Turk. J. Fish.& Aquat. Sci. 25(4), TRJFAS26748
https://doi.org/10.4194/TRJFAS26748

RESEARCH PAPER

Turkish Journal of FISHERIES and AQUATIC SCIENCES

The First Use of Baited Remote Underwater Video Systems (BRUVS) in the Turkish Seas to Assess Fish Assemblages

Adnan Çağlar ORUÇ[1,*]

[1]İzmir Katip Çelebi University, Faculty of Fisheries, İzmir/ Türkiye 35620

How to Cite

Oruç, A. Ç. (2025). The First Use of Baited Remote Underwater Video Systems (BRUVS) in the Turkish Seas to Assess Fish Assemblages. *Turkish Journal of Fisheries and Aquatic Sciences*, *25(4)*, *TRJFAS26748.* https://doi.org/10.4194/TRJFAS26748

Article History
Received 13 September 2024
Accepted 02 December 2024
First Online 11 December 2024

Corresponding Author
E-mail: acaglaroruc@gmail.com

Keywords
BRUVS
Fish monitoring
Fish assemblage
Eastern Mediterranean

Abstract

The potential of non-destructive sampling methods such as a baited remote underwater video system (BRUVS) for fish monitoring is immense. This potential is demonstrated in our study, which examined three sites with different habitats (rocky, wreck, seagrass) in the Karaburun- Ildır Bay Special Environmental Protection Area (SEPA) in the Aegean Sea. From 60 hours of video recordings, we identified 3771 individuals from 24 fish species belonging to 10 families. The rocky habitat had the highest total abundance (44.9%), with a statistical difference. The result of Shannon-Wiener's index specified the highest value in the wreck (H'WR=1.73), although the rocky had greater fish diversity (H'RR=1.54). It is clear that there is a lack of studies, especially in the Eastern Mediterranean, and the benefits of long-term periodic monitoring studies using BRUVS should not be ignored

Introduction

The Mediterranean Sea is recognized as one of the most biodiverse regions globally; however, the populations of both vertebrates and invertebrates are facing significant pressure from various stressors, including pollution (Guidetti et al., 2003), fishing (Piroddi et al., 2020), invasive species (Katsanevakis et al., 2014) and climate change (Barnett et al., 2001). As a result, there has been a decline in species richness, diversity, density, and biomass (Claudet & Fraschetti, 2010; Coll et al., 2010; Prato et al., 2013).

Marine protected areas (MPAs) are essential for supporting marine ecosystems and their ecological processes, as well as for the spatial management of critical regions and the conservation of coastal species affected by human activities (Halpern and Warner, 2002; Lester et al., 2009; Grorud-Colvert et al., 2021). Furthermore, MPAs are recognized as the most effective tools for conservation and protection, provided they are managed properly. Although MPAs encompass over a thousand sites covering 8.3% of the Mediterranean Sea, only 13% of these areas possess a national statute and a business plan (MedPAN & UNEP/MAP-SPA/RAC, 2023).

The ecological effectiveness of MPAs are often estimated based on fish assemblages (Molloy et al., 2009). Traditionally, fish diversity assessments have utilized methods such as fishing and catch operations, underwater visual census strip transects (UVCt), and baited remote underwater video (BRUV) (Aglieri et al., 2021; Murphy & Jenkins, 2010). To mitigate further damage to habitats and species, non-destructive sampling techniques are preferred over more conventional methods like dredging and trawling (McGeady et al., 2023).

The baited remote underwater video (BRUV) system is a sampling method that offers a non-destructive, non-extractive, and cost-effective alternative to traditional fishery-dependent approaches, and it has also been applied for the past two decades (Whitmarsh et al., 2017). Unlike UVC, BRUV systems are not limited by the depth and time constraints of scuba diving (Watson et al., 2005; Harvey et al., 2007); they are less labour-intensive and more economical while also providing valuable information about habitat (Collins et al., 2017). Furthermore, BRUV systems produce standardized and statistically robust data, and measurements that can be reassessed, moving beyond the limitations of diver estimates (Harvey et al., 2007, 2013; Bornt et al., 2015; Malcolm et al., 2015). The features of the BRUV system have made them widely used in many parts of the world as fishery-independent data collection tools for MPAs (Rees et al., 2004; Langlois et al., 2006; Kelaher et al., 2014) but in the Mediterranean, the number of BRUV-based study is still very limited (Stobart et al., 2015; Aglieri et al., 2021; Torres et al., 2020; Cattano et al., 2021; La Manna et al., 2021).

There are 19 SEPAs in Türkiye, five of which are on the Aegean coast. This study had a dual purpose: to assess fish biodiversity in a SEPA located in the Aegean Sea and to evaluate the feasibility of using BRUVS, a novel technique in the region, for future monitoring efforts.

Materials and Methods

The study was conducted between May and July 2023 in Karaburun-Ildır Bay SEPA, which is located in the central Aegean Sea. The wreck (WR), rocky (RR), and seagrass (SR) habitats were chosen for BRUVS deployments. The WR, originally named Alaybey, was intentionally sunk by the local government in 2016 to create a recreational diving site, and it rests on a uniform gravel bottom at a depth of 36.6 m (38.6605° N; 26.5202° E). The RR is a rocky reef at a depth of 36 m and a popular dive site located approximately 0.2 km north of WR (38,6621° N; 26,5206° E). The SR characterized by seagrass reef of *Posidonia oceanica* meadow at a depth of 26 m (38,6417° N; 26,5285° E) (Figure 1).

The BRUVS were constructed according to Langlois et al. (2020). A total of 4 diving weights, each weighing 1 kg, were fixed to the corners of the frame to enhance the stability of the system at the seafloor against potential current conditions. Crashed sardines of 0.8 kg were placed in bait boxes positioned 1.5 m in front of the camera (Dorman et al., 2012; Langlois et al., 2020) (Figure 2). Based on sea conditions, BRUV systems were deployed on the three habitats (RR, WR and SR) within 45 minutes of sunrise (06:00 am). This operation was repeated 20 times on different dates at the points marked with a handheld GPS (Garmin 64Sx) for each habitat.

The videos were recorded at a resolution of 1920 × 1080 pixels with a capture rate of 30 fps (GoPro® Hero 2018) (Harvey et al., 2010). The sixty-minute video image per deployment was viewed using VLC video player, starting after the stabilisation of the BRUVS on the bottom. The MaxN was used to measure of abundance. For this purpose, individuals were identified at the species level, and then the maximum number of a particular species seen in any one video frame across the duration of the video record was counted (Whitmarsh et al., 2017). Species richness was calculated using the Shannon–Wiener diversity index (H′) (Begon et al., 2006), while total abundance was

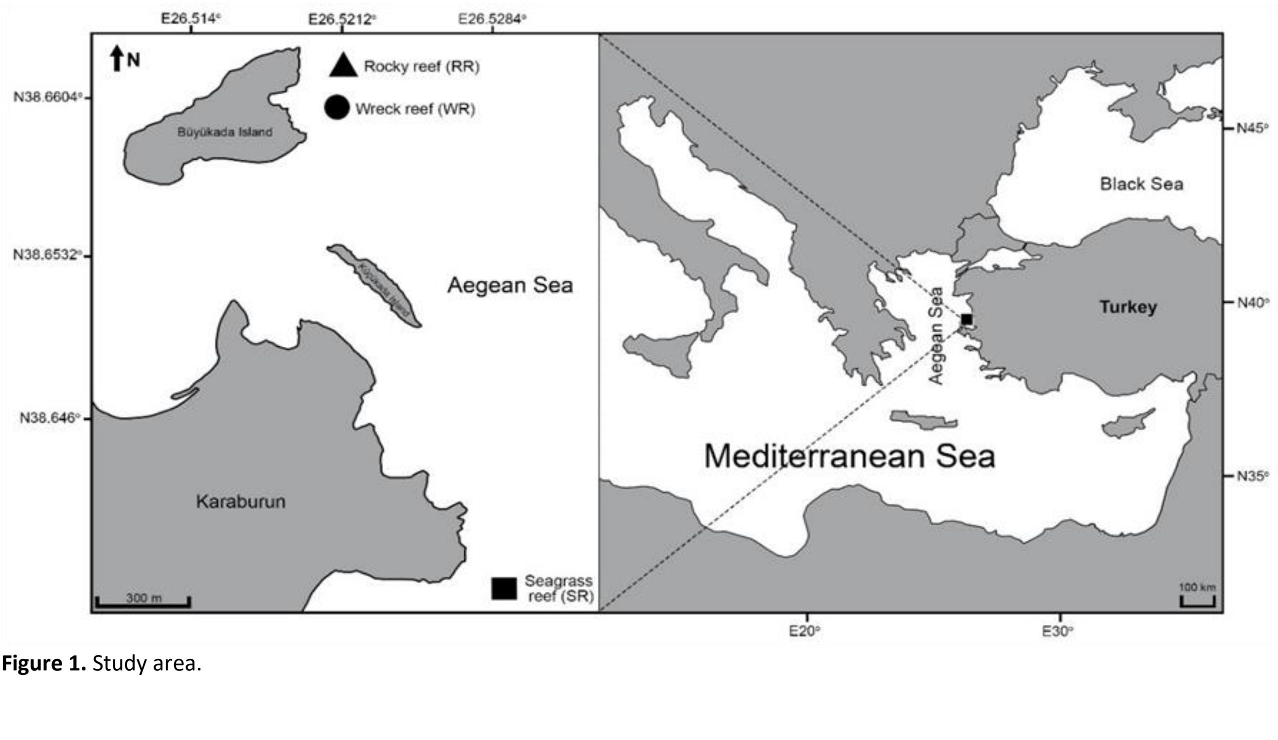

Figure 1. Study area.

determined as the sum of the MaxN of each taxon recorded. The constancy status of fish species was classified into three groups according to their frequency of occurrence of the total deployments: 'accidental' (occurrence less than 25%), 'accessory' (occurrence between 25–50%) and 'constant' (occurrence more than >50%) (Dajoz, 1978; Şensurat-Genç et al., 2022).

The one-way ANOVA test and post-hoc Tukey test (T) were used to determine differences in abundance values for the habitats, and prior to ANOVA analysis, homogeneity of variance was tested using Levene's test. A non-metric multidimensional ordination (nMDS) on ranked Bray–Curtis similarities using multi-species abundance data was produced to represent potential similarity of the fish assemblage structure between the different habitats. A cut-off level of 70% similarity is applied for analyses. Fish abundance data was transformed using a square-root transformation (Fowler & Booth, 2012; Chao et al., 2014). The SIMPER was used to determine the species that contributed most to the assemblage structure with PRIMER v7 (Plymouth Routines in Multivariate Ecological Research software).

Results

In the study, 20 successful BRUVS deployments were performed in each of the three habitats, and a total of 60 hours of video recordings were obtained. From the BRUVS deployments, 3771 individuals (WR=28.9%, RR=44.9%, SR=26.1%) of 24 fish species belonging to 10 families were identified (Table 1). The abundance per deployment was calculated (sum of MaxN) as 54.5±6.9 for WR, 84.7±8.2 for RR and 49.2±3.5 for SR. Statistically, a difference was found between the RR and other habitats, but no difference was found between the WR and SR (Levene's P=0.07, ANOVA P=0.001, T_{RR}-T_{WR} P=0.005, T_{RR}-T_{SR} P=0.01, T_{WR}- T_{SR} P=0.836).

The most diverse families were Sparidae, Labridae and Serranidae (Table 1), and five fish species accounted for 86.1% of the total abundance (*C. julis*, *C. chromis*, *A. anthias*, *B. boops*, *D. sargus*). Between the habitats, fish species with the highest number of individuals in total abundance, *C. chromis* for WR (34%), *A. anthias* for RR (35.8%) and *C. julis* for SR (67.9%) (Table 1, Figure 4). Based on the species richness, the highest number of fish species was registered in RR with 21, followed by SR (18) and WR (16). Among the reefs, *S. viridensis* and *S. smaris* were recorded only in the SR. *Anthias anthias, S. sarda*, *D. dentex* and also the loggerhead sea turtle (*Caretta caretta*) were recorded only in the RR (Figure 3). Although the RR had greater fish diversity (H'_{RR}=1.54), the result of the Shannon-Wiener's index was specified the highest value in WR (*H'*=1.73), and SR was the lowest (*H'*=1.43). Based on species richness, there was a significant difference between the WR and SR (P=0.014).

In the SR, half of the documented species were classified as constant species, which accounted for 89.5% of the total abundance values. In the RR, nearly all abundance (95%) comprised constant species, 28.6% of the overall species count. Meanwhile, at the WR, constant species were 43.8% of the total species and 91.4% of the total abundance. In all habitats, *C. julis*, *M.*

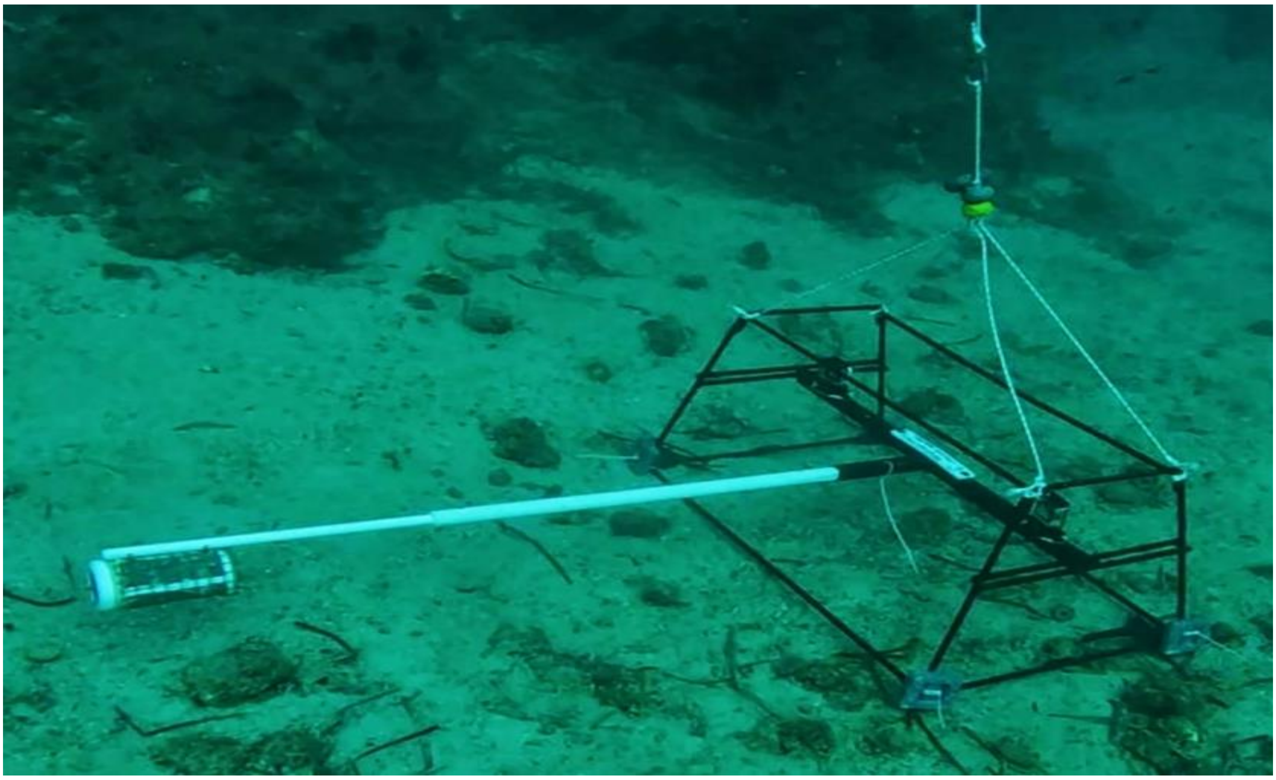

Figure 2. BRUV system was used in the study.

Table 1. Relative abundance (MaxN), species richness, and constancy status for 24 fish species recorded per BRUVS deployment in three different habitats. (Co: Constant, Acc: Accidental, Acces: Accessory).

Habitat										**WRECK (WR)**											
Taxa/Deployment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Const. stat.
Carangidae																					
Seriola dumerili						32						11							4		Acc.
Centracanthidae																					
Spicara maena		2				1			1								6				Acc.
Labridae																					
Coris julis	3	8	2	6	2	8	5	2	3	9	11	7	8	17	6	9	3	3	12	3	Co.
Symphodus mediterraneus									2												Acc.
Symphodus melanocercus											1					2		2			Acc.
Symphodus ocellatus						1											1				Acc.
Symphodus tinca								1													Acc.
Muraenidae																					
Muraena helena	1		1		1	1		1		2	1			1		1		1		1	Co.
Pomacentridae																					
Chromis chromis	26	18	21	16	8	37	32	16	9	17	23	20	6	9	22	12	32	29	8	11	Co.
Scaridae																					
Sparisoma cretense		1						2							3			1			Acc.
Serranidae																					
Serranus cabrilla	1	1	2	1	2	2	2	1	2	1	1	1	2	2	2	2	1	2	1	2	Co.
Sparidae																					
Boops boops	56	86		16		11	21		3		8	12	24	32			62	35			Co.
Diplodus puntazzo	1	3	4	2	2		2		1						2	1	1	2	2	1	Co.
Diplodus sargus	3	4	1	3	3	1	3	1	4	2	2	2	2	3	1	3	4	4	8	11	Co.
Diplodus vulgaris								3													Acc.
Spondyliosoma cantharus		2	2			3		2		1			2	2				3			Acces.
Total *N*max	91	125	33	44	18	97	65	29	25	32	47	53	44	66	36	30	110	82	35	29	**1091**
Species richness	7	9	7	6	6	10	6	9	8	6	7	6	6	7	6	7	8	10	6	6	**16**
Habitat										**ROCKY (RR)**											
Taxa/Deployment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Const. stat.
Carangidae																					
Seriola dumerili											1									1	Acc.
Centracanthidae																					
Spicara maena			3			2			2			2									Acc.
Labridae																					
Coris julis	3	17	5	12	20	14	4	11	19	29	13	24	19	37	6	18	14	21	5	44	Co.
Symphodus cinereus																			2		Acc.
Symphodus mediterraneus																	1				Acc.
Symphodus melanocercus		2			1	2		1	1							2					Acces.
Symphodus ocellatus										1											Acc.
Symphodus tinca						1			1								1				Acc.
Muraenidae																					
Muraena helena	1	3	1		1		1	1	2				2			1	1			1	Co.
Pomacentridae																					
Chromis chromis	32	158	30	18	28	31	43	28	17	19	23	9	12	11	16	14	21	16	15	28	Co.
Scaridae																					
Sparisoma cretense				2					1				1		2					3	Acces.
Scombridae																					
Sarda sarda																		9			Acc.
Serranidae																					
Anthias anthias	41	16	38	23	92	12	33	19	33	49	19	32	58	32	13	19	15	19	22	23	Co.
Serranus cabrilla		3			2						2	1	2	2	1	2	1		1	4	Co.
Serranus scriba									1	2							1				Acc.
Sparidae																					
Dentex dentex				1															2		Acc.
Diplodus annularis					2				1				2								Acc.
Diplodus puntazzo								2			1		1	1					3	3	Acces.
Diplodus sargus	4	2	2	1	1	3	5	5	6	2	4	1	4	4	3	2	3	2	3	5	Co.
Diplodus vulgaris					2				1												Acc.
Spondyliosoma cantharus	1				2		1				1	2		1				1	2	3	Acces.
Total *N*max	82	201	79	57	151	65	87	67	85	102	64	71	101	88	41	58	58	68	55	115	**1695**
Species richness	6	7	6	6	10	7	6	7	12	6	8	7	9	7	6	7	9	6	9	10	**21**
Habitat										**SEAGRASS (SR)**											
Taxa/Deployment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Const. stat.
Centracanthidae																					
Spicara maena					1				1											2	Acc.
Spicara smaris																		1			Acc.

Table 1. *Continued*

Labridae																					
Coris julis	17	21	32	42	12	28	21	12	49	51	29	38	48	38	34	29	49	53	34	32	Co.
Symphodus cinereus	2		3		1	1	2	3		2	1	1		2	3		1		2	1	Co.
Symphodus mediterraneus					1				1				1					2			Acc.
Symphodus melanocercus	1	1			1				1		2		3		1		2	2	2		Co.
Symphodus ocellatus		1		1			1			1		1	1			1				1	Acces.
Symphodus tinca	2	1						1	1		1				1			1			Acces.
Muraenidae																					
Muraena helena	2	1	2	1	1	1	2	2	1	1	2	1	5	1	2	1	2	1	1	1	Co.
Pomacentridae																					
Chromis chromis			3	6			8	2		5			4	5			18			2	Acces.
Scaridae																					
Sparisoma cretense					1			2								1					Acc.
Serranidae																					
Serranus cabrilla	1	1	1	1	2	1			3				2	2			1	1	2		Co.
Serranus scriba	4		2	2	1	2			1	2		2		1	2	3	2	1	1		Co.
Sparidae																					
Boops boops	11	5										3									Acc.
Diplodus annularis	1	2	2		2	3	2		3	1	3		4	1	3	1	5	3	6	2	Co.
Diplodus vulgaris	1	2			2		2		3	1			4	1			5	3	6	2	Co.
Spondyliosoma cantharus			2	1		3	1	3			1	2			4	1	1		2		Co.
Sphyraenidae																					
Sphyraena viridensis																		1			Acc.
Total *N*max	42	35	47	54	25	39	39	25	64	64	39	48	72	51	50	37	86	69	56	43	**985**
Species richness	10	9	8	7	11	7	8	7	10	8	7	7	9	8	8	7	10	11	9	8	**18**

helena and *S. cabrilla* were classified as constant, while *S. maena* and *S. mediterraneus* were classified as accidental (Table 1).

SIMPER analysis revealed that the highest dissimilarity between WR and SR (64,2%) and species contributing to the difference between habitats were given in Table 2. Non-metric multidimensional scaling (nMDS) based on Bray-Curtis similarities separated the habitats, and data showed approximately 50% similarity among the WR and RR (Figure 5).

Discussion

In this study, the BRUVS method was successfully applied for the first time in the Turkish Seas to assess fish assemblages, identifying 24 species. Previous studies in the Mediterranean, such as Stobart et al. (2007), identified 51 species in rocky reefs in Spain and France, and La Manna et al. (2021) recorded 46 taxa in Sardinia. In the Aegean Sea, Nalmpanti et al. (2021) identified 27 fish taxa using a remotely operated underwater drone. Consistent with our findings, both previous studies qualified *C. chromis* and *C. julis as* abundant fishes.

In the Mediterranean, UVC is the most used and preferred technique for monitoring studies compared with video-based sampling methods (Tessier et al., 2013; Prato et al., 2017; La Manna et al., 2021). To date, no studies have been conducted on the eastern coasts of the Aegean Sea using BRUVS, and previous studies in the Aegean Sea have shown a predominance of UVC. For instance, Şensurat-Genç et al. (2022) obtained similar results in a study conducted in the same area and even included the same wreck habitat as this study. In both studies, *C. chromis* was the most abundant species in the wreck. However, in contrast to this study, BRUVS detected only about one-third of the species recorded using UVC. The other studies on artificial reefs, fish farm cages, shipwrecks, and natural reefs have reported 27-40 fish species belonging to 10-22 families using UVC (Gül et al., 2006, 2011; Lök et al., 2008; Akyol et al., 2019; Acarlı et al., 2020; Oruç A. Ç., 2022). The species richness of Sparidae and Labridae, which is considered a possible situation in the Mediterranean rocky coasts (Harmelin, 1987; Ruitton et al., 2000), was also observed in this study in line with previous UVC studies in Aegean (Lök et al., 2008; De Raedemaecker et al., 2010; Gül et al., 2011, Akyol et al., 2019; Acarlı et al., 2020). The main differences between the findings of UVC-based studies could be attributed to seasonality and difference in research period. For example, Şensurat-Genç et al. (2022) carried out the UVC study for two years. Additionally, divers can search complex habitats, but cameras cannot; therefore the UVC method is more successful than BRUVS in detecting cryptic species in crevices and cavities (Watson et al., 2005; Stobart et al., 2007). If different types of bait had been used, it could have changed the sampling efficiency of BRUVS (Dorman et al.,2012). In addition, the bait's tendency to attract predator or scavenger fishes, such as Mediterranean morays (observed in 70% of deployments in this study), may have deterred some species from approaching (Cappo et al., 2004; Hardinge et al., 2013).

The BRUVS observed mainly carnivorous species in the RR and SR (*C. julis*, *A. anthias*) and planktivorous fishes in WR, *C. chromis* and *B. boops*. The planktivorous were observed to be attracted to the particles released outside when carnivores attempted to feed from the bait box (Stobart et al., 2007). It is known that *C. chromis*

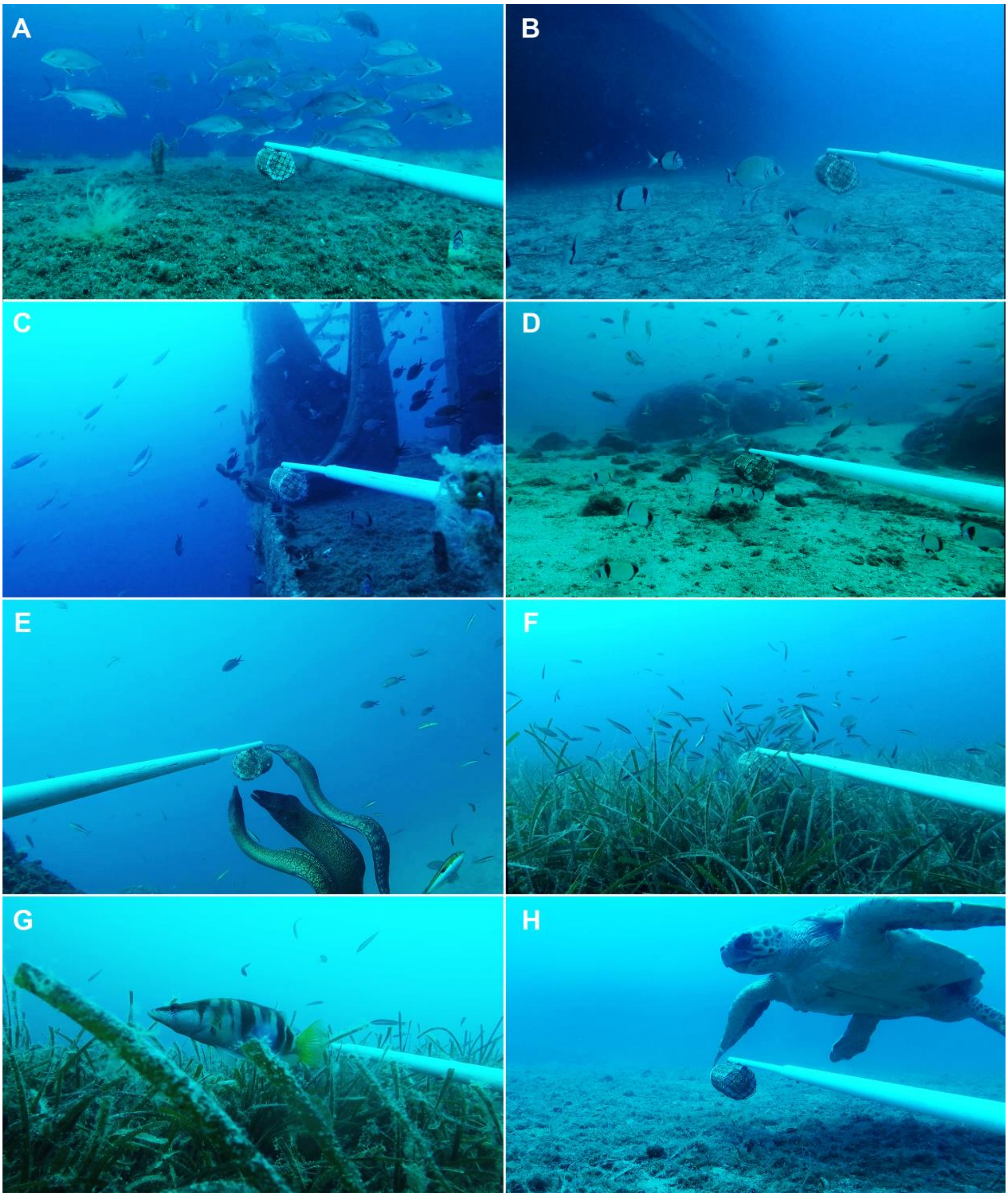

Figure 3. Photographs from BRUVS deployments (A, B, C= Wreck reef; D, E= Rocky reef; F, G= Seagrass reef; H= *Caretta caretta* at Rocky reef).

prefers sheltered areas even in daylight (Kovačić et al., 2012), and as expected, this species has the highest number of individuals in WR (34%). The predator species such as *Dentex dentex*, *S. viridensis*, *S. sarda*, *S. dumerili* and also a turtle (*C. caretta*) were recorded.

Conclusion

This study represents a substantial advancement in the application of BRUVS technology within Turkish waters. BRUVS has demonstrated its efficacy as a valuable tool for assessing fish community structure across diverse marine habitats. By offering a non-destructive and standardized approach, BRUVS presents significant potential for long-term monitoring and conservation initiatives within MPAs. Future research endeavors could integrate BRUVS with complementary methods, such as UVC, to facilitate a more comprehensive understanding of marine ecosystems. The continued application of this methodology in Turkish seas will contribute to the preservation of marine biodiversity and the enhancement of MPA management strategies.

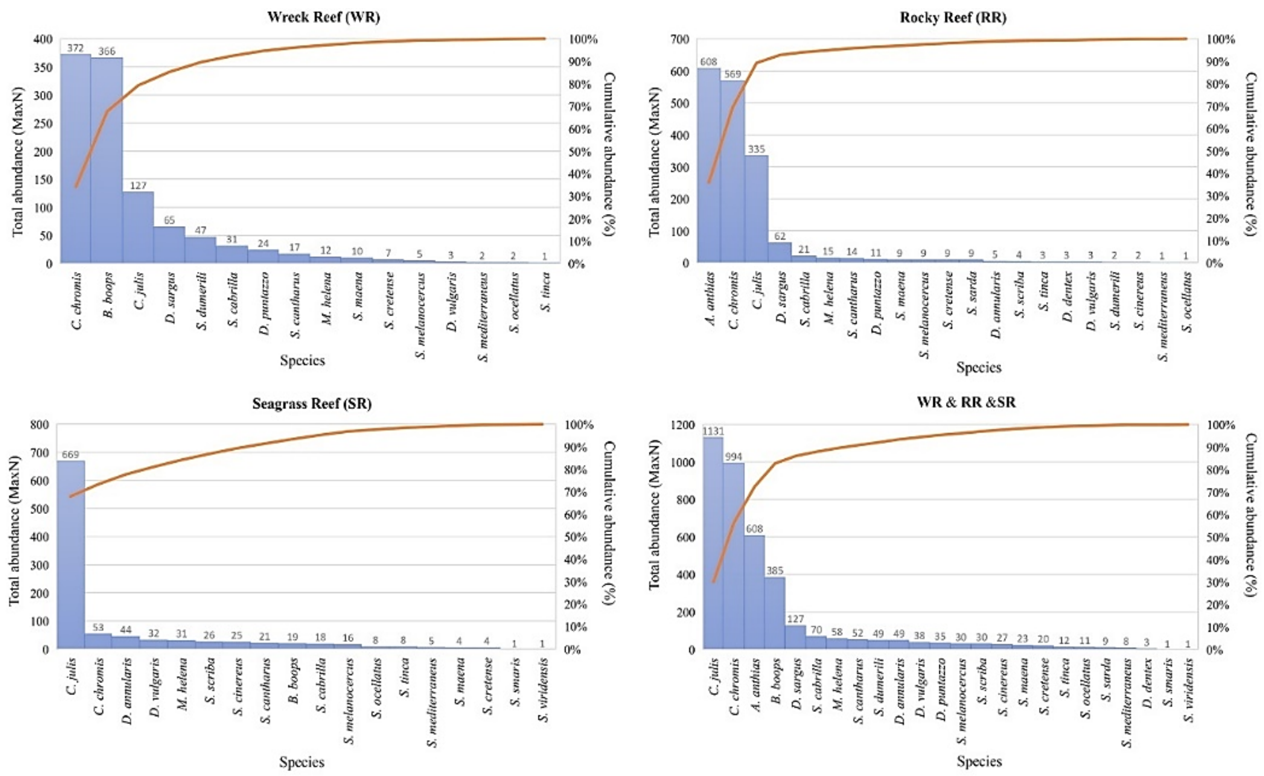

Figure 4. Total abundance (MaxN=bars) and cumulative abundance of fish species (lines) recorded in BRUVS deployments.

Table 2. Simper analysis results for fish species contributed to differences. Note: DC%= percentage contribution to total dissimilarity; WR= Wreck, RR= Rocky, SR= Seagrass.

WR&RR		**WR&SR**		**RR&SR**	
Av. dissimilarity=46,79		Av. dissimilarity=64,22		Av. dissimilarity=62,07	
Species	**DC%**	**Species**	**DC%**	**Species**	**DC%**
A. anthias	28,33	*C. chromis*	14,61	*A. anthias*	21,57
B. boops	14,98	*B. boops*	11,94	*C. chromis*	15,53
C. julis	8,43	*C. julis*	11,27	*D. sargus*	8,73
D. puntazzo	5,38	*D. sargus*	9,32	*D. annularis*	6,08
C. chromis	5,21	*D. annularis*	7	*C. julis*	5,97
S. cabrilla	4,86	*S. scriba*	4,94	*D. vulgaris*	4,47
S. cantharus	4,54	*D. vulgaris*	4,85	*S. cinereus*	4,45
		S. cinereus	4,84	*S. scriba*	4,37
		D. puntazzo	4,6		

Ethical Statement

This study does not require any ethics committee approval

Funding Information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Conflict of Interest

The author declare that they have no known competing financial or non-financial, professional, or personal conflicts that could have appeared to influence the work reported in this paper.

Acknowledgements

The author is grateful to Hamdullah Aras and Tuğçe Şensurat-Genç for helping with the fieldworks.

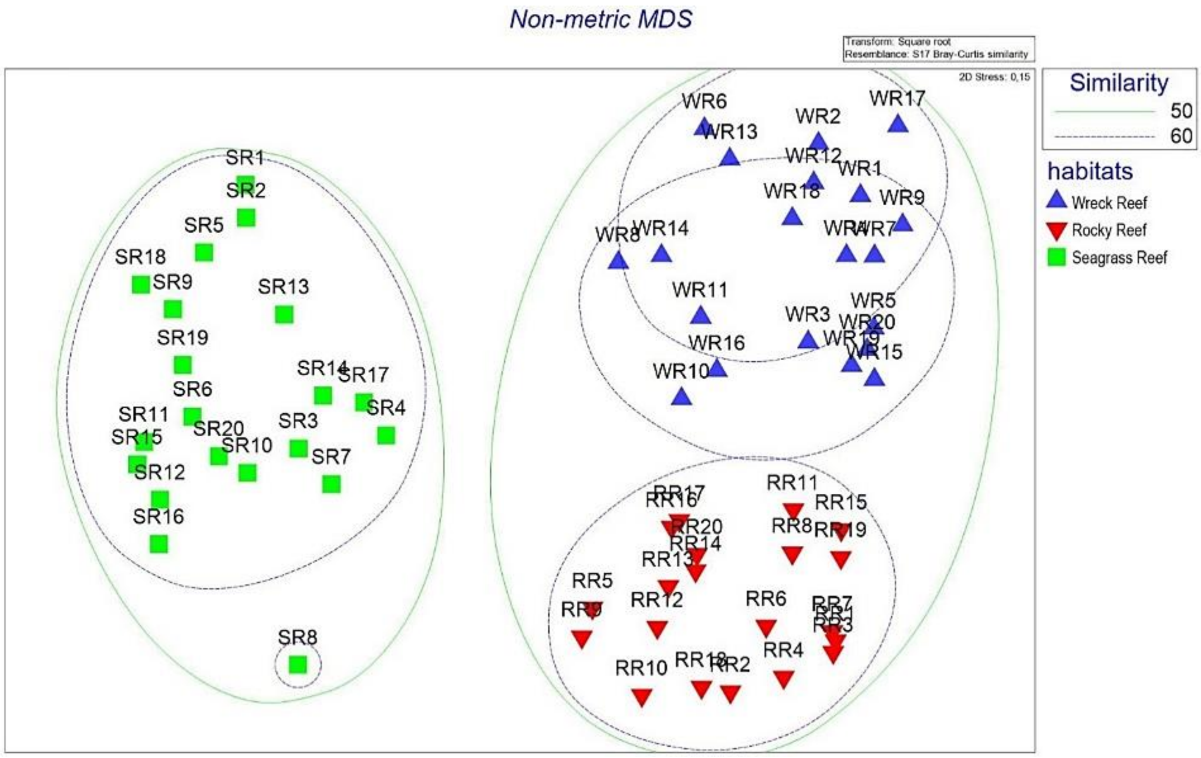

Figure 5. Non-metric multidimensional scaling (nMDS) plot of Bray–Curtis similarity indices of the reefs.

References

Acarlı, D., Kale, S., & Kocabaş, S. (2020). Biodiversity of TCSG-132 shipwreck artificial reef (Gökçeada, North Aegean Sea). *Acta Aquatica Turcica, 16*(3), 313-329. https://doi.org/10.22392/actaquatr.677175

Aglieri, G., Baillie, C., Mariani, S., Cattano, C., Calò, A., et al. (2021). Environmental DNA effectively captures functional diversity of coastal fish communities. *Molecular Ecology, 30*(13),3127-3139. https://doi.org/10.1111/mec.15661

Akyol, O., Ceyhan, T., Düzbastılar, F. O., Özgül, A., & Şen, H. (2019). Wild fish diversity around the sea-cage fish farms in the Aegean Sea. *Ege Journal of Fisheries and Aquatic Sciences, 36*(3),271-283. https://doi.org/10.12714/egejfas.2019.36.3.08

Barnett, T. P., Pierce, D. W., & Schnur, R. (2001). Detection of anthropogenic climate change in the world's oceans. *Science, 292*(5515), 270–274. https://doi.org/10.1126/science.1058304

Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Blackwell Publishing.

Bornt, K. R., McLean, D. L., Langlois, T. J., Harvey, E. S., Bellchambers, L. M., et al. (2015). Targeted demersal fish species exhibit variable responses to long-term protection from fishing at the Houtman Abrolhos Islands. *Coral Reefs, 34*, 1297–1312. https://doi.org/10.1007/s00338-015-1336-5

Cappo, M., Speare, P., & De'ath, G. (2004). Comparison of baited remote underwater video stations (BRUVS) and prawn (shrimp) trawls for assessments of fish biodiversity in inter-reefal areas of the Great Barrier Reef Marine Park. *Journal of Experimental Marine Biology and Ecology, 302*, 123–152. https://doi.org/10.1016/j.jembe.2003.10.006

Cattano, C., Turco, G., Di Lorenzo, M., Gristina, M., Visconti, G., et al. (2021). Sandbar shark aggregation in the central Mediterranean Sea and potential effects of tourism. *Aquatic Conservation: Marine and Freshwater Ecosystems, 31*(6), 1420-1428. https://doi.org/10.1002/aqc.3517

Chao, A., Gotelli, N. J., Hsieh, T. C., Sander, E. L., Ma, K. H., et al. (2014). Rarefaction and extrapolation with Hill numbers: A framework for sampling and estimation in species diversity studies. *Ecological Monographs, 84*(1), 45-67. https://doi.org/10.1890/13-0133.1

Claudet, J., & Fraschetti, S. (2010). Human-driven impacts on marine habitats: A regional meta-analysis in the Mediterranean Sea. *Biological Conservation, 143*, 2195–2206. https://doi.org/10.1016/j.biocon.2010.06.004

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Ben Rais Lasram, F., et al. (2010). The biodiversity of the Mediterranean Sea: Estimates, patterns, and threats. *PLoS ONE, 5*(8), e11842. https://doi.org/10.1371/journal.pone.0011842

Collins, D. L., Langlois, T. J., Bond, T., Holmes, T. H., Harvey, E. S., et al. (2017). A novel stereo-video method to investigate fish-habitat relationships. *Methods in Ecology and Evolution, 8*, 116–125. https://doi.org/10.1111/2041-210X.12650

Dajoz, R. (1978). *Ecologia Geral*. São Paulo: Editora Vozes e EDUSP.

De Raedemaecker, F., Miliou, A., & Perkins, R. (2010). Fish community structure on littoral rocky shores in the Eastern Aegean Sea: Effects of exposure and substratum. *Estuarine, Coastal and Shelf Science, 90*(1), 35-44. https://doi.org/10.1016/j.ecss.2010.08.007

Dorman, S. R., Harvey, E. S., & Newman, S. J. (2012). Bait effects in sampling coral reef fish assemblages with stereo-BRUVs. *PLoS ONE, 7*, e41538. https://doi.org/10.1371/journal.pone.0041538

Fowler, A. M., & Booth, D. J. (2012). How well do sunken vessels approximate fish assemblages on coral reefs? Conservation implications of vessel-reef deployments. *Marine Biology, 159*(12), 2787–2796. https://doi.org/10.1007/s00227-012-2039-x

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta e Costa, B., Pike, E. P., ... & Lubchenco, J. (2021). The MPA Guide: A framework to achieve global goals for the ocean. *Science*, 373(6560), eabf0861. https://doi.org/10.1126/science.abf0861

Guidetti, P., Terlizzi, A., Fraschetti, S., & Boero, F. (2003). Changes in Mediterranean rocky-reef fish assemblages exposed to sewage pollution. *Marine Ecology Progress Series, 253*, 269–278. http://dx.doi.org/10.3354/meps253269

Gül, B., Lök, A., Ulaş, A., & Düzbastılar, F. O. (2006). The investigation on fish composition at artificial reefs deployed on different substrates off Ürkmez Coast. *Ege Journal of Fisheries and Aquatic Sciences, 23*(1-3), 431-434.

Gül, B., Lök, A., Özgül, A., Ulaş, A., Düzbastılar, F. O., et al. (2011). Comparison of fish community structure on artificial reefs deployed at different depths on Turkish Aegean Sea coast. *Brazilian Journal of Oceanography, 59*, 27–32. http://dx.doi.org/10.1590/s1679-87592011000500005

Halpern, B. S., & Warner, R. R. (2002). Marine reserves have rapid and lasting effects. *Ecology letters*, 5(3), 361-366. http://dx.doi.org/10.1046/j.1461-0248.2002.00326.x

Hardinge, J., Harvey, E. S., Saunders, B. J., and Newman, S. J. (2013). A little bait goes a long way: the influence of bait quantity on a temperate fish assemblage sampled using stereo-BRUVs. J. Exp. Mar. Bio. Ecol. 449, 250–260. doi: 10.1016/j.jembe.2013.09.018

Harmelin, J. G. (1987). Structure and variability of the ichthyofauna in a Mediterranean protected rocky area (National Park of Port-Cros, France). *Marine Ecology, 8*(3), 263-284. http://dx.doi.org/10.1111/j.1439-0485.1987.tb00188.x

Harmelin-Vivien, M. L., & Francour, P. (1992). Trawling or visual censuses? Methodological bias in the assessment of fish populations in seagrass beds. *Marine Ecology, 13*(1), 41-51. http://dx.doi.org/10.1111/j.1439-0485.1992.tb00338.x

Harvey, E. S., Cappo, M., Butler, J. J., Hall, N., Kendrick, G. A., et al. (2007). Bait attraction affects the performance of remote underwater video stations in assessment of demersal fish community structure. *Marine Ecological Progress Series, 350*, 245–257. https://doi.org/10.3354/meps07192

Harvey, E. S., Goetze, J. S., McLaren, B., Langlois, T., & Shortis, M. R. (2010). Influence of range, angle of view, image resolution and image compression on underwater stereo-video measurements: High-definition and broadcast-resolution video cameras compared. *Marine Technology Society Journal, 44*, 75–85. https://doi.org/10.4031/MTSJ.44.1.3

Harvey, E. S., Cappo, M., Kendrick, G. A., & McLean, D. L. (2013). Coastal fish assemblages reflect geological and oceanographic gradients within an Australian zootone. *PLoS ONE, 8*, e80955. https://doi.org/10.1371/journal.pone.0080955

Jessop, S. A., Saunders, B. J., Goetze, J. S., & Harvey, E. S. (2022). A comparison of underwater visual census, baited, diver-operated, and remotely operated stereo-video for sampling shallow water reef fishes. *Estuarine, Coastal and Shelf Science, 276*, 108017.

Katsanevakis, S., Coll, M., Piroddi, C., Steenbeek, J., Ben Rais Lasram, F., et al. (2014). Invading the Mediterranean Sea: Biodiversity patterns shaped by human activities. *Frontiers in Marine Science, 1*, 32.

Kelaher, B. P., Coleman, M. A., Broad, A., Rees, M. J., Jordan, A., & Davis, A. R. (2014). Changes in fish assemblages following the establishment of a network of no-take marine reserves and partially-protected areas. *PloS one*, 9(1), e85825.

Kovačić, M., Patzner, R. A., & Schliewen, U. K. (2012). A first quantitative assessment of the ecology of cryptobenthic fishes in the Mediterranean Sea. *Marine Biology, 159*, 2731-2742.

La Manna, G., Guala, I., Grech, D., Perretti, F., Ronchetti, F., et al. (2021). Performance of a baited underwater video system vs. the underwater visual census technique in assessing the structure of fish assemblages in a Mediterranean marine protected area. *Mediterranean Marine Science, 22*(3), 480–495. https://doi.org/10.12681/mms.26639

Langlois, T., Chabanet, P., Pelletier, D., & Harvey, E. (2006). Baited underwater video for assessing reef fish populations in marine reserves. *Fisheries Newsletter-South Pacific Commission*, 118, 53.

Langlois, T., Goetze, J., Bond, T., Monk, J., Abesamis, R. A., et al. (2020). A field and video annotation guide for baited remote underwater stereo-video surveys of demersal fish assemblages. *Methods in Ecology and Evolution, 11*(11), 1401-1409. https://doi.org/10.1111/2041-210X.13470

Lester, S. E., Halpern, B. S., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B. I., Gaines, S. D., ... & Warner, R. R. (2009). Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series*, 384, 33-46.

Lök, A., Gül, B., Ulaş, A., Düzbastılar, F. O., & Metin, C. (2008). Diel variations on the fish assemblages at artificial reefs in two different environments of the Aegean Sea (Western coast of Turkey). *Turkish Journal of Fisheries and Aquatic Sciences, 8*, 79-85.

Malcolm, H. A., Schultz, A. L., Sachs, P., Johnstone, N., & Jordan, A. (2015). Decadal changes in the abundance and length of snapper (*Chrysophrys auratus*) in subtropical marine sanctuaries. *PLoS ONE, 10*, e0127616. https://doi.org/10.1371/journal.pone.0127616

McGeady, R., Runya, R. M., Dooley, J. S., Howe, J. A., Fox, C. J., Wheeler, A. J., ... & McGonigle, C. (2023). A review of new and existing non-extractive techniques for monitoring marine protected areas. *Frontiers in Marine Science*, 10, 1126301. http://dx.doi.org/10.3389/fmars.2023.1126301

MedPAN and UNEP/MAP-SPA/RAC. (2023). The 2020 Status of Marine Protected Areas in the Mediterranean. By Neveu R., Ganot D., Ducarme F., El Asmi S, Kheriji A. and Gallon S. Ed UNEP/MAP-SPA/RAC & MedPAN. Tunis 147 pages+Annexes.

Molloy, P. P., McLean, I. B., & Côté, I. M. (2009). Effects of marine reserve age on fish populations: a global meta-analysis. *Journal of applied Ecology*, 46(4), 743-751.

Murphy, H. M., & Jenkins, G. P. (2010). Observational methods used in marine spatial monitoring of fishes and associated habitats: A review. *Marine and Freshwater Research, 61*, 236–252.

https://doi.org/10.1071/MF09068

Nalmpanti, M., Pardalou, A., Tsikliras, A. C., & Dimarchopoulou, D. (2021). Assessing fish communities in a multiple-use marine protected area using an underwater drone (Aegean Sea, Greece). *Journal of the Marine Biological Association of the United Kingdom, 101*(7), 1061-1071. http://dx.doi.org/10.1017/s0025315421000904

Nalmpanti, M., Chrysafi, A., Meeuwig, J. J., & Tsikliras, A. C. (2023). Monitoring marine fishes using underwater video techniques in the Mediterranean Sea. *Reviews in Fish Biology and Fisheries, 33*(4), 1291-1310. http://dx.doi.org/10.1007/s11160-023-09799-y

Oruç, A. Ç. (2022). The Seasonal Fish Diversity of Aliağa, a Heavy Industry Zone on the Turkish Coast of the Aegean Sea. *Marine Science and Technology Bulletin*, 11(3), 361-368. https://doi.org/10.33714/masteb.1159803

Piroddi, C., Colloca, F., & Tsikliras, A. C. (2020). The living marine resources in the Mediterranean Sea large marine ecosystem. *Environmental Development, 36*, Article 100555. https://doi.org/10.1016/j.envdev.2020.100555

Prato, G., Guidetti, P., Bartolini, F., Mangialajo, L., & Francour, P. (2013). The importance of high-level predators in marine protected area management: Consequences of their decline and their potential recovery in the Mediterranean context. *Advances in Oceanography and Limnology, 4*, 176–193. https://doi.org/10.4081/aiol.2013.5343

Prato, G., Thiriet, P., Di Franco, A., & Francour, P. (2017). Enhancing fish Underwater Visual Census to move forward assessment of fish assemblages: An application in three Mediterranean Marine Protected Areas. *PLoS One*, 12(6), e0178511. http://dx.doi.org/10.1371/journal.pone.0178511

Rees, M. J., Jordan, A., Price, O. F., Coleman, M. A., & Davis, A. R. (2014). Abiotic surrogates for temperate rocky reef biodiversity: implications for marine protected areas. *Diversity and distributions*, 20(3), 284-296. http://dx.doi.org/10.1111/ddi.12134

Ruitton, S., Francour, P., & Boudouresque, C. F. (2000). Relationships between algae, benthic herbivorous invertebrates and fishes in rocky sublittoral communities of a temperate sea (Mediterranean). *Estuarine, Coastal and Shelf Science, 50*(2), 217-230. https://doi.org/10.1006/ecss.1999.0546

Şensurat-Genç, T., Lök, A., Özgül, A., & Oruç, A. Ç. (2022). No effect of nearby natural reef existence on fish assemblages at shipwrecks in the Aegean Sea. *Journal of the Marine Biological Association of the United Kingdom,* 102(8), 613-626. https://doi.org/10.1017/S0025315422001011

Stobart, B., García-Charton, J. A., Espejo, C., Rochel, E., Goñi, R., et al. (2007). A baited underwater video technique to assess shallow-water Mediterranean fish assemblages: Methodological evaluation. *The Journal of Experimental Marine Biology and Ecology, 345*, 158–174. https://doi.org/10.1016/j.jembe.2007.02.009

Stobart, B., Álvarez, D. D. F., Alonso, C., Mallol, S., & Goñi, R. (2015). Performance of baited underwater video: Does it underestimate abundance at high population densities? *PLoS ONE, 10*(5), e0127559. http://dx.doi.org/10.1371/journal.pone.0127559

Tessier, A., Pastor, J., Francour, P., Saragoni, G., Crec'hriou, R., et al. (2013). Video transects as a complement to underwater visual census to study reserve effect on fish assemblages. *Aquatic Biology, 18*, 229-241. http://dx.doi.org/10.3354/ab00506

Torres, A., Abril, A. M., & Clua, E. E. (2020). A time-extended (24 h) baited remote underwater video (BRUV) for monitoring pelagic and nocturnal marine species. *Journal of Marine Science and Engineering*, 8(3), 208. http://dx.doi.org/10.3390/jmse8030208

Watson, D. L., Harvey, E. S., Anderson, M. J., & Kendrick, G. A. (2005). A comparison of temperate reef fish assemblages recorded by three underwater stereo-video techniques. *Marine Biology, 148*, 415–425. https://doi.org/10.1007/s00227-005-0090-6

Whitmarsh, S. K., Fairweather, P. G., & Huveneers, C. (2017). What is Big BRUVver up to? Methods and uses of baited underwater video. *Reviews in fish biology and fisheries*, 27, 53-73. http://dx.doi.org/10.1007/s11160-016-9450-1