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Sustainability or fun? Recreational angling in Marine Protected Areas

by

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Abstract

Gökova Bay MPAs (southern Aegean Sea, Turkey) include six different no-take zones (NTZs: Akyaka, Çamlı, Akbük, Boncuk-Karaca, İngiliz Limanı, Bördübet), in four of which shore angling is permitted (Akyaka, Çamlı, Akbük, Boncuk-Karaca). This study determined the total catch and size of fish caught in the Akyaka MPA during recreational fishing. In total, fish representing 22 species belonging to 10 families were caught and most of them were smaller than their length at first maturity. The projection showed that the total catch weight reached significant values for recreational angling in the Akyaka MPA. The results of this study indicate that recreational angling may pose a threat to both MPAs and no-take zones, causing them to deviate from their primary conservation goal due to the harvesting of juveniles by recreational anglers.

Key words: angling, conservation, juvenile fish, no-take zone, weekend activity

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1. Introduction

The scientific literature and reports provide various definitions of a marine protected area (MPA). The most updated and relevant version is as follows: "*MPAs can be considered as a policy instrument to reduce overfishing, habitat loss, to protect rare and threatened species, to ensure sustainable ecosystem services such as human well-being, fisheries, coastal protection, tourism and recreation*" (OECD 2017). MPAs have various functions such as prevention of overexploitation, conservation of biodiversity, recovery of overexploited populations (Yemane et al. 2008), support of larval nursery, feeding and spawning grounds, spillover of exploited species, dispersion centers for larval recruitment of exploited species, stability of fisheries and socio-economic improvement of local communities (Ward & Hegerl 2003). Recovery of overexploited populations in MPAs may be the most critical of the aforementioned goals. MPAs have proven to increase the number and size of fish, as well as their diversity (Kendal & Picquelle 2003). Furthermore, proper establishment of MPAs can help maintain juvenile habitats and feeding areas of commercial species.

MPAs that are designed to protect nursery habitats generally favor the survival of settlers and juveniles (Planes et al. 2000). Well-designed and managed MPAs benefit adjacent areas through a spillover effect, in addition to benefiting the conservation of fish assemblages in NTZs (Di Lorenzo et al. 2016). Spillover has positive effects on exploitable fish communities (Stobart et al. 2009).

The spillover effect of MPAs was proven by many studies. Population replenishment is determined by the existence of juveniles, which occur densely in shallow areas where anthropogenic impacts are concentrated (Cuadros et al. 2017). Once the juvenile period is over, survivors begin to move from nursery areas to adult habitats (Macpherson, 1998). With regard to this issue, Abecasis et al. (2009) found evidence of spatial movement of *D. sargus* and *D. annularis* over a distance of 12–90 km from a lagoon area. This finding makes it easier to understand fish entry into fishery grounds. Moreover, Ashworth & Ormond (2005) showed that the abundance of Siganidae species (*Siganus luridus*, *Siganus argenteus* and *Siganus stellatus*) increased with depth, and that individuals of these species had larger sizes in fishing grounds compared to those in NTZs. Similarly, McClanahan & Mangi (2000) revealed that rabbitfishes, emperors, and surgeonfish show a major spillover effect.

On the other hand, some MPAs are declared as no-take marine reserves (NTRs) with total fishing restrictions (Mesnildrey et al. 2013; Rolim et al. 2019) and are very important areas for the preservation of marine resources (Halpern et al. 2009). In this context, Aburto-Oropeza et al. (2011) observed a large recovery of biomass in one of the NTRs and a consequent increase in total fish biomass (+ 463%) 14 years after the establishment of the no-take area; specifically, carnivores and top predators increased four and 11 times, respectively. The increase in fish biomass is associated with a combination of social (enforcement, social cohesion, and community leadership) and ecological factors, which can result in significant economic benefits and spillover effects.

The total number of MPAs and OECMs (other effective area-based conservation measures) has reached 1231, corresponding to a total surface area of 179.798 km^2 (7.14% of the total Mediterranean area). Moreover, while in 2010 NTZs covered only 202 km^2, i.e. 0.01% of the total Mediterranean surface area (GEF 2010), in 2016 their area reached 976 km^2, i.e. 0.04% of the Mediterranean (MedPAN & UNEP-MAP-SPA/RAC 2017).

The Muğla Province (south-western Turkey) has the longest coastline (≈ 1500 km; Figure 1) in Turkey (Governorship of Muğla, 2019). There are many indentations in the coastline and these areas have become a shelter for many marine species. Gökova Bay is a gateway between the Mediterranean Sea and the Aegean Sea. Therefore, this valuable area is unique for the coast of Turkey. Kıraç & Veryeri (2010) mentioned that there are 352 fish species in the Gökova Bay MPA and they represent almost 73% of all fish species in Turkey (24 of them are threatened). On the other hand, many Lessepsian fish inhabit the Gökova Bay habitats (Ateş et al. 2017).

Gökova MPAs were declared as six different NTZs (Akyaka, Çamlı, Akbük, Boncuk-Karaca, İngiliz Limanı, Bördübet; 23 km^2) on the southeastern coast of the Aegean Sea in 2010 (Bann & Başak, 2011). However, with the 2012 and 2016 regulations, the total number of shore angling areas increased to four in these six NTZs (GDFA 2012; GDFA 2016).

The sampling site, the Akyaka MPA, includes two fishery cooperatives: Akyaka and Akçapınar. Sixty families in Akyaka and 70% of the Akçapınar population rely on small-scale traditional fisheries for their livelihood (Bann & Başak 2011). Small-scale traditional fishery operations are conducted outside the NTZs. Native and Lessepsian species, especially *Saurida lessepsianus* and *Nemipterus randalli*, are major economic contributors to local fisheries (Ateş et al. 2017). Furthermore, Sparidae and Serranidae species are the most important and targeted species in Gökova Bay. Nemipteridae, Soleidae, Mullidae, Mugilidae, Carangidae, Sciaenidae, Scombridae, Siganidae, Sphyraenidae and Zeidae are also targeted or landed as by-catch (Ünal et al. 2019).

Prior to the establishment of MPAs, commercial fishers were the primary stakeholders in these areas. However, following the establishment of the MPAs, the use of these areas by recreational anglers, rather than commercial fishermen, may potentially have a negative impact on both sustaining fish populations and commercial catch. This impact becomes apparent when juvenile fish are harvested and is even more pronounced when the total number of recreational fishermen on the shore is considered and a simple projection is applied. The harvesting of juvenile fish in MPAs logically harms ecological and fisheries sustainability. It may have a knock-on effect that leads to fewer juveniles, less recruitment, less food for predators (Connel 1998), less catch (FAO 2000), less economic contribution to local fisheries (Dar et al. 2015), and overcapitalization in local fisheries (i.e. profit < capital; FAO 1999; Clark 1977). These negative effects contradict the objectives of MPAs. The issues addressed in this study are indicative of general problems in MPAs. On the other hand, the presence of a lagoon in the study area means that this area is of particular importance.

This study addresses shore angling, which is assumed to compromise MPA objectives. The analysis of the issue was supported by biological data. The annual catch per recreational angler was determined, as well as its direct damage to an MPA and indirect effects on commercial fishers were presented. The purpose of this study is therefore twofold. First, it emphasizes the importance of collecting and interpreting biological data to gain knowledge about MPAs and to understand how stakeholders may be affected by a proposed management plan. Second, the potential harm of recreational anglers in NTZs to small-scale commercial fisheries was assessed.

The methodology and results of the study can be used to understand the current situation in similar MPAs, as obtaining data on recreational fishing is often a challenge. According to the results of this study, based on the biological data from the MPA, some recommendations for fishery management authorities were proposed and interpretations for recreational angling catch in the light of conservation were provided.

2. Materials and methods

2.1. Study area and sampling

The study was conducted between August 2016 and July 2017 in the Akyaka MPA, in the southwestern part of Turkey (Figure 1). The Akyaka MPA is located on the eastern side of Gökova Bay, which includes

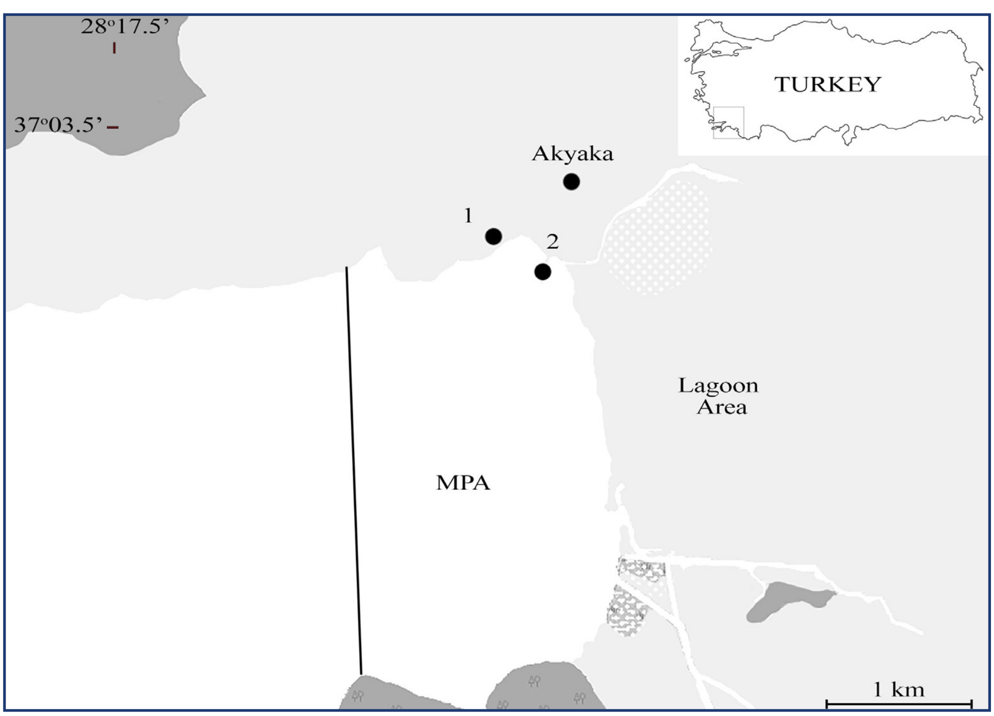

Figure 1

Study area; 1 and 2 indicate anglers' locations a lagoon area. The shore is mostly rocky and this feature makes the Gökova shore a sheltered area for juveniles of most species. On the other hand, in terms of fisheries, longlines, trammel nets and gillnets are commonly used in Gökova Bay (Ceyhan et al. 2009; Dereli et al. 2015). Gökova Bay is also a favorite fishing area for recreational fishers. Handline, demersal and pelagic jigs are prevalent techniques among recreational anglers.

Samples were collected monthly (two days on mid-month weekends; 12 months in total). The largest number of angler visits was observed on weekends. Therefore, the time and day of sampling were selected accordingly. The daily number of anglers was recorded for each sampling day. The sampling area has estuary characteristics. Most anglers perform on rocky and sandy substrates. Fishing tackle was designed according to the angling gear of other local daily anglers (i.e. anglers were mimicked; Fig. 2). Breadcrumbs were used as bait. Each sampling event started 3 h before sunset and was completed within 2 h. Sampling depths ranged from 1 and 3 m.

2.2. Laboratory examinations

Captured individuals were brought to the laboratory in ice and identified to the species level. Total length was measured to the nearest 0.1 cm and weight was determined to the nearest 0.01 g.

2.3. Catch estimation (CPUE)

Daily CPUE (kg angler^{-1} day^{-1}) was determined according to the following formula (Aydın 2011):

$$CPUE = \frac{\sum Weight(kg)}{\sum RecreationalAngler \times \sum FishingTrials(day)}$$

2.4. Extrapolations

Species caught were also categorized into commercial and non-commercial. Length at first maturity of each species (L_m or L_{50}) was obtained from scientific papers on a given species (Supplementary Table S1) and total lengths were compared with length at first maturity and minimum landing sizes (MLS) for commercial species. According to the Turkish Commercial Fishery Communique, four of the commercial species caught have length restrictions: *Pagellus erythrinus* – 15 cm, *Dentex dentex* – 35 cm, *Diplodus vulgaris* – 18 cm and *Diplodus sargus* – 21 cm. To understand the indirect potential impact on commercial fisheries, future landings of *D. vulgaris* were estimated as an example. First, the minimum size of a captured individual (6.3 cm) was considered to be at the level of length at first maturity (L_m = 13 cm). Second, that individual was considered to be of minimum landing size (MLS = 18 cm). The same numerical difference between the smallest size and L_m (+ 6.7 cm) and the smallest size and MLS (+ 11.7 cm) was added to the length of all individuals. L_m (13 cm) and MLS (18 cm) values were obtained from Soykan et al. (2015) and the Turkish Fishery Communique, respectively.

Ricker's (1975) formula was used to estimate the weight of all individuals that corresponds to at/after L_m and MLS:

$$W = a \times L^b$$

Length–weight relationship estimates were performed in Microsoft Excel (Microsoft Corporation 2018) and RStudio was used for visualization (RStudio Team 2015).

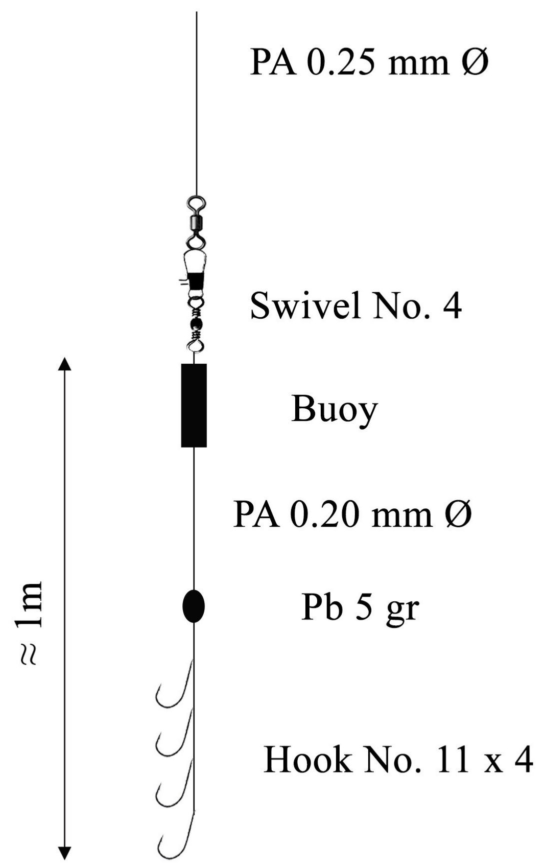

Figure 2
Fishing tackle characteristics (Soykan et al. 2020)

3. Results

A total of 24 angling operations were conducted during the study. The number of anglers varied depending on the season. While the number of anglers dropped to three anglers per day in winter, it reached up to 50 anglers per day in summer. The average daily number of anglers was determined to be 25 (± 13 angler) per day.

A total of 22 fish species (n = 487) belonging to 10 families were captured. Evaluation of each species was based on weight and abundance. *Chromis chromis* (n = 146), *Siganus rivulatus* (n = 94) and *Diplodus annularis* (n = 86) were the most common species in the catch (Table 1). Based on the total number of angling samples, the daily CPUE was 0.328 kg·angler^{-1}·day^{-1} (Table 2). It was determined that 73.16% of the total weight and 64.07% of the total number of individuals belonged to commercial species.

3.1. Projection of *D. vulgaris* future landings

The projection of future landings of *D. vulgaris* was analyzed based on the determined length–weight relationships. The results of the non-linear regression are presented in Table 3. The *b* value (3.10) for *D. vulgaris* was compared with the *b* value (3.03) for the same species obtained in the previous study (Akyol et al. 2007) conducted in the Gökova Bay fishing ground. Due to the differences in sample sizes, differences

Table 1

Ratios of species in the angling catch in the Akyaka MPA

Family	Species	Weight (g)	Number (n)	Weight (%)	Number (%)	Importance
Balistidae	*Balistes carolinensis*	25.37	1	0.32	0.21	C
Blennidae	*Parablennius sanguinolentus*	102.43	6	1.30	1.23	NC
Gobiidae	*Gobius niger*	27.61	5	0.35	1.03	NC
Labridae	*Coris julis*	50.6	3	0.64	0.62	NC
	Thalassoma pavo	95.16	3	1.21	0.62	NC
Pomacentridae	*Chromis chromis*	1449.76	146	18.42	29.98	NC
Serranidae	*Serranus scriba*	96.95	2	1.23	0.41	C
Siganidae	*Siganus luridus*	88.17	4	1.12	0.82	C
	Siganus rivulatus	2462.71	94	31.29	19.30	C
Sparidae	*Boops boops*	255.46	29	3.25	5.95	C
	Dentex dentex	92.81	1	1.18	0.21	C
	Diplodus sargus	203.68	11	2.59	2.26	C
	Diplodus annularis	1100.58	86	13.98	17.66	C
	Diplodus vulgaris	153.29	12	1.95	2.46	C
	Lithognathus mormyrus	84.96	4	1.08	0.82	C
	Oblada melanura	266.52	18	3.39	3.70	C
	Pagellus erythrinus	31.36	1	0.40	0.21	C
	Sarpa salpa	890.36	48	11.31	9.86	C
Scorpaenidae	*Scorpaena madarensis*	6.95	1	0.09	0.21	C
Tetraodontidae	*Lagocephalus sceleratus*	54.09	1	0.69	0.21	NC
	Torquigener flavimaculosus	290.94	10	3.70	2.05	NC
	Lagecephalus suezensis	42.02	1	0.53	0.21	NC
Total		7871.78	487			

*C – commercial
**NC – non-commercial

Table 2

CPUE in recreational angling in the MPA

	Total catch estimation	Catch (kg)
Daily (1 angler)	0.328 kg	0.3
One weekend (1 angler)	0.328 kg × 2 days	0.7
All weekends in a year (1 angler)	0.328 kg × 2 days × 52 weeks	34.1
3 anglers (min.)	0.328 kg × 2 days × 52 weeks × 3 anglers	102.3
25 anglers in a year (mean)	0.328 kg × 2 days × 52 weeks × 25 anglers	852.8
50 anglers (max)	0.328 kg × 2 days × 52 weeks × 50 anglers	1705.6

Table 3

Results of non-linear regression for *D. vulgaris*

N	$L_{min.}$–L_{max} (cm)	$W_{min.}$–W_{max} (g)	*a*	*b*	CI of *a*	CI of *b*	S.E. of *b*
12	6.3–13.0	4.04–37.42	0.0131	3.10	0.0068–0.0239	2.86–3.37	0.115

between *b* values were not considered significant. The *b* value for *D. vulgaris* in the present study is slightly above 3 (i.e. isometric length–weight relationships), but not significantly different from the cubic value. Therefore, it can be assumed that the projection (at and after L_m and MLS) is reliable. Estimated weights of individuals were projected for length at maturity and MLS, respectively (Figure 3).

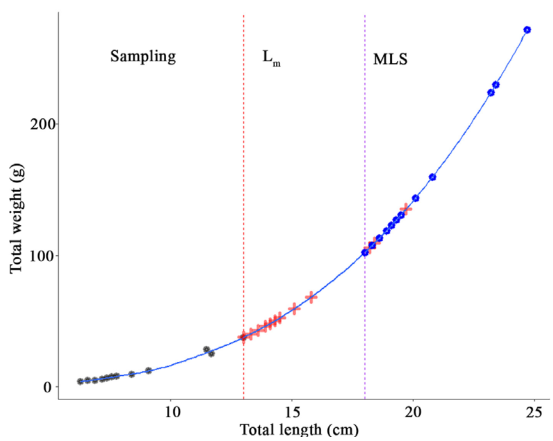

Figure 3

Weights of *D. vulgaris* at/after first maturity length (L_m) and minimum landing size (MLS) estimated from the length–weight relationships in the collected data

4. Discussion

Gökova Bay provides sheltered areas for many species. These areas have great potential for commercial contribution to local small-scale fisheries. However, recreational angling may have some negative impacts on small-scale fisheries, especially on target species and fish sizes. A total of 22 fish species belonging to 10 families were identified and many of the fish caught were smaller than length at first maturity and the landing projection showed that the total weight of the catch by recreational angling reached a significant value in the Akyaka MPA. The results of the study are discussed below under the following headings: size composition, landing projection, other examples of recreational fishing in different MPAs, spillover effect, catch-and-release fishing.

4.1. Size composition

According to the results of the study, the maximum lengths of most of the species were below maturity lengths or minimum landing sizes (Supplementary Table S1). The presence of juveniles in the catch contradicts the ecosystem-based fisheries management. Harvesting unprotected immature individuals in their early life stages may prevent the spillover of species to exploitable legal fishery grounds. Therefore, recreational angling may have a negative impact on the sustainability of local stocks.

4.2. Projection of *D. vulgaris* landing

Many Sparidae species inhabit lagoon areas (e.g. *D. annularis, D. vulgaris, D. sargus, S. salpa*) and hard seabed (Acarlı et al. 2009; Garcia-Rubies & Macpherson 1995). The shore of the Akyaka MPA has rocky substrates that are frequently used by recreational anglers. According to the results of the present study, Sparidae species caught from the rocky substrate accounted for 40.64% of the total catch.

A total of 12 individuals of *D. vulgaris* were caught in the present study (≈ 160 g). According to the length–weight projection, if *D. vulgaris* could be fished based on length at first maturity, it would reach almost five times the weight (≈ 800 g) of the sample. Thus, for length at first maturity, the MLS of *D. vulgaris* was above the maximum catch length of the sampled individuals. This clearly indicates that shore angling in the Akyaka MPA is unsustainable and an unsuitable fishing method for this area. The projection showed that ≈ 1900 g fish could be caught if the total length of individuals was above MLS. Furthermore, *D. vulgaris* landings based on the actual and extrapolated data were 0.6 kg and 8 kg per angler per year, respectively (Table 4). MSLs (Minimum Size Limits) become useful if the growth exceeds losses due to natural mortality and by-catch mortality (injuries caused by capture, handling, thermal stress, depth change, and predation). Therefore, size limits are a valuable tool to avoid catching small fish (Bohnsack 2000).

The projection presented is exactly in line with Bohnsack's (2000) statement: "*MSLs (minimum size limits) are intended to provide long-term benefits to fisheries by allowing juveniles to escape fishing mortality so that they can enter the fishery later at larger size. NTRs*

(No Take Reserves) are intended to provide similar benefits by increasing the supply of recruits and exporting fishes to surrounding fishing grounds".

Positive effects of conservation measures can be clearly understood from some observational studies. According to Harrison et al. (2012), marine reserves directly support fish and fishers. Roberts & Hawkins (2000) found that there are eight different fishing types in the area adjacent to the De Hoop Marine Protected Area (South Africa), and the De Hoop reserve provides protection to over 60 exploited species. According to Halpern (2003), density, biomass, size, and diversity of carnivorous, herbivorous, and planktivorous fish, as well as of invertebrate feeders and invertebrates are higher inside the reserves than outside. If the Akyaka MPA is properly managed under the conservation objectives, the contribution of fish and other organisms to commercial fishing grounds could be higher than at present.

On the other hand, banning the towed gear in MPAs provides an opportunity to increase species biomass (Fisher & Frank 2002). However, permitting recreational angling does not comply with the area closure management approach (Schroeder & Love 2002). Gökova Bay has an advantage due to trawl and purse seine restrictions. These restrictions are sound implementations, but shore angling may impede the recovery of the MPA and spillover of species to fishery grounds. The indirect effect of recreational anglers on the spillover of species may only become apparent over a long period of time. Commercial fishers target a large percentage of species caught by recreational fishers, and recreational fishers affect the catch of commercial fishers and their income (Font et al. 2012).

4.3. Examples of recreational angling in different MPAs

Common findings on recreational angling pressure were presented in some related studies on MPAs or NTZs. According to Schroeder & Love (2002), the primary source of fishing mortality is recreational angling. In this context, Venturini et al. (2017) determined the impact of recreational angling on fish stocks. They revealed contradictions with the law and the minimum catch size (in terms of first reproduction size). The interesting finding in their study was that NTZs (where the spillover effect occurs) attracted

Table 4

Projection of length–weight relationships in *D. vulgaris*

Catch		Landing Projection			
		After maturation		After Minimum Landing Size	
TL_1 (cm)	W_1 (g)	TL_2 (cm) (TL_1 + 6.7 cm)	W_2 (g)	TL_3 (cm) (TL_1 + 11.7 cm)	W_3 (g)
6.3	4.04	13	37.51	18	102.95
6.6	4.64	13.3	40.26	18.3	108.37
6.9	4.82	13.6	43.14	18.6	113.98
7.2	5.88	13.9	46.16	18.9	119.78
7.4	6.57	14.1	48.26	19.1	123.76
7.6	7.61	14.3	50.41	19.3	127.83
7.8	8.07	14.5	52.63	19.5	131.98
8.4	9.12	15.1	59.69	20.1	144.99
9.1	11.94	15.8	68.70	20.8	161.24
11.5	28.21	18.2	106.54	23.2	226.28
11.7	24.97	18.4	110.22	23.4	232.39
13	37.42	19.7	136.23	24.7	274.84
Total weight (g)	153.29		799.75		1868.40
S.D.	10.6		31.2		54.5
S.E.	2.9		8.7		15.1
	Catch (g)				
1 angler/day	6.4		33.3		77.8
1 angler/weekend	12.8		66.6		155.7
1 angler/year	664.3		3465.6		8096.4
3 anglers/year	1992.8		10 396.7		24 289.1
25 anglers/year	16 606.4		86 639.3		202 409.5
50 anglers/year	33 212.8		173 278.6		404 818.9

TL_1 – total length of individuals caught; TL_2 – length at/after first maturity of individuals caught; TL_3 – length at/after minimum landing size of individuals caught; W_1 – total weight of individuals caught; W_2 – estimated weight of individuals caught at/after length at first maturity; W_3 – estimated weight of individuals caught at/after minimum landing size

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anglers and the gross harvest of anglers in their study area accounted for 8% of the total yield of the small-scale fishery.

According to the Turkish amateur fishery communique, amateur fishery is defined as: "*a fishing activity carried out by a fisherman for recreation, sport, or professional purposes, other than making any monetary profit or selling fish*" (GDFA 2020). Therefore, amateur and recreational fishing are considered in the same sense in Turkey. However, small-scale fishing competes with large-scale and recreational fishing in Gökova Bay, and the exact number of recreational fishers is not known (Ünal et al. 2019). Angling (both from shore and boat) and spearfishing are the most preferred amateur fishing techniques in Gökova Bay (Ünal & Erdem 2009). Ünal & Erdem (2009) identified ten species in amateur fishing in Gökova Inner Bay: *Pagellus erythrinus*, Mugil sp., *Sparus aurata*, *Dicentrarchus labrax*, *Diplodus vulgaris*, *Lichia amia*, *Epinephelus* sp., *Mullus* sp., *Trachurus* sp. and *Euthynnus alletteratus*. In addition to these species, *Pomatomus saltatrix, Sphyraena sphyraena* and *Octopus vulgaris* are also caught. Moreover, they concluded that amateur fishers may impact small-scale fisheries. On the other hand, Dereli et al. (2015) reported a decline in local fish resources in small-scale fisheries in Gökova Bay. They found that the average catch was 15.5 $kg·boat^{-1}·day^{-1}$ for gillnet fishers and 5.2 $kg·boat^{-1}·day^{-1}$ for longline fishers in this area. In personal interviews, recreational fishers who participated in daily boat fishing tours were asked about capture statistics, and their catch ranged between 2–7 $kg·angler^{-1}·day^{-1}$ (C. Bulut, personal communications). They proposed a more efficient protection of NTZs from all fishing activities. The results of the present study showed that the approximate yield of recreational angling on the shore of the Akyaka MPA was 0.328 kg. However, if daily catch is estimated using a simple equation, total landing reaches about 1705 kg in the Akyaka MPA (Table 2) and this is considerably high for recreational fishing. This finding may indicate a negative impact of recreational angling on fish stocks.

4.4. Spillover effect

No studies on spillover have been conducted in the Gökova MPAs. However, results of previous projects showed that the spillover effect may occur in the Akyaka MPA. The first biodiversity study in the Akyaka MPA was conducted in 2010 by the General Directorate of Fisheries and Aquaculture, Turkey. Turkey Ecological Research Society (EKAD, 2013) conducted a second biodiversity study in 2013 and found that there were more fish species in the Akyaka MPA than in other areas. It was observed that while the maximum lengths of five species (*D. annularis, S. lessepsianus, P. erythrinus, B. boops, S. rivulatus*) increased, the maximum lengths of four species (*P. incisus, D. vulgaris, D. dentex, L. aurata*) decreased. The decrease in maximum lengths in the Akyaka MPA may indicate the existence of a nursery habitat and a spillover effect. According to the results of the present study, many fish do not reach the length at first maturity and have the potential to spread into fishery grounds. Therefore, it may be considered that recreational angling has a negative impact on the spillover effect.

4.5. Catch-and-release fishing in the Akyaka MPA?

Marine and freshwater species have similar mortality rates in catch-and-release fishing (CRF). Fish mortality rates in CRF are affected by hooking location, natural bait, deep hooking, use of "J" or circle hooks, water depth and temperature, playing and handling times. Regarding hook types, barbless hooks result in lower fish mortality than barbed hooks (Bartholomew & Bohnsack 2005). Aalbers et al. (2004) reported that all mortalities occurred within five days of release (i.e. released fish may have a low survival). Logically, the occurrence of release mortality is inconsistent with NTZ objectives (Bartholomew & Bohnsack 2005). As regards hook types and fishing gear manipulation, all recreational fishers in the Akyaka MPA use barbed hooks. Furthermore, it has been observed that some anglers do not use their hands in the process of removing fish from hooks, especially if they do not know what they caught, and instead they step on the fish with one foot to remove a hook and then release it. This manipulation may potentially significantly increase fish mortality. Therefore, CRF should not be considered a good option for shore angling in the Akyaka MPA. In this regard, lack of education among anglers was identified as the major shortfall. People need to be educated about marine life to ensure that mortality is reduced.

On the other hand, Sale et al. (2005) argued that too many MPAs are located in the wrong places. According to the present study, although the Akyaka MPA was established in the right place (i.e. near the lagoon), the presence of juveniles in the recreational catch indicates that this area is not properly managed. Partial protection may have benefits (like trawl restrictions for habitat protection), however, partially protected areas are not as effective as NTRs (Sala & Giakoumi 2018). More comprehensive protection plans should be put into effect.

In addition to all the above methods, lure fishing has also been observed in the Akyaka MPA. Anglers who use this method, target fish such as *D. labrax*, *S. sphyraena*, *P. saltatrix* etc. However, there are no data on lure fishing on the shore of Gökova Bay. Micheli et al. (2005) reported that the size and abundance of predatory fish species targeted by local fisheries were greater in NTRs than in exploited areas. Other than recreational angling, lure fishing may have a potential negative effect on spawning stock biomass in the Akyaka MPA.

Although recreational fishing is not a commercial activity (i.e. no fish are sold), it makes a significant economic contribution to other fisheries-related sectors (by spending money on food, bait, accommodation, travel, boat fuel, boat maintenance and fishing gear costs; Tunca et al. 2013). However, this economic contribution depends on sustainability of fish stocks (i.e. importance of juveniles).

Samples for the study were collected using simple fishing tackle that any angler can purchase. This easy access may lead to increased potential of recreational angling and may increase the pressure on juveniles. As mentioned in various studies on juveniles, the sustainability of fish stocks depends on recruitment success. In addition, negative effects of lost fishing gear that originates from recreational angling should not be ignored.

Therefore, the following conclusions can be made:

- Juveniles should be protected and the spillover effect should not be prevented to ensure the spread of species to fishery grounds; this strategy may potentially have a large economic contribution to local fisheries in the future;
- Due to the presence of the lagoon and the harvesting of juveniles, recreational fishing should be completely banned on the shore of the Akyaka MPA;
- People should be educated to ensure awareness of catch-and-release fishing, stock–recruitment relationships and MPAs.
- In conclusion, allowing recreational anglers in MPAs does not comply with the conservation objectives of NTZs due to their potential negative impact on sustainability.

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Supplementary Table 1

Length at first maturity of fish caught in the Akyaka MPA by species

Species	Total Length (cm)			Sex	MLS	Length at First Maturity (cm)		
						Researchers		
	Min.	Max	Mean			Kacem & Neifar (2014)	İşmen et al. (2004)	Bernardes & Dias (2000)
Balistes capriscus	12.5	12.5	12.5	M		21.3 FL		16.9
				F		20.26 FL		20
				M+F			>13	
						İlkyaz et al. (2018)	Filiz & Toğulga (2009)	Kırdar & İşmen (2018)
Gobius niger	6.6	7	6.8	M		11.09		
				F		11.42	7.8	
				M+F				9.58
						Tuset et al. (2005)	İlhan et al. (2010)	Zorica et al. (2006)
Serranus scriba	12.4	17	14.7	M		17.3	13.2	9.3
						Bariche 2003		
Siganus luridus	8.2	15.2	11.1	M		13.9		
				F		14.2		
						Bariche et al. (2003)	Gabr et al. (2018)	
Siganus rivulatus	9.4	18.5	12.66	M		13.25	18.35	
				F		13.65		
				M+F				
						Soykan et al. (2015)	Bottari et al. (2014)	Layachi et al. (2015)
Boops boops	8.7	12.7	9.7	M		9.35	14.2	13.3
				F		12.96	13.1	14.3
				M+F			13.8	
						Morales-Nin & Moranta (1997)	Grau et al. (2016)	Cetinic et al. (2002)
Dentex dentex	19			M		52.02	33.8	33.3
				F		34.6	34.9	34.5
				M+F				
						Mouine et al. (2007)	Benchalel & Kara (2013)	Al-Beak et al. (2017)
Diplodus sargus	6.5	13.7	9.35	M			20.2	
				F	21.0		20	
				M+F		20.95		21.27
						Chaouch et al. (2013)	Pajuelo & Lorenzo (2001)	İlkyaz et al. (2018)
Diplodus annularis	6	13.4	8.95	M		10.5	10.3	10.53
				F		10.6	12.8	10.02
				M+F				
						Dulcic et al. (2011)	Soykan et al. (2015)	Taieb et al. (2012)
Diplodus vulgaris	6.3	13	8.62	M		18.5	13.37	13.64
				F	18.0	19.1	12.87	13.84
				M+F				
						Kallianiotis et al. (2005)	Emre et al. (2010)	Alssalam et al. (2016)
Lithognathus mormyrus	9.1	15.6	12.35	M		16.21	17.8	14.15
				F		19.04	18.5	14.45
				M+F				
						Mahmoud (2010)	Cetinic et al. (2002)	
Oblada melanura	7.5	19	9.9	M		14.35	16.4	
				F		14.75	17.5	
				M+F				
						Ali Ben Smida et al. (2006)	Coelho et al. (2010)	Metin et al. (2011)
Pagellus erythrinus	12.6	12.6	12.6	M		16.75	17.58	15.08
				F		15.32	17.29	11.3
				M+F				
						Criscoli et al. (2006)	Paiva et al. (2016)	El-Etreby et al. (2015)
Sarpa salpa	9.3	14	10.94	M		19.5	24.5	21.1
				F			28.6	28.5
				M+F				
Parablennius sanguinolentus	8.2	12.4	10.42			No available data		
Coris julis	11.1	11.8	11.9			No available data		
Thalassoma pavo	12	16.9	13.9			No available data		
Chromis chromis	6.5	11	8.52			No available data		
Scorpaena maderensis	7.1	7.1	7.1			No available data		
Lagocephalus sceleratus	17.3	17.3	17.3			No available data		
Torquigener flavimaculosus	8.7	13.4	10.95			No available data		
Lagocephalus suezensis	15.3	15.3	15.3			No available data		

*No available data – no information on length at first maturity of the species

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