INTERREG MED PROGRAMME

FISHMPABLUE2 PROJECT

WP3 Testing

Del. 3.4.1: Scientific assessment of the effect of governance toolkit implementation

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1. INTRODUCTION

FishMPABlue2 project aimed to test a Small Scale Fisheries (SSF) governance-related toolkit and quantify its effectiveness in achieving expected results in terms of ecological and economic benefits, and social acceptance of management measures by stakeholders (mainly small scale fishers). The governance toolkit drafted during FishMPABlue1 project listed a set of governance-related measures identified as key factors for the successful management of SSF within and around Marine Protected Areas (MPAs).

The main objective of FishMPABlue2 project was to implement the "SSF Governance toolkit" in a set of selected MPAs (11, from 6 Mediterranean countries), in order to test its effectiveness. 9 of the 11 Pilot MPAs include a permanent no-take/no-entry zone[1] (NTZ/NEZ), surrounded by one or more buffer zones[2] under different levels of protection and that generally occupy the vast majority of MPA surface. The other 2 are composed only by NTZs and do not include buffer zones (see below for further details).

In each MPA, the project was carried out through a Pilot Action aimed to implement and test the effectiveness of the governance toolkit; it was developed through 3 main steps:

1) assessment of ecological, economic and social status of SSF in the context of MPA before the implementation of the governance measures
2) pilot action implementation, whose main activity was the application of some MPA-specific governance measures selected from the Governance toolkit
3) assessment of ecological, economic and social status of SSF after the implementation of the governance measures, allowing assessment of the latter's effectiveness for SSF.

Firstly, in each pilot MPA, a Local Governance Cluster (LGC)[3] was established in order to identify and agree on the main governance-related needs affecting the MPA. Later, the LGC, with the assistance of project partnership, selected the set of measures from the FishMPABlue1 governance toolkit to be implemented in the MPA in order to target the governance/management shortfalls previously identified.

[1] a zone where all human activities, apart from scientific research, are generally forbidden

[2] zones where human activities can be done following specific regulations

[3] a discussion platform formed mainly by the MPA management body, local small scale fishers, local Administrations, local NGOs, etc., identified by means of a governance survey (see Del. 3.2.3 for details)

Then the selected tools and the actions aimed at implementing them have been described in the Pilot Project Implementation Plans (PPIP) that have been adopted by each LGC.

At the beginning and at the end of each pilot action, 2 monitoring campaigns were carried out to assess the status of each pilot MPA in 2017 (i.e. before the implementation of the governance tool[4]) and in 2018 (i.e. after the implementation of the governance tools[5]).

With the aim to evaluate the effects of governance toolkit implementation, a final scientific assessment was produced from the data gathered in the ‘ex-ante’ and ‘ex-post’ campaign, and the current document includes the main results of this comparison between 2017 and 2018 data. Specifically, it describes the main outcomes of the toolkit implementation in each of the 11 pilot MPAs (Fig. 1) considering:

1) Ecological effects
2) Economic effects
3) Social effects

Figure 1. Map of the 11 MPAs (in 6 countries) involved in FishMPABlue2 project.

A brief description of how the governance toolkit was implemented in the Pilot MPAs is outlined to provide the proper contextual information for understanding the scientific results described.

[4] see Del. 3.3.2 - ‘ex-ante’ monitoring report

[5] see Del. 3.3.2 - ‘ex-post’ monitoring report

2. SUMMARY OF GOVERNANCE MEASURES BEING TESTED

As reported in the 6th Monitoring Report of Pilot Project Implementation[6], a set of measures were identified and implemented by each LGC in the context of the project Pilot Action. In each MPA, tool selection was made in accordance with the main governance needs previously revealed by each LGC based on the elements identified and reported in the 'Survey on MPA features'[7] and the discussion carried out during the Preparation phase meetings[8]. An exhaustive description of the measures identified by each LGC in order to implement the selected governance tools is available in the 4th Monitoring report of Pilot Project Implementation[9].

The two categories of tools most selected by the LGCs in the pilot MPAs were:

A. an increase in surveillance and patrolling
B. an increase in fishers participation in MPA-run activities (e.g. monitoring) and decision-making processes

From this perspective, in the context of pilot action implementation, all LGCs planned a series of measures aimed to accomplish these two objectives.

Other tools were selected in each MPA based on the specific needs highlighted in the above quoted 'Survey on MPA features'. The distribution of tools selected per MPA are summarized in Table 1.

[6] Deliverable 3.1.5 – July-November 2018

[7] Deliverable 3.2.3

[8] Deliverable 3.2.2

[9] Deliverable 3.1.5 - January-March 2018

Table 1. Number of governance tools, and relative category, selected by each LGC (green cells indicate the tools selected in each MPA).

MPA	Increase surveillance (MPA ENFORCEMENT)	Increase fishers engagement (PARTICIPATIVE)	Increase KNOWLEDGE	Promote SUSTAINABLE FISHING	Promote public communication and awareness (INTERPRETATIVE)	ECONOMIC	TOTAL per MPA
Egadi	■	■	■		■		4
Torre Guaceto	■	■					2
Portofino	■	■					2
Zakynthos	■	■		■			3
Es Freus	■	■					2
Cabo de Palos	■	■			■		3
Cap Roux	■	■					2
Cote Bleue	■	■		■			3
Bonifacio		■		■			2
Strunjan	■	■	■				3
Telascica	■	■		■	■	■	5
TOTAL by CATEGORY	10	11	2	4	3	1	31

In almost all cases the implementation of governance measures was completed successfully. In other cases, the implementation of governance measures is still on-going, as they were selected in the perspective of a long-term implementation that will likely determine important benefits for the MPA in the next future.

It must be noted, the scientific assessment provided in this document refers to the comparison of each MPA status over 1 year, while the accruement of potential benefits of toolkit implementation is likely to be observed especially on a much longer temporal scale (up to several years), more coherent with the time scale at which ecological processes generally act. Therefore, the main focus of this document is the onset of "early" benefits related to the implementation of new governance tools or management interventions.

Below, a complete description of the scientific results elicited from the implementation of the governance measures is provided, focusing on the ecological, economic and social aspects considered during the monitoring campaigns carried out in 2017 and 2018.

3. SCIENTIFIC ASSESSMENT OF TOOLKIT IMPLEMENTATION EFFECTS

3.1 Ecological assessment

3.1.1 Introduction

The ecological analysis aimed to **evaluate the potential effects on the environment of the governance toolkit** in each MPA after its implementation.

To do so, results from the ecological monitoring carried out in 2017 (i.e. ex ante monitoring) and 2018 (i.e. ex post monitoring) were compared against each other following a "**before vs after"** logic. Specifically, for each MPA and protection level (no-take, partially protected and unprotected), a set of descriptors of fish assemblages[10] status were compared 'before' and 'after' the toolkit implementation (i.e. after one year). Fish assemblages represent a fundamental component of aquatic ecosystems and are widely recognized as a good indicator of marine ecosystems health.

They are also a perfect indicator of protection benefits associated to marine protected areas or other conservation measures. Data for characterizing fish assemblages were collected using 2 complementary sampling or monitoring techniques:

I. Underwater Visual Census (UVC) using strip transects
II. Baited Underwater Video systems (BUV)

These techniques allowed us to estimate **fish diversity,** and **density and biomass** of each individual species identified in the 11 MPAs and under the 3 different protection levels considered[11].

In the perspective of a proper comparison, the two sampling campaigns for the ecological monitoring were approximately conducted in the same time window for each MPA (see Table 2) and trying, as far as possible, to keep similar environmental conditions (e.g. sea water temperature, turbidity, sea wave conditions) between the 2 monitoring years. This was done in order to prevent, or at least reduce, potential bias related to seasonal variability that could confound the assessment of the effect of toolkit implementation.

From this perspective, slight differences in the timing of sampling, for the same MPA, between the two years are to be ascribed to adverse or not adequate

[10] set of all fish species present in an area at a certain time

[11] For a detailed description of sampling methodologies, see Deliverable 3.1.2 ('Common methodology for design and execution of sound scientific monitoring of small scale fishery within and around an MPA')

sampling conditions in 2018, compared to the same period of 2017. In addition, all the MPAs in a single monitoring campaign have been sampled along the shortest time possible in order to keep similar conditions also among MPAs and to limit spurious patterns related to environmental variability.

Table 2. Sampling periods of the ecological monitoring in the 11 pilot MPAs

MPA	Ex-ante (2017)	Ex-post (2018)
Egadi	8-12 June	4-8 June
Torre Guaceto	14-17 June	10-13 June
Zakynthos	19-22 June	16-20 June
Cabo de Palos	2-7 July	24-27 June
Es Freus	26-30 June	29-31 June
Bonifacio	15-18 September	4-7 July
Cote Bleue	20-23 July	9-12 July
Cap Roux	25-28 July	13-15 July
Portofino	10-13 July	17-20 July
Telascica	7-10 September	22-24 July
Strunjan	15-18 July	25-27 July

In the following paragraphs the main results concerning the comparison of the ecological monitoring carried out in the two campaigns are presented by pooling together (when possible) the data coming from the two methodologies used (UVC and BUV).

For both techniques, samplings were performed under every protection level present in each MPA (no-take, partially protected and unprotected, see Fig. 2a).

In two MPAs (Cote Bleue and Cap Roux) only the no-take zone is present, with no partial protection zones (buffer) between the no-take and the unprotected (external) areas around. In these 2 MPAs external sites at different distance from MPA borders have been sampled (2 sites close to the MPAs and 2 sites far from the MPA borders, see Fig. 2b). For UVC and BUVs, for each level of protection, two sites were randomly selected and in each site 82 UVC-related (depending on site spatial extent) and 6 BUV-related replicates were performed (Fig. 2a and 2b).

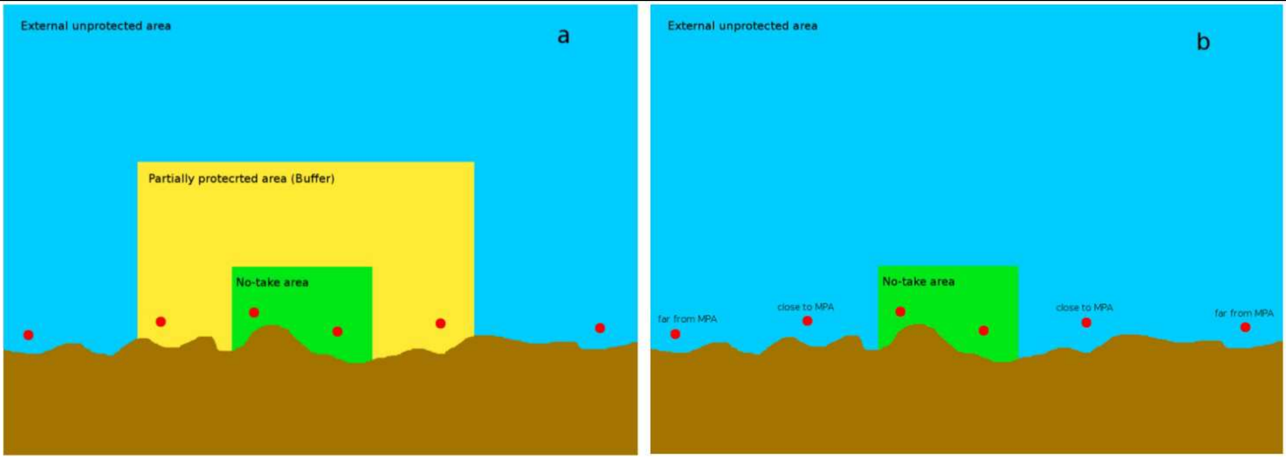

Figure 2. Scheme of MPA zoning for: a) multi-use "standard" MPA, b) no-take only MPA (also called marine reserve); and schematic site distribution in each protection level (red dots) for UVC and BUV during the sampling campaign.

3.1.2 Material and methods

Underwater visual census

Underwater Visual Censuses (UVC), based on strip transects of 25x5 m (Fig. 3), were used to assess species richness, abundance and density. Overall **more than 1,000 UVC transects were carried out in 66 sites during the two campaigns**, accounting for more than **200 hours of underwater sampling**. Actual number of fish encountered were recorded up to 10 individuals, whereas larger groups were recorded using categories of abundance[12]. Fish size (i.e. total length – TL) was recorded within 2 cm size classes for most of the species, and within 5 cm size classes for large-sized species (maximum size >50 cm) such as the dusky grouper *Epinephelus marginatus* and the brown meagre *Sciaena umbra*.

Apart from the fish belonging to the family *Mugilidae* – for which species identification is not possible during UVC – for all the other fishes it was possible to get to the species level (or *genus* in very few cases) during the monitoring.

Data about cephalopods and macro-crustaceans were recorded following the same methodology (carapace and mantel length were estimated respectively for crustacean and cephalopod).

Individual wet mass[13] was estimated from size-related data by means of length–weight relationships from the available literature.

[12] 11–30, 31–50, 51–200, 201–500, >500 individuals

[13] hereafter called biomass

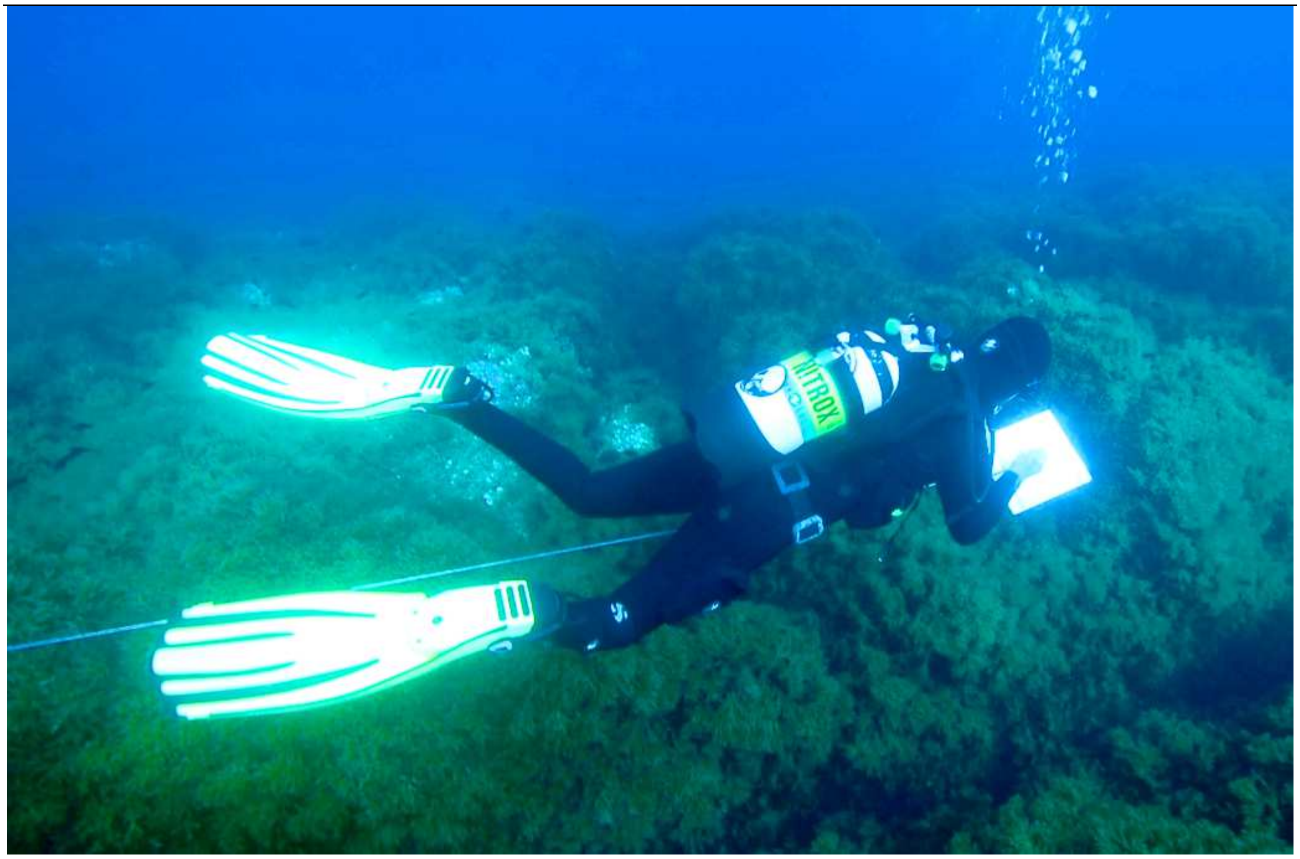

Figure 3. Operator performing UVC in Cabo de Palos MPA (*photo credit*: Javier Ferrer).

Baited underwater videos

Baited Underwater Video systems (BUVs) were deployed in the 11 MPAs during the ecological campaigns of 2017 and 2018 to assess the effects of toolkit implementation on fish species 'richness' (S) and relative abundance (MaxN).

BUVs is a sampling technique widely used to evaluate fish assemblage structure and composition. This technique consists of the deployment of a steel structure equipped with two video cameras and a bait that allows the attraction of fish species[14], such as large predators and more mobile species, which usually are not recorded by other sampling methods.

To evaluate how fish assemblage structure and composition vary among MPAs and among sites under different protection levels (i.e. no-take zone, buffer zone and external zone), BUVs were deployed in 2 random sites for each of the 3 levels of protection of 11 MPAs[15]. A total of 768 BUV replicates were deployed during the two ecological campaigns (384 deployments in each year). Each BUV was kept for ~65 min on rocky bottom between 8:00 a.m. and 3:00 p.m. within a depth range of

[14] see Deliverable 3.1.2 for further details

[15] see § 2.1

5–15 m (Fig. 4). To avoid the repeated sampling of the same individuals, BUVs were deployed at a distance >150 meters from each other.

Figure 4. BUV sampling operations: 1. BUV preparation (top left), 2. BUV deployment (top right) and 3. BUV in action, with an individual of zebra seabream *Diplodus cervinus* feeding on the bait

The bait consisted of 400g of crushed sardines placed inside a net fixed in front of the cameras (Fig. 5). From each BUVs deployment, we obtained a 60min video, which was successively analyzed to record the following variables: species richness (S) and MaxN, a conservative measure of abundance calculated as the maximum number of fish of the same species seen in a single frame over the observation period. To evaluate S, we recorded all the fish species observed in the field of view, whilst the MaxN was calculated considering only the fish individuals observed within 2 meters around the bait.

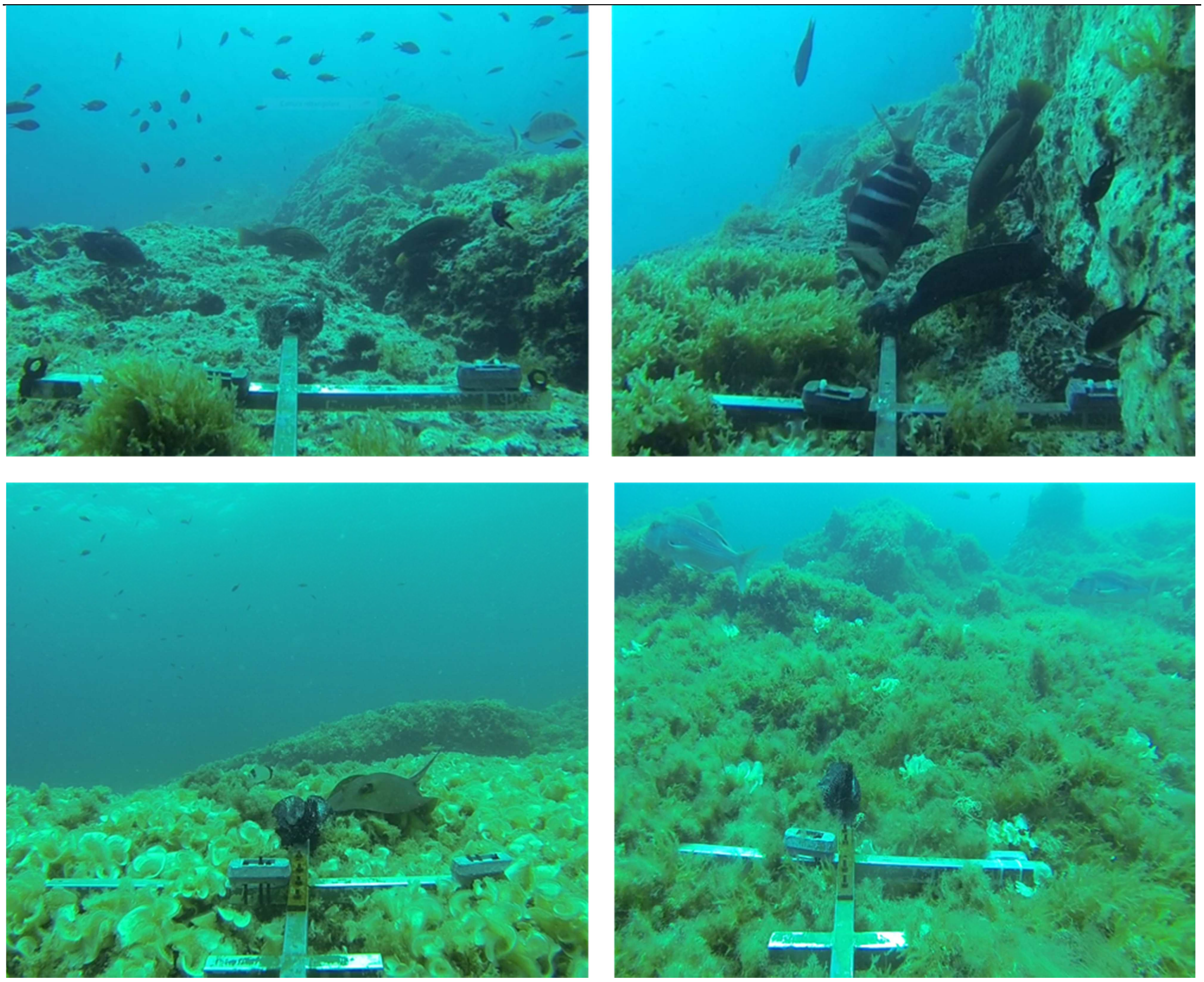

Figure 5. Frames extracted from BUVs deployed during the 2017 and 2018 monitoring campaigns

In a few instances, logistical constraints (e.g. very low water visibility or technical troubles) prevented the video-analysis of 14 and 30 BUV replicates from the 2017 and the 2018 survey, respectively. So, overall, **724 BUV deployments** were retained for analysis **over the two-year surveys** (n=370 and n=354 in 2017 and 2018, respectively). All the fishes were identified at the species level, except for Mugilidae, Clupeidae and Belonidae whose accurate identification was not possible in some instances.

3.1.3 Results

Data obtained with the UVC and BUV were assembled and analyzed comparing the two monitoring campaigns, in order to evaluate the **effects of the governance measures implemented** both in each MPA and globally, considering all the MPAs together.

Three descriptors generally used to characterize Mediterranean coastal fish assemblages were considered:

a. **fish diversity (total number of species recorded)**
b. **fish density (i.e. the number of individuals per unit of surface or time)**
c. **fish biomass (i.e. the total wet weight of fish per unit of surface or time)**

In the case of biomass, only UVC data were considered as BUV biomass data processing is considerably time-consuming and is still ongoing: BUV data, in fact, requires a considerable amount of time to be properly processed and analyzed.

Concerning fish diversity, on the whole, **103 taxa were observed** (Tab. 3) considering both campaigns: 92 in 2017 and 94 in 2018. The number of species observed (Fig. 6) in both campaigns (i.e. species common to the 2 campaigns) was 81.

Table 3. List of all taxa observed in the ex-ante and ex-post campaigns and their relative trophic level and commercial value. For commercial value: NC=non-commercial, LC=low commercial value, C=high commercial value. For trophic level: HE=herbivore, PL=planktonic feeder, DE=detritus feeder, CA=carnivore, HL=high-level predator

Taxon	Commercial value	Trophic level	Taxon	Commercial value	Trophic level
Anthias anthias	NC	PL	*Pagellus* sp	C	CA
Apogon imberbis	NC	PL	*Pagrus auriga*	C	CA
Atherina boyeri	NC	PL	*Pagrus pagrus*	C	CA
Atherina spp	LC	PL	*Palinurus elephas*	C	CA
Balistes carolinensis	LC	CA	*Parablennius gattorugine*	NC	CA
Belonidae	C	CA	*Parablennius pilicornis*	NC	CA
Blennidae	NC	CA	*Parablennius rouxi*	NC	CA
Boops boops	C	PL	*Parablennius zvonimiri*	NC	CA
Carangidae	C	HL	*Parapristopoma octolineatum*	NC	CA
Caranx crysos	C	CA	*Phycis phycis*	C	CA
Chromis chromis	NC	PL	*Pomatoschistus sp*	NC	CA
Clupeidae	C	PL	*Pseudocaranx dentex*	LC	CA
Conger conger	C	HL	*Raja sp*	C	CA
Coris julis	NC	CA	*Sardinella aurita*	C	PL
Ctenolabrus rupestris	LC	CA	*Sarpa salpa*	LC	HE
Dactylopterus volitans	NC	CA	*Sciaena umbra*	C	CA
Dasyatis pastinaca	LC	CA	*Scorpaena maderensis*	C	CA
Dentex dentex	C	HL	*Scorpaena notata*	C	CA
Dentex gibbosus	C	HL	*Scorpaena porcus*	C	CA
Dicentrarchus labrax	C	HL	*Scorpaena scrofa*	C	CA
Diplodus annularis	C	CA	*Scorpaena* sp	C	CA
Diplodus cervinus	C	CA	*Sepia officinalis*	C	CA
Diplodus puntazzo	C	CA	*Seriola dumerili*	C	HL
Diplodus sargus	C	CA	*Serranus cabrilla*	C	CA
Diplodus vulgaris	C	CA	*Serranus hepatus*	NC	CA
Epinephelus costae	C	HL	*Serranus scriba*	LC	CA
Epinephelus marginatus	C	HL	*Siganus luridus*	LC	HE
Euthynnus alletteratus	C	HL	*Siganus rivulatus*	NC	HE

Gobidae	NC	CA	*Solea spp*	C	CA
Gobius auratus	NC	CA	*Sparisoma cretense*	LC	HE
Gobius bucchichi	NC	CA	*Sparus aurata*	C	CA
Gobius cobitis	NC	CA	*Sphyraena* sp	C	HL
Gobius cruentatus	NC	CA	*Sphyraena viridensis*	C	HL
Gobius geniporus	NC	CA	*Spicara maena*	LC	PL
Gobius vittatus	NC	CA	*Spicara smaris*	LC	PL
Gymnothorax unicolor	NC	HL	*Spondyliosoma cantharus*	C	CA
Labrus bergylta	LC	CA	*Symphodus bailloni*	NC	CA
Labrus merula	C	CA	*Symphodus cinereus*	NC	CA
Labrus mixtus	LC	CA	*Symphodus doderleini*	NC	CA
Labrus viridis	C	CA	*Symphodus mediterraneus*	NC	CA
Lichia amia	C	HL	*Symphodus melanocercus*	NC	CA
Lithognathus mormyrus	C	CA	*Symphodus melops*	NC	CA
Mola mola	NC	PL	*Symphodus ocellatus*	NC	CA
Mugilidae	C	DE	*Symphodus roissali*	NC	CA
Mullus barbatus	C	CA	*Symphodus rostratus*	NC	CA
Mullus surmuletus	C	CA	*Symphodus tinca*	LC	CA
Muraena helena	C	HL	*Thalassoma pavo*	NC	CA
Mycteroperca rubra	C	HL	*Trachinotus ovatus*	C	CA
Myliobatis aquila	NC	HL	*Trachurus sp*	C	CA
Oblada melanura	C	PL	*Tripterigion tripteronotus*	NC	CA
Octopus vulgaris	C	CA	*Tripterygion delaisi*	NC	CA
Pagellus erythrinus	C	CA			

Figure 6. Pictures of some species encountered during UVC in Cabo de Palos MPA. Clockwise from top-left: brown meagre *Sciaena umbra*, dusky grouper *Epinephelus marginatus*, Mediterranean moray *Murena helena*, Redbanded seabream *Pagrus auriga*, greater amberjack *Seriola dumerili*, zebra seabream *Diplodus cervinus* (*photo credits*: Javier Ferrer)

In order to evaluate potential effects of toolkit implementation on species diversity, we considered the difference in the total number of species for each protection level in the two sampling campaigns, pooling together data from UVC and BUV. We specifically focused on protection level (i.e. no-take zones and buffer zones), as these zones are more likely (and more rapidly) influenced by the changes in the governance compared to the relative unprotected sites. From this perspective, both in no-take and buffer zones we observed a slightly lower number of taxa in 2018 compared to 2017 (Fig. 7). On the contrary, in the external sites we observed an opposite pattern with a higher number of taxa recorded in 2018 than in 2017.

From this perspective, it is important to highlight that total species diversity, although considered an interesting descriptor of fish assemblages, can be affected by a natural temporal variability that can mask the effects of other treatments. In any case, we are confident that this pattern is not related to any observational bias, because the team of observers operating UVC and BUV was the same in the two sampling campaigns. We also highlight that both in 2017 and 2018, although there was a (previously mentioned) temporal variability, **a positive trend in fish diversity can be observed moving from external to protected sites,** with the lowest number of species observed in the unprotected areas and the highest in the no-take areas of the MPAs.

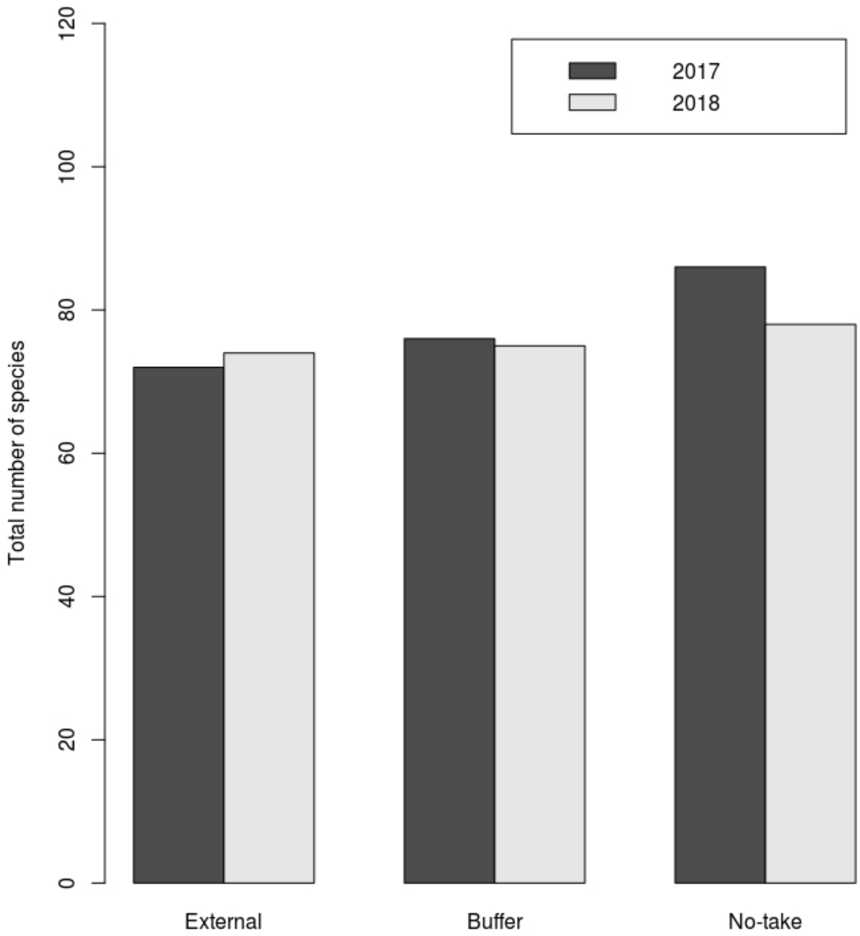

Figure 7. Total number of species observed through UVC and BUV in the three protection levels in 2017 and 2018

For what concerns fish density, in order to carry out a proper comparison between the 'before' and 'after' campaigns, we pooled together data on fish abundance per unit of surface from UVC (i.e. transect, 125 m^2) and fish abundance per unit of time from BUV (i.e. BUV replicate, 1h).

Data from 2017 and 2018 were pooled and compared by means of a **meta-analytic approach** based on the calculation of the 'effect size'. The effect size is a simple way of quantifying the magnitude of the difference between two groups (i.e. a treated group vs a control) and is particularly valuable for quantifying the effectiveness of a particular intervention (i.e. the treatment, in our case the implementation of the governance measures). Specifically, it is calculated as the natural logarithm of the ratio between the mean values of the two groups (treated and control) considered. In our case, with the aim to highlight potential differences between the two sampling campaigns we computed the effect size of the pooled density (UVC + BUV) for 2017 and 2018. Specifically, for each combination of MPA and level of protection, we calculated the effect size as the natural logarithm of pooled density measured in 2018 divided by the density measured in 2017. We also estimated the overall effect size (i.e. the effect size 2018 *vs* 2017 considering all the MPAs together) for each level of protection considered. Finally, in order to have **a measure of the 'Reserve effect' on density** (i.e. an increase in density of fish in protected locations compared to unprotected ones) we calculated: 1) the effect size on the density of fish observed in no-take zones *vs* external ones and 2) the effect size on the density of fish observed in buffer zones *vs* external ones.

By comparing the 'effect size' between the three levels of protection, within each MPA and pooling them all, it is possible to point out the positive effects of the governance measure implemented in the pilot MPAs. Specifically larger effect sizes in protected locations compared to the unprotected ones would suggest an effect of toolkit implementation (treatment) on the response variable investigated, considering that all other variables are controlled. By examining the 95% Confidence Intervals (CI) of the 'effect size' it is possible to establish if the difference in density between 2018 and 2017 is statistically significant. In particular, if the lower or upper CI does not overlap with the zero (i.e. absence of difference between treated and control group) the effect size is considered statistically significant.

These analyses were firstly carried out considering **all the fish species** observed during UVC and BUV. Then we conducted the same analysis considering: 1. only **fish with commercial value** and 2. only those fish species belonging to the category of **high level predators**, as these two groups are more likely to be positively affected by protection measures or a change in them.

Considering all the species, the overall effect size on fish abundance appears to be **slightly higher in protected locations than in unprotected ones** (Fig. 8).

The 95% confidence interval bars overlap the line of zero, indicating that the differences observed are not statistically significant. Considering the single MPAs, it can be observed that a high variability is present among the combinations of MPAs and protection levels considered. In most of the cases, effect sizes were not statistically significant, but only in 9 cases out of 31 they were negative in absolute values. In the majority of MPA protection level combinations, absolute values of effect sizes were positive, indicating a **general positive trend** from 2017 to 2018. The effect size, in fact, is calculated as a logarithm of the ratio between density data obtained in 2018 and those gathered in 2017. This means that a positive effect size corresponds to a higher value of density observed in 2018 compared to 2017.

MPAs show higher abundances in protected than in unprotected conditions as documented by the positive effect size for the reserve effect for 2018 (the same pattern was observed for 2017[16]). **No-take zones of the MPAs are associated to statistically higher fish densities compared to external unprotected zones**, while effect size for buffer zones, although positive, is not statistically significant. This is **clear evidence of the presence of an overall reserve effect.**

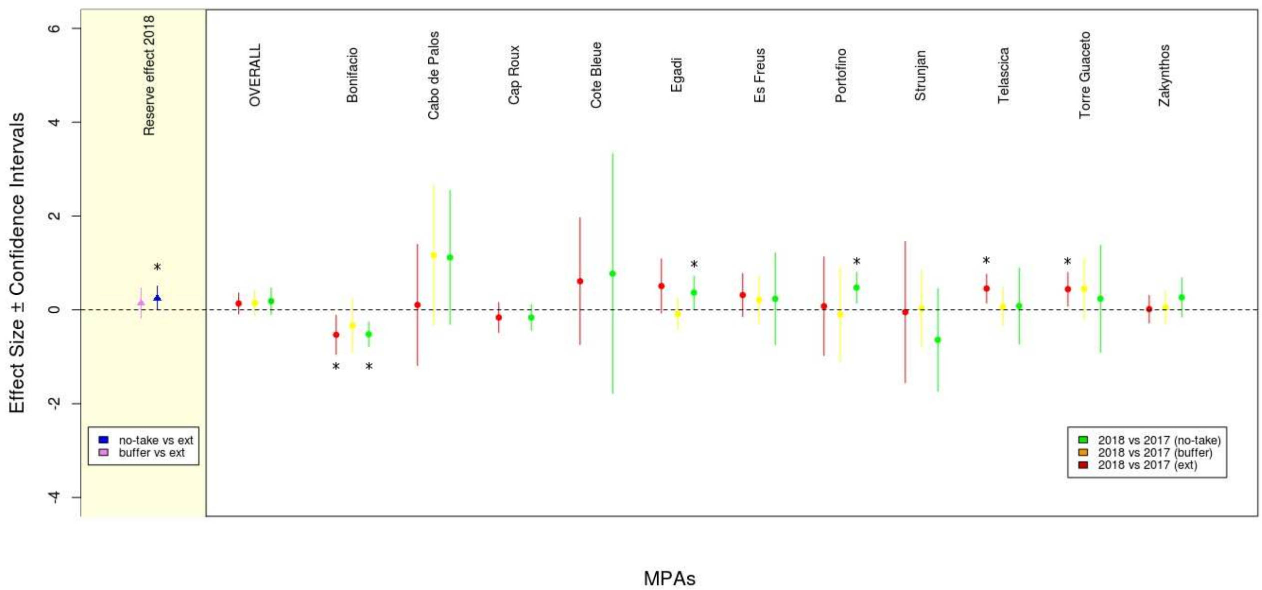

Figure 8. Effect size of fish density (all species) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size.

Focusing on commercially important species (see table 3 for the species considered in this group), a clearer pattern of effect sizes (Fig. 9) – considering all combinations of MPAs and protection levels – emerges. In this case, in fact, the majority of the

[16] see Del. 3.3.2 - 'ex-ante' monitoring report

protected locations (either no-take or buffer zones) within each MPA are associated to **a positive effect size**, while unprotected locations are generally associated to a lower or even negative effect size. For 4 out of 11 MPAs (Bonifacio, Cote Bleue, Egadi and Strunjan) effect size of unprotected locations was negative and statistically significant (6 out of 11 if we consider also Cabo de Palos and Cap Roux for which a marginal negative significance was found). This indicates that, from 2017 to 2018, these MPA-related external locations underwent an overall decrease in density of commercial species, whereas protected locations within the same MPA (either no-take or buffer or both of them) are associated to an increase or a minor decrease compared to unprotected ones.

This is even clearer by looking at the overall size effect for this group of species: external locations are, in fact, globally associated to a negative and marginally significant effect size (CI just nearly overlaps the line of zero effect) indicating a general decrease in density. On the contrary, protected locations are associated to a neutral effect size (i.e. no difference between 2018 and 2017) suggesting a greater capacity of these locations to face potential environmental or anthropogenic disturbances that could have taken place over the time period considered.

Give the well-known large variability of fish assemblages, we can reasonably assert that the effects are the same across the different protection levels, and therefore **observed positive effects could be ascribed to the implementation of the governance toolkit**. Certainly, we suggest to consider these results cautiously as density data could be affected by other factors (both exogenous and endogenous) that are not under the control of the operators.

Finally, **a clear reserve effect** emerges by looking at the comparisons between protected and external locations for 2018. In fact, both in the case of no-take areas and buffers, density estimations **resulted statistically higher** than those observed in external locations. The same pattern was highlighted for 2017 density estimations[17].

[17] see Del. 3.3.2 - ‘ex-ante’ monitoring report

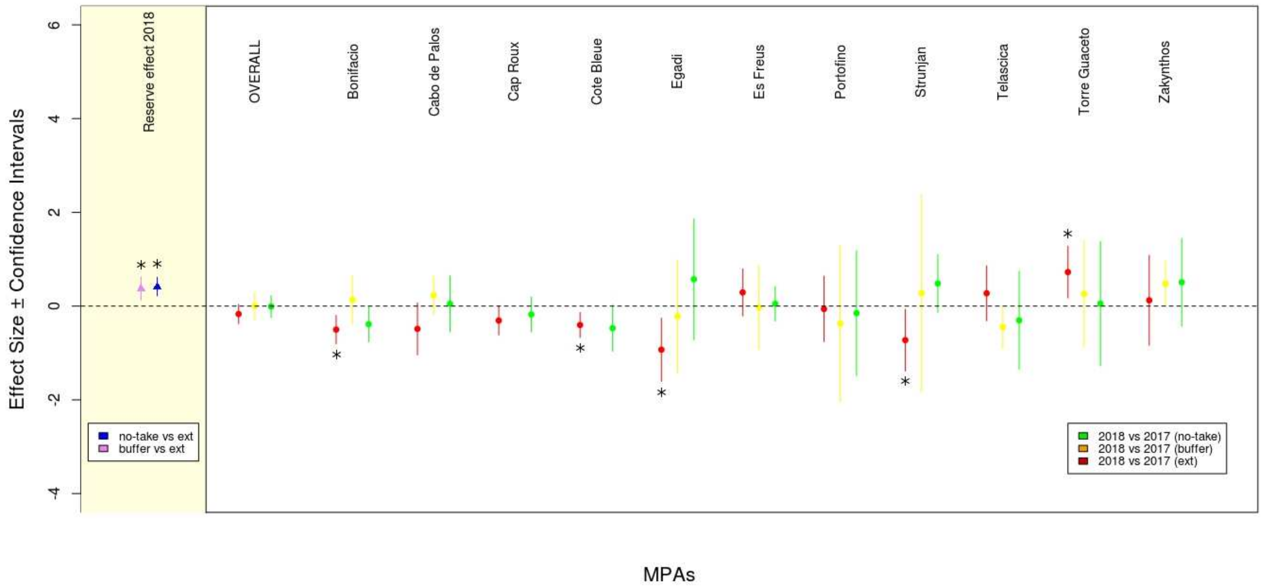

Figure 9. Effect size of fish density (commercial species only) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size

H**igh level predators**[18] **highlighted a more variable response pattern** (Fig. 10).

However we have to point out that fish high-level predators are generally present in coastal Mediterranean ecosystems (both protected and unprotected) in patchy groups and often low densities. From this perspective, it is not surprising that in few combinations of protection levels and MPAs, this category of fishes is completely absent (e.g. Strunjan and Torre Guaceto). Being present at low density, also in some protected locations, determines that even minor changes in the demography of the populations between 2017 and 2018 could have produced a change in the effect size of density.

Despite this, **an evident 'reserve effect'** emerges from our data with both no-take and buffer locations generally associated to **higher density of high level predators** compared to external areas. In fact, although the effect size is only marginally significant, the absolute value of the statistic is very high and the lack of clear statistically significance is ascribable to the above-mentioned variability associated to these species.

[18] fish species that are at high levels of the trophic food web in Mediterranean marine ecosystems; see table 3 for the species considered in this group

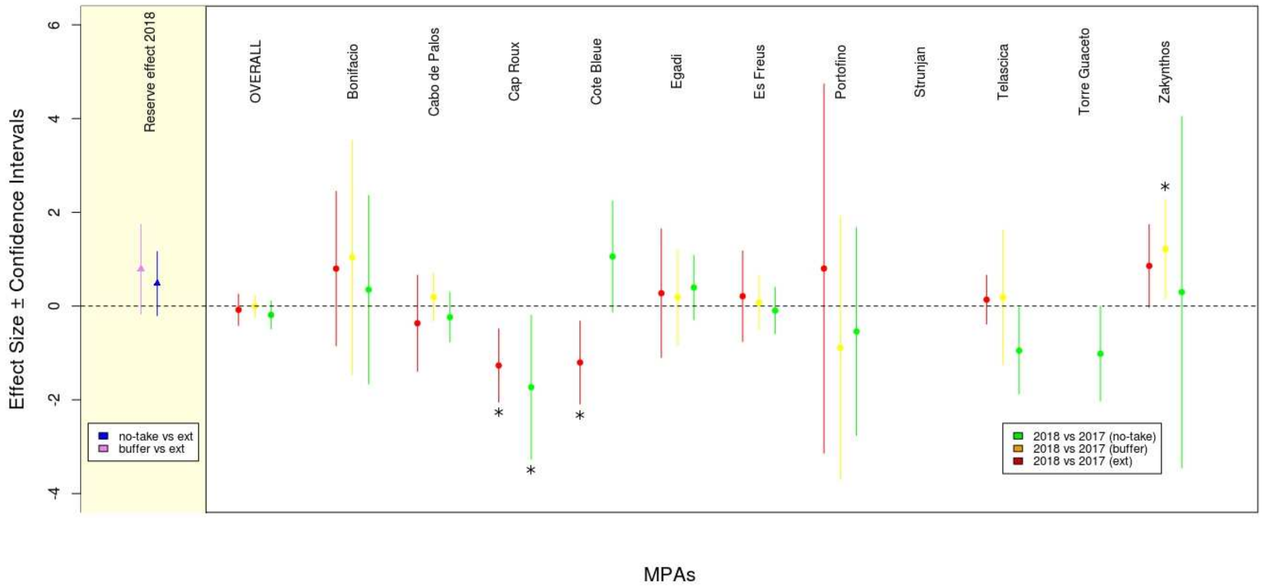

Figure 10. Effect size of fish density (high-level predator species) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size

Effect size was also used for assessing differences between treated (2018) and control (2017) condition on total fish biomass.

These analyses were only conducted for UVC data. Fish biomass is considered a good indicator of protection effectiveness as it takes into account both fish density and size of individuals. Also in this case, analyses were performed by separately considering the 3 nested groups (all species, commercially important species and high level predators) of species mentioned above.

Overall biomass was significantly higher in buffer locations (Fig. 11), whereas a neutral effect size results for external and no-take areas. **This clearly suggests that the new governance measures produced an improvement of fish biomass status in the buffer zones**.

The absence of significant effects on the overall effect size for no-take zones should not lessen the outcome find for buffer zones, given that this pattern is in line with our initial expectations. In fact, the governance measures implemented in each MPA were naturally expected to produce higher positive impacts in buffer zones compared to no-take ones. While the majority of governance measures are supposed to produce effects of similar magnitude in all the sectors of an MPA (e.g. enforcement, fishers engagement) some of the specific measures adopted could have determined a greater positive effect in buffer zones.

This is the case for all measures determining a reduction of fishing effort (e.g. a lower number of fishers allowed to fish within the MPA) in the MPAs and/or adopting a more sustainable fishing strategy (through the use of nets with larger mesh size or sustainable fish traps).

Finally, a very **clear 'reserve effect' on biomass** of all species resulted by comparing protected (both no-take and buffer) and external sites in 2018, with a **positive and statistically significant effect size** recorded for the two comparisons tested (Fig. 11).

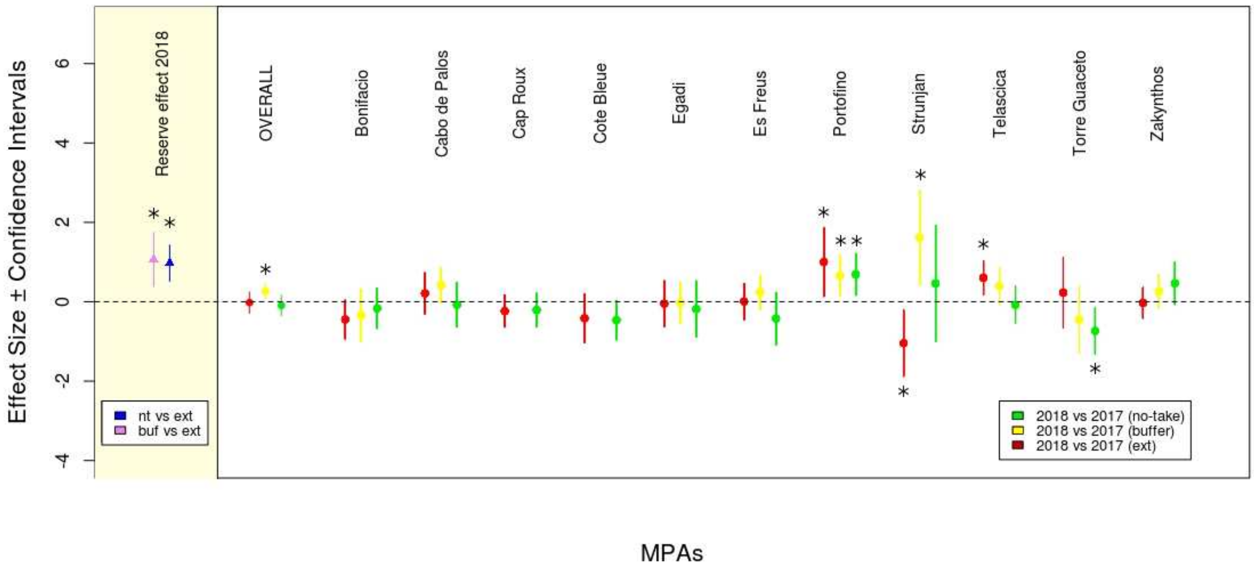

Figure 11. Effect size of fish biomass (all species) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size

A similar pattern was highlighted focusing on the biomass of commercially important species (Fig. 12) with positive effects (although non-significant) in the buffer zones and a neutral effect on no-take and external areas.

Looking at the single MPAs, only in the Egadi Islands the buffer was statistically negative, while in 7 out of 9 buffer zones investigated a positive effect size (in 3 case statistically significant) was observed, reflecting the **general improvement in MPA buffers** suggested by the overall effect.

As already proposed above, we speculate that the governance measures implemented are among the factors that contributed to the positive trend that emerged from our assessment.

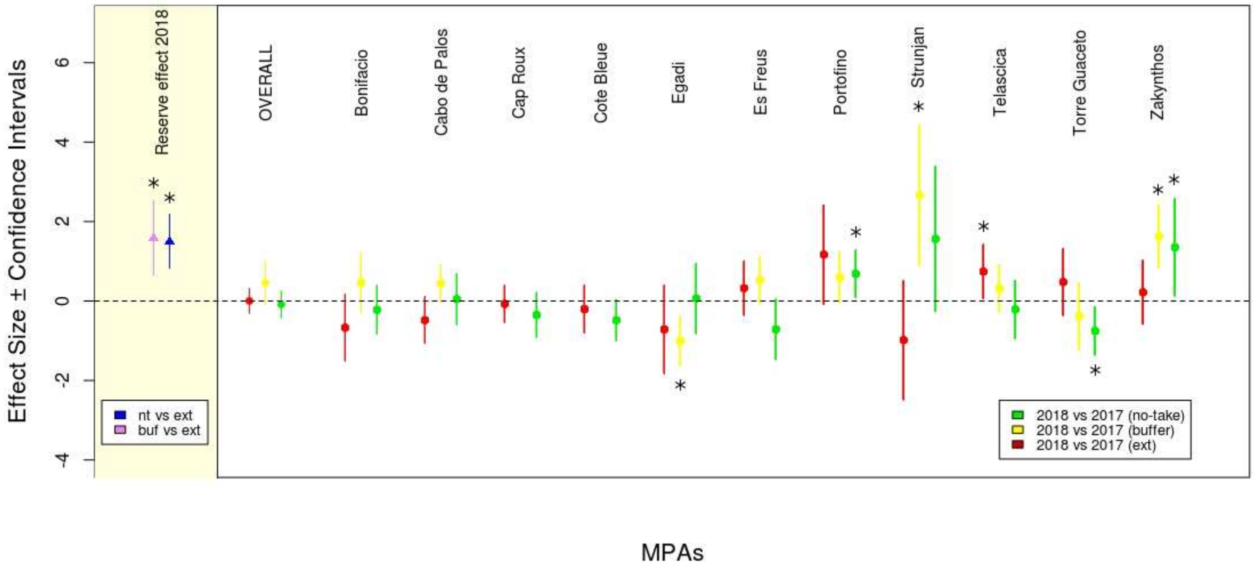

Figure 12. Effect size of fish biomass (commercial species) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size

Concerning high-level predators (Fig. 13) the outcomes are even clearer. In fact, whereas most of external sites are associated to negative or neutral effect sizes (dot indicating the value of the effect size very close or over the line of zero effect) almost all the protected conditions (no-take or buffer) are associated to a **positive and statistically significant effect**.

This is emphasized by the fact that in some MPAs (e.g. Cote Bleue and Torre Guaceto) high level predators are only present in protected locations. This suggests that not only protection can improve the status of this category of species, but also, in specific cases, it can lead to the recovery of high-level predators in marine systems where they would hardly survive under unprotected conditions.

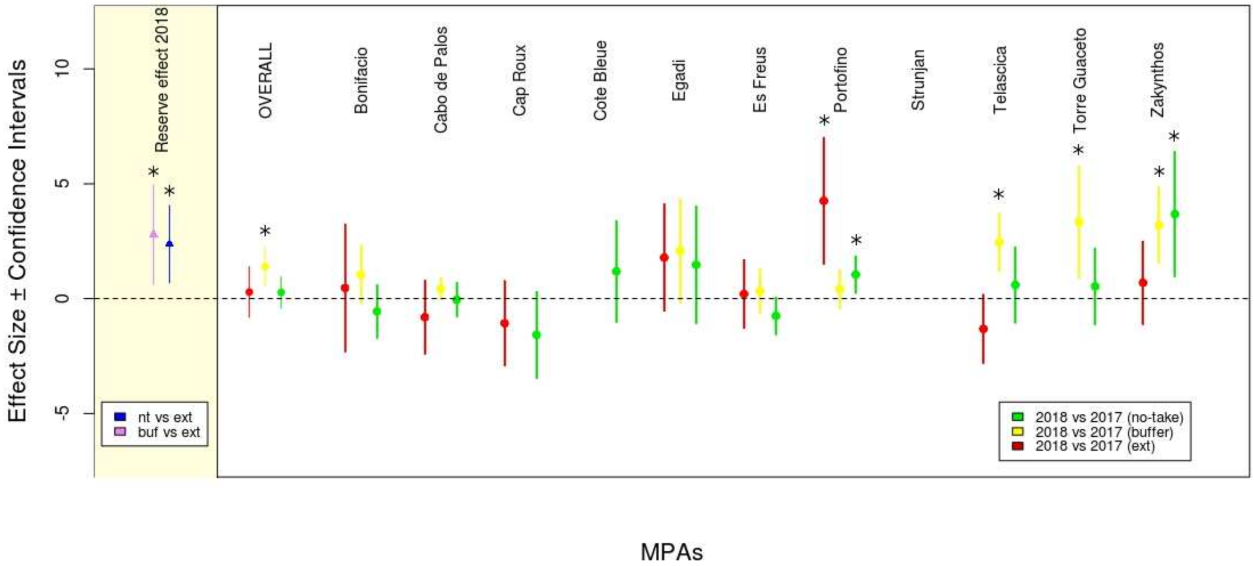

Figure 13. Effect size of fish biomass (high level predators) per protection level in the 11 MPAs comparing data from 2018 and 2017. The overall effect size, pooling all the MPAs, is also reported. In the yellow panel on the left the two effect size (no-take vs external and buffer vs external) are shown for 2018 as a measure of 'reserve effect'. * indicates a statistically significant effect size

3.1.4 Conclusions

In summary, our results show that the implementation of the governance toolkit proposed by the FishMPABlue2 project led to overall positive effects on protected fish assemblages as opposed to unprotected ones.

We can reasonably assert early signs of positive effects on fish diversity, density and biomass can be documented over one year, despite the high variability in MPA sizes, ages, local regulations, fishing efforts within MPA boundaries and even differences in national level legislation in the 11 pilot MPAs.

Remarkably, the significant increase of biomass in buffer zones;) after one year of toolkit implementation (especially evident for high level trophic predators) can suggest that the set of measures implemented (e.g. enforcement, fishers engagement, reduction in fishing effort, increase of fishing gears selectivity) can have delivered **ecological benefits to the Pilot MPAs**.

In addition, it is important to highlight that after the governance toolkit implementation an **overall significant reserve effect** has been detected both in no-take and buffer zones in terms of fish biomass.

3.2 Economic assessment

3.2.1 Introduction

The economic analysis aimed to evaluate the potential effects of the governance toolkit in each MPA.

As already reported in the pilot project monitoring reports[19], although the sampling design in the first place foresaw the assessment of economic status of MPAs and the associated small scale fishery community in two distinct 'time windows', after a scientific consultation and also based on specific features of fisheries to be investigated we chose to adopt a more efficient approach that, in addition, would have produced more solid results.

From this perspective, in some MPAs the number of fishers available for the monitoring was relatively low due both to the natural dimension of some SSF communities, to the dwindling number of fishers overtime (e.g. Cap Roux) and to the fact that not all the fishers from the communities were always available to participate in the monitoring.

In addition a number of logistic hurdles (e.g. bad weather conditions, seasonal closures, decrease in number of fishers in some communities) reduced the possibility to gather considerable number of samples (i.e. monitoring of small scale fisheries catches at landing) in a relatively short time window.

Thus, in some MPAs, it was not possible to obtain the number of fishing catches during the summer months as initially foreseen, so that, in order to fulfill the planned number of SSF catches, we decided to continue the monitoring also during the rest of the period of toolkit implementation.

Apart from the logistic advantages, this new approach allowed us to have a better picture of the economic status in each MPA: in this way, in fact, the economic monitoring took into account the temporal variability of fishing catch descriptors (e.g. catch per unit of effort and revenue per unit of effort) that are likely to be influenced by seasonal factors[20].

The total number of catches to monitor for the ex post campaign was planned to be 880, considering all the 11 MPAs (440 inside the MPA and 440 outside).

MPA staff carried out the monitoring campaign in each pilot MPA: more than 1,250 fishing operations were monitored in the 11 pilot MPAs, 653 inside the MPA or close to no-take area and 614 outside the MPA or far from no-take areas (Table 4).

[19] Del. 3.1.5

[20] see further details on the 5th Monitoring of Pilot Project Implementation – Del. 3.1.5

Table 4. Number of fishing operations monitored in each MPA per protection level

MPA	# recorded fishing catches INSIDE MPA's buffer zone (or outside MPA and close to no-take zones for Cap Roux and Cote Bleue)	# recorded fishing catches OUTSIDE MPAs (or far from MPA borders for Cap Roux and Cote Bleue)
Egadi	90	58
Torre Guaceto	80	101
Portofino	38	46
Zakynthos	80	80
Es Freus	82	81
Cabo de Palos	27	59
Cap Roux	33	35
Cote Bleue	56	62
Bonifacio	106	40
Strunjan	42	39
Telascica	19	13

3.2.2 Material and methods

A monitoring methodology was specifically developed in order to obtain reliable data on SSF catches (Fig. 14): in particular, SSF "landings" (i.e. harvested fish brought to the land) were selected as source of data.

Forty landings inside and forty outside the MPA were planned to be monitored, i.e. photographed, during the pilot action, per year and in each MPA. This number was chosen in order to have an exhaustive characterization of fish catch composition and quantities targeted by SSF[21].

For each landing monitored, we collected information about:

1) catches (i.e. the amount of fish caught)
2) fishing effort (i.e. the length of the fishing gears deployed)
3) information about ex-vessel price of each species captured, divided in size-class when the price/kg was related to individual size (in order to estimate actual fishers revenues)

The methodology used was developed in order to minimize sampling time in the field and fish manipulation: so as to cause to fishers the least disturbance possible during monitoring operations.

Specifically, the operator places the catch over a flat surface (e.g. a table or the fish box to minimize manipulation) and takes one/multiple pictures where a ruler (as

[21] Further information on the monitoring methodology are available in Deliverable 3.1.2 ('Common methodology for design and execution of sound scientific monitoring of small scale fishery within and around an MPA'

length reference) has to be visible and on the same plane as fishes (Fig. 15). Each picture is associated to a unique identifier of the fishing operation (i.e. a small piece of paper with a unique code, see Fig. 15). For species with a low commercial value, generally identified as 'soup' (and that share the same ex-vessel price), and for mollusks (for which the price/kg generally does not vary depending on individual size) the operator directly weighs all the specimens at once and annotates the total weight, taking notes of species composition.

Figure 14. Small Scale fisher deploying a trammel net in Cabo de Palos MPA

Figure 15. Pictures of SSF landings taken at Zakynthos MPA (up-left), Torre Guaceto MPA (up-right), Strunjan MPA (bottom-left) and Egadi MPA (bottom-right) using photo-sampling technique. Note the ruler and the code present in each picture

Once all the pictures relative to a specific MPA have been collected, an operator in the laboratory processes them by using the open-access image-analysis software ImageJ (Fig. 16). This allows extraction, from each picture, information on length, and then estimating the wet weight of each specimen using specific length-weight relationships.

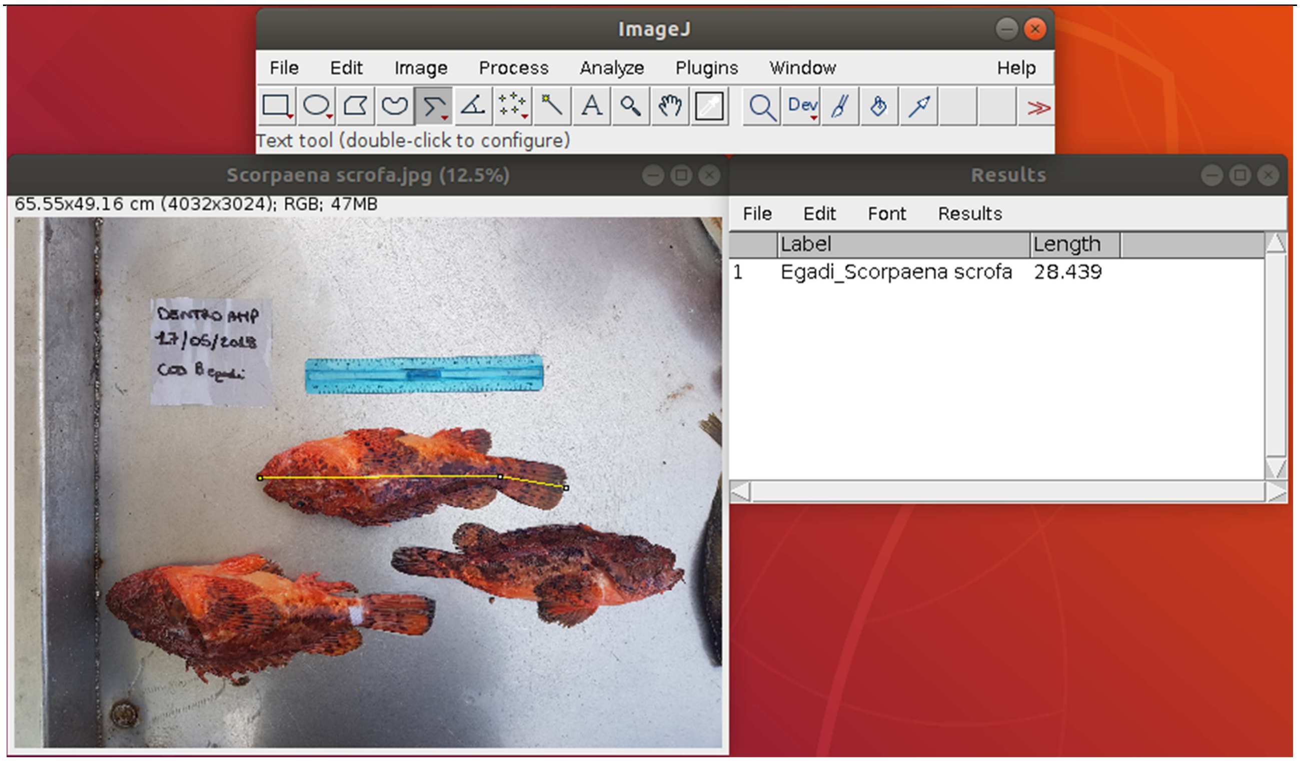

Figure 16. Example of fishery catches photo-analysis with the software ImageJ

As stated above, the initial aim of the economic monitoring campaigns was to assess the economic status of SSF in each MPA ‘before’ and ‘after’ the implementation of the pilot actions planned in the Pilot Project Implementation Plans (PPIPs), in order to assess potential effects of the relative governance measures.

Actually, this was done only in 3 MPAs, while in the other 8 we focused on assessing differences between inside and outside the MPA considering potential temporal trends over the pilot action implementation.

As a consequence of this, two types of data analysis of SSF catches were carried out:

1) the comparison of the economic status of SSF ‘before’ and ‘after’ the toolkit implementation for the 3 MPAs where these data were available (i.e. Cap Roux, Strunjan and Zakythos)
2) the analysis of trends in the economic status of SSF over time during the period of governance measures implementation for those MPAs where this type of data has been collected (i.e. Bonifacio, Cabo de Palos, Cote Bleue, Egadi, Es Freus, Portofino, Telascica and Torre Guaceto).

3.2.3 Results

Overall, considering the two campaigns, 157 taxa were identified. In most cases photo analysis allowed identification of the species, but in some cases (e.g. for species of the family Mugilidae) species recognition was not possible using a photo and the individual was assigned to the taxon at highest resolution of taxonomic identification possible.

The total list of species identified in each MPA is presented in table 5.

Table 5. List of taxa identified, in the 11 MPAs, during small scale fisheries catches photo analysis.

Taxon	*Taxon*	*Taxon*	*Taxon*
Arnoglossus sp	*Labridae*	*Raja brachyura*	*Solea sp*
Auxis rochei	*Labrus merula*	*Raja clavata*	*Sparisoma cretense*
Balistes capriscus	*Labrus viridis*	*Raja miraletus*	*Sparus aurata*
Belone belone	*Lagocephalus sceleratus*	*Raja montagui*	*Sphyraena sphyraena*
Boops boops	*Lichia amia*	*Raja polystigma*	*Sphyraena viridensis*
Bothus podas	*Liocarcinus depurator*	*Raja radula*	*Spicara flexuosa*
Chelidonichthys cuculus	*Lithognathus mormyrus*	*Raja sp*	*Spicara maena*
Chelidonichthys lastoviza	*Loligo sp*	*Rajidae*	*Spicara smaris*
Chelidonichthys lucerna	*Loligo vulgaris*	*Rhinobatos rhinobatos*	*Spicara sp*
Chelon auratus	*Lophius piscatorius*	*Rostroraja alba*	*Spondyliosoma cantharus*
Chelon labrosus	*Lophius sp*	*Sarda sarda*	*Squilla mantis*
Chelon ramada	*Maja squinado*	*Sardinella aurita*	*Symphodus bailloni*
Citharus linguatula	*Melicertus kerathurus*	*Sarpa salpa*	*Symphodus mediterraneus*
Conger conger	*Merluccius merluccius*	*Sciaena umbra*	*Symphodus melops*
Coris julis	*Merluccius sp*	*Scomber colias*	*Symphodus ocellatus*
Coryphaena hippurus	*Microchirus ocellatus*	*Scomber japonicus*	*Symphodus roissali*
Dactylopterus volitans	*Mugil cephalus*	*Scomber scombrus*	*Symphodus sp*
Dasyatis pastinaca	*Mugilidae*	*Scomber sp*	*Symphodus tinca*
Dasyatis sp	*Mullus barbatus*	*Scophthalmus maximus*	*Synapturichthys kleinii*
Dasyatis tortonesei	*Mullus surmuletus*	*Scophthalmus sp*	*Syngnathidae*
Dentex dentex	*Muraena helena*	*Scorpaena elongata*	*Synodus saurus*
Dicentrarchus labrax	*Mustelus mustelus*	*Scorpaena maderensis*	*Thalassoma pavo*
Dicentrarchus punctatus	*Mustelus punctulatus*	*Scorpaena notata*	*Torpedo marmorata*
Diplodus annularis	*Mycteroperca rubra*	*Scorpaena porcus*	*Torpedo sp*
Diplodus cervinus	*Myliobatis aquila*	*Scorpaena scrofa*	*Trachinotus ovatus*
Diplodus puntazzo	*Oblada melanura*	*Scorpaena sp*	*Trachinus araneus*
Diplodus sargus	*Octopus vulgaris*	*Scyliorhinus canicula*	*Trachinus draco*
Diplodus vulgaris	*Pagellus acarne*	*Scyliorhinus sp*	*Trachinus radiatus*
Eledone moschata	*Pagellus bogaraveo*	*Scyliorhinus stellaris*	*Trachurus mediterraneus*
Epinephelus caninus	*Pagellus erythrinus*	*Scyllarides latus*	*Trachurus sp*
Epinephelus costae	*Pagrus pagrus*	*Scyllarus arctus*	*Trachurus trachurus*
Epinephelus marginatus	*Palinurus elephas*	*Sepia officinalis*	*Trigla lyra*
Epinephelus sp	*Palinurus mauritanicus*	*Seriola dumerili*	*Triglidae*
Euthynnus alletteratus	*Pegusa lascaris*	*Serranus cabrilla*	*Trisopterus capelanus*
Gaidropsarus mediterraneus	*Phycis phycis*	*Serranus scriba*	*Umbrina cirrosa*
Gobiidae	*Pomatomus saltatrix*	*Siganus luridus*	*Uranoscopus scaber*
Gobius cruentatus	*Pseudocaranx dentex*	*Siganus rivulatus*	*Xyrichtys novacula*
Homarus gammarus	*Raja asterias*	*Solea solea*	*Zeus faber*

More than 33,000 individuals were analyzed in total. From the information on individual fish length, the total wet-weight of each fish was calculated and then the total weight of the catch was extracted by summing up the weight of all the individuals in the net. The catch per unit of effort (CPUE) was calculated by dividing the weight of the catch for the total length of the net.

Data were averaged by level of protection: for those MPAs where the buffer is not present (Cote Bleue and Cap Roux), catches close to the no-take zone and those far from the no-take zone were considered as 'buffer' and 'external' catches, respectively.

By considering the data from all the MPAs pooled together, **both CPUE and RPUE[22] resulted higher within the buffer of MPAs (or close to no-take) compared to outside**. Specifically, values of CPUE where globally 10% higher within the MPA than outside (Fig. 17).

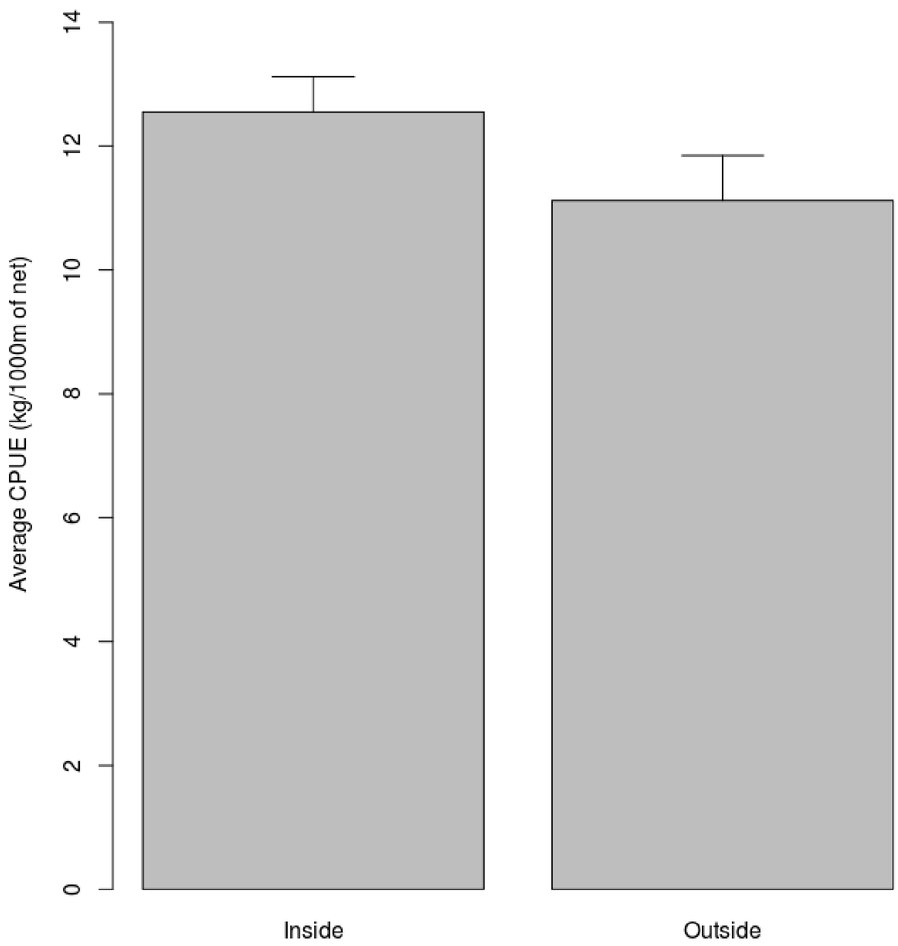

Figure 17. Average CPUE per protection level considering the 11 MPAs

[22] revenue per unit of effort

Also in the case of RPUE (Fig. 18), values recorded for catches carried out in the buffer zones were globally 10% higher than the ones carried out in external sites or far from the no take zone.

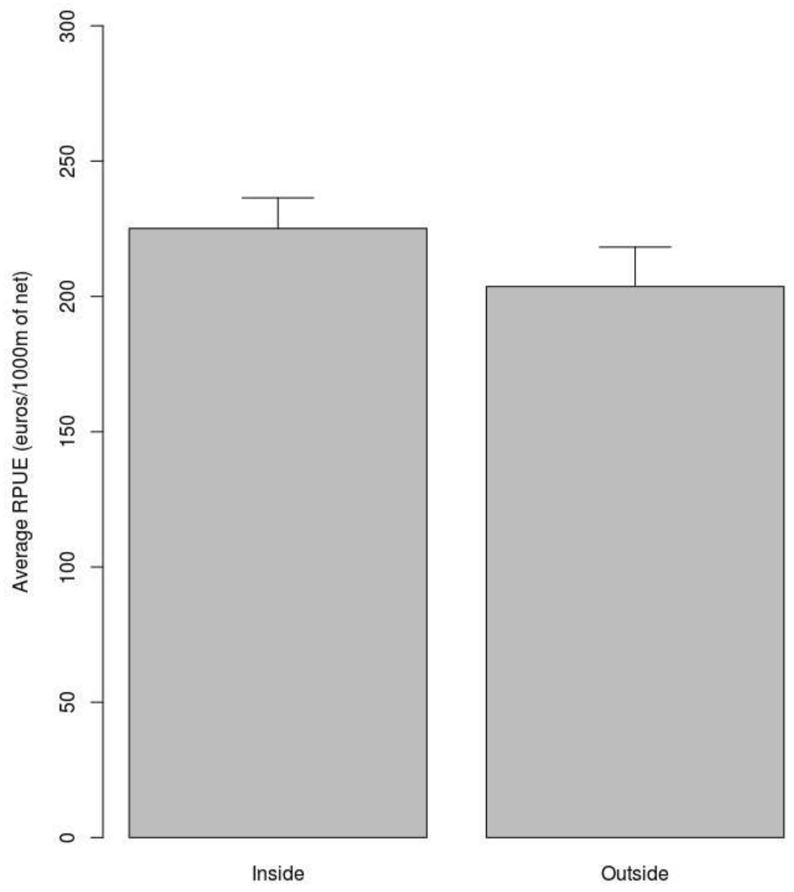

Figure 18. Average RPUE per protection level considering the 11 MPAs

Although not statistically significant, these results are a clear hint of protection benefit for SSF.

Analysis of 'Before' vs 'After' status of SSF catches

For the 3 MPAs where information on the economic status of SSF were gathered actually before and after the implementation of the governance toolkit, data were analyzed using the effect size descriptor (see above for details).

Specifically, effect size was calculated as the logarithm of the ratio between the mean CPUE of SSF catches carried out inside the MPA or close to the no-takes and the mean CPUE of catches carried out outside or far from the MPA. Effect size on RPUE was calculated in the same way. Data from the 3 MPAs were pooled together.

Concerning CPUE, results did not show any specific pattern.

The ratio between mean value of CPUE inside and outside the MPA was very similar between the two sampling campaigns (Fig. 19), indicating that no positive or negative effects seem to be induced by the implementation of the governance measures in the 3 MPAs considered in this analysis. A similar outcome was observed for the RPUE (Fig. 20).

However, looking at the specific campaigns for the two descriptors, although in both campaigns the analysis did not show a statistically significant effect, results are very close to significance: in fact, error bars associated to the response ratio (the blue dots in the Fig. 19 and Fig. 20) just slightly overlap the line of zero effect (dotted line in the picture). As already proposed above, this suggests that **fishing catches performed within the MPAs are associated to higher values of CPUE**, indicating the capacity of MPAs in providing fishery benefits.

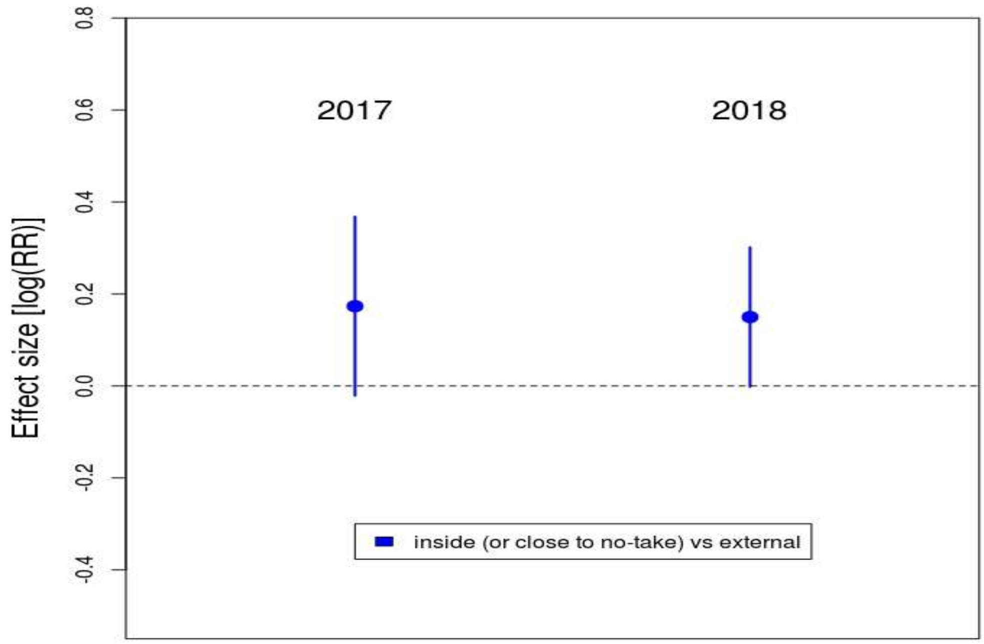

Figure 19. Effect size on CPUE in 2017 and 2018. Data from Cap Roux, Strunjan and Zakythos are pooled

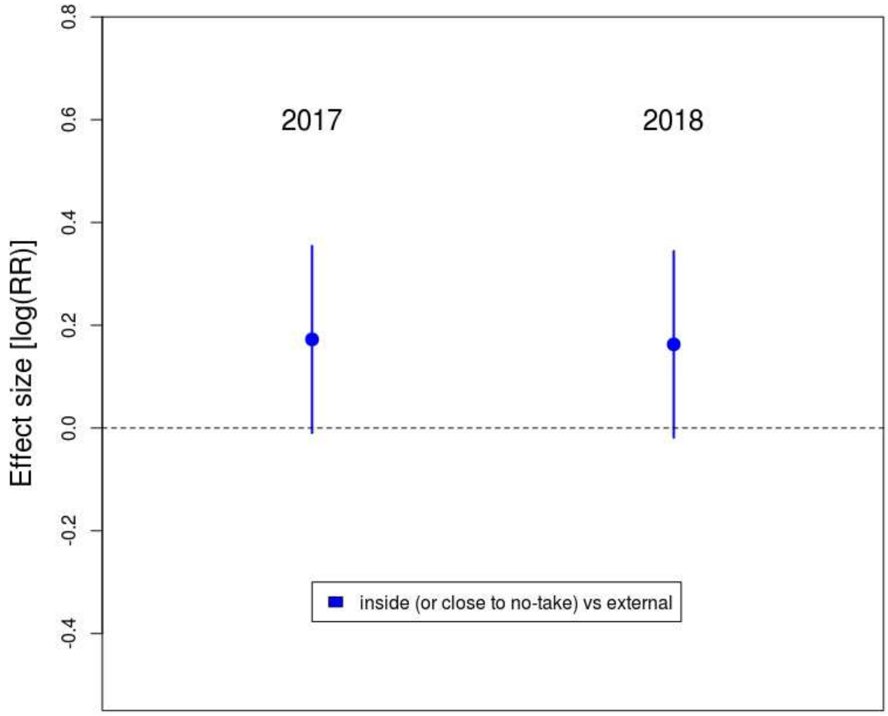

Figure 20. Effect size on RPUE in 2017 and 2018. Data from Cap Roux, Strunjan and Zakythos are pooled

Analysis of trends in SSF catches

For the 8 MPAs where information on the economic status of SSF were constantly gathered over the period of implementation of the governance measures, data were analyzed by considering the evolution of the trends of SSF descriptors (i.e. CPUE and RPUE).

Specifically, trends of CPUE and RPUE over time were analyzed distinguishing catches carried out inside the MPA or close to the no-take and those carried outside the MPA or far from no-takes. The overall trend of CPUE and RPUE was analyzed considering all the 8 MPAs pooled together. Concerning CPUE, the results of the analysis showed that although a positive trend of SSF catches from inside the MPAs was not highlighted (Fig. 21), the trend of CPUE from catches carried out outside the MPAs appears to be negative, indicating a decrease in CPUE over time.

A similar pattern was observed for the overall RPUE (Fig. 22), for which the trend relative to the catches from outside the MPAs is clearly negative, whereas RPUE values appear to be stable over time. From this perspective, we could speculate that the **implementation of the governance measures in the MPAs could have helped the protected areas in preventing the decrease in the amount of fish caught** by fishers (and economic value of the relative catches) that was observed for the catches carried out outside the MPAs (Fig. 23).

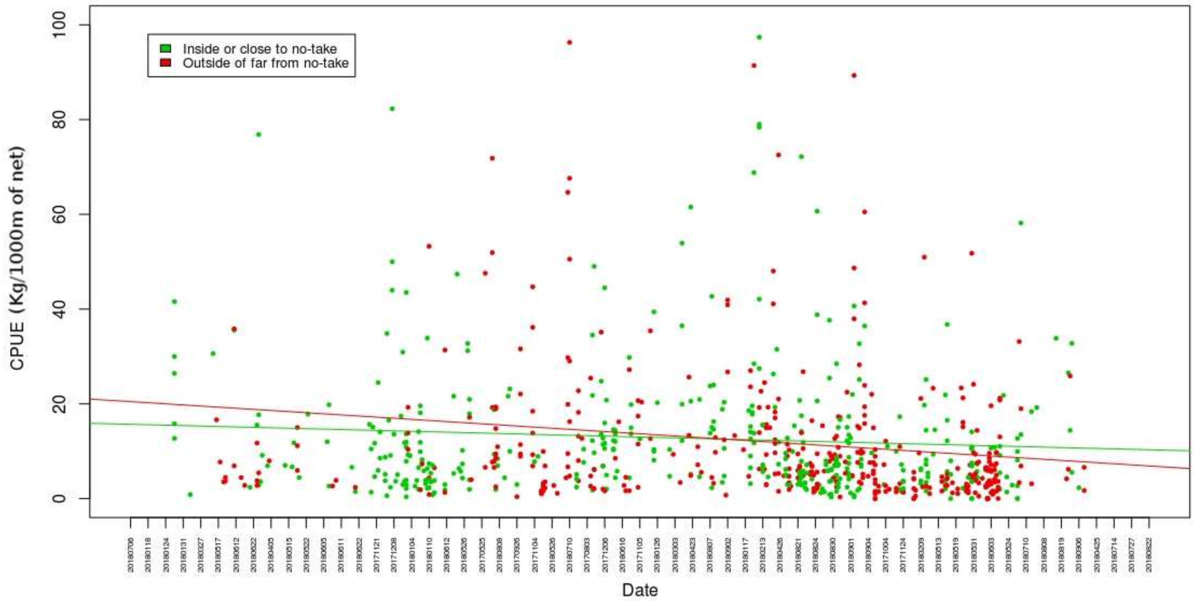

Figure 21. Trend in CPUE over the period of implementation of governance measures. Dots indicate values of CPUE per catch. Lines indicate overall trends over time. Data from 8 MPAs (Bonifacio, Cabo de Palos, Cote Bleue, Egadi, Es Freus, Portofino, Telascica and Torre Guaceto) are pooled

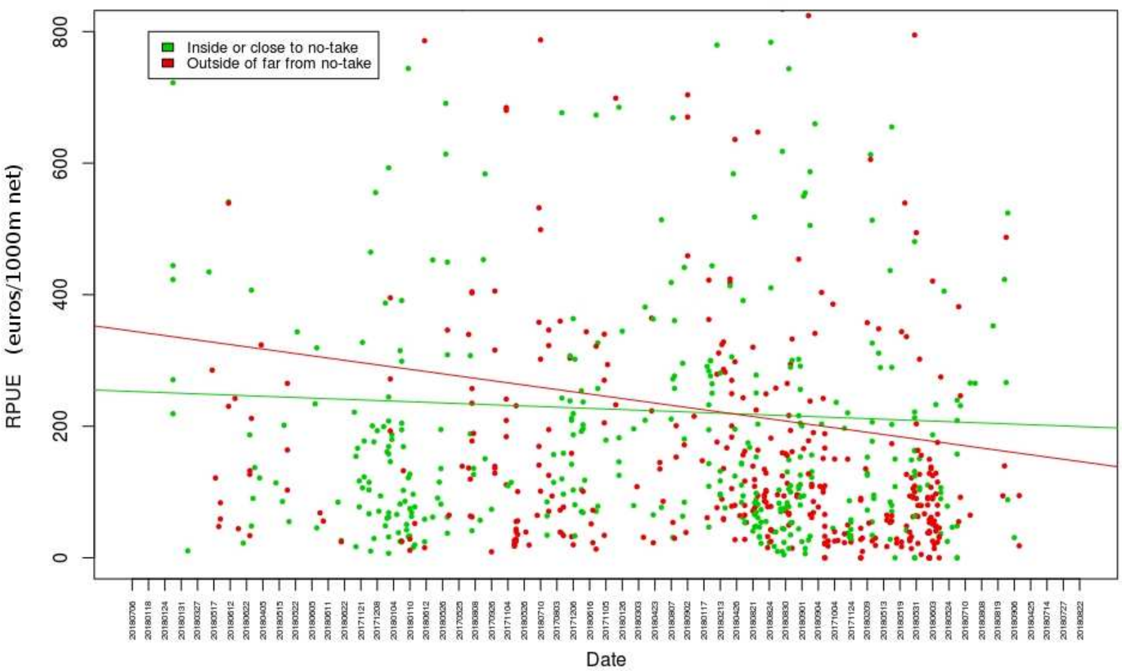

Figure 22. Trend in RPUE over the period of implementation of governance measures for all the 8 MPAs considered in this analysis. Dots indicate values of RPUE per catch. Lines indicate overall trends over time. Data from 8 MPAs (Bonifacio, Cabo de Palos, Cote Bleue, Egadi, Es Freus, Portofino, Telascica and Torre Guaceto) are pooled

Figure 23. Image of a fisher from Torre Guaceto showing a large-sized individual of common dentex (*Dentex dentex*) just caught within the buffer zone of the MPA. Note that this species, belonging to the category of high-level predators, is almost absent in the unprotected locations of the MPA, as indicated by the ecological assessment (see § 3.1.3). In addition, this is a species with high ex-vessel price (especially for large-sized individuals like the one in the photo). *Photo credit*: Magali Mabari (MedPan).

3.2.4 Conclusions

Concerning the economic evaluation of the toolkit implementation, we used two different approaches, clustering together MPA case studies on the base of the typology of data available.

For three MPAs, for which strict 'ex ante' and 'ex post' data were available, a classical before-after comparison was carried out. For these MPAs, both in terms of CPUE and RPUE, no clear effects of toolkit implementation were highlighted.

For the rest of the MPAs, for which data about catches were gathered over the time window of toolkit implementation (1 year), a potential positive trend was observed both in terms of CPUE and RPUE by comparing catches carried out inside the MPA (buffer zone or close to no-take borders) and catches carried out outside the MPA (or far from no-takes).

Specifically, while outside the MPAs, the response variables appear to decrease over time; on the contrary CPUE and RPUE inside the MPAs are more stable and do not suffer the same decreasing tendency as observed outside.

From this point of view, we can speculate that these results are a direct effect of the governance measures implemented in each MPA that could have avoided, within the MPA borders, the negative tendency in both CPUE and RPUE observed for the catches carried out outside the MPAs.

In addition it is important to highlight that overall the 11 MPAs showed clear signs of ‘reserve effect’ on small scale fisheries with CPUE and RPUE higher in buffer zone that outside, thus indicating positive effects of MPAs for small scale fishers.

3.3 Social assessment

3.3.1 Introduction

The social analysis aimed to evaluate the potential effects of the governance toolkit in each MPA after its implementation in relation to the social dimension of SSF communities.

Specifically the assessment targeted the perceptions of fishers regarding the effects of the governance measures implemented in their MPAs: a set of *ad hoc* social descriptors associated to the implementation of the governance toolkit was developed and administered to fishers through a specific questionnaire.

The data collected during the second monitoring campaign represent, in fact, a direct evaluation of potential social effects of the governance measures implementation. The questionnaire has been administered to a relevant proportion of small-scale fishers within each pilot MPAs (Fig. 24).

Figure 24. An operator interviewing fishers in Egadi MPA.

3.3.2 Material and methods

Given the large variability in the size of fishers communities investigated, a target number of interviews to be carried out was identified for each MPA: we considered a minimum percentage of each community (i.e. not below the 30% of the total number of fishers in the community) that allowed to properly characterize the social status of SSF in each MPA.

It is important to remark that participation to the social monitoring was totally voluntary, thus the percentage of fishers interviewed strongly depended on their willingness and availability to fill in the questionnaire. For the small communities (i.e. composed of less than 10 fishers) we targeted all the fishers willing to participate to the social monitoring.

A total of 121 questionnaires were administered in the 10 out of the 11 MPAs (Table 6): unfortunately in Bonifacio MPA, for the 2018 ('after') monitoring campaign, it was not possible for MPA managers to administer the questionnaires to the fishers[23], therefore this MPA was excluded from the data analysis.

Table 6. Total number of interviews carried out in each of the 10 MPAs in 2018 campaign

MPA	# of interviews done
Egadi	24
Torre Guaceto	4
Portofino	14
Zakynthos	17
Es Freus	11
Cabo de Palos	11
Cap Roux	8
Cote Bleue	14
Strunjan	8
Telascica	10

3.3.3 Results

In most of the cases, fishers were aware of the implementation of the governance measures selected by the LGC for the MPA with which they are associated (Fig. 25). More than 80% of fishers knew that a set of measures had been implemented or was in the implementation phase in their MPA.

[23] see Del. 3.1.5, 6th Monitoring Report of Pilot Project Implementation for further details

This pattern was somehow consistent throughout all the MPAs, with the only exception of Egadi where some fishers from the mainland most likely operate less often within the MPA territory and therefore could be less aware of specific management initiative implemented there.

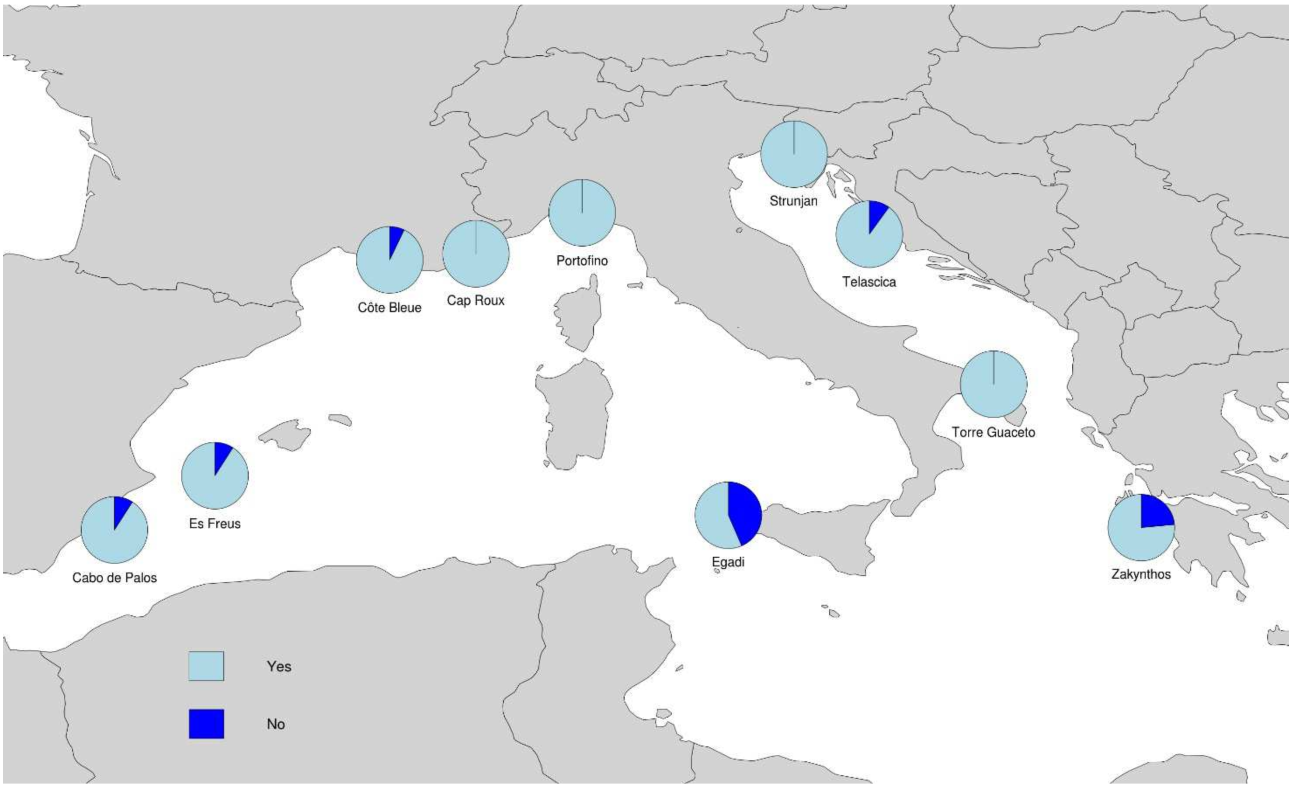

Figure 25. Frequency of fishers aware and unaware of the governance measures implemented in each MPA.

A number of questions were asked to fishers about their perceptions of the potential benefits of the specific governance measures implemented by the LGC in their MPA, covering a series of different aspects. The results of this assessment are presented below through a series of maps showing proportion of fishers' answers in each MPA.

The first question concerned fishers' perceptions about the potential effects of governance measures implemented on the abundance of fishes in their MPA: although a certain variability, the majority of fishers (~58%) think that the new measures adopted are producing or will produce in the near future positive or very positive effects on the number of fishes (Fig. 26).

Apart from a few fishers in Egadi MPA, none of the interviewees think that the changes in the governance could eventually lead to negative or dramatic impacts on fish populations in their MPAs.

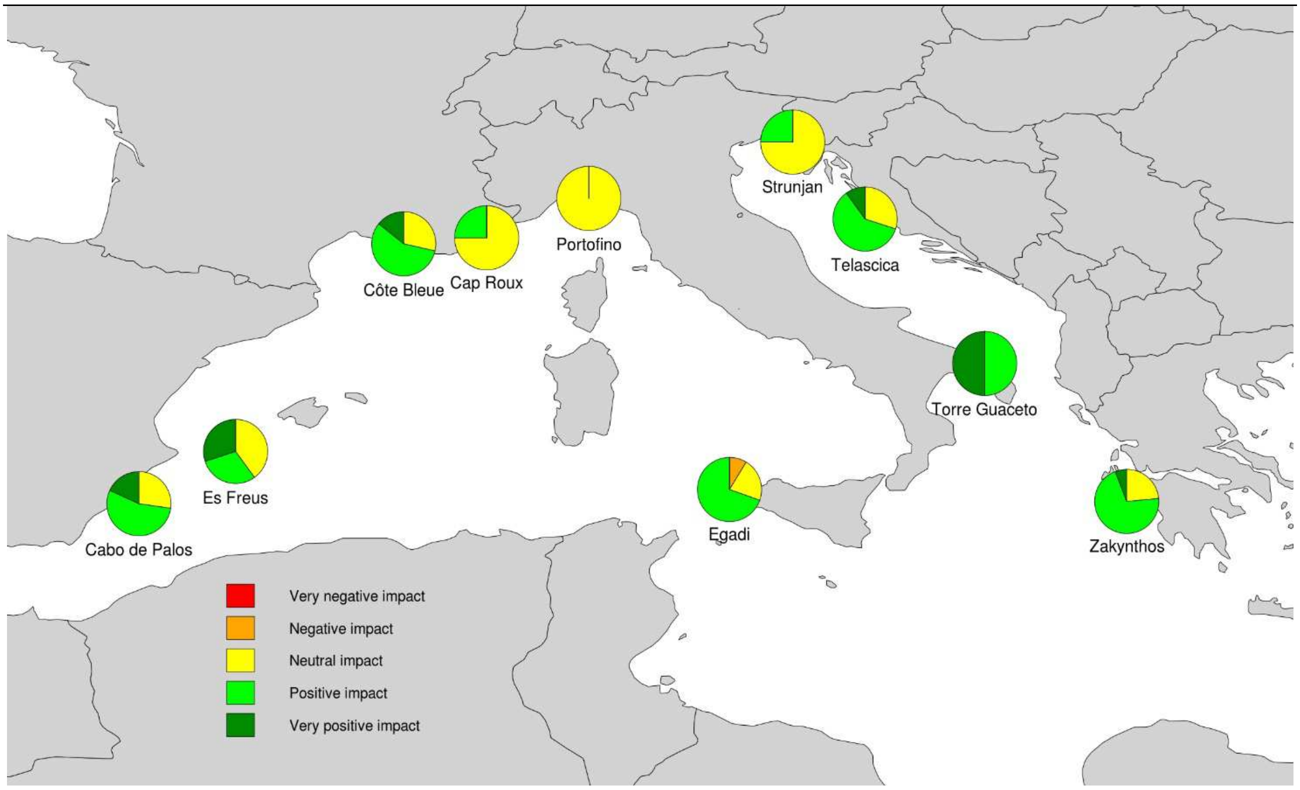

Figure 26. Distribution of perceptions about the potential effects of governance measures on the amount of fish in the MPA

The second question was about the impacts of new governance measures on the health of habitats in the MPA: the distribution of answers was very similar to the one recorded for the previous question. The majority of fishers (~58%) thought that the set of measures implemented could produce positive or very positive effects for the health of the habitats in the MPA (Fig. 27).

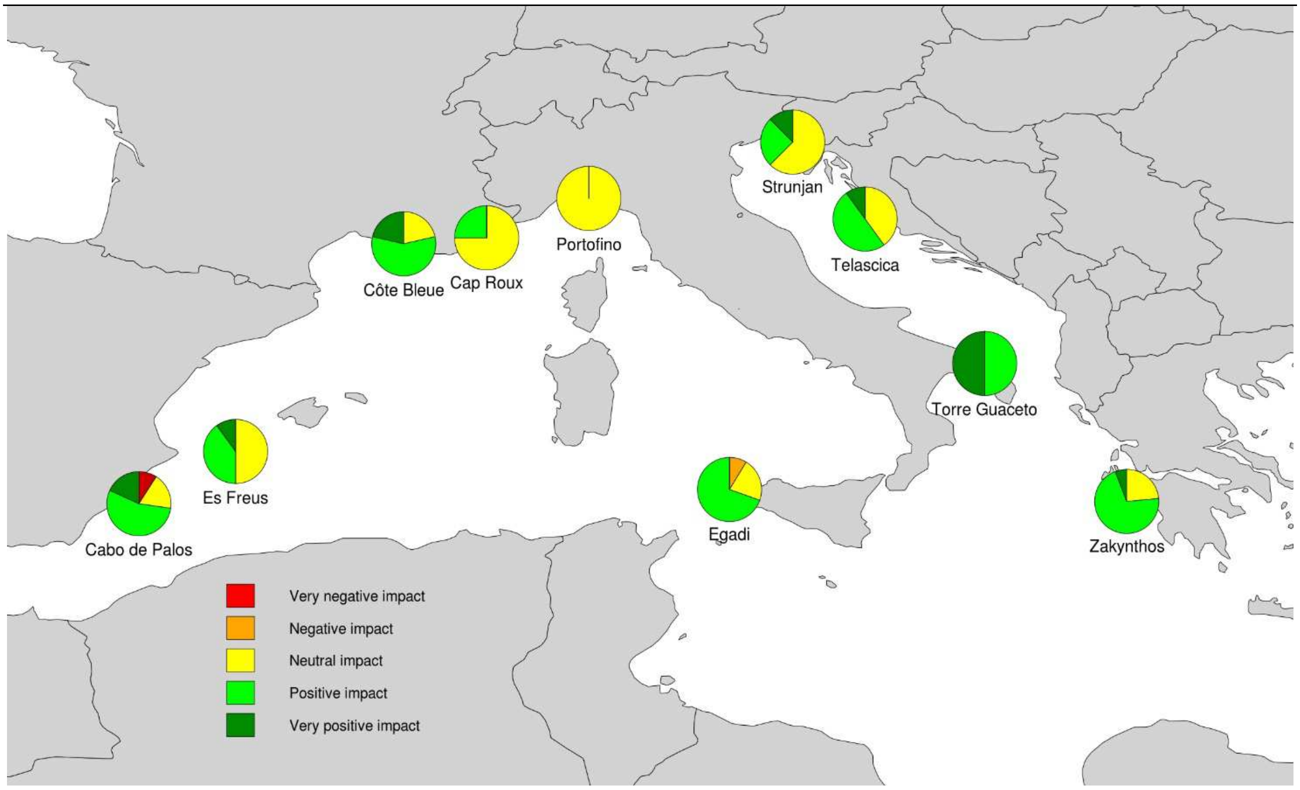

Figure 27. Distribution of perceptions about the potential effects of governance measures on the quality or health of habitat in each MPA

Also concerning fishers' perceptions on the effects of governance measures on the amount of fishes that they could catch- in most of cases (~57%) fishers stated that the toolkit can produce positive or very positive benefits on their catches while about 40% perceived neutral impact (Fig. 28).

Only a small fraction of fishers in Cabo de Palos, Egadi and Strunjan think that the new measures could generate a decrease in their catches, while, in Portofino, as it was the case for the two previous questions, all fishers agree that no positive or negative effects are going to be produced by the governance toolkit.

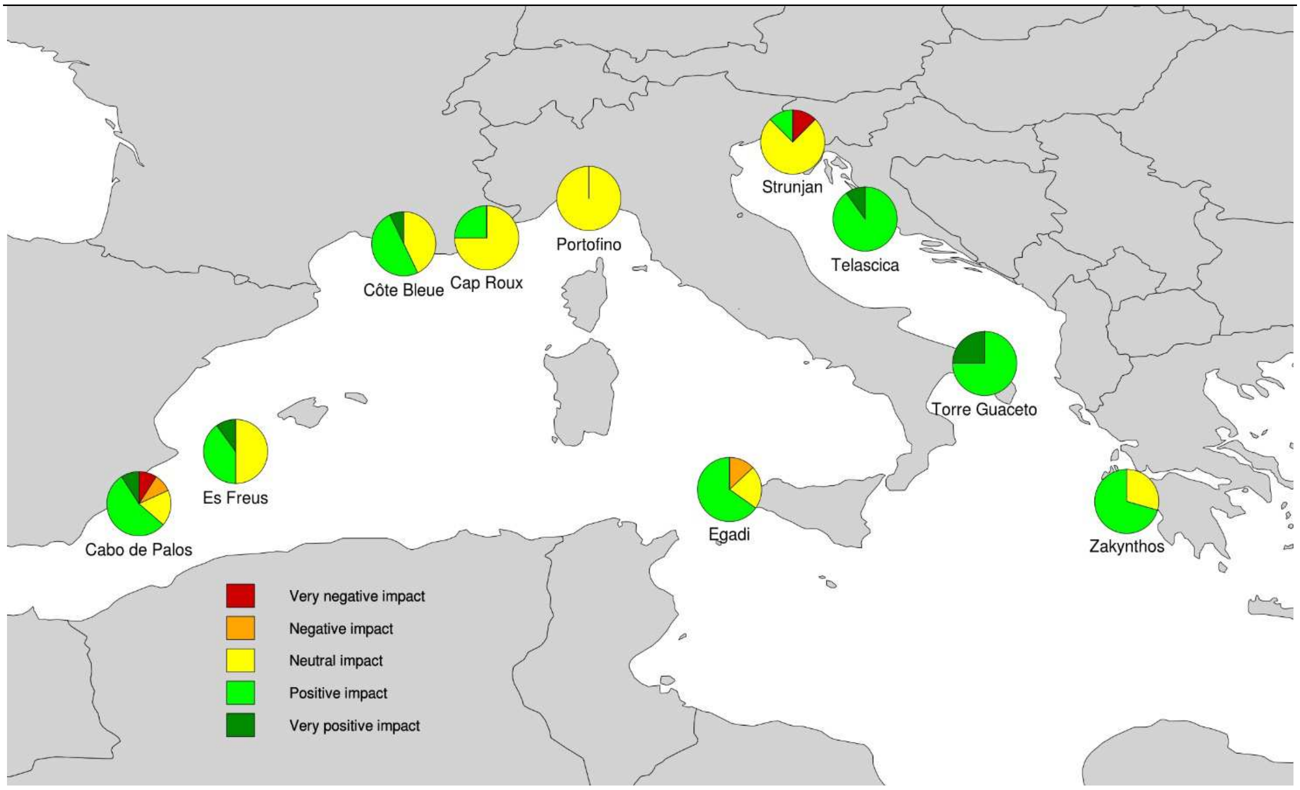

Figure 28. Distribution of perceptions about the potential effects of governance measures on the amount of fish that fishers can catch

A different pattern was observed for fishers' perceptions about the potential impacts of the governance measures on their incomes: for this aspect, 35% of fishers perceived a positive or very positive impact, while other fishers (i.e. 40%) think that no impacts (either positive or negative) are going to be produced by the toolkit (Fig. 29).

Importantly, the number of interviewees that perceived potential benefits for their incomes is higher than the ones who think that the new measures could provoke a decrease in their incomes. Very interesting is the pattern observed in the MPA of Torre Guaceto were all the fishers interviewed agree that the new measures will produce benefits for their incomes.

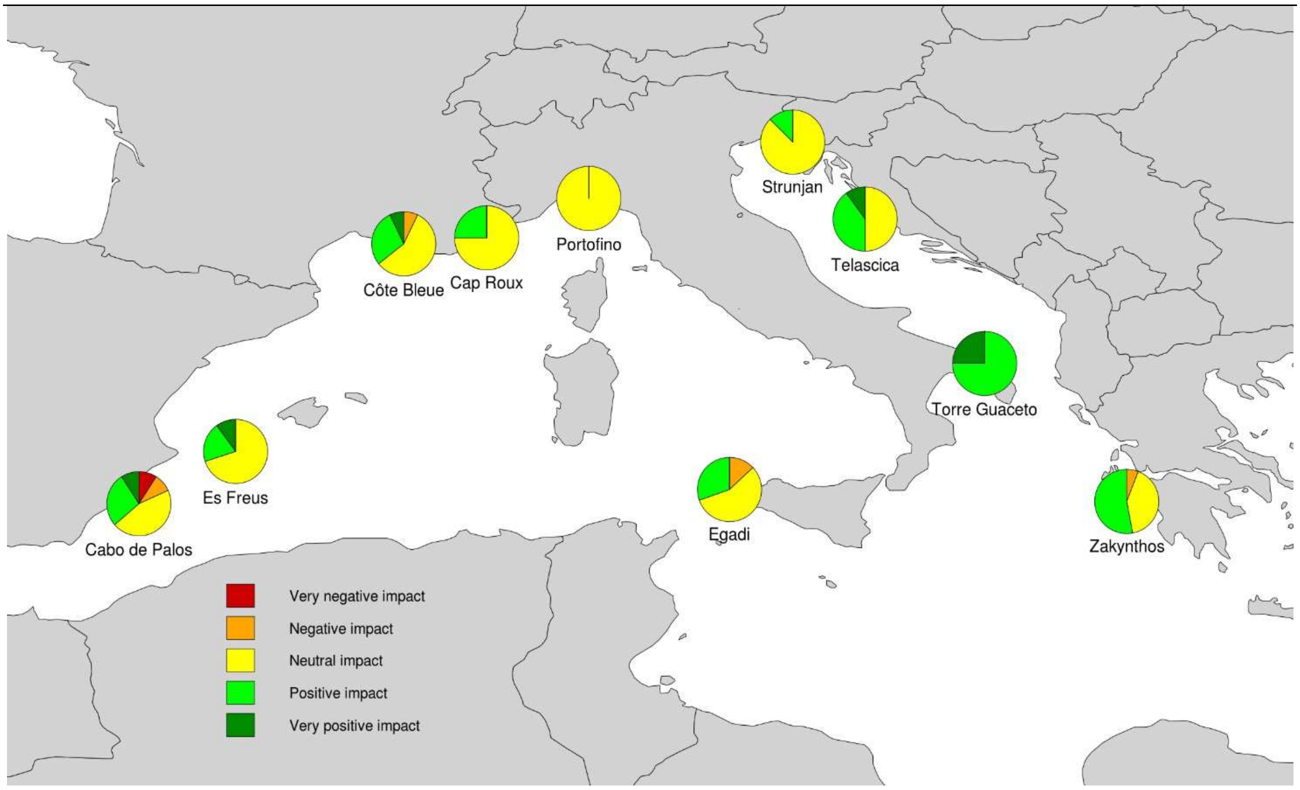

Figure 29. Distribution of perceptions about the potential effects of governance measures on the incomes of fishers

Two questions were asked about fishers' perceptions on the potential effects of the governance measures on their relationship with MPA managers (Fig. 30) and on the amount of conflicts between fishers and others MPA users (Fig. 31).

Regarding the first question, a majority of fishers (~67%) thought that the new set of measures is enhancing (or will enhance) their relationship with the management boards of their MPA.

On the other hand, in the case of their relationship with other users of the MPA and the amount of conflicts that can occur with them, most fishers (~60%) agree that the governance toolkit implemented in their MPAs will not provide any effects.

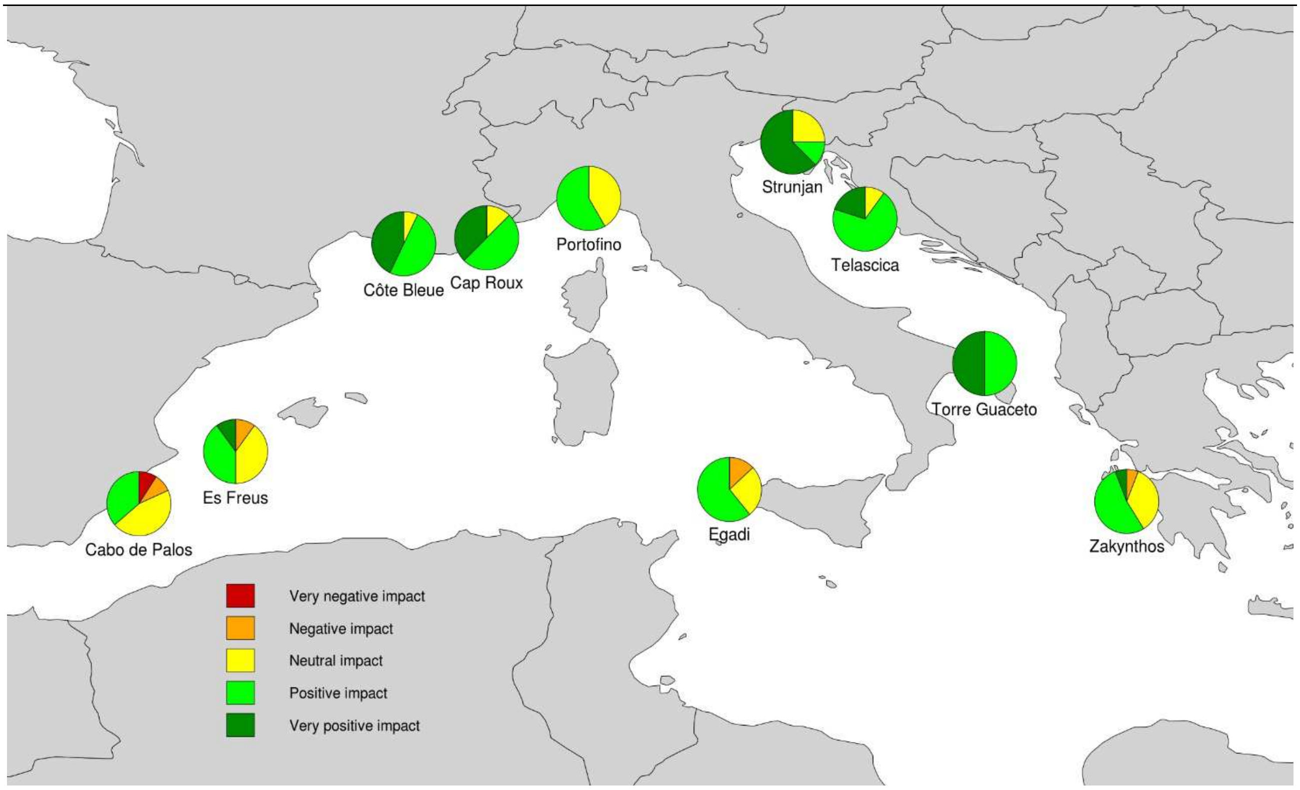

Figure 30. Distribution of perceptions about the potential effects of governance measures on relationship of fishers with MPA managers

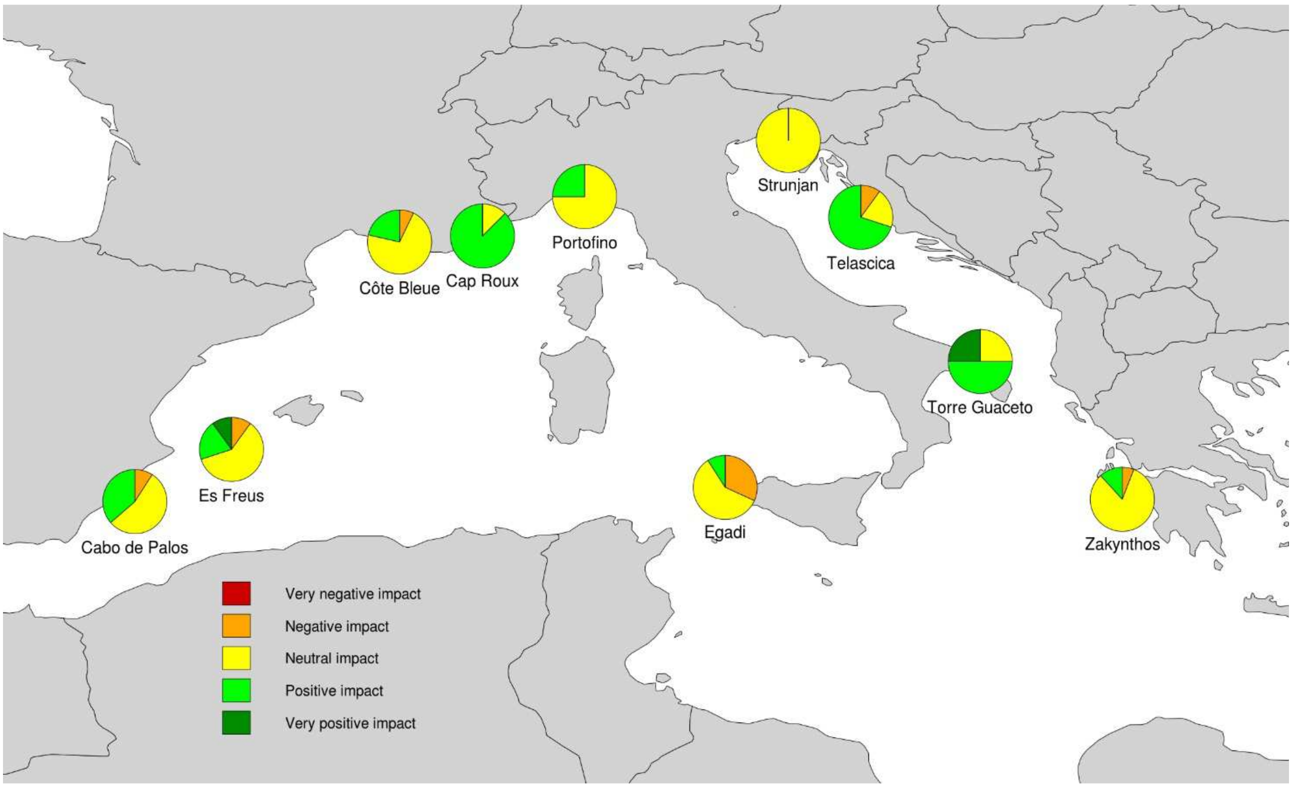

Figure 31. Distribution of perceptions about the potential effects of governance measures on the amount of conflicts between fishers and other users of the MPA

Two questions concerned the potential benefits of the governance toolkit on fishers participation to decision making and their support to the MPA (Fig. 32 and Fig. 33, respectively): in both cases, most of fishers agree that the new governance measures can provide positive benefits on these two aspects.

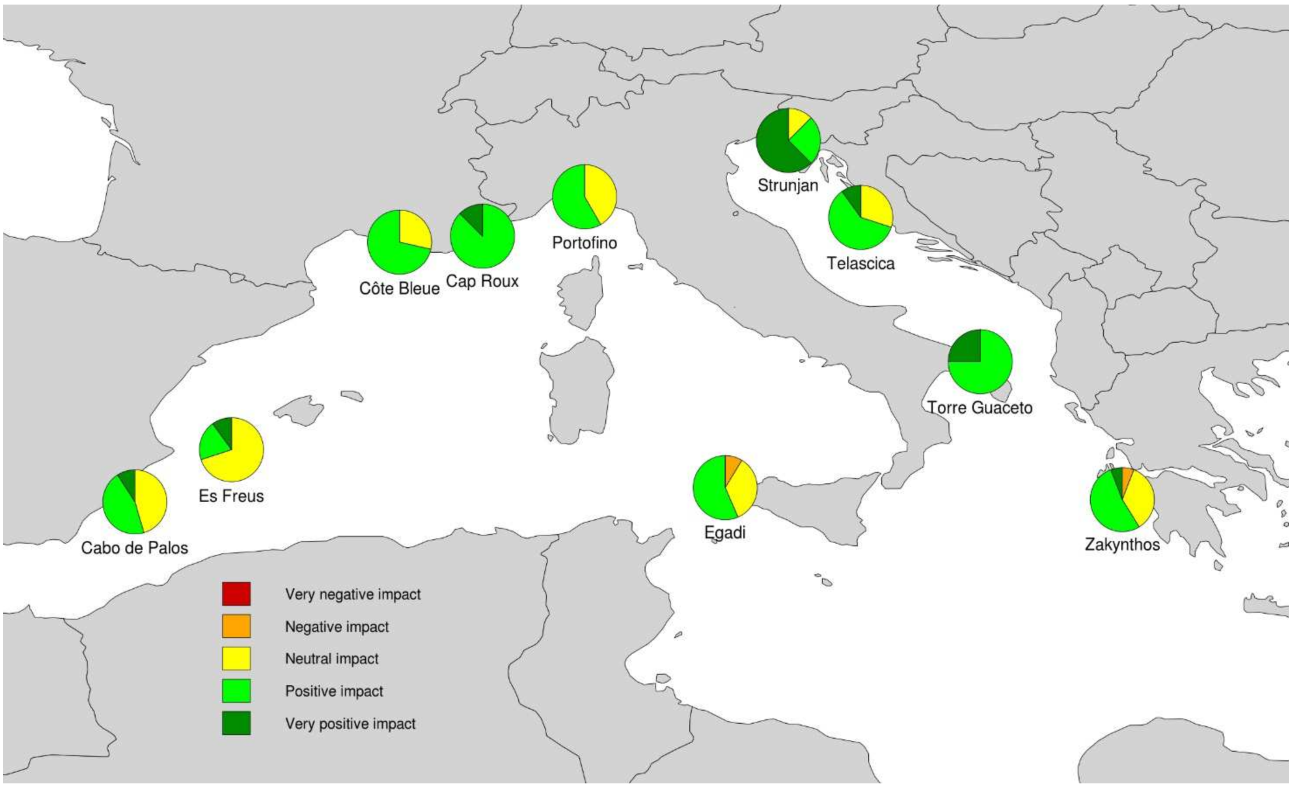

Figure 32. Distribution of perceptions about the potential effects of governance measures on the participation of fishers to decision making

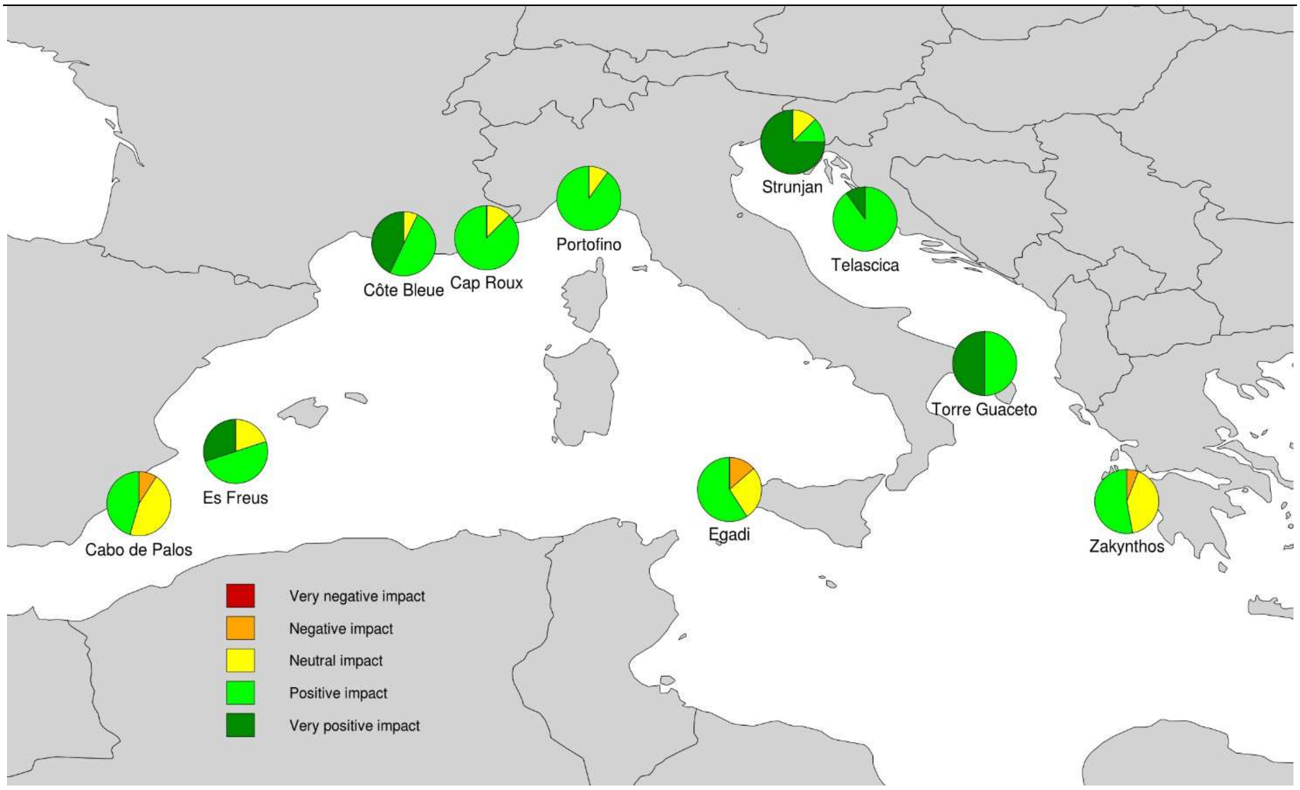

Figure 33. Distribution of perceptions about the potential effects of governance measures on the support of small-scale fishers for the MPA

The final question concerned the potential effects of the toolkit on the amount of illegal fishing or poaching activities within the MPA (Fig. 34): in this case an unclear pattern emerged from the responses.

In some MPAs, fishers agreed that the specific measures implemented in their MPAs could produce a decrease in the amount of illegal activities (i.e. Strunjan, Es Freus, Telascica and to a minor extent Cote Bleue and Zakynthos).

In the case of Portofino and Cap Roux, all respondents interviewed thought that no negative nor positive impacts will be determined by the toolkit on the poaching activities.

In the remaining MPAs (i.e. Torre Guaceto, Egadi and Cabo de Palos) the majority of fishers thought that the new measures could produce an increase of illegal activities in their MPA.

However, overall, ~47% perceived a positive or very positive effect of the implemented tools on the reduction of illegal fishing.

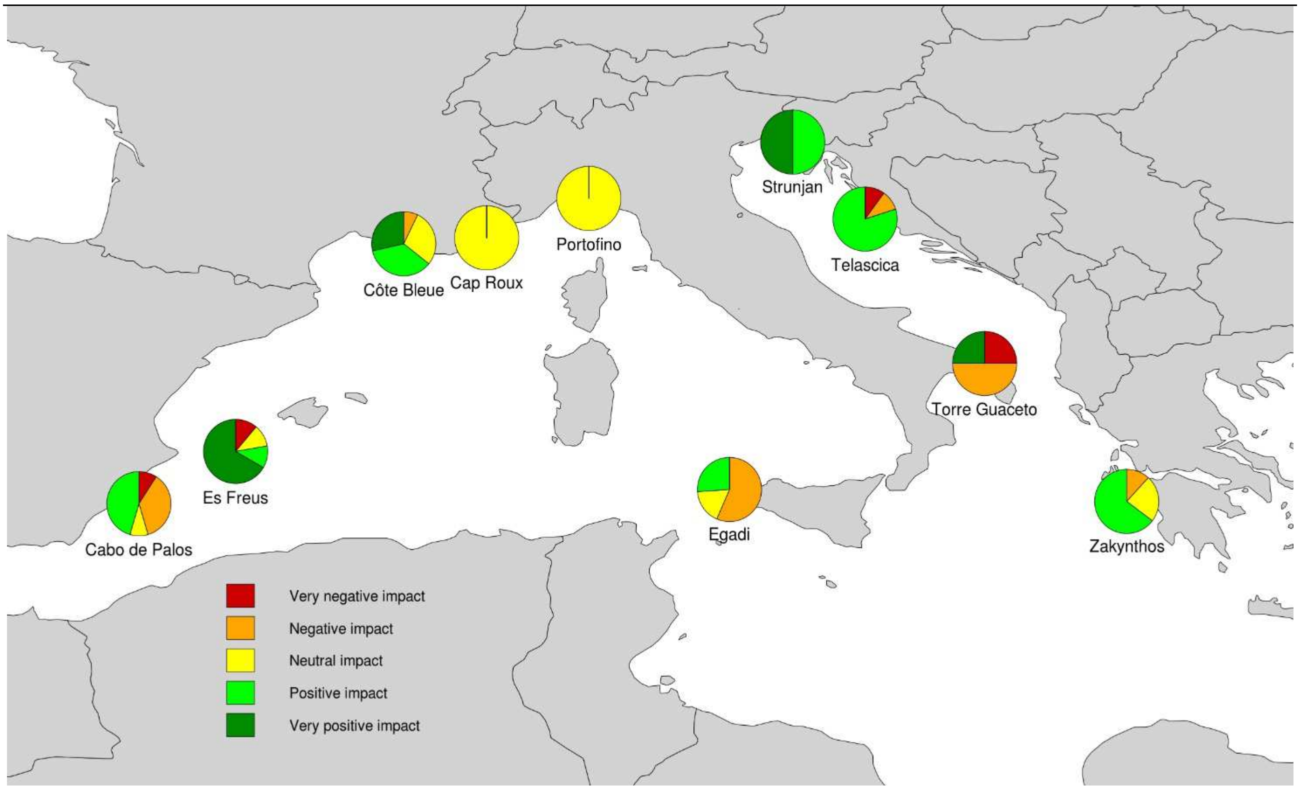

Figure 34. Distribution of perceptions about the potential effects of governance measures on the amount of illegal fishing in the MPA

3.3.4 Conclusions

For what concern the assessment of social effects of the toolkit, in most of the MPAs, overall, **fishers positively reacted to the implementation of the governance measures, also showing a great interest in the argument**, demonstrated by their almost total awareness of the on-going measures implementation in their MPA.

Specifically, fishers appeared to show on average **positive perceptions about the potential effects of the governance measures**, both on the fish assemblages and the health of the habitat, **recognizing that the new measures could produce important ecological benefits for their MPAs**.

The **same pattern was also found for their perception about the potential benefits of the implemented measures on their catches**, probably related to the fact that an increase in the abundance of fishes is likely to generate an increase in the amount of fishes they can catch.

However, although with exception, these positive perceptions were not recorded for the potential impacts of the governance measures on fishers' incomes. In fact, apart from Torre Guaceto, most of fishers thought that the measures are not going to produce any positive benefits on their incomes. In any case, it is important to note that very few negative perceptions were recorded on this point.

In general, perceptions appear to be related to the specific measures implemented in each MPA.

It is very clear, for example, fishers' perceived benefits from the governance measures with regards to their support to the MPA and their relationship with the management body, for which they generally showed optimistic positions.

This is not surprising when these two perceptions are associated to the specific measures implemented in all the MPAs: one of the measures always implemented was an increase in fisher engagement and participation to MPA management.

From this perspective, it is evident that **many of the interviewees have recognized the benefits of their direct involvement in MPA management activities**.

Similarly, other patterns are easily ascribable to the MPA-specific governance measures: in Portofino and to a lesser extent in Cap Roux, for example, many fishers replied in a neutral way to a number of questions asked by the interviewers, not identifying or expecting any potential benefit or negative impact due to the implementation of the new governance measures, a part from those related to an increased fishers engagement stated above.

This is perfectly in line with the typology of measures implemented in these two MPAs: in both cases, in fact, the selected tools were either not implemented (e.g. the Sworn Guard in Cap Roux due to major legal hindrances) or their implementation is not expected to produce any relevant benefits from an ecological or economic point of view. Thus, fishers consider that the current situation is not going to change and likely explains their neutral responses.

On the contrary, when fishers perceived that some governance measures are extremely powerful in determining benefits for them and the protected environment, they clearly showed positive positions.

This is the case of the perception about poaching reduction as a consequence of the new measures: for example in the case in which video camera systems were or are going to be implemented (i.e. Strunjan and Es Freus) as a measures of surveillance, fishers recognized the potentialities of the selected tool in decreasing illegal activities within the MPA, which would have direct positive consequences for their livelihoods.

4. GENERAL CONCLUSION

This document reports the main results of the comparison between the ‘ex ante’ and ‘ex post’ monitoring campaigns, carried out before (2017) and after (2018) the implementation of the governance tools in the 11 MPAs.

We focused our comparisons on the three dimensions (i.e. ecological, economic and social) of small-scale fishery communities in the context of MPAs, with the aim to evaluate the potential effects of the implementation of the new governance measures (i.e. the toolkit) in the 11 MPAs.

Concerning **ecological assessment**, we highlight the following results:

1. an overall increase in **fish density** after the implementation of governance tools. This is particularly evident for species with high commercial value and high-level predators, both considered good indicators of protection measures.
2. a clear positive effect following the implementation of governance tools for **fish biomass**, especially for high-level predators.
3. A consistent ecological **‘reserve effect’** in both monitoring campaigns, as we documented higher fish densities and biomasses in protected than unprotected locations, independently the toolkit implementation.

We suggest the positive ecological trends observed within the MPAs’ boundaries over just one year might be a consequence of the governance measures implemented in the varying (i.e. in size, age, regulations, fishing efforts) subsample of Mediterranean MPAs here investigated (i.e. the 11 pilot actions of the FishMPABlue 2 project).

However, it is important to remark that ecological systems do vary in time and space and a proper evaluation of the toolkit effects on the ecological system should be confirmed over the next years.

As a matter of fact, most of the governance measures implemented in the selected MPAs are thought to produce more evident ecological benefits in the longer term: although the positive signals already detected look promising, we do recommend the **implementation of the FishMPABlue2 ecological monitoring protocol as a mandatory task for the pilot MPAs in the next years**.

In the case of the **economic monitoring** we detected **higher stability in CPUE** (catch per unit of effort) **and RPUE** (revenue per unit of effort) **temporal trend** within the MPAs compared to outside, while in unprotected external locations these trends were negative, hence suggesting a progressive decrease in catch and fishers’ revenues.

This pattern can suggest an early sign of an overall positive effect of the governance toolkit implementation on small scale fisheries and its economic dimension.

Also in this case it is important to highlight that more conclusive evidence can be gathered only considering longer time series, allowing for temporal scale variations associated with the processes potentially inducing significant benefits on small scale fisheries catches (e.g. spillover of adult fishes from no-take zone to unprotected fishing ground, increase in size of individuals, etc.).

Social outcomes are undoubtedly the **most rapidly positively affected by the implementation of the governance measures**: almost all the social indicators considered highlighted clear benefits of the measures implemented.

This is related to the fact that the social dimension usually can respond more rapidly than the ecological (and so also economic) one.

We investigated fishers' perceptions related to a large set of variables and the effect of the governance toolkit on them: although fishers' perceptions do not necessarily reflect factual patterns, and are mediated by a complex set of social and cultural processes, it is extremely important to highlight that perceptions are what drive behavior and support towards conservation initiative. The social dimension is much more relevant when determining if an MPA is or will be successful.

Therefore, **a positive perception by fishers may lead to a pro-environmental behavior and increased support for MPAs**.

It is evident that, despite a natural variability in the outcomes, most of the indicators adopted in the assessment suggest a positive influence of the governance toolkit implemented in the project especially as they were tailored to meet the specific needs of each MPA.

From this perspective, we highlight the **ability of the FishMPABlue2 project to improve the effectiveness of the current governance of the set of MPAs selected in delivering ecological, economic and social benefits for small-scale fisheries**.

In addition, beside the outcomes-oriented view, it is important to highlight the merit of the governance toolkit implementation process itself, that allowed us to gather MPA managers and fishers bring them together to engage and agree upon strategies to improve conservation and fisheries related outcomes, and to assess the feasibility, advantages and disadvantages of each specific tool[24].

[24] this is thoroughly described in the Deliverable 3.5.2 Upgraded versions of governance tool