

Comparison of technical measures in the Aegean Sea to support harmonization of fisheries management policies

Hakkı DERELİ¹, Vahdet ÜNAL², Anastasia MILIOU³, Theodoros TSIMPIDIS³, Ifigeneia TROMPOUKI³, Zafer TOSUNOĞLU², Konstantinos ALEXOPOULOS³, Aylin ULMAN⁴

¹ Faculty of Fisheries, İzmir Katip Çelebi University, İzmir, Turkey

² Faculty of Fisheries, Ege University, İzmir, Turkey

³ Archipelagos Institute of Marine Conservation, Pythagorio Samos, Greece

⁴ Mersea Marine Consulting, Fethiye, Turkey

<http://zoobank.org/9A35D940-EC36-4BFC-8F1E-EBAB88B95800>

Corresponding author: Hakkı Dereli (hakkidereli@gmail.com)

Academic editor: Sanja Matić-Skokko ♦ **Received** 5 January 2022 ♦ **Accepted** 11 April 2022 ♦ **Published** 10 May 2022

Citation: Dereli H, Ünal V, Miliou A, Tsimpidis T, Trompouki I, Tosunoğlu Z, Alexopoulos K, Ulman A (2022) Comparison of technical measures in the Aegean Sea to support harmonization of fisheries management policies. *Acta Ichthyologica et Piscatoria* 52(2): 111–123. <https://doi.org/10.3897/aiep.52.80083>

Abstract

The Aegean Sea features an important archipelago in the Eastern Mediterranean, consisting of 60 inhabited islands, more than 1400 uninhabited islands, about 60–70 commercial marine taxa, along many vulnerable species. Fisheries are mainly coastal and are exploited by Greek and Turkish fishers. The multi-species and multi-gear fisheries operate within each country's 6-nautical mile territorial sea and in the international waters of the Aegean Sea. As the fisheries resources are currently declining in this region, it is clear that current management initiatives are ineffective and would benefit from a new regime aiming to improve the state of the commercial marine resources. This study offers a comparative analysis of certain fishing gear technical measures applied by Greece and Turkey in the Aegean Sea. Identified differences can provide clear and helpful insights for decision-makers for the development of a new and productive management approach in Aegean waters. The fishery regulations were shown to be highly variable, sharing few similarities and stressing many more differences, thus rendering the current management of the shared fish stocks unsustainable. The resources of both states would greatly benefit from the harmonization of management measures focusing on an ecosystem approach to fisheries, and incorporating fishers as stakeholders.

Keywords

Aegean Sea, co-management, fishing gears, Greece, Turkey

Introduction

The Aegean Sea, lies in the Eastern Mediterranean Sea between Greece and Turkey, and comprises GSA 22 of the General Fisheries Commission of the Mediterranean (GCFM). The long coastlines, numerous bays, more than 1450 islands and islets of the area render the Aegean a key fishing region in the Mediterranean. Due to its rich ichthyofauna (449 species for the Turkish coast and 510

species for Hellenic Seas including the Aegean Sea) (Bilecenoğlu et al. 2014; Papaconstantinou 2014) and a large number of artisanal fishers, it collectively supports two of the largest fishing fleets in the Mediterranean which combined represent >18% of the total of the Mediterranean commercial fishing fleet. From 2016 to 2018, 8% of total Mediterranean and Black Sea catches were from the Aegean Sea (FAO 2020). Greece reported 70 commercial taxa in 2018, and Turkey reported 60 commercial taxa

from this sea (GFCM 2021). Both countries' territorial seas in the Aegean extend to 6 nm from their coasts. Currently, 48% of the marine area falls under the national jurisdiction of the two countries, exercised by each State within its respective territorial sea. The remaining area is international waters and, thus, beyond national jurisdiction (Öztürk et al. 2002).

Fisheries in the Eastern Mediterranean are characteristic for targeting multiple species using several different types of gear (from here on multi-species and multi-gear), much like in many other Mediterranean regions (Papaconstantinou et al. 2007; Ünal and Göncüoğlu 2012). In fact, in this region, 42 taxa constitute more than 90% of catches (FAO 2020). Thus, the applications of single-species management measures are mostly ineffective, except when they are highly selective, such as bluefin tuna (*Thunnus thynnus*).

The gear types most commonly used in the Aegean Sea by Greek and Turkish fisheries are towed and dragged gears (bottom trawl, dredges), static gears (gillnets, trammel nets, longlines, pots, hook and line), and encircling gears (purse seine, small surrounding nets) (Nedelec and Prado 1990; Tokaç et al. 2010).

In 2018, 11 580 Greek vessels and 4007 Turkish vessels were operating in the Aegean Sea. Of those, 95% of the Greek vessels and 96.5% of the Turkish vessels were small-scale (TURKSTAT 2019; Conides et al. 2020), which is far greater than the 83% Mediterranean average for the entire small-scale fleet (FAO 2020). Thus, small-scale fisheries (SSF) greatly dominate the marine capture fisheries industry in the Aegean Sea, in terms of the number of vessels and fishers, in both Greece and Turkey (Conides et al. 2020; Ünal and Ulman 2020). The small-scale vessels mainly use gillnets, trammel nets, longlines, fyke nets and surrounding net types, and some traps. The large-scale vessels are trawlers (including otter trawlers), purse seiners, and drifting longliners, while Turkey has 25 additional carrier vessels used in purse seine fishing (HRMRDAF 2019). Greece authorized 356 vessels to fish in the international waters of the Mediterranean in 2018, and Turkey authorized 243 bottom trawlers to fish in international waters in 2018 (GDFA 2020a).

Fisheries in the Aegean Sea are of high importance for both countries in terms of production, food security, and, most importantly, job security and provision in coastal rural areas where alternative employment options are scarce. Around 90% of Greece's (61 955 t) and 15% of Turkey's (42 613 t) total wild marine fishery catches in 2018 were provided by fishing activities in the Aegean Sea (ELSTAT 2019; TURKSTAT 2019). A total of 20 565 employees are directly employed in the fisheries sector in Greece (ELSTAT 2019); the corresponding number in Turkey amounts to 30 878 employees, of which 21% or 6542 fishers work in the Aegean region (TURKSTAT 2019). Furthermore, Greece is the leading country employing fisherwomen, accounting for 7% of total female fishers in the EU (Elliott 2002). However, in Turkey, the official data claims only 1% of the fishers are women

(TURKSTAT 2019), but more localized studies from the Datça-Bozburun Peninsula have shown this percentage to be much higher-up to 20% (Ünal et al. 2015).

Effective fisheries management measures are essential for maintaining stock renewability and fisheries sustainability. Classically, fishery management is divided into two main typologies of capture control: input and output controls. Input controls regulate fishing effort in some manner (e.g., in number of licenses or maximum vessel lengths). Output controls regulate the amount of the catch being withdrawn from the sea (e.g., in catch composition, commercial minimum landing sizes, quotas) (Pope 2009; Bellido et al. 2020). Along with input and output controls, fishery management is also based on the adoption of technical measures that regulate the catchability of fishing gears by limiting features of the gears (Bjorndal 2002) or by their spatial or temporal regulations (Hall 2009). With the exception of large pelagics, the current fishery management regime of the Mediterranean Fisheries is predominantly based on the input control approach along with the adoption of technical measures for fishing gear (Fiorentino and Vitale 2021). The regulations and technical measures implemented by the two countries fishing in the Aegean Sea vary a great deal, forming the basis of this study. Since the two countries share their fisheries resources, many of which move freely between jurisdictions, we propose that technical measures are harmonized between Greece and Turkey, which would require both countries to work jointly to achieve this.

Greece, a member of the European Union, the Common Fishery Policy (CFP) and the relevant EU legislations apply, in addition to their National Legislations (NL) (consisting of Royal decrees-RD, Legislative decrees-LD, and Presidential decrees-PD) aim to regulate fishing effort with appropriate technical measures (Papaconstantinou et al. 2007; OECD 2008). In Turkey, the Fishing Notification is the main regulatory basis for fisheries. The most recent notification (Notification 5/1) adopted on 1 September 2020, is active for four years (GDFA 2020b). Both countries have set mandatory rules for fishing in their territorial waters and international waters of the Aegean Sea. Greek fishing vessels are permitted to fish in international waters after a specific fishing authorization is issued for a fishing license, provided that it is compliant with specific requirements pertaining to national and EU legislation, as well as international regulations on fish stock management (HRMRDAF 2019). In Turkey, unless otherwise decided by the national management authority, the same fisheries laws apply to both territorial and international waters in the Aegean Sea (GDFA 2020b).

Despite regulatory measures enforced in both states, Aegean fisheries have been declining for over two decades, demonstrating that the state of the fisheries has not benefitted under the current management framework. The total annual catches of both Greece and Turkey in the Aegean Sea follow the exact same trends, increasing with the modernization of their fisheries until efforts were maximized, before catches began to decline; although for Greece, the maximum total catch peaked four years earlier

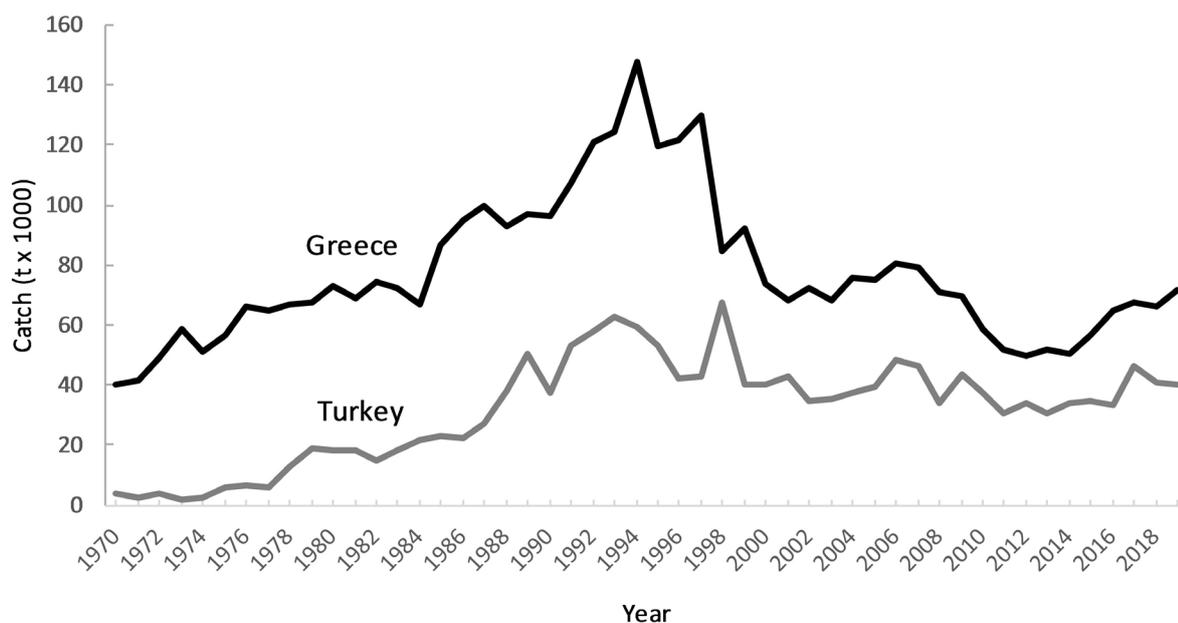


Figure 1. Greek and Turkish total marine wild fisheries catches from the Aegean Sea (1970–2019). Source: GFCM database.

than the Turkish (Fig. 1). In fact, from their peaks until 2019, Greek Aegean catches declined by 51 percentage points, and Turkish Aegean catches declined by 41 percentage points. The small increase in Greek catches in recent years was due to reporting amendments from 2017 that included smaller vessels with engines below 14.17 kW (ELSTAT 2019). A sharp decline in the Fishing-in-Balance (FiB) Index shows declining catches and marine trophic levels, signifying high overexploitation and unsustainable fisheries negatively affecting both ecosystem structure and function (Dimarchopoulou et al. 2021).

The aim of this study was to highlight the current discrepancies in the national fisheries management measures for Greece and Turkey relating to technical measures in terms of fishing gear regulations and spatial and temporal restrictions of fishing activities. We then suggest that a harmonized fisheries management system in the Aegean Sea would benefit the future of the fisheries in the Aegean Sea.

Methods

A literature review of the current fisheries technical regulations was undertaken for both Greece and Turkey. Specifically, the laws that were reviewed for technical comparisons include the relevant EU regulations (Council Regulation EC No. 1967/2006 and Regulation EU 2019/1241) applicable in Greece, as well as Greek National Legislation (NL) (RD: Royal decrees, LD: Legislative decrees, and PD: Presidential decrees) (EU 2006; Papaconstantinou et al. 2007; EU 2019) and the most recent Fishing Notification 5/1 issued by Turkey in 2020 (GDFA 2020b).

The revised International Standard Statistical Classification of Fishing Gear (ISSCFG Revision 1) (FAO 2016) was carefully considered before proceeding to the evaluation of similarities and differences of applicable

technical measures. More specifically, regulations concerning the fishing gear used were examined and compared in relation to the mesh size, net length, height, circumference, and material, as well as the maximum number of permitted gear (types) on board. Moreover, the rules prescribing fishing prohibitions and restrictions for habitats, areas, seasons, species, light sources, soak time, depth, or distance were also evaluated along with provisions pertaining to the monitoring and tracking systems used by fishing vessels. Technical and operational differences were also evaluated for fishing gear. Specifically, Greek and Turkish regulations are compared for each of the 20 different gear types. The fishing gear categorical abbreviation codes and the standard abbreviations of fishing gears used are in unison with ISSCFG.

Comparisons of technical measures of both countries are presented in Tables 1–5. References to additional measures reported in the relevant legislations of only one of the two countries are made prior to the respective Table where applicable. Measures for which no commonalities exist are instead mentioned in the main text, without the need for a table.

Results

Fisheries with surrounding nets. The information presented in Table 1 describes the regulations for surrounding nets for Greece and Turkey, in particular purse seines (PS) (01.1), which greatly contribute to total catches of both countries. Both countries implement technical measures regarding the maximum net height, minimum operating depth or distance from the coast, along with seasonal and spatial prohibitions, and light use. Greece applies three additional measures regarding a minimum mesh size of 14 mm, maximum net length of 800 m, with prohibited

Table 1. Technical measures for purse seine (PS) (01.1) fisheries in the Aegean Sea.

Parameter	Greece	Turkey
Maximum height	120 m (except tuna purse seine nets)	164 m (except tuna purse seine nets)
Minimum depth or distance	Min. distance: 300 m distance Min. depth: 50 m; 70% of purse seine's height 100 m min distance from coast line, irrelevant of depth (PD 25/93)	Min. depth: 24 m
Seasonal prohibition	NL: 15 Dec–28 Feb (for night seines) (PD 25/93) 1 Jul–31 Aug (for day seines) (PD 25/93) Saturdays and those Sundays following full moon (for both day and night seine) (LD 4711/2020 and LD 4691/2020)	15 Apr–31 Aug
Prohibited area	NL: Fishing prohibited in areas closer than 1000 m from entrance to sea farms when they are open for harvest and in areas closer than 500 m measured radially outward from permanent fishing establishments of <i>almadrabas</i> nets (a type of stationary uncovered pound nets) when they operate (PD 25/93). Special spatial prohibitions exist for night seines (PD 23.3/53)	Many spatial prohibitions detailed in fisheries notification
Light use	NL: use of underwater lights by night seines permitted only while lifting nets Use of artificial light more intense than 2000 lumens (> 133.3 W of incandescent light, or > 33.3 W led light) per drifting lighting unit prohibited (PD 25/93) Use of more than five drifting lighting units prohibited (PD 25/93) Fishing with drifting lighting units having light emitting lamp uncovered prohibited (light should be only directed at sea) (PD 25/93)	Lighting permitted only above sea level; use of white light prohibited Light prohibited in shallow waters less than 30 meters and less than 300 meters from fish farm cages 8 additional areas prohibit use of light Only one boat permitted to have light generator; light power up to 100 W does not require permission; total light power of main vessel, auxiliary vessels, and transfer vessel in light fishing allowed areas shall not exceed 8 kW; distance between light boats shall not be closer than 200 m

NL = Greek national legislation, LD = Legislative decrees, PD = Presidential decrees.

areas including seagrass beds (although derogations may be authorized within management plans if the lead-line or the hauling ropes do not touch the seagrass beds), and in all Natura 2000 sites, all specially protected areas and all specially protected areas of Mediterranean interest (SPAMI). Turkey does not yet have any Natura 2000 protected sites but is currently working towards establishing some under EU Guidance. Surrounding nets without purse lines (LA) (01.2) in Greece operate only on the basis of a management plan, and no such plan is currently in force; these gears are not prohibited in Turkey, but Turkish fishers do not use them.

Fisheries with seine nets. Beach seines (SB) (02.1) are prohibited in all Greek and Turkish waters. Fishing with beach seines above seagrass beds and coralligenous habitats and mäerl beds and in all Natura 2000 sites, all specially protected areas, and all specially protected areas of Mediterranean interest (SPAMI) are prohibited in Greece. Boat seines (SV) (02.2) are prohibited in Turkey. Seine nets can be put in operation only on the basis of a management plan in Greece, but no such plan is in force.

Fisheries with trawls. There are detailed regulations for single boat bottom otter trawlers (OTB) in both countries, which are compared in Table 2. A management plan (MD 271/2576/2014 ‘National Management Plan for Bottom Trawl Net Fishing’) specific for bottom otter trawls, approved by the European Commission, has been in force since early 2014 and is implemented throughout Greece (MRDF 2014; HRMRDAF 2019). Greece (as opposed to Turkey) implements measures relating to net characteristics and habitat protection; A balloon codend is prohibited in trawl nets; and within any single codend the number of

equal-sized meshes around any circumference of the codend shall not increase from the front end to the rear end. The circumference of the rearmost part of the trawl body or of the extension piece shall not be smaller than the circumference of the front end of the codend *sensu stricto*. For a square mesh codend, the circumference of the rearmost part of the trawl body or of the extension piece shall be from two to four times the circumference of the front end of the codend *sensu stricto*. As the habitat protection concerns trawling on seagrass beds and coralligenous habitats and mäerl beds and in all Natura 2000 sites, all specially protected areas and all specially protected areas of Mediterranean interest (SPAMI) are prohibited. The minimum mesh size for the codend is 40 mm for square mesh in both countries, while it is 50 mm for diamond mesh in Greece and 44 mm in Turkey. Turkish legislation, on the other hand, requires that the mesh of the trawl body must not be smaller than the codend. In Greece and Turkey for the Aegean Sea, the use of mid-water pelagic trawls (PTM) (03.22) and beam trawls (TBB) (03.11) are prohibited (Papaconstantinou et al. 2007; GDFA 2020b).

Fisheries with towed and mechanized dredges. Technical measures for towed dredges (DRB) (04.1) are in force in Greece, but the use of towed dredges is prohibited in the Turkish Aegean fisheries. Two dredge types are used in Hellenic fisheries, one called *argaleios*, for bivalve mollusks (smooth scallop *Flexopecten glaber*; brown venus *Callista chione* and the bearded horse mussel *Modiolus barbatus*) and another called *gagava* for sponge-fishing which is a traditional fishing method in the Dodecanese region (southeastern Aegean Sea) (Papaconstantinou et al. 2007). Greek measures include: maximum sizes of 3 m breadth (except for sponge fishing), minimum depth,

Table 2. Technical measures for single boat bottom otter trawls (OTB) (03.12) in the Aegean Sea.

Parameter	Greece	Turkey
Minimum mesh size	40 mm square mesh or 50 mm diamond mesh	40 mm square mesh or 44 mm diamond mesh
Codend	120 mm (if codend mesh smaller than 60 mm)	Mesh size of protective bag must not be smaller than 2 times of codend mesh size
Protective bag		
Material	Use of netting with twine thickness > 3 mm or with multiple twines; or netting with twine thickness > 6 mm in any part of bottom trawl prohibited Use of multiple twines prohibited on any towed net in net and codend	Use of monofilament material prohibited in codend of bottom trawl
Minimum depth or distance	Beyond 3 nm distance from coastline or beyond 50 m isobath (whichever comes first); in any case, bottom trawl net fishing prohibited at any distance < 1.5 nm from coast, regardless of depth (MD 271/2576/2014, EU Reg. 1967/2006 art. 13: 1 and 2)	Min. depth: 200 m (Area 40.3) Min. distances: 1.5 nm (Areas 40.2; 40.4; 40.6) 2 nm (Area 40.1) 3 nm (Areas 40.5; 40.7; 40.8; 40.9)
Maximum depth	1000 m	1000 m
Season prohibition	NL: 1 Jun– 30 Sep 24–31 May 24–31 Dec (MD: 271/2576/2014: G.G B 58; par. 9-a) 24 May–15 Jul (for all international waters in Aegean Sea) 16 Jul–30 Sep (in international waters west of 25 th meridian in GFCM subregion GSA 22)	15 Apr– 31 Aug (Trawl fleets can fish in international waters with permission from authorities between 15 Jul and 31 Aug)
Prohibited area	NL: many prohibited areas, mainly gulfs and bays (PD: 739/79, PD: 988/80, PD: 228/2006; PD: 68/2009; MD 271/2576/2014)	Many prohibited areas, mainly gulfs and bays specified in notification

NL = Greek national legislation, PD = Presidential decrees, MD = National management plan.

and distance requirements of 50 m isobath or 0.3 nm distance, but can be used within 3 nm (when shellfish catch is $\geq 90\%$ of the total live weight of the catch) and 50 m isobath or 0.5 nm distance from the coast (for sponge fishing); maximum depth of 1000 m; habitat restrictions where fishing with dredges above seagrass beds and coralligenous habitats and mäerl beds and in all Natura 2000 sites, all specially protected areas and all specially protected areas of Mediterranean interest (SPAMI) are prohibited; and national seasonal prohibitions from 1 August through 31 October (for *Venus verrucosa*), from 1 April through 30 June (for *Callista chione*, *Ostrea edulis*, *Modiolus barbatus*, *Donax trunculus*, *Ruditapes decussatus*, *Aequipecten opercularis*), from 1 April through 31 October (for *Flexopecten glaber*), and from 1 November

through 31 March (for *Mytilus galloprovincialis*) (PD 227/2003). Mechanized dredges (DRM) (04.3) are prohibited under Greece and Turkish regulations.

Fisheries with gillnets and trammel nets. Comparisons of technical measures for gillnets (GNS) and trammel nets (GTR) are presented in Table 3. Greece has one additional prohibited area regulation mostly pertaining to closed bays under national legislation (PD 497/88, PD 338/80, PD 986/80, PD 189/78); Turkey, meanwhile, has additional regulations for soak time where gillnets (used for *Sarda sarda*, *Lichia amia*, and *Seriola dumerili*) are prohibited between 07:00 and 19:00 in the Aegean Sea (Güllük and Gökova Gulfs), and are prohibited 500 m from fixed lift nets between 20:00 and 01:00; and

Table 3. Technical measures for set gillnets (anchored) (GNS) (07.1) and trammel nets (GTR) (07.5) in the Aegean Sea.

Parameter	Greece	Turkey
Minimum mesh size	16 mm NL: 20 mm (PD 174/2013) 100 mm (for red sea bream fishing); 68 mm (for <i>Solea</i> spp. fishing) (in Alexandroupolis area and within 3 nm from coast) (PD 986/1980); 36 mm (in Thessaloniki and Thermaikos Gulfs) (PD 189/1978); 64 mm (in part of Maliakos Gulf) (PD 338/1980); 40 mm (within 1.5 nm from coasts of Mesolongi Lagoon) (PD 68/2006); 48 mm (for trammel nets) (228/2006); and 56 mm (for trammel nets used in June in Kalimnos–Kos) (228/2006)	80 mm (for sole and flounder fishing)
Maximum length and height	Max length: 6000 m for gillnets and trammel nets Max height: 10 m for gillnets and 4 m for trammel nets	Max length: 6000 m
Material	> 0.5 mm twine thickness prohibited NL: monofilament nets prohibited (PD: 1094/1977)	Monofilament and multi-monofilament nets prohibited
Species	Bottom-set nets shall not be used to catch following species: albacore, bluefin tuna, Ray's Sardines can be caught with bream, swordfish; sharks (<i>Hexanchus griseus</i> , <i>Cetorhinus maximus</i> , Alopiidae, Carcharhinidae, Sphyrnidae, Isuridae, Lamnidae) Incidental catches of no more than three specimens of shark species pertaining to a certain list of shark species may be retained on board or landed provided that they are not protected species under EU law NL: European hake (in February) (MD 271/2576, GG B/58/2014)	gillnets all year round

NL = Greek national legislation, PD = Presidential decrees, MD = National management plan. Sea bream = *Pagellus bogaraveo*; albacore = *Thunnus alalunga*; bluefin tuna = *Thunnus thynnus*; Ray's bream = *Brama brama*; swordfish = *Xiphias gladius*; European hake = *Merluccius merluccius*.

gillnets must be marked by a surface buoy during the day and a lighted buoy at night and information must be marked on the buoy or on a visible place of the gear indicating the license number of the fishing vessel. Turkey has additional seasonal and spatial restrictions for *alamana* nets, which are prohibited from 15 April through 15 May, also called *voli* nets, which can be equipped with or without trammel nets, without eyebolts and wires, or any pursing mechanism.

Table 4 presents a comparison of regulations for combined gillnets and trammel nets (GTN) in the Aegean Sea, while Greece has an additional length regulation stating that a combined bottom-set net has a maximum length of 500 m and may have a maximum height of 30 m. It is also prohibited to have on board or use more than 2500 m of combined bottom-set nets when the 10 m height limit is exceeded. The use of drift gillnets (GND) (07.2) is prohibited in both countries' fisheries in the Aegean Sea.

Table 4. Technical measures for combined gillnets–trammel nets (GTN) (07.6) in the Aegean Sea.

Parameter	Greece	Turkey
Maximum length and height	Max. length: 2500 m Max. height: 10 m	Max. length: 6000 m Max. height: 22 m for <i>alamana</i> nets when purse seine nets prohibited
Material	Greater than 0.5 mm twine thickness prohibited	Mono and multi monofilament nets prohibited

Fisheries with pots and fyke nets. Greece has several measures for pots (FPO) (08.2) in the Aegean Sea. Greek regulations include: minimum size regulations of 10 mm for eel fishing, named *volkos* (RD 805/1968), 56 mm for crustaceans (PD 157/2004), and 40 mm (within 1.5 nm from the coasts of Mesolongi Lagoon) (PD 68/2006); size restrictions of: Diameter < 1 m, height < 50 cm, opening > 13 cm diameter (for fish cylindrical traps), and length and width restrictions of < 80 cm, height < 45 cm (for crustacean traps) (PD 157/2004), with a maximum number of 250 pots and a minimum depth of 10 m (PD 157/2004, GG A/126/2004). Greece has a 10 m minimum depth measure (PD 157/2004, GG A/126/2004) for fyke nets (FYK) (08.3), while Turkey only prohibits their use for white grouper fishing.

Table 5. Technical measures for harpoons and spearfishing (HAR) (10.1), hand implements (MHI) (10.2), and diving (MDV) (10.8) in the Aegean Sea.

Parameter	Greece	Turkey
Season prohibition	NL: 1 Jun–31 Oct (for bait collection) 1 Jan–31 Mar (for coral fishing) (PD 324/194) 1 May–31 Oct (for sea cucumbers) (PD 48/2018)	1 Jun–31 Oct (for sea cucumbers) 15 Apr–31 Aug (for <i>Donax trunculus</i>)
Soak time	Spear-guns prohibited with scuba gear and at night (PD: 471/1978) NL: Divers prohibited to fish for mollusks at night	Divers prohibited from sunset to dawn for sea cucumbers
Species	NL: Scuba divers and rebreather systems permitted only for mollusk, sponges, and coral fishing but must operate in pairs (PD: 324/94, PD: 86/98)	Commercial fishing for fish using SCUBA, nargile (surface supplied air diving operation), mask, snorkel and spearguns forbidden Special certificates needed to hunt species other than fish by diving Octopus cannot be hunted using scuba, nargile, or any artificial air source Sponge, <i>Donax trunculus</i> and sea cucumbers (latter only in certain areas) can be caught by diving

NL = Greek national legislation, PD = Presidential decrees.

Fisheries with longline. For set longlines (LLS) (09.31), Greece has much more advanced regulations than Turkey in the Aegean Sea. In Greece, there is a minimum hook length of 3.95 cm, and width of 1.65 cm (the latter only applicable for sea bream, *Pagellus bogaraveo*), there are maximum hook numbers: 1000 hooks per person onboard, 5000 hooks per vessel, 7000 hooks per vessel (for vessels fishing more than 3 days), while vessels fishing more than two days can have an equivalent number of spare hooks on board (for surface-set longlines), and there are two prohibited geographic areas, mainly closed bays (PD 435/70, PD 189/78). In the Turkish Aegean Sea, there is a minimum hook width (Turkish *ağız açıklığı*) of 0.72 cm, longlines must be marked using a signal flag (buoy) during the day and lighted buoy at night, and the license number of the fishing vessel must be visibly displayed on the buoy or gear at the surface. It is obligatory to show information (on the buoy or in a visible place of the gear) indicating the license code number of the fishing vessel to which it belongs.

For drifting longline (LLD) (09.32) regulations, both countries apply highly different measures. Greece applies maximum hook numbers (2500 hooks per vessel for swordfish fishing, 5000 hooks per vessel for albacore fishing, and 2000 hooks per vessel for bluefin tuna), with a maximum 70 km main line length measure, and prohibits swordfish fishing in December by Ministerial Decision No. 3265/60504/2018 (HRMRDAF 2019), while vessels out fishing for more than two days can have an equivalent number of spare hooks on board. Turkey applies a 2.8 cm minimum hook width for swordfish only and longlines must be marked using buoys during the day and lighted buoys at night.

Fisheries with harpoons, spear guns, and diving. Comparisons of technical measures for harpoons (HAR) (10.1), hand implements (MHI) (10.2), and diving (MDV) (10.8) are presented in Table 5. Harpoons are used for traditional swordfishing in Turkey. Spearfishing for commercial purposes is prohibited in both states and is only permitted in recreational fishing. Greece has an additional 10 m maximum depth for mollusks, and Turkey prohibits diving using lights in lagoons, areas outside Map 59 for sea cucumber fishing, and prescribes a total annual catch

for sea cucumber fishing, and sponge fishing is permitted only in the north Aegean coast between where the Meriç River flows into the sea and Babakale. In Greece, divers fishing for mollusks use handheld gear named *tsougrana* which must have three ‘teeth’, each one a maximum of eight cm long, with a minimum distance of two cm between them. Turkey also has minimum mesh size technical measures for in hand implements (wrenching gear, clamps, tongs, rakes, spears) for sieves used in grooved carpet shell (Turkish *akivades*), *Ruditapes decussatus* (as 24 mm), warty venus (Turkish *kidonya*), and *Venus verrucosa* (as 30 mm).

Comparative summary of measures

The only similarities found between the two sets of management measures of both states include the following: the prohibition of using driftnets, mid-water pelagic trawls, beam trawls, spearfishing, beach seine, mechanized dredges, otter trawl fishing during summer months and in water deeper than 1000 m, and monofilament materials in gillnet fishing, gillnets longer than 6000 m, lights by skin divers during nocturnal hunting, and the adoption of the minimum 40 mm square mesh codend opening.

As shown in the following paragraph, from the comparison of the national regulations of the two countries regarding certain gear types, many highly diverse technical measures were shown, the most striking of which relate to the complete ban of certain fishing gear types in one country, and not the other, and also maximum net lengths and maximum number of hooks in one country and not the other.

The use of towed dredges is permitted in the Greek Aegean fisheries, while prohibited under Turkish regulations. Otter trawling in Greece is prohibited within a 3 nm minimum distance from the coast or within the 50 m isobath where that depth is reached at a shorter distance. While according to the respective Turkish regulation for the Aegean, the distance determination varies between 200 m (for a very small area), to 1.5 nm, 2 nm, and 3 nm. In both states the overall cumulative timespan for seasonal closures is roughly the same, amounting to approximately 4.5 months; however, the exact time periods do not coincide. Specifically, Greek bottom trawlers are prohibited from fishing from 1 June through 30 September, with additional temporal restrictions from 24 December through 31 December and 24 May through 31 May, while in Turkey trawling is prohibited from 15 April through 31 August. Greek bottom trawlers fish in international waters after issuance from a relevant fishing authorization which is valid for one year. The authorization determines the exact geographical sub-area of the General Fisheries

Commission for the Mediterranean (GFCM) where fishing is permitted, the targeted species and the gear to be used. The use of the authorization is prohibited in GSA 22 from 24 May through 15 July and west of the 25th meridian of GSA 22 from 16 July through 1 October (MRDF 2014). Finally, the minimum mesh size of the diamond mesh in the codend of the trawl is 50 mm in Greece, and 44 mm in Turkey.

In Greece, day and night purse seine maximum net lengths are set at 800 m and the minimum mesh size at 14 mm according to the EU regulation. Turkey, on the other hand, has not yet adopted any such rules on the subject. For purse seine, there are seasonal prohibition differences. Consequently, some key species can be targeted during their reproductive seasons in one of the littoral states, while the other protects this period under diverging regulations; for example, according to Greek legislation, the use of the night purse seine is prohibited during the winter period (15 December–28 February), in order to protect sardine spawning stocks, but catch anchovy in their spawning season in summer (Papaconstantinou et al. 2007). However, in Turkey, the respective seasonal purse seine prohibition (15 April–31 August) incorporates the anchovy spawning season with the aim of protecting their spawning stocks. Fishing for European pilchard is permitted by Turkish law during their spawning season (December–February), but is prohibited in Greece during the same period (Akyol et al. 1996; Cihangir unpublished*). This demonstrates that these two important migratory pelagic stocks can still be targeted by one country’s fleet during their spawning period. Another key distinction is that the minimum operating depth for purse seines is set at 50 m in Greece, and is less than half that depth in Turkey at 24 m; thus, the Turkish purse seine fleet can fish at depths between 24 m and 50 m. This lower minimum depth limit increases the risk of adverse effects on certain benthic habitats of Turkey’s shores, as it permits fishing up to depths of 164 m (equivalent to 90 fathoms). Greece applies additional minimum mesh size, maximum net length, and protected habitats regulations for purse seines, which are absent from the respective Turkish legislation. Specifically, the additional minimum mesh size restrictions are aimed at reducing juvenile mortality within multispecies fisheries (NEMC 1985), and consequently, many of Turkey’s main fished stocks are plagued by both growth and recruitment overfishing. From a fishing effort (in days at sea) perspective, the seasonal prohibitions allow Greek purse seiners to fish in the Aegean for 260 days per year (for day seines) and 248 days per year (for night seines), while Turkish regulations only permit purse seiners to operate for 225 days per year.

Gillnets and trammel nets used by Greek vessels must have a minimum mesh size of 20 mm; with the exception of gillnets targeting *Atherina boyeri* which have a minimum mesh size of 16 mm, and 68 mm for common

* Cihangir B (1991) Ege Denizi’nde sardalya (*Sardina pilchardus* Walbaum, 1792)’nin üreme biyolojisi ve büyümesi. [Growth and reproduction of sardine (*Sardina pilchardus* Walbaum, 1792) in the Aegean Sea.] PhD Thesis, Dokuz Eylül University, İzmir, Turkey. [In Turkish]

sole (*Solea solea*) and European flounder (*Platichthys flesus*), in addition to several other regulations according to species and regions detailed in Table 3, whereas no minimum mesh size regulations exist in Turkey aside from one 80 mm measure for set net targeted sole and flounder. Greece and Turkey both have 6000 m maximum gillnet and trammel net lengths, whereas Greece has additional height and material (twine thickness) restrictions for gillnets and trammel nets. Turkey on the other hand has a maximum soak time and signal regulations in place to identify the owner for gillnets and trammel nets.

The use of pots has many Greek restrictions such as the maximum number of pots, while Turkey only prohibits their use for white grouper. However, fish pots are used for targeting groupers (*Epinephelus* spp.) in the Dodecanese region (southeastern Aegean Sea) by Greek vessels (Papaconstantinou et al. 2007).

The use of set longlines is better regulated in Greece where provisions are made for minimum hook width and the maximum number of hooks, in relation to the species targeted. There is a huge difference between the minimum hook width sizes, of 3.95 cm in Greece, and 0.72 cm in Turkey generally, however for set longlines, Turkey has the same 3.95 cm min. hook width size as Greece but does not impose any regulations for the maximum number of hooks.

The use of drifting longlines is regulated in more detail in Greece compared to Turkey, the latter which has no maximum number of hooks nor maximum total longline length prescribed, with only an implementation for a 2.8 cm minimum hook width regulation for swordfish. This presents another huge disparity, with Greek fishers only permitted to have 5000 hooks per fisher, with Turkish fishers unregulated in this regard.

With scuba diving, all mollusks, sponges and coral can be collected in Greece (except for at night), while only *Donax trunculus* and sea cucumbers can be collected in Turkey, since the catch of fish and octopus with the use of scuba is prohibited, and sponge and corals are nationally protected. For hand-held gears, Greece has maximum size and minimum distance measures for mollusk fishing, whereas Turkey has minimum mesh sizes applied to sieves used for the grooved carpet shell, *Ruditapes decussatus*, and warty venus, *Venus verrucosa*, fishing.

For special habitats, Greece prohibits the use of purse seining, bottom otter trawls, dredging, beach and boat seining above seagrass beds and in some special habitats (in all Natura 2000 sites, all specially protected areas and all specially protected areas of Mediterranean interest-SPAMI) under EU legislation. Also, bottom otter trawling, beach seining, and dredging are prohibited above coralligenous habitats, and mäerl beds in Greece. While in Turkey, industrial fishing is also prohibited in several special habitats such as *Posidonia* beds, coralligenous habitats and mäerl beds, and both beach and boat seine are already prohibited in the Aegean Sea to protect the benthic habitat, indirectly compensating their lack of more specific habitat protection, such as Natura 2000 sites, which are to be implemented in the near future.

The different mesh size regulations and hook length and width features of the two countries have highly different selectivities which diversely affect the marine resources, and such discrepancies can further negatively affect juveniles in areas where the regulations are more relaxed or non-existent.

Discussion

This study highlights numerous differences and fewer similarities existing in the technical measures of the two fishing states in the Aegean Sea which undermines the efficacy of either state to improve the overall state of fisheries. Even though Greece and Turkey apply a few similar technical measures, the many more differences detected after comparing the technical measures applied to fisheries in the two countries, pose particular (and even divergent) hurdles to the overall sustainable management goal of the shared commercial fish stocks of the Aegean Sea which compromise current management goals. As the small-scale fishers are already a highly marginalized group, especially in the Eastern Mediterranean, imposing more regulations on them towards harmonization of measures will not be favourable for many, but are of extreme importance in securing a viable future for this sector, which is currently at high risk of being compromised.

The declining state of the Aegean fisheries clearly reveals the ineffectiveness of the current management system, heavily based on technical measures, and rarely incorporating scientific advice into decision-making (Stergiou et al. 1997). Science should absolutely be used as the basis for stock rebuilding, and also needs to shift its focus to protect new recruits, juveniles, spawning grounds, and to synchronize an effective reduction of effort in both seas. The multi-species and multi-gear nature of the fisheries in the Aegean Sea poses a challenge to the current management effectiveness. The fish stocks shared by both Aegean Sea fishing states fall under highly diverse regulatory systems, and their current status corroborates the 'Tragedy of the commons' scenario, where one party typically aims to maximize their gains at the expense of community interest (Berkes 1985; Hardin 1994). Empirical studies have shown that fish stocks shared between two countries have a 7 percentage points higher chance of being overfished and are 14 percentage points more likely to be depleted than a stock fished by one country (McWhinnie 2009). However, we stress that the system can be remodeled for success by the adaptation of a new paradigm of community co-management which at the very least should include the harmonization of fisheries technical measures, stakeholder rights and an ecosystem focus. The joint exploitation of living resources in the Aegean Sea has been examined in other studies, which also suggest that these two Aegean Sea fishing countries should strive for co-operation and co-management (Aquarone 1995; Van Dyke 1996; Pratt and Schofield 2000). While for the management of small pelagics here, based just on sardine and anchovy,

the adoption of catch quota systems could be introduced with relative ease to manage these fisheries to ensure their sustainability (Fiorentino and Vitale 2021).

Fisheries management in the Mediterranean would benefit from incorporating in-depth expert fishing knowledge of fishers in the decision-making processes at regional, national and international levels (Bilgin unpublished*). The dominance and importance of the small-scale fisheries in this region needs to be reflected in management initiatives. According to the EU Mediterranean Community Action Plan (EU 2002), regional cooperation for shared resources with non-EU countries, like Turkey, needs to be improved upon. The strong imbalances on both sides vary greatly.

About 78% of assessed Mediterranean and the Black Sea stocks are currently fished beyond sustainable levels, although the situation has slightly improved since 2014 (from 88%). In terms of trends, many priority species in the Mediterranean, especially sardines, show an increase in negative exploitation rate in recent years (FAO 2020). Similarly, the major commercial fish stocks continue to decline in both countries, and these important stocks are direly in need of innovative and effective management regimes directed at their rebuilding. In this context, the FAO promotes the ecosystem approach to fisheries as an appropriate application for the sustainable management of fisheries. Recently, Vasconcellos and Ünal (2022) reported best practices based on case studies and lessons learned on how the ecosystem approach to fisheries was considered, developed and implemented in many Mediterranean fisheries. In fact, one of the good practices discussed in the report from the southern Aegean Sea of Turkey indicates that the use of new practices can lead to improved fisheries management capabilities in the Aegean Sea.

There are too many fishers chasing around a reduced amount of fish, and their combined effort and technological sophistication level is much too high in the region. Greece adopted, in accordance with EU Reg. 1380/2013, a multiannual Operational Programme for Fisheries and Sea (2014–2020), currently under review prior to implementation for the period 2021–2027, on the basis that the total number of fishing vessels has substantially decreased. In addition, Greece granted financial *de minimis* aid to commercial vessel owners (up to €25 000) for the withdrawal of boat seines (SB) (MD 145/296596/202 GG Vol. B no. 4680 (2020) implementing EU Reg. 717/2014. Turkey practiced five fisheries buy-back programs and withdrew 1253 vessels longer than 10 m from their entire fleet between 2013 and 2018 (Ünal and Göncüoğlu-Bodur 2018), but the overall fishing effort still remains about three times higher than needed to achieve optimal catch per unit effort (Ulman and Pauly 2016). Fleet mobility makes it difficult to establish the balance between fish stocks and fishing effort. To better address this, aside from technical measures

for fishing gear, the number of days the large-scale fishing fleet is permitted to fish at sea has also been restricted. However, success has not been achieved in protecting both shared and local fish stocks. In this regard, we suggest the preparation of the regional fisheries management plan in the GSA 22 area with the cooperation and coordination of both countries and the GFCM.

For Greek Aegean fish stocks, a new stock assessment method- AMSY (Abundance Maximum Sustainable Yield) tested abundance trends from scientific assessments both for commercial and non-commercial species (Tsikliras et al. 2021); Out of 74 assessed species, 20 of which were commercial species, and the others non-targeted species normally landed as commercial bycatch, 70% of the commercially targeted taxa were found to have unhealthy stock trends, and surprisingly, even 19% of non-targeted stocks were also deemed unhealthy demonstrating negative ecosystem effects on even non-commercial taxa, as secondary effects of fishing. While using the method CMSY (Catch Maximum Sustainable Yield) to assess Turkish stocks, 90% of 21 assessed Turkish Levantine stocks were found to be exploited beyond safe limits, ten of those critically (Demirel et al. 2020).

Some management measures are designed to work congruently with other measures for efficacy, especially that of minimum mesh size requirements for fishing nets, and ‘Minimum Conservation Reference Size’ (commonly used in the EU) or ‘Minimum Landing Sizes’ (MLS, commonly used elsewhere) for regulated species. The goals of both these measures are to protect juvenile fish so they can at least spawn once, and to catch the species at an optimum size. The minimum fish sizes are normally scientifically based on the female minimum length of maturity (L_{mat}). In a study on Turkish MLS sizes, it was found that several of the MLS sizes are prescribed at sizes much lower than the L_{mat} (Yildiz and Ulman 2020). For Greek fisheries, a study by Stergiou et al. (2004) found that catches from trawlers resulted in a higher percentage of juvenile fish in the catch compared to artisanal vessels, while the use of all gear types still had juvenile fish representing the majority of catches below the optimum exploitation length (L_{opt}) for Greek fisheries. Future work is needed to compare the Minimum Conservation Reference Sizes or MLS for both Greece and Turkey, as these measures also need aligning in order to help improve the health of the Aegean Sea resources.

Regional management framework

Currently, both countries are members of the General Fisheries Commission for the Mediterranean and are responsible for implementing the GFCM’s rules. GFCM membership is an advantage for the sustainability of

* Bilgin B (2008) Türkiye’nin Akdeniz’de balıkçılık yönetimi çerçevesinde Avrupa Birliği ortak balıkçılık politikasına uyumu. [Harmonization of Turkey with the European Union common fisheries policy within the framework of Mediterranean fisheries management.] EU Expertise Thesis, Ministry of Agriculture and Rural Affairs, Ankara, Turkey. [In Turkish]

the living marine resources of both countries. European Union (EU) legislation, the other common denominator between the two countries, is fully implemented in the member country Greece, and not yet applied to Turkey. However, some progress pertaining to harmonization provides hope that the discrepancies may be resolved. For instance, the recent report (EC 2021) published by the European Commission states that Turkey made good progress on fisheries in implementing the fisheries law, resources and fleet management, and inspection and control. The GFCM adopted its 2030 strategy for the Mediterranean and the Black Sea on 6 November 2021. The 2030 strategy included 35 GFCM recommendations and resolutions translating the objectives and targets of the strategy into concrete actions. The recommendations include important measures to improve fisheries management and control in the Adriatic and Black Seas, better protect sensitive species and habitats, and consolidate the monitoring and control framework, including combatting illegal, unreported, and unregulated (IUU) activities in both the Mediterranean and the Black Sea.

For the Mediterranean Sea, the key forum is the Barcelona Convention (BC), of which both Greece and Turkey are contracting parties. The Contracting Parties to the Barcelona Convention developed a set of ecological objectives, operational objectives, and indicators, which reflect Mediterranean priorities and are also coherent with the EU's Marine Strategy Framework Directive (MSFD) (2008/56/EC) (EPPA 2019). One of the key requirements of the MSFD is that EU Member States must take a coordinated approach to implementation, cooperating with other states within the appropriate marine region or sub-region, and ensure coherent and coordinated strategies (EPPA 2019). However, Turkey, unlike Greece, is not an EU member state, and, thus, it is not bound by the obligation to implement the MSFD.

Accompanying the MSFD was a set of criteria and standards to assist the implementation of the plan, which were revised in 2017 with the new Commission Decision on Good Environmental Status. Annex III is of special interest here, which was also amended in 2017 to better link ecosystem components, anthropogenic pressures, and marine environmental impacts with 11 descriptors. A 2020 report on the first implementation of the MSFD showed that although highly ambitious, the framework can be improved to tackle the main issues such as overfishing. The EU-funded Capacity Building on Marine Strategy Framework Directive in Turkey Project (MARinTURK) supports the possible adoption and implementation of the MSFD in the near future. As part of the initial assessment, the economic and social analysis of the different marine water uses has been completed.

The parties are signatory to the overarching BC goal of protecting the marine environment of the Mediterranean by boosting regional and national plans, which now includes 104 protected and 79 endangered species inhabiting the Aegean Sea. The most threatened groups are the largest species, which are crucial in their contributions to

ecosystem regulation and control, namely the top-tiered sharks, rays, fishes, and mammals (Katağan et al. 2015).

In 2008, Turkey completed an institutional twinning program to support the country's legal and institutional alignment to the EU *acquis* for fisheries policy during their candidacy process (Ünal and Göncüoğlu 2012). This process is aimed at harmonizing Turkish fisheries management measures in line with the EU, in order to be able to implement the Common Fisheries Policy (CFP). Short-term and medium-term objectives included aligning fisheries management with those of the European Union. Although the accession process is currently frozen, its framework is still maintained. One principal aim of both the MSFD and CFP is the progressive implementation of an ecosystem-based approach to fisheries management (Gros et al. 2008). Greece, which joined the European Union in 1981, therefore had EU regulations directly transcribed into national legal order and provisions are applied directly and can be enforced. EU Directives provide for the framework regulatory text in reference to a certain subject matter. In order for Directives to be transcribed into national law, further national action is required (additional implementing legislation). EU legislation doesn't exclude differentiated national legislation on the same subject, so long as national rules are stricter and under requirements.

The main issue is that the very important Aegean Sea fisheries are severely threatened and require drastic new measures if they are to remain a viable activity into the future. Ecosystems are now understood to represent the correct scale within which scientific knowledge and the management of renewable resources should be based on. The Ecosystem Approach to Fisheries (EAF) offers a long-term vision for the management of marine biodiversity: sustainable exploitation of resources while respecting the marine ecosystem (Cury et al. 2016). According to the FAO (2003), the EAF is a management planning process that was adopted by the FAO Committee on Fisheries (COFI) as the appropriate and practical way to implement the FAO Code of Conduct for Responsible Fisheries. It is well known that this code established principles and standards applicable to the conservation, management, and development of fisheries. Under such an approach, it is obvious that the allowance of sponge and coral collection in Greece needs to be reconsidered, as these are key components of the ecosystem upon which many other species depend on. Both countries would also benefit from protecting the same vulnerable and overexploited species under the protection of Key Biodiversity Areas or similarly important habitat types for birds, marine mammals, and elasmobranchs.

Another management suggestion applicable to ecoregions such as the Aegean Sea is that they be managed by using conservation targets such as sensitive habitat types including *Posidonia oceanica*, coralligenous formations, and marine cave habitats, which better represent the functional diversity of the area and can improve ecosystem resilience in the face of heightened environmental change (Giakoumi et al. 2013). Also, the creation of networks

of marine protected areas, also focusing on ecosystems can also concurrently be applied (Browman and Stergiou 2004; Papaconstantinou et al. 2007). Results have shown that partial protection of protected areas along with adaptive co-management plans involving fishers, scientists, and managers at the core can benefit the fisheries and alleviate overfishing; and it should be stressed that fisher involvement is one of the most important criteria for successful management (Guidetti and Claudet 2010).

As stated in Tsikliras (2014), the majority of pelagic fish stocks move freely between the limits of both states, and the majority of fisheries are hence shared; therefore, management measures need to be common in order to be equitable. Collective management may be more fruitful when both states share responsibilities, especially sharing their knowledge of the ecosystem and taking into consideration how their actions affect one another, and actually develop harmonized common management measures.

Conclusions

Under the Common Fisheries Policy, fisheries management regulations including technical measures, catch quotas, managing fleet capacity, market rules and support for fisheries and coastal communities are prescribed (EC 2022). Greece is a member of the EU, while Turkey is still a candidate country that is working on aligning its policies under the EU framework. Since they share many fish stocks, and the Aegean Sea basin is a highly important fisheries subregion in the Mediterranean, co-management of the marine resources, especially implementing the same rules, with a focus on rebuilding the fisheries and the ecosystems that support them should be the ultimate

priority for both parties. It is recommended that co-management, involving the adoption and application of the same, or similar, measures and the implementation of the EAF, should constitute the foundations of an Aegean fisheries management framework. First, the management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea provided for in Council Regulation (EC) No 1967/2006 should be implemented by both countries, and secondly, joint action should be taken under the guidance of the FAO Code of Conduct for Responsible Fisheries (CCRF). Both states should review and harmonize not only their technical measures for their fisheries but also their management approaches for their shared stocks and fishing areas. For this purpose, abiding by the FAO-CCRF and the EAF should be the first step toward developing harmonized management strategies. Vasconcellos and Ünal (2022) provide current information about the transition to an ecosystem approach to fisheries in the Mediterranean through a review of case studies and lessons learned in the region that can serve as a guide for managerial transitions. In conclusion, as long as Turkey is a candidate country of the EU, it will continue to harmonize (some of) its fisheries policy measures with those of the EU; thus, harmonization should be easy under this context. The recent amendment to the main Fisheries Law in Turkey will help to harmonize the code implementing the European Community rules as necessary (GDFA 2019). The same applies to the technical measures regulating the fisheries. In this context, the implementation of the EC No 1967/2006 by Turkey would fill most of these gaps, and Turkey is already taking some measures to harmonize its fisheries legislation according to the EC system for the management and conservation of the fish stocks in the Mediterranean.

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