Marine Policy xx (xxxx) xxxx–xxxx

Contents lists available at ScienceDirect

Marine Policy

journal homepage: www.elsevier.com/locate/marpol

Small-scale coastal fisheries in European Seas are not what they were: Ecological, social and economic changes

Josep Lloret[a,*], Ian G. Cowx[b], Henrique Cabral[c], Margarida Castro[d], Toni Font[a], Jorge M.S. Gonçalves[d], Ana Gordoa[e], Ellen Hoefnagel[f], Sanja Matić-Skoko[g], Eirik Mikkelsen[h], Beatriz Morales-Nin[i], Dimitrios K. Moutopoulos[j], Marta Muñoz[a], Miguel Neves dos Santos[k], Pedro Pintassilgo[l], Cristina Pita[m], Konstantinos I. Stergiou[n,o], Vahdet Ünal[p], Pedro Veiga[d], Karim Erzini[d]

[a] Institute of Aquatic Ecology, University of Girona, Spain
[b] Hull International Fisheries Institute, University of Hull, UK
[c] MARE – Marine and Environmental Sciences Centre, University of Lisboa, Portugal
[d] Centre of Marine Sciences (CCMAR), University of Algarve, Portugal
[e] Centro de Estudios Avanzados de Blanes (CEAB-CSIC), Spain
[f] LEI/Wageningen, The Netherlands
[g] Institute of Oceanography and Fisheries, Croatia
[h] Norut Northern Research Institute, Norway
[i] IMEDEA-CSIC/UIB, Spain
[j] Technological Educational Institute of Mesolonghi, Greece
[k] IPMA - Instituto Português do Mar e da Atmosfera, I.P., Portugal
[l] Faculty of Economics and Research Centre for Spatial and Organizational Dynamics, University of Algarve, Portugal
[m] Department of Environment and Planning & Centre for Environmental and Marine Studies (CESAM), University of Aveiro, Portugal
[n] School of Biology, Aristotle University of Thessaloniki, Greece
[o] Institute of Marine Biological Resources and Inland Waters, Hellenic Center for Marine Research, Greece
[p] Faculty of Fisheries, Ege University, Turkey

ARTICLE INFO

Keywords:
Artisanal fisheries
Recreational fisheries
Selective fisheries
Marine protected areas
Traditional ecological knowledge

ABSTRACT

Coastal, small-scale fisheries (SSF), whether artisanal (professional) or recreational, represent important socioeconomic activities across Europe that are currently undergoing a number of changes. This paper reviews and analyses the drivers of these changes, and makes recommendations for the future management of SSF. From the biological standpoint, the use of fishing gears that actively select certain species, sizes and sexes, the deployment of fishing gears on certain fragile habitats, the loss of fishing gears and the use of non-native species as bait are examples of how SSFs can threaten the sustainability of vulnerable coastal species and habitats. From a socioeconomic perspective, several factors are altering the traditional characteristics of coastal SSF. Among the most important is the growth of recreational fisheries in coastal waters and the disappearance of traditional low technology fisheries or their substitution by more mechanised, technical fisheries, which is leading to a loss of the traditional ecological knowledge held by artisanal fishers. On the other hand, the increasing competition between artisanal and recreational fisheries, and between them and commercial fishing operations, are also altering the classical features of coastal fisheries in some European countries. SSFs must adapt to the requirements of the new Common Fisheries Policy (CFP), namely management based on Maximum Sustainable Yield (MSY), multi-annual management plans and ecosystem based principles. It is concluded that it is necessary to integrate different assessment approaches (biological, social and economic), with active participation from stakeholders, governments and relevant research institutions, to better evaluate and manage coastal fisheries.

* Correspondence to: University of Girona, Institute of Aquatic Ecology, Campus Montilivi, 17003 Girona (Catalonia), Spain.
E-mail address: josep.lloret@udg.edu (J. Lloret).

http://dx.doi.org/10.1016/j.marpol.2016.11.007
Received 26 April 2016; Received in revised form 7 November 2016; Accepted 7 November 2016
Available online xxxx
0308-597X/

Table 1
Small-scale fisheries (SSF) trends in vessel numbers by EU Member State in the period 2000–2010. Data from [2] after Community Fishing Fleet Register (CFR) http://ec.europa.eu/fisheries/fleet/index.cfm. (1.1.2000, 1.1.2005 and 30.6.2010).

	2000	2005	2010	% change 2000–2010
Belgium	*1*	1	1	0
Bulgaria	*2,694*	2,443	2,217	−18
Cyprus	*706*	824	962	36
Germany	1,885	1,772	1,369	−27
Denmark	3,176	2,619	2,318	−27
Spain	13,272	10,415	7,958	−40
Estonia	*877*	866	855	−3
Finland	3,544	3,244	3,266	−8
France	6,790	6,799	6,212	−9
Great Britain	6,294	5,791	5,369	−15
Greece	18,515	17,228	16,138	−13
Ireland	1,261	1,543	1,830	45
Italy	12,869	10,317	9,379	−27
Lithuania	*310*	196	124	−60
Latvia	*812*	746	685	−16
Malta	*1,426*	1,196	1,003	−30
Netherlands	367	254	316	−14
Poland	*1,067*	791	590	−45
Portugal	9,815	9,123	7,737	−21
Romania	*388*	419	453	17
Slovenia	*146*	155	165	13
Sweden	1,680	1,295	1,140	−32
TOTAL EU	87,894	78,037	70,087	−20

Note: Values in italic were extrapolated by [2]

1. Introduction

Coastal fisheries, whether artisanal, recreational, subsistence[1] or a combination of the above, play an important socioeconomic role across Europe [1]. They often (but not always) fit into the category of small-scale fisheries (SSF), which according to the reformed European Union (EU) Common Fisheries Policy (CFP) in 2013 are defined as “fishing carried out by fishing vessels of an overall length of less than 12 m and not using towed fishing gear”.

In the EU, SSF fishers provide direct employment for ≈100,000 people (about 70,000 or 84% of the 25 EU Member State fleets can be considered as SSF) [1]. Greece (23%), Spain (11%), Portugal (11%), Italy (13%) and France (9%) account for the largest share of the total small-scale fleet [2]. Small-scale European fleets, compared with large-scale fleets, are composed of smaller vessels and, consequently, travel shorter distances to fishing grounds (fishing operations last usually one day or less with a usual radius of operation within 12 nm of the home port) [1,2]. The vessels are owner-operated and require relatively low capital investment compared with large-scale vessels. They have lower fuel consumption, making them less sensitive to changing oil prices, and dependence on subsidies is lower. They have smaller crews (1–3 fishers per vessel), although the global employment figure is similar to that of large-scale fleets in Europe. SSF vessels use a wide variety of fishing techniques, which are mostly (but not exclusively) passive gears to target a wide array of seasonally changing resources, although their overall catch is generally low. This relatively low catch has, however, a high unit value and the product is often destined for local or tourist markets with high purchasing power in the EU. Small-scale fishers are, in general, less involved in the fisheries decision-making process [1].

Because of the small scale nature of these fisheries (smaller catches, lower impact on habitats, less annual fuel oil consumption, less bycatch and discards and less catch reduced to fishmeal and oil) they are often considered to have less ecological impact than large-scale fisheries [3]. Furthermore, coastal SSF are often characterized by their contribution to coastal community development, rural livelihoods and/or poverty alleviation, and, in the particular case of artisanal fisheries, for their socio-cultural value [4].

Despite SSF being generally perceived as low impact that generate few discards [5, and references therein], these fisheries can affect fish stocks due to continuous, often substantial, fishing effort [6]. Although the biological impacts and socioeconomic features of coastal SSF have been increasingly studied [7], the socioeconomic and ecological changes that they are facing, have received less attention. This paper is the outcome of an international workshop held in Faro, Portugal, 15–16 September 2011 funded by the European Science Foundation, which was attended by 24 scientists experts in commercial and recreational SSF, from 8 European countries, to discuss the challenges and opportunities surrounding coastal fisheries around Europe. The paper aims to review the problems faced by European SSF, and identify options for attaining sustainability of coastal fisheries for future generations, maintaining livelihoods and ensuring food security. Although the problems analyzed may not well fit in all SSF scenarios in Europe, this study characterises the most important SSF types (artisanal, recreational and subsistence) and issues common between them, particularly in a regional or country context. Section 2 considers the main changes in SSF in Europe, while Sections 3 and 4 analyze the main biological, ecological, social and economic factors affecting the development of SSF.

2. The changing situation of SSF in Europe

2.1. The poor status or artisanal fisheries

Although artisanal SSF are still the most important component of commercial fishing activities in the EU, and its special relevance in many southern European countries, the fleet size has been declining since 2000 in many countries [2]. For instance, the EU small-scale fleet has declined from about 90,000 in 2000 to just over 70,000 in 2010, a decline of about 20% in ten years (Table 1). This decline has been greater in countries such as Spain, Lithuania, Poland and Sweden, with declines of more than 30%, and offsets increases in some countries (e.g. Cyprus and Ireland), or the relative stability observed in other countries, such as the Netherlands. As a consequence, the relative role that SSF play in regional European economies has dropped 20–30% in terms of employment and 30–50% in terms of incomes [2]. SSFs are at risk of disappearing in places such as Blekinge (Sweden) [8] and Cape Creus (Spain) [4]. Norway, a major fishing nation that is not a member of the EU, has also seen a large reduction (55%) in the number of SSF vessels (below 11 m) between 2000 and 2010 [9]. In fact there has been a steady decrease of new SSF vessels entering the fisheries in the EU since 2000 [2]. The reduction in the number of fishers has led to a reduction in the catch from artisanal fisheries in certain areas (e.g. in the Mediterranean (Fig. 1A) and Atlantic European zones, Fig. 1B).

The decline of artisanal fisheries in many coastal zones is leading to a loss of traditional ecological knowledge (TEK) of fishers [10]. The loss of TEK, apart from the disappearance of the associated socio-cultural value itself, and (potential) loss of revenue for fishers, is also leading to a loss of opportunities for scientists to improve their understanding of complex coastal ecosystems. TEK is being extensively used to complement information on abundance and life history traits of coastal fish species. Lastly, it may also be possible that the loss of TEK could lead to an increasing risk of losing traditional fishing gears because fishers are

[1] Given there is still some debate surrounding the definitions of recreational (1), artisanal (2) or subsistence (3) fisheries, which may change from country to country, for the purpose of this paper we use the current FAO definitions and terminology: (1) ‘Any fishing for which the primary motive is leisure rather than profit, the provision of food or the conduct of scientific research, and which may not involve the sale, barter, or trade of part or all of the catch.’, (2) ‘Traditional fisheries involving fishing households (as opposed to commercial companies), using relatively small amount of capital and energy, relatively small fishing vessels (if any), making short fishing trips, close to shore, mainly for local consumption. In practice, the definition varies between countries, e.g. from gleaning or a one-man canoe in poor developing countries, to more than 20m trawlers, seiners, or long-liners in developed ones’; (3) ‘A fishery where the fish caught are consumed directly by the families of the fishers rather than being bought by middle-(wo) men and sold at the next larger market.’

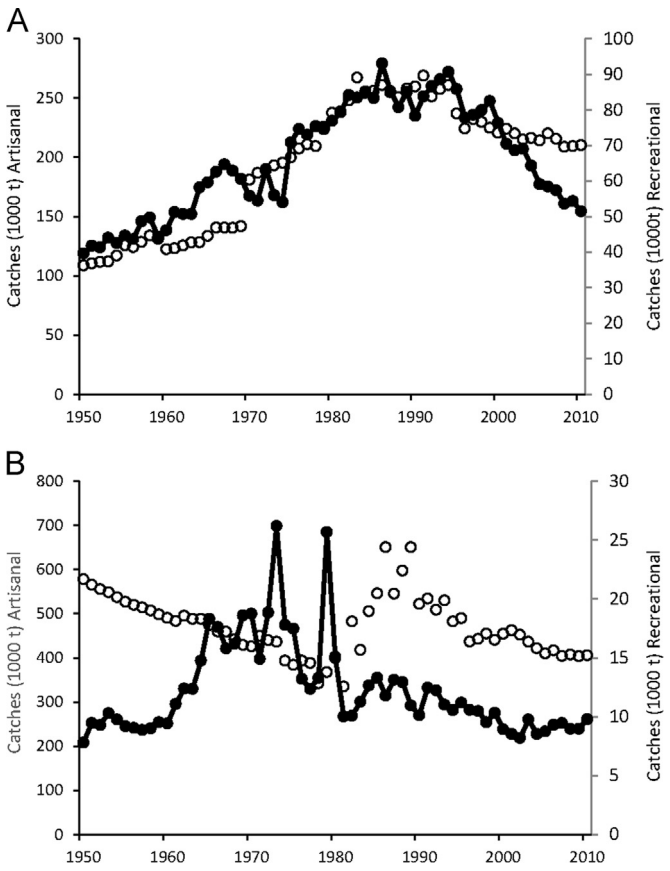

Fig. 1. A. Reconstructed catches of artisanal (black dots) and recreational (white dots) fisheries in a selection of European Mediterranean zones that includes Spain (mainland, Mediterranean and Gulf of Cádiz), France (Mediterranean), Italy (mainland) and Greece (without Crete) during 1950–2010 (data from http://www.seaaroundus.org). Reconstructed catches combine the official reported data (mainly extracted from the Food and Agriculture Organization of the United Nations (FAO) FishStat database) and reconstructed estimates of unreported ones (including major discards), with reference to individual economic exclusive zones (EEZs). The "Reported catch" line represents all catches deemed reported (including foreign) (for methodology see http://www.seaaroundus.org). B. Reconstructed catches of artisanal (black dots) and recreational (white dots) fisheries in a selection of European Atlantic zones that includes United Kingdom, France (Atlantic Coast), Spain (Northwest) and Portugal (mainland) during 1950–2010 (data from http://www.seaaroundus.org). Reconstructed catches combine the official reported data (mainly extracted from the Food and Agriculture Organization of the United Nations (FAO) FishStat database) and reconstructed estimates of unreported ones (including major discards), with reference to individual economic exclusive zones (EEZs). The "Reported catch" line represents all catches deemed reported (including foreign) (for methodology see http://www.seaaroundus.org).

losing their understanding of the habitats where they deploy such gears. A decline in SSF potentially may also result in a decrease in tourism opportunities in some European countries because SSF provide alternative "fishing-tourism" activities as well as high quality seafood to local restaurants. Actively involving fishers in the decision-making process not only encapsulates otherwise unavailable traditional and local knowledge, it also gives legitimacy to rules and regulations and is more likely to result in management strategies that are respected and complied with willingly [11].

2.2. An increase of recreational fisheries

A large number of people fish for pleasure in Europe, with more than 25% of the population participating in recreational fisheries in some countries [12]. Overall, there has been an increase of the catch made by recreational fishers since the 1980 in both the Atlantic and Mediterranean coasts (Fig. 1). Altogether the revenues gained and fish caught can be considerable. For example, in the Netherlands, around 650,000 sea anglers (in a population of 17 million) spend more than € 150 million per year on their hobby, and per person they catch considerable numbers of fish, including 0.5–2 kg of cod per year [13].

Increasing levels of tourism and leisure time, the latter especially by ageing populations, means there is more time for hobbies including fishing. For example, in Norway there has been an increase in marine fishing tourism since the year 2000 [14]. In 2009 tourists participating in the Norwegian professional marine fishing tourism sector (i.e. companies providing fishing boats and facilities as part of the tourism product) caught 3335 t of fish [15]. It is likely that this value is an underestimate, as many tourists rent private cabins or stay with family and friends and are not included in the estimate above. Norwegian residents do not need any license or registration to carry out marine recreational fishing in Norway. They can sell catch to approved buyers up to a total value of NOK 50,000 per year (approximately € 6000). Norwegian citizens can also catch as much marine fish as they want for their own consumption. Tourists in Norway can also fish without any permits, but they cannot sell their catch. Many fishing tourists specifically target "trophy fishes" [14], typically large individuals that could be important for local stock recruitment. Both Norwegian residents and foreign tourists are allowed to take up to 15 kg of fish plus one whole trophy fish with them out of Norway. Similarly, despite the main motivation for visiting Mallorca not being recreational fishing, 2.4% of tourists fished during their holidays resulting in an important economic revenue for the island [16]. Angling activities of single fishers are also complemented by fishing competitions, which have become very popular in some areas, such as the Mediterranean and the Atlantic [17]. Charter fishing (which is a commercial activity carried out for profit with professional guides assisting recreational fishers), is also becoming more popular and is already relatively common. This adds to the increasing numbers of retired professional fishers who continue their activities after retirement but fish under a recreational license, in some cases still using commercial gears, and selling all or part of their catch. In some countries, such as Spain and Turkey, it appears that most retirees who remain active reach some kind of unofficial agreement with the guild to which they belonged, allowing them to sell a certain amount of their catch - subject, theoretically, to certain limitations. Recreational fisheries in these circumstances cannot be classified as a leisure activity and should be considered as illegal, unreported and unregulated (IUU) activities. This has become a source of conflict, aggravated by commercial vessels being subject to much stricter licensing requirements.

2.3. SSF and the new Common Fisheries Policy (CFP)

In conjunction with the Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC), with its goal of achieving Good Environmental Status (GES) of EU marine waters by 2020, the new CFP, adopted in 2013 (EC regulation nr. 1380/2013) and entered into force on January 1, 2014, aims to address the shortcomings of the 2002 reform with regards to a lack of environmental and social sustainability and poor economic performance [18]. Objectives for achieving environmental sustainability, orientate around addressing fleet overcapacity and excessive fishing pressure which result in a high proportion of stocks being overfished. Actions include elimination of overfishing in the short term, reducing the harvest of juvenile fish, reduction of overcapacity and discards, implementation of decision-making systems consistent with long term sustainability, and improved responsibility, compliance, and availability of scientific advice and economic data. To address the problems of discarding, the new CFP introduced a landings obligation (LO) that represents a significant change from management based on monitoring of landings to monitoring based on catches [19]. The new CFP includes three main actions in support of SSF: extend to 2022 the right for member states to restrict fishing within 12 nautical miles; excludes SSF from transferable fishing concessions schemes; and include a series of financial measures beneficial to SSF that should

help local economies adapt to the changes.

Implementation of the CFP for SSF, such as those in the Mediterranean, faces a number of challenges [20]. Such fisheries are generally highly multi-specific and multi-gear in nature, with no quotas or Total Allowable Catches (TACs). In the absence of "output" controls such as quotas or TACs, management is based on "input" controls, namely measures to control fishing effort, to reduce fishing mortality, and technical measures such as minimum mesh sizes and minimum landing sizes that aim to reduce catches of undersized fish. Lack of catch limits, compounded by often high levels of non-compliance results in most SSF being over exploited [21].

Management of SSF is done at member-state (MS) level, with each MS being responsible for its own fisheries. Not all SSF have management plans but when they exist, they are often implemented locally, for specific fisheries, characterized by particular gears, fishing grounds, target species and by-catch. For approval of the management plan, it must be proven that the small-scale fishery in question is selective and has a minimal impact on the environment. Given the lack of management plans for all SSF in the EU, and the number and variety of SSF in the EU, the number of multi-annual management plans required in the future is likely to be very high, with correspondingly high costs and requirements in terms of data collection, stock assessment, monitoring, inspection and implementation.

How the LO is to be implemented in each MS (i.e. a discards management plan, including the processing of by-catch and unwanted catches under the LO) must be stipulated in the multi-annual management plans, prepared according to Articles 18 and 19 of Council Regulation (CE) 1967/2006. The multi-annual management plans must also include safeguards for remedial action where needed and review clauses. Under the current CFP, MSY is a target that must be contemplated in the multi-annual plans, along with a deadline for achievement of the MSY target. Given that there is no assessment for the vast majority of commercial species exploited by SSF (i.e. data-deficient stocks), estimation of MSY will depend on the development and application of new data-deficient stock assessment methods [e.g. 22].

The MS will also be required to provide documentation reporting monitoring of compliance with the LO, namely regarding all fishing operations and on-board monitoring systems. However, monitoring of by-catch and discarding practices on-board using observers or technology such as on-board cameras may not be feasible in SSF due to the vessels' small size or will be prohibitively expensive for the many thousands of small-scale fishing vessels of the EU [23].

Despite large investment in selectivity studies, improvements in selectivity in the short term are unlikely for relatively unselective static gears, such as gillnet and trammel nets. Given the large number of landing sites in each of the MS, the relatively small amounts of discards or unwanted catches from SSF, the projected costs of handling the discards within the LO framework and the lack of existing structures on land for making use of the discards, compliance with the LO will be difficult or not feasible for many SSF. Exceptions where the LO will not apply are for species which cannot legally be caught, species where scientific studies have shown that there is high survival rates after discarding back to the sea, species that have suffered predator damage, and those with catches covered by *de minimis* exemptions, that can extend to up to 5% of the total catches of all species covered by the LO. These *de minimis* exemptions are for situations where there is scientific proof that gear selectivity cannot be improved, or for cases where implementation of the LO would constitute disproportionate costs to the fishers (e.g. handling and storing the by-catch on board, transporting the by-catch and creating a use for the by-catch other than human consumption).

3. Biological and ecological threats to coastal fisheries

Despite coastal fisheries usually being considered to have less ecological impact than industrial fisheries, from a biological standpoint there are several characteristics of these fisheries that threaten the sustainability of vulnerable coastal species and habitats that have received little attention. Some of these key characteristics are reviewed in the following sections to help orientate future management frameworks for SSF.

3.1. Lack of information on coastal fisheries

Despite the important biological and socioeconomic challenges facing coastal fisheries in European marine waters, SSF are not studied to the same intensity as industrial or large-scale fisheries. Biological data are scarce and only available from a small fraction of both small-scale and recreational fishing components [24]. Available data are fragmented in time and space because there is no monitoring framework in place, except in some Marine Protected Areas (MPAs) where artisanal fisheries are monitored, and only a few coastal fish species are being assessed, but mostly focus on the major marine sectors, namely the pelagic and demersal trawl fleets [25]. Within the framework of the European Data Collection Plan (EU regulation 2001/1639), however, it has now become obligatory to gather economic data on all fishing activities, but collection of such data is only relatively recent [25]. Biological data collection is also usually restricted to standards that make sense in an European context, resulting in less visibility of SSF, such as data being projected onto maps built around the so-called ICES statistical rectangles, which is a large-scale setting that does not link with the spatial scale used by coastal SSF.

Besides logistic constraints to achieve full coverage of SSF activities, fishers often under-report their catches [26]. Consequently, total SSF catches are likely substantially higher than landing statistics suggest, indicating that IUU components probably contribute a significant proportion of catches [26]. Thus, misreporting and under-reporting of catches in coastal fisheries are serious issues contributing to discrepancies in the information about the status of stocks targeted by these fisheries, and, consequently, to their inadequate conservation and management.

3.2. Selective character of coastal fisheries: pros and cons

Small scale, inshore artisanal and recreational fisheries often fall under the category of "selective fisheries" because they traditionally use highly selective fishing methods, such as, spearfishing, hand collection, jigging and trolling, octopus and fish traps and uncovered stationary pound nets, all of which have little or no associated discards and bycatch (the unintended capture of species that are not usually target species) [27]. Unlike industrial fishing systems such as trawling, some artisanal and recreational fishing gears generally only catch individuals that surpass the minimum legal landing size (MLS) and size at sexual maturity for the species in question. For example, small longline hooks used in southern Portugal catch few fish of any commercial species under the MLS [28]. The same pattern was found for shore angling in southern Portugal [29]. This is important in the sense that individuals can achieve maturity and reproduce, and can therefore offset the growing problem of recruitment overexploitation of juveniles typical in some EU regions.

However, the negative effects of selective fishing in SSF has largely been overlooked. Many fishing gears used by small scale commercial and recreational fisheries in the Mediterranean select certain species, sizes and sexes that are appreciated gastronomically. There is also traditionally a local demand for regional, high-quality products, like rockfishes, that can only be supplied by SSF. Selective fishing may also have considerable adverse effects in the ecosystems, such as altering biodiversity and changing ecosystem functioning by removing key species (e.g. top predators) or specific size classes [30]. As a consequence, artisanal fisheries may impinge on the stock dynamics of coastal fish species through a number of mechanisms.

Firstly, size-selective artisanal and recreational fishing, particularly longline and spearfishing, affects hermaphrodite fish species, such as dusky grouper *(Epinephelus marginatus*), which can constitute a significant fraction of the catch. Fishing may disproportionately remove members of one or other sex, thereby skewing sex ratios leading to egg or sperm limitation [31]. This is particularly important for many species of Sparidae that are protrandric hermaphrodites (the individual begins life as a male and later switch to a female), where the largest individuals are female. The artisanal longline fishery in the Straits of Gibraltar is, for example, highly species selective for blackspot sea bream (*Pagellus bogaraveo*). Here the mean size of fish caught has fallen below the female size at maturity over a period of less than 20 years, leading to reduced recruitment and a decrease in population genetic variability because of the relatively small number of adult females [32]. In Northeast Spain, the average landing size of the protogynous species dusky grouper (49.1 cm) is far below its sex-change size (the size at which females switch to males, which is about 80–90 cm) and explains why artisanal fishing catches only females, thereby disrupting the sex structure of the population, because few specimens can reach the sex-change size [31]. Secondly, although removal of breeding individuals from any population has important consequences, regardless of the mating and breeding system, a number of the coastal species caught display complex mating behaviours with nest building strategies - with or without parental care, which may accelerate rates of population decline inadvertently due to harvesting [31]. For example, rockfish stocks in Portuguese waters have suffered from depletion with population resilience declining due to the removal of larger and older fish [33]. Finally, the removal of large individuals by small scale artisanal and recreational fishing can also adversely affect reproductive potential because larger females are more fecund, reproduce over an extended period and spawn bigger eggs and larvae with better survival rates than smaller females [31]. In some fisheries, a maximum size has been proposed to protect large fecund females but such a measure can only be effective if survival rates of released individuals are high, and needs to be combined with minimum landing sizes and low fishing mortality.

This problem of changing selectivity patterns has been exacerbated in recent years because in many places there has been a reduction in the diversity of artisanal fishing gears used by fishers, as many traditional techniques have fallen into disuse (e.g. the number of artisanal fishing gears used in the Cape Creus region of Spain has declined from around 14 in the 1960s to just five in the 2010s). The abandonment of traditional gears or techniques is often associated with depletion of their target species. In the Balearic Islands, for example, several artisanal gears are no longer in use because of decline in abundance of groupers and large sparids, among other species that have been heavily impacted by spear fishers throughout the Mediterranean [34]. Similarly, the introduction of trammel nets for lobster in the 1960s has made the use of traditional traps unprofitable due to the reduced abundance of lobsters and lower catchability of traps [35].

These changes have contributed to an increasing pattern of species/size selection by SSF. Currently the catch in many places is mostly concentrated on a few species, thereby altering the traditional balanced exploitation found in such diverse fisheries [30], and making some species more prone to overexploitation, as has occurred with scorpionfish *Scorpaena* spp. and spiny lobster *Palinurus elephas* in certain Mediterranean coastal areas of Spain and France [36]. It should be also stressed that a number of the targeted (selected) species are included in international conventions for the protection of biodiversity, such as those of Barcelona, Bern and Washington (CITES), the IUCN Red List or the EU Habitats Directive, or have a high vulnerability index [36]. The most vulnerable coastal species are deemed to be long-lived and slow-growing species with low reproductive potential (i.e. low number of viable offspring produced by a spawning stock) and a narrow geographic range [37], such *Epinephelus* spp., large labrids (e.g. *Labrus merula* and *L. viridis*), large sciaenids (e.g. *Sciaena umbra*) or large scorpaenids (e.g. *Scorpaena scrofa*). Vulnerable species represent a large proportion (> 50%) of artisanal fisheries landings in some areas, such as in the Strait of Bonifacio in France, whereas some species, such as large labrids (*L. merula* and *L. viridis),* have become very rare in parts of the Mediterranean [36]. Furthermore, many of these vulnerable species targeted by SSF are typically top predators and their removal contributes to fishing down the food web. These species are therefore not only vital to SSF, but also potential indicators of environmental health [e.g. 38]. There is increasing evidence that many coastal marine species may be placed under threat of local, regional and ultimately global extinction by the direct or indirect effects of selective fishing [30]. Therefore, the old fishing patterns based on a wide variety of gears and a larger number of target species may have provided a more balanced exploitation approach over time in coastal waters that could help achieve ecosystem-based fishery management.

3.3. Discards and by-catch

Despite discards and bycatch from coastal SSF usually being considered low compared with other fisheries such as trawling (Mediterranean SSF often discard less than 15% of the catch, contrasting with trawl fisheries that discarded 20–70% of the catch) [36], the problem could be higher than generally assumed, partly because data for this sector are still limited, but also because not all gears used are selective. This is especially true for trammel nets, widely used in southern European artisanal fisheries, which catch a wide variety of species and size ranges, and are characterized by relatively high bycatch and discard rates (up to ≈25%) [39]. Gillnets and longlines, also widely used in SSF, whilst being more species selective than trammel nets, also can catch considerable quantities of non-target species and exhibit discarding (up to 30%), including vertebrates such as seabirds, sea turtles and marine mammals [26,28,39]. For example, discarding from gillnetting targeting hake in the Ionian Sea can reach 30%, and trammel-netting targeting prawns in Izmir Bay (Turkey) and spiny lobster (*P. elephas*) in Spain may exceed 40% [36]. Gillnets do not harvest the largest individuals of certain species due to their size selective nature, especially where an optimal mesh size targeting specific species is retained. Furthermore, due to difficulties selecting an optimal legal mesh size in multispecies gillnet fisheries, such as those in southern European waters, generally catch significant quantities of undersized individuals of some species [28,40].

3.4. Catch and release

The practice of “catch & release” (C & R) is increasingly being followed by many recreational fishers, and despite *a priori* C & R seeming positive because fish are released alive after being caught, the practice is raising concerns [41]. Certain angling and handling techniques can cause great stress and subsequent death among fish that are caught and then released [41]. Different factors contribute significantly to mortality including hooking in internal organs, use of natural bait, removing hooks from deeply hooked fish, water depth of capture and warm water temperature [41]. Many of the harmful effects can be avoided by minimizing the duration of the activity, changing the hook size and configuration, and minimizing or eliminating handling and time out of the water. The practice of C & R in recreational fisheries differs greatly depending on the coastal area. In some French and Spanish zones the practice is not widespread (< 20% of recreational fishers return some of their catch to the sea), probably because most species caught are for human consumption but in other French areas it is estimated that more than 70% of recreational fishers return some of their catch to the sea [42].

3.5. Impact of fishing gears on coastal habitats

Other emerging ecological impacts derived from small-scale, coastal fisheries are related to the loss of fishing gear and the effects of operation on sensitive habitats and sessile species. The massive use of fixed nets (and other artisanal gears such as traps) in many traditional coastal SSF, makes ghost fishing by abandoned or discarded gears a potentially important problem in places such as the Atlantic waters off the coast of the Algarve (Portugal) [43]. SSF around Mediterranean European coasts have also been shown to impact on vulnerable habitats such as sea grass (*Posidonia oceanica*) meadows, coralligenous assemblages and deep rocky habitats that contain sessile and fragile organisms such as gorgonians, sponges and corals, and that constitute an essential habitat for many exploited fishes [36]. The impact can occur in several ways. First, during the deployment and retrieval of the gear, with anchors and gear weights damaging benthic organisms. Second, through the loss of fishing gears such as nets and hooks and lines. These lost gears affect fish through ghost fishing as they continue to entangle and catch fish, but also sessile animals such as corals and gorgonians, to which the lost gear cause abrasion [44]. The deployment of fishing gears on these fragile habitats, and the loss of fishing tackle constitutes indirect impacts that have been poorly studied; most studies have focused on the impact of trawling on the seabed.

It is also common for recreational fishers to lose, or discard, all kinds of fishing gear, such as lead weights, buoys, lines and hooks, which can cause considerable impacts on the marine ecosystem [42]. In addition, anchoring recreational fishing boats in sensitive habitats such as *Posidonia oceanica* meadows and coralligenous reefs, is increasing with increasing numbers of recreational fishing boats using these areas [42]. In the Portinho de Arrábida, Portugal, one of the few and by far the largest coastal sea grass meadows along the coast of Portugal, declined over several decades and disappeared in 2007 due to the combined effects of dredging for bivalves and anchoring of recreational boats during the summer [45].

3.6. The threats from using exotic species and terrestrial animals as baits

There is an increasing threat from the use of exotic species as bait in recreational fisheries, which can also be a threat to coastal ecosystems [42,46]. In addition, to keep the baits alive and moist, live bait is sometimes packaged with living substrates (e.g., live algae) that fishers commonly discard into the sea and may support other living organisms, such as small crustaceans, snails and worms. This may result in exotic invertebrates establishing in the new ecosystem, as has recently occurred with the introduction of the Korean ragworm (*Perinereis linea*) in Mar Menor (western Mediterranean) [47]. While these exotic, imported baits are not used in artisanal fisheries, pieces of terrestrial animals from butchers and slaughterhouses are occasionally used as baits in basket traps used in artisanal fisheries in specific areas, and these terrestrial baits may cause local contamination problems or constitute a vector of pathogen transmission. We are not aware if these threats from terrestrial or exotic baits occur in other fisheries using baits, such as offshore long-line fishing.

3.7. Temporal changes in fishing effort

Until recently, the general perception was that artisanal fisheries had, generally speaking, a larger impact than recreational fisheries because of much greater fishing effort. This perception is, however, being questioned with an increase in recreational fishing effort and a concomitant decline in artisanal fisheries. For example, estimated rod and line recreational catches for one of the most important target species, the common sea bream (*Diplodus sargus*) were equivalent to 65% of the commercial landings of the SSF on the south and southwest coasts of Portugal [29]. Estimates of total recreational harvest of sea bass for France, the Netherlands, England and Belgium in ICES North Sea and North Atlantic Subareas IV and VII amounted to 1400–1500 t [48]. Similarly, dusky grouper (*E. marginatus)* and brown meagre *(Sciaena umbra)* have become highly vulnerable to spearfishing, one of the common gears used in recreational and sports fishing during the summer along the Mediterranean coast [49,50].

There also appears to have been seasonal changes in recreational fishing effort that have led to changes in exploitation patterns. More people now have the possibility to fish all year round (e.g. retired and unemployed people) and this has extended the fishing season from the tourist (summer) season to other seasons. This pattern seems to have also occurred in artisanal fisheries in some places, such as Cape Creus: in former times some fishing gears, such as trammel nets, were only used in spring and summer when small boats encountered optimum weather conditions. Nowadays trammel nets are used all year round because of upgrading of fishing boats' size, and improvements in engine and gear technologies. Overall, these seasonal changes in fishing effort have broken the "natural seasonal closure" that existed during the winter, which over the long term could affect negatively a number of coastal species.

3.8. "Fishing the line" in marine protected areas

Marine protected areas (MPAs) can be beneficial for rebuilding coastal fish stocks and enhancement of fishing yields [49]. However, the establishment of MPAs, particularly of no-take areas, is often viewed as a conflict between conservation and fishing [36]. Although MPAs with partial protection seem to confer advantages, such as enhanced density and biomass of fish, compared with areas with no restrictions, the strongest responses seem to occur for areas with total exclusion of fishing [51]. However, fishing restrictions in MPAs and the implementation of no-take zones have forced a spatial redistribution of fishing effort to areas adjacent to the new restricted fishing zones [52]. The redistribution of fishing effort has resulted in effort concentration near MPA boundaries ("fishing the line"), that in turn can affect the net export of adult biomass (spillover effect) from the marine reserves outwards into the adjacent waters and weakens the fisheries enhancement benefits of the MPAs [53]. Although this effect may also occur in industrial fishing modalities, such as trawling and purse-seining, it mostly affects SSF in protected areas as has been observed in French, Spanish and Maltese MPAs [36].

3.9. Increasing complexity of coastal fisheries

Recreational fisheries are becoming increasingly more complex because of improvements in technology and gears, which *de facto* increase fishing efficiency. For example, recreational boat and shore fishers in coastal zones now use increasing levels of technology of fishing gears and related components such as boats, and electronic equipment, and take advantage of the latest technologies such as GPS, depth sounders or fluorocarbon lines and graphite in fishing rods. There is also an increasing sophistication of the techniques and bait types used (from artificial to natural ones, with the extensive use of exotic species; see Section 3.6) to target particular species. For example, the 'slow pitch' technique and new artificial lures such as jigs seem to increase the catchability of vulnerable species such as *Dentex dentex* and jigging imported from Japan impacts on squid. Finally, recreational fishing competitions, which are becoming increasingly popular in many places on the Mediterranean and Atlantic coasts, often target certain fish sizes and vulnerable species [34]. For example, spearfishing competitions can temporarily reduce the abundance of *Labrus bergylta*, their main target species, by up to 83% in Galician waters in the north-western Spain [54].

Although it may not be as evident as with recreational fishers, artisanal fishers have also progressively shifted towards more sophisticated fishing gears. Despite the general decline in the number of

artisanal fishers in many coastal areas, certain fishers have invested in larger boats equipped with the latest technology and therefore can employ a much greater fishing capacity than previously. An example is the Balearic Islands where, despite a notable decrease of the number of boats, landings have remained stable [55].

3.10. Negative effects of invasive species

Invasive species are now becoming a serious issue in marine environments, both directly through competition, predation and spread of diseases and indirectly through change in species composition and ecosystem functioning. These species are either deliberately introduced to increase productivity or value of product, especially of aquaculture systems, or they have invaded through human induced pathways such as ballast water, or new waterway connections, such as the Suez Canal; the latter are known as Lessepsian species. While some Lessepsian species provide economic benefits for coastal fisheries in European Mediterranean countries, others cause economic losses. For example, the silver-cheeked toadfish (*Lagocephalus sceleratus*) is causing economic losses to small-scale fishers in the Mediterranean by damaging their fishing gears and eating the fish entangled in the nets. It also poses a risk to human health if consumed, as it is highly poisonous. This species has caused total losses of around € 2 million per year for small-scale fishers along the Mediterranean coast of Turkey [56].

Another invasive species causing concern in the Mediterranean is the jellyfish *Ropilema nomadica*. The jellyfish exhibits frequent bloom events, with huge population explosions, and creates hazards to coastal fishing activities. Sometimes it can account for 80% of gillnet, trawl or purse seiner catches and the fishing gears are so overloaded with this species that fishers leave the nets in the sea [57]. Another important consequence of the jellyfish blooms is reduction in zooplankton and ichthyoplankton biomass and the subsequent altering of trophic webs on which higher predators rely. In this way, jellyfish affect coastal fisheries [58].

3.11. Climate change

Increase of sea temperature is impinging on the abundance of some cold water species by shifting their stock distributions towards colder waters (higher latitudes or deeper waters, see e.g. [59,60]). Together with the habitat expansion for some warm water species [59,60], this is likely to lead to increases in fish productivity at higher latitudes at the expense of tropical and sub-tropical areas [60]. The latter includes southern European coastal areas and many developing countries in Africa and Asia where small-scale fisheries play an important role. SSF could be more affected by climate change in some areas such as the Venice Lagoon (Italy) where the catch is composed entirely of species from cold and temperate latitudes [36]. Whereas recreational fishers may be able to adapt to these shifts provoked by climate change by shifting their operations (hobby) towards new areas, the intrinsic nature of artisanal fishing can be a handicap for many fishers that rely on local, nearshore stocks. The low investment level of the activity (small boat size) does not allow (or restricts) the movement of these fishers to other fishing places when local fish stocks decline for whatever reason. Furthermore, increasing sea temperatures are increasing the threat of invasive species in coastal ecosystems, which in turn can affect SSF. As explained in Section 3.10, state in the Eastern Mediterranean, the invasive species pufferfish (*L. sceleratus*) affects particularly SSF because this poisonous species feeds on commercial species entangled in nets, leading to significant losses of income and damage to fishing gears [56].

4. Socioeconomic factors

4.1. Competition between stakeholders

The increase in recreational and subsistence fisheries is altering the classic features of coastal fishing and placing increasing pressure on vulnerable coastal species, some of which are being intensively targeted by fishers [61]. In many places this is leading to an increase of competition for coastal resources between recreational and artisanal fishers. For example, in two Turkish MPAs almost all (96%) recreational fishers sold their catch on the black market, creating illegal and unfair competition in the market with professional fishers [24]. In other countries such as Spain, the Netherlands and Portugal there are also complaints by professional fishers that recreational fishers sell their catch to local restaurants [36,62]. Although the sale of catches from recreational fishing is not permitted in any Mediterranean EU country (except Malta, where nothing is specified in the legislation), over 50% of managers of Mediterranean MPAs confirmed they are aware of the existence of the illegal sale of catches by recreational fishers [62].

The increase in recreational fisheries raises a major challenge when it comes to measuring economic benefits. Recreational fisheries generate mainly non-market benefits, and hence measuring them requires the use of, for example, contingent valuation and travel cost methods [62]. However, the economic value of recreational fishing is usually significant, as has been shown for Baltic salmon harvested by commercial and recreational fisheries [63].

Small-scale fisheries in Europe also face competition, for space and market access, from other fishing activities such as commercial trawling and recreational activities such as scuba diving or aquaculture. Among these uses, trawling appears to be an increasing source of conflicts with SSF. For example, in Greece and Spain there is strong competition between SSF and trawling in gulfs and other closed areas where trawling fishing is forbidden [4,64]. In the German Baltic coast, competition between SSF and trawling targeting the western Baltic herring (*Clupea harengus membras* L) stocks arose after the decline of the cod stocks [65].

4.2. Other socioeconomic factors

Apart from competition between different fisheries stakeholders, the observed decline in artisanal fisheries in many European countries is driven by other socioeconomic factors. They include a shift in employment towards service activities such as tourism, the substitution of artisanal activities by more industrialised, technical fisheries, and less support from governments (which tends to favour industrial fisheries; [4]). Moreover, the high mean age of artisanal fishers and low profit from most fishing activities threatens the next generation of fishers [4,7]. For example, it is difficult for young fishermen in Greek, Swedish and Spanish waters to continue with the family fishing tradition because they considered that 'there is no future in fishing' and therefore the younger generations look for alternative jobs [4,8,66]. However, in most instances, these alternative employment opportunities are not suitably matched to the skill sets, education or desires of small-scale fishers [2,66].

Another cause for the decline of artisanal fisheries (and other fleets) is related to the management of national quotas using ITQ systems, such as in the Netherlands and Denmark. Fishers, especially young and small scale fishers, find it difficult to get access to quotas, since prices to buy or lease quotas are high [67] and as a solution Dutch SSF fish non quota, high-value species. The immense amount of bureaucracy and regulations (e.g. prohibition to fish for multiple species) are also a handicap for artisanal fishers in countries such as Sweden [8], because they make it difficult for them to sustain their livelihoods and their way of life. Finally, it is also important to note that despite the general decline in number of artisanal fishers, in some places people have

enrolled as artisanal fishers in recent years as the economic crisis has forced them to find supplementary jobs or sources of income [68].

Limited institutional capability to conduct monitoring, control and surveillance of fishing activities is also being exploited by SSF fishers (large number of landing ports, inspections not frequent enough to encourage compliance and lack of control over the issuing of professional SSF licenses in some countries such as Greece). A proportion of the total catch goes unreported, finishing directly in restaurants or on the black market (these landings should not be ignored).

5. Recommendations for the management of coastal fisheries

Modern fisheries management strategies draw on insights into biological, environmental, social and economic issues, and on how they are interconnected at local, regional and/or national scales [69]. Taking into consideration all aspects previously discussed, coastal fisheries are going through a period of major transition that is not only changing traditional perceptions about these fisheries, but is also encompassing new biological and ecological impacts on coastal ecosystems that remain poorly understood or even unknown in some cases. It is difficult to generalise about the social and economic challenges and the associated biological impacts of the recreational and small scale artisanal fishing sectors, because each of the fishing methods has its own characteristics. Nevertheless, a number of recommendations regarding the future of coastal fisheries to address the gaps in knowledge and management were forthcoming from the workshop on which this paper is based. In the face of the sustainability problems of many industrial fisheries, coastal fisheries should play a key role in the search for exploitation patterns with lesser ecological impact, and therefore particular actions are needed to tackle the challenges identified.

5.1. Address the lack of information on coastal fisheries

Given the paucity of high quality data about SSF, it would be desirable to implement cost-effective data collection, promote regular monitoring using appropriate methods (e.g. onboard/port surveys, historical reconstruction through the installation of blue boxes on board vessels). The development and implementation of a common monitoring scheme, for both artisanal and recreational fishing, is urgently needed in European and adjacent waters. In particular, data on new species targeted by recreational fisheries should be collected at sea through the data collection framework (DCF) and social and economic data should be gathered to obtain an accurate profile of these fishers and their activities. Data collection should take into consideration the requirements of newly developed data-deficient methods for stock assessment and the MSY and ecosystem based management guidelines under the reformed CFP. It is essential to investigate in greater depth local fishing practices and the economic dependence of local communities on SSF and recreational fisheries, as well as to improve our understanding of the consequences of stopping illegal fishing on local economies and livelihoods [1]. It is also desirable to implement biological assessment studies using new methods, e.g. fish tracking devices, data loggers, mobile phone systems, spatial analysis/management, models (e.g. Ecopath/Ecosim/OSMOSE/ISIS) and indicators (e.g. trophic level and vulnerability of fish) to improve our understanding of the importance and functionality of these fisheries [e.g. 69]. An integrated comparative assessment of the sustainability of fishing exploitation patterns (combinations of area, season, fishing gear, and target species), which includes biological, conservation, socioeconomic, and management criteria, the so called the “Métier Sustainability Index” is an example of such an approach. It is designed using the traffic lights approach and comprises 25 indicators that refer to the “health” of the fisheries [27].

The monitoring, study and management of coastal fish and fisheries should thus be a priority if a sustainable, integrated use of coastal resources is to be achieved, which is a goal of the EU Marine Strategy framework. In this sense, governments (regional, national and EU) and other institutions with interests in coastal fisheries science, assessment and management (i.e. expert committees such as STECF, GFCM, FAO; research centres, universities and recreational and artisanal fishing organizations or associations) need to address the paucity of information required for appropriate management of coastal resources and make adequate preparation for the challenges arising from environment impacts, climate change and socioeconomic challenges in coastal fisheries. It is also imperative to estimate accurately the social and economic value of coastal fisheries as well as their biological and ecosystem impacts, and compare them against large scale fisheries.

5.2. Implement effective management actions

There is an urgent need for coastal fisheries management to become more adaptive, practical and objective-oriented if we want to maintain SSF for future generations. Where traditional management measures and exploitation patterns are not realising sustainability, it may be necessary to consider some specific actions for SSF. Although many of these actions could also be recommended for other types of fisheries, such as trawling, these actions need to be developed particularly for SSF in specific countries, areas and fishing modalities. They include: (1) Effort control and access limitations [55], with effective surveillance; (2) MPAs and the establishment of new protected areas with no take zones (NTZs) and closed seasons; (3) Promote best practices to reduce bycatch and reduce discard mortality while avoiding damage to sensitive marine species and habitats; (4) Implement existing legislation (and formulation of legislation where it does not exist), such as establishment of recreational fishing licenses [14], and fisheries certification systems and restrictions on gears to protect juveniles and mega spawners; (5) Conduct pilot studies on the ecological and socio-economic feasibility of the landing obligation (discards ban) in different types of métiers that would fall within the SSF umbrella; (6) Promotion of a balanced approach that distributes a moderate fishing effort among species and sizes above the mean length at maturity. A “balanced approach” might alleviate many of the ecological effects of fishing by avoiding intensive removal of particular components of the ecosystem, while distributing a moderate mortality from fishing across the widest possible range of species and sizes in an ecosystem and supporting sustainable fisheries [30]. However, it should be noted some consider that empirical evidence supporting the balanced approach is scarce and questionable [e.g. 70], and that moderate harvesting of resilient species for human consumption, with least possible impact on stocks and ecosystems, is still the most promising approach for sustainable use of the marine resources. (7) In the context of the balanced approach there is a need to promote traditional and less impacting fishing gears. For example, there have been attempts to substitute trawls used in deep water crustacean fishing in Portuguese waters by traps, which have a much lower impact on bottom habitats [71]. In terms of recreational fisheries, there are also examples of attempts to mitigate ecosystem impacts through the use of alternative fishing tackle, such as circle hooks (to minimize bycatch mortality) and non-lead sinkers [e.g. 72].

Having said that, it is also important to recognise that the use of transitional (or adaptive) management strategies will likely be less disruptive to social systems, more likely to build social consensus, and promote more appropriate tools for each situation, rather than extreme actions such as discard bans, quota introductions and spatio-temporal restrictions [73], and these should be considered at the onset. Four steps can be used to manage SSF: (1) diagnose the fishery regularly; (2) enable an adaptive management system; (3) constrain exploitation within ecological limits; and (4) share management responsibilities [74]. Such actions should help address conflicts between commercial and recreational fisheries should they exist [75].

In addition, different economic measures could be considered to improve the economic performance of the fisheries, such as direct selling, which has a potential economic advantage. In some places it is forbidden to sell catches directly to fishmongers or individual buyers (this is considered as black market), although artisanal fishers do not always follow this rule. In some other places, it is legal to sell directly: several Dutch small-scale fishers try to sell their products in organic markets, to local restaurants, and to small organic supermarkets. As these small-scale fishers often target species that are not regulated by quota, they are not obliged to register their fish at the auction [25]. Some catches show a substantial increase in value from the time of landing to the final sale, doubling or tripling their value at the last step of sale. Thus direct sales could be considered if this is done under a regulated system where information about the sale (quantity and price) is recorded. It is also important to give more attention to the seasonal change in value of catches from artisanal fisheries. In some parts of the EU, mostly the south, during the tourist season (summer time) fishers get improved revenues, even though the volume of catches is not great, due to higher demand in restaurants and fish markets.

Poaching, a general word for illegal fishing actions such as fishing in forbidden areas, selling on the black market, using banned gears, using more and longer gears than allowed by regulation, or the existence of retired professional fishers still commercializing their catch, is common in coastal fisheries and must be tackled by increasing surveillance, environmental awareness and enforcement. The EU and its member states must establish specific management plans and legislation for SSF and recreational fisheries. For the SSF sector, it is necessary to determine the social and economic importance of this activity, to gain legitimacy for exploiting fisheries resources and to enhance its development (e.g. through marketing and infrastructure-investments). For recreational fisheries, it is necessary to document/demonstrate the social and economic value of the activity using appropriate indicators, such as the recreational fishing index, contingent valuation, or travel and harvest cost assessment rather than absolute values of the catch to appreciate the considerable economic importance of recreational fisheries [24].

Irrespective of the above measures, steps must be taken regarding the implementation of the landings obligation adopted in the 2013 reform of the CFP. By 2019, all fisheries in the EU managed under the CFP will be required to land all catches, including bycatch, but evidence about the benefits of this action to SSF is still needed [20]. Additional challenges, such as the need to increase labour for handling and sorting on board, as well as processing at ports and raising awareness of fishers to promote fishing strategies that minimize unwanted species and size of fish, also need to be addressed [20,23].

Co-management approaches, promoting fishers' awareness and participation in the decision-making process and implementation in all regulations, are without any doubt needed to help achieve the CFP goals. Managers should promote the involvement of traditional small-scale fishing organizations (such as prud'hommies, confraries or cofradías), which traditionally had responsibilities regarding management of fishing activities in their zones through regulatory, jurisdictional and disciplinary powers. The involvement of recreational fishing clubs and associations in the decision-making process should also be promoted [76]. Participation of fishers in the management process will contribute to incorporate fisher's knowledge and views in the design, zoning decisions, creation and development of new MPAs (particularly no-take zones), as well as the implementation of fisheries management plans, has the potential to increase compliance with rules and regulations. Furthermore, partnership charters between fishers and fisheries managers, such as those established in Port-Cros and Banyuls-Cerbere (France) and the Strait of Bonifacio (Italy), should be promoted as a useful tool to engage fishers in the co-management of their activity. However, it should be recognised that not all small scale fishers are well organised and represented [25]. Finally, area-based fishing rights, commonly referred to as Territorial Use Rights for Fishing (TURFs) programmes, which allocate secure, exclusive privileges to fish in a specified area to groups, or in rare cases individual artisanal fishers, should also be considered. TURFs are based on co-management approaches to common property resources and they promote the transfer or establishment of rights among key fishery stakeholders who have an interest to mitigate or solve some of the problems associated with the use of common resources under open-access regimes. All these aforementioned approaches and management plans should be considered within the framework of the Ecosystem Approach to Fisheries (EAF), the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication [77], and the EIFAC Code of Practice for Recreational Fisheries [78], which represent a global consensus on principles and guidance for artisanal and recreational fisheries governance and development. In this sense governments should respect and protect all forms of legitimate tenure rights of small-scale fishers, taking into account, where appropriate, customary rights to aquatic resources and land and small-scale fishing areas enjoyed by SSF communities.

5.3. Small-scale coastal fisheries policy integration: a multidisciplinary perspective

Considering all biological and socioeconomic characteristics of SSF in the EU, it is concluded that it is necessary to focus on coastal fisheries policy formulation where any further collaborations and discussions should be multidisciplinary, with active participation from stakeholders (artisanal and recreational fishing), government and relevant research institutes and universities. The desired policy issues need to be identified, based on current knowledge, but allowing for adjustments and changes as scientific understanding of coastal fisheries and their impacts increases. The integration of key policy and science needs must create an opportunity to advance key measures that are important to both artisanal and recreational fisheries in a collaborative and multidisciplinary manner. In this context, it is necessary to integrate the different approaches (biological, social and economic), with active participation from stakeholders, government and relevant research institutions, to better evaluate and manage coastal fisheries and the challenges they face if a sustainable use of coastal resources and healthy livelihoods are to be achieved.

Acknowledgments

The authors would like to thank all participants including scientists and stakeholders, at the workshop "Coastal Fisheries", for their ideas and contributions to this paper. The workshop was funded by the European Science Foundation (ESF). Cowx was supported under EU funded CERES project nr. 678193 for drafting the manuscript.

References

[1] O. Guyader, P. Berthou, C. Koutsikopoulos, F. Alban, S. Demanèche, M.B. Gaspar, Small scale fisheries in Europe: a comparative analysis based on a selection of case studies, Fish. Res. 140 (2013) 1–13.

[2] G. MacFadyen, P. Salz, R. Cappell, Characteristics of small-scale coastal fisheries in Europe. Brussels: European Parliament's Committee on Committee on Fisheries. (2011) ⟨http://www.europarl.europa.eu/RegData/etudes/etudes/join/2011/460059/IPOL-PECH_ET(2011)460059_EN.pdf⟩ (last accessed 3.10.16)

[3] J. Jacquet, D. Pauly, Funding priorities: big barriers to small-scale fisheries, Conserv. Biol. 22 (2008) 832–835.

[4] S. Gómez, J. Lloret, M. Demestre, V. Riera, The decline of the artisanal fisheries in Mediterranean coastal areas: the case of cap de Creus (Cape Creus), Coast. Manag 34 (2006) 217–232.

[5] M.I. Batista, C.M. Teixeira, H.N. Cabral, Catches of target species and bycatches of an artisanal fishery: the case study of a trammel net fishery in the Portuguese coast, Fish. Res. 100 (2009) 167–177.

[6] K.I. Stergiou, D.K. Moutpoulos, M.C. Soriguer, E. Puente, P.G. Lino, C. Zabala, P. Montero, L.A. Errazkin, K. Erzini, Trammel net catch species composition, catch rates and métiers in southern European waters: a multivariate approach, Fish. Res. 79 (2006) 170–182.

[7] F. Maynou, B. Morales-Nin, M. Cabanellas-Reboredo, M. Palmer, E. García,

A.M. Grau, Small-scale fishery in the Balearic Islands (W Mediterranean): a socio-economic approach, Fish. Res. 139 (2013) 11–17.
[8] K. Krogseng. The Decline of Small-Scale Fisheries: A Case Study in Blekinge, Sweden. Master Thesis Swedish Univesity of Agricultural Sciences (2016), ⟨http://stud.epsilon.slu.se/8834/1/krogseng_k_160218.pdf⟩ (last ac cessed 04.10.16)
[9] Norwegian Fisheries Directorate. ⟨http://www.fiskeridir.no/content/download/8253/101987/version/6/file/fiskefartoy-2015.xlsx⟩ (last accessed 04.10.16).
[10] M.A. Gasalla, A.C.S. Diegues, People's seas: 'ethno-oceanography' as interdisciplinary means to approach marine ecosystem change, in: R.E. Ommer, R.I. Perry, K. Cochrane, P. Cury (Eds.), World fisheries, a socioecological analysis, Wiley-Blackwell, Oxford, 2011, pp. 121–136.
[11] M. Dimech, M. Darmanin, I.P. Smith, M.J. Kaiser, P.J. Schembri, Fishers' perception of a 35-year old exclusive Fisheries Management Zone, Biol. Conserv. 142 (2009) 2691–2702.
[12] R. Arlinghaus, R. Tillner, M. Bork, Explaining participation rates in recreational fishing across industrialised countries, Fish. Manag. Ecol. 22 (2015) 45–55.
[13] Ecomare. Encyclopedia Man and the environment (2016) ⟨http://www.ecomare.nl/en/encyclopedia/man-and-the-environment/recreation-and-tourism/sport-fishing-rod-and-line/⟩. (last accessed: 15.09.16).
[14] T. Borch, M. Moilanen, F. Olsen, Marine fishing tourism in Norway: structure and economic effects, Økon. Fisk. 21 (2011) 1–17.
[15] J.H. Volstad, K. Korsbrekke, K.H. Nedreaas, M. Nilsen, G.N. Nilsson, M. Pennington, S. Subbey, R. Wienerroither, Probability-based surveying using self-sampling to estimate catch and effort in Norway's coastal tourist fishery, ICES J. Mar. Sci. 68 (2011) 1785–1791. http://dx.doi.org/10.1093/icesjms/fsr077.
[16] B. Morales-Nin, F. Cardona-Pons, F. Maynou, A.M. Grau, How relevant are recreational fisheries? Motivation and activity of resident and tourist anglers in Majorca, Fish. Res. 164 (2014) (45–39).
[17] A.I. Guerreiro, P. Veiga, K. Erzini, Catches of the sport fishing competitions along the Algarve coast (Portugal): species, sizes, catch rates, and trends, Acta Ichthyol, Piscat 41 (2011) 165–169.
[18] European Commission. Green Paper, Reform of the Common Fisheries Policy, 2009.
[19] D. Damalas, Mission impossible: discard management plans for the EU Mediterranean fisheries under the reformed Common Fisheries Policy, Fish. Res 165 (2015) 96–99.
[20] P. Veiga, C. Pita, M. Rangel, J.M.S. Gonçalves, A. Campos, P.G. Fernandes, A. Sala, M. Virgili, A. Lucchetti, J. Brčić, S. Villasante, M. Ballesteros, R. Chapela, J.L. Santiago, S. Agnarsson, O. Ögmundarson, K. Erzini, The EU landing obligation and European small-scale fisheries: what are the odds for success?, Mar. Policy 64 (2016) 64–71.
[21] P. Vasilakapoulos, C.D. Maravelias, G. Tserpes, The alarming decline of Mediterranean fish stocks, Curr. Biol. 24 (2014) 1643–1648.
[22] ICES. Report on the Classification of Stock Assessment Methods developed by SISAM. ICES CM 2012/ACOM/SCICOM:01., 2012, 15 pp.
[23] S. Villasante, C. Pita, C. Pazos Guimeráns, J. Rodrigues, M. Antelo, S. Rivero Rodríguez, J.M. Da Rocha, M. Coll, G. Pierce, L. Hastie, R. Sumaila, R, To land or not to land: how stakeholders perceive the zero discard policy in European small-scale fisheries?, Mar. Policy 71 (2016) 166–174.
[24] S. Tunca, V. Ünal, B. Miran, H. Güçlüsoy, A. Gordoa, Biosocioeconomic analysis of marine recreational fisheries: a comparative case study from the Eastern Mediterranean, Turkey, Fish. Res. 174 (2016) 270–279.
[25] B. De Vos, M. Kraan, To define or not to define; implications for the governability of small-scale coastal fisheries in the Netherlands, in: Jentoft Svein, Ratana Chuenpagdee (Eds.), Interactive Governance for Small Scale Fisheries, Global Reflections, Springer, Heidelberg, 2015, pp. 629–647.
[26] FAO, Report of the Expert workshop to estimate the magnitude of illegal, unreported and unregulated fishing globally, FAO, Rome, 2-4 February 2015, ⟨http://www.fao.org/3/a-i5028e.pdf⟩.
[27] E. Tzanatos, J. Castro, A. Forcada, S. Matić-Skoko, M. Gaspar, C. Koutsikopoulos, A Métier-sustainability-index (MSI25) to evaluate fisheries components: assessment of cases from data-poor fisheries from southern Europe, ICES J. Mar. Sci. 70 (2013) 78–98.
[28] K. Erzini, J.M.S. Gonçalves, L. Bentes, P.G. Lino, J. Cruz, Species and size selectivity in a multispecies Portuguese artisanal longline fishery, ICES J. Mar. Sci. 53 (1996) 811–819.
[29] P. Veiga, J. Ribeiro, J.M.S. Gonçalves, K. Erzini, Quantifying recreational shore angling catch and harvest in the south of Portugal (Northeast Atlantic): implications for conservation and integrated fisheries management, J. Fish. Biol. 76 (2010) 2216–2237.
[30] S.M. Garcia, J. Kolding, J. Rice, M.J. Rochet, S. Zhou, T. Arimoto, Reconsidering the consequences of selective, Fish., Sci. 335 (2012) 1045–1047.
[31] J. Lloret, M. Muñoz, M. Casadevall, Threats posed by artisanal fisheries to the reproduction of coastal fish species in a Mediterranean marine protected area, Estuar. Coast. Shelf Sci. 113 (2012) 133–140.
[32] K. Erzini, M. Salgado, M. Castro, Dynamics of black spot sea bream (*Pagellus bogaraveo*) mean length: evaluating the influence of life history parameters, recruitment and exploitation patterns, J. Appl. Icht 22 (2006) 183–188.
[33] F. Baeta, M. José Costa, H. Cabral, Changes in the trophic level of Portuguese landings and fish market price variation in the last decades, Fish. Res. 97 (2009) 216–222.
[34] J. Coll, M. Linde, A. García-Rubies, F. Riera, A.M. Grau, Spear fishing in the Balearic Islands (west central Mediterranean): species affected and catch evolution during the period 1975–2001, Fish. Res. 70 (2004) 97–111.
[35] J.F. Amengual-Ramis, M. Vázquez-Archdale, C. Cánovas-Pérez, B. Morales-Nin, The artisanal fishery of the spiny lobster *Palinurus elephas* in Cabrera National Park, Spain: comparative study on traditional and modern traps with trammel nets, Fish. Res. 179 (2016) 23–32.
[36] T. Font, J. Lloret, Improving the efficiency of MPAs as fisheries management tools and benefits from involving the small scale fisheries sector. MedPAN Background Report for Panel 3, FAO/GFCM Regional Conference for Building a Future for Small Scale Fisheries in the Mediterranean and Black Seas (Algers, Algeria). MedPAN/GFCM, 2016.
[37] W.W.L. Cheung, T.J. Pitcher, D. Pauly, A fuzzy logic expert system to estimate intrinsic extinction vulnerabilities of marine fishes to fishing, Biol. Cons. 124 (2005) 97–111.
[38] J. Ferri, N. Stagličić, S. Matić-Skoko, The black scorpionfish, *Scorpaena porcus* (Scorpaenidae): could it serve as reliable indicator of Mediterranean coastal communities' health?, Ecol. Indic. 18 (2012) 25–30.
[39] J.M.S. Gonçalves, K.I. Stergiou, J.A. Hernando, E. Puente, D.K. Moutopoulos, L. Arregi, M.C. Soriguer, C.V. Fernández, R. Coelho, K. Erzini, Discards from experimental trammel nets in southern European small-scale fisheries, Fish. Res. 88 (2007) 5–14.
[40] K. Erzini, J.M.S. Gonçalves, L. Bentes, P.G. Lino, J. Ribeiro, K.I. Stergiou, Quantifying the role of competing static gear: comparative gear selectivity of monofilament gill nets and small hook longlines in the Algarve (southern Portugal), Sci. Mar. 67 (2003) 341–352.
[41] R. Arlinghaus, S.J. Cooke, J. Lyman, D. Policansky, A. Schwab, C. Suski, Understanding the complexity of catch-and-release in recreational fishing: an integrative synthesis of global knowledge from historical, ethical, social, and biological perspectives, Rev. Fish. Sci. 15 (2007) 75–167.
[42] T. Font, J. Lloret, Biological and ecological impacts derived from recreational fishing in Mediterranean coastal areas, Rev. Fish. Sci. Aquacult. 22 (1) (2014) 73–85.
[43] K. Erzini, C.C. Monteiro, J. Ribeiro, M.N. Santos, M. Gaspar, P. Monteiro, T.C. Borges, An experimental study of gill net and trammel net "ghost fishing" in the Algarve (southern Portugal), Mar. Ecol. Prog. Ser. 158 (1997) 257–265.
[44] S.S. Uhlmann, M.K. Broadhurst, Mitigating unaccounted fishing mortality from gillnets and traps, Fish. Fish. 16 (2013) 183–229.
[45] A.H. Cunha, J.F. Assis, E.A. Serrão, Seagrasses in Portugal: a most endangered marine habitat, Aquat. Bot. 104 (2013) 193–203.
[46] S.M. Weigle, L.D. Smith, J.T. Carlton, J. Pederson, Assessing the risk of Introducing exotic species via the live marine species trade, Conserv. Biol. 19 (2005) 213–223.
[47] A. Arias, A. Richter, N. Anadón, C.J. Glasby, Revealing polychaetes invasion patterns: identification, reproduction and potential risks of the Korean ragworm, *Perinereis linea*(Treadwell), in the Western Mediterranean, Estuar. Coast. Shelf Sci. 131 (2013) 117–128.
[48] ICES, Report of the Working Group on Recreational Fisheries Surveys (WGRFS), 2015.
[49] M. Harmelin-Vivien, J.-M. Cottalorda, J.-M. Dominici, J.-G. Harmelin, L. Le Diréach, S. Ruitton, Effects of reserve protection level on the vulnerable fish species *Sciaena umbra* and implications for fishing management and policy, Glob. Ecol. Cons. 3 (2015) 279–287.
[50] J. Lloret, N. Zaragoza, D. Caballero, T. Font, M. Casadevall, V. Riera, Spearfishing pressure on fish communities in rocky coastal habitats in a Mediterranean marine protected area, Fish. Res. 94 (2008) 84–91.
[51] M. Sciberras, S.R. Jenkins, R. Mant, M.J. Kaiser, S.J. Hawkins, A.S. Pullin, Evaluating the relative conservation value of fully and partially protected marine areas, Fish. Fish. 16 (1) (2013) 58–77. http://dx.doi.org/10.1111/faf.12044.
[52] V. Stelzenmüller, F. Maynou, G. Bernard, G. Cadiou, M. Camilleri, R. Crec'hriou, G. Criquet, M. Dimech, O. Esparza, R. Higgins, P. Lenfant, A. Pérez-Ruzafa, Spatial assessment of fishing effort around European marine reserves: implications for successful fisheries management, Mar. Pollut. Bull. 56 (2008) 2018–2026.
[53] T. Agardy, G.N. di Sciara, P. Christie, Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning, Mar. Policy 35 (2011) 26–32.
[54] P. Pita, J. Freire, Assessing the impact of spear fishing by using competitions records and underwater visual censuses, Sci. Mar. 80 (1) (2016) 27–38 http://dx.doi.org/10.3989/scimar.04352.15A.
[55] B. Morales-Nin, A.M. Grau, M. Palmer, Managing coastal zone fisheries: a Mediterranean case study, Ocean Coast.Manag. 53 (2010) 99–106.
[56] V. Ünal, H. Göncüoğlu, D. Durgun, Z. Tosunoglu, C. Deval, C. Turan, Silver-cheeked Toadfish, *Lagocephalus Sceleratus* (Actinopterygii: Tetraodontiformes: Tetraodontidae), causes a substantial economic losses in the Turkish Mediterranean coast: a call for decision makers, Acta Ichthyol. Piscat. 45–3 (2015) 231–237.
[57] EastMed, Report of the Sub-Regional Technical meeting on the Lessepsian migration and its impact on Eastern Mediterranean fishery. GCP/INT/041/EC–GRE–ITA/TD-04, Nicosia, Cyprus, 9 December 2010, ⟨http://www.fao.org/3/a-ap961e.pdf⟩.
[58] A.H. Richard, E.P. Jennifer, Substrate preferences of scyphozoan *Aurelia labiata* polyps among common dock-building materials, Hydrobiologia 616 (2009) 259–267. http://dx.doi.org/10.1007/s10750-008-9595-6.
[59] J. Lloret, A. Sabatés, M. Muñoz, M. Demestre, I. Solé, T. Font, M. Casadevall, P. Martín, S. Gómez, A multidisciplinary approach involving ethnoecology, biology and fisheries can help explain the spatio-temporal changes in marine fish abundance resulting from climate change, Glob. Ecol. Biogeogr. 24 (2015) 448–461.
[60] A.L. Perry, P.J. Low, J.R. Ellis, et al., Climate change and distribution shifts in marine fishes, Science 308 (2005) 1912–1915.
[61] J. Lloret, T. Font, A comparative analysis between recreational and artisanal

fisheries in a Mediterranean coastal area, Fish. Manag. Ecol. 20 (2013) 148–160.
[62] T. Font, J. Lloret, C. Piante, Recreational fishing within marine protected areas in the Mediterranean. MedPAN North Project, WWF Fr. (2012) 168 ⟨http://www.medpan.org/documents/10180/0/Recreational+Fishing+Within+Marine+Protected+Areas+In+the+Mediterranean/7b9f4bfb-e80c-4c7a-a097-dd8db8ef9067?version=1.0⟩ (last accessed 15.09.16).
[63] S. Oinonen, P. Levontin, K. Parkkila, E. Nieminen, H. Pulkkinen, A. Romakkaniemi, P. Pintassilgo, L. Grønbæk Kronbak, M. Laukkanen, M. Lindroos, International fisheries management and recreational benefits: the case of the Baltic Salmon, in: Proceedings of the 21th Annual Conference of the European Association of Environmental and Resource Economics, University of Helsinki, Helsinki, Finland, 2015, pp. 24–27.
[64] D.K. Moutopoulos, G. Prodromitis, I. Mantzouni, C. Koutsikopoulos, Quantifying the implementation of Common Fisheries Policy: patterns of fisheries violations and penalties imposed in Greek waters, Mar. Policy 70 (2016) 65–76.
[65] R. Döring, Small scale versus trawl fisheries in coastal waters. The case of the German Baltic Herring Fishery (2013), in: P. Hartet al. (Ed.) Who owns the sea: Workshop proceedings, Tjärnö, Sweden, 24–27 June 2002. pp. 113–114. ⟨www.vliz.be/imisdocs/publications/74382.pd⟩, 2013.
[66] E. Tzanatos, E. Dimitriou, L. Papaharisis, A. Roussi, S. Somarakis, C. Koutsikopoulos, Principal socio-economic characteristics of the Greek small-scale coastal fishermen, Ocean Coast. Manag. 49 (7–8) (2016) 511–527.
[67] E. Hoefnagel, B. de Vos, E. Buisman, Quota swapping, relative stability, and transparency, Mar. Policy 57 (2015) 111–119.
[68] S. Gomez, J. Lloret. The SSF Guidelines as a tool for marine stewardship in the Mediterranean: the case of the Cap de Creus Marine Protected Area, in: Edited Volume about the Voluntary Guidelines for Small-scale Fisheries (SSF Guidelines) (Eds: Svein Jentoft and Ratana Chuenpagdee)
[69] S. Jennings, Indicators to support an ecosystem approach to fisheries, Fish Fish 6 (2005) 212–232.
[70] R. Froese, C. Walters, D. Pauly, H. Winker, O.L.F. Weyl, N. Demirel, A.C. Tsikliras, S.J. Holt, A critique of the balanced harvesting approach to fishing, ICES J. Mar. Sci. (2015). http://dx.doi.org/10.1093/icesjms/fsv122.
[71] A.M. Leocádio, D. Whitmarsh, M. Castro, Comparing trawl and creel fishing for Norway lobster (*Nephrops norvegicus*): biological and economic considerations, PLoS ONE 7 (7) (2012) e39567. http://dx.doi.org/10.1371/journal.pone.0039567.
[72] C.I. Goddard, N.J. Leonard, D.L. Stang, P.J. Wingate, B.A. Rattner, J.C. Franson, S.R. Sheffield, Management concerns about known and potential impacts of lead use in shooting and in fishing activities, Fisheries 33 (2008) 228–236.
[73] T. McClanahan, J. Castilla, A. White, O. Defeo, Healing small-scale fisheries by facilitating complex socio-ecological systems, Rev. Fish. Biol. Fish. 19 (2009) 33–47.
[74] H. Erikkson, M. de la Torre-Castro, S.W. Purcell, P. Olsson, Lessons for resource conservation from two contrasting small-scale fisheries, AMBIO 44 (2015) 204–213. http://dx.doi.org/10.1007/s13280-014-0552-5.
[75] F. Cardona-Pons, B. Morales-Nin, Angler's perceptions of recreational fisheries and fisheries management, Ocean Coast. Manag. 82 (2013) 146–150.
[76] P. Veiga, C. Pita, L. Leite, J. Ribeiro, R.B. Ditton, J.M.S. Gonçalves, K. Erzini, From a traditionally open access fishery to modern restrictions: Portuguese anglers' perceptions about newly implemented recreational fishing regulations, Mar. Policy 40 (2013) 53–63.
[77] FAO, Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. Fao (Rome), 2015, 18 pp⟨http://www.fao.org/3/a-i4356e.pdf⟩ (last accessed 30.09.16).
[78] FAO. EIFAC Code of Practice for Recreational Fisheries. SEC/EIFAC/OP42. EIFAC Occasional Paper. No. 42. Rome, 2008, 45 pp