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Marine Protected Areas Odyssey

Dilek Peninsula National Park

August 2022

Marine Protected Areas Odyssey - Report of the 2022 mission to the Dilek Peninsula Büyük Menderes Delta National Park

Janvier 2023

FOREWORD

Context, fundings and partner: This study report is part of the "MPA Odyssey in the Mediterranean Sea" program, supported by WWF-France. This report presents the actions undertaken and the results of the field mission of August 2022, carried out on the territory and with the partnership of the Dilek Peninsula Büyük Menderes Delta National Park (DPNP). The partners associated with this mission are the WWF Turkey and Septentrion Environnement (SE). The project is co-funded thanks to the financial support of the company CMA CGM.

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Blue Panda Crew (Seanergie) : Stéphane Minguneau (Captain), Pauline Faugères (sailor), Emmanuelle Bily (sailor).

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1. Introduction

This study is part of the "MPA Odyssey in the Mediterranean" programme, directed by WWF-France. The MPA Odyssey is a multi-year scientific field expedition, carried out on board the Blue Panda, and aiming at reinforcing the level of protection within Mediterranean MPAs.

This report presents the actions carried out and the results of the August 2022 field mission carried out in and with the partnership of the Dilek Peninsula Büyük Menderes Delta National Park (DPNP).

The main objective of this mission was to collect data *via* underwater visual census aimed at describing the state of ichthyological populations (Harmelin-Vivien et al., 1985) within the DPNP: (1) Firstly that was done in order to assess the level of protection provided by the MPA of the DPNP, sites inside and outside the no-fishing zone, along the entire coastline of the Park, were sampled ; (2) Besides, these data were gathered as a "baseline" in order to characterise particular sites and/or those that are likely to be integrated into strong protection zones in the future ; Moreover, (3) we aimed to put these data into perspective with data from other MPAs in the Mediterranean (Harmelin-Vivien et al., 2008).

2. Conduct of the mission

The team consisted of 6 scientific divers who carried out the underwater visual census, a mission leader, 3 crew members, and 2 scientific supporters.

Scientific team

Olivier BIANCHIMANI – Septentrion Environnement – Diving organisation and safety supervision, scientific diver.
Adrien CHEMINÉE - Septentrion Environnement – Scientific supervision, scientific diver.
Justine RICHAUME - Septentrion Environnement – Scientific diver.
Tristan ESTAQUE – Septentrion Environnement – Scientific diver.
Denis ODY – WWF France - Mission leader, surface security, scientific diver.
Sébastien PERSONNIC – Septentrion Environnement – Scientific diver.

Blue Panda Team

Stéphane MINGUENEAU – Seanergie - Captain
Pauline FAUGÈRES – Seanergie - Sailor
Emmanuelle BILLY – Seanergie – Sailor

3. Material and methods

3.1. Location and presentation of sampling areas and sites

Thirty-five sites, located in four areas, were sampled during the mission (Fig. 1).

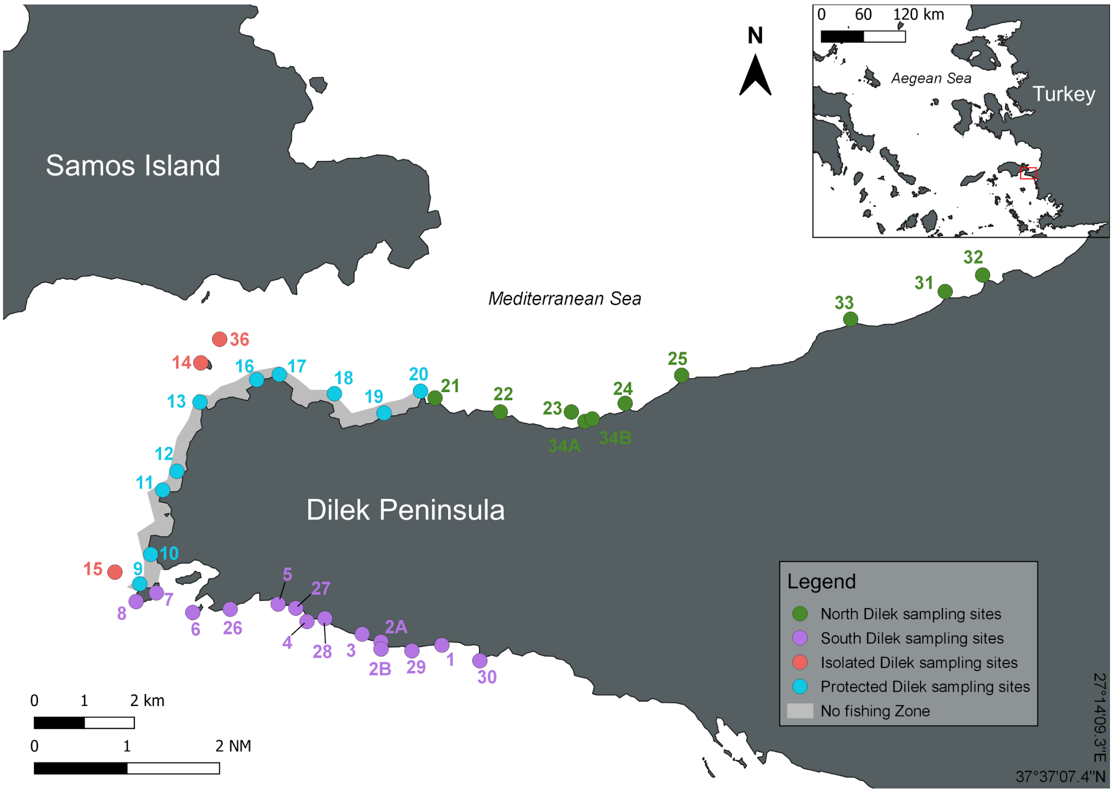

Figure 1. Map of the different areas and sites sampled during the MPA Odyssey mission - Dilek Peninsula Büyük Menderes Delta National Park. Each site is represented by a dot and number. Blue dots are sites located within the protected zone where fishing is restricted (see method section).

The study sites (Fig. 1) were selected on the basis of available data concerning the description of biotopes and biocenoses and on the advice of local managers and scientists. Study sites were selected along the coastline and had to present habitats with the following characteristics: infralittoral rocky reef with few *Posidonia oceanica* cover (<50%) and located between 7 and 15 meter deep. We targeted this habitat since it is known to be a representative case study in order to quantify the response of fish assemblages to protection level (Garcia-Rubies and Zabala, 1990). Nevertheless, some variations in habitat characteristics still remained, and sometimes displayed shallower rocky bottoms (4-5 m) or areas mixed with a small percent cover of *Posidonia oceanica* meadow growing over the rocky bed. Sites and their characteristics are listed in Appendix A01 and in the result database (available upon request).

Sites were *a priori* grouped into four areas that displayed homogeneity in terms of both geomorphological and regulation characteristics : North Dilek area was exempt of any regulation, it was characterised by a relatively intense nautical activity (recreational boats). Protected Dilek was under fishing restriction, as only recreational fishing remained allowed, excluding professional fishing. South Dilek area was characterised by its remote location, far and exempt from recreational nautical and fishing activities occuring in the north, but was being used as a professional fishing zone. In terms of geomorphology, these areas differed in terms of sediment charge into the water column, as the South area was characterised by the vicinity of an estuary causing more turbidity. Finally, Isolated Dilek area included sites characterised by their location apart from the shoreline, displaying bottoms characterised by less rocky cover and a rather mixture of rocky and soft bottoms.

3.2. Protocols for underwater inventories

As regards the sampling method, we used underwater visual census (UVC) of fish assemblages, performed along 25 m long and 5 m wide belt-transects. Inside each sampling unit, abundances of all fish species were recorded, or estimated for large groups, and individual size was estimated in 2 cm increments (for individuals smaller than 30 cm), and 5 cm increments for larger ones (Harmelin-Vivien et al., 2008; Harmelin-Vivien et al., 1985). Only one pass per transect was made, focusing on necto-benthic species (sparidae, labridae, serranidae, etc.) (Harmelin, 1987), but excluding cryptic ones (Scorpaenidae), since necto-benthic ones are the most sensitive to the level of protection (Garcia-Rubies and Zabala, 1990).

In each site, sampling units (n = 6 transects, except in special cases) were carried out according to stratified random sampling, targeting the habitat described above, among an average depth range of 7 to 15 meters, and in such a way as to limit the percentage of seagrass cover (maximum of 50%, where possible).

3.3. Data Analysis

Data analysis was performed using visual observation data (fish abundances and sizes) acquired by scientific divers within 207 transects conducted within 35 sites, grouped into 4 areas (Fig. 1). Descriptive variables of the fish assemblages included species occurrence, total abundance and biomass, species richness, relative abundance and biomass by species (assemblage composition), and abundance by size class for given taxa. Biomass was calculated from abundance and size of individuals, using size-biomass correspondence coefficients commonly used (Thibaut et al., 2017). Gregarious species (*C. chromis, Spicara* spp., *B. boops* and *Atherina* spp.), which were very abundant on the majority of the transects, were subsequently removed from the data after examining the occurrence of species. Indeed it allowed us to perform the analysis without masking the signal of less abundant species. The commercial species were also examined in more detail. These consisted of : *D. annularis, D. puntazzo, D. sargus, D. vulgaris, C. julis, L. merula, L. viridis, M. surmuletus, S. scriba, S. salpa,* and *S. aurata*. The explanatory variables of the sampling design were the observation area (fixed factor with 4 modalities) and the observation site (factor nested in area, with 35 modalities). We also calculated the -log ratio of abundance divided by biomass. This descriptor helps to check if at constant abundance the fish are bigger or smaller in an area or not.
An analysis of the ratio of abundance inside NTZ (No Take Zone) versus outside NTZ and of the ratio of biomass inside NTZ versus outside NTZ allowed us to compare the effectiveness of the protections implemented in the marine protected areas studied in the BIOMEX project (Harmelin-Vivien et al., 2008) and the MPA Odyssey project. A comparison with the average ratios of increase in abundance and biomass between unprotected and fully protected areas found in other Mediterranean MPAs (Giakoumi et al., 2017) also allowed the positioning of the average observed in the MPA studied here.

All figures and descriptive statistics were computed with R Studio v. 4.0.5 software (R Core Team, 2017).

4. Results

4.1. Sampling and main quantitative properties of Teleost communities

In total, the 6 scientific divers realised 207 transects. In general, 6 transects per site were realised, except for site 25 (4 transects) and site 1 (5 transects).

4.1.1 Occurrence frequency and species richness

Including the gregarious species, *C. julis* was the most regularly observed species (occuring in 97.1% of transects), followed by *D. vulgaris* (90.8%), *D. sargus* (86.0%) and *S. tinca* (82.1%) (Fig. 2). It is interesting to note, because it's unusual in other MPAs, that *D. vulgaris* and *D. sargus* were present in the majority of transects and that *S. cretense* was present in 57.5% of transects. The alien species *Siganus* spp. were present in 28.5% of transects.

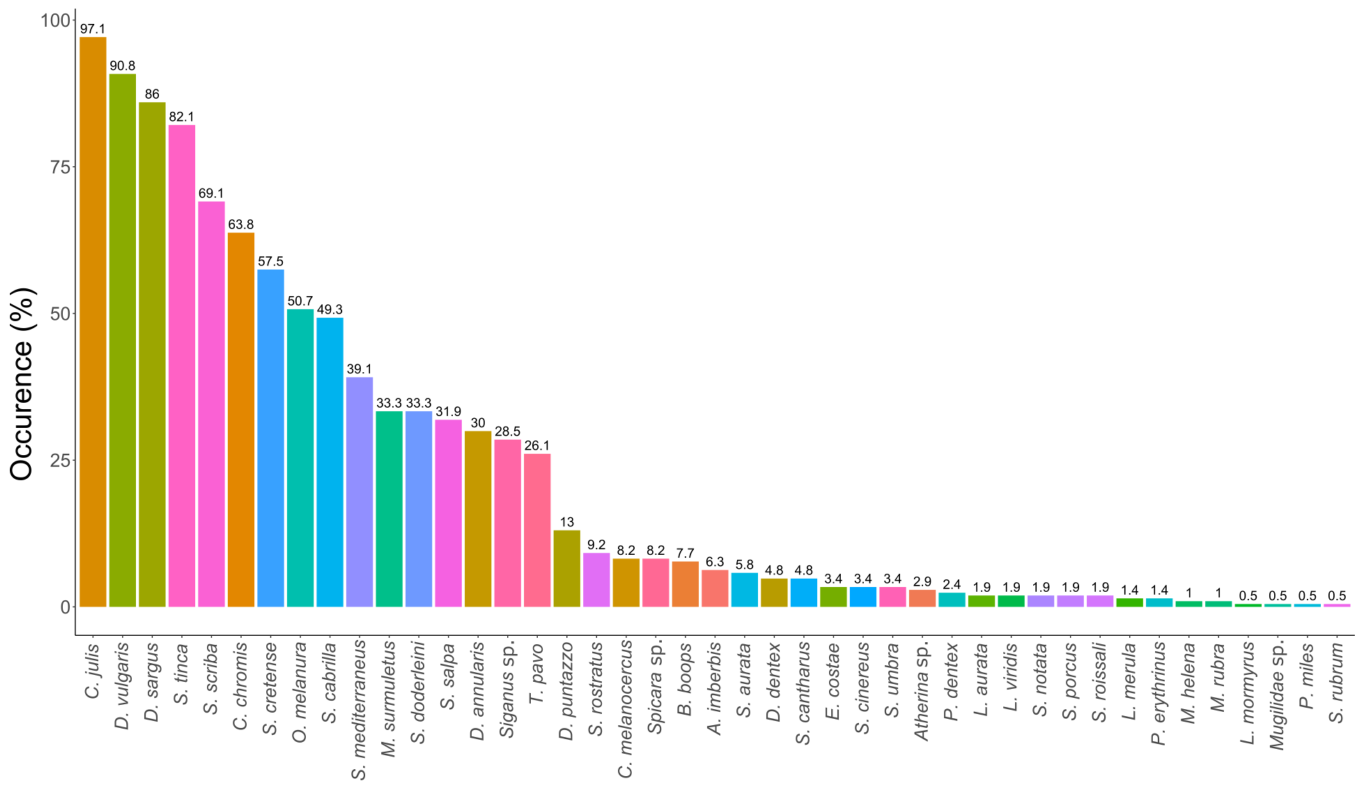

Figure 2. Occurrence frequency of species observed during the mission, on all transects, all sites combined (with gregarious species).

In terms of dominance, the most abundant species recorded was *D. vulgaris* (Fig. 3), which represented 21.1% of all fish recorded. It was followed by *C. julis* (20.5%), *O. melanura* (17.9%) and *D. sargus* (9.3%).

Species richness per transect across all sites and areas was on average 10 taxa. Species richness per transect averaged by site varied (Fig. 4), from 6 taxa for site 25 (North Dilek area) to 13 taxa for site 33 (North Dilek area). Considering the average richness by area (i.e. cumulated richness per transect, averaged by area) (Fig. 5), this average species richness varied from 7.5 taxa for Isolated Dilek to 10.2 for the North Dilek area.

Total species richness (i.e. all transects cumulated) per site varied from 13 taxa for site 14 (Isolated Dilek area) to 24 taxa for site 2 (South Dilek area). Considering all areas, the total species richness was 43 taxa, and ranged from 23 taxa for Isolated Dilek to 35 taxa for Protected Dilek and South Dilek.

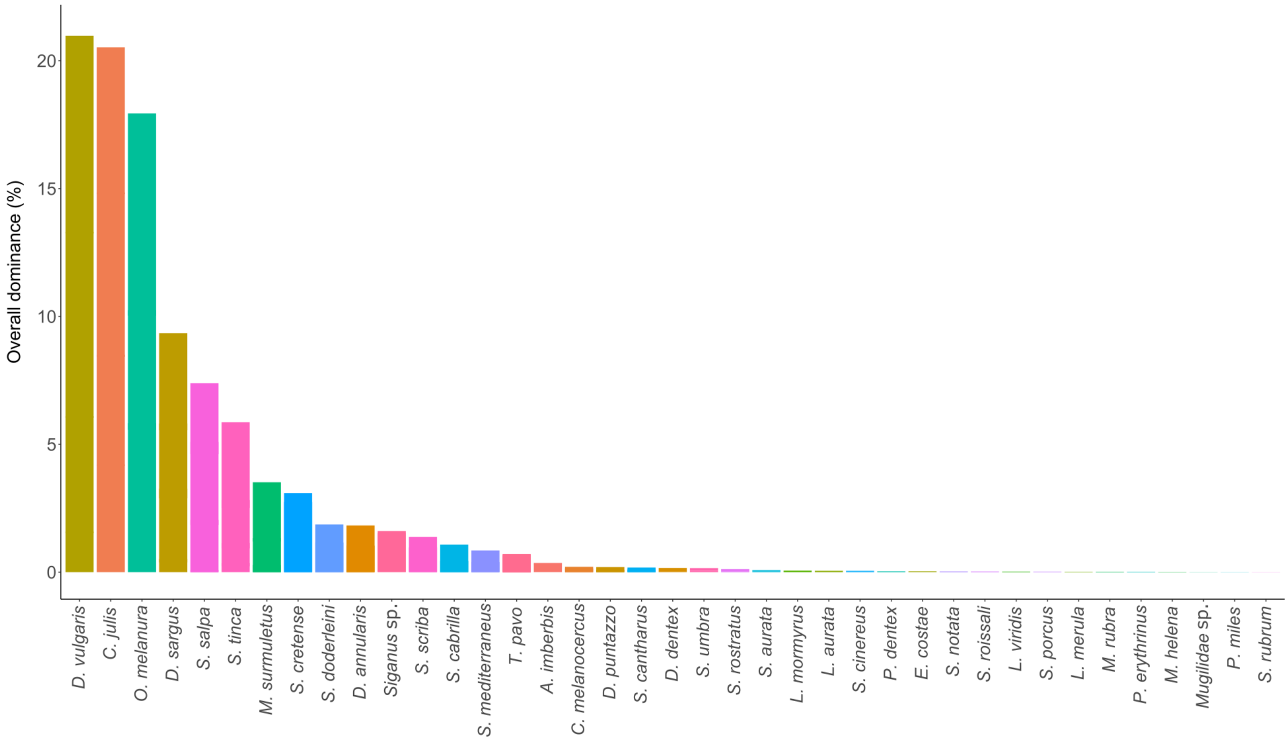

Figure 3. Global dominance of species observed during the mission, on all transects, all sites combined (excluding gregarious species).

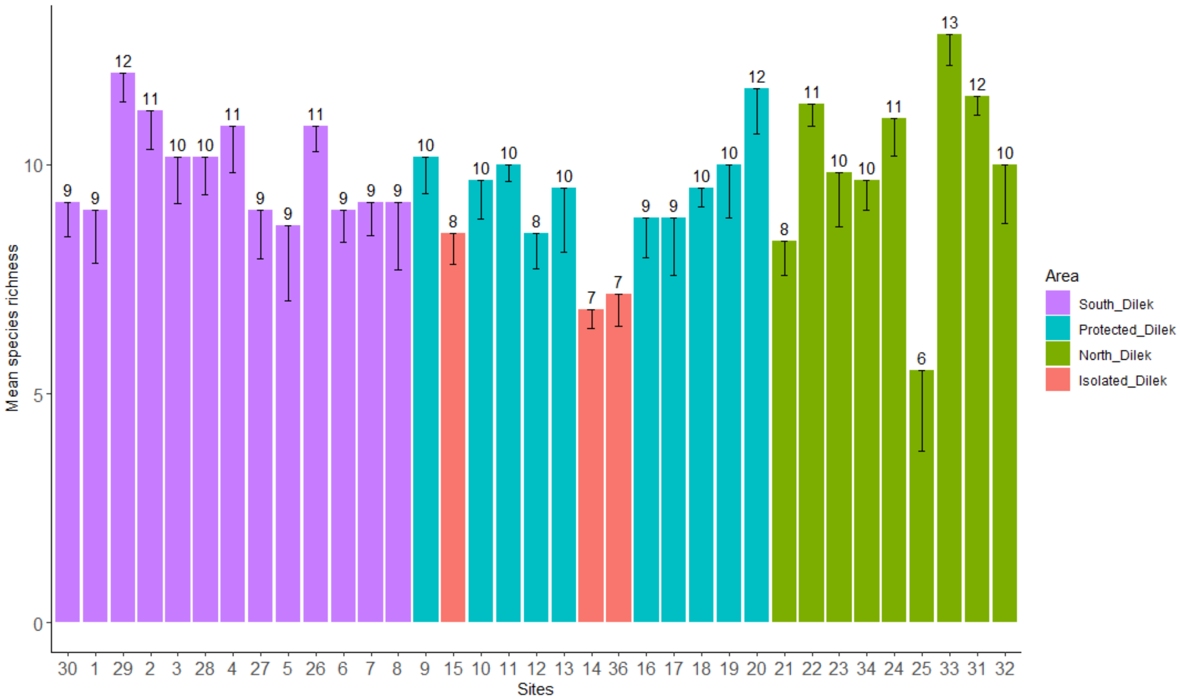

Figure 4. Average species richness per transect by site (with gregarious species). Colors indicate the area to which the site belongs and sites are classified in geographical order. The error bars (whiskers) correspond to the standard error, represented here only as a negative value (-E.S.) for a better display.

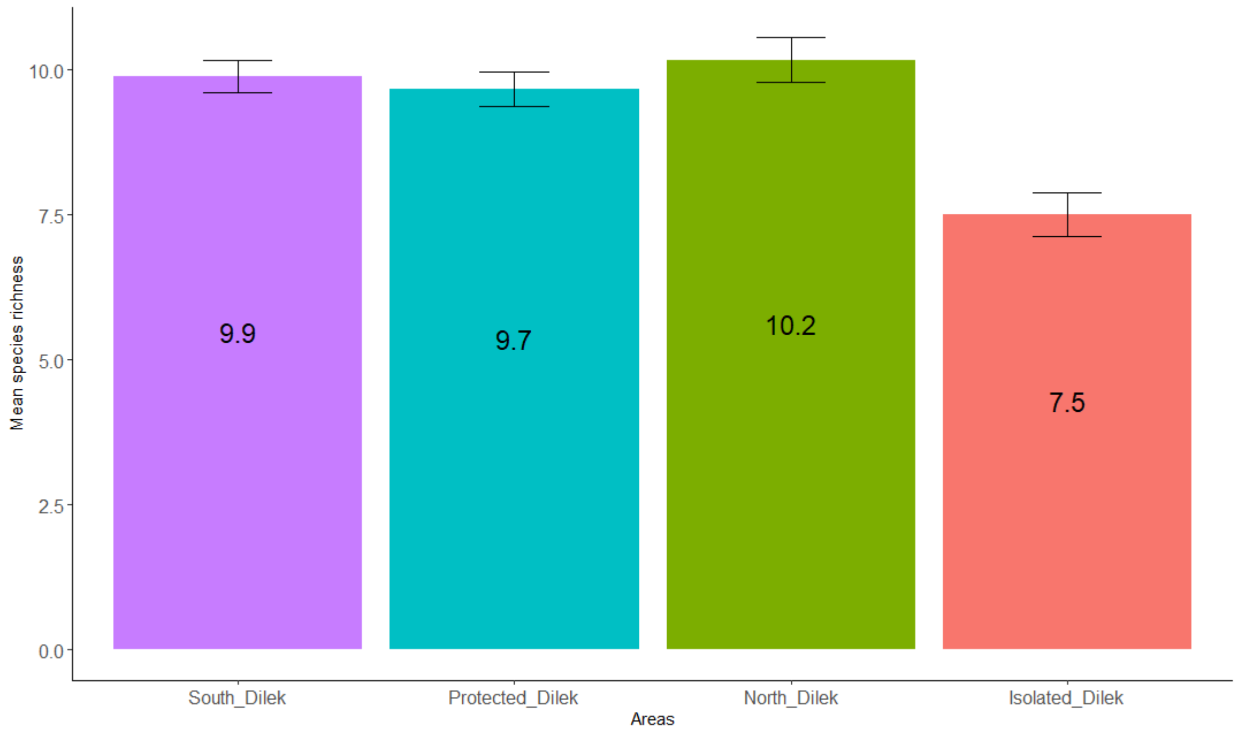

Figure 5. Species richness per transect, averaged per area, all sites combined (with gregarious species). Error bars correspond to the standard error (+/-).

4.1.2. Total abundance

The average total fish abundance without considering gregarious species (all taxa) per site (Fig. 6) ranged from 47 ind.125 m^{-2} for site 25 (area: North Dilek) to 178.5 ind.125 m^{-2} for site 24 (area: NorthDilek). The mean abundance for all sites combined was 101 ± 5 ind.125 m^{-2}.

Some sites seemed to contrast with the others in terms of mean abundance. Some taxa were responsible for such discrepancies : sites 24 and 21 were characterised by a high mean abundance of *O. melanura* (55 ind.125 m^{-2} and 92 ind.125 m^{-2} of *O. melanura* respectively). At site 9, on average many *D. vulgaris* (40 ind.125 m^{-2}) and *S. salpa* (39 ind.125 m^{-2}) were observed. Site 26 was characterised by a high average abundance of *M. surmuletus* (58 ind.125 m^{-2}). Site 16 had a high average abundance of *C. julis* (65 ind.125 m^{-2}) and *D. vulgaris* (29 ind.125 m^{-2}).

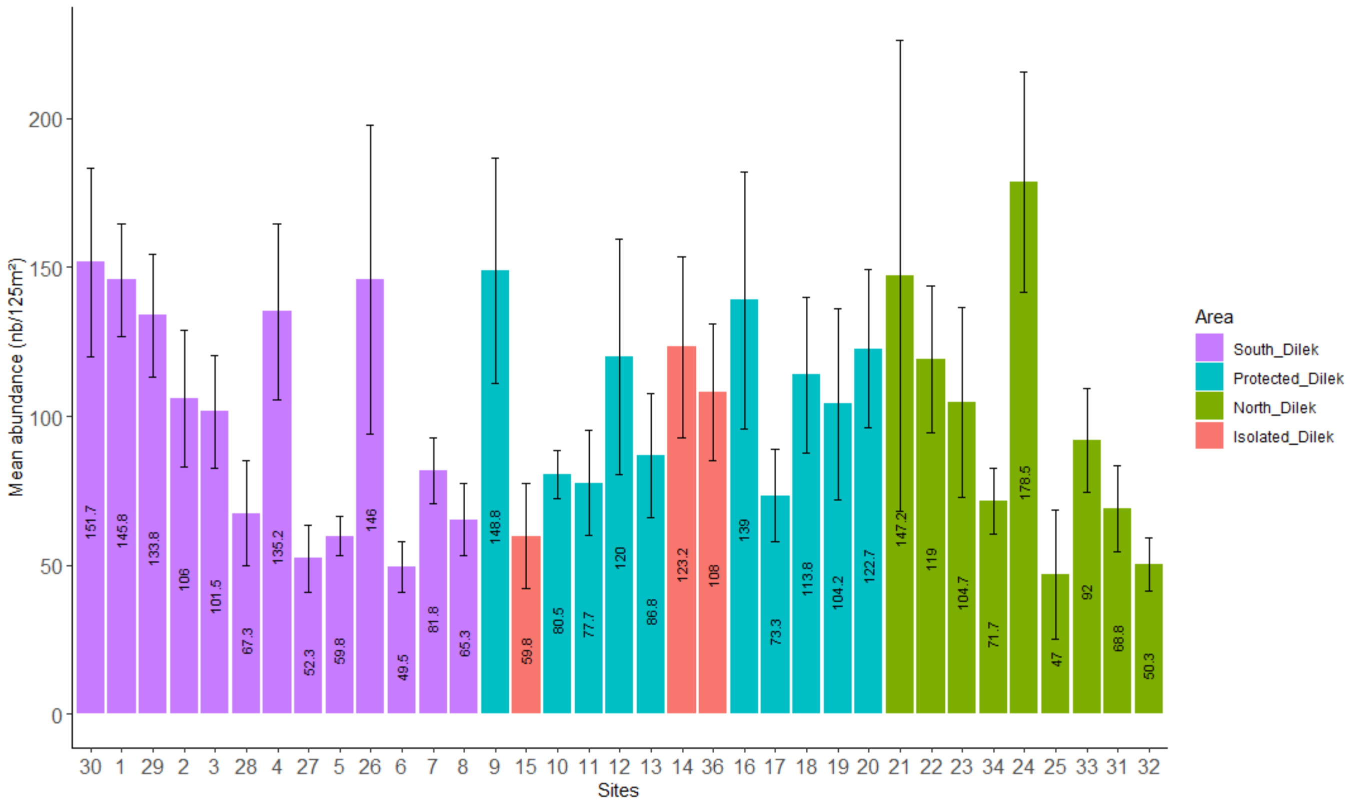

Figure 6. Mean abundance (ind.125 m-²) per site. The whiskers correspond to the standard error (+/- S.E.).

The mean total abundance per area (Fig. 7) ranged from 97 ind.125 m^{-2} for Isolated Dilek to 106.7 ind.125 m^{-2} for Protected Dilek. Differences in abundance between areas were not significant (Kruskal-Wallis, Chi^2 = 1.249, p = 0.741). In the Protected Dilek area we found the most important mean abundance of *D. vulgaris* (25 ind.125 m^{-2}) and *S. salpa* (11 ind.125 m^{-2}). There was also a lot of *C. julis* (22 ind.125 m^{-2} in average). In the Isolated Dilek zone we observed the highest mean abundance of *C. julis* (49 ind.125 m^{-2}). In the North Dilek area there was the highest average abundance of *Siganus* sp. (4 ind.125 m^{-2}) and *O. melanura* (23 ind.125 m^{-2}).

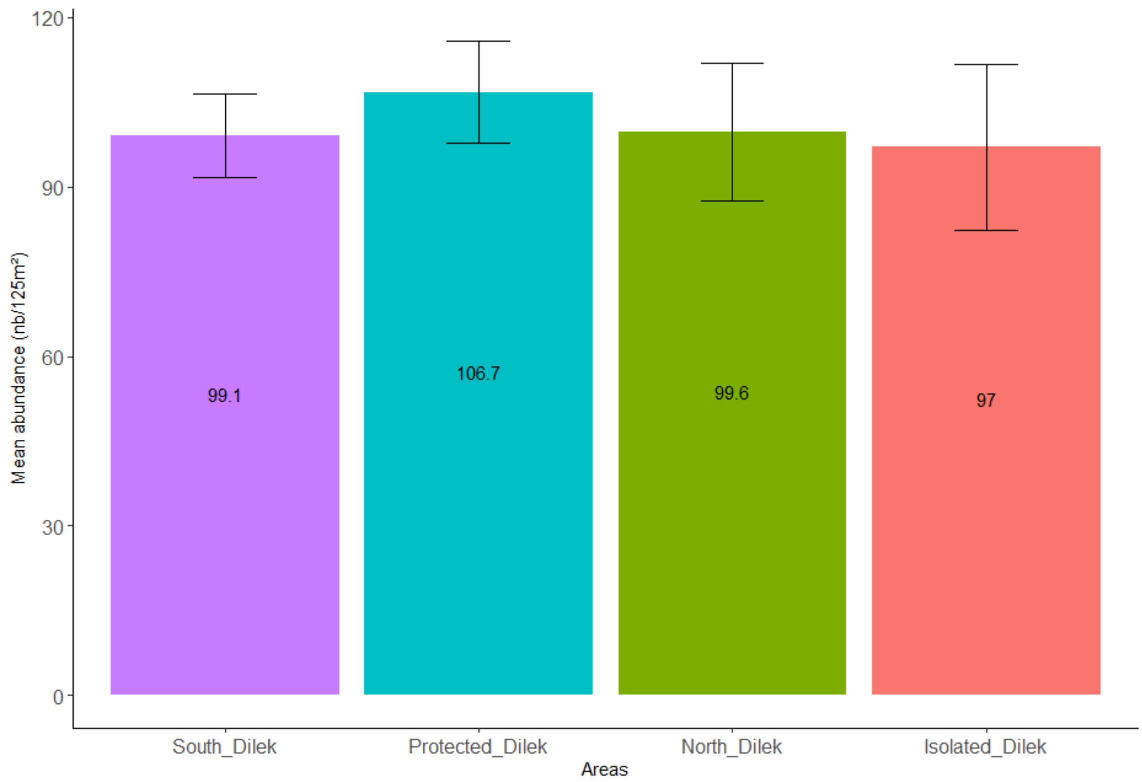

Figure 7. Mean total abundance (ind.125 m-2) per area. The whiskers correspond to (+/-) the standard error (+/- S.E.).

4.1.3. Mean Total Length (TL)

Overall, for each teleost species surveyed, the individuals showed fairly similar average sizes (TL: Total Length) between the different areas (Tab. 1). Within Protected Dilek area, the different species targeted by fishing (i.e. *Diplodus* spp., *C. julis*, *O. melanura*, *P. erythrinus*, *S. aurata*, *S. salpa*, *M. surmuletus*, *Labrus* spp., *S. scriba.)* did not show significant differences in size from the other areas. The different species of *Symphodus* spp. were not larger in size in the Protected Dilek area.

Table 1: Mean Total Lenght (TL - cm) of taxa individuals by areas.

Taxa	South Dilek	Protected Dilek	North Dilek	Isolated Dilek
A. imberbis	5.5	8.5	7.9	8.0
***Atherina* sp.**	-	3.3	6.0	-
B. boops	10.2	10.1	-	-
C. chromis	7.2	7.0	6.1	5.7
C. julis	9.9	9.8	9.5	9.8
C. melanocercus	8.6	7,6	7.8	8.0
D. annularis	9.4	8.8	8.9	9.2

D. dentex	11.8	–	20.0	17.0
D. puntazzo	15.6	16.3	20.0	20.0
D. sargus	11.2	10.5	10.7	12.7
D. vulgaris	12.1	11.4	12.0	13.0
E. costae	26.7	–	30.0	–
L. aurata	40.0	39.1	–	–
L. merula	32.0	–	22.5	–
L. mormyrus	25.0	–	–	–
L. viridis	30.0	22,5	–	–
M. helena	–	40.0	60.0	–
M. rubra	–	–	–	68.3
M. surmuletus	9.0	8.2	12.4	10.1
***Mugilidae* sp.**	–	–	30.0	–
O. melanura	14.1	11.8	11.6	–
P. dentex	20.0	45.0	23.0	–
P. erythrinus	22.0	–	–	–
P. miles	–	15.0	–	–
S. aurata	24.6	25.0	27.0	–
S. cabrilla	10.6	10.0	8.5	10.3
S. cantharus	15.6	6,5	–	10.0
S. cinereus	7.4	8.7	–	–
S. cretense	24.8	19.1	17.2	22.6
S. doderleini	7.0	6.8	6.8	7.0
S. mediterraneus	10.4	10.3	8.6	9.0
S. notata	–	8.0	7.6	–
S. porcus	12.0	7,5	10.0	–
S. roissali	–	9.3	8.0	–

S. rostratus	9.7	9.7	6.0	9.7
S. rubrum	-	-	14.0	-
S. salpa	18.1	12.9	14.2	13.1
S. scriba	13.6	13.5	12.4	11.7
S. tinca	10.5	9.2	10.3	6.4
S. umbra	28.3	21.5	-	17.6
***Siganus* sp.**	23.2	18.1	18.1	0
***Spicara* sp.**	13.8	11.3	-	12.0
T. pavo	11.3	12.3	10.3	12.3

4.1.4. Biomass

The mean biomass for all transects combined was 4315 ± 302 g.125 m^{-2} gregarious species included, and 2991 ± 203 g.125 m^{-2} when not considering gregarious species. The mean total biomass per site (Fig. 9) varied from 1076.2 g.125 m^{-2} for site 6 (area: South Dilek) to 6907.8 g.125 m^{-2} for site 29 (area: South Dilek). Within the Protected Dilek area sites 9, 10, 13 and 20 showed a mean biomass of over 4000 g.125 m^{-2}.

Some sites contrasted with others in terms of mean biomass. Site 29 was characterised by a high mean biomass of *S. salpa* (2948 g.125 m^{-2}), as were sites 4 and 2 (2892 g.125 m^{-2} and 1964 g.125 m^{-2} respectively). Site 13 had a high biomass of *S. cretense* (1806 g.125 m^{-2}), as did sites 20 and 24 (1818 g.125 m^{-2} and 1305 g.125 m^{-2} respectively). Finally, site 25 had a high mean biomass of *D. vulgaris* (1302 g.125 m^{-2}).

At the area level (Fig. 10) the mean total biomass varied from 1861.3 g.125 m^{-2} for the Isolated Dilek area to 3312.4 g.125 m^{-2} for the Protected Dilek area. The Protected Dilek area appeared to show a higher biomass. This difference was at the limit of significance (Kruskall-Wallis, $Chi^2 = 7.683$, p-value = 0.05). This significance was mainly due to the low biomass present at the Isolated Dilek sites. The Isolated Dilek area showed the lowest mean abundance (Fig. 7) and the lowest mean biomass (Fig. 10).

The Protected Dilek area had the highest biomass of *S. cretense* (812 g.125 m^{-2}). There was also a high average biomass of *D. vulgaris* (719 g.125 m^{-2}) and *S. salpa* (523 g.125 m^{-2}). The South Dilek zone had the highest average biomass of *D. vulgaris* (725 g.125 m^{-2}) and *S. salpa* (846 g.125 m^{-2}) where the species was the largest on average (18 cm). The North Dilek zone had the highest average biomass of *Siganus* sp. (359 g.125 m^{-2}). Finally, the Isolated Dilek zone showed the lowest average biomass, but had a fairly high biomass of *D. vulgaris* (683 g.125 m^{-2}), which was also the largest on average (13 cm). The Isolated Dilek area also had the highest average biomass of *C. julis* (372 g.125 m^{-2}).

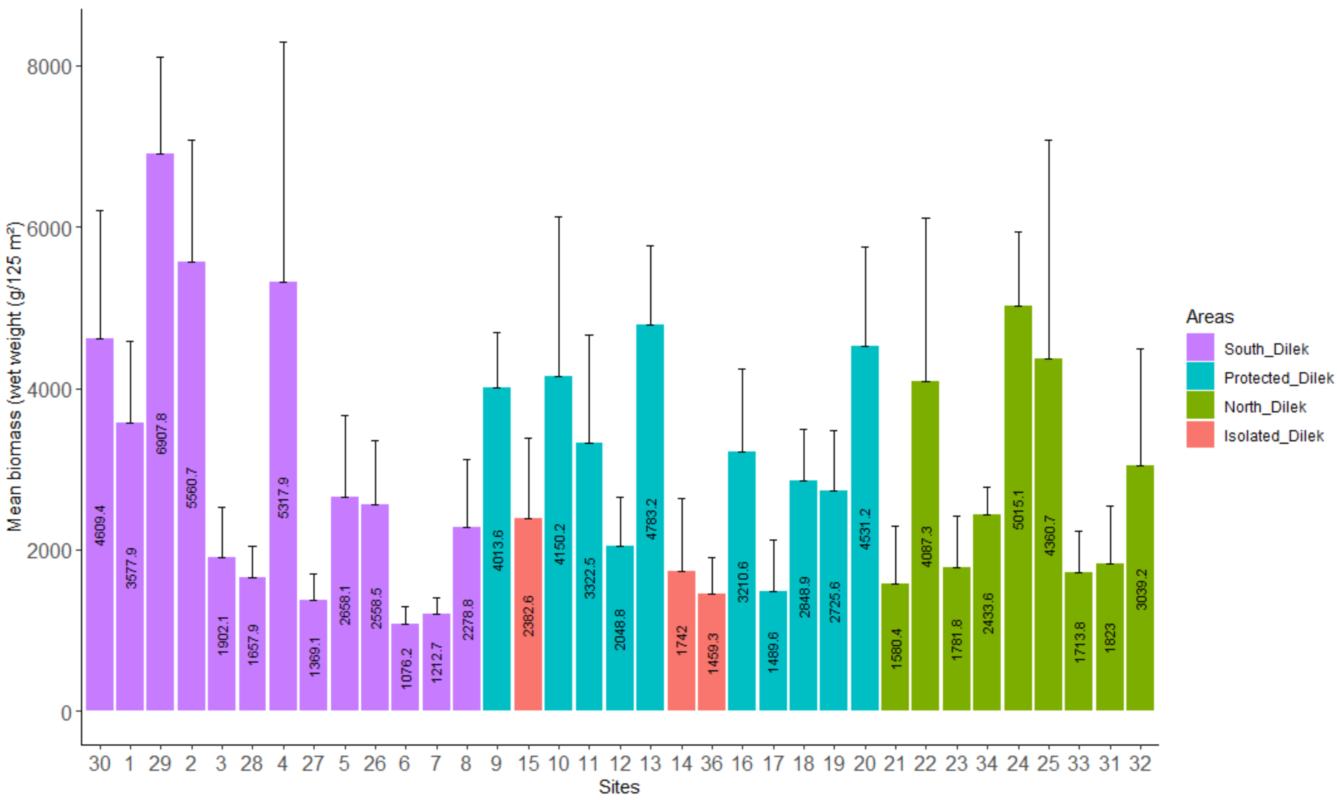

Figure 9. Average total biomass (wet mass in g.125 m^{-2}) per site (excluding gregarious species). The whiskers correspond to the standard error (+ S.E.).

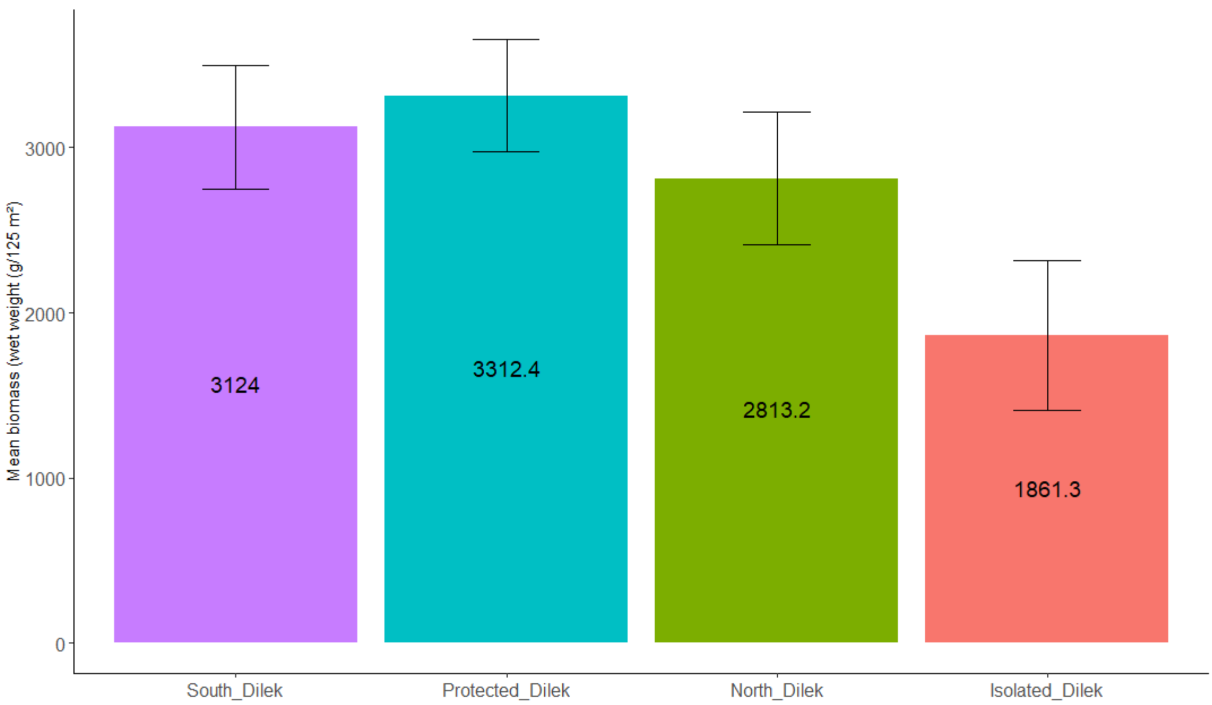

Figure 10. Average total biomass (wet mass in g.125 m^{-2}) per area (excluding gregarious species). The whiskers correspond to the standard error (+/- S.E.).

4.1.5. Emblematic species (*Epinephelus* spp. et *Sciaena umbra*)

The only recorded *Epinephelus* species was *E. costae*. Overall, few individuals of *E. costae* and *S. umbra* were observed (Fig. 11). Seven individuals of *E. costae* not exceeding 40 cm in size were observed throughout the mission, including 3 at site 29. As for *S. umbra,* 33 individuals not exceeding 35 cm in size were observed, including 10 at site 4 and 10 at 15. In General way, these two species did not therefore constitute a significant abundance and biomass on average at the sites where they were recorded (Fig. 11) except in site 29 for *E. costae* (mean = 390 g.125 m^{-2}) and site 4 and 15 for *S. umbra* (458 g.125 m^{-2}).

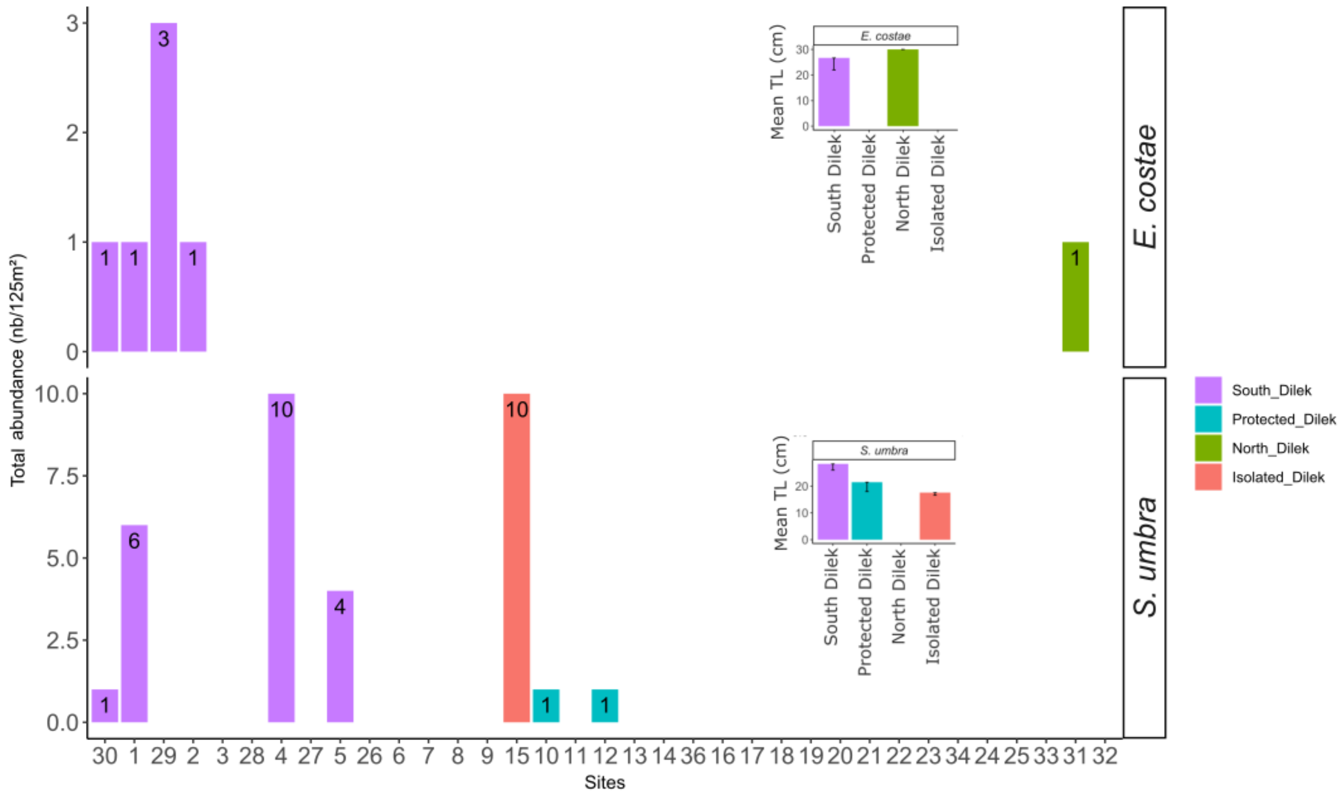

Figure 11. Abundance per site and average size (TL: Total Length, in cm) per area of the emblematic species *E. costae* and *S. umbra*.

4.1.6. Alien species (*Siganus* sp., *Pterois miles, Sargocentron rubrum*)

Only one individual of *Pterois miles* and one individual of *Sargocentron rubrum* were recorded at sites 10 and 31 respectively. In contrast, numerous individuals of *Siganus* spp. were recorded at most sites, except in the Isolated Dilek area (Fig. 12A). *Siganus* spp. individuals represented a significant biomass, particularly at sites in the Protected Dilek and North Dilek zones (Fig. 12B).

Individuals of *Siganus* sp. were less numerous in the South Dilek area, but they were on average the largest in this area (Fig.12 C). In the North Dilek area where they were most numerous, individuals of *Siganus* sp. were present at all sites except site 25.

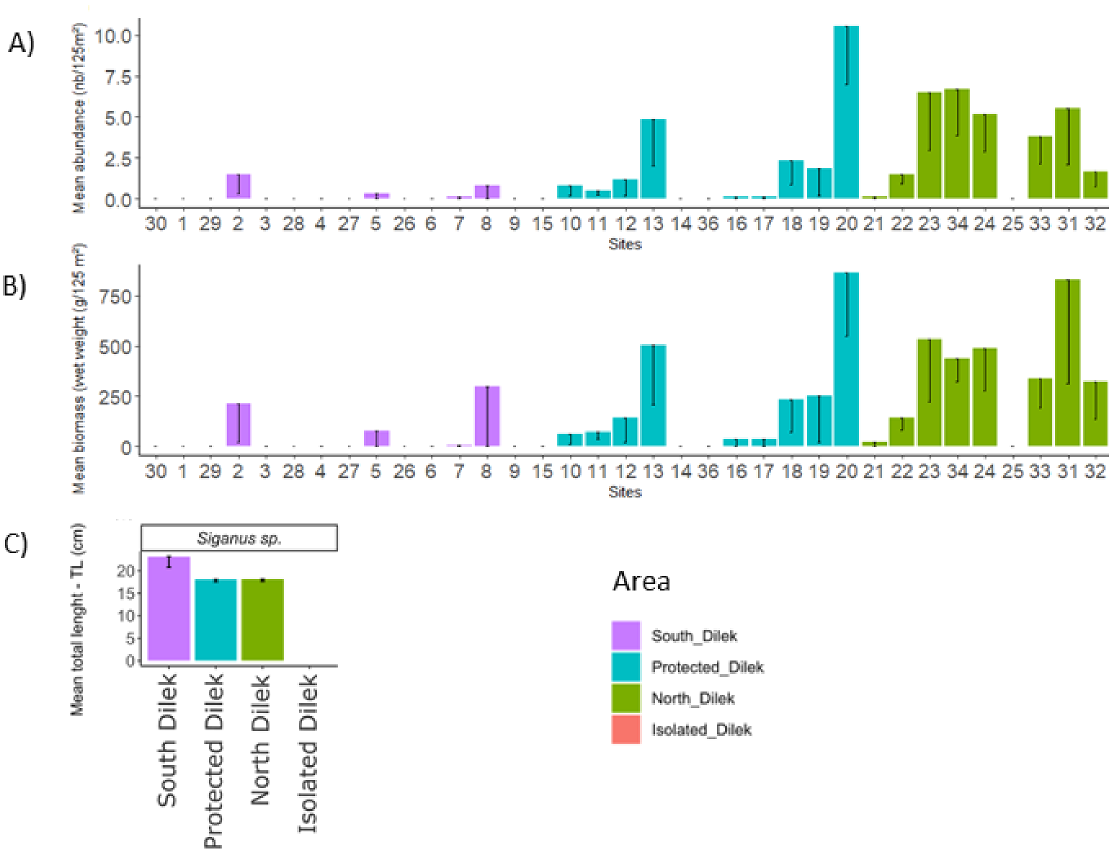

Figure 12. A) Average abundance (ind.125 m-2) of *Siganus* spp. per site. B) Average biomass (g.125 m-2) of *Siganus* spp. per site. C) Average size (TL: Total Length, in cm) per area of *Siganus* spp. The whiskers correspond to the standard error (- S.E.).

4.1.7. Commercial species

The Protected Dilek area showed a higher mean abundance of *D. vulgaris*, *L. viridis, S. salpa* and *S. scriba* (Fig. 13) but only the last shows a higher biomass (Fig. 14). In terms of mean size (Tab. 2), no commercial species showed a higher mean size within the Protected Dilek area. For *D. sargus*, the South Dilek and North Dilek areas showed similar biomass (Fig. 14). For *D. vulgaris*, the South Dilek and Protected Dilek areas showed similar biomass (Fig. 14).

With the exception of site 10, the -log ratio of abundance to biomass is not greater for sites in the Protected Dilek area than for other sites (Fig. 16). This shows that at constant abundance, the fish individuals targeted by the fishery are not larger in the Protected Dilek area. This means that the Protected Dilek area does not allow the fish to grow larger.

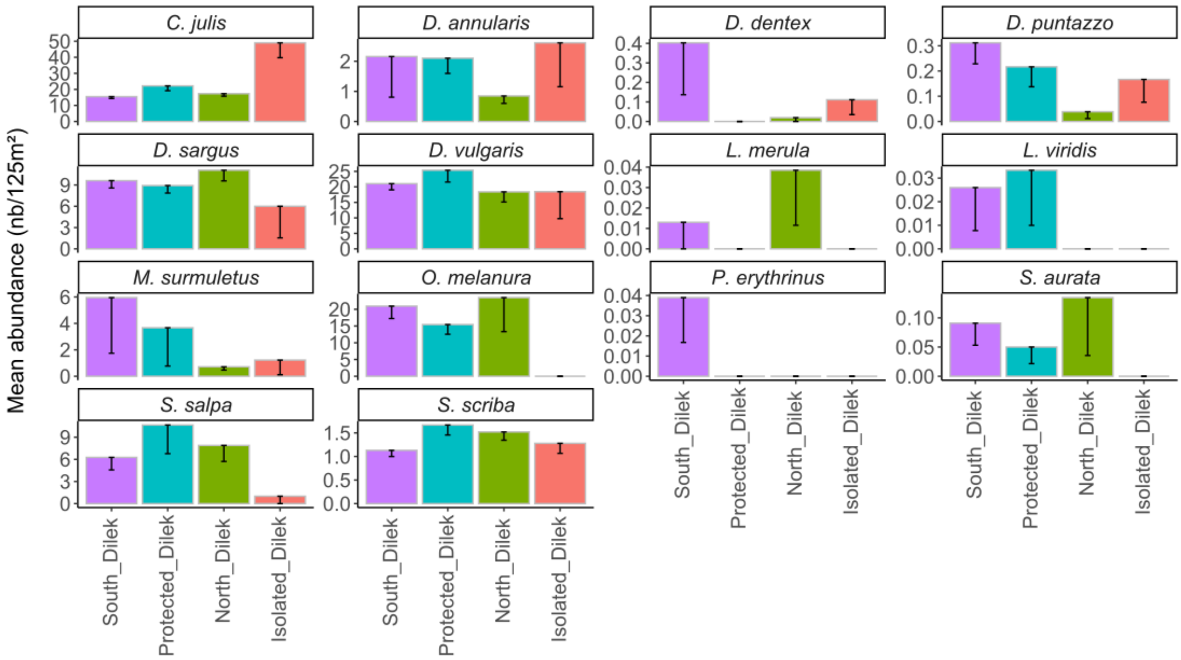

Figure 13. Average abundance (ind.125 m-2) of species targeted by the fishery by area. The whiskers correspond to the standard error (- S.E.).

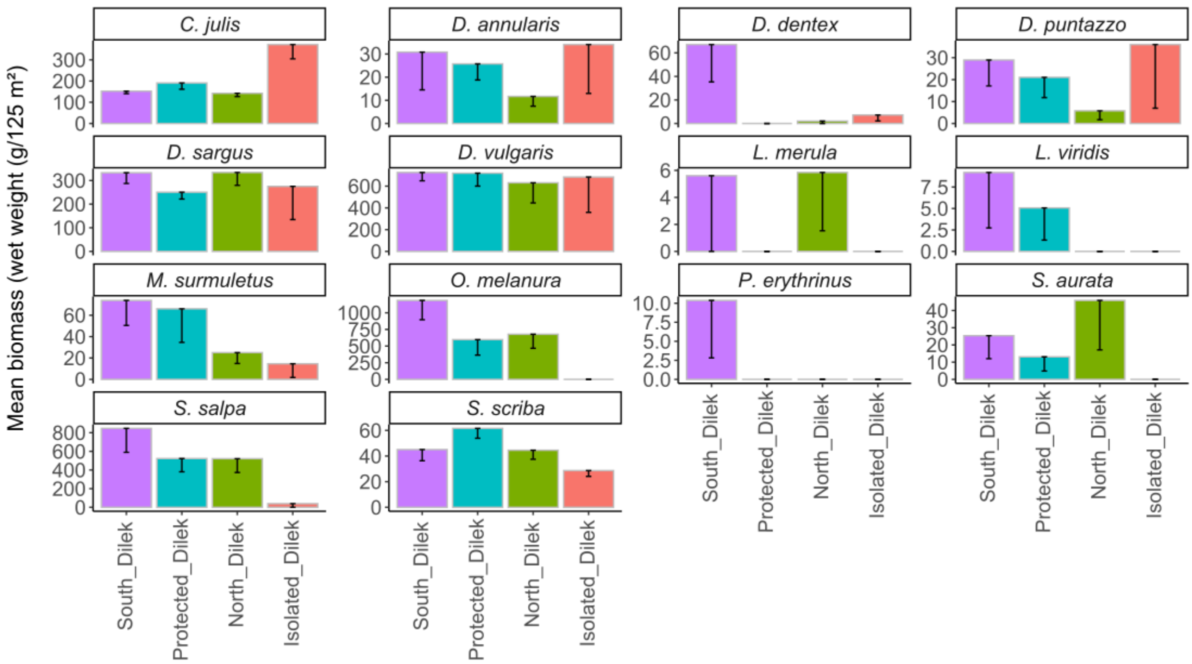

Figure 14. Average biomass (g.125 m-2) of species targeted by the fishery by area. The whiskers correspond to the standard error (- S.E.).

Table 2. Mean Total Lenght (TL - cm) of species targeted by the fishery by area.

Taxa	South Dilek	Protected Dilek	North Dilek	Isolated Dilek
C. julis	9.9	9.7	9.5	9.8
D. annularis	9.4	8.8	8.9	9.2
D. dentex	11.8	-	20	17
D. puntazzo	15.6	16.3	20	20
D. sargus	11.2	10.5	10.7	12.6
D. vulgaris	12.1	11.4	12	13
L. merula	32	-	22.5	-
L. viridis	30	22.5	-	-
M. surmuletus	9	8.2	12.4	10.1
O. melanura	14.1	11.8	11.6	-
P. erythrinus	22	-	-	-
S. aurata	24.6	25	27	-
S. salpa	18.1	12.9	14.2	13.1
S. scriba	13.6	13.5	12.4	11.7

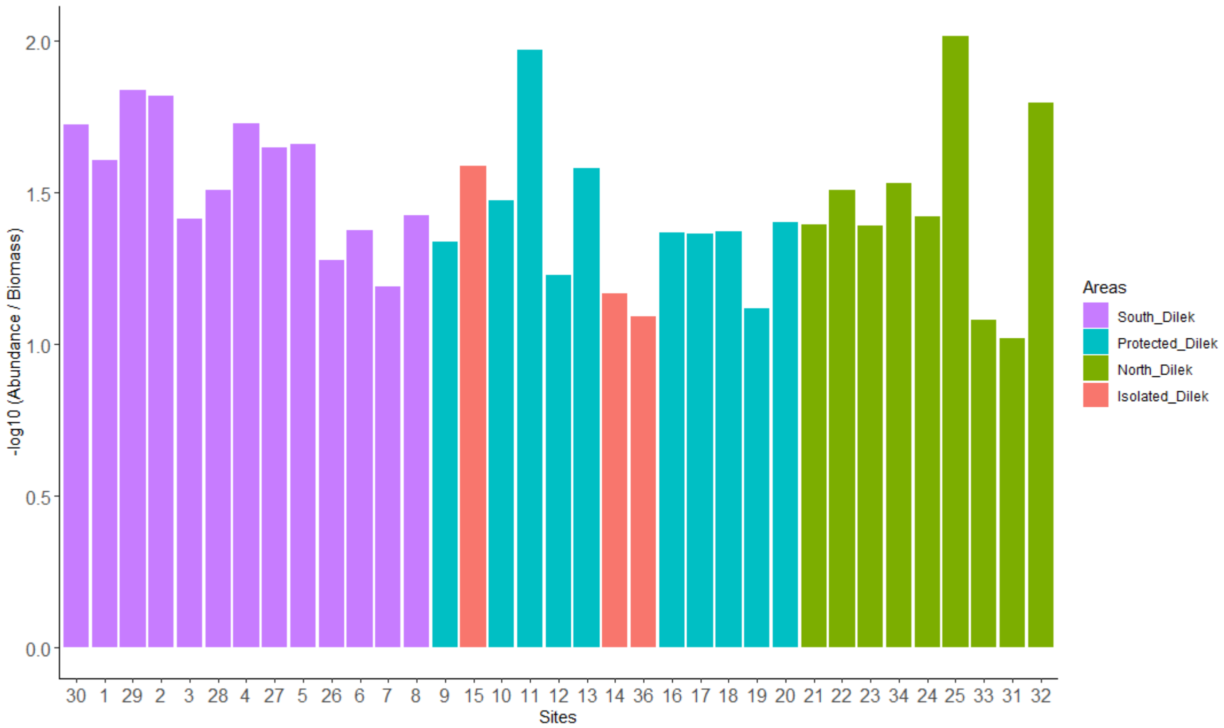

Figure 16. Log ratio (Abundance/Biomass) of species targeted by the fishery (overall per site). N.B.: this -log ratio increases when the biomass increases at constant abundance, which is the case when the individuals are larger.

4.2. Comparison with other Mediterranean MPAs

Data from other MPAs studied in the framework of the MPAs Odyssey project and from previous studies (BIOMEX programme, Harmelin-Vivien et al., 2008), allow us to put our results into perspective (Annexes A03a and A03b).

In terms of species richness, the average observed in the other MPAs studied under the BIOMEX programme is 12.5 inside the protected zone and 11.2 outside the protected zone. Within Cape Corsica MPA studied in 2021 the richness was 10.4 in the protected zone and 9.9 outside the protected zone. The Protected Dilek area showed an average species richness per transect of 9.7.

Similarly, in terms of total abundance, the average observed in the other MPAs studied in the BIOMEX programme is 90.6 ind/125m² in protected zones compared to 63.6 outside protected zones. For the Cape Corsica MPA the average abundance we observed was 58 ind/125m² in the protected zone and 63.6 ind/125m² outside the protected zone. The Protected Dilek area showed a mean abundance of 106.7 ind/125 m² *versus* 100 ind/125 m² outside the protected area.

Finally, in terms of biomass, the average observed in the other MPAs studied under the BIOMEX programme was 15114 g/125m² in the protected zone compared to 2957 g/125m² outside the protected zone. For the Cape Corsica MPA the biomass obtained was 2778 g/125m² in protected zone and 2246 g/125m² outside the protected zone. The Protected Dilek area showed an average biomass of 3909 g.125 m² *versus* 3720 g.125 m² outside the protected area. .

For the Dilek Protected Area the mean abundance was higher than that of the Cape Corsica MPA sampled a year earlier. For the MPAs studied in the BIOMEX programme, only the Tabarca MPA showed a higher mean abundance (Fig. 17). The mean biomass observed in the Protected Dilek area was almost equal to the biomass observed in the Cape Corsica MPA, but was much lower than the biomass observed in the protected zones of BIOMEX MPAs. All the outside protected zones of the Dilek MPA had comparable mean abundance with inside protected zones of the BIOMEX MPAs (Fig. 17).

These differences in mean biomass and mean abundance could also be due to natural differences (specific local environmental influences). But the comparison of biomass and abundance ratios inside the MPAs *versus* outside the MPAs (Fig. 18) shows that the protection implemented within the Dilek Peninsula MPA is not effective since the abundance and biomass ratios are well below the Mediterranean standards of the other MPAs studied (Fig. 18).

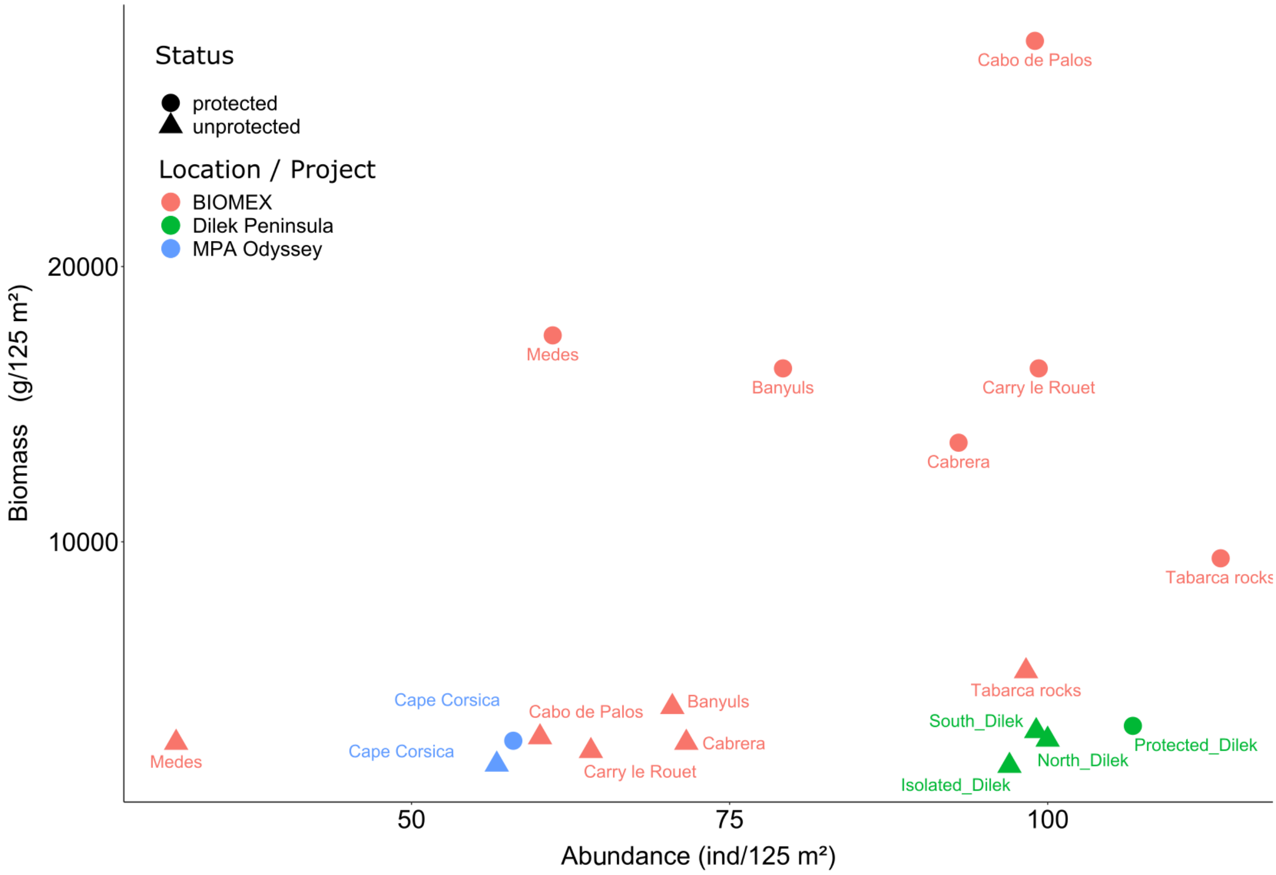

Figure 17. Descriptors (mean biomass and total abundance) of teleost communities in protected and unprotected areas of various locations in the Mediterranean - 2022 data from the Dilek Peninsula Büyük Menderes Delta National Park (Dilek) are presented alongside those from the western study areas of the BIOMEX programme (Harmelin-Vivien et al., 2008) and the MPA Odyssey project (2021).

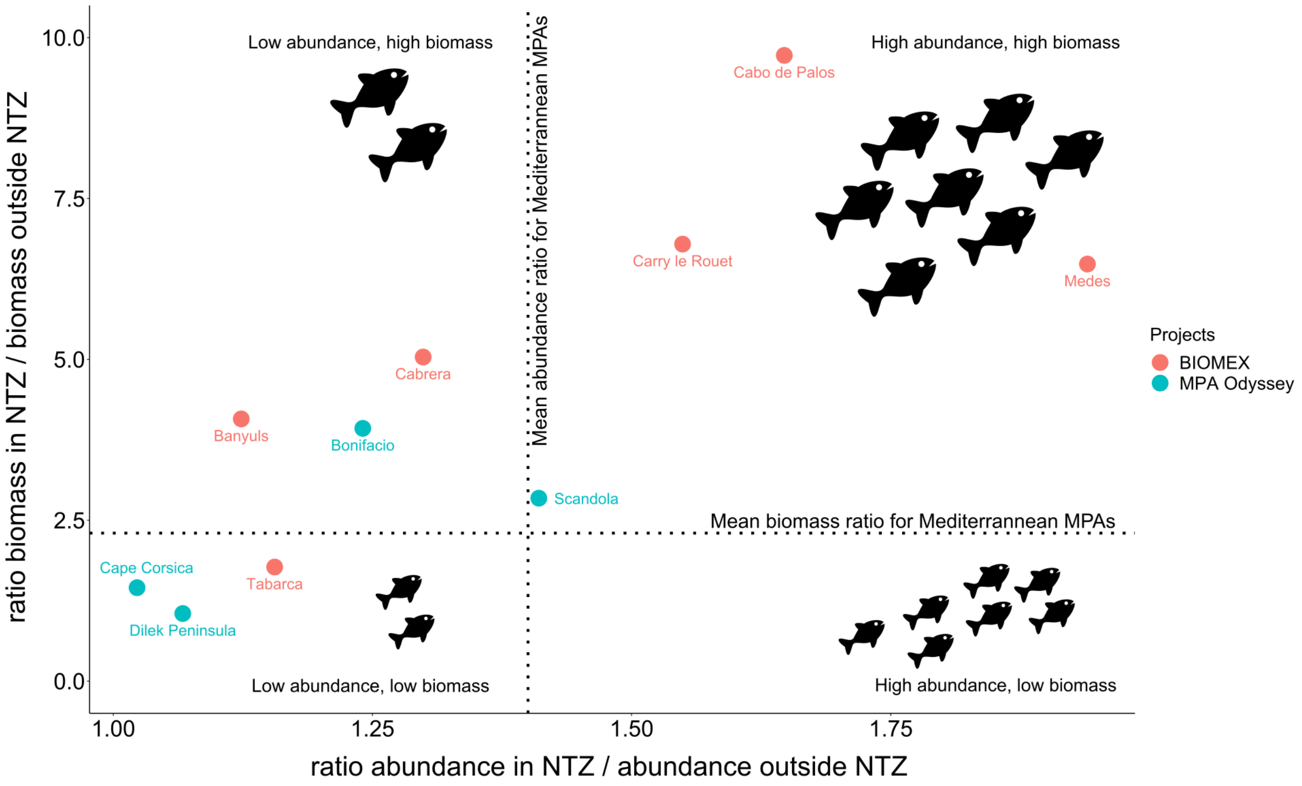

Figure 18. Effectiveness of each MPAs (dots) studied in the BIOMEX and MPA Odyssey projects in terms of the ratio inside NTZ (No Take Zone) *versus* outside NTZ for respectively abundance (x axis) and biomass (y axis). For Dilek, the ratio is calculated for inside *versus* outside the zone prohibited to professional fishing. The dotted lines indicates the average ratio found for a set of representative Mediterranean MPAs by (Giakoumi et al., 2017).

5. Discussion

5.1. Robustness of the method

The Underwater Visual Census (UVC) method is a well-tested approach that gives reliable results provided that operators are trained and inter-calibrated, a precaution that was taken here (Harmelin-Vivien et al., 1985). More recent methodological variants exist, for example with a transect width that varies according to the species considered (Prato et al., 2017), but the classic version of the UVCs has been preferred here in order to be able to compare the results with the existing literature on previous studies in Mediterranean MPAs(Harmelin-Vivien et al., 2008).

It should be remembered here that this method is adapted to the inventory of necto-benthic species only. It is therefore not surprising that our data do not contain observations of crypto-benthic species, such as Scorpaenidae.

One of the difficulties we faced consisted in sampling a constant habitat: the target habitat (infralittoral rocky reefs at a depth of 7 m to 12 m) was not always present, leading us to sometimes consider a mixed habitat of rocky bottoms partially covered by *P. oceanica* meadows (taking care not to exceed 50% cover). This variability in the characteristics of the habitat between our samples inevitably leads to a relative bias, although acceptable, that must be kept in mind.

It should also be noted that, due to logistical constraints or spatial configuration, the number of study sites per zone was sometimes not constant, which should lead us to moderate certain interpretations: for example, in the Isolated Dilek zone, only three sites were sampled; this may not be sufficiently representative of the zone. In our results, this zone appeared on several occasions to be particularly distinct from the others (i.e. lower species richness and lower biomass in particular), so these conclusions must be considered with caution.

5.2. General status of the communities

Overall, no site or area showed a clear distinction from the others, either in terms of average species richness, average abundance or average biomass. All the sites and zones showed fish communities that were fairly similar to the average community found on the biocenosis of the infralittoral rocky reefs with photophilic algae. Besides, and as this is generally not the case, it is important to point out that without considering gregarious species, *D. vulgaris* was the most dominant species, just before *C. julis* (Fig. 2). On the other hand, the majority of the sites and all 4 study areas showed **high average abundances** (Fig. 6, Fig. 7, Fig. 17), **but low average biomasses** (Fig. 9, Fig. 10, Fig. 17). Indeed, the majority of the surveyed fish were small on average (Fig. 8), which resulted in a low biomass compared to other Mediterranean MPAs. The Protected Dilek area had the highest mean abundance (Fig. 7) and the highest mean biomass (Fig. 10) of the 4 studied areas . The mean abundance observed in all 4 areas was quite high compared to the other MPAs studied previously. In contrast, the mean biomass of the 4 areas was very low and was comparable to the mean biomass observed outside the fully protected zones for other mediterranean MPAs (Fig. 17). The Isolated Dilek area had a lower species richness. This may be related to the isolation of the sites, as it is known that island and isolated areas have lower species richness (Blondel, 1986). It is also possible that this observation is a consequence of the pressure exerted on these sites. However, these conclusions should be treated with caution as only 3 isolated sites were sampled.

The emblematic species (*Epinephelus* spp. and *Sciaena umbra*) were rarely observed. However, it is interesting to note that at sites 4 (South Dilek) and 15 (Isolated Dilek) 10 individuals of *S. umbra* were observed (Fig. 10).

Many individuals of *Siganus* sp., a non-native species that can cause ecological imbalances and catastrophic trophic cascades (Sala et al., 2011, 1998) were observed during the surveys (Fig. 12). But in the North Dilek area, where individuals of *Siganus* sp. were the most abundant, they did not take the place of other herbivorous species such as *S. salpa*. *Siganus* sp. was particularly abundant in the Protected Dilek and North Dilek areas. Only one individual of *P. miles* and one individual of *S. rubrum* were recorded at sites 10 and 31 respectively. Although those are scarce individuals, the observation of these individuals certainly indicates a settlement of these two species in the waters of the Dilek Peninsula. Knowing the general tendencies for alien species, favoured by rising sea-surface temperatures trends, their abundances will most probably keep increasing.

5.3. Effects of the Protected Dilek area

5.3.1 Comparison of fish communities inside and outside the highly protected area

Overall, the community descriptors do not show a clear "reserve effect" for the Protected Dilek area. The Protected Dilek area displayed the highest fish abundance and biomass (Fig. 7, Fig. 10). However, this difference was not significant and not clearly marked in comparison to the other areas. At the scale of the sampled sites, sites within the Protected Dilek area were not the sites with the highest mean abundance (Fig. 6) or the highest mean biomass (Fig. 9). There was therefore no general trend indicating a clear tendency of higher mean abundance or biomass at sites within this protected zone. The plausible explanations for this observation are not obvious from our data.

At least two possible and non exclusive factors may explain this : first, the Dilek protected area isn't a properly said no take zone as recreational fishing activities are still allowed. Another plausible cause includes a probable lack of enforcement in the Protected Dilek area and thus possible poaching. In order to disentangle the source of harvesting pressures (types of harvesting), some species may be indicative : some species considered to be indicative of angling (*Serranus* spp.) suggested that angling would be more prevalent in the Protected Dilek area , but the data from others of such species (*C. julis)* do not allow us to draw a clear conclusion in this sense. On the other hand, as for the species indicative of poaching pressure by spearfishing, such as *S. umbra* and *Epinephelus* spp., these were simply not very abundant or even absent, whatever the area. Indeed, only two individuals of *S. umbra* were observed in the Protected Dilek area, and no individuals of *Epinephelus* spp. were observed.

The "-log ratio"descriptor is usually helpfull to detect the apparition of a reserve effect along a gradient of sites across a reserve boundary : indeed, as the sampling moves towards the inner part of an effective protected area, this ratio is expected to increase. In our case, this ratio did not reveal any trend within the Protected Dilek area.

5.3.2 Comparison with other mediterranean MPAs

Data from previous studies, from the BIOMEX programme (Harmelin-Vivien et al., 2008) and the MPAs Odyssey project carried out in 2021 in the Cap Corsica MPA, allow us to put our results into perspective (Cheminée et al., 2021). The descriptors of the Dilek Peninsula fish communities that we collected over the 4 study areas (South Dilek, Protected Dilek, North Dilek and Isolated Dilek) are below Mediterranean standards in terms of average biomass per area (Fig. 17). In contrast, in terms of mean abundance the study areas of the Dilek Peninsula are well ranked: the Protected Dilek area ranks second among the MPAs considered here, just behind Tabarca Island (Spain) and the three unprotected areas of the Dilek Peninsula have higher average abundances than some protected areas of other Mediterranean MPAs (Fig. 17). However such absolute value differences may be linked to environmental influences and the true indicator of MPA effectiveness is the ratio of abundance (or biomass) between inside versus outside the MPA (Fig. 18). The low ratio (both for biomass and densities) that we observed in Dilek underlines a clear absence of reserve effect in the Protected Dilek area, in contrast to the other Mediterranean MPAs studied in the framework of the BIOMEX programme, where the strongly protected areas show higher average descriptor values than outside the strongly protected areas (Fig. 18).

5.3.3 Considerations for the protection level and the size of the Protected Dilek area

As regards the size of highly protected areas, previous works in other areas highlighted that, for a given species, densities were significantly higher inside fully protected (i.e. no take zones) when fully protected areas were larger than the known home range of that given species ; on the contrary, no change in density occurred when fully protected areas were smaller than home ranges (Di Franco et al., 2018). Consequently, this study highlighted that there is a direct link between the effectiveness of fully protected areas and species' home range: Di Franco and collaborators suggested that fully protected areas of at least 3.6 km2 may increase the density of local populations of these coastal marine species (e.g. *Diplodus* spp. *Serranus* spp. *Epinephelus* spp., *S. salpa*, *S. cretense*).

As an application of these studies, we highlight that full protection (i.e. no take) and a larger surface are characteristics that should be considered for improving Dilek MPA effectiveness (see next section for recommendations).

5.3.4 Status of the other areas

The South Dilek area showed some interesting results. This area had a fairly high average abundance like the other areas (Fig. 7), but it also had the second highest average biomass of the 4 areas studied, behind the Protected Dilek area (Fig. 10). In the South Dilek area the fish recorded tended to be larger on average than in the other areas (Fig. 8). Species targeted by the commercial fishery were fairly well represented both in terms of mean abundance (Fig. 13) and mean biomass (Fig. 14). The southern zone is also the zone where the most individuals of the emblematic species *Epinephelus* spp. and *S. umbra* were recorded. It is the only area where *E. costae* individuals were recorded (n = 6), and the area where the most *S. umbra* were recorded (n = 21). This area was also the one where the fewest individuals of the non-native and potentially invasive species *Siganus* sp. (Sala et al., 2011) were observed with only 4 sites out of 14 where the species was present (Fig. 12). Two guitar rays (*Rhinobatos* sp.) were also observed in the southern zone at sites 1 and 2. These guitar rays could be *Rhinobatos rhinobatos* or *R. cemiculus*, species classified as endangered by the IUCN. These observations would then be a good thing. But these guitar rays could also be *Glaucostegus halavi* which is a lesseptian species which would make this observation bad news.

The South Dilek area is the least frequented by mass tourism as it is far from the main town of the region (Kuşadası), in contrast to the North Dilek area. There are therefore fewer boats and less noise pollution. There is also very little recreational fishing due to this isolation. There is some commercial fishing but our surveys show that the fish species targeted by commercial fishing are on average as well represented as in the Dilek Protected Area.

6. Management and possible scenarios

We recommend a large-scale scenario, summarized in figure 19, that includes enhanced differentiated regulations according to the areas, as described here below.

6.1. Protected Dilek: implementation of an effective fisheries control, enhancement of its protection level, and enlargement of its size

The Protected Dilek area does not seem to be an effective strong protection area. Overall there is a high average abundance but a very low average biomass and mean total length of the fish recorded compared to the other Mediterranean MPAs studied previously, most likely due to a lack of enforcement. It has been shown that strong protection areas generate the most benefits (Ban et al., 2019; Zupan et al., 2018a, 2018b) through the export of eggs, larvae, juveniles or adults that they generate and it is unfortunate that the regulatory efforts made are not followed by the expected positive effects on the field. Besides, its current size (235 ha = 2.35 km^2) is below the recommended average of 3.6 km^2 necessary to have an effective reserve effect for the main coastal species (Di Franco et al., 2018). Consequently we recommend that this area should be enlarged up to the boundaries of the National Park (Fig. 19) and that its protection level should be enhanced and fully enforced: recreational fisheries, along with professional ones, should be effectively banished to obtain a true “no-take” area.

6.3. Dilek south : professional fishing allowed, recreational fishing banned

We were able to identify the South Dilek area as an area with fish communities in better condition than the other study areas, and which, due to its certain isolation, would be worth considering for new regulation. Its remote location, far from the recreational activities of the north, may confer it a “self protection”. We recommend that this area could remain open to professional fishermens, while being prohibited to recreational ones. As regards professional ones, good practice may be introduced in order to progressively increase the size of individuals (notably *Diplodus* spp. that are numerous), therefore favoring better incomes and exportation of biomass towards surrounding areas. Good practice may include a diversification of fishing gear and target species, and an increase of the mesh sizes. Additionally, targeting non native species may become a valuable commercial objective as their presence increases, as already practiced in southern parts of the country (see the Gokova fishermen cooperative initiatives). Ultimately, a moratorium on emblematic species (such as groupers) may be foreseen.

6.3. Dilek north : a buffer zone

In parallel to the new protections instated for the protected and south areas, the north area could be organised as a buffer zone, where recreational activities are allowed, but with some regulations: recreational fishing may be regulated with the use of quotas per species per boat, for example. Some specific activities may be assessed for their environmental impact (e.g. “party boats”) and accordingly regulated. As mentioned for the south, invasive species such as Siganids, abundant in the north area, should be considered for new culinary practices, and encouraged as a new target species.

6.4. Implementation of a long term monitoring strategy

The methodology used in the present study has enabled a status report to be drawn up on the populations that could be used as a reference in the future as a "zero state" or a “baseline” database in a situation without special protection measures. If management measures with strong protection were to be introduced in these areas, it would be advisable to carry out new inventories at regular intervals in order to monitor the state of the fish communities over time and to watch for the expected appearance of a "reserve effect". Besides, we recommend that the fishery activities should be monitored into details to better estimate the fishing pressure (both pro and recreational).

Figure 19. Future management scenario recommendations (see section 6. for explanations)

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8. Appendix

Table A01 : Location, date and time of sampling and main characteristics of the surveyed sites

Areas	Site	Longitude	Latitude	Date	Time
South Dilek	1	37.6415500	27.0701000	2022/08/17	09:35
South Dilek	2	37.6421315	27.0563201	2022/08/17	09:35
South Dilek	3	37.6435167	27.0520500	2022/08/17	10:22
South Dilek	4	37.6457833	27.0395500	2022/08/17	10:30
South Dilek	5	37.6489000	27.0330000	2022/08/17	10:16
South Dilek	6	37.6473833	27.0136500	2022/08/17	11:27
South Dilek	7	37.6509000	27.0053833	2022/08/17	14:55
South Dilek	8	37.6493500	27.0008167	2022/08/17	15:01
Protected Dilek	9	37.6525167	27.0016333	2022/08/17	15:42
Protected Dilek	10	37.6578000	27.0041333	2022/08/17	15:51

Protected Dilek	11	37.6693167	27.0068333	2022/08/18	09:25
Protected Dilek	12	37.6726833	27.0100500	2022/08/18	09:28
Protected Dilek	13	37.6850667	27.0152833	2022/08/18	10:30
Isolated Dilek	14	37.6921000	27.0154833	2022/08/18	10:18
Isolated Dilek	15	37.6546167	26.9960167	2022/08/18	11:11
Protected Dilek	16	37.6890833	27.0281500	2022/08/18	15:30
Protected Dilek	17	37.6900167	27.0332833	2022/08/18	15:39
Protected Dilek	18	37.6865833	27.0457500	2022/08/18	16:20
Protected Dilek	19	37.6831000	27.0570000	2022/08/18	16:28
Protected Dilek	20	37.6870167	27.0652667	2022/08/19	09:56
North Dilek	21	37.6858167	27.0685500	2022/08/19	10:02
North Dilek	22	37.6833000	27.0833500	2022/08/19	10:40
North Dilek	23	37.6833000	27.0994500	2022/08/19	10:45
North Dilek	24	37.6848500	27.1116500	2022/08/19	11:35
North Dilek	25	37.6898667	27.1244500	2022/08/19	11:45
South Dilek	26	37.6479833	27.0221333	2022/08/20	10:33
South Dilek	27	37.6481667	27.0370167	2022/08/20	10:34
South Dilek	28	37.6463333	27.0436167	2022/08/20	11:20
South Dilek	29	37.6405167	27.0633167	2022/08/20	11:30
South Dilek	30	37.6387500	27.0787167	2022/08/20	12:41
North Dilek	31	37.7048667	27.1841667	2022/08/21	09:22
North Dilek	32	37.7078167	27.1926500	2022/08/21	09:32
North Dilek	33	37.6999167	27.1627500	2022/08/21	10:25
North Dilek	34	37.6816000	27.1025167	2022/08/21	10:45
Isolated Dilek	36	37,6963330	27,019750	2022/08/22	09:27