of FADs starting from 8 nm offshore and proceeding outwards a number of miles, depending on the size of the vessel and the district. Vessels of less than 8 m in length venture out about 60 nm deploying around 200 FADs, while larger vessels may cover more than 100 nm to deploy double the number of FADs. The number of FADs deployed in a *rimja* is not fixed, and is mostly determined by the size of the vessel – however, as a general observation, the larger the vessel the more FADs are deployed, and the higher the catch rate. Between 1995 and 2014, the Maltese fishing community caught a total of 6 500 tonnes of dolphinfish with a value of EUR 17 million, averaging 328 tonnes and EUR 880,000 per year.

From 2015–2019, the fleet spent an annual average of 1 543 days at sea, and landed approximately 318 tonnes of fish each year (Table 2). The fishery contributes 11 percent of Malta's total annual commercial fisheries catch – in 2019 this totalled EUR 1 433 000.

Table 2. Total weight and value of catch plus days spent at sea in the dolphinfish fishery.

Year	Weight (kg)	Value (EUR)	Days at sea
2015	328 262.2	1 415 000	1 479
2016	231 033.4	1 290 000	1 407
2017	229 509.1	1 108 000	1 381
2018	400 722.8	1 966 000	1 779
2019	404 536.1	1 433 000	1 669

Most of the fish is sold on the local market through a national auction run by the government through middlemen on a daily basis at 4am. Following the auction, fish vendors sell the *lampuki* via different retail means, either from shops or from specially equipped vans that travel around island villages – a vibrant tradition during peak season. The local population looks forward to this, and in August the fish fetches higher prices than during the rest of the year. Moreover, since this season coincides with the peak of the tourist season, the fish has become a Maltese delicacy offered to visitors in many of the local restaurants. This has been crucial in keeping the species' market value stable. In a good season, when plenty of fish are landed on a daily basis, there is concern over market saturation affecting the price of the fish, and hence the economic returns for the fishers. A case in point is the situation of 2019. Even though the total dolphinfish catch in 2019 was nearly 4 tonnes greater than in 2018, the market value was higher in 2018: fish sold then at EUR 4.90 per kilo, while in 2019 the price plummeted to EUR 3.54 (Figure 6). The price in 2020 was also affected by COVID-19, which meant that the tourism market was low and retail outlets did not have high demands for the fish. When the market is saturated, a number of fishers export their catches to foreign markets; however, since it has not been possible to establish longer trading patterns, fishers have not managed to implement any harvest plans to regulate the market, at least to date.

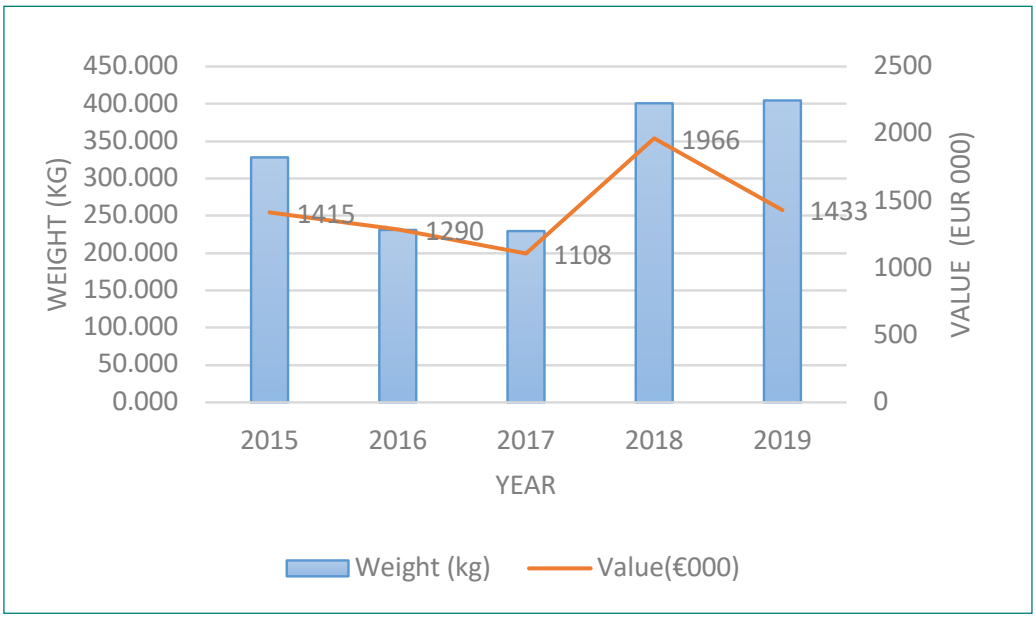

Figure 6. The relationship between the total weight and value of dolphinfish landed from 2015 to 2019.

As well as these economic and marketing considerations, ecological and climate stressors also affect the sustainability of the fisheries. Institutional forces have the greatest influence of all, mostly because the dolphinfish stock is shared, targeted by various countries including Italy, Tunisia, Spain and Malta. The diversity of cultures and political economies across the region have made the management of the fisheries complex, especially when it comes to better understanding stock status and how best to manage it at a regional level. European Member States have been requested to implement management plans for their fisheries since 2006, however, such efforts are always dependent on fishing activity in countries which do not fall under the same regulatory regime. Efforts have been underway for some time to create a level playing field for managing these fisheries. The recent implementation of Recommendation GFCM43/2019/1 on a set of measures for the use of anchored FADs in common dolphinfish fisheries in the Mediterranean Sea has improved the management regime, although to what extent is yet to be seen given that the measures only came into force in 2020.

2. MANAGEMENT CONTEXT

The management of the dolphinfish fisheries in Malta has taken an integrated approach by focusing on the maximum sustainable yield of the local fishery along with the economic viability of the sector. In the past 10 years the Maltese government has sought to achieve two major objectives: (i) to enhance the research aspect of the fishery, and (ii) to manage its exploitation through a national management plan, in line with European Union provisions. In principle, these two elements have been implemented with a view to achieving an ecosystem approach to fisheries.

2.1. Research on the dolphinfish fishery

2.1.1 National data collection framework: biological and socioeconomic aspects

Malta collects and analyses data about its fisheries, including dolphinfish, to produce sound scientific information on the state of fisheries resources. The data, collected in line with the European Union data collection multi-annual programme (DC-MAP), is focused on different datasets including (i) biological data about the fishery (sex, maturity, age), and (ii) transversal data which incorporates fishing activity, capacity, effort and landings, as well as economic data that looks into financial investments and returns from the fisheries (Gatt, 2015). Through such data and bioeconomic assessments, the government is able to study trends and assess the sustainability of the fishing practices; as well as provide scientific advice on the way forward and the best way to manage the available stocks. In 2013, for example, the government noted that the 10-cm decrease in the length frequency distribution of dolphinfish captured through FAD fisheries between 2005-2011 could have been signifying a trend of overfishing (DFA, 2013). Given that the dolphinfish is a shared stock, however, it has been difficult to interpret such data without an understanding of the fishery at the regional level, predominantly the exploitation trends by neighbouring countries including Tunisia, Italy, Spain, among others.

2.1.2. Regional research

The sustainability of shared stocks requires data collection and bioeconomic assessments that go beyond national waters to account for the cumulative fishing effort of the various countries. A number of research projects have been undertaken in the past 20 years to enhance knowledge of Mediterranean dolphinfish fisheries, including the CORY programme under the FAO regional project Coordination to Support Fisheries Management in the Western and Central Mediterranean (CopeMed). The project supported the collection of data and other information to improve knowledge of the biology, catch and effort levels, catch-length composition estimation, fleet dynamics

and catch-at-age data. These data sets provided an overview of the dolphinfish fishery, with the main aim of establishing the basis of future dolphinfish management at a regional level. This was essential in Malta, one of countries participating in the study, since information and data on the dolphinfish fishery was very scarce (Camiñas and Fernández, 2011). One of the objectives of the CORY programme was to assess the dolphinfish fishery in the central-western Mediterranean Sea. A study carried out by Camilleri and Darmanin (2002) assessed Maltese catch and effort data to inform the management of the fishery.

Malta also participated in a number of sub-regional meetings in the framework of the CopeMed project, where the results of various phases of these projects were discussed with Spain, Algeria, Italy, France, Libya, Tunisia, Morocco and representatives of the GFCM, the International Commission for the Conservation of Atlantic Tunas (ICCAT), and FAO staff.

Malta recently participated in a regional study coordinated by CopeMed (Molto *et al*., 2020) to improve knowledge of dolphinfish biology and the fishing activity variables of the fishery. The focus was on the interannual movement of *Coryphaena hippurus* stock, which affects inter-country fishing catches, changes in prices, and the accuracy of fishing effort estimates. The study also made a number of management recommendations, such as to collect knowledge on different dolphinfish populations, to carry out further stock assessments, and to explore potential environmental factors influencing the shifts in dolphinfish distribution. Further research efforts are underway at both national and regional levels to ensure that the variables that determine the sustainability of this fishery are well understood and integrated into management plans.

2.2. Managing dolphinfish fishery resources

2.2.1. Regional management: GFCM and European Union

Management at regional level began with efforts by the GFCM, the first of which included recommendation GFCM/30/2006/2 establishing a closed season for common dolphinfish fisheries using FADs. The common dolphinfish is a GFCM priority species, and this measure was the first move towards prohibiting fishing activities in the breeding seasons during the months of January through August. This recommendation also advised that the GFCM's Scientific Advisory Committee should analyse fishing effort and catch to have a better understanding of regional catch rates. GFCM members were thus obliged to provide various data sets on their catches including fishing period, geographical subarea, total landings, number of vessels, and total gross tonnage of the fleet.

Further management measures have been implemented through the recent recommendation GFCM43/2019/1, which aims to ensure the conservation and sustainability of the biological, environmental, economic and social aspects of the dolphinfish fishery. This recommendation in particular focuses on the need for identification on fishing gear, fishing authorizations, and improved information on catch and effort. It encourages countries to adopt environmentally friendly fishery measures including the use of biodegradable material for their FADs, as well as marking their fishing gear for its necessary retrieval. Countries are in fact required to put in place a system to manage the deployment and recovery of FADs and their potential loss. This recommendation also establishes that FADs should only be used by the owners of the vessels which deploy them, thus prohibiting vessels from fishing with the devices of others. These measures aim to produce a level playing field of regional regulations, similar to what is already required by the European Union. Such collective data obligations, as well as the implementation of common effort management and technical measures, will help to bring harmonized management to regional fisheries.

2.2.2. National management

The national management of the dolphinfish fishery was implemented through a management plan that was formulated between 2009 and 2011. This plan was based on in-depth data analysis by the fisheries department research team, with management measures founded on sound scientific advice. The results were presented to the Ghaqda Nazzjonali tas-Sajd and Kooperativa Nazzjonali tas-Sajd fishing cooperatives, and – following a number of meetings – the management plan was adopted in 2013. Bottom-up engagement with the sector and the inclusion of social, economic and ecological aspects in management planning were necessary for a holistic ecosystem-based approach. Fisher participation was also important to ensure that the measures were agreed collectively, so as to facilitate a smooth uptake at the sector level.

This plan was focused on biological, social and economic objectives, also taking into consideration EAF principles. It was based on stock status data compiled between 2005 and 2011, and landings data from 1954 to the present was also used. This data showed that the historic dolphinfish stock was stable (Department of Fisheries and Aquaculture, 2013). The management plan makes it clear that, in order to ensure that the fishery is kept at maximum sustainable yield, local catch trends must remain stable and natural fluctuations of stock biomass must be considered. It also highlights that catches need to stay near an annual average of around 350 tonnes. A precautionary maximum catch level was implemented to avoid overfishing and also to try and curb market saturation to maintain stable prices. In this regard the management plan appears to have been successful, since catches increased in 2015, 2017, 2018 and 2019 with only 2016 seeing a decrease (Figure 3). From the bioeconomic perspective, the fishery has been performing well over the past years since the catches have increased, resulting in an increase in economic returns for fishers (Molto *et al*., 2020). Moreover, at the regional level, Molto *et al*. (2020) indicates that even though there is not a clear understanding of the Mediterranean common dolphinfish stock, available data indicates that the fishery is not at risk of overexploitation. This does not however negate the fact that consistent and coherent data needs to be continuously collected, both from commercial and recreational fishing segments, to ensure the availability of concrete scientific advice for effective fishery management.

3. SUCCESSES AND LIMITATIONS IN ACHIEVING EAF

The vision of adopting an ecosystem-oriented approach to Malta's dolphinfish fisheries is underpinned by a structural system of governance by the Department of Fisheries and Aquaculture (DFA). DFA has invested in data collection and fish stock assessments, as well as the management of the fishery, and activity monitoring through control programmes. The Fisheries Research Unit collects data in accordance with the European Union data collection multi-annual programme (DC-MAP), which is focused on biological, transversal and economic data. This is carried out through onboard observations with fishers at sea and through fish market surveys. The policy unit then formulates the management plan for the fishery on the basis of the advice provided by the scientists. (Fishers are consulted, but at later stages – this is not a co-managed fishery as such. In an ideal scenario, the process would include fisher consultations at earlier stages during the collection of data.) Finally, the policy unit communicates the management plan to the European Commission, and it is then ratified by legislation and implemented by fisheries protection officers at the Fisheries Control Unit of the DFA. Given the stock's shared nature, however, these national efforts have not been enough to ensure an ecosystem-based approach, and governance issues remain unresolved beyond national jurisdictions.

3.1. Biological and ecological concerns in achieving EAF

Given that the dolphinfish is a shared stock, the success of Malta's management is contingent on a number of factors including regional fishing activity. Although the

Maltese fishery seems to be working at a sustainable yield, having kept its landings in the 350–400-tonne range, Italy's landings have increased dramatically since 2005, while Spanish and Tunisian landings have increased steadily since the 1990s and 1980s respectively (Department of Fisheries and Aquaculture, 2013). The intensification of the fishery at regional level over the last 15 years raises concerns about overfishing, and further data is needed to establish future forecasts to ensure that the stock is fished within its sustainable yield.

According to the European Commission (2008), this species is targeted mainly at the age of two to eight months; therefore its annual recruitment is highly variable. The latter report concluded that the size and maturity relationship is not regular, and that the parameters used to measure fishing effort (number of FADs deployed and fishing trips, as required by regional norms) provide only limited information on the level of fishing pressure and stock abundance trends. These factors limit the capacity to assess the status of the stock and to establish clear management measures in line with maximum sustainable yield parameters at the regional level.

The lack of data from the recreational segment is also a problem at the Mediterranean level. A report compiled by the GFCM in 2011 clearly states that recreational fisheries in the Mediterranean are not well managed, since the information on them is very scarce (Camiñas, 2011). Indeed, the lack of management of recreational fishing of *C. hippurus* is considered to be a regional problem for the GFCM area (Camiñas, 2011).

Apart from the lack of knowledge of fishing effort for the dolphinfish and the hidden harvests that might be landed by the recreational or non-authorized segments, other ecosystem-related matters could also be playing an important yet invisible role in the sustainability equation. As a case in point, it has been noted that following the successful recovery of bluefin tuna in the Mediterranean which has been underway since 2009 (The PEW Charitable Trusts, 2007), there could be a situation of increased predation on the common dolphinfish. This observation was made by Maltese fishers, who are increasingly finding bluefin tuna around their FADs. In other words, given that the Atlantic bluefin tuna is a highly predatory fish, it could be targeting pelagic species including dolphinfish. This is not unlikely, since their seasons are relatively close to each other and both frequent the pelagic zone (Oceana, 2020). Nonetheless, further investigation is needed into predation relationships as one of the variables in the ecosystem-based approach to this fishery. More information is also needed on the shifts brought about by climate change – including rising sea temperatures and other oceanographic parameters (water chemistry, current shifts, weather patterns) – that could be affecting the stock population (Philips and Perez-Ramirez, 2018).

Keeping the annual harvest at an average of 350 tonnes is an important tool in ensuring the sustainability of the stock, given the fact that other external factors that cause variations in dolphinfish distribution in Maltese waters cannot be controlled as easily. The management plan created in 2013 did take climate change into account since it acknowledges the fact that when the temperature rises, the dolphinfish can be found in open waters. Moreover, landings varied in different districts during the season, as dolphinfish tend to migrate in an anticlockwise manner as the fishing season progresses (DFA, 2013). Such information – grounded in fishers' local ecological knowledge – was triangulated with the mean landings across the years. The fusion of scientific data and local ecological knowledge has been crucial to build understanding, and is an important bridge to maintain an ongoing flow of knowledge about the fishery.

Another biological and ecological concern of this fishery is its bycatch aspect. FADs are used to attract dolphinfish, but other fish such as amberjack and pilot fish are also attracted to the shade they cast. Bycatch may also include amberjack and pilot fish predators such as elasmobranchs and turtles. In addition, bluefin tuna is a top predator that feeds on dolphinfish which may be attracted to the FADs and subsequently netted

– however, if the bluefin tuna season is over and the dolphinfish vessel has no permit to capture it, it must be declared as bycatch. Amberjack and pilot fish above minimum sizes are generally landed due to their marketability; however, amberjack and pilot fish below minimum sizes are generally discarded at sea. Certain elasmobranch species that are not protected may also be landed, however some may be discarded due to their low marketability. Protected elasmobranchs and turtles that are captured are usually discarded whether alive or deceased, although in the case of injured turtles certain NGOs such as the Nature Trust can be summoned to take them for rehabilitation at the Malta Aquaculture Research Centre at San Lucjan.

3.2. Socioeconomic concerns in achieving EAF

Achieving EAF requires a clear understanding and appropriate management to deal with the socioeconomic challenges that affect the sector. Apart from the problems related to market saturation as described in Section 1, the fishery has been the source of major resource conflicts both within national waters and on the high seas. In national waters, conflicts happen with recreational fishers who troll over the commercial FADs and at times disrupt the fishery. However, the main concern for the dolphinfish fishery is the presence of foreign vessels which, fishers report, are fishing on the FADs deployed by Maltese vessels. This issue has been consistently reported in the national media (Vella 2019, Azzopardi 2020), and bilateral discussions are underway to discuss a common solution. Maltese fishers report that such fights can be intense, sometimes violent, and at worst escalate to threats at gunpoint. Recent articles in Malta Today (2019) have illustrated how the local dolphinfish fishery has been plundered by non-Maltese vessels for the past 15 years.

With the new GFCM recommendation coming into force for the season of 2020, fishing off FADs deployed by another vessel has been forbidden: Article 32 states that 'It shall be prohibited for a CPC vessel to catch fish attracted by a FAD that has not been set by this CPC vessel.' To be compliant with this recommendation, Malta implemented a monitoring and surveillance plan to ensure that vessels flying the Maltese flag follow the measure; however, there seems to still be a problem related to the lack of a level playing field for monitoring and surveillance across the Mediterranean region. Recently, Malta has been in further discussions with the European Commission aiming to find a solution to enhance compliance with the recommendation.

3.3 Heading to a co-managed fishery through a bottom-up EAF approach

The potential future benefits of a bottom-up ecosystem-based approach to fisheries management are noteworthy (Staples and Funge-Smith, 2009). Presently the DFA is engaging in a participatory process to understand how the dolphinfish fishery can be run more effectively through a co-management approach. Preliminary outcomes of the discussions include the implementation of an assessment of biodegradable material for FADs, and improved spatial organization of FADs to reduce existing conflicts. For the former, efforts to retrieve lost material from FADs and the nylon used in surrounding nets should be increased after the season has ended by providing fishers with further incentives to collect lost gear. Regarding spatial conflicts, a plan could be implemented to define the number of FADs that could be deployed by each vessel, a measure that can be determined by the length of the FAD course line and the size of the vessel. Another recommendation has been to assign non-popular course lines to recreational fishers to minimize the spatial conflicts with their professional counterparts. Such recommendations form part of a new journey towards a revised co-management ecosystem-based approach for the dolphinfish fishery in Malta and Gozo.

4. CONCLUSION

Over the years Malta has been committed to continuously improving the management of its important dolphinfish fishery through an ecosystem-based approach. The successful implementation of EAF principles – including the collection of a long-term series of data, the implementation of a management plan with the participation of the fishing community, and regional agreements for a level playing field – has made a significant positive difference. Nevertheless, there must still be regular analysis of the health of the stock, the threats it faces, and its management and conservation.

According to the Secretariat of the Convention on Biological Diversity (2000) this type of approach recognizes that *'the ecosystem is a functional unit at any spatial scale... that humans are an integral part of many ecosystems… and requires adaptive management techniques.'* In the case of the Maltese islands, this is reflected by the representation of the two fishing cooperatives on the fisheries board, which allows fishers to voice their concerns. Given that *lampuki* is a key fishery for Maltese fishers, the fishing cooperatives have made a serious effort to achieve a more harmonized approach towards the species at the regional level. Engagement with the local fishing industry has also been fostered and maintained by local scientists, who join fishing trips to better understand the realities of the fishery and its management needs. Local knowledge shared by fishers – including the example of predation activities that are not yet factored in the stock assessments, as well as the shifting patterns of *lampuki* migration – has been essential in building the understanding needed to take an EAF.

However, the fishery needs to be managed on a regional level (in accordance with the EAF), to ensure that it is fished in a sustainable and environmentally friendly way and to guarantee it will be there for future generations. To reach the latter goal, it is essential that national management plans are supported by regional management plans. Such plans then need to be implemented and fully enforced, with enough resources provided for data collection and monitoring as well as enforcement of the management measures in place. The existing bodies at EC and GFCM level provide the bedrock for these management plans to be implemented at the regional level, with support from scientific advisory councils and basin control agencies. For example, the joint inspection schemes that are currently in place for trawling and bluefin tuna activities in the Strait of Sicily could provide a successful mechanism for inspections at regional level. A similar form of joint inspection could also be successful for the implementation of regional management of the common dolphinfish .

Further studies are needed to analyse the spatial distribution of dolphinfish throughout the Mediterranean Sea, since regional data on the fishery is limited. It may be beneficial to identify nursery grounds in order to manage fishing activities in these areas during breeding seasons to ensure the sustainability of dolphinfish stocks. Analysis of the bycatch species captured, specifically amberjack and pilot fish, could be implemented to gain a more holistic understanding of the fishery (FAO, 2005). Another study that could usefully be carried out would be to evaluate the natural mortality of the species, as well as its relationship with top predators. Stomach analysis of top predators such as bluefin tuna would help assess whether they are affecting the overall population of the dolphinfish fishery, and this would allow further studies on the natural mortality of *C. hippurus.* Ultimately, given the frequent conflicts on the high seas, further fisheries governance research is needed to identify how best to ensure a level playing field for all countries. It may also be beneficial to carry out further studies on the use of biodegradable material such as cork to decrease environmental impacts on the seabed, and to explore how to decrease conflicts both within Malta's 25 nm zone and on the high seas. Further studies on dividing the FAD lines into different lengths can also be undertaken to decrease the chances of conflicts between local fishers. Only through such enhanced ecosystem-based management at the regional level can fair competition and sustainability be ensured.

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Chapter 6: Implementing the ecosystem approach to fisheries through co-management: a case study of the Catalan sonsera fishery

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INTRODUCTION

The ecosystem-based management plan for artisanal fishing with boat seines (*sonseres*) in Catalonia aims to contribute to future efforts to promote sustainable development and integrated management by means of an ecosystem approach to fisheries (EAF). The EAF highlights the need to maintain ecosystem resources while identifying humans as an integral part of the process – which means the social and economic implications of each applied management measure must also be assessed.

The co-management system applied in the management plan for artisanal fishing with boat seines in Catalonia fits perfectly with an EAF ideology, empowering the stakeholders involved to achieve the best outcomes for marine resources in balance with the greatest possible human welfare benefits.

With the purpose of promoting dynamic and effective decision-making, a multi-actor management model has been implemented. This co-management committee has decision-making power and involves fishers, administrators, non-governmental organizations and scientists. The experience gained and lessons learned through years of scientific and operational monitoring may well prove to be an essential tool in formulating key guidelines for taking an EAF.

Catalonia's ecosystem-based management plan for artisanal fishing with boat seines also follows the recommendations of international fisheries management bodies and their related international agreements.

This case study aims to present the Catalan model as a paradigm to show how setting flexible and cooperative fishery management measures can help align economic and social needs with reaching maximum sustainable yield.

1. FISHERIES CONTEXT

Small-scale fishing with '*sonsera*' (from the Catalan '*sonso*', which refers to the two sand-eel species caught with small seine gear) is controlled by the co-management committee for the sand eel fishery, which has created its own management plan.

The *sonsera* fleet today comprises 26 vessels, each crewed by one to three fishers. The boats are no more than 10 metres in overall length, and do not exceed 75 kw in engine power. They are spread between seven fisher cooperatives on the central and northern coast of Catalonia (NW Mediterranean) (Table 1).

Table 1. Fleet composition.

FLEET COMPOSITION	
Fishing vessels	26
Fishers	75
Fisher guilds	7
Provinces	2 (Barcelona and Girona)

Boats operate on a daily basis, five days a week, going out to fish in the early morning when sand eels emerge from the sand.

Generally (Girona is an exception due to its marine topography) the fishing gear is composed of two long sidebands, called wings, up to 125 m long and 35 m high (60 m in Girona), and a central bag, the codend of which has a maximum length of 30 m. Attached at the end of each wing is a rope no longer than 100 m (200 m in Girona), and at the other end the codend has a cylindrical net extension from where the catch is removed (Figure 1).

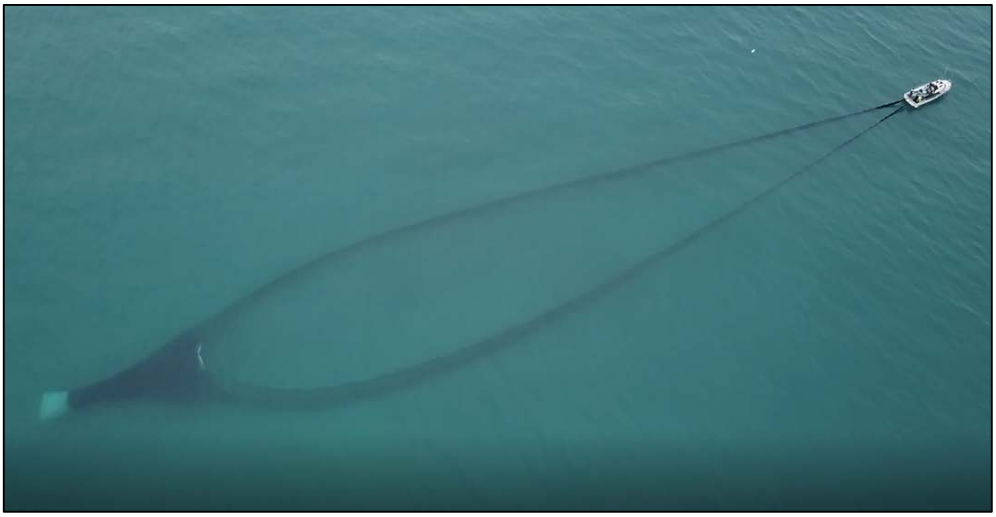


Figure 1. *Sonsera* gear, from wings to codend.

Fishing operations (Figure 2) take place in depths from 4 m to 30 m, and catches are made by forming a circle around the shoal and pulling the wings. This manoeuvring forces the fish to enter the codend with only limited contact with the bottom, which means the method has a low impact on habitats. In any case, scientific monitoring has shown that the *sonsera* fleet does not operate in areas with the presence of sea grass meadows, in particular *Posidonia oceanica* (STECF, 2018).

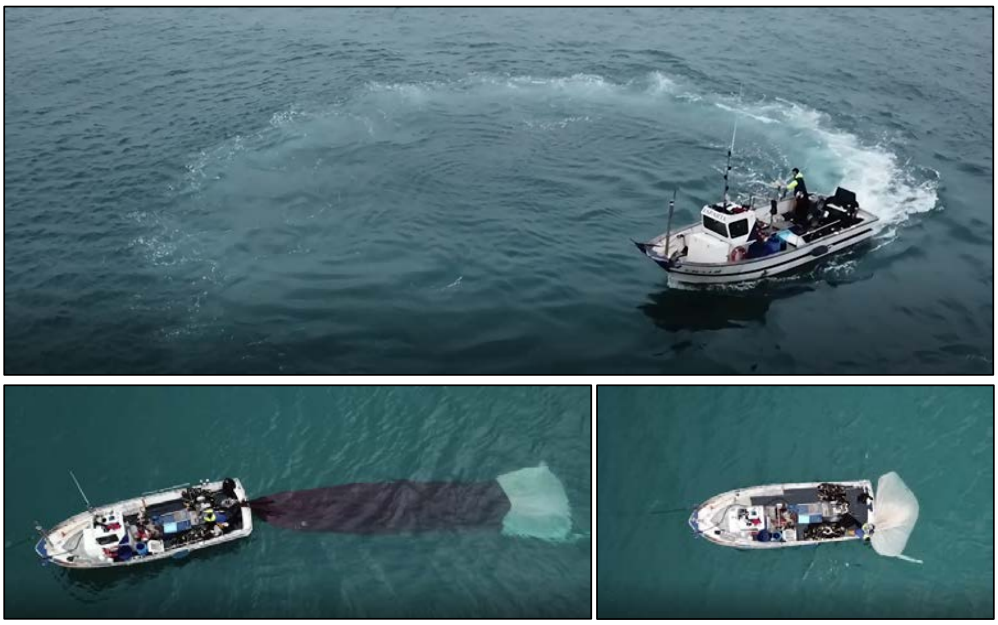


Figure 2. Details of fishing operations.

The map below (Figure 3) shows the location of the fishing grounds along the Catalan coast:

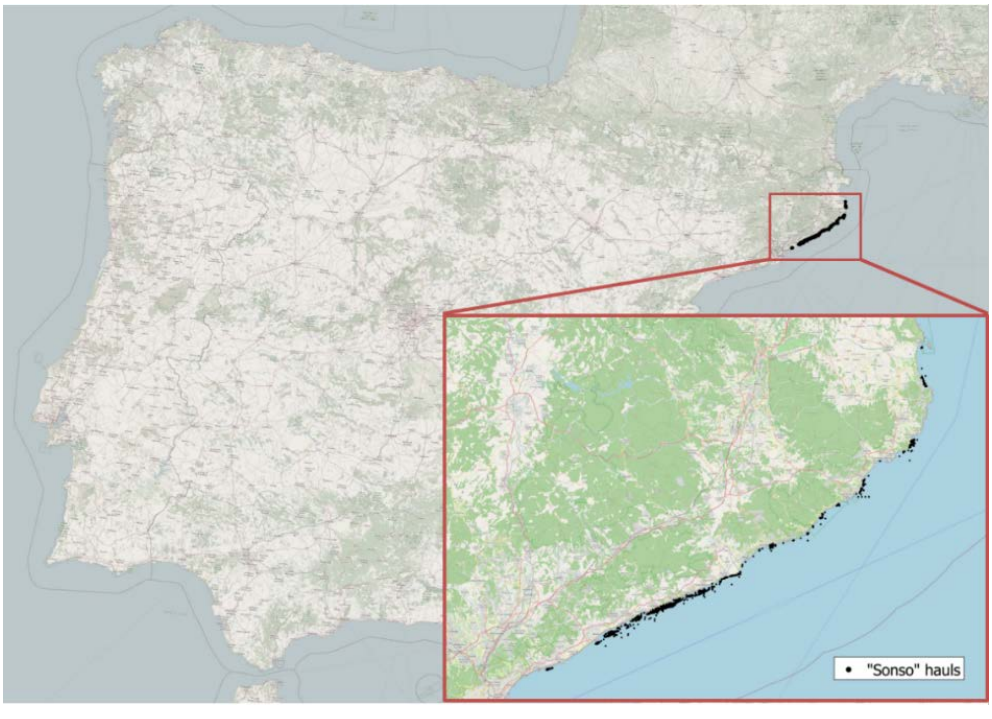


Figure 3. General chart of geographical distribution of fishing hauls. Source: Directorate-General for Fisheries and Maritime Affairs.

The small-scale seine boats catch less than 1,000 tonnes per year of sand eel (*Gymnammodytes cicerelus* and *Gymnammodytes semisquamatus* – both are locally known as 'sonso') (Figure 4). They also occasionally land very low quantities of *Aphia minuta* and *Crystallogobius linearis*, locally called '*llengüeta*'.

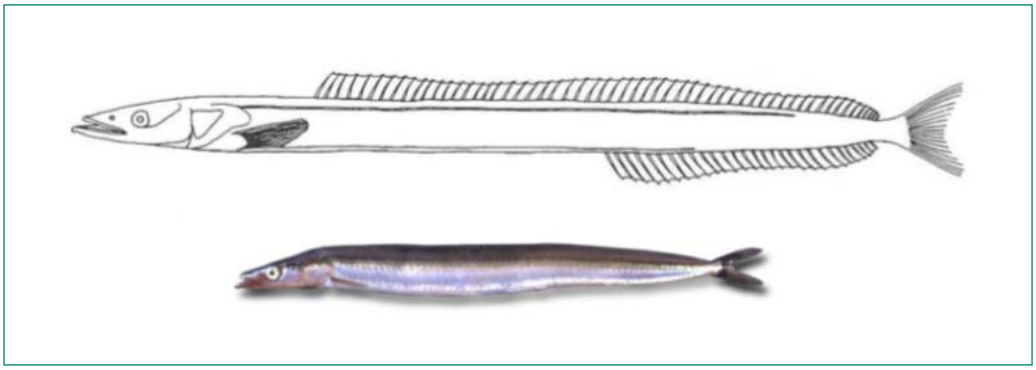


Figure 4. Adult *Gymnammodytes cicerelus* from Catalan coast.
Source: Sabates *et al.*, 1990.

The entire catch is sold locally, thanks to high demand from restaurants and domestic consumers. The average harbour market price for the last four years has been EUR 7.76/kg. The gross annual revenue of the fleet amounts to EUR 1 909 214, which corresponds to average annual landings of 245 894 kg.

Sand eel represents 98 percent of the total catch by weight in the *sonsera* fishery. It is a short-lived demersal species that occurs in depths of 0 to 15 m, in the area between Barcelona and l'Estartit (Girona). It is a winter spawner with a length at first maturity of 7.32 cm (the main species, *G. cicerelus*). Studies suggest this species probably feeds on plankton.

The scientific monitoring supporting the management plan and conducted by the Catalan Institute for Ocean Governance Research (ICATMAR) shows that the gear used by the sonsera fleet is highly selective, with an average bycatch volume of 2-3 percent compared to target species. Among the more abundant non-target species found in catches are *Pagellus erythrinus, Xyrichtys novacula, Bothus podas, Trachinus draco* and *Synodus saurus*. In any case, scientific monitoring (ICM, 2017) suggests that individuals from these species have a high survival rate when released alive at sea.

Given the general lack of information on the biology and status of sand eel stocks in the Mediterranean – the species has an extremely short lifespan (typically one year), spends a large proportion of the day buried, and its abundance depends strongly on abiotic factors affecting reproduction and recruitment– it is particularly challenging to ascertain the precise state of the local stocks.

The real-time scientific monitoring associated with the management plan is, therefore, the most reliable data source for assessment. The following information is extracted from the most recently published reports (ICM, 2019): i) the mean age of the catch (<1 year) indicates that the Catalan sand eel fishery is fully dependent on recruitment, ii) results from studies carried out on the relationship between spawning stock biomass and recruitment (SSB-R) of the sand eel fishery are seen as helpful for deciding the monthly total allowable catch (TAC) in the absence of common biological reference points such as maximum sustainable yield (F_{MSY}), iii) total catches have undergone a substantial decline in recent years, and iv) the highest number of females in an advanced stage of maturation or laying occurs between January and March.

2. MANAGEMENT CONTEXT

Building the basis

Artisanal *sonsera* fishing on the Catalan coast has been regulated since 1987, by the Order of 15 January 1987 which regulates fishing for G. *cicerellus* sand eels.

Council Regulation (EC) No 1967/2006 of 21 December 2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (MedReg), issued strong limits on the use of *sonsera* boat seines (among other gears), in terms of mesh size, depth and distance from the coast.

The provisions of the new Regulation came into force in May 2010, and consequently sonsera fishing risked a ban as it conflicted with articles 9 and 13 of the MedReg.

However, the same Regulation stated that, at the request of a Member State, the European Commission (EC) could authorize an exemption provided certain conditions were fulfilled. In this regard, a derogation could keep the fishery active if there was scientific justification and it was covered by a formal, fully-fledged management plan.

A proposal for a management plan was sent to the EC in 2010, with the aim of being granted an exemption. After some exchanges, a new version was sent in 2011. In June 2012, however, the proposal was finally rejected on the grounds of the scarcity of scientific data supporting it. As a consequence, the *sonsera* fishery was temporarily closed in April 2012.

The closure of the fishery produced a major crisis in the fishing sector, which asked for help from environmental NGOs (WWF and Greenpeace), the Catalan administration (Directorate-General for Marine Policy and Sustainable Fisheries of the Government of Catalonia), and the scientific community (Institute of Marine Sciences, ICM-CSIC).

The four groups of actors – fisheries, administration, civil society and scientists – started working together to reopen the fishery under a radically new framework that would ensure good governance (Lleonart *et al.* 2014). This is how an ad hoc body called the **Co-management Committee for the sand eel fishery** was created on 26 April 2012. Its goals included to achieve ecosystem-based management in the fishery.

The new participatory body established a unique fisheries management model focused on co-management, in which all the stakeholders actively participated, on an equal footing, in the decision-making process (Figure 5). The new co-management committee undertook the task of developing a new, more robust management plan proposal.

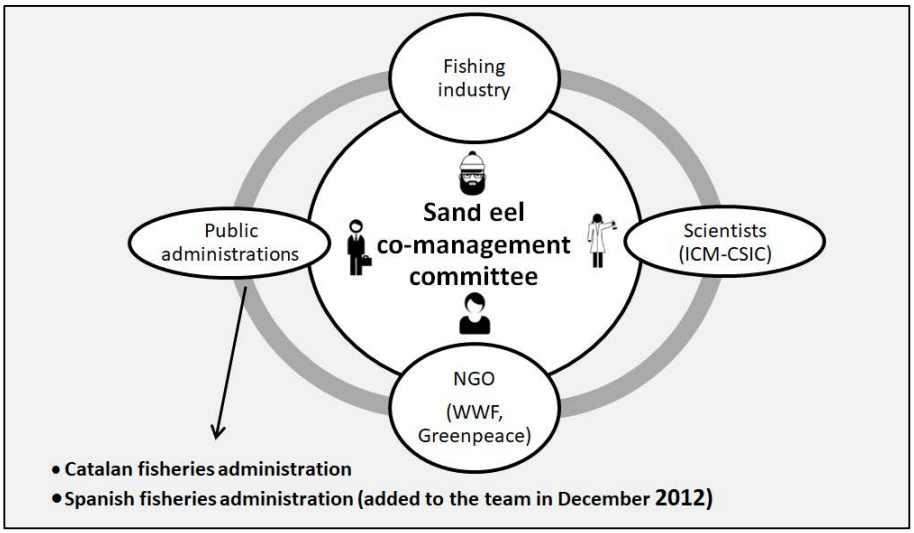


Figure 5. Co-management Committee for the sand eel fishery: composition and structure.

The first achievement came in May 2012 when, in order to get the data needed to develop the required management plan, the Co-Management Committee obtained authorization from the EC for 18 months of scientific fishing – provided it took place under very strict rules and included a significant reduction in effort.

During this first period of scientific monitoring, which was entirely funded by the fishing sector, the vessels were allowed to commercialize the *sonsera* fishery target species. Non-target species were prohibited from sale. (Today, bycatch is allowed only if it makes up, at most, 3 percent of the total volume landed.)

With all the stakeholders working together, each contributing their knowledge and experience to the process, the management plan was designed with the objective of securing sustainable fishing based on an ecosystem approach.

On 11 June 2013, the Co-management Committee received the WWF award for conservation merit in Wyoming, United States of America. One year later, on 20 February 2014 – on the basis of the results of the scientific monitoring, the quality of the management proposal, and a sustained awareness campaign on the new governance approach (meetings were held with the EC DG-MARE and other fishing sector actors, international symposia were attended etc.), the management plan received the European Commission's approval. In 2018, approval was extended for another four years – and, once the report sent by the Directorate-General for Marine Policy and Sustainable Fisheries was assessed by the Scientific, Technical and Economic Committee for Fisheries (STECF) and a favourable report having been issued by the European Commission, the regulation of exceptions has accepted a new three-year extension, until 2024.

Scientific monitoring repealing Article 13(1) of the Council Regulation (EC) No 1967/2006 provided up-to-date scientific and technical justifications to prove that the sonsera fishery fulfilled the requisites established. These are:

- Requirements of Article 4, 8(1)(h), 9(3)(2) and 23
- No fishing above seagrass beds of, in particular, *Posidonia oceanica* or coralligenous habitats and mäerl beds
- No interference with activities of vessels using gears other than trawls, seines or similar towed nets
- Be regulated in order to ensure that catches of species mentioned in Annex III, with exception of bivalve molluscs, are minimal
- Not target cephalopods.

In addition, Catalan administrators used historical catch records to prove that fishing activities would be carried out only by vessels already authorized – and thus guaranteed there would be no future increase in the fishing effort.

At present, scientific monitoring[2] continues within the context of the management plan in order to achieve a sustainable exploitation of the species. This uses three different data sources: i) official statistics from the Directorate-General for Marine Policy and Sustainable Fisheries of Catalonia, ii) daily catch reports from fishers, and iii) monthly sampling performed on board fishing vessels. This constantly updated information – on biological parameters (size distributions, length-weight relationships, growth and maturity stages, stock-recruitment relationships), by-catch composition, fishing effort, geographical distribution of fishing hauls, characteristics of the fishing grounds and gear used – is all analysed in order to diagnose, in real time, the condition of the stocks.

Co-management becomes the governance model for fisheries in Catalonia

On the strength of the successful sand eel fishery experience and other pilot case studies, in June 2018 the government of Catalonia adopted the first European legal framework regulating fisheries co-management: the **Decree on the governance model for professional fisheries** (Decree 118/2018 of 19 June 2018).

This decentralized and multi-actor decision-making model set the frame for multi-annual management plans and defines the structure and functioning of co-management committees, setting a multi-stakeholder co-management approach to fisheries as a general management mechanism in Catalonia.

The decree includes procedures for setting up the committees, their internal structure, composition and functions, the figures of the chair and secretary, the mechanisms for reaching agreements and voting, and the goals of the management plans and the associated socio-economic programmes.

But the main breakthrough under this new scheme is the formal devolution of decision-making powers from the administration to all the stakeholders involved in the committee. In this sense, the Catalan model establishes an equitable distribution of power among the four areas of co-management (fishing community, scientists, administration and civil society organizations). An area of 'other interests' can be established if it is justified and agreed upon.

The Co-management Committee for the sand eel fishery had to be slightly adapted to meet the provisions of the new Decree, as it predated the new legislation. Today though, not only does the *sonsera* management fit into the new governance approach, but five more co-management committees are actively working in Catalonia, further integrating the approach into national fisheries (Figure 6).

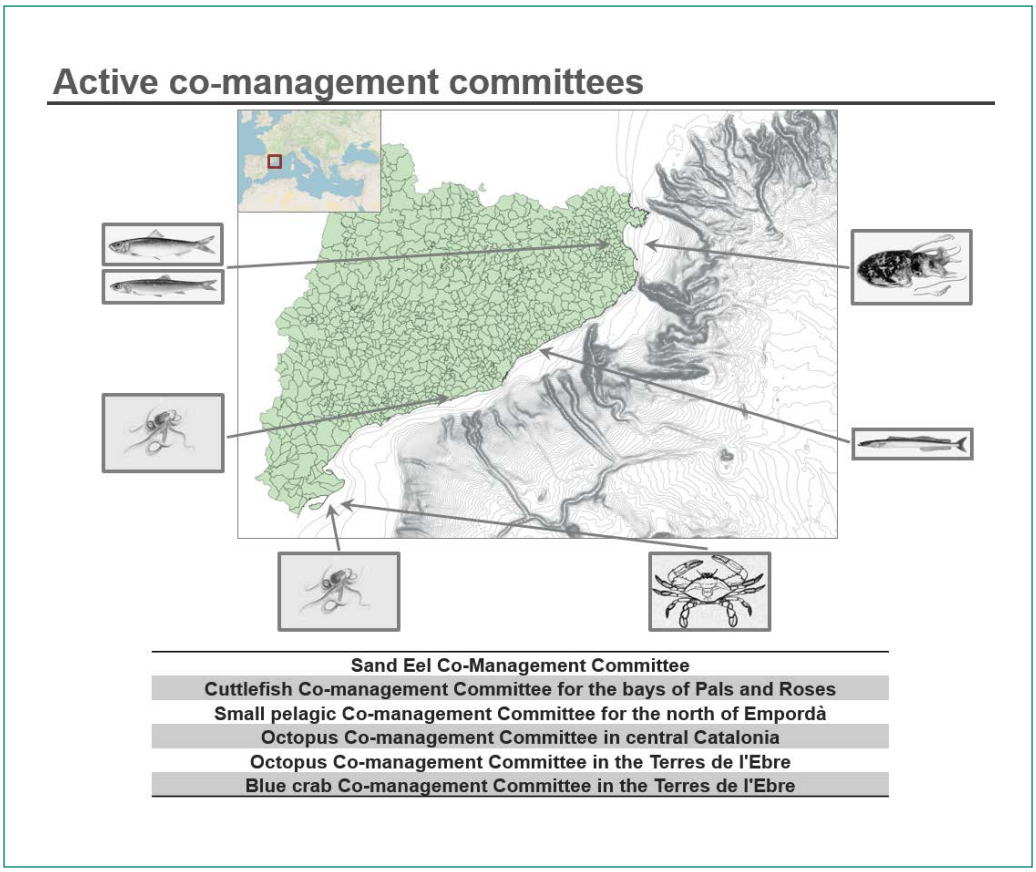


Figure 5. Co-management committees in Catalonia as of October 2020.

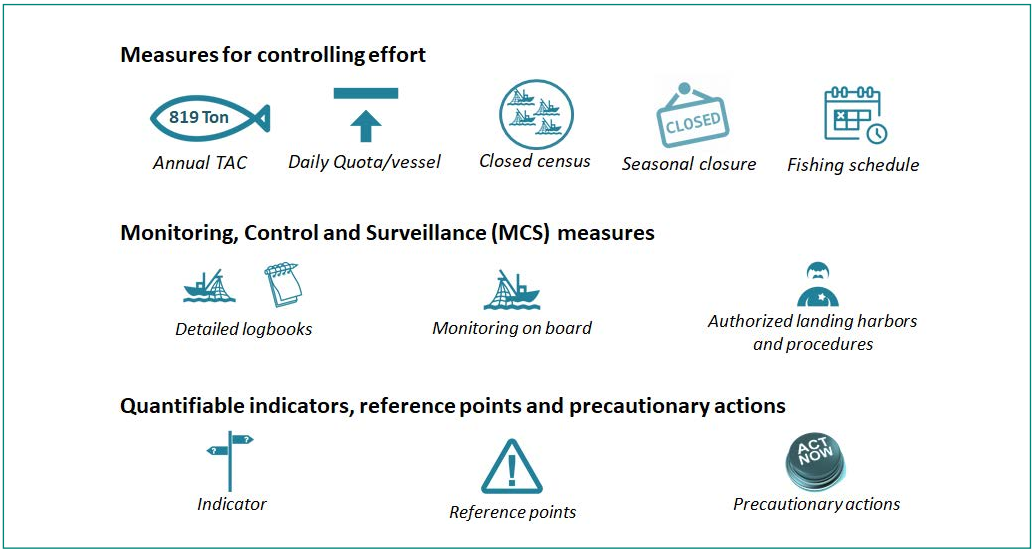
On 26 September 2018, the Catalan co-management fisheries governance model won an award for best practice at the GFCM-FAO High Level Conference on Small-Scale Fisheries in the Mediterranean and Black Sea held in Valletta, Malta.

3. ACHIEVEMENTS OF THE PLAN

Management plan

On 28 March 2014, Catalonia's first formal management plan for artisanal fishing with boat seines (*sonsera*) entered into force (Order AAM/87/2014 of 20 March 2014) and, once the extension of the Commission Implementing Regulation was approved, a new management plan document was published (Order ACC/155/2021) on 20 July 2021. Since then, the Co-management Committee for the sand eel fishery has managed fishing activities based on scientific and fishery data while taking into account socioeconomic parameters, thanks to a scheme which is flexible enough to enable real-time modifications in its technical measures to adapt them to a dynamic ecosystem and human context (Figure 7).

The management measures adopted



Annual TAC set at 819 tonnes (based on 2012 landings)
Quotas/vessel/day
2.5 months of annual fishery closure during the spawning period
Two groupings of vessels that fish every other week (halving the number of boats working simultaneously)
Technical and scientific monitoring
Regulated marketing channel: first sale has to be held at the fishing auction (in order to control all landings)
Total emergency closure of the fishery or shortening the annual fishing season on scientific advice basis
Other former rules were maintained: restricted fishing time/day, special licence required, and technical characteristics of the gear
Additional sanctions imposed by the Co-management Committee for lack of compliance

Figure 7. Examples of management measures adopted by the Co-management Committee for the sand eel fishery.

As has been evidenced by the landings of the target species, the establishment of the co-management committee marked a breakthrough for the fishery, both in terms of catches and of incomes. Table 2 and Figure 8 clearly illustrate the success of the management plan.

Historical landings of sand eel (*Gymnammodytes cicerelus*)				
	Before co-management committee (estimate)	**2012 First year of the co-management committee** (real data)	**2017 Year with very low fish abundance** (real data)	**2019 Year with normal fish abundance** (real data)
Catch (tonnes/year)	1 600	819	54	394
Fishing days (per vessel)	200	95	65	93
Average price (EUR/kg)	0.75	2.07	14.85	6.99
Total income (EUR)	1 200 000	1 696 394	804 252	2 754 117

Table 2. Historical landings of the main fishing resource.

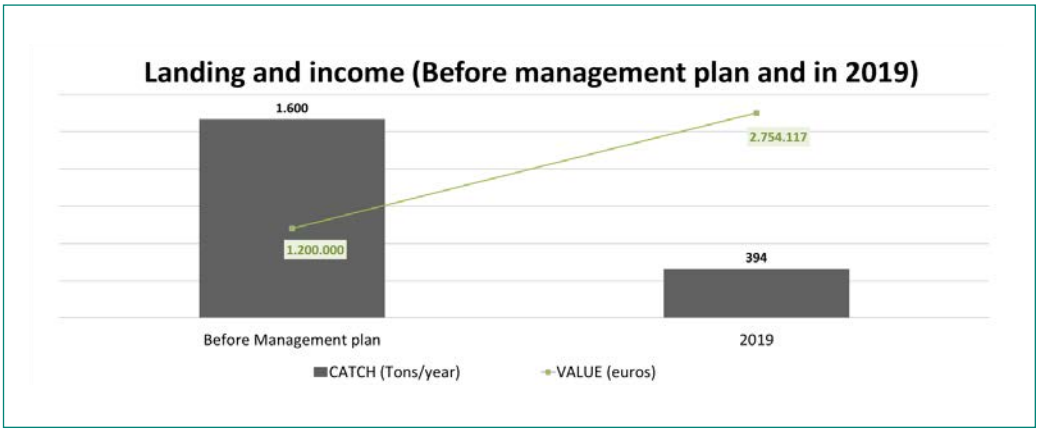


Figure 8. Landings and total income comparisons (before and after creation of co-management committee).

Participatory mechanisms

From the beginning, even before the committee was supported by a strong legal framework, all four groups within it have had an equal say in decision-making, and the Director-General for Fisheries legally endorsed the agreements as his own. Today, the co-management committee for the sand eel fishery is fully adapted to the system established by the governance Decree, being already an officially recognized managing body with decision-making powers which works under a transparent legal framework.

The management measures are adjusted in monthly meetings (some measures literally overnight), usually by consensus agreement and always according to the criteria laid down in the flexible management plan.

The committee is composed of two different structures with different functions and tasks:

- The Technical Committee, an essential working body, is composed of eight representatives (two from each stakeholder group: sonsera fishing sector, scientists, NGOs and fisheries administration). It meets monthly and its tasks include the following:
  - Carry out continuous technical monitoring of the fishery.
  - Coordinate the annual stock evaluation (scientific study).
  - Adjust the adaptive management plan based on the monitoring results.
  - Develop protocols and measures for the fishery and ensure compliance.
  - Establish disciplinary measures for failing to comply with the negotiated agreements.

So far, all the agreements have been achieved by consensus – although there is, if necessary, a voting procedure.

- The Co-management Committee Plenary consists of eight members from the five stakeholder groups (overall fishing sector, sonsera fishing sector, scientists, NGOs and fisheries administration). It meets annually and also whenever proposed by at least two members of the Technical Committee. It is the sovereign body which validates the high-level agreements (such as the approval of the management plan or the closure of the fishery) reached by the Technical Committee.

While the committee must have only a limited number of members in order to allow for smooth decision-making, all the fishers from the sonsera fleet have attended at least one meeting as observers (who may take the floor but not vote).

Daily quotas and other technical measures: a good example of participatory management

The annual TAC is set at 819 tonnes, but in recent years total landings have been well below the maximum fishing possibilities. This is because after several years with low catches and even fishery closures, fishers apply precautionary measures to ensure the sustainability of the resource in order to maximize the chances of there being enough for the next year.

Nevertheless, according to the results of the scientific monitoring, the sand eel population does not seem to respond to conventional fisheries management; the mean age of the catch (<1 year) indicates that the population is fully dependent on recruitment which itself depends on environmental biotic and abiotic factors.

Accordingly, there is not enough scientific information supporting an annual TAC based on the MSY. This means that daily quotas need to be set in real time, at the beginning of each season, and be reviewed and modified by the co-management committee through monthly meetings, allocating a daily quota per vessel for the next month depending on fish abundance estimated from scientific monitoring.

Prior to each season, in January and February, sampling is increased with fishers' echo sounders coordinated with the scientific monitoring. Based on the data collected, at the year's first meeting of the co-management committee, the fishers and scientists propose a starting quota – always with a precautionary approach – with the option of increasing it later in the year as individuals grow, if the population status allows.

During the following monthly meetings, fishers propose a monthly quota to the committee, based on the previous month's catches and their perception of the status of the resource. Sometimes, if needed, before making their consensus proposal, the fishers carry out a preliminary vote among themselves.

Once the proposal is made it is discussed by the committee, which looks particularly carefully at its sustainability on scientific grounds. Usually the proposal is accepted, since the sector is aware of overfishing risks and ensures sufficiently precautionary measures.

Judging by the landings of the target species, the establishment of the Co-management Committee has marked a breakthrough in the fishery, both in terms of catches and incomes. Figures in Table 2 and Figure 8 clearly illustrate the success of the management plan. The data collected at the first annual meeting of the Co-management Committee to propose a starting quota is always used to support a precautionary approach, with the option to increase it later in the year, if population status allows, as individuals grow.

During the following monthly meetings, fishers first propose a monthly quota to the committee, according to the previous month's catches and their opinion of the current status of the resource. If needed, before making the consensus proposal, fishers carry out a preliminary vote among themselves.

Once the proposal is launched, it is discussed in the committee, which particularly addresses its sustainability on scientific grounds. Usually the proposal is accepted, since the sector is aware of overfishing risks and ensures sufficiently precautionary measures.

Since F_{MSY} for the resource is not known, local knowledge is the basis for a precautionary first proposal. The precautionary approach is reinforced by the fact that fishers continuously finetune quotas downwards to ensure a fair market price. In any case, proposals are always discussed at the monthly committee meetings among all members according to updated scientific information.

For social purposes (to maximize employment) daily quotas are allocated per vessel based on crew size. Initially there were only two crew members per boat, but this measure has led to an increase in jobs on board as quota increases with crew size.

To allow for flexibility, a 10 percent excess in daily quotas is allowed, although this has to be compensated for at the end of the week. Lack of compliance is sanctioned with a drastic reduction of the quota, worth twice the weekly excess.

Another measure that introduces flexibility is the possibility of operating vessel associations that conduct joint management of the quotas.

Despite all the measures discussed above, and because sand eel stocks are largely dependent on environmental conditions, there have been years that have seen an alarming reduction in catches. In such cases, the committee follows robust harvest control rules – fishery closure if safety threshold for catches are not met, or a shorter season on the basis of scientific advice:

- If catches are below 75 percent of the quota the Committee imposes a reduction of half of the quota planned for the following month.
- If catches are below 50 percent of the new reduced quota, the Committee closes the fishery the following month, keeping a scientific experimental observation of CPUE.

It must be emphasized that harvest control rules included in the management plan were previously agreed and approved by the Committee.

During the years in which the management plan has been in force, the fishery has been closed several times due to a drop in sand-eel apparent abundance, always on the initiative of the fishing sector. In these cases, the vessels were not allowed to fish with other gears, so they remained inactive until the resource once more became accessible to the fleet.

There have also been several agreements to reduce quotas, especially in recent years, in which cuts have been applied over several months according to the biology of the species and also for commercial reasons. As an example, lower quotas have usually been established during the months when sand eels have only grown to small sizes, to ensure that enough recruitment reaches maturity and spawns.

Finally, an annual closed season of 2.5 months is enforced every year, from 15 December to 1 March, to respect the spawning season of the two sand-eel species.

4. CONCLUSIONS

Some key aspects of the sand eel co-management scheme – and lessons learnt since its inception – are summarized below.

Turning a crisis into an opportunity: the trigger

Fishing with "sonsera" risked becoming illegal in April 2012.

Faced with the closure of their fishery, fishers took the initiative to get themselves out of the impasse. This enhanced the sense of co-responsibility in the fishing sector that was key to the success of the process.

There are many elements in the current management plan that rely on the sector itself, such as the organization of the fishing work schedule, the daily management of quotas per vessel, or the ways to compensate for potential overfishing. All this can only be achieved if the sector has a high level of compliance with and commitment to the system. The fact that the fishery operates under a closed census of only 26 units and that fishing for sand eel can only be done with *sonsera* gear means there is a strong incentive for fishers to capitalize on the benefits of good management.

A multi-stakeholder team

The multidisciplinary committee established a new fisheries management model.

A key reason for success is the participatory management scheme that includes very different stakeholder groups contributing their diverse knowledge and skills, from legal and administrative support to negotiating skills, dissemination actions, science or traditional and practical knowledge.

For instance, the engagement of civil society organizations – in this case, environmental – has given great institutional impetus, has been valuable for facilitation, has increased dissemination capacity, and offers an essential advisory service.

High meeting frequency, the key to adaptive management

The Co-management Committee for the sand eel fishery meets once a month.

Ensuring information flow and frequent meetings is crucial to allow for the adaptability and agility needed to achieve real-time management.

On the other hand, meetings contribute to teambuilding through enhancing mutual trust and understanding, making it easier to find shared solutions and helping participants dismantle prejudices and value the knowledge of all members.

Transparency and openness

All the sonsera fishers have attended a Co-Management Committee meeting at least once.

This reinforces transparency and promotes confidence in the system for all actors, even if they are formal representatives on the committee. Besides, good internal communication is essential. The Technical Committee has always operated smoothly, ensuring swift communications and notification of proposals, through email, videoconferences and other means whenever necessary.

Reinforced enforcement and sanctioning power

The Technical Committee can impose disciplinary measures.

Although under the co-management arrangement infractions have fallen dramatically, they still exist. Thus, the Technical Committee acts as an ex-officio sanctioning body, often after information has been brought to its attention by the fishers themselves. This adds to the general formal fisheries sanctioning scheme in force in Catalonia.

After detecting clear violations of the rules, the committee meets and proposes the sanction, which is generally a reduction in the quota or even a temporary cessation of activity. Usually the fisher is called for a hearing and agrees with the punitive measures.

Currently, the committee is working to implement conservation incentives to move from imposing sanctions only to also reward good practices, as provided for in the Catalan governance decree.

Adaptive flexible legislation allowing for real-time adjustments

The sonsera management plan was designed to be flexible and not too prescriptive.

The order which regulates the management plan must be as flexible and generic as possible, so that agreed adaptive adjustments in management measures can be readily adopted as an administrative decision.

Thanks to the flexibility of the plan, committee members can coordinate the regular scientific monitoring, adjust the adaptive management plan based on the monitoring results, assess compliance against management measures, and suggest appropriate sanctions in case of non-compliance. In fact, the committee can even change its own composition.

In the end, thanks to its open management plan, the committee can deliver routinely adaptive management.

The socioeconomic programme: a task to be developed by the multidisciplinary team

The Co-management Committee for the sand eel fishery manages fishing activities based on scientific and fishery data and socioeconomic considerations.

As provided for in the Decree on the governance model for professional fisheries in Catalonia, management plans will ensure an integrated scope by accounting for bioeconomic and social considerations. Each plan, therefore, has to develop a specific socioeconomic programme consistent with the relevant biological and ecological conservation requirements that should guide management decisions.

Scientific monitoring at the core

Management is strictly based on the results of the scientific monitoring.

Being able to count on a recognized research centre (ICM-CSIC) as a member of the Co-management Committee, tasked with carrying out the scientific monitoring and co-deciding on decision-making, provides strength and reliability to management measures.

During the first few years of the Co-management Committee, the cost of scientific monitoring and assessment was covered by fishers out of the benefits generated by the fishery. Nowadays the scientific work is supported by the Catalan administration and the European Maritime and Fisheries Fund (EMFF).

The Catalan co-management models work at the scale that matter, which is the scale of the fisheries, most of them quite local. Therefore, it soon became obvious that a specific approach to scientific monitoring and assessment should be established to capture the particular needs of the new governance approach. The new Catalan Institute for Ocean Governance Research (ICATMAR) is an operative scientific body that was born as a partnership between the ICM-CSIC and the Catalan fisheries administration in response to this challenge.

Searching for the highest economic yield (fishing for euros, not fish)

The Co-management Committee was a breakthrough for the economic profitability of the sand eel fishery.

The sonsera management plan clearly shows that the concept of maximizing economic yield is not at odds with ecosystem-based management – in fact, the reverse is true.

Historically, sand eel was consumed (and known) at a very local level, and prices were very low (with 'sonso' often used as cheap bait for other fisheries). Stringent regulations under co-management (e.g. complete closure of the black market) and an efficient bioeconomic approach focused on improving commercialization and strictly controlling supply has resulted in a boom in demand and price. Nowadays, sonso fits a completely different niche market than it did a decade ago. This has allowed fishers to keep decent profits even during the worst years of the fishery.

Co-management brings adaptive management, which opens the door to bioeconomic management and delivers an ecosystem approach to fisheries

High fishing selectivity and low catches of the target forage fish species, that sustain a rich and fragile coastal ecosystem, ensure ecological sustainability.

Fishing operations are carried out in clear habitats of coarse sand; bycatch species represent a negligible share of the total catch (between 2 percent and 8 percent), and individuals are mostly released alive.

Adaptive management is also a tool for bioeconomic management, aimed at adjusting fishing effort and quotas in order to reconcile biological sustainability with keeping overall profits high while minimizing time at sea. The result has been to limit landings well below the annual TAC in order to i) keep prices high, and ii) maximize spawning success by allowing enough mature individuals to survive until the breeding season. Mediterranean

sand eels are a crucial forage species in the highly oligotrophic Catalan coastal ecosystem, and sustain vulnerable species such as the European shag, *Phalacrocorax aristotelis*.

Besides these general positive lessons, the following reflections are useful food for thought for future co-management developments:

Human and financial resources are crucial

A dynamic co-management scheme delivering an ecosystem approach to fisheries undoubtedly requires sufficient financial investment in scientific research and human capacity. Besides, it also relies on strong commitment – in terms of considerable personal involvement – from committee members, in particular in the Technical Committee (responsible for the real-time monitoring and adjustments).
In Europe, the EMFF provides substantial co-financing mechanisms to support scientific monitoring and assessment.

Joint quota management through vessel associations is a double-edged sword

Under normal circumstances, joint quota management through the partnering of a few individual vessels is a powerful tool to optimize quota consumption: it helps to guarantee supply and, consequently, keep a stable market price. But it has been noted that in times of resource scarcity it is beneficial to remove vessel associations. This way the boats with less fishing skills will not be able to benefit from the others. In a context of resource scarcity if a vessel does not reach its quota – something likely to happen since it is more difficult to find the resource – it cannot take advantage of a possible excess capture from another more expert fisher. This results in less pressure on the stock.

Co-management structures need to be clearly defined

At the very beginning, the committee was created on an ad hoc basis with an excessive number of representatives and without clear decision-making procedures. This led to some initial problems, with some interests external to the fishery questioning the legitimacy of decisions.

It is essential to limit the number of representatives attending the meetings to ensure these are dynamic and efficient. On the other hand, the establishment of voting procedures is necessary for when consensus is not reached.
This situation was overcome after the Decree on the governance model for professional fisheries – providing, inter alia, for decision-making procedures and the composition of co-management institutions – came into force.

Never underestimate anthropological issues

Currently, daily quotas for sonso are low as a precautionary measure to maximize reproductive success in an extremely short-lived species, but also due to marketing planning (keeping prices high). The daily catch is achieved with very few hours at sea, and activity takes place every other week.

While it is rewarding in terms of overall economic profits and improved quality of life (more free time), some fishers find fishing under such conditions rather 'boring' and report that they miss the traditional 'hunter-gathering' life. Others, by contrast, having more free time now invest it in improving marketing and commercialization.

Real stakeholder co-decision, with well-grounded alliances among the sectors involved and a transparent participation and decision-making process, results in a holistic approach that ensures the well-being and equity of people while maintaining productive fish stocks within healthy marine ecosystems.

The Catalan model of fisheries governance based on co-management committees delivers on the UN's 2030 Sustainable Development Goals 1, 2, 3, 8, 10, 12, 14 and 16.

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Chapter 7: Co-management experience for the transparent goby fishery: en route to the ecosystem approach to fisheries

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1. INTRODUCTION

The fishing community of the Balearic Islands (Spain, Western Mediterranean) has been a pioneer in generating its own regulations for the sustainable management of fishing activity and the protection of marine resources. It established a regulatory framework adapted to the current needs of the fishing sector and the conservation of its ecosystems, which was also geared to achieve the principles of the European Union's Common Fisheries Policy.

The transparent goby fishery is considered as a 'special fishery' by the European Commission (Anonymous, 2004). 'Special fisheries' are permitted in restricted areas of the western Mediterranean where the resource is abundant and traditionally exploited, managed locally under special management plans. In Mallorca the transparent goby fishery is an important seasonal resource for the fleet, which is allowed to catch the species from mid-December to the end of April. This fishery is one of the key métiers (sensu ICES 2003) forming part of the rotating system for the small-scale fishery of Mallorca: it is a valuable catch – transparent goby is considered a delicacy – and is caught in winter, when other fisheries are not very productive (Palmer *et al*., 2017).

Our case is a seasonal small-scale fishery based on the recruitment of pelagic neotenic fishes that are less than one year old and which have two spawning periods corresponding to summer and winter. In winter the spawning fish aggregate for reproduction and are fished, while in summer spawning occurs in deeper waters and is not exploited. The exploited fraction are therefore spawners that were born in the previous summer (Iglesias and Morales-Nin, 2001; Morales-Nin *et al*., 2017). This peculiar life cycle and the dependence of the fishery on seasonal recruitment means that it cannot use current population evaluation methods, and stakeholders must focus on maintaining sustainability in their practices.

In this contribution we describe the gradual evolution of the management of this traditional fishery, from practices focused on maximizing yields, to a more ecosystem-based approach to fisheries (EAF) management. Due to the nature of this seasonal fishery, the Balearic Islands managers (Direcció General Pesca and Medi Marí DGPMM) have adapted to the new European Union regulations and increased stakeholder involvement in the management process. The management relies on the best available knowledge to inform decisions, and applies precautionary measures. Our aim in this work is to explore how a participatory approach can be successfully used in the management of a special fishery in the context of a changing environment.

2. FISHERY CONTEXT

In the Balearic Islands, boat-seine nets known as '*jonquillera*' are used to catch two very similar species of pelagic gobies, '*jonquillo*' (*Aphia minuta*) and '*caboti*' (*Pseudaphya ferreri*). The fishery is artisanal, selective and highly commercial.

A part of the artisanal fleet of Majorca, the largest island, focuses its winter and spring activity on catching shoals of these species in coastal waters at depths between 10 and 30 m (although specimens are also found in deeper areas). Fishing takes place on sandy detritic bottoms throughout Mallorca: it is most frequent in the bays of Palma, Alcudia and Pollença, as well as on the southwest coast of the island.

2.1 The target species

The transparent goby '*jonquillo*' (*Aphia minuta*, Risso 1810) is a pelagic neritic goby common in the European Atlantic (ranging from Gibraltar to the Norwegian coast of the Baltic Sea) and in the Mediterranean and Black Seas (Miller, 1986). However, the species is not found along the North African coast (La Mesa *et al*., 2005). It is a small fish (< 60 mm in the Mediterranean Sea) with a lifespan of approximately one year (Buen, 1931). From December to April this progenetic species gathers in bays to spawn in shoals close to the bottom (5 m to 40 m deep), while a second spawning season occurs from September to October in deeper areas (40 m to 90 m) outside bays (Iglesias and Morales-Nin, 2001). The breeding fish quickly die after spawning (La Mesa *et al*., 2005).

The *jonquillo* population targeted in Mallorca consists of fish from 2 to 8 months old (Iglesias *et al*., 1997). Another two gobies which share the *jonquillo's* pelagic lifestyle and its morphological and evolutive traits (Kon and Yoshino, 2002) are secondary species of the fishery, the '*caboti*' (*Pseudaphya ferreri*) (Buen and Fage, 1908) and the '*cabot de vidre*' (*Crystallogobius linearis*) (von Düben, 1845). *Jonquillo* is popular in the Mediterranean region and can fetch high prices at market (from EUR 20 to 40 per kg first sale price depending on the proportion of *jonquillo* to other species in the landing).

The fishery exploits a short-lived species (< 1 year) which reproduces when it is 4 to 5 months old (Iglesias and Morales-Nin, 2001), and thus depends on recruitment success, which is subject to annual variability. A depletion model is used to estimate abundance, similar to the stock depletion model used by Baino *et al*. (2001) for the Thyrrenian *Aphia minuta* fishery, which is still in operation.

2.2 Jonquillera: traditional boat-seine net

The *jonquillera* shooting gear consists of three main parts (bands, sleeve and codend) made of six net pieces of about 25 m in length, with a decreasing mesh size as they approach the bottom, called '*randa*'. The bands, which start from the codend, have a length close to 90 m and are made up of four pieces which also have a decreasing mesh size towards the codend. The top rope is set with floats and the bottom with leads, and the height of the net in action is about 7 m.

The net pieces have a mesh size ranging from 40 mm to 3 mm, and use nylon as a base material. The seine net is launched from a boat over the area to be fished, and hauled with the boat at anchor pulling the lines up through bow and stern rollers.

The procedure means this fishing is highly selective – and in any case the fishers are not interested in catching other species, because it lowers prices. Sometimes, because of the concentration of resources in large schools, the drop of a single net can be enough to reach the maximum daily catch established by local legislation. The target species makes up almost 100 percent of the total catch, consequently discards are practically non-existent.

2.3 The fishing fleet and effort

The fishing fleet in the Balearic Islands (GSA05) is composed of 297 boats: 85 percent are involved in small-scale fisheries (SSF) (which employ 530 people) and 12.8 percent are trawlers, with the rest using different techniques (DGPMM survey data, December 2019).

In most sustainable SSF, boats alternate between several mètiers during the year according to resource availability, market demand, and other factors such as local environmental characteristics and interaction with other fishing gears (Maynou *et al*., 2011). The traditional boat seine fishery is responsible for 15 percent of the islands' fishing activity. Only vessels from the fishing guilds of the 15 ports allowed to fish this resource are able to request the right to participate in each fishing season. The number of authorized vessels varies each year to a maximum of 55 – there were 39 active vessels in 2017–18 and 2018–19, and 40 in 2019–2020. These numbers have not changed significantly since 1982, and represent around 13 percent of the fleet (Iglesias *et al*., 1994).

The fishery is active from mid-December to April when the schools of *jonquillo* come into the bays; they are detected using echo sounder devices and are easily identified because their schools do not disaggregate. Once a school is detected, it is captured with a seine net on a bottom of sand, pebbles, or flat rock in depths from 10 m to 30 m. The vessels engaged in the fishery range from 5 to 12 m in length and have engines of between 20 and 155 HP.

Boat size and engine power are not directly related to fishing effort, probably because the vessels in the fleet are relatively similar. There are minor variations in length but, although the differences in horsepower are slightly more significant, the more powerful boats do not produce higher daily outputs or make more trips per season.

There are two main sources of information for estimating fishing effort: the compulsory skipper log-books, and the daily sales registers on the fishing wharf, the only authorized first-sale location in Mallorca (Table 1). The total number of days fished varies depending on the month and also on fishery closures. Another measure of effort is the number of hauls by fishing day. A DGPMM observer who conducted 66 daily on-board surveys (for a total of 229 hauls) determined that the number of hauls conducted each day per vessel was 3.47 ± 0.21SE (RANG: 1-7) (DGPMM ump.dat.).

Balearic regulation fixes the catch quotas per season, at a maximum of 40,000 kg for all gobies. If these quotas are exceeded, the season is brought to an end. These are based on the daily quotas that were self-imposed by the fishers before the management plans came into operation: their purpose was primarily commercial rather than to regulate fishing effort, with the aim of keeping market prices stable (see below).

2.4 Temporal evolution of the fishery

The traditional *jonquillo* fishery has been in operation for many years, with Sañez-Reguart (1791) and Habsburg-Lorena (1887) providing the first information on it. It has changed little over time, but in recent decades a series of regulations have been introduced (Table 1) that have altered its model. Strict controls were required due to its seasonal nature, because it was a highly valued resource on the island of Mallorca and because it could be captured at the same time as other species in the larval-juvenile stage: since the 1986/87 fishing season, the DGPMM, in conjunction with the fisher guilds, has fixed a closed season (Morales-Nin *et al*., 2010).

According to EC Regulation 1967/2006, boat seine and shore seine fisheries are severely restricted (articles 4.1 and 9.1), although they are allowed (articles 4, 9, 18 and 19) if a multi-annual management plan is developed and approved by the Member State and the European Union. Consequently, the Management Plan for Fishing with

Traditional Boat Seines in the waters of the Balearic Islands (Decree 17/2009 and Decree 46/2013) was developed for the two fisheries targeting *jonquillo* and *Spicara smaris*. This specific regulation was established because of the socioeconomic importance of the fishery, and because of its possible impact on other fisheries. The results of scientific monitoring and input from the fisher associations concerned were taken into account during its development.

The objectives of the management plan fit within the framework of an EAF, and are stated as follows:

(i) To provide long-term high yields consistent with the historic maximum registered yields and to guarantee a low risk of *Aphia minuta* and *Spicara smaris* stock collapse.

(ii) To maintain the effort level and to avoid exploiting other less selective and overused fishing equipment.

(iii) To maintain a seasonal summer closure of the *jonquillo* fishery to protect the May to December spawning season.

The management plan was developed to satisfy the European Union special fisheries requirements. Its different phases were informed by and jointly discussed with the stakeholders, although the final rules were fixed by the DGPMM. While the first objective may seem to favour maximizing yields, in fact the quotas are fixed based on previous landings and maintain the status quo.

Table 1. Reports and management measures for the Mallorca transparent goby fishery.

Year	Item
1791	Description of the fishery by Sánchez-Reguart
1887	Balearic Islands fishery described by Archiduke
1986/1987	A fishing ban is established for the *jonquillo*. Resolution of the Council of Agriculture and Fisheries, of October 21, 1985, which establishes the obligation of an express authorization to fish for *jonquillo*.
1995	European Union deregulation (Council Regulation (CE) No. 1626/94)
2006	European Union Mediterranean regulation (Council Regulation (EC) No. 1967/2006 of 21 December 2006, on management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea)
2009	Balearic islands new regulation Decree 17/2009 of 6 March, which establishes a management plan for fishing with traditional boat seines in Balearic waters
2013	Co-management and daily record fishing established Decree 46/2013 of 4 October, which establishes the Pluri-island Management Plan for Fishing with Traditional Boat Seines in the waters of the Balearic Islands
2019	New regulation Decree 19/2019 of 15 March, which establishes the Pluri-island Management Plan for Fishing with Traditional Boat Seines in the waters of the Balearic Islands

2.5 Landing trends

The data series of catches covers the fishing seasons from 2001/02 to 2019/2020 (Figure 1), although the registers mix *jonquillo* and *caboti* together in line with commercial sales. There has been a significant variation in annual catches, from a maximum of 40.1 tonnes in 2008/09 to minimums of 9.4 tonnes in 2006/2007 and 4.4 tonnes in 2011/2012 (Table 2).

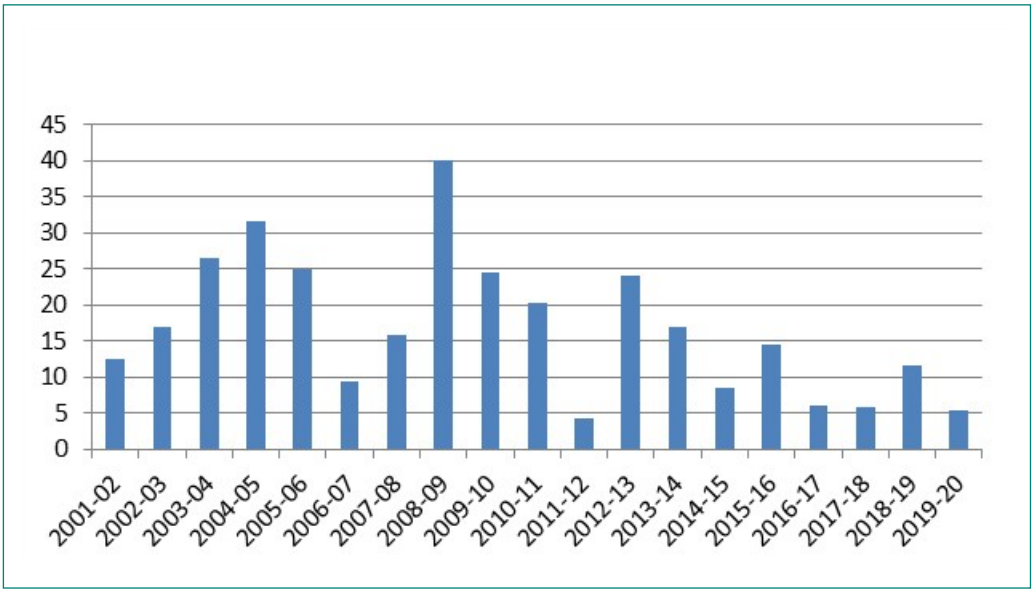

Figure 1. Evolution of the annual catch (tonnes) for the transparent goby fishery (captures of *jonquillo* and *caboti* are reported together).

In the fishing seasons from 2015 to 2017, the effort (fishing days) was reduced from 593 to 231 and 266 fishing days respectively, estimated from the sales registers (Table 2). However, the logbooks and sales registers show different results for each variable measured, so exact figures cannot be determined.

Table 2. Monthly catches and sales from compulsory logbook reports and from sales registers for *jonquillo* and *caboti.*

Fishing season/ month	December	January	February	March	April
2015/16					
Daily capture by logbook (kg)	2 020	5 018	3 673	2 955	872
Effort by logbook (days)	103	190	156	107	35
Mean capture by boat per day from logbook	19.67 ± 2.64	26.41 ± 2.04	23.55 ± 2.24	27.61 ± 2.84	24.91 ± 5.2
Daily sales on the fishing wharf (kg)	2 175	4 398	3 376	2 095	152
Effort from the number of daily sales registers (days)	124	204	171	89	5
2016/17					
Daily capture by logbook (kg)	676	998	1.707	2.096	622
Effort by logbook (days)	28	39	54	59	20
Mean capture by boat per day from logbook	24.13 ± 5.13	25.59 ± 6.00	31.61 ± 4.92	35.52 ± 4.12	31.11 ±7 .21
Daily sales on the fishing wharf (kg)	591	1 002	1 217	2 618	1 187
Effort from the number of daily sales registers (days)	28	34	46	81	42
2017/18					
Daily capture by logbook (kg)	119.7	2 017	1 840	1 571	251
Effort by logbook (days)	14	83	73	52	12
Mean capture by boat per day from logbook	8.55± 3.88	24.30±3.14	25.21±3.48	30.22±4.59	20.91±6.97
Daily sales on the fishing wharf (kg)	167	2 122	2 019	2 045	130
Effort from the number of daily sales registers (days)	15	89	86	69	7

In 2019/20, as in the two preceding seasons, *cabotí* was the most abundant species (Table 3). The sale of *cabotí* makes the season viable and means there is enough resource to supply local demand, although its sale price to the public is lower than that of *jonquillo*. If only *jonquillo* fishing had been counted, the administration would have had to adopt restrictive measures (elimination of fishing days). Almost all of the *jonquillo* captured usually comes from the south of Mallorca (Palma and Andratx), although fishing operations are centred on the main two bays (Figure 2, Table 3).

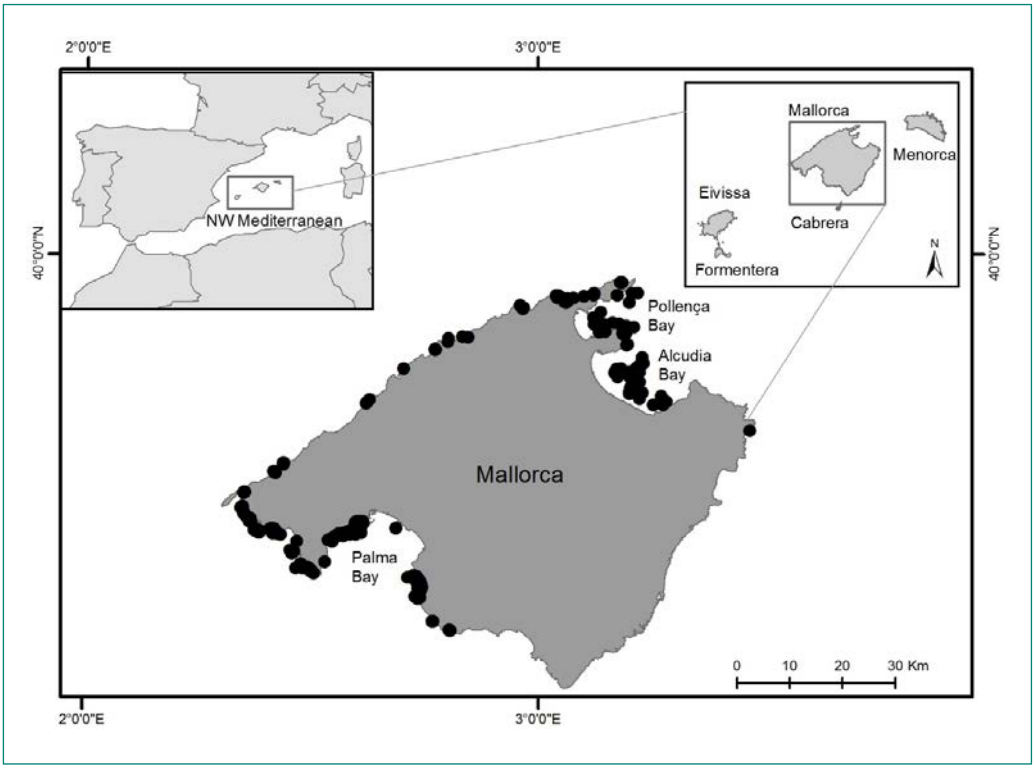

Figure 2. Fishing areas off Mallorca for the 2017 to 2020 fishing seasons (obtained from skipper logbooks). Source: Directorate General for Fisheries of the Balearic Islands (DGPMM).

3. MANAGEMENT CONTEXT

The essence of co-management is that the government and user groups share responsibility for managing the economic and ecological values of the resource, to achieve fishery sustainability. In 2014, the DGPMM established a Survey Commission (SC) that consists of the following members: stakeholders (three fisher representatives – two from the Balearic Federation of Fishers Guilds, and one from OPMallorcaMar, the producer organization which manages sales on the Majorcan fishing wharf); external agents (technical and scientific partners including IMEDEA (CSIC/UIB) and social partner NGOs (WWF)); and the Balearic government (DGPMM). Sometimes fishers interested in the subject and who request it are also invited. The co-management system is advisory: fishers and the other sectors represented advise DGPMM, then DGPMM takes measures (Sen and Nielsen, 1996). However, it can also be considered as adaptive, as decisions are taken depending on the results of the fishing in order to maintain resource sustainability.

Within the EAF context and reflecting European Union regulations, this fishery is regulated by annual permits issued by the DGPMM, to small-scale boats that have operated for at least 5 years in the fishery and with certain restrictions on their size

and engine power. Their landings must be made in any of the permitted ports, their fishing must be conducted in depths of less than 30 m, and their target species can include *jonquillera* (*A. minuta*), *Pseudaphya ferreri*, *Gymammodytes cicerellus* and *Crystalogobius linearis*, as well as '*artet*' (*Spicara smaris*).

The closed season extends from May 1 to December 14. The catch limits, closed season, and boat permits are reviewed annually. Vessels are allowed to be at sea between 06:00 and 16:00 h, and the mean time spent at sea each day by the fleet is 7 hours (± 16 min SE). This varies depending on the distance from the port to the fishing grounds.

Boats licensed to use seines for *jonquillo* fishing are required to keep logbooks that record daily catches, and to deliver these logs to the institutional authorities. The logs contain the date, the departure time from the base port and the time of each haul, the daily catches of gobies (kg/haul), the areas fished in (coordinates and depth), and discards. In the monthly SC meeting, the landing values (both as reported in the logbooks and from the sales at the fishing wharf) are checked against the minimum monthly threshold for daily capture by boat, which is fixed annually for each month prior to the beginning of the fishery season. Because of a lack of information regarding the demography of the species, the average performance (CPUE) of the fleet dedicated to its capture (kg/vessel/day) is used to calculate its abundance index. As we have commented, the inclusion of other components in the effort calculation – like boat size or engine power – does not make any significant difference to the result. The evolution of the CPUE shows the average daily yield increases from the beginning of the season to reach a peak in January and February.

The monthly threshold reference value of CPUE (kg per boat per day) has been defined with reference to the first quartile (25 percent percentile) of the data from the historic data series beginning in 2002.

If the monthly threshold is not reached, the fishing effort is reduced (see below). Because production is calculated on a daily basis (kg/boat/day), the effort reduction does not affect calculations for future periods.

If the average yield per boat per day remains above this threshold, there are no changes in permissible activity. However, if the threshold is not reached, some reduction in effort must be adopted, such as reducing the fishing days to four days per week – or, if the monthly yield is again under the threshold, the fishery must be closed. During the 2014/15 fishing season, low landings in February led to a reduction in the number of fishing days per week (the fishers chose one day from Monday to Friday not to fish). Despite this measure, the mean capture in March did not reach the threshold and the fishery was closed, except for 3 boats (7 percent of the authorized vessels) that continued monitoring the resource. The data from these boats allowed the stability of the landings during April to be monitored. Only once in the following seasons (2016-2020) was it necessary to repeat this drastic measure: the established threshold was not reached in December 2017/18, and as a consequence the SC agreed to reduce the number of fishing days per week in the following month (Table 3).

The establishment of the monthly monitoring SC for the last seven years has been a management and conservation tool that has enabled all sectors with an interest in the resource to be involved in joint decision-making.

4. ACHIEVEMENTS AND LIMITATIONS

The decision-making processes of the Balearic government have guided the adoption of specific regulations and administrative measures that have strengthened economic value (based on efficiency) and ecological value (based on resource sustainability) in the transparent goby fishery in the context of an ecosystem approach.

In 2016 a survey showed that most fishers were satisfied with the management measures (63.64 percent) and felt well represented in the SC (45.45 percent). However, the question about representation in the SC was the most unanswered (18.18 percent), and also had numerous negative answers (27.27 percent). Most respondents said they had not experienced higher economic revenues since implementation of the management plan. Opinions on preferred management measures varied. Several fishers suggested a reduction in the daily quota to 20 kg, in addition to beginning the fishing season in January to avoid catching smaller fish. There was consensus on the need for an extended daily timetable because fishing operations were slow and required more time. This measure was supported with the existence of a daily quota. The number of fishing licences issued was also considered, to eliminate boats that do not report or that do not catch the permitted quota (Morales-Nin *et al*., 2017).

However, these proposed measures have not been enforced by the SC, which decides on the quota and the number of fishing days. Depending on the quota adaptive measures have been taken (Table 3), although market circumstances have also influenced the activity (see 2020, Table 3).

Table 3. Regulation measures declared by the Survey Commission.

Fishing season	Monthly catches vs established threshold	Corrective action
2015/16	The established threshold was not reached in February	Reduction of one day of fishing per week during March, whose average yield far exceeded the threshold
2016/17	The minimum threshold was exceeded in all months	No exceptional management measures were taken
2017/18	The established threshold was not reached in December	Reduction of one fishing day per week throughout the season, although in following months the threshold was always exceeded
2018/19	Every month of this season the established minimum threshold was exceeded	No fishery management measures required
2019/20	The established threshold was not reached in March	It was not necessary to apply any fishing effort management measure, because *jonquillo* fishing ended that month due to COVID-19. In the last two weeks of March, fishing activity was adapted to fit market changes, sales and the starting price. Only two boats fished, one for 8 days and one for 6 days.

In general the SC has been working satisfactorily, with significant input from DGPMM including data, a monthly activity report, and suggested measurements. Most information is exchanged in monthly meetings and prior bi-lateral discussions to facilitate the plenary SC meetings.

There is some feeling that fishers are not sufficiently represented on the SC, possibly due to a lack of communication with participants (3 fishers from the main ports, 2 heads of fisher guilds). There may need to be more information flowing both ways – from bottom up and top down – to make fishers feel they can play a more active part in successful management.

The main problem in the fishery has been the decreasing abundance of *jonquillo* in the landings and the substitution of *caboti*, a less appreciated species (Table 4). *Jonquillo* represented 38.24 percent of the landings in 2016/2017 and only reached 30.46 percent in 2019/2020, while *caboti* reached 69.88 percent in the 2016/2017 landings, decreasing to 63.87 percent on 2019/2020. The mixed commercial categories have changed slightly as a percentage of total landings, but the '*Jonquillo* mix' category (where *jonquillo* is predominant) has decreased notably (Table 4). The causes of this change are unknown: while there is reasonable knowledge of the biology of *jonquillo* (albeit very little is known about its migration and distribution), *caboti* is poorly known, therefore only speculative hypotheses like environmental changes can be advanced.

Table 4. Relative composition of landings with the following sales categories: '*Jonquillo*' – almost all *A.minuta*; 'Mix *jonquillo*' – mix of gobids with significant *A.minuta* presence (> 60 percent); '*Cabotí*' – all *P.ferreri;* 'Mix *cabotí*' – mix of gobids with significant *P.ferreri* presence (> 60 percent).

Composition (kg)	2019/20	2018/19	2017/18	2016/17
Jonquillo	156.6	478	159	209
Mix *jonquillo*	140.5	294	440	423
Total kg	**297.1**	**772**	**599**	**632**
Cabotí	3 271.57	6 931	4 121	3 820
Mix *cabotí*	1 849.7	4 014	1 129	1 646
Total kg	**5 121.27**	**10 945**	**5 250**	**5 466**

The management measures in place are the result of efforts to limit the number of fishing licences and the fishing hours and days, to limit spatial access (fishing at depths of less than 30 m), and to limit landings (fixed quotas). The SC meets monthly to determine the effort (fishing days) for the next month in order to keep landings at a fixed quota calculated from the historical data series. In one case, the SC reduced effort and closed the fishery one month early for the season.

The system used to manage the *A. minuta* fishery uses daily fishing activity to monitor the state of the resource (CPUE: kg per boat per day). Two sources of information are available: the self-reporting of the fishers, and the sales registries. The DGPMM also regularly monitors the fishery to obtain data on fishing practices, landings, discards, and target species biology. During the implementation plan, a consistent trend of lack

of reporting has emerged, as well as differences between the estimates on board and at time of sale, resulting in varying catch and effort estimates.

Despite the efforts of the SC to control the fishery and ensure its sustainability and efficiency, an emergent issue has appeared. The catch composition is changing with a predominance of *P. ferreri* in recent years and a decrease of *A. minuta* (Table 4); this last species is also reducing its geographical presence (DGPMM data) in shore waters. This might be a result of a combination of environmental factors that require further investigation. Moreover, despite the regulation of the fishing activity the fishery is dependent on recruitment success, and is therefore heavily influenced by environmental variables.

5. CONCLUSION

The initial regulations proposed by the stakeholders were to ensure profit, limiting catches to avoid declines in the sales price due to market saturation. However, the evolution of the management, enforced by European Union regulations, has resulted in an EAF with the objective of sustainability. Effort controls in this fishery could have affected the effort in other métiers, due to the rotating activities of SSF, but this effect has not in fact been detected. Fishers report they are satisfied and that they are maintaining their level of income, despite the more restrictive practices. Stakeholder participation in the SC has made it possible to apply measures that could otherwise have caused conflict. The basis of an EAF is being gradually created by the stakeholders through their participation in the SC. A notable signal of its success is that the guilds representing the dolphinfish fishers – the islands' most important in terms of landings – have requested that the same co-management approach be applied to their fishery.

The main lesson is that the creation of co-management mechanisms, where fishers are directly involved in decision-making in the adaptive management of the fishery, is a very effective mechanism to integrate good practices in all areas of activity, including ecosystem management.

Co-management committees help fishers and other stakeholders understand that scientists and managers do not propose measures for arbitrary or ideological reasons, but in an effort to achieve common benefits. In this sense, it is essential to find synergies between the legitimate economic interests of fishers and the measures inherent in an EAF – which, in fact, exist more often than one might expect.

This article has already explained that the establishment of daily catch quotas for *jonquillo*, an effort reduction mechanism, was nevertheless in line with the aims of fishers who wanted to regulate prices and guarantee a minimum income – and in the Balearic islands there are other similar cases. The most notable, in our opinion, is that of the minimum mesh sizes of gillnets in marine reserves, which is 60 percent larger than for meshes in nets outside reserves (80 mm vs 50 mm) (Decree 41/2015, of 23 May). The main objective of this measure, agreed with the fishers, is to eliminate unwanted bycatch, but it also means less time is needed to set the nets and deal with the catches while a similar or higher income is generated – in general, bigger fish are worth more than smaller ones.

Conversely, the main bottleneck in applying ecosystem management mechanisms is a lack of good communication with the fishers affected. This can lead fishers to interpret ecosystem management measures as an attack on their interests, and an attempt to eliminate them.

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Chapter 8: Implementation of ecosystem approach to fisheries principles as a tool for the management of small-scale fisheries in the El Bibane lagoon, Tunisia

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INTRODUCTION

Today, a significant proportion of the world's fisheries are subject to excessive fishing effort, and are suffering from fairly severe overexploitation. To remedy this situation, experts advise that the real exploitation potential of these fisheries should be assessed, and that management plans to ensure their sustainability should be implemented. Several management approaches have been developed, including the ecosystem approach to fisheries (EAF) which has had positive results in many cases around the world. With this in mind, an EAF was adopted in order to implement a management plan for the artisanal fishery of the El Bibane lagoon in Tunisia. The plan was initiated and coordinated by the National Institute of Marine Sciences and Technologies, through its Fisheries Sciences laboratory, and has been supported and reinforced by FAO through the FAO/CopeMed II regional project.

This report briefly summarizes the main steps taken and the key results obtained. We begin by describing and analysing the fishery context – the lagoon and its geographical location, the fishing methods and techniques used, and the characteristics of the artisanal fishery in El Bibane. Next we examine the management context, describing the reasons for the changes in the management system, the key institutions and stakeholders involved, and the factors that facilitated or hindered the plans. Finally, we summarize the main achievements and lessons learned from this interesting experience.

1. FISHERY CONTEXT

In Tunisia, the fishing sector plays an important and strategic role in the national economy, and is even considered as one of the pillars for the development of agriculture in the country: the sector ensures food security, guarantees an income for a large number of families, and contributes to agricultural exports. The latest statistics from the General Directorate of Fisheries and Aquaculture (DGPAq) show that in 2019 annual production of fishery products reached 150 890 tonnes (Anonymous, 2019a). According to the same source, Tunisian exports of fishery products reached 27,972 tonnes – or 18.5 percent of overall production – for a value of KD 557.6 million.

The Tunisian coast stretches for about 1 300 km. There are five coastal lagoons (Bizerte, Ghar El Melh, Tunis, Boughrara and El Bibane) and a single inland lagoon (Ichkeul). Situated in the Gulf of Gabes, the lagoons of Boughrara and El Bibane are the largest and most productive. During 2019, total production from all the Tunisian lagoons was about 339 tonnes, which represents 0.3 percent of the total national production (Anonymous, 2019a). The El Bibane lagoon was responsible for 33 percent of that amount, producing 112 tonnes, followed by the lagoons at Boughrara, Bizerte, Tunis and Ghar El Meleh (Anonymous, 2019a).

Over the last 10 years, the El Bibane lagoon has reported average annual fish production of around 190 tonnes (Anonymous 2009–2017), with an average annual value of around TND 1.8 million.

1.1. El Bibane lagoon

The El Bibane lagoon is located in southern Tunisia near the border with Libya, in the governorate of Medenine, at 33° 15' N and 11° 15' E (Figure 1). It is the largest lagoon in the country. With an elliptical shape, it covers an area of 25,000 ha and its average depth is around 4 m (Lemoalle, 1986). It has limited communication with the open sea (Medhioub and Perthuisot, 1977). This unique ecosystem, listed as a Ramsar site since 2007, has very specific geological, sedimentological and physicochemical characteristics. In addition, it contains a remarkable diversity of fauna and flora and provides an essential habitat for several species of birds, as well as key commercial fishery resources. Many species of commercial interest share the lagoon, notably the European bass *Dicentrarchus labrax*, the sea bream *Sparus aurata*, the annular sea bream *Diplodus annularis*, mullets *Mugil* spp., the bluefish *Pomatomus saltatrix*, the lich *Lichia amia*, the sole *Solea aegyptiaca* and the caramote prawn *Penaeus kerathurus.*

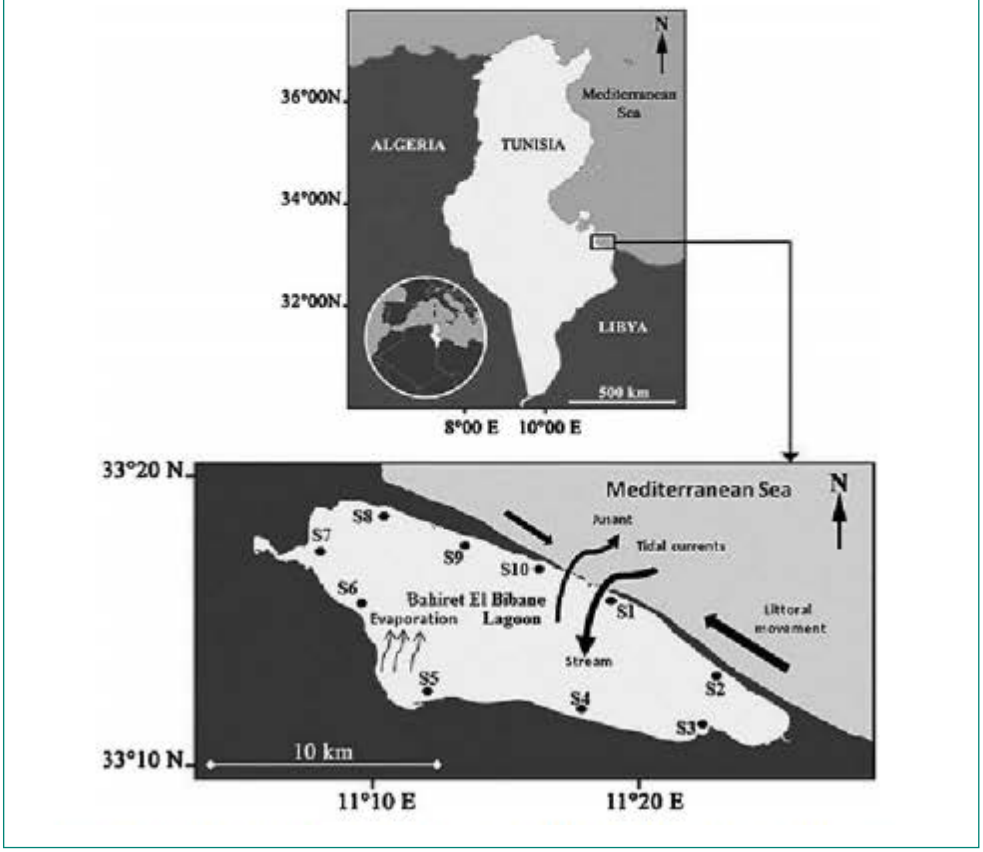


Figure 1. Geographical location of the El Bibane lagoon, Tunisia.
Source: Barhoumi *et al.*, 2016.

The lagoon has a unique fisheries exploitation system, which is based on an annual concession: a private individual pays money to the state to rent the lagoon each year. The set-up is governed by an agreement, in the form of specifications, between the concessionaire and the government (represented by the DGPAq). The agreement sets out the details of permitted fisheries techniques and the concessionaire's management and control responsibilities. In addition to this concession, the authorities also grant annual licences to a limited number of private fishers. The number varies from year to year: 87 licences were given out in 2019, while in 2017, for example, there were 122.

The El Bibane lagoon is the most productive lagoon in Tunisia, and it is especially well known for the quality of its fish. Each day, fish are caught by '*bordigue*' (catch rooms, see below), lines and nets. Generally, a dealer purchases the catches of private fishers. Three workers sort the fish by species and size, and then it is kept refrigerated. The production goes to both local and national markets, the main ones being at Sfax and Tunis. Prices vary depending on the species (*D. labrax* and *S.aurata* are generally more expensive), the season and also the size of the fish.

1.2. Fishing gears and methods

Four main types of fishing gears are used in the El Bibane lagoon:

'Bordigue' fishing: The El Bibane lagoon has likely been exploited since ancient times by fishers using dams and traps, such as the 'Charfias' that is common in the region (Zaouali, 1982). The lagoon includes a fixed barrier of more than 3.6 km which closes its main passage at the level of the central channel (Djabou, 2006), and means that fish migrating from the lagoon to the sea can be trapped in the '*bordigue*', or catch rooms (Figure 2). This *bordigue* operates for an average of 306 days per year, and comprises a total of around 40 catch rooms (11 are shown in the aerial view below). It is a masterpiece of engineering dating back at least as far as the end of the 14th century, and today is a unique piece of Mediterranean heritage.

Figure 2. Aerial view of the El Bibane lagoon, with some of the bordigue catch rooms marked.

Line fishing: The concessionaire is in charge of this activity, and they employ fishers to carry it out on their behalf. During the winter season, some fishers in the village of Jdaria are also employed and paid by the kilogram. This fishing method is used throughout the year except for two months when fishing is closed, or when the meteorological conditions do not allow it (too much wind and current in the 'Oued'). It is generally done from rowboats by two people (a rower and a fisher) or by a single person working from a fixed point on foot. The baits used are shrimp, blenny, mullet or ray belly. Practised day and night, the timing of this activity depends on the target species: European bass and sea bream are fished from October to January, bluefish from April to January, and lich from April to October. Currently some nine boats and nine fixed fishers are involved in this activity, and one boat brings in an average of 15 kg to 20 kg of sea bream or European bass per day.

Fishing with nets: Private fishers with annual permits can use nets to fish in the El Bibane lagoon. Trammel net fishing was introduced in the lagoon around the 1990s, and three types of net are in use: shrimp trammel nets, red mullet trammel nets and cuttlefish trammel nets. The shrimp trammel net is used throughout the lagoon, set in the evening and recovered early in the morning. This fishery is only open from 1 May to 30 June each year, and mainly targets the caramote shrimp *Penaeus kerathurus*. Red mullet trammel net fishing activity began relatively recently – it is not mentioned in the literature during the 1970s, 1980s or 1990s. Red mullet trammel nets are used in all parts of the lagoon, set in the evening and hauled in the morning. Depending on the distance, the nets are either taken in or left at sea all day. In general, this fishery is practised during two seasons of about two weeks each: at the end of December and at the end of May. It mainly targets the red mullet *Mullus barbatus*, as well as the juveniles of many other species.

1.3. Main characteristics of the El Bibane fishery

- ***Declining resources and threatened heritage***

The lagoon's production has been falling for 50 years, but the trend has accelerated in recent years. Approaching a maximum volume of nearly 600 tonnes per year in the 1960s, production has not exceeded 200 tonnes since 2012 (with the exception of 2017, with 238 tonnes) (Figure 3).

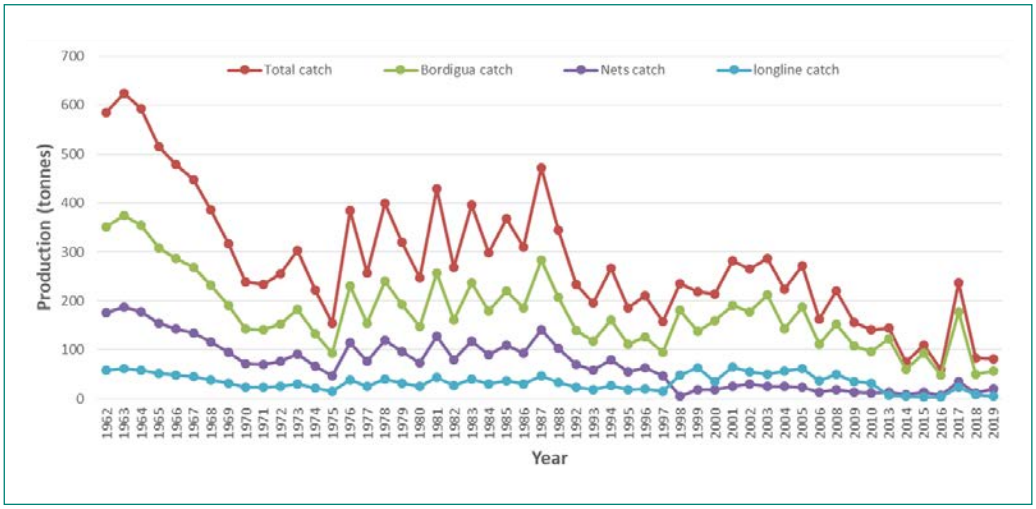


Figure 3. Annual evolution of El Bibane fishery production by fishing activity from 1962–2019 (Anonymous, 1962–2019).

Some species have almost disappeared from the lagoon, catches are low, and the fish caught are getting smaller. Outside the lagoon – in the Gulf of Gabès and the waters of southern Tunisia that feed it – the situation is also worrying, since the overexploitation of demersal resources has been growing for years. Fishing pressure is still increasing, and illegal, unreported and unregulated (IUU) fishing is accelerating overexploitation and habitat degradation, threatening a valuable economic activity for the region and a unique piece of Mediterranean biological and cultural heritage.

This decline in production is a clear threat to the lagoon fishery, and it was one of the primary factors that triggered the change in the current system of management.

- ***Vulnerable and precarious local population***

The El Bibane lagoon is located in an area of relatively low population density. Zarzis, the biggest town in the region, is about 30 km away and Ben Guerdène, the nearest town, is located about 10 km south of the lagoon. The regional population lives mainly from fishing, pastoralism, tourism and trade (with Libya in particular). Only the village of Jdaria is located on the edge of the lagoon, and here the locals have little choice other than to work in fishing. The poor condition of the fishery and the lack of alternative income-generating activities mean the local population has a very low standard of living, and is in a precarious and vulnerable situation.

- ***Global climate change, a worrying reality***

The worrying situation of the lagoon and its resources has been changing for several years, as new phenomena are appearing. Fishers report changes in the rhythm of the seasons and the movement of species. New invasive species such as the blue crab *Portunus segnis* have recently appeared in the lagoon. Extreme climatic episodes such as storms and drought are more intense and more frequent, directly threatening the equilibrium of this fragile ecosystem.

2. MANAGEMENT CONTEXT

In Tunisia, living marine resources are a vital heritage that must be well managed and efficiently exploited, and in recent years Tunisian fishing operations have been subject to strict regulations aiming to make the majority of fisheries sustainable. In force today is Law No. 94-13 of 31 January 1994 (JORT, 1994). This consists of 45 articles, some of which have been repealed or modified as the sector evolves, and it regulates fishing activity in all Tunisian waters, including the fishery in the El Bibane lagoon. It focuses in particular on prohibited fishing areas, fishing gear and mesh size, minimum authorized landing size, fishing effort, fishing seasons, protected species and recreational fishing.

For the lagoon, the main applicable measures are:

- Closed season each year for 2 months (February and March), during which time all fishing activities are forbidden
- A complete ban on trawling
- Minimum legal landing size for each species: *Dicentrachus labrax* – 20 cm standard length (SL); *Sparus aurata* – 20 cm SL; *Diplodus annularis* 10 cm SL; *Mugi*l spp. – 20 cm (SL); *Mullus* spp. – 12 cm SL; *Lithognatus mormyrus* – 15 cm SL; *Pomatomus saltatrix* – 22 cm SL; *Lichia amia* – 40 cm SL; and *Solea ageyptiaca* – 20 cm SL.
- The length and the mesh size of trammel nets used are fixed by Tunisian law
- The granting of fishing licences is subject to the same rules as in other fisheries in Tunisia.

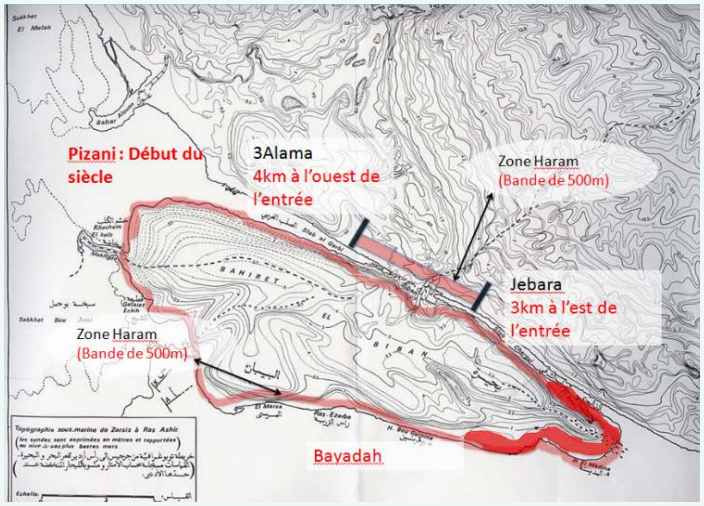
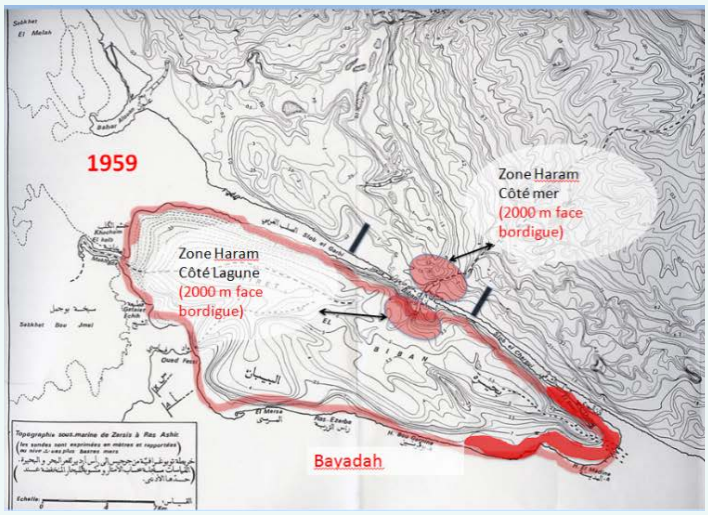
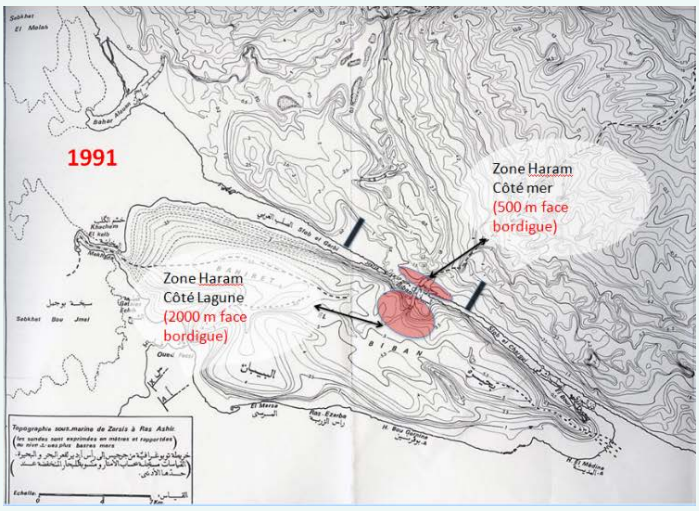
As has been mentioned, the lagoon fisheries are exploited under a concession between a private investor and the Tunisian state (Minister of Agriculture, Fisheries and Hydraulic Resources). It follows specifications signed by the two partners, which are based on 24 articles. These articles clearly set out the conditions of the arrangement, the rights and the obligations of each partner. The responsibilities of the concessionaire concerning management and control of the lagoon's fisheries are summarized as follows:

- The concessionaire must carry out fishing activities under the conditions set out in the authorization granted by the competent authority.
- The concessionaire must not use fishing gears except those used in the lagoon (nets, lines and fixed gear), unless a study on the environmental effects of any proposed new gear is carried out and the results are approved by the competent authority.
- The concessionaire must not introduce new animal or plant varieties into the lagoon, or feed fish without obtaining prior authorization from the competent authority.
- The concessionaire must maintain a suitable level of exploitation in the lagoon. In the event of incompatibility between the fishing effort and the stock, the concessionaire must obey the instructions of the competent authority to restore the balance, based on the opinion of the technical committee created by article 14 of the specifications and according to the studies that the operator may be asked to conduct under article 15.

Given the evident decline in production, it is clear that these arrangements did not do enough to guarantee sustainable management of the fishery. The introduction of EAF planning principles was an attempt to broaden the range of actors involved in decision-making, including not only the concessionaire but also fishers and other organizations, as part of a co-management process.

In the El Bibane lagoon, the fixed fisheries and other associated gear and techniques have been developed and passed down from generation to generation based on experience and observations of the natural world. These observations – of seasonal species migrations, of the impacts of winds, temperatures and rain, and of sensitive areas for reproduction and growth – underpin elaborate traditional practices and inform well respected rules concerning the sustainable exploitation of resources and the ecosystem. But these traditional management practices are in danger of disappearing if they are not valued. It is important to recall that *bordigue* fishing is the oldest technique used in the El Bibane lagoon. One of the method's most important features is the notion of 'haram' no-fishing zones around the *bordigue*. However, these zones have been modified and – according to former fishers – the modifications are among the main causes of stock degradation (Table 1).

Table 1. Evolution of 'haram' no-fishing zones in the El Bibane lagoon.

No-fishing areas during the installation of the bordigue by Pizani (beginning of 20th century)	
No-fishing areas, 1959	
No-fishing areas, 1991	

These traditional rules are, however, a very valuable source of information for the sustainable management of the lagoon fishery.

2.1. Factors leading to changes in the management system

The first factor driving the launch of the process to enhance fisheries management in El Bibane was the commitment of all stakeholders to change the situation. They were aware of the gravity of the position they faced, and knew that actions were needed to improve it for everybody's benefit. In fact, the aim of the plans at El Bibane – the sustainable management of the fishery resources of the lagoon – mirrors the policy goals described in various other economic and sectoral frameworks, particularly the national strategy for the development of the fishing sector in Tunisia (Anonymous, 2019b). Indeed, the protection and conservation of Tunisian fishery resources, particularly demersal resources, is one of the main objectives of this strategy.

The management plan is the result of collaboration between national institutions, the concessionaire, fishers and civil society. It has been developed through a consultation process according to EAF principles since the first information and project start-up mission in September 2016. Subsequently several field missions were organized, as well as two consultation workshops (December 2016 and March 2017) which identified and brought together the El Bibane actors and stakeholders to inform them about the project and to start the planning process together. The first step was to produce a baseline reference report on the lagoon's fisheries, which was produced in March 2017. This study made it possible to bring together all the available knowledge and to make an inventory of the current fishery situation. Subsequently, the main factors threatening the fishery were identified. Finally, during a last workshop held in September 2017, the main actors involved in the EAF process used the previous analyses to clarify the management objectives, prioritize the main issues, and identify suitable management measures. These steps enabled the development – using a participatory approach – of a management process specifically adapted to the context of Tunisia, and to the region of El Bibane in particular.

Considering the socioeconomic importance of fishing in the El Bibane lagoon and the current threats to the fishery, resulting in particular from high levels of exploitation, measures must be taken to ensure the sustainability of the fishery. This management plan has been designed to help managers and stakeholders make decisions for the sustainable use of resources based on the priorities and recommended actions jointly identified by the main stakeholders in the fishery. The plan was designed in accordance with the FAO Code of Conduct for Responsible Fisheries, following the principles and methodology of the EAF. During the various workshops, the actors identified and assessed the risk of the main issues affecting the sustainability of the lagoon fisheries. Some issues were rated as a priority and others were considered as important but not a priority in the current context (Table 2).

Table 2. The main issues threatening the sustainability of the lagoon fisheries.

Ecological wellbeing	**Priority level**
Overexploitation of main resources	Priority
Destruction of coastal habitats	Secondary
Pollution of the lagoon	Secondary
Human wellbeing	**Priority level**
Valorization of fishery products	Priority
Vulnerability and strong dependence of coastal communities on fishing activity and the need for income diversification	Priority
Lack of basic infrastructure	Priority
Attenuated organization of civil society	Secondary
Instability and precariousness	Secondary
Governance and external factors	**Priority level**
Lack of consultation/communication between the different partners	Priority
Non-compliance with existing regulations and traditional management rules	Priority
Insufficient research and monitoring of fishing activities	Priority
Modification of the environment and global climate change	Priority
Uncontrolled tourism	Secondary
Recreational fishing	Secondary
Proliferation of invasive species (blue crab)	Secondary
Attenuated organization of civil society	Secondary

In addition, the analysis identified six strategic axes for the management plan. These strategic axes are as follows:

- Strategic axis 1: Updating the fishery regulations
- Strategic axis 2: Fight against IUU fishing and strengthening of monitoring, control and surveillance (MCS)
- Strategic axis 3: Sustainable exploitation and management of fisheries
- Strategic axis 4: Improvement and dissemination of knowledge
- Strategic axis 5: Reducing vulnerability and improving social and economic conditions
- Strategic axis 6: Adaptation to climate change

2.2. Key institutions and stakeholders involved

All direct and indirect stakeholders were involved from the start of the process. In fact, a plenary meeting was organized inviting all stakeholders to inform them about the project and to obtain their opinion and consent for the implementation of EAF as a management tool for the El Bibane fishery. Key stakeholders include:

- ***The concessionaire:*** The concessionaire is the main operator of the El Bibane lagoon fishery and is directly responsible for fishing activities. They have the necessary equipment and resources for exploitation, and employ 38 fishers and workers. They have decision-making responsibility, and this is clearly indicated in the specifications they have signed with the General Directorate of Fisheries and Aquaculture (DGPAq).

- ***The fishers:*** In addition to the concessionaire, the lagoon is also exploited by 87 private fishers who operate with fishing licences issued by the competent authorities. They are part of a union represented in particular by the Tunisian Union of Agriculture and Fisheries (UTAP). They are direct actors and they are responsible for all the fishing actions carried out in the lagoon – and they are directly affected, like the concessionaire, by the positive or negative consequences of any management plans.

- ***The administration at regional and central level:***
  - The CRDA: The Commissariat of Agriculture Development in the Medenine region, particularly the Fishing District in Zarzis. This body represents, at the regional level, the DGPAq.
  - The GIPP: The Interprofessional Group of Fishery Products is a public establishment of economic interest endowed with civil liability and financial autonomy. It is an inter-professional body responsible for regulating the market, improving quality, supervising professionals and promoting exports in the fisheries and aquaculture sector in Tunisia. Its role includes ensuring the link between the different phases through which the products pass. It facilitates consultation between professionals and the administration in order to set the objectives of the various sectors. It contributes to market balance by using the various appropriate mechanisms in collaboration and coordination with the professional and administrative bodies concerned.
  - The APAL: The Coastal Protection and Management Agency is a non-administrative public establishment, created by law n° 72-95 of 24 July 1995 (JORT, 1995). It is called upon to execute state policy in the field of protection and development of the Tunisian coastline, to protect the maritime public domain against encroachment and illegal occupations, and to give its approval to any development and equipment project on the coast before its execution, including in the lagoon area.

- The APIP: The Ports and Port Installations Agency is a public company with legal personality and financial autonomy. Its main responsibilities are the exploitation, operation, maintenance and development of fishing ports. It is also responsible for the management of the public port domain and the provision of services to boats, and it participates in construction and extension studies of fishing ports.
- The AVFA: The Agricultural Extension and Training Agency is a public administrative establishment placed under the authority of the Ministry of Agriculture, Maritime Fisheries and Hydraulic Resources. As the name suggests, the agency is involved in the training of fishers in different disciplines. In terms of vulgarization, it is responsible for supporting field extension programmes developed by the Regional Agriculture Development Commissions with the aim of improving the level of skills and know-how of extension workers by organizing workshops and the development of popularization materials.

- ***The DGPAq:*** The Central administration responsible for fisheries management plans in Tunisia: this is the General Directorate of Fisheries and Aquaculture. It has many tasks; it is responsible, in particular, for the collection and processing of statistical data on production and fishing effort. The DGPAq also issues fishing authorizations, controls and monitors the fishing activities of all units, draws up and implements fisheries management plans, and ensures the application of the fishing regulations in force. It has direct administrative responsibility for all fishing activity in the lagoon, and it is responsible for the design, approval and implementation of any management plan. The DGPAq was informed of the EAF process from the beginning, and it has been aware of all activities that have taken place. Its regional representatives were involved in all the implementation steps of the EAF.

- The INSTM: National Institute of Marine Sciences and Technologies (INSTM). The Laboratory of Fisheries Sciences of INSTM is the initiator of this EAF action, in close collaboration with the FAO CopeMed II project. Its director is the national case study coordinator and is also the Chair of the Technical Monitoring and Consultation Committee (TMCC) of the management plan. In addition, a team of scientists is permanently in charge of carrying out and monitoring the research activities identified by the management plan, and the results obtained are presented and discussed during meetings.

- The National Marine Guard (NMG): This is a Tunisian military security force, distinct from the armed forces by virtue of its membership of the Ministry of the Interior.

2.3. Factors that enabled or blocked modification attempts

The main enabling factor in the process was the strong spirit of consultation and exchange of ideas shared by all stakeholders. The process opened up a discussion where everyone could express their ideas and debate at all times without any fear of sanction. The decisions taken were therefore collective, and adopted by all stakeholders in the fishery. In addition, the basic work of collecting available information on the fishery and carrying out surveys in the field greatly contributed to facilitate the discussions to identify issues and propose appropriate solutions. All of this was led and organized by a specialized team of national and international scientists and experts who guided the process and brought it to fruition. In the event, there were no factors which impeded the implementation of the EAF to manage the El Bibane lagoon fishery.

3. ACHIEVEMENTS AND LIMITATIONS

The management plan for the El Bibane lagoon fisheries is relatively recent, its adoption by the competent authority dating back only to June 2018. Even so, many results have already been achieved:

- The first was the creation of a Technical Monitoring and Consultation Committee (TMCC) for the management plan of El Bibane in September 2018. The Committee is made up of regional representatives of all direct stakeholders in the lagoon fishery (concessionaire, fishers, UTAP, DGPAq, APAL, GIPP, APIP, NMG, INSTM). In line with its terms of reference, the Committee meets at least twice a year to:
  - Analyse available data and scientific and statistical information on fisheries, marine resources and the coastal and marine environment.
  - Propose actions aimed at the sustainable management of fishery resources on the basis of scientific advice.
  - Formulate opinions and recommendations on all questions concerning the sustainable exploitation of fishery resources and the conservation of the natural and cultural heritage of the lagoon and transmit them to the central administrations directly responsible for the management of the fisheries of the lagoon.
  - Set up and format the results so that they can be presented, if necessary, during regular meetings of the enlarged Steering Committee for monitoring fishing activities in Tunisia, among others those of the El Bibane lagoon.

The Committee is financially supported by the FAO-CopeMed II regional project. In the future, its activities will be under the control of the INSTM as national coordinator. It should be noted that the fourth and last meeting of the TMCC was held in Zarzis on 26 June 2020.

However, it is important to point out that the role of the TMCC is purely consultative. The decisions and recommendations taken by it are reported to the competent authorities which are already members of the Committee at the regional level. In addition, a member of the Committee is also a permanent member of the Select Committee created at the level of the DGPAq for the monitoring of fishing activities in the lagoon.

- The 'Cahiers des Charges' specifications, which represent a contract between the competent authorities and the concessionaire for the exploitation of the lagoon, have been updated and reformulated according to the recommendations of the management plan. Indeed, the first operational objective of the plan stipulates that the fishing regulations must be updated, clearly defining the roles and responsibilities of each actor, the operating methods, and deterrent penalties in case of non-compliance.

- The creation and ratification of a fishing 'Charter' between fishers and the concessionaire, defining the modalities of the fishing activity and the good practices to be respected.

- To fight against IUU fishing and strengthen MCS of fishing activities in the lagoon, the management plan must have an operational and efficient MCS system. This system was initially created through the establishment of an ambulatory surveillance team, and a CRDA office was set up in Jdaria. Unfortunately, logistical difficulties intervened and the system did not work effectively. The authorities and the TMCC are informed, and are currently working to fully restore this important facility.

- In line with strategic axis 4 of the management plan, 'Improvement and dissemination of knowledge', a whole series of scientific research activities have been launched in the lagoon since its adoption. The main objective of these activities is to provide updated information and research results that can be used for fisheries management. They were coordinated and carried out by a specialized research team from the Fisheries Sciences Laboratory of INSTM and they included several components, such as:
  - The assessment of the main target species stocks
  - The study of species migrations and the location and estimate of recruits
  - The study of the possibility of setting up calendars and fishing seasons
  - The study and monitoring of the environmental parameters prevalent in the lagoon
  - The assessment of biological rest and study the possibilities of changes over time

The majority of these activities were launched thanks to the support of the FAO CopeMed II project, which made a financial contribution and provided international expertise in certain areas, particularly the study of the mechanism of fish migration (sea – lagoon and lagoon – sea). In addition, the team responsible for this scientific work had the full support of the concessionaire, the fishers and the regional and central administrations. Many results were obtained, presented and discussed during the regular meetings of the TMCC.

Furthermore, it is important to note that a considerable effort has been made to disseminate information concerning the implementation and progress of the management plan of the El Bibane lagoon through publications (FAO, 2018), national and international meetings. The process has also been shared with stakeholders in neighbouring regions of El Bibane. Indeed, another case study of the implementation of the EAF was launched with the artisanal fisheries of Djerba island, and another is in progress in the fisheries in the region of Zarzis.

However, certain limitations and difficulties were encountered which need to be resolved to ensure greater success for the El Bibane management plan. These can be summarized as follows:

- Some fishers do not respect the clauses of the management plan. They continue to practise illegal fishing, and sometimes obstruct the rules of good fishing practice in the lagoon. These fishers remain in the minority, and an additional effort should be made to increase their awareness and to improve compliance through enforcement.

- Some management plan actions require more funding, which has not yet become available despite best efforts to raise finance. In this regard, the EAF group has recently created a synergy with the FAO inter-regional Technical Cooperation Programme 'Blue Hope in the Mediterranean,' to support a preparation of investment plans to accomplish the actions still needed at El Bibane.

- There is still a lack of logistical resources: the CRDA control unit in Jdaria, set up as soon as the management plan was launched, is not regularly present.

- Stock recovery takes time, and improved revenues cannot be instantaneous. The management plan has only been in operation for two years.

4. CONCLUSION

In general, the implementation of the ecosystem approach to fisheries to manage the fishery in the El Bibane lagoon in Tunisia has been a successful operation. Indeed, this case study was launched in 2017 with a major effort to collect reliable information on all aspects of the fishery. At the same time, the study teams made a considerable effort in field surveys and consultation with all stakeholders in the fishery. This was reinforced and complemented by the organization of numerous meetings with all stakeholders to discuss and exchange ideas on the most important problems of bad management in the lagoon fishery. Subsequently, the challenges to the fishery were identified and possible solutions were proposed to resolve them. The management plan with its major strategic axes was developed and adopted by the competent authorities at the central level, namely the General Directorate of Fisheries and Aquaculture. The plan's adoption was immediately followed by the creation of a Technical Monitoring and Consultation Committee, bringing together all the representatives of the stakeholders at regional and central levels. This committee, whose main role is to supervise the implementation of the management plan and its execution, is also open to outside expertise and external intervention.

In conclusion, it is important to highlight the most important lessons learned during the EAF process for such an approach to be successfully applied at El Bibane and beyond. We also note once more the obstacles or mistakes to avoid, and the aspects that facilitated the process which should be encouraged and promoted. For the success of the EAF in the El Bibane lagoon fishery or any other fishery, these points are essential:

- The first step in collecting information is very important, and constitutes the basis of the plan. This information should take into account all aspects of the fishery and should be taken from reliable sources. The reference baseline report for the fishery must be elaborated in constant consultation with all stakeholders.

- Local fishery techniques and traditional knowledge have to be documented to assess their application to sustainable fisheries management. Traditional management rules are generally very relevant for the actual management process.

- The EAF team should be specialized, multidisciplinary, experienced, and supported where necessary by international expertise. Some members of the team should be from the region of the fishery. In addition, the team should use easy language and a clear methodology.

- For the identification of challenges and possible solutions, it is important to take into account the opinion of all stakeholders involved directly or indirectly in the fishery: fishers, operators, managers, scientists, associations, groups, the young, the old, the more experienced, the optimists and the pessimists.

- It is important to collect as many opinions and ideas as possible, and not to exclude any details or information – everything could be useful.

- Once adopted, the execution of the operational objectives of the plan should be immediately monitored by the TMCC, and regular committee meetings should be held at least twice a year. The results of the scientific activity programme must be presented and discussed during these meetings, as well as the planning of new actions.

- The achievement of certain operational objectives of the plan requires funding. These funds could be found at the national level or through international cooperation. Maintenance of the *bordigue* is a case in point: this appears to be a pressing need, particularly in light of damage caused by the increase in winds and storms in recent years as a result of climate change.

- Administrative managers at the regional level have a particularly important role in supervising fishers and monitoring fishing activities.

- It is also important to disseminate information and to communicate the actions of the management plan. The work at El Bibane has prompted neighbouring regions to request the implementation of the EAF principles, as is the case for Djerba island and Zarzis.

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ANNEX 1. LESSONS LEARNED FROM THE PRACTICAL IMPLEMENTATION OF THE EAF PLANNING PROCESS ACCORDING TO FAO GUIDELINES

CASE STUDY: EL BIBANE FISHERY (TUNISIA)

Steps	Activity (what was done)	Comments and observations about this step	Cases where it went wrong, and why	Cases where it went well, and why
1. Initiation and scope	• Identify and put together the team that will be responsible for carrying out the case study • Carry out a first general survey and make the first contacts at the regional level to obtain the consent of all stakeholders on the feasibility of the study	• The team should be specialized, multidisciplinary, dedicated to study and reinforced, if necessary, by international expertise • Very important action to launch the study on a solid basis	• At the beginning some stakeholders and fishers did not accept the idea of the EAF approach. A significant effort has been made to convince them of the usefulness and effectiveness of the approach for effective management of the fishery	• Some members of the team were originally from the region of the study. This greatly facilitated the first contacts and the explanation of the objectives of the study to stakeholders and fishers at the regional level
2. Identification of assets, issues and their priority	• Organize numerous consultations and debate meetings with all stakeholders • Carry out numerous surveys and make direct contacts with stakeholders at home and in the workplace to gather and discuss opinions • Investigate and document traditional fisheries knowledge • Prepare a baseline reference report summarizing all the information collected which will serve as a basis for the proposal of the development plan	• The step allowed us to learn a lot about the ecological functioning of the lagoon, the evolution of the fishing activity and the traditional management rules • The baseline report must be complete, containing reliable and up-to-date information on all aspects of the fishery	• Sometimes the issues and priorities are not the same for all stakeholders (differences of ideas and interests). Discussions are longer and more difficult • The fishers are not always available. To collect information, we need to move to meet them in the ports, markets or even in their houses • Sometimes there were discrepancies in the information provided. Considerable analysis and verification efforts must be made to minimize gaps and errors	• All discussions and debates, even if they take time, always result in agreement by all stakeholders on the issues and priorities • Necessary and interesting action to compile and complete all the information. This is an opportunity to meet people who could not attend the meetings and who might have updated information and different ideas • Traditional knowledge and management rules were very important in the management plan elaboration process. The former fishers felt listened to and the younger ones became aware of the deterioration of the situation. They discovered traditional management rules. • The baseline report was presented and discussed during consultation meetings. This made it possible to adjust and better refine the information retained

Steps	Activity (what was done)	Comments and observations about this step	Cases where it went wrong, and why	Cases where it went well, and why
3. Development of management systems	• Preparation of a first draft of the management plan and present it in a plenary meeting where all stakeholders are invited • The final management plan is officially submitted for adoption at the level of the central administration responsible for the fisheries sector in Tunisia	• Very important step to modify, add and adjust the content of the plan according to the latest recommendations and opinions of all stakeholders • This step should be preceded by unofficial preparatory work with managers to inform them and encourage them to adopt the plan	• Political instability and change of leadership could delay the adoption of the plan	• When the plan is well prepared and its content is complete and validated and supported by all stakeholders, it will have a better chance of being adopted and applied
4. Implementation, monitoring and performance review	• The creation of a Technical Monitoring and Consultation Committee (TMCC) for the execution of the plan • Maintain regular meetings (at least twice a year) to monitor the progress of the plan at all levels • Ensure the research activities programmed and identified during the development of the plan take place	• The Committee is well represented by all stakeholders in the fishery • These meetings are prepared in advance and each time the agenda is discussed and approved in advance • These activities concern almost all aspects of the fishery. Their results, which are presented and discussed during Committee meetings, are of great use in making the development plan successful	• The need to allocate a special budget at the national level to ensure, without logistical difficulties, the meetings of the Committee on a regular basis • Some aspects, such as that of stock assessment, require a relatively long historical series of data to estimate the state of exploitation of the fishery	• The coordination of TMCC activities is well assured. The Committee is at its fourth meeting since the adoption of the plan towards the end of 2018 • The activities carried out in the El Bibane lagoon are reinforced by international expertise thanks to the support of the FAO CopeMed II project

Chapter 9: An ecosystem approach to fisheries management for small-scale fisheries in Gökova marine protected area, Turkey: challenges encountered during the transition process

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1. INTRODUCTION

The ecosystem approach to fisheries (EAF) is a fisheries management framework gleaned from decades of international conventions, agreements, treaties and studies aimed at achieving sustainable exploitation of natural resources while ensuring there is a balance between the wellbeing of humans and ecosystems (Bianchi, 2008; Dimech *et al*., 2014; Cury *et al*., 2016). The EAF concept has gained widespread support due to general dissatisfaction with traditional fisheries management strategies, which have often focused solely on the sustainability of a single species or stock unit – and which have, in many instances, neither been able to keep fisheries sustainable nor prevented fisheries all over the world from collapsing (Jennings, 2004; Pikitch *et al*., 2004; Francis *et al*., 2007). The EAF goes beyond conventional approaches to fisheries management. It is more holistic, cross-sectoral, bottom-up, transparent, adaptive, inclusive and participatory and it also allows trade-offs when balancing human and ecological wellbeing. The EAF considers the impact of fisheries activities on all ecosystem components, rather than merely on the fisheries resources utilized by a particular activity. In addition, the EAF also takes the cumulative effects of all other natural and anthropogenic activities impacting the ecosystem into consideration (Bianchi, 2008; Kempf, 2010; Cury *et al*., 2016). The EAF was recommended by the FAO Conference on Responsible Fisheries in the Marine Ecosystem in Reykjavik in 2001, and was subsequently adopted by the FAO Committee on Fisheries in 2003 (Garcia *et al*., 2003; Bianchi, 2008; Cury *et al*., 2016). Following a request from its Members, FAO prepared a set of technical guidelines and a toolbox (FAO, 2003, 2005, 2009, 2012) designed to guide the implementation of the EAF.

Although various challenges have been experienced during the practical application of the EAF framework to fisheries management (Kempf, 2010; Berkes, 2012; Cowan *et al*., 2012; Link and Browman, 2017), substantial progress has nevertheless been made towards successfully implementing it in an increasing number of fisheries around the world (Pitcher *et al*., 2009; Fletcher *et al*., 2010; Petersen *et al*., 2015; Cury *et al*., 2016; Gullestad *et al*., 2017; Townsend *et al*., 2019). Implementation of the EAF management framework in the Mediterranean Sea has been somewhat slow when compared to many other important fishing regions in the world, even though there is high regional public awareness regarding the importance of the protection of ecosystems and biodiversity and sustainable fishery activities (e.g. the recent Malta MedFish4Ever Declaration).

There is also a well-established regional fisheries management organization, the General Fisheries Commission for the Mediterranean (GFCM), and appropriate legal instruments such as EcAp-MED I[1] in place. In addition, other binding legal instruments for Mediterranean European Union (EU) countries apply. These include the Common Fisheries Policy (CFP) which declares that the EAF is to be implemented in fisheries management in the European Union, and the Marine Strategy Framework Directive (MSFD), which is the European Union's concerted initiative to apply an ecosystem-based approach to the regulation and management of human activities impacting the quality of the marine environment across Europe.

Turkey has progressed similarly to other Mediterranean countries. The first concrete step taken, with the aim of putting the EAF principles and tools into practice in Turkey, was the initiation of a pilot case study to develop an EAF management plan for the small-scale fishery (SSF) in Gökova Bay in 2016. This came following a request from Turkey's Ministry of Agriculture and Forestry (MoAF) and was carried out with the financial support and guidance of the FAO-EastMed project (Ünal *et al.*, 2018, 2019). In addition to the the MoAF, which is in charge of the management of fisheries in Turkey, contributors and collaborators in the project comprised of stakeholders including fishery cooperatives, non-governmental organizations, several ministerial and other governmental and public institutions, and universities (Ünal *et al.*, 2018, 2019). This chapter aims to document and discuss the experiences gained and the major challenges faced in the course of the EAF pilot study in Gökova Bay.

1.1. Study area: Gökova Bay

Gökova Bay is situated on the eastern Aegean coast of southwestern Anatolia, Turkey. It is one of the largest bays in the country. The bay refers to the sea and coastal areas to the east of the virtual line between the Bodrum Peninsula's Hüseyin Cape in the north and the Datça Peninsula's Knidos Cape in the south. It is approximately 92 km long on the east-west axis, with a width of approximately 20 km in the middle of the bay (Kıraç *et al.*, 2010). A part of Gökova, including marine and land areas, was designated as a Special Environmental Protection Area (SEPA) by Decree no. 88/13019 of the Cabinet of Ministers of Turkey in June 1988. Later, a border change of the Gökova SEPA was approved by Decree no. 90/1117 by the Cabinet of Ministers (dated 22 October 1990) (Figure 1). However, when considering only the marine area of Gökova SEPA, the preferred term is 'Gökova marine protected area (MPA)' (Ünal *et al.*, 2019). In the following it will therefore be referred to as such.

There are 31 protected areas in all in Turkey, of which 15 include MPAs covering a total area of 346 000 ha. This means that about 4 percent of the country's territorial waters are presently under legal protection. With an area of 82 700 ha, Gökova MPA includes 20 no-fishing zones (NFZs), where any type of commercial fishing activity is forbidden, designated as core zones (Aktaş *et al.*, 2011; Güçlüsoy, 2015, 2016; TVKGM, 2019; Ünal *et al.*, 2019).

[1] EcAp-MED I: Implementation of the Ecosystem Approach (EcAp) in the Mediterranean by the Contracting parties in the context of the Barcelona Convention for the Protection of the Marine Environment and the Coastal region of the Mediterranean and its Protocols

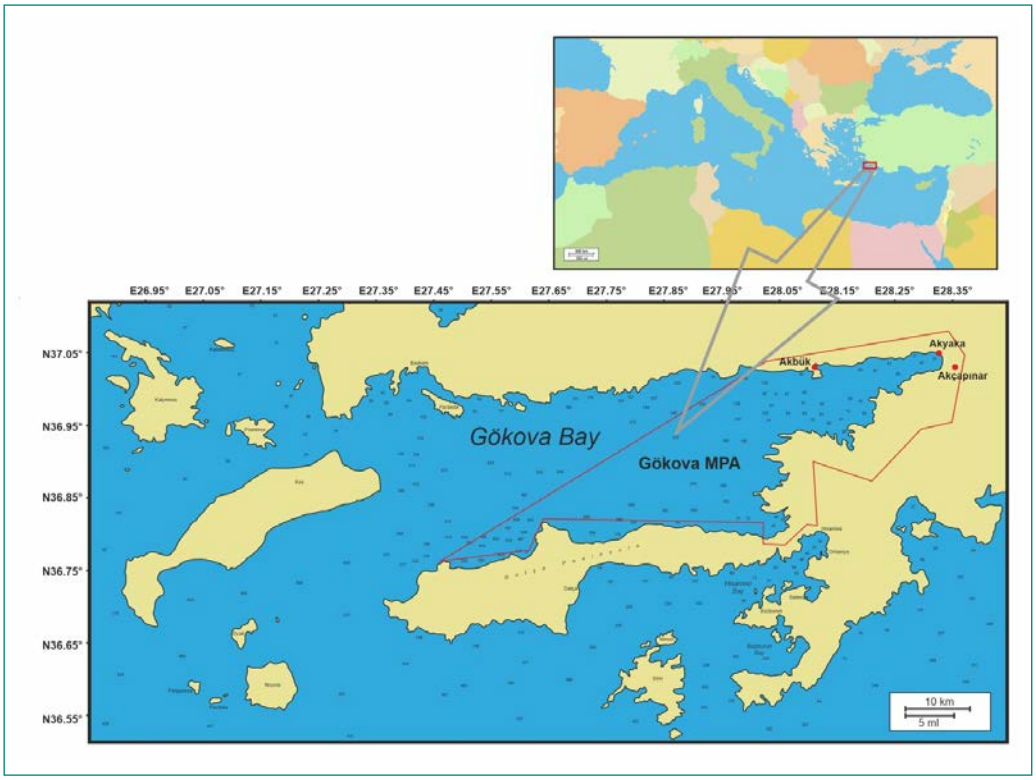

Figure 1: Location of Gökova Bay and its marine protected area, southwest coast of Turkey.
Source: Ünal, 2020.

There is high biodiversity in Gökova Bay. A total of 723 macroscopic species from 19 taxonomic groups have been identified within the Gökova MPA area. Thirty-four of these species are protected under national and international treaties. Twenty-six species have moved into the Mediterranean Sea through various routes and some have even become dominant over the local species over time (Okuş *et al*., 2006). Interestingly, in spite of its rich biodiversity, the region is noticeably poor in terms of fish productivity and its fish biomass is one of the lowest on Turkey's Mediterranean coast (Sala *et al*., 2012; Ünal and Kızılkaya, 2019).

The fishery in the bay is a typical multispecies and multigear small-scale fishery targeting both demersal and pelagic species, like in most other Mediterranean countries. More than 100 vessels are reported to fish within the Gökova MPA, and approximately 15 additional vessels occasionally arrive from neighbouring areas. Gillnet and longline fisheries dominate the small-scale fishery in the bay, and two local purse seiners also fish there. The SSF boats are between 6–12 m long and built locally out of wood. The boats are usually operated by one to two fishers. They use gillnets, trammel nets, combined nets, and longlines. The SSF provides considerable employment in the region – approximately 200 fishers work directly on the boats (Ünal *et al*., 2019; Ünal and Kızılkaya, 2019).

Gökova Bay has become a centre of interest for many NGOs and scientists in Turkey. There have been a considerable number of national and international projects, meetings, workshops, and scientific articles related to fisheries in this region during the last two decades.

1.2. Characteristics of fishers and their organizations

Fishing is one of the major livelihoods in Gökova Bay. It plays an important role in food security and nutrition in local communities, since all the fish caught are consumed by people in the local settlements. Three main settlements in the study area – Akçapınar, Akyaka and Sarnıç-Akbük – established their own fishery cooperatives in 1973, 1992 and 1999 respectively (Ünal *et al*., 2009). All except the Sarnıç-Akbük fishery cooperative provide services for marketing their members' products; all have strong relations with fisheries stakeholders such as NGOs, universities and management authorities; and all are partners of national and international projects related to many aspects of fisheries such as combating illegal fishing, retrieving lost fishing gears, supporting the marketing system of Lessepsian fish species, improving marine biodiversity and ecosystem health, and designing a management plan based on the EAF.

A recent study showed that the average age of fishers operating in Gökova Bay is around 51 years, which means that there has been an increase in average age over the last decade (Ünal, 2020). According to Ünal and Franquesa (2010) it was 43 in Akyaka and 45 in Akçapinar in 2010 and 46 years in Turkey as a whole in 2020 (Ünal and Ulman, 2020).

More than half of the fishers in Gökova MPA depend on fishing as their main source of income (Figure 2). Because most fishers fish alone or together with a family member, there is rarely a need for temporary labour (crew) to support the fishing activity.

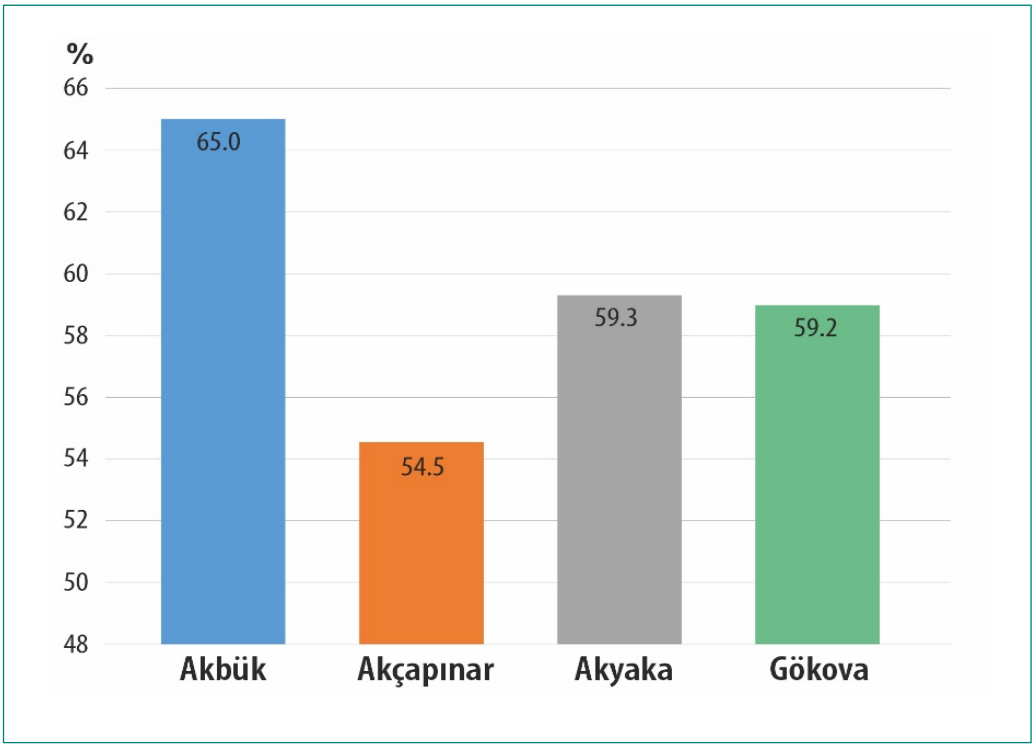

Figure 2: Percentage of the surveyed fishers' total income generated by fishing.
Source: Ünal, 2020.

1.3. Main fishing gears

Fishers in Gökova Bay use traditional small-scale fishing gears such as trammel nets, bottom set gillnets, combined nets and longlines. While gillnets are used to catch a single target species, many species are captured with a trammel and combined net set-up (trammel-gillnet). Although larger-sized fish (e.g. groupers, dentex) are commonly caught by thick longlines with a hook size of 7 or 8, smaller-sized fish (mostly breams) are caught by thin longlines fitted with smaller-sized hooks.

1.4. Target species, landings and value

The Akyaka fishery cooperative is the most efficient cooperative in Gökova Bay. It has well-kept records of its own fishing activities. Reliable data pertaining to catch, price and value for each vessel has been collected regularly since 2015. Almost half of the landings since then came from various entangling gill nets (49.5 percent), and the rest from longlines. The portion of Lessepsian fish in the landings and value was about 22 percent and 9.6 percent respectively. Randall's threadfin bream *Nemipterus randalli*, brushtooth lizardfish *Saurida undosquamis*, rabbitfishes (dusky spinefoot and marbled spinefoot) *Siganus luridus* and *Siganus rivulatus* are currently the main Lessepsian species in Gökova Bay. Fishers report that the share of Lessepsians has been increasing steadily in recent years. The common pandora *Pagellus erythrinus* was the most landed species (24.4 percent), followed by gilthead sea bream *Sparus aurata* (12.9 percent), *N. randalli* (12.8 percent) and *S. undosquamis* (7.2 percent). When considering the sales value of the species in terms of their contribution to the gross income of the cooperative in 2019, *P. erythrinus* (25.8 percent), *S. aurata* (19.9 percent), grouper *Epinephelus aeneus* (8.6 percent), *N. randalli* (6.3 percent) and caramote prawn *Melicertus kerathurus* (6.2 percent) were the most important species in the Gökova MPA (Table 1).

The annual average CPUE calculated per 1 000 m net length in Gökova MPA was 2.5 kg (sd: 1.9) in 2019, whereas this value was substantially higher for longline hooks at 15.1 kg (sd: 8.7) per 1 000 (Figure 3).

Table 1. Total landings (kg) and value (USD) of Akyaka fishery cooperative in 2019.

Landing			**Value**		
Species	**kg**	**%**	**Species**	**USD**	**%**
Pagellus erythrinus	5 269	24.4	***Pagellus erythrinus***	35 845	25.8
Sparus aurata	2 783	12.9	***Sparus aurata***	27 655	19.9
Nemipterus randalli	2 765	12.8	***Epinephelus aeneus***	11 987	8.6
Saurida undosquamis	1 562	7.2	***Nemipterus randalli***	8 816	6.3
Mugil spp.	891	4.1	***Melicertus kerathurus***	8 550	6.2
Epinephelus aeneus	783	3.6	***Epinephelus costae***	6 017	4.3
Sardinella aurita	602	2.8	***Dentex dentex***	4 954	3.6
Caranx rhoncus	600	2.8	***Octopus vulgaris***	4 598	3.3
Octopus vulgaris	573	2.7	***Mugil spp.***	3 676	2.6
Melicertus kerathurus	556	2.6	***Saurida undosquamis***	2 866	2.1
Other	5 232	24.2	***Other***	23 895	17.2
Total	**21 616**	**100.0**	**Total**	**138 860**	**100.0**

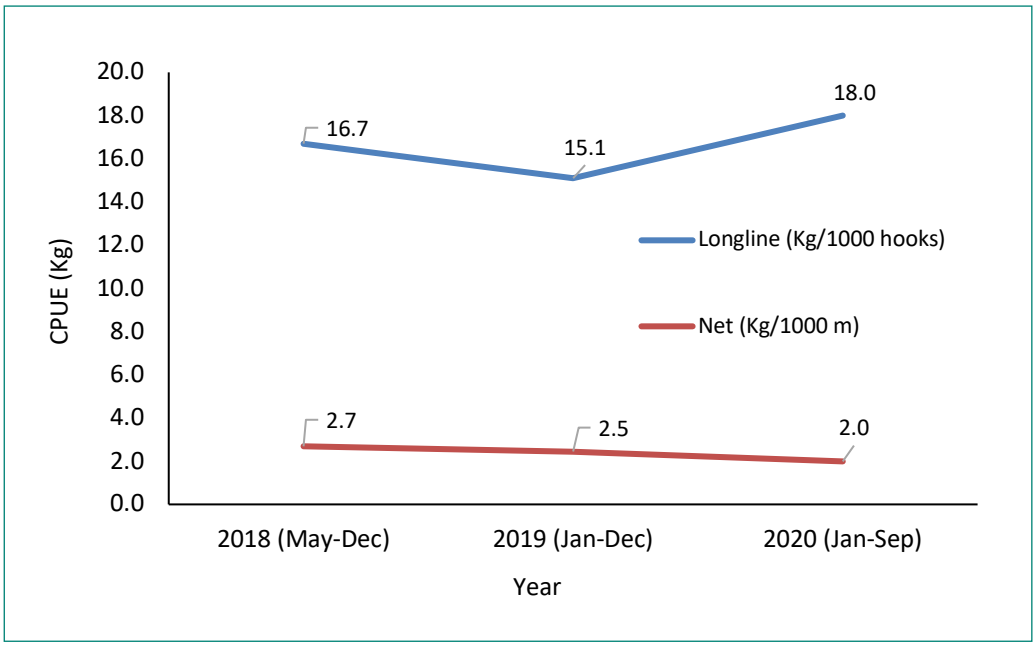

Figure 3. Average annual CPUE (kg) per 1 000 m net length and 1 000 hooks a day from 2018 to 2020 in the Akyaka fishery cooperative.

1.5. Habitats and status of fish stocks

A considerable variety of habitats are found in Gökova Bay (Okuş *et al*., 2006). In addition to the pelagic zone, various substrate types form different benthic habitats hosting diverse groups of fish and other marine animals. Perhaps the most important habitats in the bay are the vegetated habitats, particularly the seagrass meadows of *Posidonia oceanica* and *Cymodocea nodosa* which serve as an important nursery area for many fish species. The other habitats include sandy, muddy, sandy-muddy areas and hard rocky substrates. Shallow muddy areas, which are predominantly associated with freshwater inlets, also function as fish nursery areas.

The SSF in Gökova Bay exploit a large number of fish species (Ünal *et al*., 2019). Some of these species are caught frequently regardless of seasonal changes, while others are caught less regularly or their availability is affected by seasonal variations. Members of the Sparidae and Serranidae families are the most important and most targeted fish species in Gokova Bay. Several other demersal and pelagic species from various families including Nemipteridae, Soleidae, Mullidae, Mugilidae, Carangidae, Sciaenidae, Scombridae, Siganidae, Sphyraenidae and Zeidae are also targeted or landed as bycatch (Ünal *et al*., 2019).

No assessments have been conducted for any of the fish stocks of the Aegean Sea, nor is any scientific or managerial information available for the boundaries of the stocks (Ünal *et al*., 2019). The only continuous primary source of information regarding the status of fisheries in Turkey is the official fishery statistics which are collected, compiled and published annually by the Turkish Statistical Institute. Unfortunately, these statistics pool all the data collected in different regions of the Turkish Aegean Sea and present one single figure – an annual total catch for the whole sea area. Data regarding fishing efforts are provided in a similar fashion. In addition, the accuracy, precision, coverage and representativeness of these catch statistics have long been debated (Tıraşın and Ünlüoğlu, 2012). There seems to be consensus that the catch figures reported in these statistics are underestimates of the fish that are actually caught, and that a substantial part of the catch goes unreported. Even so, to date, there has been no agreement about the magnitude of the bias. Another

[1] See also https://www.washingtonpost.com/graphics/2019/national/climate-environment/climate-change-world/.

concern is the inaccuracy of the information provided, particularly at the species level. The organism names given in the statistics do not always strictly correspond to the distinct biological species. Sometimes, data on several closely related species are merged and presented under only one name. Again, the statistics for some similar-looking species are considered to be inaccurate because these species are often mistaken for one another and their common names are repeatedly swapped locally (Tıraşın and Ünlüoğlu, 2012). Thus the official catch statistics of the main target species in the Gökova Bay fisheries – i.e. *E. aeneus, P. erythrinus, S. aurata, Mugil* spp., *N. randalli* and *S. undosquamis* – do not provide any insight about the stock status of these species in the area. Nevertheless, the overall view the catch statistics provide is that the fisheries resources in the Aegean Sea have shown a clear declining trend since 2009 (Ünal *et al*., 2019).

2. MANAGEMENT CONTEXT

2.1. Legal framework

According to the Fishery Law No. 1380, MoAF is the main state organization responsible for fisheries management including administration, regulation, protection, promotion, monitoring and technical assistance throughout the four General Directorates. However, surveillance is shared among different institutions including the MoAF. All fishery activities must adhere to the Fisheries Law No. 1380 presented in 1971, amended by Laws 3288 in 1986 and 4950 in 2003 (Ünal and Göncüoğlu, 2012). However, a new law (No. 7191) to amend the Fisheries Law was accepted at the General Assembly of the Turkish Grand National Assembly on 6 November 2019 and was published in the Official Gazette on 22 November 2019. Thus, the new Fishery Law of Turkey has been in effect since November 2019. The MoAF issues Fishing Notifications to regulate commercial and recreational fishing activities in order to ensure resource conservation and achieve sustainable fishing after consulting with stakeholders including research institutes and universities. Commercial and recreational fishing activities are regulated by notifications which are published in the Official Gazette. These notifications establish prohibitions, restrictions and obligations concerning commercial and recreational fishing activities.

Gökova Bay is the pilot study area, and it should be noted that its legal status as a SEPA was determined by Decree no. 88/13019 in 1988. The Ministry of Environment and Urbanization and the Ministry of Agriculture and Forestry are respectively responsible for the management of the area and for the management of the fisheries within it. This however requires both coordination and cooperation between the two institutions, as well as with other stakeholders.

2.2. Policy framework

The objectives of the fisheries management policy in Turkey are set by the Ministry of Development following a three-day meeting of fisheries experts every five years. Over the last two decades, sustainable management of fishery resources has been the main objective for Turkey's fisheries policy. In the 10th Five Year Development Plan (2014–2018), the ideal future fisheries industry was envisioned as 'A highly competitive sector that uses its resources in a sustainable manner, managed scientifically and effectively with the participation of stakeholders, has completed its functional sectoral organization and infrastructure'. Although a transition to an EAF was mentioned, the EAF concept was probably not well understood by the expert commission at that time (Anonymous, 2014).

However, the long-term goal of the latest 11th Development Plan for the fisheries industry is to protect and develop fisheries habitats, taking ecological criteria into consideration, and to strive for efficient and sustainable management of water resources (Anonymous, 2018). This plan also refers to the EAF-based fisheries management plan for SSF in the Gökova MPA.

2.3. Triggering factors that led to the changes in the management system

Although demands for radical change in the fisheries management approach and strategies had not yet been made at a national level, the lack of fisheries management in Gökova Bay started to get a great deal of attention in the early 2000s due to the many problems faced by the fishers in the region. The Gökova MPA has since served as a pioneering area for NGOs, academics and administrative bodies. The FAO Mediterranean Project EastMed (Scientific and Institutional Cooperation to Support Responsible Fisheries in the Eastern Mediterranean) showed an early interest in the implementation of EAF principles for the SSF that have traditionally dominated fishing in this area, and initiatives were put in motion to prepare a fisheries management plan. The main triggering factors that made changes in the fisheries management in Gökova inevitable were the decreases in the catches and income of the fishers and also the increase in illegal fishing activities. The annual total catch value of the Akyaka fishery cooperative decreased by 22 percent from 2006 to 2009 (Ünal *et al*., 2019), and the disappearance of shrimp and a major decline in the abundance of groupers threatened the livelihoods of fishers who had previously received 40 percent of their total fishing income from these species. Decreasing fishing incomes made it almost impossible for fishing activities to be viable in Gökova Bay (Ünal and Kızılkaya, 2019). The dramatic decreases in catches of groupers and shrimp, the most valuable species in the region, brought fishers, academics and NGOs together in an effort to find solutions to these issues. The fisheries management authority was involved as a part of this group and in related projects. Notably, a poisonous and aggressive invasive pufferfish became a serious problem locally as it damaged fishers' nets and longlines as well as preying on fish caught on fishing gears (Ünal *et al*., 2015). Economic losses caused by the pufferfish continue (Ünal and Göncüoğlu-Bodur, 2017; Öndes *et al*., 2018). Meanwhile, stomach content studies have revealed that this species preys on 92 different species (Kalogirou, 2013). The potential threat the pufferfish poses is more than simply socioeconomic; it brings to mind the catastrophic events that followed the discovery of other invasive species in the area. For instance, soon after the silver-cheeked toadfish *Lagocephalus sceleratus* had been discovered in Gökova Bay, the prawn fishery, which had previously been the backbone of the Gökova Bay fishing economy, collapsed completely. In 2008 landings of octopus dropped to negligible amounts (Ünal and Kızılkaya, 2019), and by 2009 the shrimp had almost completely disappeared. The need for a management plan was put on the agenda for the first time in 2010 and a discussion paper was prepared in order to form a basis for the management plan (Ünal, 2010). In the same year, some areas were declared as marine reserves and closed to all types of fishing activities (Official Gazette, 2010; Ünal *et al*., 2015), but at a stakeholder meeting three years after the announcement of the no-fishing zones it was revealed that the protection in the area was weak and illegal fishing had increased greatly. Figure 4 shows the events in chronological order in Gökova Bay fishery.

2.4. Key institutions and stakeholders involved

NGOs (e.g. the Mediterranean Conservation Society, AKD), academics and local fishery cooperatives are the key stakeholders in Gökova Bay, and they continue

Figure 4. Timeline of fisheries management in Gökova Bay, Turkey.

to play an important role in initiatives to stop overfishing and illegal fishing. For instance, within Gökova Bay's six no-fishing zones (which together cover 27 km^2), the AKD coordinates daily community-led patrols to reduce the threat of destructive and illegal fishing practices which not only deplete fisheries resources and harm underwater habitats, but also present a risk to turtles and other threatened marine fauna through bycatch and injury. Alongside this, the AKD conducts surveys to assess ecosystem health and collaborates with local fishing cooperatives to monitor fisheries resources, record fish catches, and improve revenue. Thanks to this collaborative effort, fish stocks are slowly recovering, which is leading to an improvement in the income of small-scale fishers and increasing the availability of prey for monk seals and other predatory marine species (FFI, 2020). In addition, work has been going on to change the management system from centralized to local-based, although this is not yet complete.

With the cooperation and contribution of official management authorities, stakeholders have carried out many projects related to fisheries in Gökova Bay. The main fisheries stakeholders involved in preparing the management plan for SSF in Gökova Bay include the Directorate General of Fisheries and Aquaculture (DG-Fisheries) of MoAF, fishery cooperatives, the AKD, Turkish Coast Guard Command, universities and the FAO-EastMed. The AKD and Akyaka fishery cooperative are the two most effective and active stakeholders: in the Gökova MPA, the monitoring studies which are essential components for fisheries management have been carried out entirely by these two main actors.

3. ACHIEVEMENTS AND LIMITATIONS: A NOVEL INITIATIVE IN FISHERIES MANAGEMENT IN TURKEY

3.1. Managing fisheries with or without a plan

Fisheries in Turkey are not managed with regional-based, fishery-based or species-based plans. Conventional management measures (e.g. closed areas, closed seasons, minimum mesh sizes and minimum landing sizes) are however observed (Ünal and Göncüoğlu, 2012; Ünal and Kızılkaya, 2019), and the transition to an EAF strategy is among the goals mentioned in the 10th Five Year Development Plan (2014-2018). However, present approaches and strategies have not been successful in dealing with significant problems such as overfishing, illegal fishing, low fishing income, habitat loss, invasive alien species or climate change. Some NGOs – together with fishery cooperatives, administrative units and other stakeholders – attempted to solve the problems by designating some areas as reserves and closing them to fishing activities. They hoped that by protecting these areas, fish stocks might recover and allow fishers to catch more fish and earn more money. In addition, in recent years (2012–2017) the government has operated fishing vessel buyback programmes: a total of 1 253 fishing vessels with licenses were removed from the fleet through five separate buyback programmes (Göktay *et al*., 2018; Ekmekci and Ünal, 2019; Ünal and Göncüoğlu-Bodur, 2020a, b). Unfortunately, undesirable human activities such as overfishing and illegal fishing continued in spite of these efforts. In the end, realizing that fishing simply cannot be managed without holistic plans, and bearing in mind also that a transition to an EAF plan was included in the 10th Five Year Development Plan (2014–2018) by the Ministry of Development (Anonymous, 2014), a pilot case study on the EAF in Gökova Bay was initiated in 2016 within the framework of the FAO-EastMed Project. For Turkey, this was the first time an attempt had been made at managing a fishery by using a management plan prepared through a series of meetings and workshops where all stakeholders had been allowed to participate fully. No less than four stakeholder meetings were organized within one year. In addition, before

the final draft version of the plan was presented to the stakeholders, a meeting was held with DG-Fisheries in Ankara, in order to make sure the plan was fully backed by the fisheries administration at the highest possible level. After this, a final stakeholder meeting was held where the management plan was unanimously accepted. Once the management for the SSF in Gökova Bay had been prepared and approved by all stakeholders in March 2018, the next big challenge was to implement it. Moving forward, DG-Fisheries was expected to ensure that the plan was being implemented. It is hoped that there will not be disappointment among the stakeholders due to delays or setbacks, but that the spread of the approach will be accelerated by the eventual successful implementation of the plan.

3.2. Participatory approach and designing a management plan based on EAF

The very first step in the process that several years later would result in the preparation of an EAF-based management plan was a training activity held in Antalya in September 2014. It was organized as an EAF workshop by FAO-EastMed, and aimed to improve the understanding of the EAF and the processes involved in its implementation. Following the workshop, consultations with the fisheries administration lasted for almost a year and a half before the EAF process was launched in Akyaka, Gökova. During this time a core meeting was held in Antalya in 2015 to decide on a potential pilot study for the implementation of EAF, the first of several stakeholder meetings was held to introduce the concepts, and a draft EAF baseline report was prepared for the Gökova SSF. This plan contained a synthesis of all available information on the socioeconomic, environmental and institutional aspects of the fishery that were considered relevant for the development of a management plan (Ünal *et al*., 2019), and it was presented and discussed with the relevant stakeholders in the second stakeholder workshop organized in March 2017 (EAF project – WS 2 Report, 2017). In the two workshops that followed, in May and June 2017, stakeholders first identified priority issues and risks for management and capacity development interventions for EAF (EAF project – WS 3 Report, 2017), and then developed a management strategy for

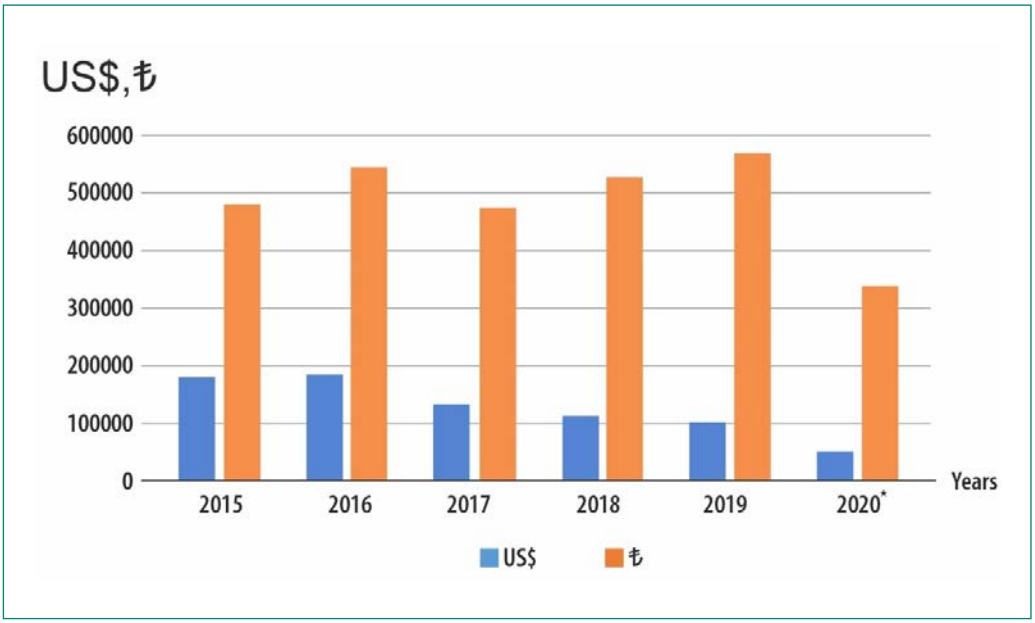

Figure 5. Landing value (USD/year and Turkish lira ₺/year) of the Akyaka fishery cooperative (*consists of the first nine months of 2020).

all priority issues identified, including operational objectives, indicators, performance measures, data requirements, current management practices and future management measures for the SSF in Gökova MPA (EAF project – WS 4 Report, 2017). Participants identified 110 issues under the EAF components of ecological wellbeing, social and economic wellbeing, and ability to achieve. After the risk assessment process, 67 of these issues were categorized as low, 12 medium and 31 high. After the risk assessment analysis, the following elements were defined for each high priority issue: operational objectives, indicators, performance measures, data requirements, current management practices, and future management measures (Anonymous, 2017).

As mentioned previously, before the final draft version of the plan was presented to the stakeholders on 16 March 2018 in Akyaka-Gökova, a meeting was organized with DG-Fisheries in Ankara on 21 December 2017 in order to ensure that the plan had the full support of the fisheries administration at the highest possible level. After this, the fifth and final stakeholder meeting was held on 16 March 2018 in which the FMP was accepted by all participants, including the representatives of DG-Fisheries. During a short period following this meeting a number of other initiatives were advanced by stakeholders, and these initiatives were included in the final preparation of the plan.

Although it was a lengthy process, the outcome – a bona fide fisheries management plan in accordance with EAF principles – made the effort worthwhile. In the final session of the fifth stakeholder meeting participants were reminded of the tasks that now lay ahead, such as the establishment of a Fisheries Management Advisory Committee at the local level, and it was emphasized that DG-Fisheries was now in charge of and responsible for the implementation of the plan. The contents of the workshops and decisions made within them were shared in written form in both Turkish and English with all stakeholders, and by the end of the first half of 2018 everything needed for the implementation of the plan was ready and in place.

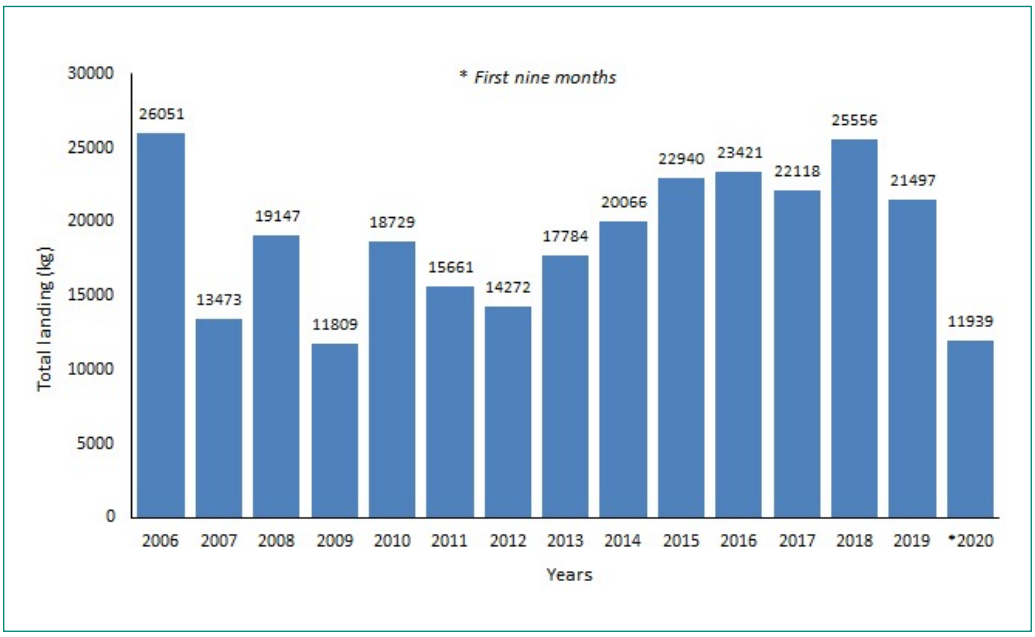

Figure 6. Total landings (kg) of fish by the Akyaka fishery cooperative between 2006-2020.
Source: Akyaka Fishery Cooperative & AKD.

3.3. EAF management plan: an end or a beginning?

The application of the EAF in Turkey – which began in Antalya in 2014, was supported throughout by the FAO, and which resulted in the Gökova SSF management plan in 2018 – has yet to be officially published (Ünal and Kızılkaya, 2019). Needless to say, the preparation of the plan did not instantly solve all of the problems and ensure a sustainable fishery in the Gökova MPA. The final drafting of the management plan was as such not an end but a beginning: the efforts made have not yet all paid off, and full implementation of the plan has yet to be achieved. An Advisory Committee on Fisheries Management has not yet been decided on. The relevant parties now need to come together and get back on track, or else risk complete stagnation.

Although the issues related to the implementation of the plan have not been overcome, improvements have been seen in recent years in the socioeconomic status of the fishers. According to Ünal and Kızılkaya (2019), the initiatives by stakeholders, particularly the AKD, have led to positive improvements in local fishery management, such as increased incomes for local fishers. The increase in income results from a stricter enforcement of no-fishing zones, which has led to both a reduction in illegal fishing (demonstrated by the decrease in the average number of fishing boats) and to an increase in fish stocks.

Although the Akyaka fishery cooperative has seen an increase in the value of its landings value (USD/year), the loss of value of the Turkish lira against the US dollar in recent years means there has been a year-on-year decrease in fishing revenues in dollar terms (Figure 5).

However, within the scope of FAO's Blue Hope Project, Gökova Bay was accepted as a pilot area, and three fishers (one from each of the three cooperatives in this region) were selected as pescatourism candidates. In this context, new studies have been initiated to introduce pescatourism practices in Turkey and to prepare the legal infrastructure for this work. All Gökova Bay stakeholders support this initiative.

In spite of the lack of an approved plan for fisheries management in the area, there are still actions being implemented by stakeholders to move the system towards the established goals. This is also an EAF process, which goes beyond the management plan itself. In fact, the no-fishing zones in the Gökova MPA were established as an alternative way of managing fisheries and the marine ecosystem. The AKD and cooperatives have been running this process for years and have been obtaining some positive results. The management plan has not yet been fully accomplished, but that does not mean that the EAF-based process has not progressed at all. The implementation of the plan will give greater responsibilities to local stakeholders, and this will likely strengthen the process; however the process does not start (nor end) with the plan alone.

The amount of landings recorded by the Akyaka fishery cooperative in Gökova Bay has varied annually (Figure 6). The highest landings were recorded in 2006 and 2018, with 26 051 and 25 556 kg respectively. In 2020, due to the Covid-19 pandemic, the landings fell notably (Table 1).

3.4. Factors that enabled or blocked the attempted changes

Considerable efforts have been made by many stakeholders to promote and implement an EAF-based SSF management plan in Gökova Bay. These efforts would have been greatly helped and their effectiveness much enhanced had the management plan been adequately supported by governmental institutions. Although government agencies did contribute significantly during the preparation phase, the situation changed completely when the time came for the implementation of the plan. Annex 1 shows the planning process with details of experiences and lessons for the EAF in Gökova Bay, Turkey. Regrettably, government agencies have had significant difficulties in

implementing the decisions made during this process, and these difficulties constitute the single largest obstacle to success. It is hoped that within the framework of the new Fisheries Law of 2019 these problems may be overcome. In the most recent communiqué from DG Fisheries, it was confirmed that the Provincial Directorate of Agriculture and Forestry in Muğla (the province where Gökova Bay is situated) would officially be given the responsibility of establishing and governing the Fisheries Management Advisory Committee in early 2021. This will be a most welcome first step towards the implementation of the EAF-based management plan for SSF in Gökova Bay.

4. CONCLUSION

The first EAF-compliant fisheries management plan for Turkey was developed over a period of approximately two years. The process began with extensive background surveys and was followed by a series of stakeholder consultation workshops where all the stakeholders demonstrated a serious commitment and willingness to contribute to the preparations. Needless to say, these workshops also served to assist managers to help them make better informed decisions for the sustainable use of the resources, based on the priorities and recommended actions identified by the main stakeholders in the Gökova SSF. However, it is not clear to what extent the plan and its rationale have been taken on board by the institutions involved, especially DG-Fisheries and the fishery cooperatives.

It was recently reported in *Fauna and Flora International* (FFI, 2020) that the AKD has been leading conservation efforts in Gökova Bay since 2012. In parallel with these efforts, articles and book chapters have continuously been published and conferences held to increase awareness and put pressure on the communities and authorities to implement the EAF-compliant management plan without delay. However, the authorities responsible for implementation seem to be dragging their feet. Fishery cooperatives have grown impatient and want to know whether or not they have wasted their time working on the process. This is understandable, as more than two years have passed since the unanimous adoption of the management plan but no action has yet been taken by the management authorities. A recent development regarding the future of EAF in Gökova Bay is that DG Fisheries has declared that it will officially put the Provincial Directorate of Agriculture and Forestry in Muğla in charge of the establishment of the Fisheries Management Advisory Committee. This is scheduled for early 2021.

In the meantime, on 16–17 November 2020, the authors of this chapter found an opportunity to attend the EAF Implementation Monitoring Tool (IMT) baseline workshop organized by FAO, and evaluated the Gökova case for the first time using the IMT. The structure of the EAF IMT is very familiar to those who have already engaged in EAF activities and processes (FAO, 2021). The structure is the same as in the FAO EAF Toolbox (FAO, 2012) and starts off with the three main EAF components: ecological wellbeing, human wellbeing, and ability to achieve. The tool is easy to use and visually appealing. The information and requirements are clearly organized and easy to locate. This serves to simplify the process and minimizes the chance of the user missing out on any relevant issues or information. Like the EAF process it aims to monitor, the application of the EAF IMT requires a high level of participation from all relevant stakeholders. Following an initial evaluation by a small group of experts, all relevant stakeholders are required to participate actively in this process. However, this first application of the EAF IMT in Turkey was initiated by the authors of the present study – ideally, both fisheries managers and fishers ought to have participated with at least one representative each, but this was not possible. Therefore, there is a danger that this initial assessment may be somewhat biased, and inclined to take a more academic view of the EAF progress in Gökova Bay than might otherwise have been the case. Nevertheless, the authors are satisfied that the tool provided a good, usable, well documented and transparent assessment of the progress

and implementation of EAF in the Gökova Bay SSF. This initial evaluation showed that the EAF process in Gökova Bay is only halfway there. The ecological wellbeing and the human wellbeing component scores are almost identical at 52 percent and 53 percent, while the ability to achieve component scored only 40 percent. Needless to say, a good number of obstacles will have to be overcome and many tasks still need to be carried out in order to complete the process. The authors however believe that the tool and its application will serve as a motivator and help facilitate this work. Of course, the next step must involve a more inclusive process with wider stakeholder participation, to review and validate the scores and the justifications provided in the present initial assessment.

As a result, the biggest obstacle to the implementation of the EAF has been the reluctance of the relevant official institutions to act. From beginning to end, the entire process leading up to the finalizing of the plan exceeded expectations and carried great promise for a successful transition to an EAF in Turkey. The EAF initiatives, as well as related indicators of success and failure, were clearly summarized in *Initiatives for The Ecosystem Approach to Fisheries Management in Turkey: Is There Hope for a Successful Implementation?* (Ünal *et al*. 2018), and a concluding remark rings true still: "the biggest challenge will now be to implement it". It is imperative that DG-Fisheries assumes the role of ensuring the implementation of the management plan. Should this venture prove unsuccessful, there will be great disappointment among the stakeholders who put their hopes into the project.

In conclusion, whatever the final destiny of this first EAF-based management plan is for Turkey, efforts towards saving the fisheries resources of the Mediterranean must never be allowed to cease. As the Mediterranean is surrounded by a densely populated coastline and is exposed to intense human activity as well as continuously increasing levels of marine pollution and diminishing fish stocks, it remains in dire need of an EAF.

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ANNEX 1. SUMMARY OF AND LESSONS LEARNED FROM THE PREPARATION AND PRACTICAL IMPLEMENTATION OF THE EAF PLANNING PROCESS ACCORDING TO FAO GUIDELINES

Steps	Activity (what was done)	Comments and observations about this step	Cases where it went wrong, and why	Cases where it went well, and why
1. Initiation and scope The 1st meeting/ workshop of the stakeholders: 19-20 February 2016, Akyaka, Muğla	The project was introduced to the stakeholders, a suitable platform was created for getting to know each other, and participants were informed about the project and about the application of EAF in Turkey.	The meeting was held according to plan, completed successfully and kept in line with the project schedule.	In the initial stages of the planning process, the preparations as concerns logistics, invitations, announcements and basic groundwork left a lot to be desired. If this had been handled differently, better representation of stakeholders might have contributed to giving the project a better start.	It was the project experts, their communication skills and solid relationships with stakeholders as well as their efforts over a long period of time which made the project possible and ensured that the meeting took place as planned.
2. Identification of assets, issues and their priority The 2nd meeting/ workshop of the stakeholders: 15–16 March 2017 Akyaka, Muğla & The 3rd meeting/ workshop of the stakeholders: 10–11 May 2017 Akyaka, Muğla	(a) The EAF baseline report was reviewed and consolidated. (b) Priority issues and risks for management were identified by using risk assessment methodology and capacity development interventions of EAF in Turkey. The meeting resulted in 110 issues identified under the EAF components ecological wellbeing, social and economic wellbeing, and ability to achieve. After the risk assessment process, 67 of these issues were categorized as low, 12 as medium, and 31 as high.	Very useful contributions were gathered from participants on how to evaluate and improve the report. The participants' input continued to be of a high quality during the second day in which issue prioritization and risk assessment activity were carried out. A list of species divided into categories labelled Target, Non-target, Discarded, Threatened, and Bait species was prepared by the participants during the ecological wellbeing session. Then threats and impacts to these species were discussed. Effects of fisheries on the marine ecosystem were also debated. Then socioeconomic issues were identified and a debate about threats and impacts in relation to these issues was held.	Fishers who attended the workshops experienced some loss of income for the days they missed work. Offering to compensate for these losses would probably have increased the fishers' support for the project. Also, these initial workshops turned out to be rather demanding, lengthy, intensive and time-consuming. More effort was needed at this stage than during any other time in the process and some participants were discouraged and lost their motivation before the workshop was over.	All of the sessions and debates were attended by a large number of participants (37 participants from 19 different institutions). This happened thanks to the strong, longstanding relations that existed between the project team and fishers in the area. This phase of the project required both time and concentrated effort and that led to some discouragement among a few of the participants. However, the hard work yielded good results and the aim of the workshops was achieved. The moderators' professionalism and expertise in guiding the process proved essential to the overall success of the workshops.

Steps	Activity (what was done)	Comments and observations about this step	Cases where it went wrong, and why	Cases where it went well, and why
3. Development of management systems The 4th meeting/ workshop of the stakeholders: 22 June 2017, Akyaka, Muğla	The task of prioritizing the issues was finalized at this stage of the project. In addition, the management systems were prepared for all of the identified issues including operational objectives, indicators, performance measures, data requirements, current management practices and future management measures.	The level of engagement and motivation shown by the participants was notably higher than at previous stages in the process. In addition, a representative of the recreational fishers participated for the first time since the establishment of the Gökova MPA. The workshops resulted in the development of a complete set of EAF management systems including operational objectives, indicators, performance measures, data requirements, current management practices, and future management measures.	No difficulties were encountered at this stage of the project. On the contrary, management systems for all of the issues were prepared with great enthusiasm by all of the participants.	A great amount of effort was shown by all of the stakeholders (24 participants from 12 institutions) at this stage. All of them contributed actively to the development of the management systems. It is likely that the great interest shown by the stakeholders at this stage was closely related to the pre-meetings and preparations made by the national experts. These efforts kept the stakeholders, and particularly the fishery cooperatives' representatives engaged and motivated.
4. Core meeting 21 Dec., 2017 DG-Fisheries, Ankara	The draft FMP was reviewed and discussed with the decision-makers in the Directorate General of Fisheries and Aquaculture (DG-Fisheries) in Ankara before the final stakeholder meeting.	The core meeting with the fisheries management authority was conducted in a very pleasant and professional manner and was successfully concluded. All aspects of the plan were clearly explained to and received by the General Director and department heads. Contributions were made and taken into account and necessary adjustments and fine-tuning were made. Both FAO experts and project consultants left this meeting in high spirits.	No controversy was encountered at this stage. All parties were eager to finalize the work in a timely fashion.	Because ensuring the backing and full support of the General Director of Fisheries and all relevant heads of departments was of paramount importance for the acceptance, continuation and future implementation of the plan, the meeting was attended by both the FAO officials and the national project consultants. The successful conclusion of the meeting was the result of solid work and preparation by all parties.
5. Implementation, monitoring and performance review The 5th and final meeting/ workshop of the stakeholders: 16 March 2018, Akyaka, Muğla	Approval of EAF-FMP of SSF in Gökova: The Draft FMP was presented to the stakeholders.	The FMP was accepted by all the participants including the representatives of DG-Fisheries by using an anonymous voting method.	No difficulties were encountered at this stage of the project.	The unanimous acceptance of the 'Draft Management Plan for the Small Scale Fisheries in Gökova MPA' was the best possible conclusion to the process thus far. That backing and support had been secured from DG Fisheries at the core meeting previous to the final meeting was important for this very successful outcome.

Chapter 10: Co-management as a way to make the transition towards ecologically and economically sustainable small-scale fisheries: preliminary findings from case studies in Italy, Croatia, Greece and Turkey

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INTRODUCTION

When looking at the Mediterranean, the status of the stocks of the priority species, as selected by the General Fisheries Commission for the Mediterranean (GFCM), is used as the indicator to describe the overall status of fisheries in the region. However, although it is an excellent proxy, it is focused on the status of stocks exploited by industrial and semi-industrial fishing fleets. Today, the stock assessments show that – although these fisheries are subject to many stressors – the fact that they overfish their own target stocks is the key threat to their economic viability.

Seventy-five percent of all assessed stocks in the Mediterranean and Black Sea are overfished (FAO, 2020). However, while this percentage represents the best estimate of the status of fisheries in the region, the assessment only paints a partial picture. Regional fisheries are in fact not only the domain of the vessels that bring in most of the economic revenues (74 percent), i.e. the trawlers and the purse seiners. As the GFCM makes clear (FAO 2020), the overwhelming majority of fishing in the region is conducted by small-scale artisanal fishers: they represent 83 percent of the total Mediterranean fishing fleet, employ about 57 percent of all fishers (approximately 127 000, including the Black Sea), and generate 29 percent of total sector revenue.

The small-scale fisheries (SSF) sector is historically and culturally rooted in the region, but although SSF have been targeting multi-species inshore resources in the Mediterranean for thousands of years, knowledge of the status of most of the stocks they fish (e.g. sea breams, scorpion fish, conger and moray eels, sea bass, cuttlefish, octopus, lobsters) is still largely minimal, and sufficient only in limited locations such as marine protected areas (MPAs).

SSF have coevolved with coastal communities in the region, and their management of fishing effort and capacity is extremely variable – but in most cases absent. In a few areas (e.g. in Italy) there is a management consortium of SSF fishers, while in other countries SSF fishers are embedded in local rights-based management units (such as Cofradias in Spain), or in co-management schemes (e.g. Catalonia, Spain). Along most of the Mediterranean coastline, however, no form of local management exists.

The need to remedy both this lack of knowledge (on SSF figures and on the status of targeted stocks) and lack of management is now a priority in the Mediterranean, as is articulated by the GFCM's Regional Plan of Action for Small-Scale Fisheries in the Mediterranean and the Black Sea (RPOA-SSF). This policy document was adopted in Malta in September 2018, aiming to implement a series of concrete actions to manage SSF over the next 10 years.

Such gaps may be overcome by the implementation of fisheries co-management, which is an increasingly globalized concept and a cornerstone of the Voluntary Guidelines for Securing Sustainable Small-scale Fisheries in the Context of Food Security and Poverty Eradication, adopted by FAO Members in 2014 (Tilley *et al.*, 2019). Fisheries co-management is defined as a relationship between a resource-user group (e.g. local fishers) and another entity (e.g. government agency or non-governmental organization) in which management responsibilities and authority are shared (Pomeroy and Berkes, 1997; Evans *et al.*, 2011).

The rationale behind co-management, and particularly the need for directly involving user groups, is based on three main elements (Hoefnagel *et al.*, 2006):

1) Resource users have in-depth knowledge of the fishery and its resources, which can be added to the information attained by fisheries scientists.

2) Involvement of the community encourages compliance because they fully understand the policy and why it was created, which leads to them giving it commitment and support.

3) In a democracy, those who are affected by a management decision should have their say.

There are many similarities between adaptive co-management and the ecosystem approach to fisheries (EAF). The purpose of the EAF is:

'To plan, develop and manage fisheries in a manner that addresses the multiple needs and desires of societies, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by marine ecosystems. An ecosystem approach to fisheries strives to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries.' (FAO, 2003)

EAF is a means of implementing sustainable development concepts in fisheries by addressing both human and ecological wellbeing.

Complex ecosystems are subject to cumulative impacts and continuously evolve, hence their management requires an adaptive governance strategy that accounts for the difficulty of control, the lack of data (thus the need to proceed in the face of uncertainty), and the importance of dealing with diversity and conflict among stakeholders (Ollson and Folke, 2004). Establishing a path to strengthen stakeholders' participation in management and co-management schemes is essential to ensure the successful implementation of the EAF.

THE PROJECT: 'TRANSFORMING MEDITERRANEAN SMALL-SCALE FISHERIES'

In 2017, WWF started a project to transform SSF at selected pilot sites in Italy, Croatia, Greece and Turkey. This project, together with others already underway (in Spain, France, Slovenia, Albania, Tunisia and Algeria), consolidated and expanded WWF's drive to promote EAF principles (sensu Garcia, 2003) and establish co-management schemes for SSF fishers at Mediterranean level (Figure 1). By engaging local communities through to high-level decision-makers, the project aims to facilitate the establishment of SSF co-management at all levels from hyper-local to regional.

The main goal is to improve the income and wellbeing of coastal communities at the pilot sites and beyond, while reducing fishing effort and shifting the sector towards sustainability; following the ecosystem approach where communities and other relevant stakeholders like management authorities, scientists and NGOs are included in the decision making-process. By following EAF as 'a way of managing fisheries that balances the different objectives of society (e.g. ecological and economic objectives) and by applying an integrated approach across geographical areas that reflect natural ecosystems' (Staples and Funge-Smith, 2009), the project aims to establish co-management in selected Mediterranean countries, to make fisheries management more participatory, to make resource-users an integral part of the decision-making process, and to ensure sustainable development for SSF communities.

The project is ongoing and will end in 2022, but initial results are promising. They suggest that it will successfully drive the development of local SSF that support the livelihoods and wellbeing of people both directly and indirectly impacted by the project, that it will preserve biodiversity, and that it will potentially ensure, in the long term, the resilience needed to adapt to climate change (Freitas *et al*., 2018).

Figure 1. Map of the sites where WWF is engaged in participatory processes or co-management in small-scale fisheries. Case studies are shown as round blue symbols.

The project's assumption is that the most effective way of improving income while reducing fishing effort and shifting SSF towards sustainability is to directly involve the people that understand the local situation better than anyone else – the fishers themselves (d'Armengol *et al*., 2018; Damalas *et al*., 2015). Small-scale fishers often have the in-depth local knowledge that, coupled with scientific research, is required to ensure the development and implementation of management strategies and actions that suit the needs of the area and its resources.

The lack of effective local management of typical multi-species SSF in the pilot sites makes it hard if not impossible to react to old and new challenges arising from threats like dwindling fish stocks (FAO, 2020), climate change, competition from other industries, a lack of alternative livelihoods, and weak political representation. Men and women working directly in or depending indirectly on the SSF sector have

little control over how the resources are managed in the pilot sites, and they often mistrust the imposition of changes or new rules. In general, the sea and its resources are governed by policies crafted in offices that are perceived as being too far away from coasts and coastal communities.

In Italy, the pilot sites are in the Gulf of Patti, Sinis, and Porto Cesareo. The SSF fishers in the first site are managed by a local consortium system called COGEPA, in the latter sites SSF fishers operate in MPAs under MPA regulations. In all three sites fishers use set nets, bottom longlines and traps. Some of them are already increasing their incomes with pescatourism (Tables 1 and 2).

In Croatia, the pilot sites are Lastovo, Telašćica, and the Velebit Channel (Table 1). The first two sites are MPAs, and the latter is a fishing ground closed to trawlers. In the MPA sites, fishers use set nets, bottom longlines and traps. In the Velebit Channel, fishers only use traps (Tables 1 and 2).

In Greece, the sites are located in the Northern Cyclades archipelago, on the islands of Andros, Tinos, Syros, and Kythnos. The SSF community is made of polyvalent multi-target species fishers, who use set nets and bottom longlines at all the sites. Fisheries management is centralized (Tables 1 and 2). In Turkey, the pilot sites are Kaş-Kekova, Erdemli, Mordoğan and Foça, and here too fisheries management is centralized. The fishers use set nets and bottom longlines at all the sites (Tables 1 and 2).

Table 1. Characterization of the small-scale fishing fleets at all pilot sites ('number of fishers' refers to active small-scale fishers).

Country	Name of the site	No. of vessels	No. of fishers	Gear			
				set nets	longlines	traps	hand-picking/ diving
Croatia	Lastovo	35	35	✓	✓	✓	
	Telašćica	15	15	✓	✓	✓	
	Velebit	35	35			✓	
Greece	Andros	40	37	✓	✓		
	Kythnos	19	19	✓	✓		
	Syros	31	31	✓	✓		
	Tinos	15	15	✓	✓		
Italy	Gulf of Patti	69	134	✓	✓	✓	
	Porto Cesareo	77	133	✓	✓	✓	
	Sinis	90	189	✓	✓	✓	✓
Turkey	Erdemli	32	32	✓	✓		
	Foça	61	61	✓	✓		
	Kaş-Kekova	43	43	✓	✓		
	Mordoğan	40	40	✓	✓		

In general, fleets at pilot sites are comprised of small (< 12 m) polyvalent vessels, with one to two fishers per vessel, mostly deploying set nets and longlines. The fishers target between three and 11 main species, with the only exception being in the Velebit Channel (Croatia) where a highly selective trap fishery solely targets *Nephrops norvegicus*. The most common target species across all sites is *Diplodus sargus* (Table 2).

Table 2. Occurrence of target species across all pilot sites.

	Lastovo	Telašćica	Velebit	Andros	Kythnos	Syros	Tinos	Gulf of Patti	Porto Cesareo	Sinis	Erdemli	Foca	Kaş-Kekova
Alosa fallax													
Coryphaena hippurus								✓				✓	
Boop boops												✓	
Diplodos sargus				✓	✓	✓	✓	✓	✓	✓		✓	
Mugil cephalus												✓	
Mullus barbatus											✓	✓	
Mullus surmuletus				✓		✓	✓	✓	✓	✓			
Nephrops norvegicus			✓										
Oblada melanura												✓	
Octopus vulgaris								✓	✓	✓		✓	
Pagrus pagrus				✓	✓	✓	✓						
Palinurus elephas	✓							✓	✓	✓			
Paracentrotus lividas										✓			
Penaeus kerathurus											✓		
Phycis phycis	✓								✓				
Pterois miles													✓
Sarpa salpa		✓										✓	
Scomber scomber												✓	
Scorpaena scrofa	✓	✓						✓	✓	✓			
Sepia officinalis											✓		
Siganus luridus													✓
Siganus rivulatus													✓
Solea solae											✓		
Sparisoma cretense													✓
Sparus aurata		✓										✓	
Thunnus thynnus					✓								
Trachurus trachurus												✓	
Xiphias gladius					✓								

A socioeconomic analysis carried out in 2018, which will serve as a baseline to measure the impact of the project in 2022, showed that the majority of the SSF fishers interviewed at pilot sites (290) come from long-standing fishing families (79 percent) and are on average over 40 years old (82 percent). The fishers' households rely on fishing as their main source of earnings: on average, 54 percent of their income comes from fishing activities. Almost 90 percent of the fishers indicated that 'being a fisher' is central to their identity.

With the exception of SSF fishers operating within MPAs (where, in some cases, specific local regulations are in force), management in these case study areas is mainly centralized, under the direct control of national authorities. In a few instances there are also regional governance mechanisms (e.g. a local consortium under regional administration in Sicily, municipal authorities in Turkey).

Management varies widely across the project pilot sites. In some it is based on national rules aligned with macro-regional frameworks (as is the case in Italy, Croatia, and Greece), where the national rules comply with the Common Fisheries Policy; while others – such as those in Italy's MPAs – have their own local rules under the direct control of the MPA management bodies, which in turn are governed by centralized authorities responsible for environmental issues, and not for fisheries.

PRELIMINARY FINDINGS, ACHIEVEMENTS AND LIMITATIONS

In 2018, a survey was carried out in the different sites to gauge the interest of fishers in increased involvement in fisheries management. The results showed that 80 percent were highly interested, despite only 49 percent of them being familiar with the term 'co-management'. The majority of fishers (68 percent) were dissatisfied with their involvement in decision-making processes, and 60 percent felt there was a general lack of information on management decisions and the status of the resources.

In 2022 the same assessment will be performed to evaluate the effectiveness of the project, to see whether fishers have become more satisfied with their involvement in managing their resources. An in-depth analysis of their views will be performed at the end of the project.

The project is ongoing and to date has achieved significant and promising results, whose effects will be visible during the two remaining years.

As of 2020, local co-management schemes have been established in seven out of 13 pilot areas, ranging from formal agreements (based on a Memorandum of Understanding signed by participants to regulate the participatory process) to legally recognized co-management agreements. Four fisheries management plans have been developed, two in Croatia and two in Italy. Sustainable measures have been supported by the fishers, and include no-take zones, the use of sustainable fish aggregating devices, limits on fishing effort (e.g. maximum number of traps or nets, bans of specific gear within defined areas), and a change of gears to improve the selectivity of set nets. In one site in Italy (Sinis), fishers actively support the monitoring of vulnerable marine mammals, and are collaborating with the national research institute and WWF to identify solutions to the problematic interactions between SSF fishers and dolphins which take catches from their nets (Snape *et al.*, 2018).

At the end of the project, the effectiveness of these decisions will be evaluated. To date, we can only report the decisions taken in the local context of the case studies. The enabling conditions, the difficulties encountered and the main barriers to project implementation are under evaluation. In the process that led to the current decisions, issues and conflicts have emerged, which will be addressed in the remaining two years of the project (e.g. co-management boundaries with respect to the resources under local management, conflicts with recreational fishers, absence of mechanisms to limit increased SSF fishing effort in case of trawl bans, absence of rights-based management opportunities).

Within the co-management of Lastovo (Croatia), a local 'Blue Business Incubator' was established to: i) identify opportunities for alternative livelihoods; ii) offer opportunities to community leaders and fishers to pitch their ideas and facilitate the implementation of economic activities and solutions; iii) facilitate access to concessions, micro-credits, seed money and investments; and iv) to develop partnerships, bankable projects, business models and sustainable investment. The selected ideas aim to achieve sustainable development for the community that goes beyond sustainable fishing, and include production of other commodities like wine and oil, and sustainable tourism including pescatourism. Pescatourism in particular has proven to be an alternative income activity that helps reduce fishing effort while not only increasing fishers' annual income but also their wellbeing, since they spend fewer fatiguing hours working at sea.

Successful exchange visits have been organized in Spain, Greece and Turkey, and have served as accelerator mechanisms for the establishment of co-management and to share identified solutions. Results show that exchange visits are a valuable activity to connect fishers from different cultural and socioeconomic backgrounds, to share best practices and lessons learned, to build on peer-to-peer information-sharing, and establish new social networks among fishers across countries.

The practice of sharing and discussing within participatory processes and through co-management made fishers more confident and inclined to participate in the discussion of SSF management topics, both at national and international level (e.g. SSF representatives from pilot sites attended the High-level Conference on Sustainable Small-Scale Fisheries in the Mediterranean and Black Sea (September 2018, Malta), the 5th International Conference on Marine Mammal Protected Areas (ICMMPA5, April 2019, Greece), and the GFCM Online Forum webinar on 'The experience of small-scale fisheries in promoting resilience and economic innovation in the face of the COVID-19 crisis' (July 2020). SSF fishers from pilot sites are also contributing to the development of SSF-related advice drafted by the Mediterranean Advisory Council (MEDAC).

By engaging with fishers at pilot sites, several decisions in favour of an EAF have been taken and further challenges have been identified. Many challenges remain, from the varying levels of support from national authorities to the overall lack of fishing resources, which generates competition and general mistrust among fishers. In Greece in particular there are notably negative attitudes, with almost 80 percent of the fishers interviewed saying they were dissatisfied with their income, their wealth, and their physical working conditions. This overall dissatisfaction seems to be the main obstacle to co-management in Greece, with five out of the 13 case study areas having not yet established co-management schemes.

In general terms, one of the main threats identified by the SSF fishers is competition with recreational fishing, both legal and illegal. Seventy-four percent of all fishers (n=290) indicated recreational fisheries as a major source of conflict, because of recreational fishers' lack of knowledge, their lack of recognition of their potential impact on fishing resources (Font *et al*., 2014; Lloret *et al*., 2019), the lack of regulation (Hyder *et al*., 2018) and the lack of management (Öndes *et al*., 2020). According to SSF fishers, the threats stemming from recreational fishing include the removal of biomass from marine fish stocks, unfair competition, and the uncertainty recreational activities introduce into the assessment of fisheries resources and other scientific research. The latter aspect is particularly important, and has emerged as a main project challenge following the engagement process with fishers in the case studies. Usually, the conflicts that are highlighted by SSF fishers are attributable to the competition for resources with semi-industrial or industrial fishers (trawlers or purse seiners). However, in these case studies this problem was only found to exist when large-scale fishing takes place inshore and in illegal conditions (since trawling is banned from the coast in every country where the case studies are located); while on the other hand recreational fishing causes competition on a daily basis, and is particularly significant because it occurs in an unregulated and poorly controlled environment.

CONCLUSION

The achievements that have been obtained at this halfway stage in the case studies confirm that stakeholder involvement, participatory processes and co-management are valuable preparatory tools for the implementation of EAF management actions. However, the participatory and engagement process needs to involve every component of society, particularly in decision-making. The lack of involvement of the central or regional administration has been one of the key limiting factors. The involvement of decision-makers in the process of developing co-management schemes is of fundamental importance, and their absence may limit the success of the process. In our case studies, the best results were obtained where there was a structured involvement of fishers, local and national administrators, as well as researchers and non-governmental organizations. However, legal and institutional mechanisms that allow the co-management to exist and which regulate its governance are key for long-term success, and still need to be set up in most Mediterranean countries.

Setting up a space (also virtual), managed and supported by a facilitator, allows fishers, scientists, local administrators and NGO representatives to deal with the problems (such as competition with recreational fishers, competition among SSF fishers of the same community due to the scarcity of resources, or widespread illegality scarcely controlled by the authorities) that undermine the possible acceptance of common rules, of management plans, and of long-term planning in favour of economic and personal investments.

The factors that have helped unblock this impasse can be grouped in clusters: the constant involvement of fishers in discussions and in identifying potential solutions, adaptive management of the engagement modalities, and a constant evaluation of the local context and of the evolving dynamics among engaged stakeholders.

The involvement of fishers in peer-to-peer exchanges and their participation in relevant national and international events is vital. Equally important has been the facilitation of opportunities for them to participate (through written contributions or by attending in person) in public consultations or high-level events aimed at defining and implementing SSF fisheries management measures.

The involvement of administrators and policymakers at all levels has also been crucial for the approval of local co-management schemes. Equally important has been the participation of representatives of fisheries associations. In some cases, the participation of the entire local community was essential. To manage stakeholder engagement, we followed the guidelines produced by the H2020 'Minouw' project (http://minouw-project.eu/wp-content/uploads/2018/06/D2-1-Implementation_Plan.pdf).

Committed involvement from the fishers and the constant presence of the facilitators (WWF) allowed the co-management schemes to remain active during the COVID-19 emergency, with stakeholder discussions moving into a virtual environment via digital platforms.

The case studies already show that effective stakeholder engagement is a key factor to facilitate understanding of the state of local resources (when no stock assessments are performed), the landings, the fishing activities, and the economic features of the local fishing sector including employment, profitability, value chain, demographic trends and decent work. It also increases understanding of the risk factors that may destabilize co-management actions – such as competition with recreational fishers, illegal fishing, and competition between fishing sectors – and can help identify potential solutions.

In conclusion, as previously confirmed (Lleonart *et al*., 2014; Morales-Nin *et al*., 2017), bottom-up and participatory approaches which target all involved stakeholders give the best chance of achieving EAF management in small-scale fisheries communities in the Mediterranean.

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Chapter 11: Current fisheries management in the Strait of Sicily and progress towards an ecosystem approach

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1. INTRODUCTION

In the Mediterranean Sea, production from commercial capture fisheries peaked in the 1980s at about 1.9 million tonnes per year (1988) then began to decline, reaching a low point of about 1 million tonnes in 2014. Since then, it has varied at around 1.2 million tonnes per year. Fisheries in the region are subject to many stressors, chief of which is the high level of overfishing that affects 74 percent of the assessed stocks (FAO, 2020). To improve fishery sustainability, the ecosystem approach to fisheries (EAF) was adopted by the FAO Technical Consultation on Ecosystem-based Fisheries Management (Reykjavik, 2002): since then, it has been promoted by FAO as the appropriate approach for the sustainable development and management of fisheries, including in the Mediterranean. The EAF attaches great importance to the human dimension, involving fishers and scientists in the management decision-making process, and valuing the socioeconomic aspects of fisheries. However, integrating EAF principles into management plans which involve actors from several countries operating in international waters is a particular challenge, and it has seldom been attempted to date.

The Strait of Sicily is an important transitional area in the central Mediterranean Sea, separating the Eastern and the Western basins. Currently, the Strait of Sicily (referred to in this chapter as the SoS) is defined as the entire marine area which separates Italy, Malta and Tunisia, and which extends to the western coast of Libya (Figure 1).

The European and the African continental shelves are separated by deep water in the middle part of the SoS. The shelf is wider off the south coast of Tunisia than it is off Sicily. In its narrowest part, between Cap Feto (Italy) and Cap Bon (Tunisia), the SoS is 145 km wide. In oceanographic terms, the SoS is characterized by the cold and less salty Atlantic waters coming from the western side of the Mediterranean, and the Levantine Intermediate Waters (warmer and saltier) coming from the east. The Atlantic waters entering the SoS area originate in two streams, the Atlantic Tunisian Current in the south and Atlantic Ionian Stream in the north. These two streams respectively generate upwelling and downwelling along the Sicilian and Tunisian coasts. The Atlantic Ionian Stream also generates two main gyres or vortexes, namely the Adventure Bank Vortex and the Ionian Shelf Break Vortex (Figure 1). These oceanographic features contribute to making the SoS one of the most productive areas for demersal fishing in the Mediterranean. Within it, the offshore fleets of several countries exploit the same fishing grounds. As a result, most of the target and secondary species captured by these fleets are regarded as shared stocks. As in many other oceanic regions, the existence of shared stocks means that internationally agreed fisheries management measures and/or plans are needed.

The aim of this contribution is to describe the experience of managing bottom trawl fisheries in the SoS in light of EAF principles, to support FAO's global effort to identify lessons and good practices for EAF implementation.

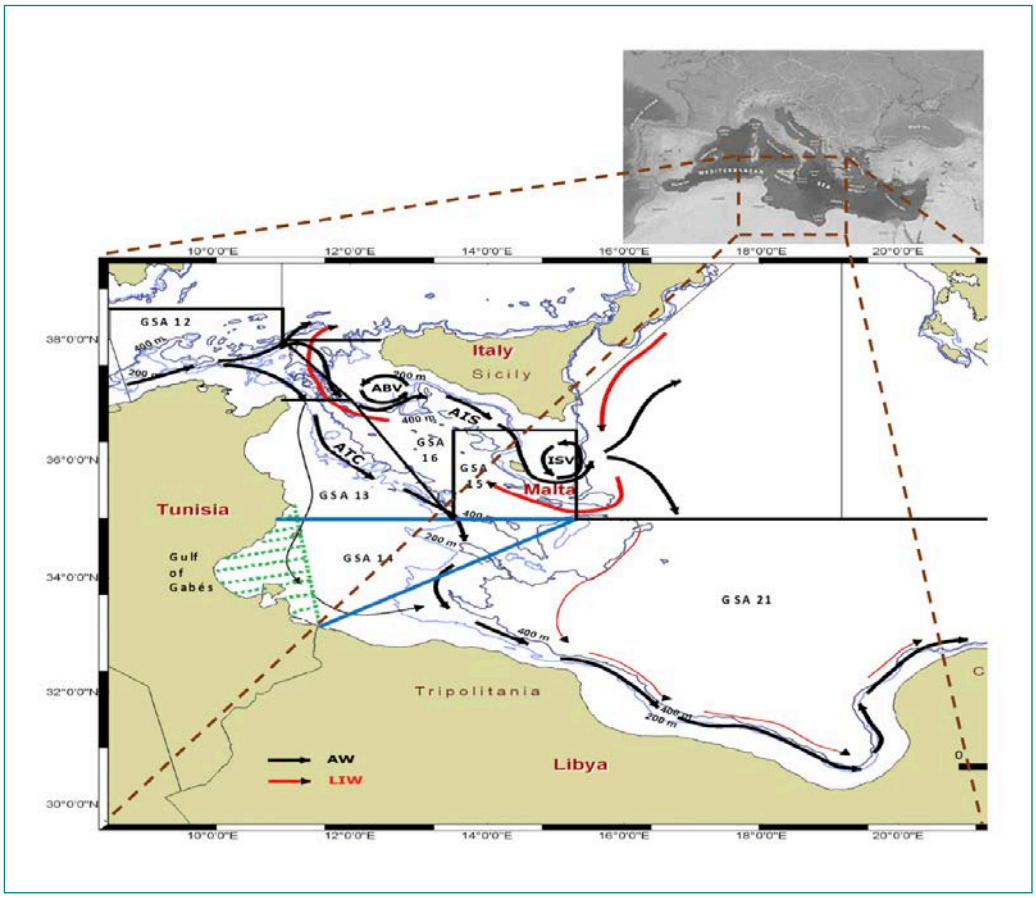

Figure 1. Strait of Sicily divided by GSA (from Garofalo *et al.*, 2008, MedSudMed Technical Document 19 modified). The Gulf of Gabès, covering the coastal area of GSA 14, is shown by green dotted lines. The main bathymetric and oceanographic patterns are also described. AW = Atlantic Waters, LIW = Levantine Intermediate Waters, ATC = Atlantic Tunisian Current, AIS = Atlantic Ionian Stream, ABV = Adventure Bank Vortex, ISV = Ionian Shelf Break Vortex.

2. FISHERY CONTEXT

Historically the SoS has been subject to intense fishing pressure, and today bottom trawling is the most significant activity. Two main types of trawl fishing take place in this area:

- ***Inshore trawling***, mainly based on the exploitation of the continental shelf by mixed fisheries vessels generally smaller than 24 m length overall (LOA). Trawlers leave port at night and return to port to land and sell their fresh catch in the afternoon. Most of the catch comprises red mullets (*Mullus* spp.), European hake, sea breams (*Pagellus* spp.), Atlantic stargazer (*Uranoscopus scaber*), weevers (*Trachinus* spp.), common octopus (*Octopus vulgaris*), cuttlefish (*Sepia officinalis*), hornet and musky octopus (*Eledone* spp.), squids (mainly Loliginidae), deep-water rose shrimp (*Parapenaeus longirostris*), John Dory (*Zeus faber*) and skates (*Raja* spp.).

- ***Offshore trawling***, conducted by trawlers generally over 24 m LOA mainly exploiting fishery resources in international waters and working on the continental shelf and slope to a depth of 700–800 m. In shallower waters the main target species are *Mullus barbatus* and *Mullus surmuletus* and most of the species also exploited by inshore trawling. Between depths of 150 m and 300 m the main target is deep-water rose shrimp (*P. longirostris*), with other species including European hake (*Merluccius merluccius*), Norway lobster (*Nephrops norvegicus*), squids, anglerfish (Lophius spp.), John Dory and skates. At depths below 300 m, the main target species are giant red shrimp (*Aristeomorpha foliacea*) and blue and violet shrimp (*Aristeus antennatus*), with European hake, anglerfish (*Lophius* spp.), deep-water scorpionfish (*Helicolenus dactylopterus*) and skates as secondary species. Trawlers operating at depths below 300 m generally undertake long fishing trips (15–30 days), selling most of their catch frozen. For this reason, these boats are also known as 'distant trawlers'.

Due to their importance for the fisheries in the SoS, both in terms of total yield and economic value, deep-water rose shrimp, European hake and red mullet (*Mullus barbatus*) have been the subject of several studies, and the species have been routinely assessed since 2009, 2010 and 2015 respectively by Italian, Tunisian and Maltese researchers sharing data and methodologies within the FAO's regional MedSudMed project.

2.1. Fishing fleet

The main characteristics of the fisheries resources whose stock status is currently assessed in the GFCM SAC working groups are described below. These are: i) the deep-water rose shrimp fishery which, with the associated species hake, represents the main fishery on the outer shelf and upper continental slope; and ii) the red mullet fishery, which represents one of the main targets of shallow-water fisheries. Deep-water rose shrimp, hake and red mullets are exploited by the fleets of the various countries operating in the SoS. Another important fishery in this area is for deep-water red shrimp, which is mostly carried out by the Italian fleet. To date, no stock assessment endorsed by the GFCM is available for deep-water red shrimp.

The DPS fishery

According to the latest appraisal, deep water rose shrimp (DPS) is targeted by four fleets: Italian coastal trawlers, Italian distant trawlers, Tunisian trawlers and Maltese trawlers (Table 1, Gancitano *et al.*, 2019). These fleets generally capture, as commercial accessory species, hake, anglerfish (*Lophius* spp.) and scorpionfish (*Helicolenus dactylopterus*), with horse mackerel (*Trachurus* spp.) and juvenile European hake being the main discarded fish (Milisenda *et al.*, 2017).

Table 1. Fleet segments targeting deep-water rose shrimp in the Strait of Sicily during 2018. Source: Gancitano *et al.*, 2019, modified.

Fleet segment	Fishing ground	LOA	Number
Italian coastal trawlers	Outer shelf and upper slope	12–24 m	276
Italian distant trawlers	Offshore in Italian and international waters	> 24 m	107
Tunisian trawlers	North and east of Tunisia	Average 24 m	82
Maltese trawlers	6 NM from the Maltese coast	12–24 m	14

The HKE fisheries
European hake (HKE) is the main accessory species of the DPS fishery and contributes a significant proportion of inshore mixed trawl landings (Figure 2). The species is also fished by boats using fixed gears, i.e. longlines and gillnets (Falsone *et al.*, 2019).

The MUT fisheries
According to recent studies (e.g. Gargano *et al.*, 2017), three main stock units of red mullet (*Mullus barbatus*) (MUT) in the SoS are considered for stock assessment purposes: one stock unit in the south of the Strait along the Tunisian coast (GSAs 12, 13 and 14; Ben Abdallah *et al.*, 2019), one stock unit in the north along the Italian coast (GSA 16; Scannella *et al.*, 2019), and the third around the Maltese islands (GSA 15; Micallef *et al.*, 2018). These three units are generally exploited by different fleets.

- Offshore on the southern side of the SoS, the species is caught by Tunisian and Italian trawlers (> 24 m LOA). In shallower depths, red mullet is caught both by small Tunisian trawlers (< 24 m LOA) and coastal boats using trammel nets.
- On the northern side of the SoS, the species is fished mainly by Italian trawlers (< 24 m LOA) operating at depths of up to 100 m.
- Around the Maltese islands, the species is exploited by Maltese fishers, both coastal trawlers and trammel/gill-netters.

In addition, it is important to note that, as well as the fishing fleets from Tunisia, Italy and Malta, several fishing units from other countries operate, almost all year round, in the SoS. Reliable information on their numbers, fishing grounds and catch is scarce.

Employees on board
In 2016 in Italy, there were about 1 720 crew members working on fishing vessels in the Strait of Sicily. A comparison of data from 2008 and 2016 shows a reduction of about 20 percent in fisher numbers in recent years. This could be linked to the socioeconomic impact of both the reduction in fishing vessels and the lower profitability of the sector, particularly during the period from 2012–2014 (Maiorano *et al.*, 2018).

In Tunisia, in 2016, about 5 100 fishers operated in bottom trawl fisheries, of which about 800 (16 percent) were involved in DPS and HKE fisheries in north Tunisia (GSA 12). An average of 11 fishers are generally employed on offshore trawlers. The number of fishers has been relatively stable in recent years, and the profitability of the DPS and HKE fisheries has slightly increased driven by demand for DPS (the main target species) on the international market (Jarboui, personal communication).

2.2. Fishing gears

Bottom trawling is the fishing system that produces the largest landings. Depending on the target species, three main kinds of trawls are used in this area:

- The Italian bottom trawl (known as '*volantina*') for deep-water rose shrimp. It has a vertical opening between 2–3 m.
- The high vertical opening trawl ('*fandari*') used in Tunisia for deep-water shrimps, mainly rose (*P. longirostris*) and red shrimps (*A. foliacea*). The trawl is generally equipped with two bridles.
- The demersal fish trawl, with a small vertical opening (0.8–1 m), used without bridles. It usually features knotted polyethylene netting panels and a short trawl length.

2.3. Catches

Over the last 15 years, DPS has dominated catches among the main shared stocks in the SoS, with an annual capture production ranging between 8 000 and 10 000 tonnes, while capture production of HKE and MUT in the same period generally varied between 2 000 and 4 000 tonnes per year (Figure 2). This data comes only from the Tunisian, Italian and Maltese fleets, as there is no reliable information concerning the other fleets that operate in the region.

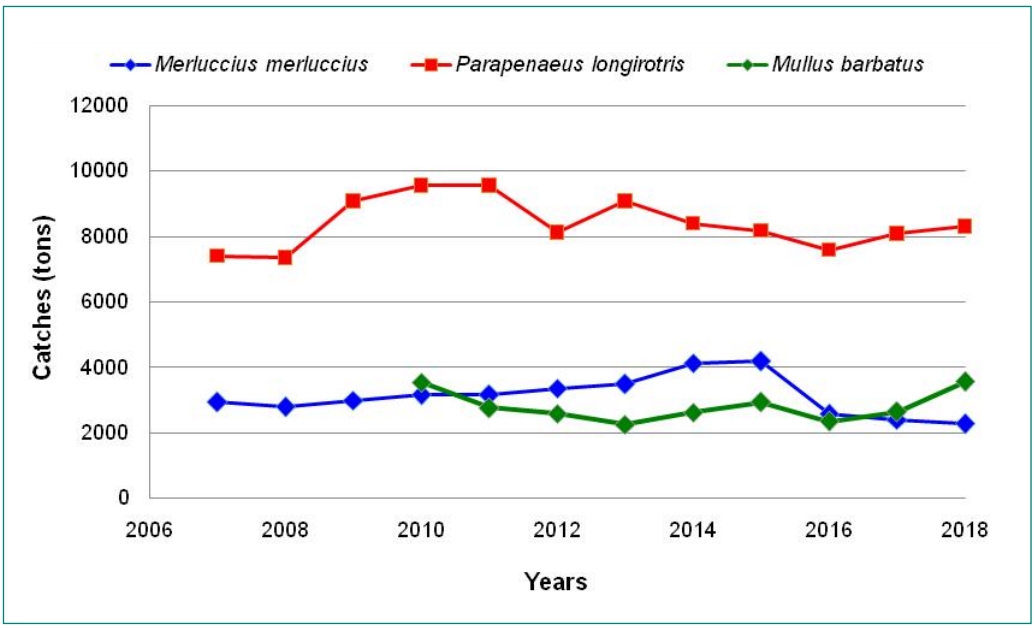

Figure 1. Annual catches of rose shrimp, hake and red mullet landed by Italian, Tunisian and Maltese fleets in the Strait of Sicily during the period 2007–2018 (GFCM Task 1).

In the SoS, most of the DPS landed is sold frozen on the international market, with freezing taking place on board. The remaining DPS, together with the HKE and MUT, is generally sold fresh at local (national) markets.

2.4. Main species features

The SoS is high in marine biodiversity (Garofalo *et al.*, 2007; Di Lorenzo *et al.*, 2018), and fishery resources are diversified. The main biological features of deep-water rose shrimp, European hake and red mullet are described below. Reviews of available information on the biology, ecology and exploitation of the main target species of demersal fisheries in the SoS can be found in Fiorentino *et al.* (2008; 2013).

- ***Deep-water rose shrimp, Parapenaeus longirostris***

  P. longirostris generally lives in depths of 80–600 m, and is most abundant between 150–400 m. The maximum observed carapace lengths (CL) are 46 mm for females and 41 mm for males. It is a short-living species (3–5 years) characterized by rapid growth and a high mortality rate (Abellò *et al.*, 2002). *P. longirostris* breeds almost all year round, with a peak during the summer period from June to July (Levi *et al.*, 1995; Ben Mariem *et al.*, 2001). Its size at first sexual maturity varies between 20.9 mm CL in females and 13.7 mm in males (Gancitano *et al.*, 2019).

- ***European hake, Merluccius merluccius***
  M. merluccius is generally found at depths ranging from 70 to 800 m. The largest individuals generally live in deep water (> 400m), while juveniles prefer shallower water. In the SoS, a maximum total length (TL) of > 95 cm and a maximum weight of 6 kg has been recorded for the species. Hake is a long-living species, with a lifespan reaching up to 25 years (Vitale *et al.*, 2016). It spawns all year around and reaches sexual maturity at 28.5 cm TL (male/female average, Falsone *et al.*, 2019).

- ***Red mullet, Mullus barbatus***
  M. barbatus is generally found at depths between 5–200 m, and is most abundant at depths of less than 100 m. Its maximum size in the SoS is 28–29 cm TL for females and 23 cm TL for males. Specimens found in commercial landings generally range from 10–20 cm TL. Spawning occurs between May and July, with a size at first sexual maturity between 13–14 cm TL (Ben Abdallah-Ben Hadj Hamida *et al.*, 2019; Scannella *et al.*, 2019).

2.5. Stock status

The latest stock assessment study showed that demersal resources in the SoS are in a state of overfishing, with the exception of *M. barbatus* in GSA 16 (Gancitano *et al.*, 2019; Falsone *et al.*, 2019; Ben Abdallah-Ben Hadj Hamida *et al.*, 2019; Scannella *et al.*, 2019). This overfishing varies from species to species, with HKE found to be in the worst state (Table 2).

Table 2. Diagnosis of the stock status of deep-water rose shrimp, hake and red mullet in the Strait of Sicily (Falsone *et al.*, 2019; Gancitano *et al.*, 2019; Ben Abdallah-Ben Hadj Hamida *et al.*, 2019; Scannella *et al.*, 2019).

Species	GSAs	Diagnosis
Parapenaeus longirostris	12 to 16	The ratio F_{curr}/F0.1 ranged between 1.52 ($F_{0.1}$ = 0.84) and 1.37 ($F_{0.1}$ = 0.93). Accordingly, the stock status is assessed as Intermediate Overfishing. SSB from XSA on the whole stock resulted at Relative Intermediate level in the available time series (2007–2018). The trend of MEDITS biomass indices in GSA 15 showed a low level of standing stock in recent years, while it is increasing in GSA 16.
Merluccius merluccius	12 to 16	The ratio F_{curr}/F0.1 is 4.0 ($F_{0.1}$ = 0.2) by XSA analysis and 1.66 (FMSY = 0.29) with the SS3 model. Accordingly, the stock status is assessed as High Overfishing and Intermediate Overfishing. SSB from XSA on the whole stock resulted in a low level in the available time series (2007–2018); the trend of MEDITS biomass indices in GSAs 15 and 16 showed a decrease of standing stock in recent years.
Mullus barbatus	12 to 14	In a state of High Overfishing (F_{curr}>$F_{0.1}$) and overexploited with relative intermediate biomass. A reduction of fishing mortality towards the proposed reference point is advised.
Mullus barbatus	16	The ratio F_{curr}/$F_{0.1}$ is equal to 0.72, the stock status is in Sustainable Exploitation with relative high biomass.

To overcome the overexploitation status and ensure fisheries sustainability, scientists have recommended reducing fishing mortality and adopting technical measures to reduce the catch of undersized juveniles in the case of HKE.

It is well known that bottom trawling impacts both on marine populations and seabeds; and there are increasing investigations of its direct and indirect impacts in the SoS. Milisenda *et al*. (2017) evaluated discard composition by species and volume, reporting differences among the main DPS fishing grounds exploited by Italian trawlers. The impacts of bottom trawling on vulnerable marine ecosystems (VMEs) in GSA 16 were evidenced by Lauria *et al*. (2017). Studies on the biocoenoses of trawled areas have also been planned within the framework of the FAO MedSudMed Project (FAO MedSudMed, 2017). In order to minimize the negative impacts of bottom trawling, some management measures have been adopted at Mediterranean level, and others have been proposed as a result of experimental studies. These measures are aimed at enhancing selectivity to reduce discards of undersized or unwanted species (Vitale *et al*., 2018) and at regulating fishing effort in areas with high quantities of bottom trawl discards or a high probability of VMEs (Despoti *et al*., 2020; Milisenda *et al*., 2021).

3. MANAGEMENT CONTEXT

3.1. National level

Italy – The management of the Italian fleet in the SoS is based on control of capacity (number of fishing licences, number of trawlers), fishing activity (days at sea), and technical measures (cod-end mesh size, area closures and fish-size limits). Concerning the technical measures, the Mediterranean Regulation EC 1967/2006, amended by the Regulation EU 1241/2019, fixed a minimum harvest size for DPS of 20 mm CL and a minimum mesh size (opening) of 40 mm square or 50 mm diamond for European Union bottom trawling vessels (this affects Italian and Maltese trawlers). The same regulation established a minimum landing size of 20 cm TL for HKE.

A national multiannual management plan (IMAP) for trawlers was implemented in the SoS for the period 2008–2013. The plan aimed to reduce fleet capacity by 25 percent in a two-step process, from 2008–2010 (-12.5 percent) and from 2011–2013 (-12.5 percent). The IMAP also adopted a trawling ban of 30 days per year, generally in late summer or early autumn. The IMAP was updated in January 2018 for a period of three years (2018–2020). In 2018 there were a total of 404 Italian trawlers operating in the SoS. The new IMAP aimed for a reduction of fishing days (effort control) of 5 percent in 2019 and 10 percent in 2020, taking the 2018 fishing effort as baseline reference.

Fisheries in Italian territorial waters are further regulated by four local multiannual management plans (LMAPs) promoted by the Sicilian government and drawn up according to Reg. (EC) n. 1198/2006. These MAPs concern the fleets of the main fishing ports in south Sicily – Trapani, Mazara del Vallo, Pantelleria, Lampedusa and Porto Palo di Capo Passero – and include measures concerning both artisanal and trawl fishing. The measures concerning bottom trawling include limits on operations in critical areas not mentioned by the IMAP. Within the area covered by the LMAP for Lampedusa trawling by boats of > 24 m LOA and/or with engine power greater than 500 kW is forbidden; while trawling is not allowed from January to April between depths of 100 m and 200 m on the northern side of the island between Punta Ponente and Punta Grecale and on the eastern side between Punta Grecale and Punta Sottile. The aim of this additional trawling ban is to preserve the juvenile *P. longirostris* and spawning *M. barbatus*. In the case of the LMAP of Mazara del Vallo, trawling is prohibited within 6 nm of the coast in the area between the mouth of the Belice river and Cape Granitola from 1 to 31 January, from 1 April to 31 May and from 15 October to 31 December each year. This closure is aimed at

protecting the reproduction and recruitment of coastal species, and at limiting conflicts between artisanal fishing and trawling.

Malta – In 2015, 14 trawlers in Malta were operating on a full-time basis. An analysis of the capacity of the fleet showed that there was a 39 percent reduction from 2011 to 2015. Fishing effort and capacity in the 25 nm fisheries management zone are managed by limiting vessel size and total engine power (EC 813/2004; EC 1967/2006). Trawling is allowed within this designated conservation area, but only by vessels not exceeding 24 m LOA and only within designated parts of it. Vessels fishing in this management zone hold a special permit in accordance with Article 7 of Regulation (EC) No 1224/2009, and are included in a list containing their external marking and Community Fleet Register number (CFR) which is provided to the Commission annually by the Member States concerned (EC 813/2004).

Tunisia – In 2018, 82 fishing vessels based in north (GSA 12) and east (GSA 13) Tunisia regularly exploited DPS and HKE. In addition, more vessels based in south Tunisia (GSA 14) target these resources for a few months each year, their numbers ranging generally from 100 to 140. Several measures have been adopted in Tunisia to regulate bottom trawling, mostly involving spatial or temporal closures, and conservation measures like the setting of minimum sizes for the main target species. These regulations are included, among others, in the Decrees of the Minister of Agriculture of 20 September 1994 and 28 September 1995.

The areas in which bottom trawling is forbidden (Article 27 of the 1995 Decree) are i) inside the area between the low water mark and the 3-mile offshore line, and ii) in all depths of less than 50 m. The same article prohibits the use of both benthic and pelagic trawls in the Gulf of Tunis within the straight line joining Cap Sidi Ali El Mekki, Ile Plane, the northern point of Ile Zembra and Cap Bon. However, the competent authority may choose to authorize trawling in this area during the month of July at depths more than 50 m. In the Gulf of Gabès (GSA 14) trawling for coastal shrimp is authorized in depths of more than 30 m, but only during two periods each year: from 15 May to 30 June, and from 16 October to 30 November. In the same area, there is an annual closed season during which trawling is prohibited from 1 July to 30 September. The aim of the closed season is to protect recruits of several coastal species. Minimum landing sizes exist for a number of species harvested by the Tunisian fleets, including 20 mm CL for DPS and 20 cm standard length for HKE. The minimum legal mesh size used by demersal trawlers in Tunisian waters is 40 mm.

3.2. International level

The GFCM Multi Annual Plan – Owing to their importance for the countries bordering the SoS, the GFCM adopted a series of recommendations targeting the DPS and HKE fisheries: i) REC-GFCM/39/2015/2 on the establishment of a set of minimum standards for bottom trawling fisheries of demersal stocks in the Strait of Sicily, including a common minimum reference conservation size of 20 mm CL for DPS and 20 cm total length for HKE, pending the development and adoption of a MAP; ii) REC-GFCM/40/2016/4 establishing a MAP for the fisheries exploiting HKE and DPS in the SoS (GSA 12 to 16) which applies to vessels operating with bottom trawls over 10 m in total length when the total catch of these species represents at least 25 percent of the catch in live weight or value); iii) REC-GFCM/41/2017/8 on an international joint inspection and surveillance scheme in waters outside of national jurisdiction in the Strait of Sicily (GSA 12 to 16); REC-GFCM/43/2019/6 on management measures for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Strait of Sicily (GSA 12 to 16).

To protect juveniles and reduce discards, three Fisheries Restricted Areas (FRAs) in which bottom trawling is prohibited were established in the northern sector of the SoS (GSA 15 and 16) based on the REC.CM-GFCM/40/2016/4. Periodic scientific studies are planned to verify the effectiveness of the measure. More studies should be carried out to identify HKE nursery areas in GSAs other than 15 and 16, to evaluate the possibility of proposing additional FRAs to protect nursery areas throughout the SoS area.

The REC. GFCM/40/2016/4 sets out for the first time the following specific management objectives:

- Apply the precautionary approach to fisheries management in the SoS
- Ensure that HKE and DPS exploitation levels are at maximum sustainable yield (MSY) by 2020
- Protect nursery areas and Essential Fish Habitat (EFH) areas of HKE and DPS
- Gradually eliminate discards
- Provide for measures to adjust the fishing capacity of the fleets to the stock productivities by fishing authorization
- Pursue fishing mortality targets between 0.12 and 0.18 for HKE and between 0.84 and 0.93 for DPS

As a further feature, the GFCM MAP includes a biological reference point framework, even if no specific harvest control rules were adopted.

Further to these specific measures, a series of resolutions and recommendations have been adopted by the GFCM to protect VME and reduce the overall impact of bottom trawl fisheries (Table 3).

Table 2. Main GFCM resolutions and recommendations relevant to EAF implementation in the Strait of Sicily.

Resolution GFCM/43/2019/6 on the establishment of a set of measures to protect vulnerable marine ecosystems formed by cnidarian (coral) communities in the Mediterranean Sea
Resolution GFCM/43/2019/2 on enhancing the conservation of cetaceans in the GFCM area of application
Resolution GFCM/43/2019/1 on the mapping of measures applicable to Fisheries Restricted Areas in the GFCM area of application
Recommendation GFCM/43/2019/6 on management measures for sustainable trawl fisheries targeting giant red shrimp and blue and red shrimp in the Strait of Sicily (geographical subareas 12, 13, 14, 15 and 16)
Recommendation GFCM/43/2019/4 on a management plan for the sustainable exploitation of red coral in the Mediterranean Sea
Recommendation GFCM/42/2018/7 on a regional research programme on blue crab in the Mediterranean Sea
Recommendation GFCM/42/2018/2 on fisheries management measures for the conservation of sharks and rays in the GFCM area of application (amending Recommendation GFCM/36/2012/3)
Resolution GFCM/41/2017/5 on a network of essential fish habitats in the GFCM area of application
Recommendation GFCM/36/2012/3 on fisheries management measures for conservation of sharks and rays in the GFCM area of application
Recommendation GFCM/30/2006/3 on the establishment of Fisheries Restricted Areas in order to protect the deep sea sensitive habitats
Recommendation GFCM/29/2005/1 on the management of certain fisheries exploiting demersal and deep-water species and the establishment of a Fisheries Restricted Area below 1 000 m

Within this context, given the international nature of the GFCM MAP, effort was needed to convene research institutes from the countries involved (Italy, Libya, Malta and Tunisia) to share expertise, knowledge and data to enhance knowledge on fisheries resources and fisheries in the SoS. The cooperative framework established over time by the FAO MedSudMed Project was instrumental in reaching this goal. Under this framework, a fruitful environment for scientific cooperation was established, resulting in the preparation of the shared assessments of the state of common stocks. In the same environment, collective discussions on the scientific advice for fisheries management were held. In addition, the scientific cooperation developed under MedSudMed provided the basis for launching multi-level discussions involving fishers, scientists and managers from all the countries involved to develop a shared approach to the management of HKE and DPS fisheries in the SoS. With the support of MedSudMed, the results of joint studies and cooperative discussions were convened into the GFCM framework through the Working Group on Stock Assessment and the Subregional Committee for the Central Mediterranean.

4. ACHIEVEMENTS AND LIMITATIONS

4.1. GFCM MAP implementation with an EAF perspective

The formal adoption of the GFCM MAP in the SoS involved an international agreement between several countries. Cooperative discussion among managers, scientists and fishers was necessary to reach this agreement. Currently, the GFCM MAP includes two levels of stakeholder engagement. On one side, the GFCM provides a forum for scientists and administrations to discuss and formally adopt management measures (i.e. Subregional Committees, Scientific Advisory Committees, and the Commission itself). This mechanism does not see the direct involvement of fishers, although they participate as observers at some GFCM meetings. On the other side, through different mechanisms (national consultations and projects, FAO regional projects etc.) some form of wider consultation with fishers and other stakeholders is pursued. This is the 'preparatory' phase of the GFCM MAPs. In the case of the SoS, the MAP was formulated, discussed and adopted in the GFCM framework, with a limited involvement of stakeholders in its final development phase. During the preparatory phase, however, the involvement of several actors was sought. The preparatory phase itself was a complex process that included several meetings of stakeholders from coastal countries, including managers, fishers, NGO representatives, and researchers. The meetings were held both at national and regional level, organized by individual countries within the European MANTIS project (Fiorentino *et al.*, 2020) or by the FAO MedSudMed project, and were aimed at: i) sharing the results of recent studies among stakeholders, ii) integrating scientific results with the empirical knowledge of fishers, and iii) developing a common view on possible fisheries management strategies. Scientific institutions from Italy (IRBIM-CNR), Tunisia (INSTM), Libya (MBRC) and Malta were all involved, together with their national fisheries departments and fisher and NGO representatives. In this context, fishers and scientists collaborated in the identification of the main essential fish habitats of HKE and DPS in the SoS, the most commonly used fishing grounds, and in the preliminary identification of areas that could be subject to measures like spatial and temporal fisheries closures.

On the other hand, the involvement of main stakeholders (fishers, NGOs, researchers, managers) in numerous meetings facilitated collective agreement on the EAF measures included in the GFCM MAP, such as the implementation of the three Fisheries Restricted Areas in the northern sector of the SoS. These areas were identified as nurseries for HKE, and their closure to bottom trawling was expected

to improve both the state of *M. merluccius* and *P. longirostris* stocks and the overall fishery performance in the whole SoS (Russo *et al*., 2019). However, since these closures can affect different fleets according to the spatial position of their traditional fishing grounds, further studies to assess the possible negative economic effects of management measures at local level should be developed.

Discussion with stakeholders also focused on the best way to harmonize the seasonal trawling bans that had already been implemented at national level. Overall, while stakeholder involvement was not fully achieved in the development phase of the GFCM MAP, the efforts to involve fishers, civil society, scientists and managers in joint discussions to define objectives and management approaches could be considered clear examples of applying EAF principles in the SoS. Among the factors that made this process possible was the presence of a regional FAO project, MedSudMed. MedSudMed was the catalyst for launching the multi-lateral and multi-stakeholder studies and consultations in the SoS, and provided a neutral forum for instigating a cooperative approach in the region. The consultation continued at national level thanks to the efforts of scientists and research institutions. However, the process is not yet complete, and although a first MAP has been put in place, several more steps are needed to further develop it and to implement the EAF principles in a more comprehensive way. In this context, more attention should be given in future to stakeholder feedback when adopting the MAPS.

4.2. Further EAF elements in SoS fisheries management

The objectives of the MAP adopted in the SoS are within an EAF framework and they are clearly interconnected because the protection of the Essential Fish Habitats where undersized individuals aggregate is a tool to reduce discards in Mediterranean bottom trawling (Milisenda *et al*., 2021). Both these aspects are expected to reduce the impacts of fisheries on the environment, to improve stock renovation and, eventually, to ensure fisheries' sustainability and profitability – all principles well acknowledged in the EAF.

One of the most controversial aspects of the present MAP is the indication of achievement for both DPS and HKE of MSY for 2020. This objective is not realistic due to the very different level of fishing mortalities corresponding to the MSY of the two species (Fiorentino and Vitale, 2021).

However, fisheries management systems currently implemented in the SoS do not consider other relevant marine ecosystem-related aspects also included in the EAF, such as those linked to the effects of fisheries on the food web or those of climate on dynamics of fisheries resources. A recent attempt to include ecological considerations in assessing the dynamics of multi-species resources exploited by multi-gear fisheries in the Strait of Sicily using an Ecopath with Ecosim (EwE) model was made by Agnetta *et al*. (2019). Results showed a complex food web characterized by a significant role for omnivores and the existence of a large set of weak interactions. Most of the energetic fluxes in the food web were exchanged between bacteria and the various types of detritus, and then transferred from the detritus to the upper trophic levels. The results suggest that i) the high productivity and consumption of the SoS are diffused across the trophic spectrum, and ii) consumers can increase by feeding on occasional prey, thus triggering a depression of their usual food sources.

According to the EwE model, bottom trawlers had the highest cumulative impacts on benthic, demersal and pelagic domains in the SoS, followed by longliners and purse seiners. The most highly exploited groups were swordfish, large HKE, DPS and bluefin tuna. Pandora *Pagellus erythrinus*, large *Mullus barbatus* and large pelagic

fishes also suffered high exploitation rates. Globally, the demersal domain was most directly impacted by fishing activities.

An assessment of the synergic effects of climate change and fisheries on resource dynamics in the Mediterranean, including the SoS, was made by Moullec *et al.* (2019). Simulating trends in the Mediterranean catch by coupling a biogeochemistry (Eco3M-S) and multispecies individual-based model (OSMOSE), under current fishing pressure and CO2 emissions the total catch of the GSAs of the SoS is expected to increase by 10–20 percent from 2070 to the end of the 21st century, with the exception of GSA 12 for which a light decrease in yield is projected. Winner species would mainly belong to the thermophilic and/or exotic pelagics, of smaller size and from low trophic levels, such as DPS; while loser species will be large-sized, some of them such as HKE of great commercial interest. It should be noted that these long-term ecological projections are recent and were not included in the current SoS demersal fisheries management strategy. Despite several different ecosystem models being available in an EAF perspective (Stecken and Failler, 2016), the scientific advice is short term and based on single species models, because the scientific community lacks full confidence in multispecies models (Hilborn, 2011; Fogarty, 2014). A key challenge for the future management of Mediterranean fisheries is to integrate the management objectives, the assessment methodologies and the adopted measures into a more comprehensive framework based on EAF principles.

5. CONCLUSION

The current management measures for bottom trawl fisheries in the SoS are based on control of fishing effort integrated with technical measures, including spatial and temporal closures. However, there are no fleet quotas fixed by the GFCM MAP, and the sections of the GFCM MAP related to monitoring, control and surveillance require further improvement. The GFCM MAP aims for only a limited number of trawlers to be authorized to fish for DPS and HKE in the SoS, identified through an ad hoc GFCM list of authorized vessels supplied by the countries involved. In spite of this mechanism, however, unauthorized trawlers are frequently present in the SoS, resulting in the fishing effort controls in the GFCM MAP becoming less effective, and an increase in IUU fishing in the area. In addition, there are no limits to fishing activity or catch for authorized vessels in the GFCM MAP, which makes it difficult to reduce the current overfishing of most of the exploited stocks. On the other hand, the reduction of fishing effort on shelf bottoms in GSA 16, and the consequent reverse of the state of red mullet to sustainable, proves that reductions like this can enhance the stock status of exploited species.

The current GFCM MAP in the SoS is the first example of a MAP for distant fleets and shared stocks in the region, and can be seen as an important first step in the application of EAF concepts in Mediterranean fishery management. Nevertheless, fisheries management in the SoS requires further improvements to be fully in line with EAF principles.

Achievements in view of EAF principles

- Stakeholder have been involved in defining management objectives and the overall approach.
- The results of scientific studies were taken as the baseline for setting management measures.
- Both technical and spatio-temporal control measures were adopted to reduce fishing mortality and the impact of trawling on the ecosystem (protection of Essential Fish Habitat in terms of nurseries of HKE and DPS; adoption of a summer trawling ban

in sensitive areas to protect juveniles of shallow-water species and selachians).
- Further scientific studies are planned to monitor and evaluate the management measures' performance.
- The consolidated international scientific cooperation was – and will continue to be – the key factor for initiating the entire process leading to the development of the MAP, and for addressing some of the aspects that require further improvement.

Areas to be further improved
- Stock status of target species – Despite the fact that the GFCM MAP started in 2015, the management measures taken so far have not been able to revert the increase in overfishing. In particular, HKE fishing mortality has been increasing since 2010.
- Sharing of information – Additional effort should be devoted to enhance sharing of information and results both of scientific studies and of monitoring activities among all stakeholders at national and regional level.
- Socioeconomic assessment – Assessment studies should be expanded to include the socioeconomic implications of management measures adopted. To be effective, these studies should address both sub-regional and local fishing activities, and include single fleets (by harbour) located in the SoS.

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Chapter 12: A tool to monitor implementation of the ecosystem approach to fisheries management: examples of application in the Mediterranean

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1. INTRODUCTION

The ecosystem approach to fisheries (EAF) is a risk-based management planning process that covers the principles of sustainable development, and it has been adopted by the FAO Committee on Fisheries (COFI) as the most appropriate and practical way to fully implement the Code Conduct for Responsible Fisheries (FAO, 2003). While much has been written on the EAF, very little is known about monitoring its implementation. As part of the FAO EAF-Nansen Programme 'Supporting the Application of the EAF Management Considering Climate and Pollution Impacts', the EAF Implementation Monitoring Tool (IMT) was developed to enable partner countries to monitor progress with the implementation of the EAF and their achievements in managing fisheries in a sustainable manner (FAO, 2021). In other words, the EAF IMT has been developed to measure the degree to which each of the EAF principles (FAO, 2003; EAF-Net Toolbox, www.fao.org/fishery/eaf-net) are being adopted and implemented.*

The EAF IMT is a tool for decision support and planning in the fisheries management process. It can be used by countries in strategic and operational planning processes for each of their fisheries, to determine where they are making acceptable progress and where there continue to be gaps and difficulties to address. This tool makes it possible to note and review all the components of fisheries management, thanks to a simple and replicable methodology whatever the context, size and location of the fishery.

* This chapter is an extract from the publication: **FAO. 2021.** *Ecosystem approach to fisheries implementation monitoring tool – A tool to monitor implementation of the ecosystem approach to fisheries (EAF) management. User manual. Rome.*

The EAF IMT was developed through an expert process from 2018 to 2020. Concept and methodology workshops were organized to identify and validate the approach, structure and scoring system. The tool was tested in several contexts and fisheries in 2020, and it was applied to develop the baseline and first scoring reference for the small and medium pelagic fishery in the United Republic of Tanzania and for the beach seine fisheries in the Gulf of Guinea (FAO, 2021). In the Mediterranean, the IMT was tested on four EAF pilot studies supported by the FAO Management Support Projects CopeMed II and EastMed: small-scale fisheries in El Bibane lagoon (Jarboui *et al.*, this volume), demersal fisheries in the Mediterranean coast of Egypt (ElHaweet and Megahed, this volume), small-scale purse seine fisheries in Lebanon (Nader *et al.*, this volume), and small-scale fisheries in Gökova Bay (Ünal *et al.*, this volume). The testing was carried out during two online sessions (16 November and 2 December 2020) with the authors of the respective chapters. The preliminary results of this testing are provided here to illustrate the use of the tool, its structure and potential use as a fishery planning tool.

2. STRUCTURE OF THE IMT

The EAF IMT is structured according to the three main risk assessment components addressed in the development of management plans following EAF guidelines (FAO, 2003): ability to achieve, ecological wellbeing, and human wellbeing.

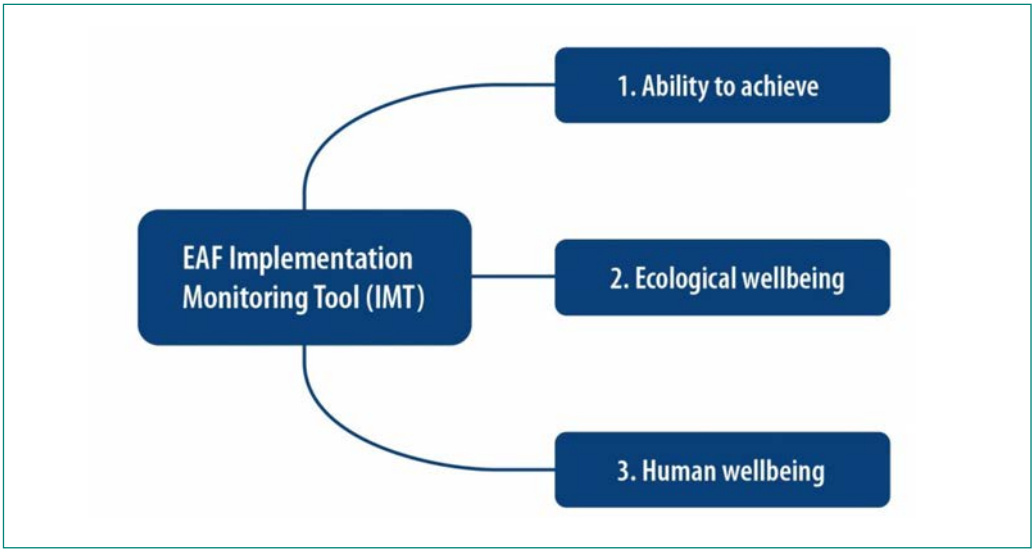

Figure 1. The three components of EAF used in the EAF IMT (FAO, 2021).

2.1. The ability to achieve component

This represents the management and institutional systems in place or proposed to deliver the desired outcomes (e.g. access and tenure systems, compliance, democratic processes, conflict resolution, stakeholder participation), along with the external drivers (not controlled by the fisheries authorities) which may be affecting its performance. Accordingly, this component contains two subcomponents: governance and external drivers (Figure 2).

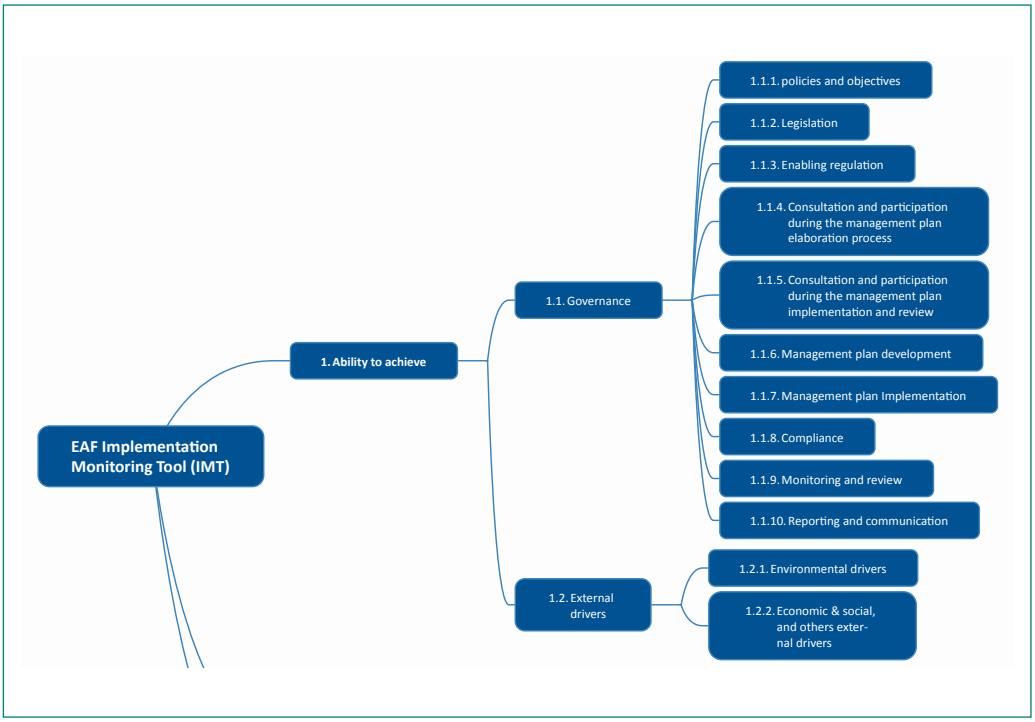

Figure 2. Structure of the ability to achieve component (FAO, 2021).

2.2. Ecological wellbeing component

This component concerns all ecological 'assets' (e.g. stocks, habitats, ecosystems) relevant to the fishery and the ecosystem in which it occurs, and the issues and impacts being generated by the fishery that may be affecting them. This component has three subcomponents: retained species, non-retained species and general ecosystem (Figure 3)

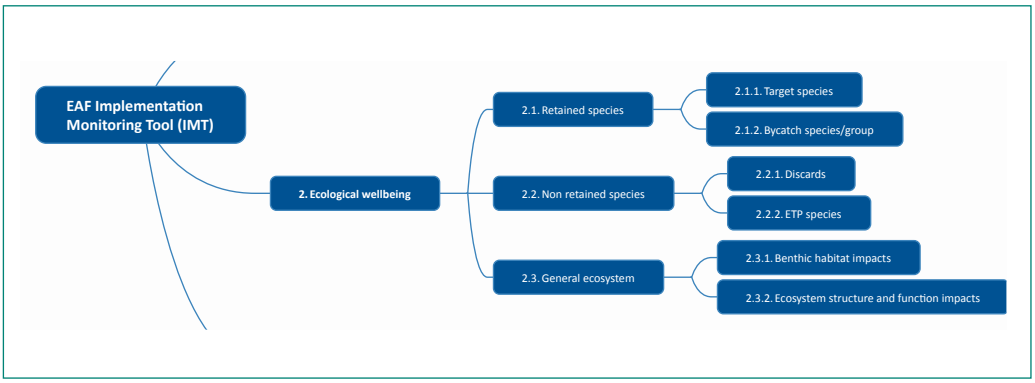

Figure 3. Structure of the EAF ecological wellbeing component (FAO, 2021).

2.3. Human wellbeing component

Human wellbeing is one of the key drivers in an EAF and is defined by FAO as: 'a condition in which all members of society are able to determine and meet their needs and have a large range of choices to meet their potential' (Garcia *et al.*, 2003). Ecosystem health is fundamental for human health and wellbeing, and EAF-based fisheries management seeks to maintain the capacity of aquatic resources to produce food and employment fundamental to human wellbeing. The EAF-IMT analyses human wellbeing according to four categories of components: livelihood, food security, health and safety, and gender and equity.

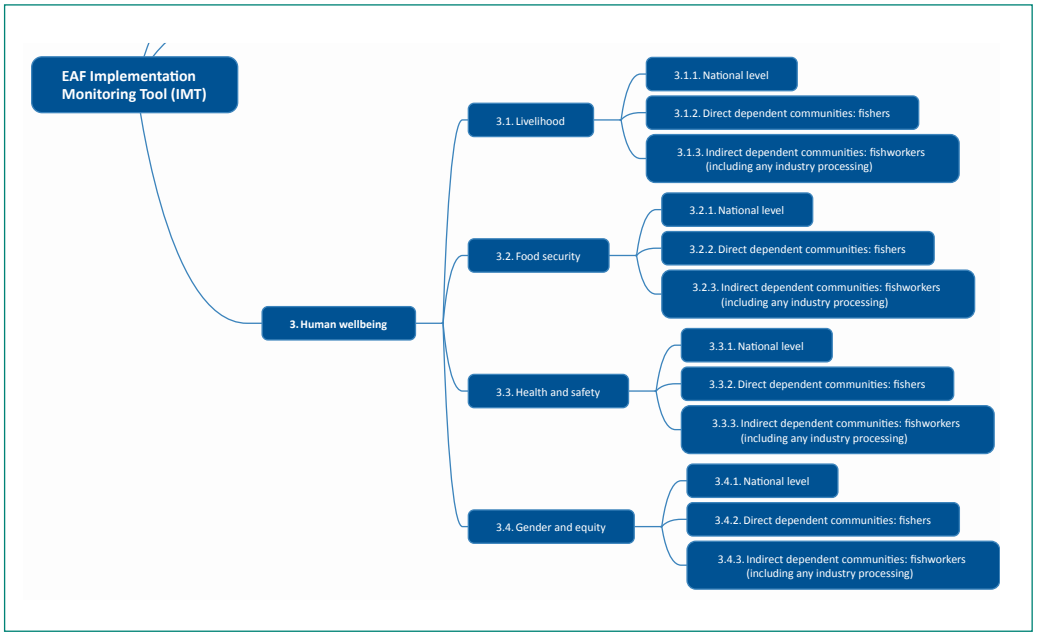

Figure 4. Structure of the human wellbeing component (FAO, 2021).

Finally, the global structure of EAF IMT contains 3 components, 9 subcomponents and 30 elements to score (Figure 5).

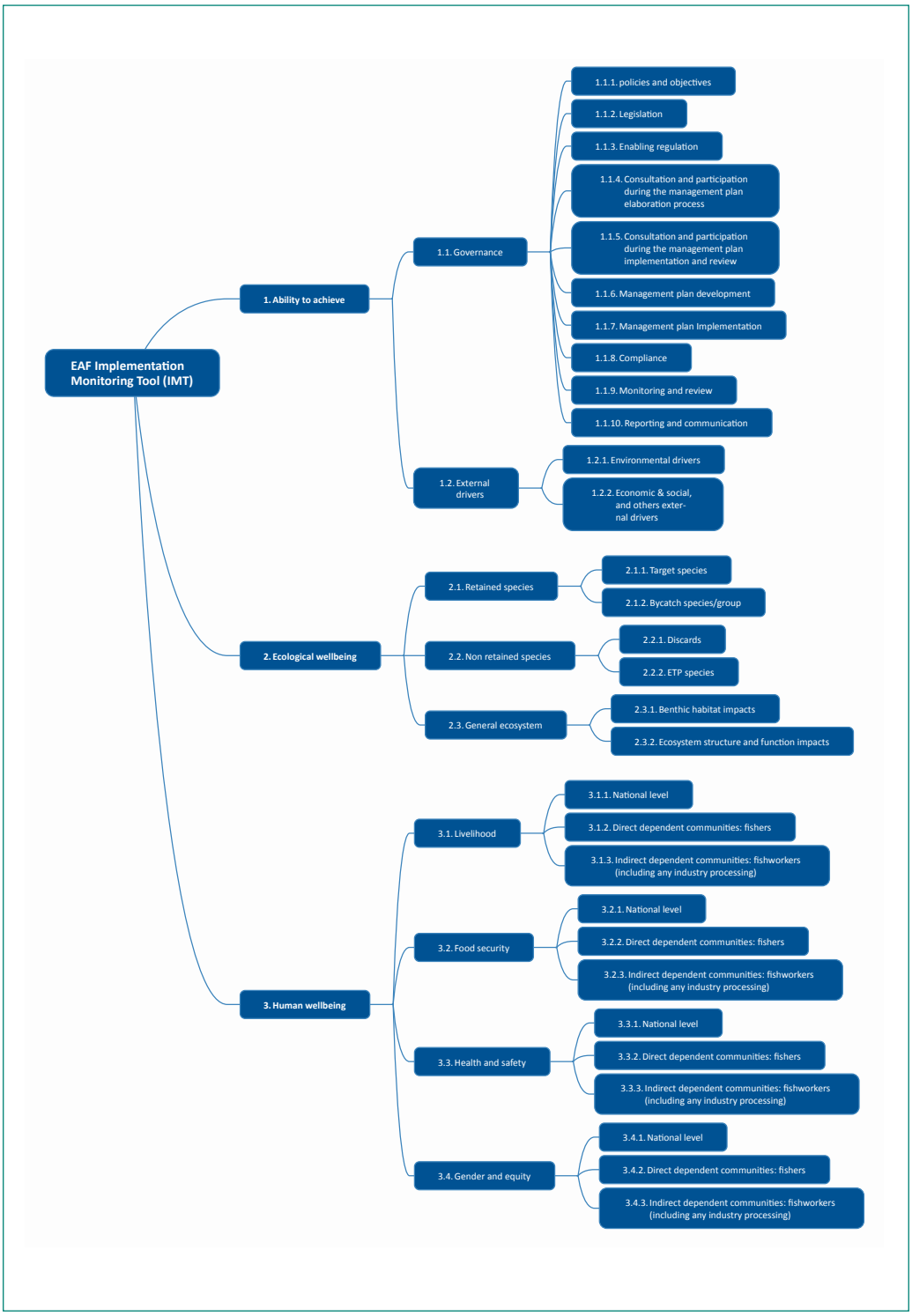

Figure 5. Overall EAF IMT structure (FAO, 2021).

3. SCORING A FISHERY

Ideally, a small group of stakeholders with relevant expertise, knowledge and experience of the fishery, can undertake an initial scoring for each fishery. This should be a group of six to 10 people, made up of scientists, fisheries managers and fishers. Using the EAF IMT scoring tables (cf scoring table below) and template, the group decide and agree on indicative scores for all the 30 elements through the three components, and document suitably detailed justifications with the source materials that were used (FAO, 2021).

In the following sections we provide examples of scoring tables for each of the main EAF components and demonstrate examples of outcomes obtained during practical implementation for four case studies in the Mediterranean covered in previous Chapters (Jarboui *et al.*, this volume; El-Haweet and Megahed, this volume; Nader *et al.*, this volume; Ünal *et al.*, this volume). The EAF IMT scoring shown for each fishery was obtained during practical demonstration sessions with the participation of a core team of experts from each case study. They are presented here for illustration purposes only and do not represent a consensual representation of the status of the case study fisheries.

3.1. Governance scores

The governance elements are scored directly using a single scoring table based on the extent to which these have been developed in accordance with EAF principles.

For example, in the governance subcomponent the seventh element to score is 'Management plan implementation and review'.

In this example the scoring evaluates if, for the selected fishery, there is a clear set of appropriately binding management measures and arrangements (e.g. allocation of access, catch control, harvest strategy etc.) implemented and reviewed to achieve each of the agreed objectives.

We use the following scoring table to decide which score best reflects the situation of the fishery, based on the score descriptions, the scoring rationale and the knowledge and appreciation of the people in charge of the scoring of the fishery.

Table 1. Scoring table on 'Management plan implementation and review' subcomponent (FAO, 2021).

Scoring	0	1	2	3
Management plan implementation and review	A management plan has not been implemented.	A management plan has been partially implemented.	A management plan has been implemented but not reviewed.	A management plan has been implemented and reviewed.
Scoring rationale	No operational and annual work plan has been developed.	Some of the plan has operated for at least one full decision-making cycle.	The full plan has operated for at least one full decision-making cycle.	The plan has operated for at least one full decision-making cycle of the harvest strategy and its performance has been independently reviewed.

After scoring all the elements of this component, the tool generates a graphical representation of the scores. Below is the example of the governance subcomponent score for the demersal fishery in Egypt (El-Haweet and Megahed, this volume).

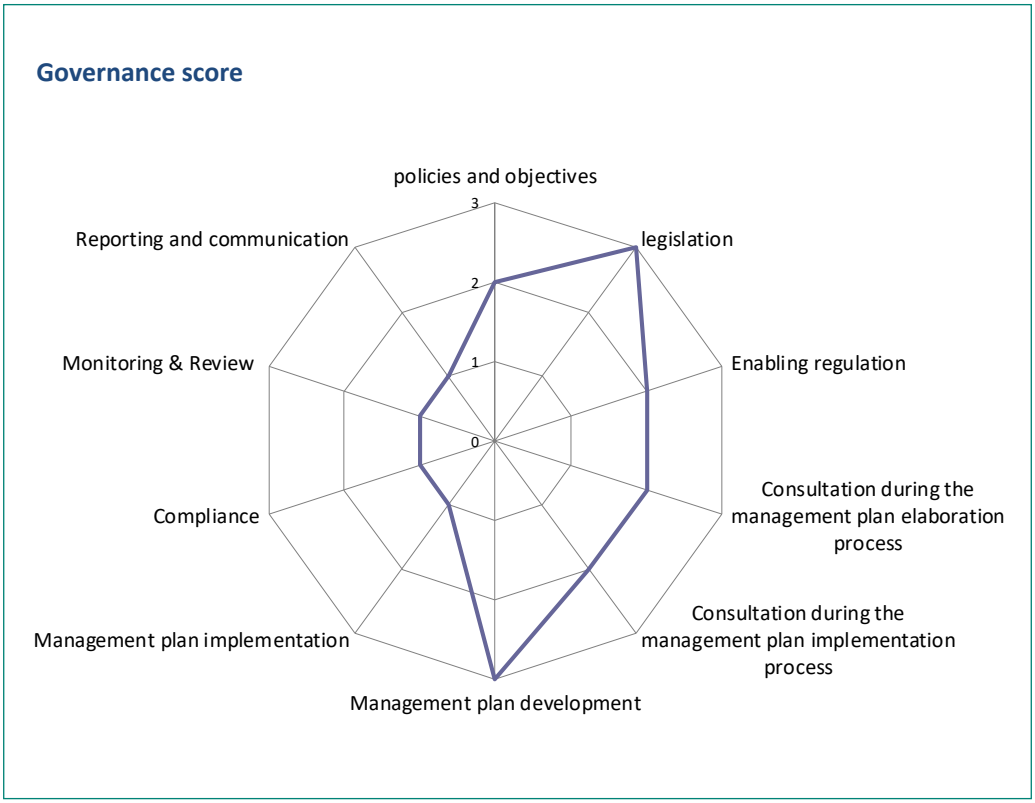

Figure 6. Graphical representation of the governance score for the demersal fishery in Egypt.

In this particular case of the demersal fishery in Egypt, the scoring highlights that the fishery has comprehensive legislation in place and a management plan developed in consultation with stakeholders, but that the process of implementation of the management plan and measures lags behind. This reflects the current situation since the development process has just been initiated and the management plan has not yet been implemented.

3.2. Ecological wellbeing scores

The scoring protocol used has three scoring categories that reflect the EAF risk-based methodology. This methodology of notation in three steps is used to score all the elements of the ecological and human wellbeing components (FAO, 2021).

1. The first category consists in the identification and assessment of EAF issues against agreed objectives. This category (named A for assessment) evaluates if there is already sufficient understanding about the relevant EAF issues for each fishery, including having confidence in their identification and assessment of their risk levels. This category is especially relevant when initiating the implementation of EAF (FAO, 2021).

2. The second category (category M for management) evaluates if management measures appropriate to risk levels have been developed and implemented. This category measures if the management procedures and systems are appropriate given the current risk levels identified for each EAF issue, and if these measures are now being implemented (FAO, 2021). This category will be more relevant to measure after the assessment phase has been completed.
3. The third category (category AO for achieving objectives) evaluates the outcomes of the management system, and to what degree the management system is moving towards delivering each of the agreed objectives and desired outcomes (FAO, 2021). This category is likely to be relevant and measurable after the management measures have been in place for a suitable period of time.

Table 2 below is an example of the scoring category A for the target species. The score has to reflect if there is sufficient confidence in the assessment of risk status of the target species and the associated management advice.

Table 2. Example of scoring table: Target species/scoring category A.

Scoring	0	1	2	3
Appropriate assessment completed against agreed objectives	No assessment.	Low level of confidence in the assessment and management advice.	Variable levels of confidence in the assessment and management advice for the target species against agreed objectives.	High level of confidence in the assessment and management advice for all target species against agreed objectives.
Scoring rationale	No formal or informal assessment of stock status for any of the target species.	There is some formal or informal assessment of stock status for some of the target species, but very high levels of uncertainty in the assessment and in the associated advice.	There are some of the target species or some of the objectives with an acceptable level of confidence in the assessment and advice, and other target species and objectives where the confidence level is not acceptable.	This would require: • reliable data • clear objectives • robust assessment • clear management advice.

Table 3 is used to score if management measures appropriate to addressing the target species risk levels have been developed and implemented.

Table 3. Example of scoring table: Target species/scoring category M.

Scoring	0	1	2	3
Management measures appropriate to risk level developed and implemented	No appropriate management measures are in place.	Appropriate management measures are under development.	Appropriate management measures have been developed but are not fully implemented.	Adequate management measures have been developed and are being implemented.
Scoring rationale	There are no appropriate management measures in place or under development. Any current management measures are considered ineffective or inadequate to begin addressing the identified risks.	There are no appropriate measures in place, but processes are underway for their development.	This requires an integrated set of management measures within a suitably formalized management plan. These measures could include: • indicators • performance measures • harvest strategy • integrated set of fishing regulations (e.g. catch and effort control).	This requires both the development of the management plan but also that it is fully operational for at least one fishing season.

The last scoring category is assessing the degree to which the management system is moving, or has moved, towards delivering the agreed objectives and desired outcomes (Table 4).

Table 4. Example of scoring table: Target species/scoring category AO (FAO, 2021).

Scoring	0	1	2	3
Achieving agreed objectives	No progress towards achieving objectives.	Progress towards achieving some objectives.	Progress towards achieving some objectives.	All agreed objectives are currently being achieved.
Scoring rationale	As above.	As above.	As above.	As above.

After scoring all the elements of this component, the tool generates a graphical representation of the score by category (A, M and AO) for the ecological wellbeing elements (Figure 7). In this particular example of the El Biban lagoon fishery (Jarboui *et al.*, this volume), the scoring highlights a level of assessment which is relatively homogeneous and satisfactory even if there are still gaps in particular concerning the target species. The management process reveals an advanced level of implementation on the majority of ecological components which seems to produce results in accordance with expectations.

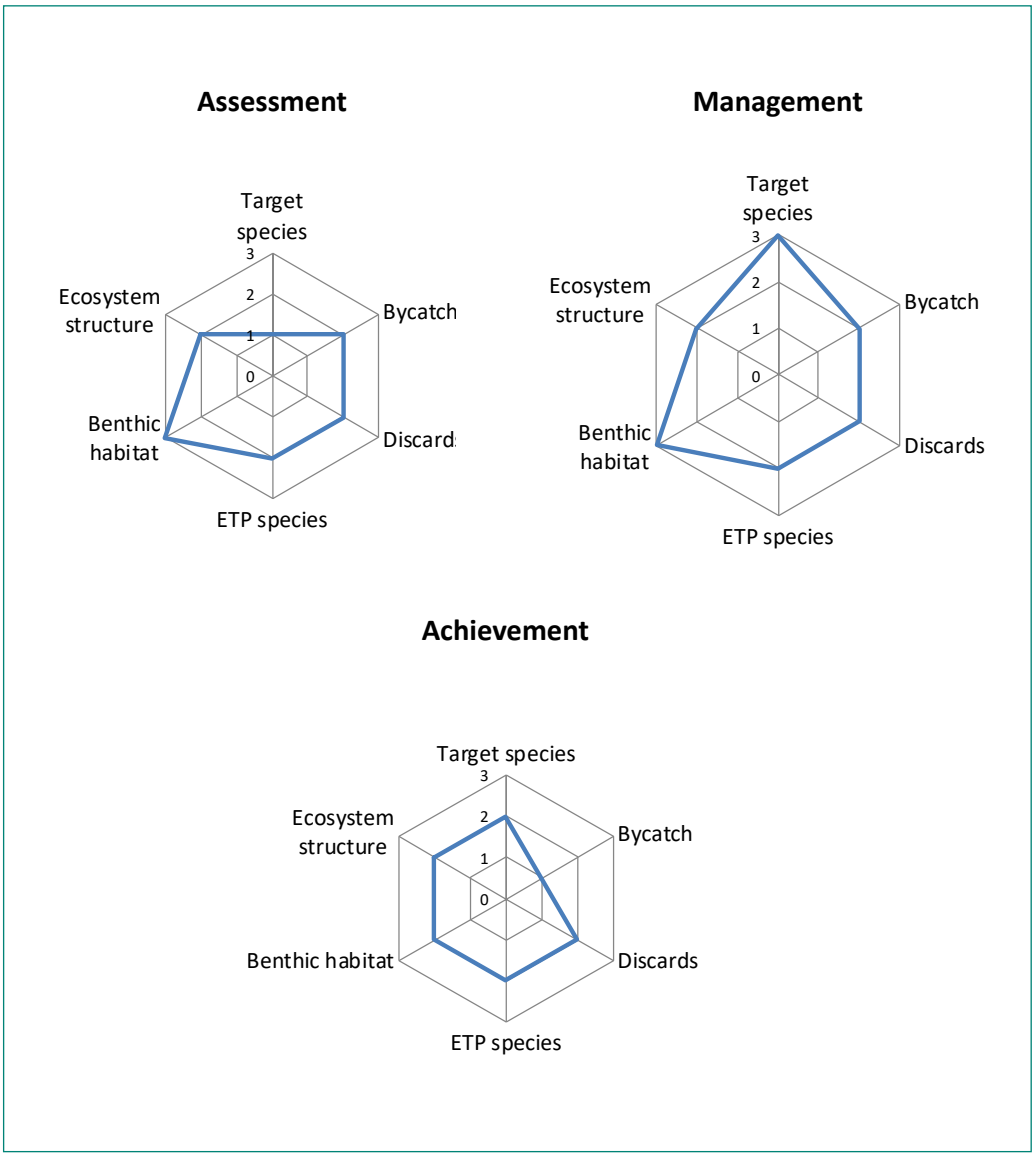

Figure 7. Graphic representation of the scores for assessment, management and achievement categories of the ecological wellbeing elements of the small-scale fisheries in El Bibane lagoon, Tunisia.

3.3. Human wellbeing scores

As for the ecological wellbeing component, the same methodology of notation is used for the human well-being component. Assessment, management and achievements are scored for the four elements of this component (Livelihood, Food security, Health and safety and Gender and equity) at three different levels (FAO, 2021):

1. at national level;
2. at the scale of directly dependent fishing communities;
3. at the scale of indirectly dependent fishing communities.

The scoring table below (Table 5) is an example to score the confidence in the identification and assessment of the risks and opportunities at national level in achieving appropriate livelihoods outcomes and other agreed objectives.

Table 5. Example of scoring table: Livelihoods at national level/scoring category A (FAO, 2021).

Scoring	0	1	2	3
Appropriate assessment completed against agreed objectives	No assessment.	Few elements have been assessed.	Most elements have been assessed.	Comprehensive assessment completed.
Scoring rationale	There is no identification or assessment available of the relevant risks and opportunities for livelihoods at national level.	Only some of the relevant opportunities or risks for livelihoods at national level have been identified or assessed.	Most of the relevant opportunities or risks for livelihoods at national level have been identified or assessed.	There is a comprehensive identification and assessment of the relevant opportunities or risks for livelihoods at national level.

Table 6 is used to score if fishery management and other measures appropriate to addressing the risk levels for livelihoods at national level, which are also consistent with each of the other agreed objectives, have been developed and implemented.

Table 6. Example of scoring table: Livelihoods at national level/scoring category M (FAO, 2021).

Scoring	0	1	2	3
Fisheries management and other measures developed and implemented appropriate to risk levels and constraints/ conflicts	No appropriate measures in place for identified risk issues and opportunities.	Appropriate measures under development or in place for only a few risk issues and opportunities.	Appropriate measures in place for most risk issues and opportunities.	Appropriate measures for risk issues and opportunities have been developed and are being implemented.
Scoring rationale	There are no appropriate measures in place or under development. Current measures are considered ineffective or inadequate to begin addressing the identified risks and opportunities.	There are no or few appropriate measures in place, but processes are underway for the development of a more comprehensive set of measures.	Most of the relevant opportunities or risks for livelihoods at national level have been identified or assessed.	The measures within the suitably formalized management plan adequately consider the risk issues and opportunities without impacting the achievement of the other agreed objectives.

The last scoring category is assessing the degree to which the management system is moving towards delivering agreed objectives and desired outcomes (Table 7).

Table 7. Example of scoring table: Livelihoods at national level/scoring category AO (FAO, 2021).

Scoring	0	1	2	3
Achieving agreed objectives	No progress towards achieving objectives.	Appropriate measures under development or in place for only a few risk issues and opportunities.	Appropriate measures in place for most risk issues and opportunities.	Appropriate measures for risk issues and opportunities have been developed and are being implemented.
Scoring rationale				

After scoring all the elements of this component, the tool generates a graphical representation of the results. Figure 8 illustrates an example of the score by category (A, M and AO) for the human wellbeing elements in the small-scale fishery in Gökova MPA (Ünal *et al.*, this volume). In this case, the results indicate that in this fishery, the level of knowledge and risk assessment is irregular with some gaps in particular concerning certain elements of the human wellbeing component. The management process seems to consider mainly gender, equity and health and safety, and the achievements seem to be linked to the management planning process initiated.

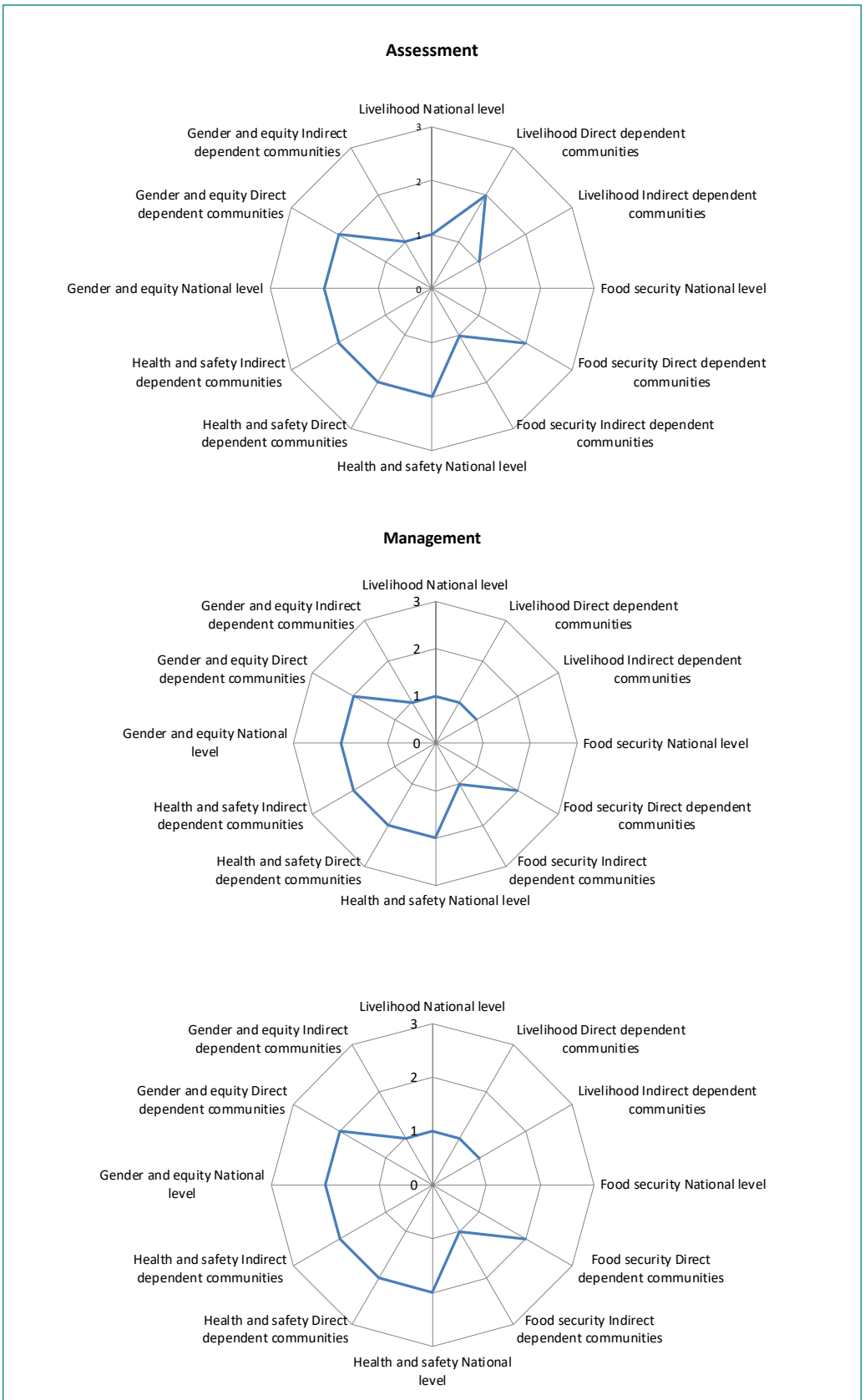

Figure 8. Example of graphic display of results of the scoring of human wellbeing components for the small-scale fishery in Gökova Bay, Turkey.

3.4. Overview scores

After scoring all the components of the fishery the tool generates a graphical representation to visualize the scores of each component and the global score of the fishery. Figure 9 shows an example of the global scores for the sardine fishery in Lebanon (Nader *et al.*, this volume).

We observe percentages by component and for the fishery, calculated by the ratio of the total score of the component or the fishery by the maximum possible score. The traffic light table shows the reference level by component and for the fishery. It is considered that below 60 percent the level is unsatisfactory, between 60 percent and 79 percent the level is encouraging, and when it is above 80 percent the level is satisfactory.

In this case, where the management process is at the very beginning, scores for all components and the fishery are below minimum requirements.

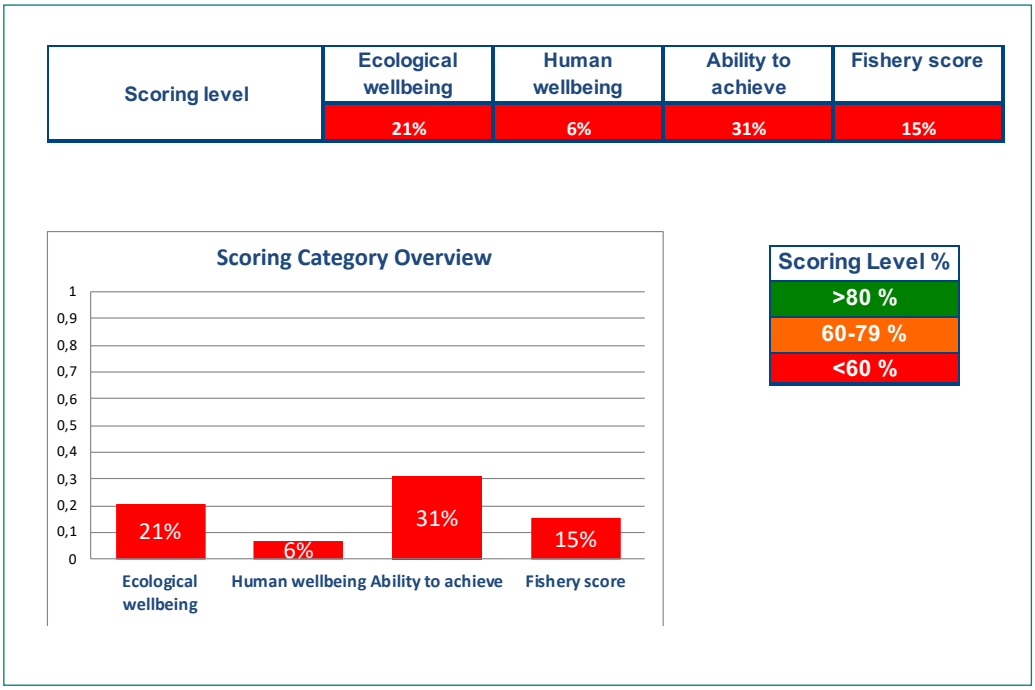

Figure 9. Example of graphic display of the overview score in the sardine purse seine fishery in Lebanon.

4. CONCLUSIONS

Although this scoring exercise using the EAF IMT tool was not carried out with a wide consultation of stakeholders, as recommended by the methodology (FAO, 2021), this experience produced very interesting results.

First of all, all the participants easily adopted the tool and succeeded in using it to go through all the stages of the EAF management process for their own fisheries. They underlined that the scoring methodology is simple to use and replicable whatever the context of the fishery and the level of implementation of the management process.

The score assigned for each of the fisheries faithfully reflects the current situation of the management process. This allows comparisons to be made between fisheries which have just started a management process and other fisheries which implemented this management process several years ago.

The review and scoring of the ability to achieve component helps to realize all the elements of fisheries governance: the legal, policy and legislation context, the process of consultation and participation of stakeholders in the decision-making process, the level of development and implementation of the management plan, the compliance, and finally monitoring, evaluation and communication of the EAF management process. This first review really stresses not only the degree of implementation of the management process but also all the prerequisites necessary for an inclusive participation of stakeholders in the identification and implementation of the management responses. The compliance system, very important to achieving the management objectives, is also evaluated and scored.

The review and scoring of the ecological component allows scrutiny of the available level of knowledge on resources and ecosystems, if a management response is accordingly identified and implemented, and if this process is achieving desired outcomes.

This is also the case for the human wellbeing component, which is reviewed by analysing livelihoods, food security, health and security, and gender and equity, at three different levels: at the national level, at the level of fishing communities directly dependent on the fishing activity, and at the level of communities indirectly dependent on the fishing activity. This very detailed review of all the economic and social components of fishing activity allows identification of the gaps in information necessary for fisheries management, but also in terms of appropriate responses to resolve complex human, economic and social situations.

The tool is designed to generate scores, but one of the most valuable benefits of its application is the discussion that the scoring process generates, and the discipline required to clearly justify each of the scores.

In order to monitor the progress made, we recommended repeating the EAF IMT assessment at regular intervals, as well as at critical times (e.g. at the start of the planning process), including a wider participation of stakeholders.

In conclusion, all of the gaps and weak points we identified and characterized in this analysis may guide fisheries managers to understand their fishery and take decisions in order to improve the management quality of their fishery. Finally, the way the tool enables analysis of EAF implementation across any fishery proves its usefulness and broad applicability: it could likely be frequently applied to monitor and evaluate progress towards achieving the objectives of sustainable fisheries management.

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Chapter 13: Emerging lessons from case studies

1. COMMON TRIGGER FACTORS THAT INFLUENCED/DROVE THE CHANGES TOWARDS EAF-LIKE MANAGEMENT SYSTEMS

The implementation of an ecosystem approach to fisheries management encompasses different processes, such as the formulation of high-level policies and legislation, the development of management plans with operational objectives, the evaluation and monitoring systems, and appropriate adaptation mechanisms (FAO, 2009). However, the path to implementation does not necessarily follow this order of processes in phases, as is customarily depicted in technical guidelines for capacity development. Consistent with the notion that EAF represents an evolution of traditional management systems, implementation can occur in any of these processes or phases and on different scales, depending on the factors – whether ecological, social, economic or institutional – that trigger the change in the fishery management system (De Young, Charles and Hjort, 2008; Defeo and Vasconcellos, 2020). Some of the common factors behind the changes described in the case studies are briefly discussed below.

Changes in laws and regulations to support management planning as part of a precautionary approach to fisheries

One aspect that played an important role as a trigger of change in some of the case studies was the legal requirement to adopt precautionary management systems through the development of fisheries management plans. In the context of fisheries in European waters, for instance, the establishment of the regulatory framework for the Mediterranean (Regulation (EC) 1967/2006) created several restrictions for fishing operations and made mandatory the development of management plans in line with EAF principles. By forcing a change in the exploitation patterns of the fleets, these regulations caused in some cases a certain level of socioeconomic distress (see for instance Carlucci, 2015; Rodon *et al.,* this volume; Lucchetti *et al.*, this volume). This situation drove the sector, local authorities and NGOs to work collaboratively in the development and adoption of appropriate management plans and measures. Although important, the legal obligation to develop a management plan is obviously not a sole condition for successful fisheries management. There are numerous examples around the world of management regulations and plans that are not enforced due to limited implementation capabilities (e.g. Mora *et al.*, 2009). On the other hand, the willingness and engagement of stakeholders to develop a plan can be far more important than a legal requirement. Hence, other factors help to enable the successful implementation of these management plans, and they are discussed in the following sections of this report.

Ecological and socioeconomic risks and impacts associated with weak fisheries management

In several of the case studies analysed here, the attempts to improve the management systems were influenced by the poor status of resources and related socioeconomic impacts caused by weak or de facto absent fisheries management. High levels of overfishing have been reported in Mediterranean fisheries for many years (FAO, 1994; Vasilakopoulos *et al.*, 2014; Guidetti *et al.*, 2014; FAO, 2020 a,b), impacting not only the main commercial stocks but also diverse coastal stocks targeted by small-scale fisheries.

Deterioration in fish stocks can have diverse socioeconomic implications such as loss of income and jobs, and it also impacts on food security. However, there are limited socioeconomic data to infer the true importance of these impacts over time in the Mediterranean. In addition, the lack of socioeconomic monitoring studies in some coastal regions, or the lack of reliable socioeconomic data, prevents the accurate and comprehensive assessment (also understanding) of the socioeconomic status of small-scale fishers. Data recently available at regional level indicates that Mediterranean fleets have an overall positive cash flow (representing on average 24 percent of the revenue), generate about 225 000 jobs onboard fishing vessels and an average annual remuneration per fisher of USD 6 671 (varying from USD 4 868 for fishers in small-scale fisheries to USD 11 x273 in industrial trawlers) (FAO, 2020b). In addition, the data reveals the importance of complementary sources of income generated by fishers by diversifying the use of vessels for non-fishery-related activities, such as tourism, recreational activities, and support to other industries such as aquaculture and oil and gas. Preliminary estimates indicate that these alternative sources of regional fleet income can be substantial, generating approximately USD 107.6 million per year –with about half the total coming through small-scale vessels (FAO, 2020b). Nevertheless, despite these positive economic indicators, the wellbeing generated by the sector can in some contexts be quite low compared to other sectors in the economy. Pinello *et al.* (2020) for instance demonstrated that fisher remuneration can be lower than the minimum wage of the manufacturing sector in some eastern Mediterranean countries, which makes the sector unattractive to prospective workers. This relative unattractiveness is also reflected by the older age of the workforce in the different fleet segments, with 49 percent of fishers being aged over 40 (FAO, 2020b). Other data and anecdotal information provided in the case studies illustrate how the perceived and/or expected worsening in ecological and socioeconomic conditions associated with IUU fishing were important motivations for stakeholders to improve the productive capacity of their fisheries through better management systems (e.g. Nader *et al.*, this volume; Jarboui *et al.*, a,b, this volume; Ünal *et al.*, this volume; Lucchetti *et al.*, this volume; El-Haweet and Megahed, this volume). The noticeable decline in fish stocks (Colloca *et al.*, 2013) and the reduction in fishing income triggered solidarity and collective action among stakeholders, especially fishers.

Conflicts among sectors/countries sharing resources and areas

In the management of resources shared by many actors (fishers, sectors and/or countries), if rules are not established and enforced to control access and sustainable exploitation, competition can lead to uncontrolled fishing. This results in the overexploitation of resources and conflicts among actors. Conflicts over access to and control of shared resources – and the social unrest resulting from them – can be important triggers for changes in management systems (Bennett *et al.*, 2001; Pomeroy *et al.*, 2007; Berkes 2009). The case study on dolphinfish (Laspina and Said, this volume) illustrates how unregulated fisheries by countries sharing a common migratory resource led to conflicts which triggered the consideration of the EAF and the adoption of regional measures to harmonize management practices. Conflicts can also arise because of competing fishing grounds. In the case of clam fisheries in the Adriatic Sea (Lucchetti *et al.*, this volume), conflict between the clam fishers and small-scale fishers sharing the same fishing ground causes periodic social problems (i.e. in late spring), which often prevents transparent management and inter-sector communication. In Gökova Bay, the increasing number of recreational fishers, illegal fishing activities and the destructive impacts of trawlers and purse seiners triggered small-scale fishers (organized through the fishery cooperatives) to seek more effective fisheries management in order to protect their resource (Ünal *et al.*, this volume).

Impacts of multiple stressors in the coastal zone affecting habitat, resources and livelihoods

Several of the case studies provided examples of how fisheries can be impacted by additional stressors related to human activities in coastal zones and also by environmental changes. Stressors related to coastal habitat degradation and pollution (Nader *et al.*, this volume), changes in water quality (Lucchetti *et al.*, this volume) and the spread of non-indigenous species and their diverse destructive impacts (Ünal *et al.*, this volume) put additional pressure on resources and can negatively affect the living conditions of fishers. In most cases, these factors are beyond the control of the fisheries sector but need to be better accounted for in the governance of coastal and marine ecosystems. Appropriate adaptive policies should also be implemented in cases where climatic events and trends have impacts on fishing livelihoods (Barange *et al.*, 2018). The absence of appropriate inter-sectoral governance structures and decentralized and adaptive fisheries management strategies to cope with these additional stressors contributed to create a demand for an ecosystem-based approach to fisheries management.

Enhanced availability of information and awareness among fishery managers

Information availability and knowledge are important determinants of public awareness and perception of environmental issues (e.g. Malka *et al.*, 2009; Gelcich *et al.*, 2014), which in turn can affect decision-making regarding management priorities and the need for change. Awareness raising depends not only on the availability of information, but also on how such information is communicated to stakeholders (Durgun *et al.*, 2021). Increased awareness of the interactions and impacts of fisheries in aquatic ecosystems is recognized as one of the main reasons for the adoption of an ecosystem approach to fisheries globally (FAO, 2003). As reported in some of the case studies, increased awareness about the poor status of resources, declining fisheries production and the environmental impacts associated with unregulated fisheries was a key motivation for the attempted changes in management systems. In Lebanon, for instance, Nader *et al.* (this volume) describe how the improvements in basic fisheries data acquisition shed light on trends in fisheries production and the national importance of the sardine purse seine fishery. The previous lack of reliable information was an impediment to any management initiatives and to decision-making in general. In Egypt, the enhanced knowledge of fisheries managers regarding the multiple dimensions of the fishery sector (socioeconomic, ecological and technological) was a trigger for the pilot testing of an ecosystem approach to demersal fisheries management (El-Haweet and Megahed, this volume). In this regard, the authors also highlight the importance of effective mechanisms to communicate and share experiences with other Mediterranean countries, facilitated through FAO projects and bodies. In the case of the clam fisheries in Italy (Lucchetti *et al.*, this volume), the cooperation established between the fishing industry and research bodies provided a positive stimulus in the fishing sector by improving the information available and increasing awareness of decision-making processes. In Turkey's Gökova Bay, the exposure of fisheries stakeholders – and especially participants from government institutions – to the EAF-based fisheries management planning pilot process was important for raising awareness of the appropriateness and replicability of this approach for managing fisheries in other areas of the country (Ünal *et al.*, this volume).

Changes in national governance systems

In many cases, the transition towards an ecosystem approach to fisheries does not occur in isolation from other sectors in society, but it is instead immersed in and affected by overarching changes in national governance and economic systems. Defeo and Vasconcellos (2020) discussed how the socioeconomic impacts following the

collapse of small-scale benthic fisheries in Chile, coupled with the strengthening of social movements resulting from the transition to democracy in the late 1980s and early 1990s, created the conditions for a transformation of the governance system for small-scale fisheries in line with EAF principles. As is noted in the case study of demersal fisheries in Egypt, the attempted changes towards an ecosystem approach followed wider transformations in national governance systems, influenced by the adoption of more liberal policies and the impact of globalization (El-Haweet and Megahed, this volume). The move from a traditional centralized management system to a more participatory model of governance through co-management was also highlighted as an important factor in the case of the Italian clam fisheries (Spagnolo, 2007; Lucchetti *et al.*, this volume).

2. ENABLING CONDITIONS

The comparison of case studies allowed the identification of common conditions that apparently facilitated the development and implementation of EAF-compatible management systems. These conditions are discussed here in two sets: existing conditions or inherent characteristics of the case study fisheries that facilitated the changes in the management systems (*ex ante*); and the factors or conditions that were created during the transition and contributed to the progress achieved (*ex post*).

2.1. Existing conditions that facilitated progress towards EAF (ex ante)

Favourable policies, legislation and regulatory frameworks

It is clear that a transition towards EAF requires that policies and legal frameworks are sufficiently aligned with the general principles and objectives of the approach. There has been an increasing level of uptake of EAF as an overall fisheries management framework by national fisheries administrations and regional fisheries bodies (RFBs). According to FAO (2018), the percentage of countries adopting EAF or a similar approach increased globally from 69 percent in 2011 to 79 percent in 2015, and more than 40 percent of RFBs included in their convention text a specific reference to the ecosystem approach as a management principle. The Mediterranean is no exception to this trend. The approach is explicitly recognized and acknowledged in the GFCM Agreement, and it informs the Commission's scientific programmes and multi-annual management plans. At the European Union level, the EAF is recognized in the objectives and measures established by the Common Fisheries Policy and the regulatory frameworks, including Regulation (EC) 1967/2006. The existence of these regional and supranational management frameworks has for instance been key for efforts to harmonize management measures across jurisdictional borders when dealing with shared resources (e.g. dolphinfish (Laspina and Said, this volume); demersal fisheries in the Strait of Sicily (Jarboui, Ceriola and Fiorentino, this volume)), favouring the principle of spatial compatibility of management measures promoted by EAF. These case studies also highlight how the coupling of the regional management frameworks with regional mechanisms for scientific cooperation – promoted for instance by FAO Regional Projects (MedSudMed and CopeMed) – was instrumental to advance towards the harmonization of management measures and the adoption of sub-regional management plans. This topic is discussed in more detail below.

The case studies presented in this report also demonstrate how the approach is being adopted nationally in fisheries development plans (e.g. Turkey, Ünal *et al.*, this volume) and in the reform of fisheries laws (e.g. Lebanon, Nader *et al.*, this volume). More specifically, the case studies show how the implementation of some of the key principles of an EAF requires appropriate legal frameworks. For instance, central to the EAF is the development of a management plan as a guiding instrument for decision-making. Such instruments are not always recognized in fisheries' legal frameworks. The lack of legal recognition does not preclude the development of a plan, but a plan

will have only limited enforceability if it is not formally recognized. Many of the case studies demonstrate a situation where the development and approval of a multi-annual management plan is a precondition for the fishery to operate (e.g. Rodon *et al.*, this volume; Lucchetti *et al.*, this volume).

The same also applies to the principle of participatory management. EAF adheres to the principles of transparent and participatory decision-making: this requires, among other aspects, some level of devolution of responsibility to groups or organizations at local level. This is viewed as a way to improve compliance, improve cost-effectiveness of management, and facilitate the use and translation of traditional management practices into formal regulation. Effective participation and decentralization of management decisions cannot be effective without proper legal recognition. The case studies presented in this report showcase different mechanisms for formalizing the participation of stakeholders in decision-making. Lucchetti *et al.* (this volume), for instance, described how the first Italian clam management programme in the late 1990s delegated management responsibility directly to industries and operators through a co-management system centred on the Bivalve Molluscs Management Consortia. In Tunisia, the existing regulatory framework that gives rights and responsibilities to a private actor to use, monitor and manage the fisheries in the El Bibane Lagoon was a key factor that facilitated the development and implementation of a plan locally with the full involvement of local actors (Jarboui, Djabou and Bernardon, this volume). In the case of transparent gobid fisheries in the Balearic Islands, a co-management committee is regulated by a specific decree that establishes the committee compositions and decision-making process (Morales-Nin, Moragues and Grau, this volume). At the very beginning of the sandeel fishery co-management process in Catalonia, a committee was created on an ad hoc basis with an excessive number of representatives and without clear decision-making procedures. This led to some initial problems, with some interests external to the fishery questioning the legitimacy of decisions. The situation was resolved after a decree establishing and regulating a governance model based on co-management came into force (Rodon *et al.*, this volume). A similar path was observed in the case studies in Egypt and Tunisia, where an informal consultation mechanism established during the management planning process led to the establishment of a formal advisory/monitoring committee when the plan was adopted by the national management authority (Jarboui, Djabou and Bernardon, this volume; ElHaweet and Megahed, this volume). Such transition from informal to formal recognition of stakeholders' involvement has not yet materialized in the other FAO-supported case studies in the region. For instance, although a fisheries management plan based on EAF has been prepared by all stakeholders including governmental bodies for Gökova Bay (Ünal *et al.* this volume), the fisheries management authority has not yet created an advisory committee for fisheries management, or put any part of the plan into practice.

Regional mechanisms for scientific collaboration in support of transboundary fisheries management

Two case studies deal specifically with stocks that are shared among two or more countries. In the case of dolphinfish (Laspina and Said, this volume), the fishery in Malta targets a migratory stock that is exploited at different life stages by different fleets in the Western and Central Mediterranean. The bulk of the catches come from small-scale FAD fisheries targeting juvenile dolphinfish in Malta, the Balearic Islands (Spain), Sicily (Italy), Tunisia and Libya. Smaller amounts of adult dolphinfish are also caught as bycatch in longline fisheries and in recreational fisheries (Molto *et al.*, 2021; Laspina and Said, this volume). In order to deal with the transboundary aspects of the fishery, substantial effort has been made to enhance scientific understanding of the dolphinfish fishery and stock dynamics in the region under an international collaborative research programme supported by the FAO CopeMed and MedSudMed

projects. This collaborative effort paved the way for the establishment of common regulatory measures for the fishery under the umbrella of the GFCM (e.g. common regional closed season for the FAD fishery, Recommendation GFCM 30/2006/2; regulation of anchored FADs, Recommendation GFCM 43/2019/1) and more recently for the preliminary assessment of the stock in the Central and Western Mediterranean (GFCM Working Group on Stock Assessment, 18–23 January 2021). In the Strait of Sicily the offshore bottom trawling fleets of the bordering countries (Italy, Libya, Malta and Tunisia) exploit the same fishing grounds, targeting shared stocks of deep-water rose shrimp, hake and other accessory species (Jarboui, Ceriola and Fiorentino, this volume). Until 2015, when the first regional management recommendation was adopted at the GFCM level (Recommendation GFCM 39/2015/2), efforts to manage these fisheries were made separately by each country by means of technical measures and national and local management plans. A regional multiannual management plan was adopted in 2016 with the Recommendation GFCM/40/2016/4. Given the international nature of the management plan, it was necessary to establish a mechanism for sharing expertise, knowledge and data among all the countries concerned. The cooperative framework established by the FAO's MedSudMed project was instrumental in reaching this goal. The project created an environment for scientific cooperation which led to the preparation of joint assessments of the state of common stocks and scientific advice for fisheries management within the framework of the GFCM. The strong level of scientific cooperation also helped the organization of informal, multi-level discussions among fishers, scientists and managers from all the countries involved to develop a common view on the management of the shared resources in the Strait of Sicily.

Both examples show the importance of establishing mechanisms for regional scientific cooperation when dealing with transboundary fisheries management. The approach taken in the Mediterranean was based on the creation of fisheries management projects that worked separately from the fisheries management organization (i.e. the GFCM) but supported its objectives. The projects were implemented with the support of multiple donors during an extended period, starting in 1996 with the approval of the CopeMed project, and were executed by the FAO Fisheries Division. They were created based on certain key premises: (i) that sustainable fisheries in the Mediterranean could only be achieved through effective cooperation among national fisheries institutions; (ii) improved scientific and technical capacity were needed to advance towards the joint management of fisheries resources; and (iii) cooperation requires (at least initially while trust is developed) a neutral work environment that is separate from the management organization.

Since their inception, the projects have provided very important development support to regional fisheries management and research capacities. Moreover, they have helped countries to effectively improve their own domestic fisheries management and research, and also to efficiently engage with the GFCM for joint regional fisheries management. The projects have thus complemented the work of the regional fisheries management organization. This approach has guided operations until this point, although it is currently being reshaped following the decision of contracting parties and donors to strengthen the mandate of the GFCM on capacity development and technical assistance (2017 Malta MedFish4Ever Declaration). The recent change in standing of the GFCM on these issues is viewed as a positive outcome of the long-term investments in capacity development and cooperation achieved through the management support projects.

Favourable market conditions for precautionary management measures

Markets can play an important role in fostering sustainable fisheries. Defeo and Vasconcellos (2000) discussed how markets acted as an external driver affecting the management performance of important commercial fisheries in Latin America. The most prominent factor was the globalization of the fish trade. The increase in demand for fishery products from major international consumer markets – determined by decreases in supply caused by the overfishing of stocks in traditional fishing grounds and/or stricter catch quotas for stocks in process of recovery – associated with a sustained increase in consumer demand for fish products globally (OECD-FAO, 2020), have increased prices and triggered both positive and negative impacts on the fisheries. In a positive context, high prices and a favourable market led in some cases to carefully managed fisheries development and a drive for eco-certification to consolidate the positioning of the products internationally. In a negative context, variations in global supply/demand affected prices and the economic performance of fisheries, sometimes rendering management efforts ineffective. The authors also discussed how the unmet international demand for lucrative products, when coupled with weak local fisheries governance, can lead to overexploitation of resources (e.g. sea cucumber in the Galapagos Islands; Purcell *et al.*, 2013). On a domestic level, the authors documented the case of a small-scale yellow clam fishery in Uruguay where a change in the marketing strategy, shifting from a high volume/low price product used for bait to a low volume/high price product for human consumption, has favored the adoption of fisheries strategies to enable the recovery of the stock following climate-induced mass mortality events (Gianelli, Martínez and Defeo, 2015; Defeo *et al.*, 2021). The change in marketing strategy maximized economic benefits for the local community, even in a situation of reduced abundance.

Among the case studies examined in this report, there are at least four examples of favorable market effects on fisheries performance following the adoption of precautionary fisheries management systems. In the case of the sandeel fishery of Catalonia (Rodon *et al.*, this volume), catches are mostly used for human consumption, since the sandeel is a popular product locally. Stricter regulations and controls following the establishment of the co-management scheme led to a drastic reduction in effort and catch and an increase in profits for fishers. Several factors contributed to this outcome (Sainz-Trápaga *et al.*, 2015): (i) the elimination of the illegal market that existed prior to co-management, which saturated supply and meant far lower prices; (ii) the strict control of the amount of fish at the auction market through the implementation of an individual (vessel) daily quota; (iii) improved commercialization of the product; and (iv) the creation of a more valuable niche market. These factors enabled fishers to obtain decent profits even during years of very low catches (Rodon *et al.*, this volume).

The transparent goby fishery in the Balearic Islands is an example of a seasonal fishery for a resource that is considered a local delicacy and can command high market prices. One of the key features of the management system was the establishment of daily quotas, which were already self-imposed by fishers before the management plan. The daily quotas aimed to avoid reductions in prices due to oversupply in the market, and therefore to ensure the profitability of the fishery. The limitation of catches also served biological sustainability goals, which were later adopted with the fisheries management plan (Morales-Nin, Moragues and Grau, this volume).

Malta's dolphinfish fishery is also a case of a traditional resource that is considered a delicacy locally and in some other Mediterranean countries. As the fishing season coincides with the peak of the summer tourism season, the fish can fetch high prices. During good fishing seasons, market saturation is a source of concern as it affects the profitability of the fishery. The establishment of a precautionary maximum catch level was implemented to prevent overfishing, and also to try to avoid oversupply on the market to maintain stable prices (Laspina and Said, this volume).

The venus clam fishery in Italy is an example of a fishery inserted in a larger and more complex market system which acts as an important driver of fisheries performance (Lucchetti *et al.*, this volume). The product is sold mostly fresh, with about 30 percent to 40 percent of production sold in Italy and the remainder supplying foreign markets (e.g. Spain). The products also compete in the market with the Manila clams that are cultivated both in Italy and abroad and also harvested in the northern Adriatic Sea. The management system was designed to ensure a balance between the biological objective of avoiding the overexploitation of the resource and the economic objective of increasing the added value of the harvested clams by regulating catches according to market demands. A daily quota per vessel is established by the fisheries Consortia responsible for fisheries management decisions. The Consortia consider the market demand and collect just enough clams to maintain higher prices and avoid saturating the market. This close connection between the management organization and the market (through the producers' organization) is considered a key element for ensuring profitability and employment in the industry. The improvement in fishery and commercial management during the last 10 years has helped stabilize the situation (DGPEMAC, 2019). Additionally, it is worth noting that the clam fishery is one of the few examples of a Mediterranean fishery that has obtained an eco-certification (through the MSC) as a strategy to access preferential international markets for certified products with higher added value. The certification adds not only opportunities for increased economic returns but also creates further incentives for the implementation of EAF-compatible management systems (Pérez-Ramírez *et al.*, 2016).

All these cases demonstrate how a close linkage between the management system and the market helps to enable a transition to sustainable fisheries. In general, these systems managed to increase fishery profitability by lowering catches (and effort) and increasing the value of the catch. The lower fishing pressure in turn favours the sustainable exploitation of fish stocks. Three of the cases deal with localized markets for specialized products that were naturally less exposed to changes in supply and demand from international markets. The clam fishery, on the other hand, had a more complex market context and was more vulnerable to external factors affecting supply and prices. Even so, the close connection between the fishing industry, the management authorities and the markets, facilitated by the co-management governance model, made the fishery more resilient to these external drivers. In all cases, the positive interaction with markets was made possible due to well-founded management systems based on closed-access regimes and well-defined use rights (discussed in the next section).

Key social processes improving (or affecting) fisheries management

The case studies highlight the importance of some key social factors for the implementation of management schemes, such as a well-organized fisheries sector, plus committed leadership and a strong sense of stewardship from fishers. These social aspects have been considered essential for facilitating the implementation of participatory governance systems and co-management in small-scale and industrial fisheries alike (Gutiérrez, Hilborn and Defeo, 2011; Defeo and Vasconcellos, 2020). Examples of well-established and active fishers' organizations include the fishing cooperatives in the Balearic Islands (Morales-Nin, Moragues and Grau, this volume), Catalonia (Rodon *et al.*, this volume), Malta (Laspina and Said, this volume), Turkey (Ünal *et al.* this volume), and the Consortia in the clam fisheries in Italy (Lucchetti *et al.*, this volume). A strong sense of stewardship and fisher commitment is also evident when the organizations are provided with clear tenure rights and management responsibilities, such as in the sandeel fishery in Catalonia, the transparent goby fishery in the Balearic Islands, and the clam fisheries in Italy. In the sandeel fishery, for instance, many elements of the management system rely on the sector itself, such as the daily setting of quotas and the organization of the fishing work schedule, and the success of the system relies on a high level of compliance and commitment from fishers (Rodon *et al.*, this volume).

Inherent characteristics of the fishery systems, including size, diversity of practices and types of resources

There are different fishery characteristics that may favour the establishment of successful management systems. For instance, smaller fisheries (in terms of number of participants and geographical coverage) are usually easier to plan, manage and control than larger and geographically dispersed fisheries. In fact, most of the examples covered in this report concern fisheries of a relatively small size (see Table 1 in the Introduction). This condition (small size and low number of participants) tends to enhance social cohesion, communication, trust and shared vision among participants, which have been identified as key factors for the successful management of natural resources (Ostrom, 2009). The homogeneity of the fishery segment, in terms of fishing technologies and practices, was another recognized favourable condition in the case of the clam fishery in Italy (Lucchetti *et al.*, this volume). According to the authors, the homogeneity of the fishery facilitated the implementation of the management rules on a large scale and not only on a compartmental level within the area of resource distribution.

The type and diversity of the target resources have been also identified as important factors. In general terms, it is expected that specialized fisheries with a limited number of target species will be simpler to assess and monitor than multi-species fisheries. Likewise it is more difficult to manage a fishery where various types of fishing gears at different scales (e.g. gillnetters, longliners, trawlers, purse seiners, anglers) are in competition and conflict with each other in terms of fishing ground and target species. Moreover, as specialized fisheries supply specialized markets (e.g. sandeel in Catalonia, transparent gobids in the Balearic Islands), their exposure to variations in price will tend to be more manageable than fisheries with multiple target species which operate in more complex markets. Finally, the life cycle and mobility of fishery resources are key elements that can enable the successful implementation of management approaches. In particular, sessile, sedentary or mobility-impaired benthic resources tend to facilitate EAF implementation by enabling the development of management plans in well-defined ecological boundaries and a more precise definition of areas where fishing rights can be exercised (Gutiérrez, Hilborn and Defeo, 2011; Defeo and Castilla, 2012; Defeo and Vasconcellos, 2020). This factor is highlighted by Lucchetti *et al.* (this volume) for the case of the clam fishery in Italy. The sedentary character of the main target resource, which is distributed in specific areas easily identified in each maritime district, facilitated the management of the fishery through TURFs. Although the situation is slightly different in the case of Gökova Bay (Ünal *et al.*, this volume), the fact that the region is by law a special environmental protection area with clearly defined borders has facilitated the preparation of a fisheries management plan in accordance with the EAF.

Support (financial and technical) from external actors

The support of external organizations, in terms of both technical and financial assistance for capacity development, is discussed in some of the case studies, including the pilot studies supported by FAO Regional Projects (Jarboui, Djabou and Bernardon, this volume; El Haweet and Megahed, this volume; Nader *et al.*, this volume; Ünal *et al.*, this volume) and the co-management sites supported by WWF (Costantini, Niedermuller and Prato, this volume). In the clam fishery in Italy, financing from the European Maritime Fisheries Fund (EMFF) facilitated the search for technical innovations to improve the fishery selectivity (Lucchetti *et al.*, this volume). The availability of such external sources of support can be an important enabling factor for increasing awareness and capacity with alternative management approaches and measures. However, it is important to note the factors that make access to these resources possible. For example, in the case of Gökova Bay, access to these resources was possible thanks to the skills, experience and knowledge of AKD, an NGO which has been carrying out international

projects in the region since 2012 (Ünal *et al.*, this volume). The experience with the pilot EAF study in El Bibane, Tunisia (Jarboui, Djabou and Bernardon, this volume) also shows how the continuous support of an external actor over multiple years was important to complete the process of management planning, improve the information available for management decisions, and consolidate the participatory mechanisms for monitoring the implementation of the adopted management plan. This example highlights the need to consider the appropriate time scale for international assistance on EAF capacity development.

2.1 Factors contributing to the progress achieved (ex post)

In the previous section, we discussed a set of conditions that favoured the changes in the fisheries management system towards precautionary, participatory and more holistic management systems – i.e. in line with the EAF principles. However, beyond the existing enabling conditions, and during the implementation process, there were also a set of factors that were identified as key elements for achieving progress with the different initiatives.

Closed access and well-defined fishing rights

The establishment of appropriate rights regimes and regulatory frameworks for controlling access and defining use rights are widely recognized as essential for the management of common property resources such as fisheries (Ostrom, 1990; Berkes *et al.*, 2001; FAO, 2003; Ostrom, 2009; FAO, 2012). The exact nature of the property-rights regimes and use rights will depend on the local context, institutions, culture and traditions, varying from individual to community; and also in terms of form, such as access to catch shares, territories, fishing time etc. In the majority of the examples covered in this publication, the fisheries were under a closed access regime where the number of participants was controlled by a limited number of fishing licences. In El Bibane Lagoon, Tunisia, a concession arrangement is applied in which the State delegates to a private sector actor the right to exploit the fisheries resources in the lagoon using the traditional *bordigue* system (Jarboui, Djabou and Bernardon, this volume). Leasing the use of coastal lagoons to local fisher groups, cooperatives or private companies is not uncommon in the Mediterranean (Cataudella, Crosetti and Massa, 2015). The lack of effective mechanisms for limiting access was on the other hand recognized as a high-priority issue to address in the process of management planning for small-scale fisheries in Lebanon (Nader *et al.*, this volume) and Turkey (Ünal *et al.*, this volume). In Turkey, for instance, the existing national system for limiting access fixed the number of licences at national level (there were even five vessel buyback programmes to reduce the fishing fleet) but it did not specify the licence holders' boundaries of operation, creating a situation where vessels from the Black Sea can also fish on the Aegean and the Mediterranean coasts of the country. The fact that Gökova Bay is under a special management regime for biodiversity conservation – it is a Special Environmental Protection Area by law, and its marine portion is considered an MPA – favoured the development of an EAF-based fisheries management plan for the area. However, fishing in the area is open to any licence holder.

The form of the access rights also varies. In the dolphinfish fishery in Malta, the system of access rights adopted in the legislation formalized a traditional lottery system that gives individual licence holders the exclusive right to deploy and moor their FADs within a specific area off the coast (Laspina and Said, this volume). In the management plan for bivalve molluscs in Italy, vessels are given exclusive territorial rights similar to a TURF to exploit the stocks of clam (Lucchetti et al., this volume). Daily catch limits per vessel are used in the cases of the sandeel fishery in Catalonia (as well as a closed census fixed at 26 fishing units in the fishery) and the transparent goby in the Balearic Islands, Spain (Rodon *et al.*, this volume; Morales-Nin, Moragues and Grau,

this volume). The authors discuss the advantages of managing fisheries based on closed access and well-defined tenure systems, including the creation of individual incentives to conserve resources, the facilitation of the control of illegal fisheries, and also the improvement of the economic performance of individual fishing units, adding value to their catches in the market.

Intense dissemination and outreach

The efforts made to promote and implement changes in the management systems were usually accompanied by actions to increase visibility and recognition of the developing plans. Several of the examples addressed in this report describe bottom-up processes of reorganization of the fisheries management with the participation of a wide range of stakeholders. The wide dissemination of these participatory processes, both nationally and regionally within the framework of regional fisheries bodies and international symposia, was important to give visibility to the achievements and to enhance recognition and acceptance of the new management approach. It is worth noting that two of the case studies (the sandeel fishery in Catalonia and small-scale fisheries in Turkey's Gökova Bay) were recognized as examples of best practices for co-management of small-scale fisheries by the GFCM and the European Union MedFish4Ever strategy. Costantini, Niedermuller and Prato (this volume) also note the value of promoting the participation of fishers in peer-to-peer exchanges in national and international events and public consultations where management measures for small-scale fisheries are under discussion. In at least four case studies, we found that the dissemination of the local experiences prompted the interest of authorities and fishing communities in other areas to replicate the experiences. For instance, in Spain, the co-management systems established for the sandeel fishery and the transparent gobies were precursors for other similar processes in their respective regions, and paved the way to mainstream co-management as an accepted approach to fisheries management. In Tunisia and Turkey, the dissemination of the positive experience with the EAF pilot studies prompted the interest of neighbouring communities to follow a similar path. Although Turkey has not yet succeeded in implementing the management plan prepared in Gökova, it continues its efforts in this regard while launching a second initiative to develop an EAF-based management plan for Gökçeada, the largest island in the country. An article about the Gökova Bay and Gökçeada EAF experiences, challenges and progress was published in the June 2021 issue of the fisher magazine (https://www.sur.coop/surkoophaber.aspx) owned by the Central Union of Fishery Cooperatives (SÜR-KOOP), which represents almost 20 000 fishers. The magazine reaches all fisheries stakeholders in Turkey, and by presenting these two EAF cases to its wide readership including fishing communities, decision-makers, NGOs and academics, it will undoubtedly raise further awareness of the EAF.

Another point to highlight is the importance of internal communication to disseminate information about the management plan and to keep fishers and other stakeholders aware of the decisions being taken. Different strategies are described in the case studies. In Egypt, for instance, circular letters and brochures were used to promote fishers' compliance with the norms established in the management plan (El Haweet and Megahed, this volume). In Tunisia, similarly, the creation and the ratification of a fishing "charter" between fishers and the concessionaire, defining the good practices to be respected, was used as a tool to disseminate information about the norms in place and to stimulate compliance (Jarboui *et al.*, this volume). Promoting the participation of fishers, and not only representatives, in technical and advisory committee meetings of the co-managed fisheries is another strategy that has been shown to enhance internal communication and reinforce transparency and trust in the system by all actors (Rodon *et al.*, this volume; Jarboui, Djabou and Bernardon, this volume).

Mechanisms implemented to favour adaptive management

Fisheries management must deal with many different types of uncertainties related to the dynamics of the resources, ecosystem, fishing activities, markets etc. Practices commonly evoked for coping with uncertainties involve the adoption of precautionary measures and the implementation of adaptive fisheries management. These practices are an integral part of an ecosystem approach to fisheries (FAO, 2003). Adaptive management is an approach that takes the view that resource management policies can be treated as "experiments", whether actively or passively, from which managers can learn and then adapt or change (Walter, 1996; FAO, 2009; Nielsen *et al.* 2018). It is a structured and iterative process which aims at optimizing decision-making and decreasing uncertainty over time by a feedback process of "learning by doing" that allows the continuous revision of policies and management actions. To make the process effective, it is essential that a robust system of monitoring and feedback is in place to guide management decisions (Nielsen *et al.* 2015). Moreover, it is important that the decision-making system can respond rapidly to changes in conditions. The case studies show different practical examples of mechanisms that were put in place to ensure the effective implementation of adaptive management. Rodon *et al.* (this volume) describe for instance how the flow of information from the scientific monitoring and the high frequency of meetings of the co-management committee (once a month), associated to a flexible (not too prescriptive) management plan, were crucial to allow for the adjustment of measures according to the assessed level of compliance. The process of regular review of management measures based on the results of resource monitoring is also employed in other fisheries examined in this report (Morales-Nin, Moragues and Grau, this volume; Laspina and Said, this volume; Lucchetti *et al.*, this volume; Jarboui, Ceriola and Fiorentino, this volume). Management adaptation is guided by a co-management committee or by technical/advisory committees based on agreed harvest control rules (see below). In Tunisia, the management plan includes the establishment of a technical advisory committee that meets at least twice a year to discuss the results of programmed scientific activities and to plan for new actions identified by the stakeholders (Jarboui, Djabou and Bernardon, this volume). This system currently provides a forum for stakeholders to monitor progress with the implementation of the measures agreed in the management plan, and will function as an advisory body for management authorities to review management measures based on the results of the ongoing scientific monitoring.

Mechanisms implemented to reinforce compliance

Lack of compliance with management norms is widely recognized as one of the main impediments for sustainable fisheries worldwide. Fishers' motivation to comply with regulations has been shown to depend on different factors, including economic and demographic conditions, level of awareness, social norms and controls, sanction certainty and severity, among others (Karper and Lopes, 2014; Cepićand Nunan, 2017; Saputra, 2020; Al-Qartoubi and Al-Masroori, 2021). The issue is acknowledged as a problem affecting to some extent all case studies examined in this report (see also section on Challenges). Although the reasons and measures to address non-compliance were not investigated in depth in the papers, reference is made to different strategies being used to ameliorate this problem. One of the expected benefits of a participatory approach to management is that norms established in consultation and agreement with the sector are more likely to be followed. This aspect is highlighted in the Italian clam case study (Lucchetti *et al.*, this volume), where the participation of operators in the designing of rules was a recognized factor in favour of more effective compliance. Rodon *et al.* (this volume) also indicate the reduction of infractions following the adoption of the co-management regime in the sandeel fishery in Catalonia. Strategies based on raising fisher awareness of the norms and promoting the adoption of a commitment to good practices by fishers are described in the case studies in Egypt (ElHaweet and

Megahed, this volume) and Tunisia (Jarboui, Djabou and Bernardon, this volume) respectively. However, solely relying on positive perceptions and attitudes towards regulations is recognized as insufficient to make fishers abide by regulations. More stringent controls and sanctions were also applied to ensure improved compliance. For instance, in the sandeel fishery in Catalonia, a reinforcement of the sanctioning power of the co-management committee has been implemented to curb infractions, allowing the technical committee to confront fishers engaged in illegal practices and propose and impose disciplinary measures (Rodon *et al.*, this volume). In the Strait of Sicily, international joint inspections and surveillance schemes in areas beyond national jurisdiction have been employed under the umbrella of the GFCM to combat illegal fishing practices (Jarboui, Ceriola and Fiorentino, this volume). The effectiveness of this initiative is, however, unknown.

Integrated scope of management plans and strategies accounting for biological and socioeconomic considerations

One of the central elements of an ecosystem approach to fisheries, as promoted by FAO, is the integration of the multiple dimensions of sustainability (ecological, socioeconomic and institutional) in the process of management planning and implementation. This approach, pursued in the case studies in Turkey (Ünal *et al.*, this volume), Egypt (ElHaweet and Megahed, this volume), Tunisia (Jarboui, Djabou and Bernardon, this volume) and Lebanon (Nader *et al.*, this volume), resulted in the identification of management actions that concern not only the biological sustainability of stocks and the conservation of ecosystems but also the sustained and improved socioeconomic conditions of fishers and affected communities. Issues such as the poor valorization of fish products, the lack of alternative livelihoods, the vulnerability of the fishing communities and weak social protection mechanisms appear side by side with the overexploitation of fisheries resources as major impediments for sustainable fisheries. In the small-scale fisheries in Gökova Bay, Turkey, incomes for local fishers have increased. The increase in income results not only from catching more fish, but also from supporting the marketing system of Lessepsian fish species, from stricter enforcement which has led to both a reduction in illegal fishing and a decrease in the average number of fishing boats, and an increase in fish stocks (Ünal and Kızılkaya, 2019; Ünal *et al.*, this volume). These pilot case studies thus reinforce the principle that to be successful, fisheries management needs to tackle these different dimensions of sustainability in an integrated way. This integration of biological and socioeconomic considerations is highlighted as key to advances made in other case studies presented in this report. For instance, in Catalonia, the adopted governance model ensures that management plans develop specific socioeconomic programmes consistent with biological and ecological conservation requirements (Rodon *et al.*, this volume). In the specific case of the sandeel fishery, stringent regulations under the co-management scheme and an efficient bio-economic approach focused on improving commercialization and strictly controlling supply ("fishing for euros, not fish"; Rodon *et al.*, this volume), resulted in increasing demand and price while reducing the pressure on the stock. In other case studies (e.g. dolphinfish (Laspina and Said, this volume); venus clam (Lucchetti *et al.*, this volume), transparent gobid (Morales-Nin, Moragues and Grau, this volume)) the consideration of economic returns was central to the development of the management plans and to the decision-making process regarding annual catch quotas. Social and traditional aspects are also taken into consideration in the Maltese dolphinfish fishery, in view of the numerous fishers and the years of tradition involved in this fishery. In some of the cases, the implementation of the management plan is guided by harvest control rules based on biological and economic considerations. For instance, in the Italian clam fishery (Lucchetti *et al.*, this volume), the scientific bodies have defined average values for the density of clams, both as a threshold value below which fishing

is not to be permitted and as an optimal value to be pursued to obtain optimal fishing revenue. In the gobid fishery in the Balearic Islands (Morales-Nin, Moragues and Grau, this volume) a multistakeholder commission monitors the monthly CPUE data during the season against agreed minimum thresholds established based on historical data and with the objective of maintaining the sustainability of the fishery while preserving economic returns. In the sandeel fishery in Catalonia, harvest control rules based on empirical indicators (catches and CPUE) define the number of fishing days and quotas with the objective of keeping prices high and maximizing spawning success. These case studies demonstrate that the concept of maximizing economic yield is not at odds with resource conservation when strategies are put in place and market conditions are favourable for shifting the focus from quantity (high volume of catches and lower price) to quality (low volume and higher price).

Enhanced scientific monitoring as a pillar of the management plan

Several of the case studies covered in the report describe how the implementation of management plans and measures relied on the results of tailored scientific monitoring programmes. In some instances, the monitoring was carried out in close collaboration with the fishing industry. For instance, in the clam fishery in Italy (Lucchetti *et al.*, this volume), monitoring of the resource is carried out autonomously by each Consortium with the support of a scientific body, which provides the information needed to assess the spatial distribution and the abundance of the commercial and the undersized portions of the stock. The results of this monitoring inform decisions on seeding, rotation and restocking activities. Rodon *et al.* (this volume) describe how, during the first few years of co-management of the Catalonian sand-eel fishery, the cost of scientific monitoring and assessment was covered by fishers from the benefits generated by the fishery. Nowadays, as the co-management model has become common, it has been necessary to create a new scientific body – the Catalan Research Institute for the Governance of the Sea (ICATMAR) – to develop the sort of detailed and fine-scale scientific assessment and monitoring required. In Gökova Bay, a fishery cooperative (Akyaka) and an NGO (AKD) in collaboration with academics have been carrying out joint projects and collecting regular and detailed fisheries data over a number of years to support the monitoring of changes in the ecosystem (Ünal and Kızılkaya, 2019; Ünal *et al.*, this volume). On a wider scale, the case studies on dolphinfish fisheries (Laspina and Said, this volume) and demersal fisheries in the Strait of Sicily (Jarboui, Ceriola and Fiorentino, this volume) highlight the importance of collaboration at the regional level over the scientific monitoring and assessment of transboundary resources managed under a common framework.

The enhancement of scientific knowledge is also explicitly recognized as one the fundamental pillars of management plans developed for data-limited areas. For instance, in El Bibane Lagoon (Jarboui, Djabou and Bernardon, this volume) a series of scientific research activities have been launched since the adoption of the management plan, aiming to improve information on the status of fishery resources and to understand the links between the lagoon and adjacent ecosystems. This information will help inform future adjustments in management measures. These examples reinforce previous findings regarding the key role of information and data in successful fisheries management (Gutierrez *et al.*, 2011; 2017; Melnychuk *et al.*, 2017; Defeo and Vasconcellos, 2020).

Consideration of fishers' local knowledge

It can also be very important to include fishers' local knowledge in management planning. At least five case studies describe how fishers' knowledge complemented scientific knowledge in the development of management plans and measures. Jarboui, Djabou and Bernardon (this volume) describe the assessment of the baseline situation in El Bibane Lagoon, and note that local fishers made a particular contribution to the

understanding of the traditional management system historically used in the lagoon fisheries. Because the fishers were not always available to participate in meetings, where knowledge sharing normally occurs, the authors highlight the importance of reaching out to fishers through surveys and field visits during the development of management plans. In Malta, the integration of scientific data and local ecological knowledge on the migration and availability of dolphinfish in relation to environmental change was seen as crucial to the preparation of the management plan (Laspina and Said, this volume). Costantini, Niedermuller and Prato (this volume) remark how effective stakeholder engagement can be key to enhancing understanding of the state of resources when no formal stock assessment is available, and illuminating socioeconomic features of a fishery such as employment, profitability, value chain, demographic trends and working conditions. Jarboui, Ceriola and Fiorentino (this volume) report the contribution of fishers in identifying the spawning and nursery areas of the main commercial species targeted by trawlers in the Strait of Sicily. In the case of Gökova Bay, the local knowledge of fishers and scientific study data were brought together in the process of defining no-fishing zones, whose contribution to the environmental and economic sustainability of fisheries has been acknowledged by all stakeholders. The overlap of the areas for protection recommended by the fishers with the important ecological areas identified by the scientists in the biodiversity report (e.g. the areas of *Posidonia oceanica*, nursery grounds, spawning areas) facilitated the planning process. In the sandeel fishery in Catalonia, collaboration between fishers and scientists on the co-management committee proved crucial for developing monitoring and assessment schemes to remedy a situation of severe data poverty (Rodon *et al.*, this volume). Lastly, it should be noted that development of the EAF management plans in Turkey, Lebanon, Egypt and Tunisia were largely based on the integration of knowledge from fishers and scientists (Ünal *et al.*, this volume; Nader *et al.*, this volume; ElHaweet and Megahed, this volume; Jarboui, Djabou and Bernardon, this volume).

Other factors that facilitated the development and adoption of management plans

Two additional factors were identified as key for successful outcomes:

- The presence of a local actor, independent of management authorities, to champion and facilitate the management planning process and the co-management operations. Success comes easier when this actor is a good leader, connects stakeholders, and devotes their time to improving fisheries management. In the case studies in this volume, we highlight the role of universities, academic institutions and NGOs (e.g. Ünal *et al.*, this volume; ElHaweet and Megahed, this volume; Nader *et al.*, this volume), research institutes (e.g. Jarboui, Djabou and Bernardon, this volume) and NGOs (e.g. Costantini, Niedermuller and Prato, this volume; Ünal *et al.*, this volume).
- The participation and endorsement of a management authority from the start. In line with the definition of co-management as a process of sharing responsibilities between government and users in the management of natural resources, it is imperative that management authorities endorse and participate in the process of management planning from the start. The lack of proper engagement with management authorities can be a major impediment for effective adoption and implementation of management plans. Jarboui, Djabou and Bernardon (this volume) note, for instance, how the adoption of the management plan for El Bibane Lagoon was preceded by unofficial preparatory work with managers to keep information flowing with the management authority. Since 2018 fisheries in Catalonia have benefited from a clear legal regulatory framework that devolves effective powers to co-management committees, all of which include representatives from the fisheries administration on a par with the other stakeholder representatives (Rodon *et al.*, this volume). Costantini,

Niedermuller and Prato (this volume) note how the involvement of administrators and policymakers at all levels has been crucial to facilitate the approval of local co-management arrangements. However, the participation of management authorities in bottom-up management planning processes does not guarantee that plans will be adopted and implemented, as other factors may block the continuation of the process (see section below on challenges).

3. CHALLENGES TO THE IMPLEMENTATION OF EAF

The case studies presented in this report highlight a set of factors that represent challenges to the implementation of EAF-like management systems. These factors are here grouped into external factors (factors operating at scales that are beyond the boundaries of the system and/or represent processes that are outside the scope of the fisheries management authorities) and internal factors.

External factors

Vulnerability to environmental changes

Several of the case studies report the susceptibility of fisheries to environmental changes affecting recruitment, productivity, species composition and water quality. These external drivers can have a profound impact on the fisheries and on the performance of the management systems. The fisheries for short-lived species are more susceptible to fluctuations in recruitment. Both the sandeel and transparent gobid fisheries case studies describe instances when the fishery had to be closed to safeguard the stock in periods of low recruitment (Rodon *et al.*, this volume; Morales-Nin, Moragues and Grau, this volume). In the clam fishery, changes in water quality associated with intense rainfall, river runoff and pollution can cause mass mortalities and lead to temporal interruptions of fishing activities (Lucchetti *et al.*, this volume). In the fishery for dolphinfish, both recruitment fluctuations and the (suspected) increased predation of tunas have been associated to changes in productivity (Laspina and Said, this volume). Changes in species compositions are also reported in two case studies. Morales-Nin, Moragues and Grau (this volume) describe environmentally driven changes in the catch composition of the transparent gobid fisheries in recent years, with an increase in *P. ferreri* (lower-value species) and a decrease in catches and geographical range of *A. minuta*. Ünal *et al.* (this volume) report how the invasion and spread of the silver-cheeked toadfish, *Lagocephalus sceleratus,* has been associated with the demise of the prawn fishery that was once the backbone of the Gökova Bay fishing economy. The arrival and expansion of this species has also driven a reduction in catch quality and has caused damage to fishing gears. In some instances, consideration of these external drivers early in the management planning process triggered the adoption of precautionary and adaptative measures to alleviate the impact on stocks (e.g. Laspina and Said, this volume; Morales-Nin, Moragues and Grau, this volume; Rodon *et al.*, this volume). Nonetheless, these processes still pose important challenges for management authorities and the fishing industry, which are exposed to additional sources of vulnerability.

Unbalanced regulation and control of competing sectors

Another recurrent problem affecting established management systems is the poor regulation and control of sectors that compete for the same fishery resources. Two types of issues are reported in this regard. The first relates to uneven regulation, monitoring and control among countries sharing the same resources. This issue is noted in the case studies of dolphinfish (Laspina and Said, this volume) and the demersal fisheries in the Strait of Sicily (Jarboui, Ceriola and Fiorentino, this volume). In the case of dolphinfish, weak regulations and controls applied in the different countries sharing the dolphinfish stock threaten the effectiveness of nationally adopted management plans.

In the Strait of Sicily, the frequent presence of unauthorized fishing vessels in areas beyond national jurisdictions threatens the effective implementation of the regionally adopted management plan. The other recurrent issue is competition between small-scale and recreational fisheries, which tend to be poorly regulated and monitored across the Mediterranean. Conflicts between these two sectors are reported in the case studies on dolphinfish (Laspina and Said, this volume), demersal fisheries in Egypt (ElHaweet and Megahed, this volume), small-scale fisheries in Gökova Bay (Ünal *et al.*, this volume), and El Bibane Lagoon (Jarboui, Djabou and Bernardon, this volume). Ulman and Ünal (2020) identified a number of different sources of conflict between small-scale and recreational fisheries sectors in the Mediterranean, including conflicts over resources (e.g. targeting the same species), conflicts over space (e.g. unclear or unregulated access or tenure rights to fishing grounds), and competition stemming from regulatory imbalances (e.g. perceived higher regulatory pressure or monitoring requirements in one sector compared to the other). The authors concluded that considering the two sectors within an ecosystem approach to fisheries management can facilitate conflict resolution and promote opportunities for transitioning to new revenue-generating employment opportunities (e.g. pescatourism) while also reducing pressure on the resources (FAO, 2020).

Consumer behaviour

As discussed in the previous section, markets can play an important role in facilitating or blocking the transition to sustainable fisheries. In this section we highlight the fact that consumer behaviour can create preferential markets for products that are not in line with sustainable use practices. This effect is described in at least two case studies. ElHaweet and Megahed (this volume) note that the high marketability of small fish encourages the targeting of the immature portion of the stocks by Egyptian demersal fisheries. A similar situation is found in the small-scale purse seine fishery in Lebanon, where traditional fishing practices with lampara lights in nursery areas and the preferential market for small clupeids put pressure on the juvenile portions of small pelagic stocks (Bariche, Alwan and EL-Fadel, 2006; Nader *et al.*, this volume). The traditional taste for small-sized fish, however, has been beneficial to the co-managed sandeel fishery in Catalonia as the species has become a prized alternative to juvenile small pelagic fish, whose capture is banned (Rodon *et al.*, this volume).

Unfavourable governance environment

Fisheries governance refers to the processes that determine the agreements on who fishes, what, when and how, as well as the organizations and partner institutions that implement these agreements. Fisheries governance can be affected by institutional processes that transcend the fishing system itself, which thus represent an external force of key importance (Defeo and Vasconcellos, 2020). Ünal *et al.* (this volume) discuss, for instance, processes that are hindering the improvement of governance systems for small-scale fisheries in Turkey, including the unwillingness of government authorities to decentralize decision-making, the lack of coordination among institutions with authority over the area (discussed also below), and the slow process of legal formalization of norms and plans. These factors are compounded by the relatively low priority of the small-scale fisheries sector compared to other productive sectors in the country. Nader *et al.* (this volume) refer to the chronic political delay in endorsing and activating plans and strategies as an important challenge for implementing the management plan for Lebanon's purse seine fisheries.

Weak coordination and communication among institutions and stakeholders

The transition to an ecosystem approach to fisheries broadens the spectrum of institutions and stakeholders that need to be engaged in the fisheries management

process. Establishing adequate coordination and communication among these different players is often a challenge for fisheries management authorities. Some of the case studies present examples of the complexities involved in this regard. Ünal *et al.* (this volume) note for instance how the priorities identified in the management plan for the small-scale fisheries in Gökova Bay require a level of coordination among institutions dealing with environment, fisheries and transport issues that is still lacking in the area. In Egypt's demersal fisheries, poor communication and engagement with institutions dealing with other sectors (e.g. tourism and oil exploration) which may threaten the environmental conditions of coastal and marine areas is a recognized challenge to the management plan (ElHaweet and Megahed, this volume). In the case of Italy's clam fisheries, periodic beach replenishments and other coastal engineering activities carried out without proper consultation/coordination with fisheries management authorities results in a constant reduction of areas of the Northern Adriatic Sea traditionally used as fishing grounds, and the modification of the sediments (Lucchetti *et al.*, this volume). Cardinale *et al.* (2021) also discuss how the lack of coordination among regional fisheries scientific bodies in the Mediterranean (GFCM-SAC and EU-STECF) can lead to duplication of advice on stock status and confuse the fisheries management process.

Internal factors

Problems with fisher representation in participatory management

The issue of weak fisher representation in participatory fisheries management has been long discussed in the common property resources and co-management literatures (Pomeroy and Berkes, 1997; Ostrom *et al.*, 1999; Jentoft, 2000) and can represent a real challenge for an ecosystem approach. The effective representation of fishers' interests in co-management usually requires that fisher communities have member organizations to represent their interests in management meetings and committees (the issue of community organization is also discussed as an enabling condition). In some cases, effective fishing cooperatives and associations already exist. However, such capacity should not be taken for granted, as in many cases cooperatives and associations were established to deal with other objectives such as improving marketing, access to social security systems, union and labour issues etc., and these may not be able to engage in resource-management discussions without some form of institutional development (Pomeroy and Rivera-Guieb, 2006). The issue is reflected in the challenges discussed in three case studies. In the demersal fisheries in Egypt, ElHaweet and Megahed (this volume) mention the limited power and influence of fisher associations over individual fishers' practices as a limiting factor for the implementation of agreed management measures. In the transparent gobid fisheries, the authors describe how fishers feel poorly represented in the co-management committee, foregrounding the need for enhanced communication between stakeholders and their representatives (Morales-Nin, Moragues and Grau, this volume). On the other hand, the case study on the demersal fisheries in the Strait of Sicily (Jarboui, Ceriola and Fiorentino, this volume) highlights the importance of establishing a clear and permanent mechanism for consultation with the fishing industry and other stakeholders for the regular review of management plans and measures adopted regionally for shared resources. Such a mechanism would improve the current ad-hoc initiatives established through the FAO regional projects to facilitate the conversation among stakeholders from the different countries.

Poor compliance

Compliance is a common challenge identified across the case studies. It is an issue directly related to the limited capacity for monitoring, control and surveillance, which creates opportunities for illegal fishing activities (e.g. Jarboui, Djabou and Bernardon, this volume; Ünal *et al.*, this volume; ElHaweet and Megahed, this volume; Jarboui, Ceriola and Fiorentino, this volume). The case studies report on the different strategies implemented to address the problem, such as sharing management responsibilities through participatory decision-making, raising fisher awareness, and increasing controls and sanctions (see previous section). However, a more in-depth analysis is needed on the motivations behind non-compliance, as well alternative ways of addressing it, especially in fisheries with limited human and financial resources.

Knowledge gaps

As discussed in the previous section, the success of fisheries management initiatives also depends on information from scientific programmes and local knowledge. Several of the case studies show the challenges caused by a lack of knowledge of different aspects of the managed fishery system. In the purse seine fishery in Lebanon, the lack of reliable information on the status of the main target stock is considered an important limiting factor for supporting decisions by management authorities (Nader *et al.*, this volume). Jarboui, Djabou and Bernardon (this volume) highlight some basic uncertainties that preclude further progress in management decisions in El Bibane Lagoon, including knowledge on the migration patterns of key target species and the linkages between fisheries outside and inside the lagoon. Lucchetti *et al.* (this volume) note the importance of improving the collection of fishery-dependent and fishery-independent data in order to assess trends in the exploitation rate of the target resource as well as to monitor the benthic impacts of fishing activities on different temporal and spatial scales. The lack of an assessment of the social and economic consequences of the adopted management measures is recognized as a main limitation for improving the regional management plan for the demersal fisheries in the Strait of Sicily (Jarboui, Ceriola and Fiorentino, this volume). In order to close data gaps, ElHaweet and Megahed (this volume) discuss the importance of linking the scientific programmes of research institutes with the data gaps identified in management plans. In this regard, the authors note that the current low interest in the subject shown by universities and research centres is a challenge for the management of demersal fisheries in Egypt.

Availability of human and financial resources

The lack of sustainable sources of funding to implement a management plan is a critical challenge confronted by several case studies, particularly in developing countries. In specific terms, the required improvements in monitoring, control and surveillance, investment in research to address critical knowledge gaps, improvements in the value chain, in social services etc. can have heavy financial implications that are not easy to overcome. The case studies show examples where international organizations, NGOs and the fishing industry have had a role in sustaining some of the objectives of the management plans for some time (e.g. Jarboui, Djabou and Bernanrdon, this volume; Ünal *et al.*, this volume; Rodon *et al.*, this volume), but these are no substitute for a long-term strategy for self-sustained fisheries management plans. In general, the costs of providing fisheries management services are mostly met by governments. In OECD countries, for instance, the cost of the management service relative to the landed value of the catch was on average 17 percent in 1999 (OECD, 2003). However, there was significant variation around this average for individual countries, which ranged from 1 percent to 70 percent. Furthermore, some countries were unable to provide data on the costs of every component of fisheries management.

Conversely, Hilborn *et al.* (2020) have clearly shown that where fisheries are intensively managed the stock status and trends are better than where the management is less intense. In order to improve the efficacy and cost-effectiveness of fisheries management, some countries have introduced cost-recovery programmes where a proportion of the costs are recovered from the fishing industry and the remainder are covered by the government (e.g. New Zealand, Harte, 2007). The costs can be affected by different factors, including fisheries' size and complexity and also by the type of management measures and the institutional arrangements involved – that is, how decisions are made, how monitoring and enforcement take place etc. It is expected that higher user participation in these fisheries management components will lower the cost of management. If, for instance, user participation translates into higher compliance rates, then less resources will be needed for enforcement and control, which is one of the costliest components of fisheries management. The same principle applies for fisheries research and monitoring, which can be more cost-effective in collaborative management arrangements where stakeholders such as the fishing industry, research agencies, universities and NGOs take part in the collection of information needed to assess the status of stocks and the provision of management advice (e.g. Rodon *et al.*, this volume). However, the increase in complexity of the management system under an EAF will increase the need for various types of information that will be challenging to obtain without additional financial support.

Socioeconomic risks

The transition from a state of weak fisheries management to a state of sustainable fisheries is more challenging when fishers are faced with precarious social and economic conditions. Under these conditions, proposed changes in fishing practices to improve stock status can increase the risk of reduced catches, incomes and jobs to levels that are unacceptable to the fishers. This perception of increased risk can create resistance to management measures. This issue, highlighted in the case study of demersal fisheries in Egypt (ElHaweet and Megahed, this volume), is expected to be particularly significant in other developing countries. In addition, after the designation of no-fishing zones in Gökova Bay in Turkey, the fishers reacted unfavourably because of weak enforcement and surveillance as well as a loss of fishing income. This continued until the establishment of a community-based marine ranger system (Ünal *et al.*, this volume). EAF-based management plans are founded on the consideration of human and ecological wellbeing goals, which need to be pursued together if this type of challenge is to be overcome.

Extended timescales for results and proof of feasibility

The period of time between the development of a management plan and observation of its results can be lengthy, and this can be discouraging for stakeholders. The recovery of stocks and catches can take several years, and the improvement in revenues expected with improved management cannot be instantaneous. The case studies of sandeel fisheries in Catalonia (Rodon *et al.*, this volume), transparent gobid in the Balearic Islands (Morales-Nin, Moragues and Grau, this volume) and clam fisheries in Italy (Luchetti *et al.*, ref.) describe for instance the results of the implementation of new fisheries management arrangements over a period of more than 10 years. On the other hand, the case studies from El Bibane Lagoon (Jarboui, Djabou and Bernardon, this volume) and the demersal fisheries in Egypt (ElHaweet and Megahed, this volume) represent fisheries that are in the early phases of management plan implementation, and are still defining management strategies and addressing priorities such as improved enforcement. In the Strait of Sicily, the management measures taken since the adoption

of the management plan in 2015 have not yet been able to remedy the high levels of overfishing of the target species (Jarboui, Ceriola and Fiorentino, this volume). The case studies from Gökova Bay (Ünal *et al.* this volume) and Lebanon (Nader *et al.*, this volume) demonstrate situations where management plans have still not been adopted or implemented, despite it being many years since their development with the active participation of stakeholders. Such slow progress can fuel discontent with management institutions, and add additional challenges for any future initiatives to engage stakeholders in participatory management.

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The ecosystem approach to fisheries (EAF) has been promoted as an appropriate and holistic approach for the sustainable development and management of fisheries, in accordance with the FAO Code of Conduct for Responsible Fisheries. With a view to contribute to the identification of lessons and good practices for the implementation of the approach, this publication looks at 10 case study fisheries in the Mediterranean Sea that attempted to develop EAF-compatible management systems. The comparative analysis of the case studies identifies lessons concerning the trigger factors that contributed to the changes in local management systems, the enabling conditions that favoured the changes, and the main obstacles and challenges for strengthening EAF implementation in the region.

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