



The Saga of the Management of Fisheries in the Adriatic Sea: History, Flaws, Difficulties, and Successes toward the Application of the Common Fisheries Policy in the Mediterranean

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OPEN ACCESS

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Specialty section:

This article was submitted to
Marine Affairs and Policy,
a section of the journal
Frontiers in Marine Science

Received: 17 March 2017

Accepted: 11 December 2017

Published: 22 December 2017

Citation:

Carpi P, Scarcella G and Cardinale M (2017) The Saga of the Management of Fisheries in the Adriatic Sea: History, Flaws, Difficulties, and Successes toward the Application of the Common Fisheries Policy in the Mediterranean. *Front. Mar. Sci.* 4:423. doi: 10.3389/fmars.2017.00423

In the past 40 years, the fishery in the Mediterranean Sea has seen numerous changes in technology, fleet composition, effort allocation, and management strategies. In this paper, our aim is to summarize the improvements, and highlight the flaws and difficulties that have characterized fisheries management in the Mediterranean Sea in the past decades. We (the authors) advocate the importance of the regionalization of the Common Fisheries Policy (CFP) in the Mediterranean. We focussed on the Adriatic Sea, with two case studies—the fishery for sardine and anchovy, and the fishery for Nephrops. The former is emblematic as it is one of the most valuable and well-studied fisheries in the Mediterranean but it is also an example of a management process that is slowly bearing fruit. Nephrops, on the other hand, has been facing the same destiny as other stocks in the Mediterranean; namely, its peculiar biology, a complex fishery, a poorly tailored data collection and inadequate assessments, have delayed action until very recent times. We use these examples to cover several aspects of Mediterranean fisheries management: (i) a historical overview of the development of these fisheries and their management; (ii) an overview of the main players involved in the scientific analysis and management process and their current and ideal roles; (iii) the flaws of the current stock assessment system; and (iv) recent developments and potential solutions to comply with the latest reform of the CFP before 2020. We argue that to align Mediterranean management with the CFP and achieve MSY targets, the lack of coordination and definition of roles between the General Fisheries Commission for the Mediterranean, the European Commission Directorate-General for Maritime Affairs and Fisheries, the Scientific, Technical and Economic Committee for Fisheries and the Joint Research Centre need to be resolved. There is a need for adequate assessment models and

data to answer increasingly complex management questions, as well as regular external review of the stock assessment models to assure their quality. Finally, the need for the implementation of a TAC system as an effective tool for Mediterranean fisheries to achieve sustainability is discussed and advocated.

Keywords: CFP, regionalization, Adriatic Sea, small pelagics, *Nephrops norvegicus*, total allowable catch

INTRODUCTION

The Common Fisheries Policy (CFP) is the instrument used by the European Union to ensure the sustainable exploitation of marine resources exploited by European fishing fleets. After many years of criticisms and failures, in 2014 the CFP underwent substantial reforms which were thoroughly discussed in the so called “Green paper” of the European Commission (EC) (CEC, 2009). The content, in an innovative and modern fashion, tried to address all the problems and faults of previous management identified by policy makers, scientists and stakeholders, ranging from biological and economic aspects, to legal and political features (Payne, 2000; Khalilian et al., 2010; Villasante et al., 2011; Da Rocha et al., 2012).

At the time of its inauguration in 1982, the CFP was, *de-facto*, a regional policy centered on the North Sea. Since then, the area of action has expanded enormously, and the lack of regionalization has been recognized as one of the main flaws of this earlier version of the CFP; however, this issue was never taken into consideration in subsequent reforms. Following repeated expression of the need for regionalization, the reduction of a centralized top-down management system in favor of a decentralization of power to regional bodies became a major aspect of the new reform that took effect in 2014. The idea of regionalization aims to set up broad, common objectives and underlying principles for a sustainable management, whilst possibly implying a transfer of responsibility for detailed management to regional or sub-regional bodies. This important shift, from a central authority in Brussels to multiple organizations, intends to bring decisions closer to those mostly affected and having deeper knowledge and experience on specific fisheries and/or environment (Symes, 2012).

The importance of regionalization is even more striking when comparing the issues faced by Northern Europe with those pertinent to the Mediterranean area (Raakjær, 2011). A different management system, the interaction with non-EU countries, a long history of exploitation and a series of cultural gaps between the two regions increase the risk of making ineffective measures that do not take into account this diversity.

The concept of a regionalized CFP is in theory also supported by the effort devoted to the development of an ecosystem approach to fisheries management: if each ecosystem is to be managed at the right geographical scale, it should be treated as a single eco-region, allowing tailor-made regulations based on an understanding of the dynamics of specific fisheries and eco-systems (Raakjær, 2011).

Another important aspect to be considered is the link that the original CFP shares with the concept of the Total Allowable Catch (TAC): in fact, in the words of Holm and Nielsen (2004),

it can be argued that the “TAC Machine and the CFP constituted each other reciprocally.” When first established, the negotiation over the CFP focussed on the importance of sharing the fisheries resources among member states following some rules dictated by the new-born methodology known as Virtual Population Analysis (VPA) (Holm and Nielsen, 2004). The TAC philosophy has several advantages, such as a tidy division of labor between science and politics, the routinization of scientific work, and the definition of a clear management objective whose achievement is in theory measurable (Holm and Nielsen, 2004; Hoydal, 2011). Its success is strongly dependent on the implementation of the rule itself at the political level: in the Northern seas, where most species are subject to quotas, failures occurred due to final regulations from EU advising for much higher catches than what scientists advised (Cardinale and Svedäng, 2008; Villasante et al., 2011). TAC has never really taken over in the Mediterranean area, where such output control might be complicated by the mixed fisheries context: here the fishery is mostly regulated through the control of fishing effort and fishing capacity, specific technical measures, minimum conservation reference size, and closures of areas and seasons for fishing; these measures however haven't proven to be successful either and substantial actions are now required (Cardinale and Scarcella, 2017).

Despite the initial idea behind the reform of the CFP, the constraints imposed by the competence order established in the Treaty on the Functioning of the European Union (TFEU) do not allow an effective re-ordering to fit a regional scale (see Salomon et al., 2014 for details). Surely, this provision can be a starting point and a prototype model for Member State cooperation, but the lack of an appropriate organization of the bodies involved, together with closure toward the variety of different political, social and legal frameworks and situations around Mediterranean coastal countries, is slowing the process and affecting achievement of the final goal.

In the last decade, several papers have been published to discuss, eviscerate and review the intrinsic problems of the old and new CFP (Daw and Gray, 2005; Frost and Andersen, 2006; Da Rocha et al., 2012; Hegland et al., 2012; Svedäng and Gipperth, 2012; Salomon et al., 2014; Ross, 2015; Soma et al., 2015; Van Hoof and Kraus, 2017) most of them however have mainly focussed on the Northern areas, with little focus on the Mediterranean region. The reasons for this may be found in the struggle that Mediterranean scientists face when promoting their scientific findings outside their scientific fora, but now the time has come to analyse the issue at a Mediterranean level and provide a different point of view.

In this paper, we will identify some of the main difficulties that the CFP faces in the Mediterranean Sea, using two emblematic case studies in the Adriatic Sea to illustrate our point. The

first section will provide a general overview of the two fisheries and the stock status in the area, including main regulations and management strategies of the last decade. The second section will focus on the process currently in place—in the Mediterranean in general and in the Adriatic Sea in particular—for the management of marine resources, and how science is translated into advice. The main bodies in charge and their current and ideal roles will be described. The third section will identify the main flaws of the current system, but will also describe how, after decades of apathy, the efforts made in the most recent years are slowly showing their fruits. Finally, the fourth section will provide our view on the measures that could help achieve the objectives of the CFP before 2020, given the current situation in the Mediterranean.

SETTING THE SCENE

The Development of the Fishery

The current fishing pattern in the Mediterranean Sea is the result of a long history of exploitation of marine resources which started several thousands of years ago (Farrugio et al., 1993; Lleonart and Maynou, 2003). Within the area, the Adriatic Sea (**Figure 1**) represents the perfect case study on several aspects of fishery management: a great variety of fisheries, the richness and diversity of species caught and the relative high productivity—especially in the Northern area—(Fonda-Umani et al., 1992), a difficult management due to shared resources (Bastardie et al., 2017), the long history and the long time-series of data (Fortibuoni et al., 2017) and finally its relative isolation from the rest of the Mediterranean.

To understand the context and issues related to the management of such a complex environment, it is important to set the fisheries in their historical, social and political context. Firstly, analogous to what is now happening in several of the coastal Mediterranean countries (e.g., North Africa, Turkey, Syria), the recent past political situation in the Balkan areas has been harsh, with the management of the fishery being irrelevant compared to other problems. Furthermore, similarly to other areas of the Mediterranean, the entrance of Croatia into the European Community is only recent: the past relationship between the two main Adriatic players, Croatia and Italy, thus suffered from the lack of an easy agreement afforded by this political channel, worsened by the fact that fishermen still play an important role in political decisions. On top of that, in Italy the situation has been further complicated by an indiscriminate release of licenses in the past, a weak data collection system until the early 2000s, a general lack of political interest on the issue which often translated into a lack of control, and conflicts between fishermen (northern vs. southern, Italian vs. Croatian, as well as between categories). These circumstances impaired any possibility of common agreements and broad cooperation.

Small Pelagics: Anchovy and Sardine

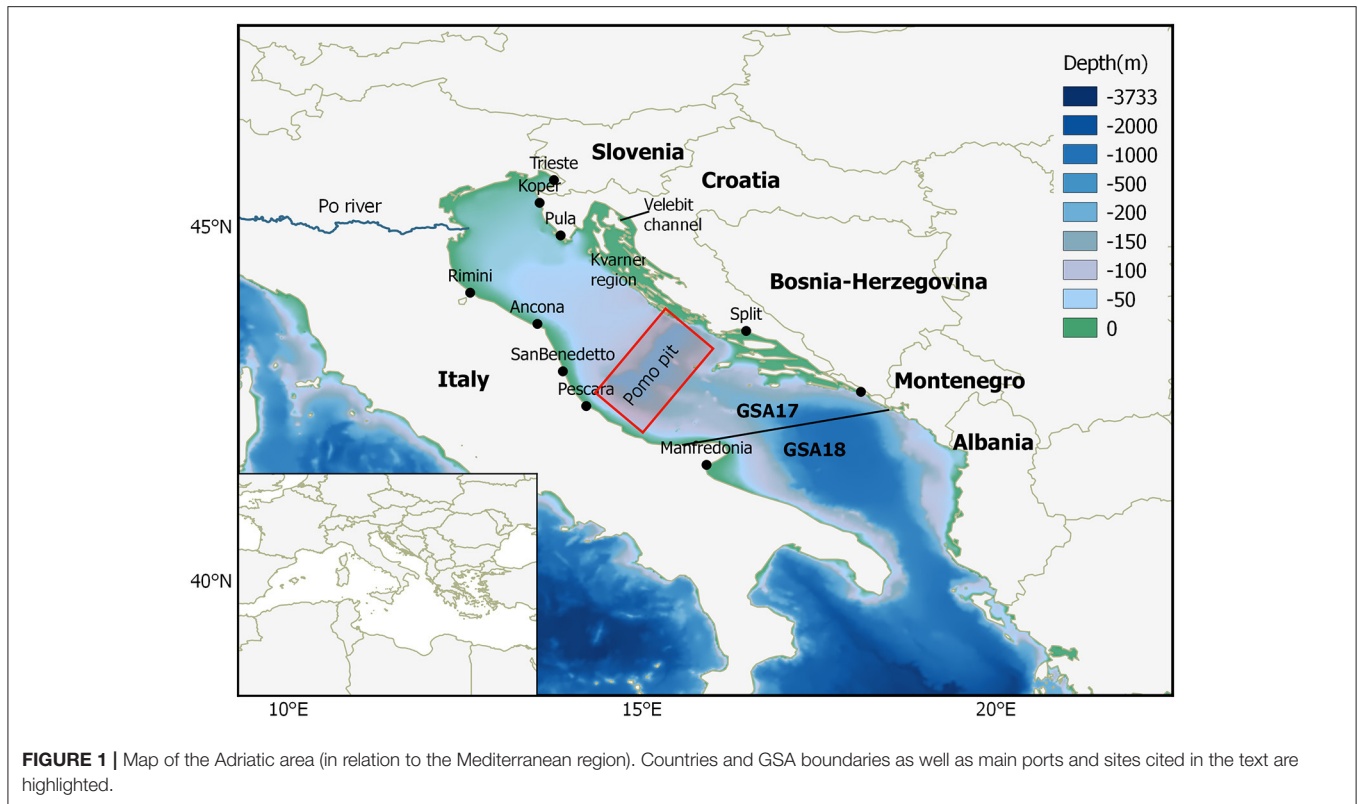
Small pelagics; i.e., anchovy (*Engraulis encrasicolus*) and sardine (*Sardina pilchardus*), have been, and currently are, the main

contributors to total landings for the whole Mediterranean (Lleonart and Maynou, 2003).

Both species have a short life span (about 5–6 years for anchovy and 7–8 for sardine), early maturity, a long spawning period and schooling behavior. Anchovy is an euryhaline species widely spread over the entire basin (Sinovcic, 1978; Palomera et al., 2007; Morello and Arneri, 2009; Zorica et al., 2013). The spawning period goes from April to October (Regner, 1996), with two peaks in May–June and August–September (Regner, 1972; Sinovcic and Zorica, 2006; Morello and Arneri, 2009; Zorica et al., 2013). The main spawning areas are located all along the western coast; few areas have been identified also in the eastern Adriatic (Regner, 1996; Sinovcic, 2000; Morello and Arneri, 2009). The diet is composed mainly by mesozooplanktonic preys (Borme et al., 2009). The spawning period of sardine takes place from late autumn to early spring, with the highest sexual activity in December and January (Sinovcic et al., 2003; Morello and Arneri, 2009), and its more intense in the north-east Adriatic (Morello and Arneri, 2009). Sardines are partially phytoplankton feeders and can digest phytoplankton cells as well as copepods (Grbec et al., 2002; Morello and Arneri, 2009).

In the Adriatic Sea, the two main countries contributing to total catches are Italy, targeting mainly anchovy, and Croatia, targeting mainly sardine. The Croatian fishery saw a period of forced closure in the 1990s due to the war in ex-Yugoslavia: when the war finished, the fleet was renewed with the entrance of the big purse seiners that currently constitute the main component of their fishing fleet. Currently, the Italian share of anchovy and sardine accounts for ~30% of total national catches; in Croatia small pelagics represent about 80% of the total national catches (EU, 2016). Both species are fished all year round by pelagic trawlers and purse seiners covering great part of the basin, but mostly concentrated in the Northern part (**Figure 2**). Landings of anchovy have followed cyclic fluctuations over the years, with very high values in the late 1970s–early 1980s, partly attributed to the availability of subsidies from the European Community, and again in the late 2000s; both peaks were followed by a more or less marked decline (Carpi et al., 2015). The first, dramatic collapse was recorded in 1987 and has been attributed primarily to 2 years of very low recruitment, result of adverse environmental conditions: the fishery might have played a role in the disruption of the stock, nevertheless, the decrease in biomass started well before relevant changes in fishing effort were recorded (Santojanni et al., 2006). Sardine landings, on the other hand, after enormous values at the beginning of the eighties around 90,000 tons, decreased dramatically until 2005, when they reached the historical minimum of 1,900 tons. Landings then increased again, booming in 2007, mainly due to an important increase of the Croatian fisheries, hitting the second highest value of the entire time series in 2014, at 82,000 tons. Grbec et al. (2002) associated the increase and successive decline of sardine before 2000 to changes in the advection of Levantine Intermediate Waters (LIW) due to climatic fluctuations.

During and after both events, little or no action was taken by the competent authorities to regulate effort to allow the stock to recover, or to minimize potential losses in fishing opportunities



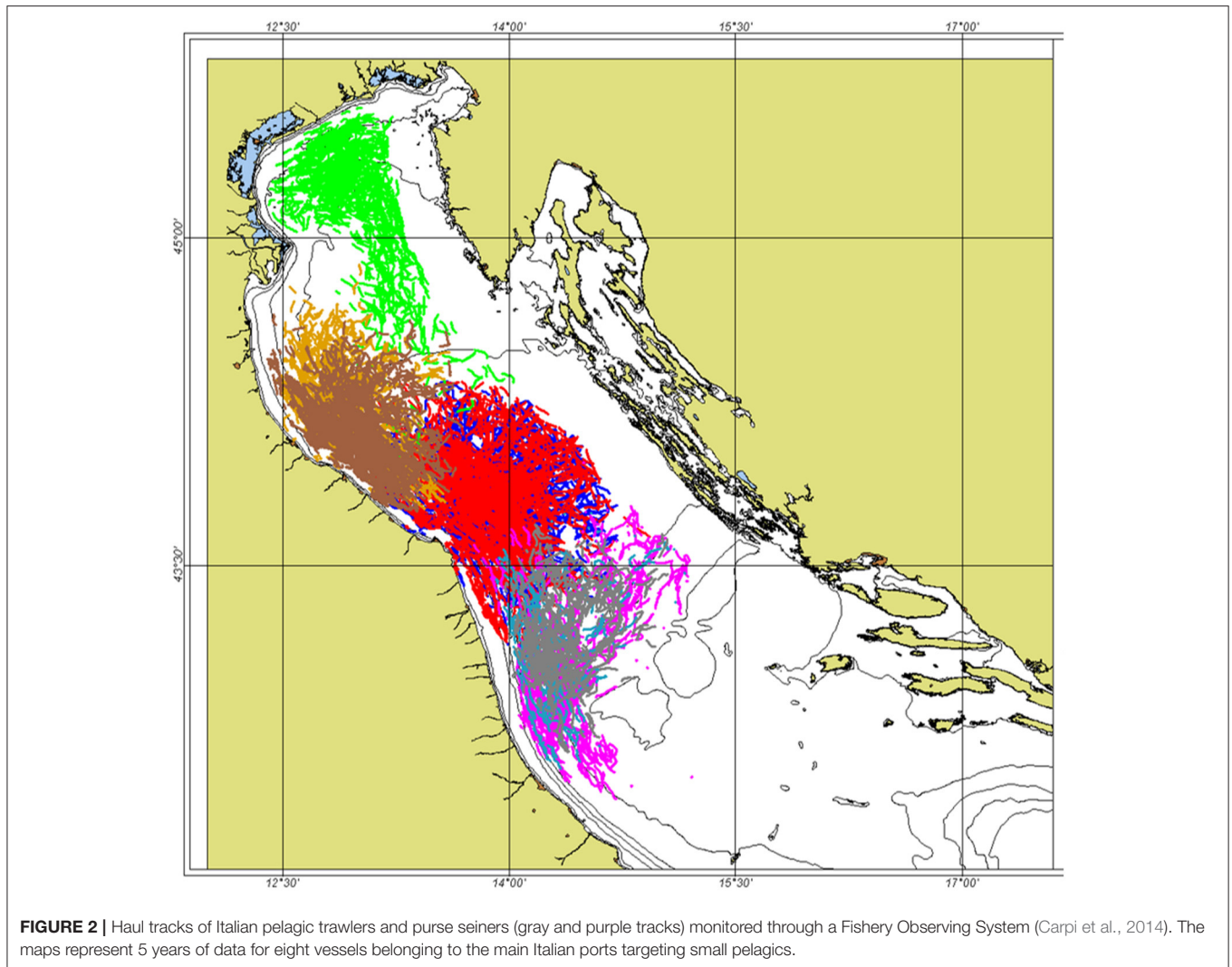
in hypothetic future situations of impaired recruitment. The consequences of this apathy are now evident: the Italian sector, whose fishery has always focussed on anchovy, is now suffering, with a decrease in the number of vessels and a general feeling of dismay. The Croatian fleet, targeting mainly sardine for tuna farms, is still stable: it is, however, natural to wonder for how long an already suffering stock of sardine will be able to sustain such harvest rate; the use of low-value (in marketing terms) whole feed-fish species for the growing and fattening of tuna in Croatian waters with locally caught sardines is a practice that is unlikely to be sustainable in the long term, with a food conversion ratio that, at best, is equal to 12.5:1 (Allan, 2004).

In defense of the authorities, it must be said that scientists, despite suggesting a reduction of fishing pressure for many years, have not been very emphatic about this. This has been partly due to the lack of a formal framework to enable specific action, but also to disagreements within the scientific community and possibly to the sometimes overbearing political influence of national administrations on scientific matters.

Although it is unquestionable that environmental variables play an important role for the stock development of pelagic species, it is also true that the exploitation pattern to which the two stocks have been subjected in the last 15 years is unsustainable, with values of fishing mortality estimated by stock assessment models that are beyond safe limits. The current situation, with huge catches for sardine well beyond precautionary levels, a general struggle of the anchovy stock with current F being above the F_{MSY} reference point, and the

average landing size of both species in decline, requires strong and immediate action (GFCM, 2016).

The assessment of small pelagics in the Adriatic Sea has been carried out since the eighties, with a well-established sampling program that for many years extensively covered all the fishing ports on the Italian side, together with some sampling along the Croatian coast. An acoustic survey is available for the Italian side from the 1970s, and from 2004 the whole area has been covered to assess the status of these stocks and to keep enhancing the knowledge available on these species (MEDIAS, Mediterranean Acoustic Survey). These are the longest and richest time series of data available in the Mediterranean and have made these two stocks the focus of several debates and management experiments. The stock assessment, historically carried out using a single species VPA-type model, in the last decade has undergone significant changes: the methodology moved to a more sophisticated statistical catch at age model (SAM), and the whole dataset has been entirely revised to improve the quality of the results and provide more accurate scientific advice (GFCM, 2014, 2015). However, the biggest improvement lies in the fact that these stocks have been the guinea pig for a series of processes that are meant to become common practice in the region, following the ICES example: their stock assessment was subjected to a benchmark process (GFCM, 2015), the EU prepared a multiannual management plan for the management of these stocks that has been adopted with recommendation GFCM/37/2013/1 of the General Fisheries Commission for the Mediterranean (GFCM), and a Management



Strategy Evaluation (MSE)-like process was initiated in 2015–2016 and is still ongoing (GFCM, 2016). Due to the amount of data available, to the high value of the fisheries and the high political interest for the shared nature of these resources, the EU has, lately, focussed a lot of attention and invested plenty of resources on these stocks: this has surely had some positive effects, however we think that this effort has not always been properly channeled, and would have been more effective with the constant involvement of the right parties and a continuous collaboration with the bodies involved.

Norway Lobster

Norway lobster (*Nephrops norvegicus*; *Nephrops* hereafter), is the most valuable crustacean species landed in the Adriatic Sea (Vrgoč et al., 2004). This species is exploited on muddy seafloors prevalently by means of bottom trawls and to a lesser extent, in smaller areas (e.g., the northern-eastern Adriatic channels), by means of baited traps (Vrgoč et al., 2004; Ungfors et al., 2013). In the Adriatic Sea, it occurs on muddy (silty-clay) grounds at depths from around 50 m to over 400 m (Artegiani et al., 1979;

Wieczorek et al., 1999), with important concentrations occurring around 70 m depth off Ancona, around 220 m depth in the Pomo pit and in the Velebit Channel, Kvarner and Kvarnerić region along the Croatian coast (Karlovac, 1953; Crnković, 1964, 1965; Froglija and Gramitto, 1981, 1986, 1988; IMBC et al., 1994; Froglija et al., 1997). Trawl nets and baited traps sample different portions of the population: trawls will only catch individuals when they happen to be outside of their burrows, whilst the bait in traps entices animals out of their burrows meaning they can also catch berried females (Morello et al., 2007, 2009).

Nephrops are bottom-dwellers building complex burrows in muddy sediments; emergence from their burrows varies with time of day, season, animal size, sex, and reproductive status (Froglija, 1972; Atkinson and Naylor, 1976; Naylor and Atkinson, 1976; Aréchiga et al., 1980; Chapman, 1980; Froglija and Gramitto, 1986; Tuck et al., 2000). In particular, emergence follows diel and seasonal patterns with peaks of daily emergence differing according to depth (Bell et al., 2007) and seasonal ones depending on sex (females who do not leave their burrows during the egg-bearing period; Marrs et al., 2000, 2002; Bell et al., 2007).

This all means that the trawl fishery exploits the population selectively and in a different manner according to sex. These factors all affect the availability of *Nephrops* to trawls, their absolute catches and the sex ratio of animals caught. This is particularly important when considering that the main index of abundance available for Mediterranean demersal resources is a trawl survey; i.e., the MEDiterranean International Trawl Survey (MEDITS; Bertrand et al., 2002). Issues with MEDITS are both general (i.e., the survey is designed in such a manner as to not be efficient at catching *Nephrops*) and GSA-specific (the survey in GSA 17 does not follow the spatio-temporal protocol in all years, notable examples being 2007 and 2014—Table 2), and it suffers the same problems as the trawl fishery with respect to the burrowing behavior of the species (see STECF, 2016b for details).

The main actors in the trawl fishery for *Nephrops* in the Adriatic are Italy and Croatia, with Italy fetching by far the highest catches since the 1970's (FAO, 2011–2017). The contribution of Croatia to total Adriatic landings, on average, accounts for 25% in weight. Total catch has been characterized by marked fluctuations throughout the years; in Italy, this peaked around 2,000 tons in 2005 and has followed a decreasing trend since. Very little information is available for the Croatian trap fishery, which is an artisanal activity carried out mainly in channel areas of the northern Adriatic.

The geographic distribution of *Nephrops* is highly discontinuous because heavily dependent upon sediment composition which should be muddy and preferably medium-grained (around 40% of clay and silt) (Farmer, 1974; Afonso-Dias, 1998; Bell et al., 2007). Importantly, there seems to be a stock-specificity to the relationship between burrow density and sediment composition which has been found to hold true over time (Campbell et al., 2009). This aspect, added to the fact that *Nephrops* is a sedentary species (Chapman and Rice, 1971), means that *Nephrops* is generally characterized by spatially segregated populations (or stocks) with little or no exchange between them (Bell et al., 2007). Heterogeneity in distribution is also present within smaller areas, giving rise to smaller “subpopulations” or “stocklets” (Chapman and Bailey, 1987) with different densities and life-history characteristics (Maynou and Sardà, 1997; Bell et al., 2007). This appears to be exactly the case of the Pomo/Jabuka pit in the central Adriatic Sea (Figure 1): here, growth rates have been reported to differ markedly from other Adriatic areas (Froglia and Gramitto, 1988; IMBC et al., 1994), fact which, paired with the oceanographic characteristics of Pomo/Jabuka, results in a “subpopulation” of smaller, slower-growing animals. Consequently, it is very likely that treating and assessing the *Nephrops* population at a GSA (GFCM Geographical Sub Area) or joint GSA level may be questionable and could lead to an inaccurate and imprecise evaluation of the status of the resource. Furthermore, the assessment of *Nephrops* is fraught by a number of difficulties, from the lack of reliable age-determination methods, to the marked sexual dimorphism, the definition of the functional units, the uncertainty about growth, and their burrowing behavior that results in different selection patterns. Moreover, the lack of spatially explicit catch data complicates the assessment

issue further as it has been found that Italian southern Adriatic trawl fleets (GSA 18) often fish in the Pomo/Jabuka pit (GSA 17) and land in GSA 18, withdrawing any reference regarding the spatial origin of the catches (Russo et al., in press).

Attempts to analytically assess *Nephrops* have passed from the initial use of length cohort analyses (LCA) (GFCM, 2009) relying on the unrealistic equilibrium assumption (Dobby and Hillary, 2008) to dynamic assessment models such as VPA, eXtended Survivors Analysis (XSA; Shepherd, 1999) being the most common. VPA-like methods are age-based and thus, in the case of a species that cannot be aged directly, catch-at-length is sliced into catch-at-age on the basis of the growth function assumed: this simple selection of ages from a growth curve is not sufficient given the fact that the growth of *Nephrops* is sex and stage-dependent, that these animals are long-lived (14+ years old), and given the absence of strong modes in catch data. These methods result in imprecise estimates of most recent numbers and are not capable of accounting for growth variability (Dobby and Hillary, 2008; Edwards et al., 2012). In the Adriatic Sea, *Nephrops* was assessed using XSA in GSA 17-18 in 2016 (STECF, 2016b) and in GSA 18 in 2015 (STECF, 2015), and using a production model (Surplus Production in Continuous Time, SPiCT) in GSAs17-18 combined (STECF, 2016a). Despite good diagnostics, the former XSA assessment was deemed not acceptable owing to the flawed scientific assumptions it was based upon, among these: (i) it was carried out on the entire GSA not accounting for differences in the Pomo/Jabuka pit, and (ii) the XSA methodology—which was imposed by EC Joint Research Centre (JRC)—EC Scientific, Technical and Economic Committee for Fisheries (STECF) against the opinion of the expert carrying out the work—was unsuitable. Similarly, the SPiCT production model, which was used to provide the latest scientific advices in the STECF framework, is not in line with other models used around the globe for the same species; besides the outcomes provide a worryingly optimistic status of exploitation ($F/F_{MSY} = 1.3$) if compared with other *Nephrops* stocks in the Mediterranean; finally, it is not considered to be adequate to the biology and fisheries of *Nephrops* and should therefore be abandoned.

Explicit length-structured, sex-, fleet-, and area-based integrated assessment methods, directly using length data in the form of size-transition matrices (or using a fully integrated statistical slicing) and fishery-independent surveys or commercial LPUE information for tuning, have been put forward as alternatives (ICES, 2013). Efforts have thus been made to estimate Italian catches within and outside the Pomo/Jabuka pit (Russo et al., 2011, in press) and integrated stock assessment methodology such as CASAL (Bull et al., 2005) and Stock Synthesis (SS3; Methot and Wetzel, 2012) are being attempted in the Adriatic Sea, but have yet to be submitted and validated. In advocating the devil's work, the use of transition matrices, and the results yielded in terms of F , are heavily dependent upon, and confounded by, the growth function assumed (Dobby and Hillary, 2008): in other words, the dog seems to chase its own tail.

Thus, despite some authors advocating analytical methods such as LCA and XSA as yielding the most “realistic and

TABLE 1 | (A) Participation of EU and non-EU countries to GFCM Working Group on Stock Assessment of Demersal species (WGSAD) and GFCM Working Group on Stock Assessment of Small Pelagics (WGSASP); **(B)** Participation of EU and non-EU countries to STECF Working Group (Mediterranean Assessment part I and II).**(A) Participants to WGSAD and WGSASP (excluding Black Sea)**

		2012	2014 I	2014 II	2015	2016
WGSAD	EU	11	12	27	4	30
	Non-EU	6	7	9	9	10
WGSASP	EU	7	13	13	13	18
	Non-EU	6	4	5	9	7

(B) Participants to STECF-Mediterranean Assessment (Part I and II)

		2012-I	2012-II	2013-I	2013-II	2014-I	2014-II	2015-I	2015-II	2016-I	2016-II
EWG	EU	18	19	20	20	21	19	21	21	13	13
	Non-EU	0	2	0	0	0	0	0	0	0	0

TABLE 2 | Temporal distribution and number of hauls for the Medits trawl survey in the Adriatic Sea from 2000 to 2016.

Year	Italian survey			Croatian survey		
	Starting date	End date	No of hauls	Starting date	End date	No of hauls
2000	08/06/2000	02/08/2000	88	26/06/2000	02/07/2000	47
2001	11/06/2001	05/07/2001	88	25/05/2001	31/05/2001	48
2002	17/07/2002	26/09/2002	121	02/09/2002	11/09/2002	59
2003	17/06/2003	12/08/2003	121	20/06/2003	26/06/2003	59
2004	29/06/2004	11/08/2006	120	02/08/2004	08/08/2004	61
2005	29/06/2005	27/09/2005	121	01/08/2005	08/08/2005	59
2006	05/07/2006	18/08/2006	121	25/07/2006	01/08/2006	59
2007	12/06/2007	17/07/2007	122	26/06/2007	03/07/2007	60
2008	11/06/2008	31/07/2008	123	12/07/2008	22/07/2008	59
2009	07/05/2009	07/06/2009	123	24/07/2009	30/07/2009	60
2010	01/06/2010	16/07/2010	122	23/06/2010	30/06/2010	60
2011	03/06/2011	04/08/2011	122	29/06/2011	06/07/2011	60
2012	20/04/2012	18/08/2012	122	16/07/2012	24/07/2012	60
2013	10/06/2013	01/08/2013	122	03/07/2013	18/07/2013	59
2014	14/08/2014	23/11/2014	180	05/07/2014	06/08/2014	56
2015	16/07/2015	20/08/2015	180	03/07/2015	19/07/2015	66
2016	15/08/2016	20/09/2016	180	04/07/2016	21/07/2016	56

reliable” population estimates for *Nephrops* (Sardà et al., 1998; Sardá and Aguzzi, 2012), the issues with slicing and others related to the fact that they assume little or no mis-reporting of catches, have led ICES to stop the use of analytic assessments. This was done in favor of the direct use of Under Water TV survey (UWTV) data to provide absolute estimates abundance to which harvest rates are applied to recommend catch and landings (ICES, 2013). This is now the standard and ICES strongly recommends the development and use of UWTV surveys where *Nephrops* assessments are required (ICES, 2013). A yearly UWTV survey covering the Pomo/Jabuka pit area in the Adriatic Sea was established jointly between Italy and Croatia in 2009 and has been ongoing since. This survey is partly funded by the FAO-AdriaMed regional project, but it is generally not

supported by national or European funds and for this reason it is spatially restricted to the Pomo/Jabuka pit, preventing these data from being usable for a GSA-wide evaluation of *Nephrops*.

Management History: Legislations

This chapter will not try to cover all legislation in place in the Adriatic Sea, but aims to provide an overview of the main regulations that have affected and currently affect the Adriatic small pelagic and demersal fisheries. Several multilateral environmental agreements, which may indirectly impact these two fisheries, have been adopted but will not be considered here since they are not relevant to the scope of this paper. Italy and Slovenia, initially as part of the European Economic

Community (ECC) and subsequently the European Community, which was afterwards absorbed into the European Union, need to follow EU regulations: Member States can take measures for the conservation of the stocks in waters under their sovereignty, as long as these are not less restrictive than the EU regulations in place. In 2001, Croatia signed a “Stability and Association Agreement” with the EU; i.e., a formal commitment toward the integration of the EU *aquis*, which bound the country to the acceptance of the Common Fisheries Policy (CFP). This agreement did not stop Croatia from undertaking, since 2004, an important fleet renewal, with the construction of new vessels and a net increase in capacity of the fleet. In addition, the Croatian government attempted to establish an Ecological and Fisheries Protection Zone (EFPZ) that was somehow against the agreement contained in the CFP, having the potential for the exclusion of EU fisheries within the Croatian zone: after several years of debates and negotiations, in 2008 the EFPZ was enforced, with a special derogation for EU vessels. Despite the improvement in most recent years, in particular after Croatia joined the EU, Croatia is still highly influenced by internal politics and dynamics (Mackelworth et al., 2011).

Hand in hand with EU regulations, the framework of National regulations in Italy has historically acted to control several aspects of the fisheries, such as the number of issued licenses, gear characteristics, technical features of the fishing vessels, spatial and temporal restrictions. A similar approach was adopted by Croatia, whose main pieces of legislation were drafted in 2000 and 2006 and regulate fishing zones through fishing effort and fishing capacity in terms of gears, temporal and spatial restrictions, and species protection (AdriaMed, 2007).

In line with these legislations, following the directives included in the reformed CFP, as well as the pressure from the scientific community and the worries of the fisherman themselves, recent measures have been enforced for both small pelagic and demersal fisheries. Recently, a series of measures stemming from GFCM recommendations (Rec. GFCM/38/2014/1, Rec. GFCM/39/2015/1, Rec. GFCM/40/2016/3), have been adopted: a reduction of the number of fishing days for both anchovy and sardine to a maximum of 144 days; the closure, in Italy, of the 6 mile strip along the entire coast for 6 months from 1st July to 31 December and a closure in Croatia of the inner seas for 6 months in 2016 and again in 2017, from 1 April to 30 September; extra temporal closures between 1 October and 31 March for sardine and between 1 April and 30 September for anchovy; as well as the imposition of catch and fishing capacity limits for both species. Further, an area of the Pomo/Jabuka Pit, which is an important nursery area for European hake and hosts a resident population of Norway lobster—was closed to the trawl fishery for 15 months in 2015/2016. Since October 2016 it is open to a limited number of authorized bottom trawlers and closed to bottom longliners. This measure, which mainly affected Italian vessels, was associated with the development of a specific monitoring program that started in 2015 and it is planned to be carried out every year (Colloca et al., 2015).

All these measures seem like an attempt to answer to a sudden and long-delayed increasing pressure from the EU, whose focus

for the Adriatic region has grown since Croatia joined. The General Fisheries Commission for the Mediterranean (GFCM) has fully come on board, setting its target to reverse the declining trend of Mediterranean stocks by 2020 through their ambitious mid-term strategy, and, more specifically, recommending that exploitation levels of small pelagic species in the Adriatic Sea be at the maximum sustainable yield by 2020 (Rec. GFCM/40/2016/3). However, to comply with these 2020 MSY objectives and definitely align with the regulations included in the new CFP, action may have come too late.

THE CURRENT MANAGEMENT

Bodies Involved

The main players of the management of marine stock in the Mediterranean Sea can be divided in four big entities: (i) the Food and Agriculture Organization (FAO) with its own Regional Fisheries Management organization (RFMO), the GFCM, as well as its Scientific Advisory Committee on Fisheries (SAC) and regional projects, (ii) the European Commission (EC) and its bodies (i.e., STECF and JRC), (iii) the national authorities and iv) fisheries associations coordinated by the MEDiterranean Advisory Council (MEDAC) (Figure 3).

The GFCM, established in 1949, is the official RFMO of the Mediterranean and Black Sea and it is part of FAO. The main purpose of GFCM was to promote the development, conservation and rational management of marine fishery resources in the Mediterranean and the Black Sea, creating a common ground for discussion for European and non-European countries. In 1997, it became a Commission and since then it has the authority to adopt binding recommendations for fisheries conservation and management in its area of application, and plays a critical role in fisheries governance in the region. The recommendations of the GFCM become compulsory for each individual Member State once they have notified. The GFCM receives scientific input from the SAC whose mandate is to provide independent advice on the technical and scientific basis for decisions related to fisheries conservation and management.

Hand in hand with the GFCM, the FAO regional projects operate in the Mediterranean to connect countries and sub-regions to promote and support the conservation of marine resources. In the Adriatic Sea, the main player is the AdriaMed regional project: born in 1999, it has now a catalytic role in encouraging cooperation aimed at fisheries management in the area.

The Directorate-General for Maritime Affairs and Fisheries (known as DG-MARE) is the right arm of the European Commission when it comes to the implementation of the CFP and the Integrated Maritime Policy. DG-MARE receives scientific inputs to implement the common fisheries policy from ICES, whose competence area is Northern Europe, and the STECF, an EC body that is meant to be the EC scientific forum and operate in all the areas under EU control, including the Mediterranean.

The national authorities (such as ministries and port authorities) have the main role of implementing the regulations established by the GFCM and the EU. In Italy and Croatia,

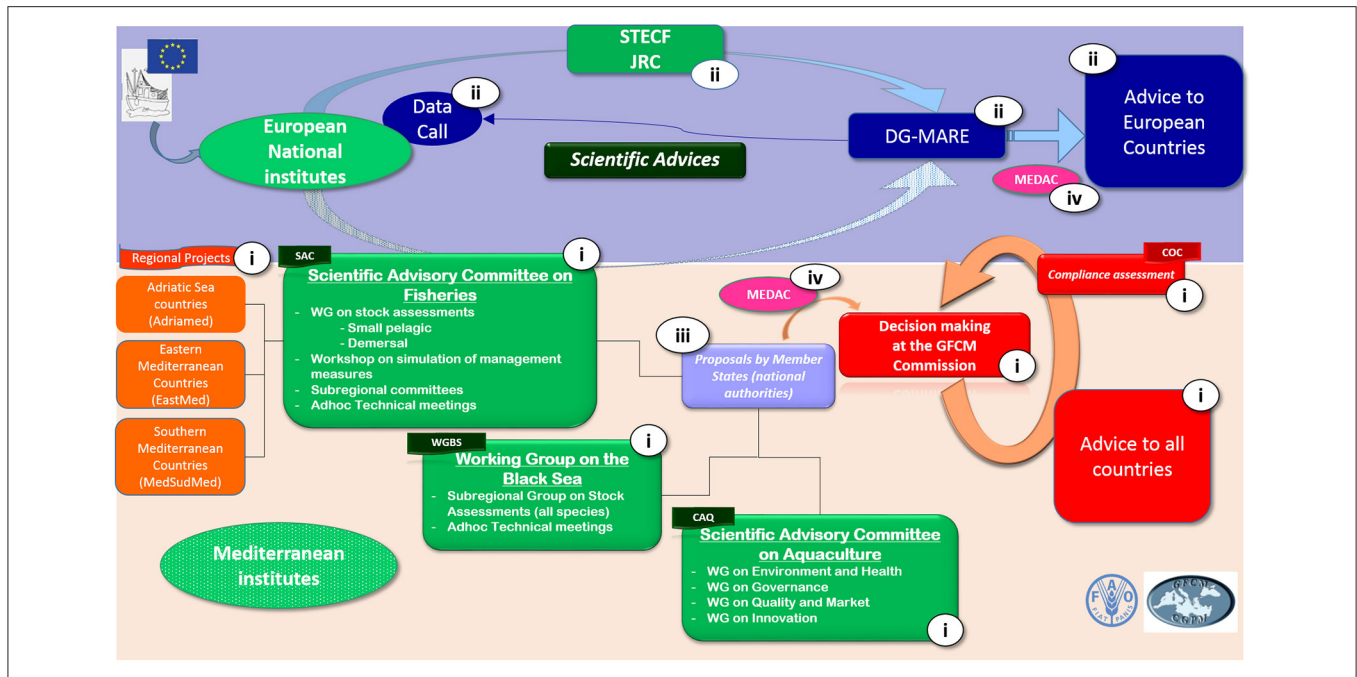


FIGURE 3 | Management process in the Mediterranean Sea. Roman numbers match the order used in the text. Coloring: green boxes refers to scientific bodies; red boxes refer to FAO bodies; blue boxes refer to EU bodies; pink boxes refer to stakeholders.

the fisheries directorates under the Ministry of Agriculture are responsible for carrying out this task. These are the competent authorities for Monitoring, Control, and Surveillance (MCS).

The governments regularly convene the sector to inform them of the resolutions and changes that affect or may affect the fishery. The fisheries sector participates in the MEDAC. The MEDAC is made up of European and national organizations representing the whole fisheries sector and other interest groups (such as environmental organizations, consumer groups, and sports/recreational fishery associations) which operate in the Mediterranean area within the framework of the CFP. The role of MEDAC includes the preparation of opinions on fisheries management and socio-economic aspects in support of the fisheries sector in the Mediterranean. Such opinions are submitted to the Member States and the European institutions in order to facilitate the achievement of the objectives of the CFP; MEDAC also proposes technical solutions and suggestions, such as joint recommendations (ex. Art. 18 Reg.1380 / 2013) at the request of the Member States.

The Stock Assessment Processes: Main Criticism

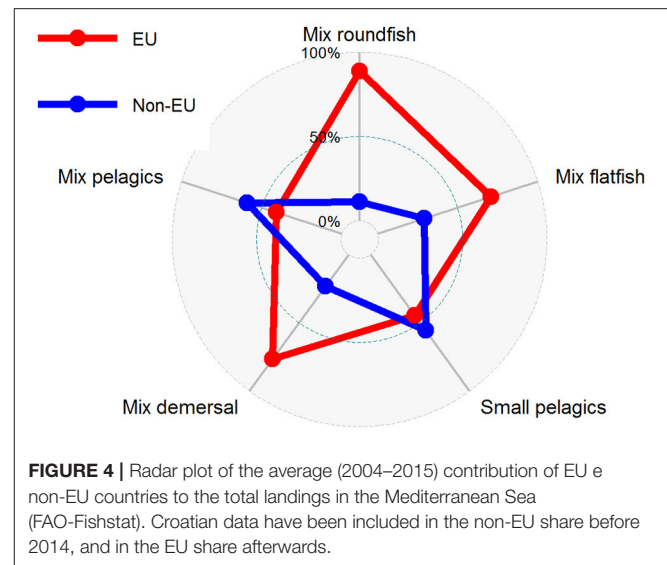
Currently, in the Mediterranean, the stock assessment process is carried out on two levels. First and foremost, as it includes all Mediterranean riparian countries and not just EU Member States, at the level of the GFCM-SAC Working groups: in general, the FAO-regional projects help with the process, coordinating the member states, easing the availability of the data among countries, and supervising the assessment process to make sure that an agreement is reached before presenting the results to

the dedicated GFCM working group. Importantly, within this entire process, full flexibility is given to the experts in matter of data and assessment methods used toward obtaining the best possible outcome, given the information available and the scientific assumptions considered acceptable for the species in question. The working group is then charged of critically revising the assessment in terms of data used, assumptions made and results obtained and ensure that the assessment is correct from a scientific point of view. Finally, the results of the working group are presented to and approved (or not) by the SAC before arriving at the GFCM Commission table. The GFCM then, on the basis of what has been recommended by the SAC, together with the national authorities and including the EU, which is a Contracting Party, decides on the specific measures to be taken. In parallel, assessments of EU Member State stocks are also carried out by the STECF through working groups specifically devoted to the Mediterranean Sea. The process is similar to that adopted by the GFCM-SAC in that the STECF calls on experts (hired to act as consultants) to carry out the assessment of selected species for which official data—which have been prepared following the specific guidelines decided by DG-MARE—are provided at the time of the meeting. The whole group is then called to evaluate the work done, resulting in the assessments being accepted or not. If accepted, the assessments proceed to the table of the STECF plenaries where they are scrutinized by STECF members, which are very often the same experts who carried out the assessments. The scientific advice of the STECF is then available for EU managers and can be used in a wide framework of policy actions [from the balance of fishing capacity and fishing opportunities, to the Marine Strategy Framework Directive (MSFD)].

The process as it is should be enough to efficiently respond to the need for a proper management of the resources. However, complications arise because the two bodies (i.e., GFCM and STECF) find themselves in charge of the same pieces of work (often producing different assessment and advice for the same stock), overlapping with each other's mandate, without a clear distinction of their respective roles; this situation is very delicate and requires strong actions, new agreements and coordination from all sides, conditions not always easy to achieve. As a matter of fact, the current lack of coordination between GFCM-SAC and STECF-DGMARE-JRC has hindered the assessment of some Mediterranean stocks fuelling the difficulties related to the already complex process of aligning management in the Mediterranean with the CFP and the MSY target.

In addition, the specific requirements of the CFP and in general of the whole management process, are becoming more and more complicated: this increased complexity not only demands for new and more advanced stock assessment approaches to be used (e.g., integrated assessment, ecosystem models and management strategy evaluation), but also require enormous amounts of data (i.e., genetic, movements, fleet based information, estimates of natural mortality, and growth etc.), not always equally available throughout the area, while concurrently demanding more and more expertise from the scientists.

One of the shortcomings of the approach adopted by the European Commission so far has been the poor involvement of non-EU countries in matters of common interests, such as shared stocks: the contribution of non-EU countries to the overall exploitation of the stocks can be substantial (Figure 4), but this has not helped to move from a European-centric to a Mediterranean-centric management. This has been true especially for Croatia (before joining the EU), Albania and Montenegro in the Adriatic where the lack of engagement—notably in the past—fuelled a general sense of mistrust and bitter feelings toward every action. An example of this is related to the STECF: its role is clear and well-established with respect to ICES; but it is still ambiguous in the Mediterranean context, mainly due to the poor dialogue with the GFCM until very recently. In our opinion the STECF has been doing a great job and has given a huge contribution in terms of the scientific inputs brought to the Mediterranean community. Our criticisms arise, however, for its reluctance in involving non-EU scientists in the scientific discussion in the Mediterranean context (Tables 1A,B) (quite different the situation for the Black Sea) and for a recent tendency of imposing its view and *modus operandi* in scientific fora. In this context, the role of the STECF, supported by the activity of the JRC, officially acting as STECF secretariat, is unclear and appears to be transitioning toward becoming a decisional organ, which in some cases is guiding, rather than assisting, several processes of Mediterranean assessment and management, from data collection to the methods to be used for the assessments and, lastly, in the formulation of scientific advice. Such emerging difficulties are surely due to the historical weakness of GFCM-SAC but also to the uncertain role of the latter with respect to DG-MARE and its scientific advisory bodies (especially when it comes to the role of JRC), and to very little guidance from DG-MARE concerning the strategy to be



used to achieve the objectives of the CFP in the Mediterranean. This experience is leaving scientists with the impression of not being free to think and act according to their expertise (as they are, in theory, called to do in these occasions), also due to the tangible mistrust expressed by the EC regarding anything that is done outside its supervision (in line with the same independent thinking mentioned above). This has become evident in the last few years, with the STECF's tendency of duplicating the work of the GFCM-SAC on many occasions, not only jeopardizing the success of management due to a general confusion, but also muddling the efforts and the progress done so far and drifting away from its own purposes. All this said, the situation on the other side is not a bed of roses either: the participation of the scientists to the scientific fora of the GFCM-SAC is not mandatory, no reviewing process has been implemented so far, and the assessments are revised during working groups where more than 30 stocks are discussed over a few days, and in many cases little or no space is left to a comprehensive review of the input data, the methodology used and the output.

The final goal of the STECF is surely valuable: the methods to get there, however, should be revised and streamlined toward being more considerate of the differences and needs of the countries involved, the specific issues of each region and stock, and in light of the lack of a uniform and centralized authority when third countries are involved. This is where regionalization would become essential toward achieving the objectives of the CFP. In this sense, the GFCM, through the new agreement of 2014, has formally adopted a sub-regional approach to management within the Mediterranean and Black Sea, with the primary objective of supporting sub-regional management plans and identifying sub-regional priorities to support the work of the SAC. The problems encountered are unquestionably part of the process, and both parties have implemented important approaches and processes that can contribute to it, but until they decide to sit together and discuss a common strategy where

they become equally supportive one of the other and where the EC realizes that management in the southern areas has different challenges compared to the management in northern Europe, no improvements can be foreseen. The provision of effective scientific advice for the sustainable exploitation of fisheries resources must be transparent and coordinated among the main actors, requiring, in the case of the Mediterranean, a significant change of the current situation: clarifying roles, involving external peer reviewers and nominating yearly (at least) stock coordinators committed to follow the assessment process from the collection of data to the formulation of the management advice.

Recent Evolutions and Successes

There is no progress without struggle, and despite all the problems highlighted so far, we also believe that the situation described above has been the catalyst for a series of important actions and measures that have been taken in the last few years, most notably in the Adriatic Sea. Above all, the requirement that the MSY objective be reached by 2020: its establishment in the new CFP and the pressure from the EU have stimulated some important improvements from both scientific and regulatory points of view, which we will try to summarize below.

In the case of Adriatic Sea small pelagics, the entire dataset used in the assessment—including the biological information provided—was revised through a number of workshops and working groups supported by the FAO regional projects; these working groups also involved the participation of external experts and were organized with the main objective of arriving prepared to the first benchmark assessment proposed and guided by the GFCM. In light of the poor status of both stocks, a management plan (MP), which included a Harvest Control Rule (HCR), was proposed and adopted in 2012. This MP had its flaws (e.g., a harvest control rule of little use since it was going from no measures to a drastic reduction of effort when biomass is below B_{trigger}) but was a first important step in the right direction. In order to achieve its requirements, extra emergency measures had to be taken in 2013, 2014, and 2015 by both Italian and Croatian administrations, reducing the number of days at sea allowed (even though the efficacy of this measure is doubtful since the number of days remained still really high), closing areas inside the 6 miles during the spawning period, and adding extra days of closure to the canonical closure period. 2016 has seen the establishment of the first tentative quota system for anchovy and sardine in the Mediterranean Sea: despite the value of this quota still being too high, it marks the starting point for future updates and is the first example of this kind in the Mediterranean Sea. In 2017, the EC adopted the proposal for a multiannual management plan for small pelagic stocks in the Adriatic Sea which has followed several consultations with stakeholders, scientists and the public. Concurrently, the stock assessment process has been improving, and reference points based on F_{MSY} have been estimated: these have implicitly replaced those included in the MP and have been used in the advice for anchovy and sardine in 2015. Finally, in 2015, under request of the EC, the GFCM initiated a process to perform a Management

Strategy Evaluation (MSE) on small pelagics in the Adriatic Sea. The process involved stakeholders from both countries, external experts from Spain, the FAO regional projects and the scientists: a stakeholder consultation was carried out to help defining harvest control rules to be tested, and one technical working group was entirely dedicated to the MSE procedure. Finally, the results were discussed at the GFCM Sub Regional Committee for the Adriatic Sea (SRC-AS). This process was repeated in 2017 and the aim is to include socioeconomic components in a formal MSE process in the future. The close collaboration between SAC-GFCM and STECF is a vital requirement if this exercise is to be successful.

For Nephrops, the main challenges are represented by the biology of the species itself and the structure of the stock in the area: in this respect, the Italian ministry first enforced the closure of the Pomo pit area for 1 year, and subsequently funded a monitoring program to be carried out in the region. In parallel, a process of appraisal and evaluation of the stock and the data available was undertaken and has resulted in scientists, and indirectly the managing bodies, being forced to address and come to terms with important issues. One of those concerned the determination of the geographic scale required for an appropriate evaluation of a stock: the prescriptive notion that Mediterranean stocks should necessarily be assessed on a GSA level was questioned and a methodology was developed to determine Italian catches toward catering for the biological needs of the species (Russo et al., in press). This becomes especially important when the only management measure taken with respect to this species is a spatial one, i.e., the closure of the Pomo pit, but official data are not available at that same scale. It also raises questions on (i) the spatial aspects of data collection (in Croatia for example the statistical data collection is subdivided into smaller areas) and (ii) the appropriateness of necessarily carrying out analytical assessment to manage a species: is management based on a flawed analytical assessment better than management based on direct observations (e.g., the use of UWTV to determine catch limits) or on proxy management of another species (e.g., the management of European hake in the Pomo/Jabuka pit would implicitly serve as a management tool for *Nephrops*)?

We are fully aware that there is still a long way to go to reach a smooth assessment process, an integrated management and an efficient system, but the steps taken not only show a general interest in achieving the result of a sustainable use of the resources, but also manifest the will of scientists to improve their work and their cooperation.

TOWARD THE COMMON FISHERIES POLICY

The management of the fisheries in the Mediterranean is currently facing many challenges and there is no easy solution. The 2020 deadline is getting closer and, despite all the efforts, it is hard to believe that the objectives will be met in time. We feel that the long-discussed issue of regionalization, right now more important than ever, has been forgotten. The next few years will be crucial, but if significant effort is not devoted to solving some

of the issues summarized above, this attempt will likely fail. We don't claim to have the silver bullet, but there are certainly some measures that could increase the probability of success, if not by 2020, within a reasonable time frame. Regionalization could contribute to balance preferences across actors and institutions, improve efficiency in the realization and provide more effective policies and measures (Hegland et al., 2012). Regionalization can occur at different levels and in several forms, and we are not here to propose one or the other. There are several examples around the world, both positive and negative, that might show the way and we should learn from the failures and successes of others. Common features to failures of the regionalization approach are (i) unclear prioritizing with conflicts between fishery and conserving species; (ii) lack of transparency, critical review and broad stakeholder involvement in the definition of management measures; (iii) a patchwork of authorities with their own rules and policies lacking a clear and harmonized role (Ocean2012, 2012; Svedäng and Gipperth, 2012; Soma et al., 2015). Following these general lessons, we think that a start would be to restore the original roles, delegating the technical and advisory aspects of the management of the Mediterranean to the GFCM that, from its inception, has had the mission of collating all the Mediterranean countries into a unique body. In this view, STECF would provide technical support, working side by side with the GFCM-SAC, providing experts and revisions when needed. In this supportive role, STECF should encourage the participation of third countries: this would be beneficial to improve collaboration, to restore a general feeling of trust, to help the formulation of more appropriate advice, and, most importantly, to export knowledge and technical expertise to all Mediterranean countries, leveling skills and therefore improving the management process at all levels. The EU should avoid intervention in the scientific discussion and provide, on the other hand guidance in the technical aspects and capacity building, with clear terms of reference and coordination. This structure, equivalent to archetype 2 proposed by Hegland et al. (2012), hypothesizes considerable authority placed with the GFCM, in order to allow it to develop different approaches to management according to the needs of the countries involved, with the EU maintaining a coordinating role as well the ability to set the overarching goals and the frame for the regional approaches. This setting could be beneficial toward the achievement of an Ecosystem Approach to Fisheries Management helping and guiding the process to reach common agreements on matters such as indicators and methodologies or Good Environmental Status assessment within Mediterranean countries, whose lack of coherence has been seen as a potential impediment to the realization of the objectives of the CFP (Raicevich et al., 2017). Possibly, another outcome of this type of management would also be to reduce the gap between the decision-making body and the place where the management takes place and would favor the communication with third countries taking advantage of a framework that already foresees and facilitates that. In this respect, the GFCM should improve by all means its framework, and establish a revision process of all the assessments carried out, in a stepwise manner, from the input data to the

final advice, to involve external experts from all around the world.

Finally, the establishment of TAC would be an important step forward in the management process. Input control (i.e., effort control) is the traditional system used for managing fisheries in the Mediterranean Sea, but there is clear evidence that it has not achieved its conservation objectives and has actually failed to control fishing mortality (Cardinale and Scarcella, 2017). Although many studies have focussed on the scientific and institutional caveats of the TAC system (see, Kell et al., 2006; Schwach et al., 2007) a case-by-case shift from effort control to a quota system consistent with MSY principles is advisable in the Mediterranean Sea. In particular, the two fisheries considered in the present study are good candidates for such radical change. In this context, the recent GFCM recommendation GFCM/40/2016/1 imposes a catch (and fishing capacity) limit to small pelagics in the Adriatic Sea. This measure is still "business as usual," as it imposes the limit to be equal to the catches of 2014, which were quite high, for sardine in particular. It is, however, a clear change from a strategic management perspective: not only is it a strong move in the right direction but it also implies a MCS system that is effective in governing the small pelagic fishery production in the area. Of course, such change needs to be appropriately analyzed in terms of socio-economic impacts and must be implemented within a participatory framework. The case of *Nephrops* is more complex but could benefit from a similar approach. It is well-established in other areas that analytical assessments may not be ideal for this species (and in the case of the Adriatic still requires a lot of work on data and methods), so a simpler path based on the determination of catch limits derived from UWTV surveys through the application of harvest rates may be a more effective measure for Adriatic *Nephrops*. The setting up of this process would benefit from the experience matured in ICES areas, but would also require an important scrutiny of the data available at present as well as an expansion of the area covered by the surveys. To this end, the role of a strong and legitimate RFMO would be, again, key: it would act as a facilitator, ease enforcement, and allow access of all countries to the negotiations.

FINAL REMARKS

In this paper we tried, at the best of our knowledge, to summarize the changes and the challenges that Mediterranean fisheries have been facing in the last decade, using two case studies as an example. We are far from having the silver bullet able to solve all issues and bring the Mediterranean close to the 2020 target, but surely there is a very evident need for a common effort from all the parties involved. Regionalization has been put forward as one of the focal points of the new CFP, but we feel that somehow this feature has been lost along the way, despite the CFP anticipates tools to incorporate the regional perspective, e.g., the multiannual plans (Prellezo and Curtin, 2015), and we believe it's worth to work on that. We don't insist in putting forward one scientific and management body or the other, but an efficient use of the available instruments would, with the minimum effort, maximize

the yield and surely contribute to achieve the MSY objective in the next decade.

AUTHOR CONTRIBUTIONS

PC conceived the work. All authors wrote and revised the paper.

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ACKNOWLEDGMENTS

We wish to thank Dr. Elisabetta B. Morello for the discussions, the suggestions and the revisions that greatly improved the manuscript. We thank Callum Scougal for the map and the editors and two reviewers for comments and suggestions.

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Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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