

Is there a negative interaction between biodiversity conservation and artisanal fishing in a Marine Protected Area, the Port-Cros National Park (France, Mediterranean Sea)?¹

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Résumé. Les espaces protégés ne sont plus considérés comme des "îles" de nature préservée entourées par un "océan" d'usages incompatibles. Ils s'intègrent aujourd'hui dans une gestion régionale de l'environnement (espaces protégés et espaces non protégés) et l'homme n'est pas exclu *a priori* des espaces protégés. Dans la plupart des Aires Marines Protégées (AMP) de Méditerranée, la pêche artisanale est autorisée, ou n'est interdite que dans une petite partie de l'AMP. C'est le cas du Parc national de Port-Cros.

Pour être autorisés à pêcher à Port-Cros, les pêcheurs doivent toutefois signer une charte. Outre l'obligation de respecter la législation générale (ce qui est important puisque la législation générale n'est pas respectée en dehors des AMP), ils acceptent certaines contraintes (e.g. maille des filets plus grande, nombre limité d'engins par pêcheur, heures des calées, restriction de l'utilisation des hameçons (y compris les palangres), interdiction du chalut) et ils doivent remplir un "carnet de pêche"; ils y précisent, pour chaque journée de pêche, le secteur, le nombre de pièces des filets trémails utilisés et enfin les captures des principales catégories de prises. Des enquêtes parallèles sur le nombre et la localisation des engins de pêche dans les eaux du Parc, et l'embarquement de scientifiques sur les bateaux de pêche, montrent que les données des carnets de pêche sont relativement fiables.

En Méditerranée, où la fréquentation touristique est considérable, les prises de la pêche amateur (pêche à la ligne et chasse sous-marine) sont loin d'être négligeables, peut-être du même ordre de grandeur que celles de la pêche artisanale; c'était le cas à Port-Cros, avant qu'une réglementation plus contraignante soit mise en place. En outre, il y a souvent un large recouvrement entre les prises de la pêche amateur et les espèces cibles de la pêche artisanale. Il en résulte que la pêche amateur, outre son possible impact sur la biodiversité, est un usage en compétition avec la pêche artisanale pour l'accès à la ressource. Pour ces raisons, à Port-Cros, la chasse sous-marine est interdite (depuis 1963) et la pêche à la ligne n'est autorisée que depuis une embarcation, à au moins 50 m de la côte, seulement dans une partie des eaux du Parc (depuis 1999).

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Dans les conditions où elle est pratiquée, la pêche artisanale nuit-elle à la mission de conservation de la biodiversité du Parc national de Port-Cros? Aucune donnée scientifique ne permet pour le moment de la mettre en cause. La diversité des espèces et des communautés, la densité et la biomasse des poissons sont élevées (ce que confirme le succès de Port-Cros comme site de plongée de loisir). Une espèce emblématique comme le mérrou brun *Epinephelus marginatus* voit même ses effectifs s'accroître; l'état de santé des peuplements benthiques, en particulier ceux qui sont victimes du chalutage en dehors des Aires Marines Protégées, est satisfaisant; par exemple l'herbier à *Posidonia oceanica* et le mollusque *Pinna nobilis*. Inversement, les contraintes imposées à la pêche artisanale nuisent-elles à son efficacité? Les données actuelles montrent que l'effort de pêche et les captures par unité d'effort (CPUE) à Port-Cros sont au moins équivalents à ceux des zones voisines non protégées. L'absence d'interactions négatives entre protection du patrimoine naturel et la pêche artisanale, dans les conditions où elle est pratiquée à Port-Cros, peut s'expliquer par une meilleure gestion du stock et par la réduction de la compétition entre pêche artisanale et pêche amateur.

Abstract. Protected areas are no longer seen as "islands" of nature and tranquillity surrounded by a "sea" of incompatible uses, but are a part of a broader regional approach to land and sea management. Local people should not be excluded *a priori* from protected areas. This is the case in the Port-Cros national Park: artisanal fishing (i.e. small-scale commercial fishing) is authorised in most of the area, though subject to additional constraints to those enforced by the general legislation (wider mesh size, limited amount of gear per fisher, time for the setting and removal of gear, restrictions on the use of hooks, long-lining included, prohibition of trawling, etc.). In the Mediterranean, recreational fishing catches (spear fishing and angling) are far from negligible: so the competition between recreational and artisanal fishing may be significant. At Port-Cros, spear fishing is banned and angling partly prohibited, which can relieve the total (recreational + artisanal) fishing pressure on the fish stock. The benthic ecosystems of the Port-Cros National Park are healthy and species diversity is high. As far as artisanal fishing is concerned, fishing effort and fish yield cannot be considered as lower at Port-Cros than in non-protected areas. Overall, it seems that there is no negative interaction between biodiversity conservation and artisanal fishing (at least in the way it is practised).

Nature conservation and Marine Protected Areas

Until the late 1960s, the key concept behind protected areas was that these were areas that were not materially altered by human exploitation or occupation, and that steps should be taken by the competent authority to prevent or eliminate exploitation or occupation. So protected areas were seen as "islands" of nature and tranquillity surrounded by a "sea" of incompatible resource uses (McNeely, 1994; Raffin, 2001). Yet such an "island" mentality is fatal in the long term because protected areas will not be able to conserve biodiversity if they are surrounded by degraded habitats that limit gene-flow, alter nutrient cycles, provide invasive species and cause regional climate change which may ultimately lead to the disappearance of these "island parks" (Fig. 1) (McNeely, 1994). Invasive species clearly illustrate this problem. The park boundary of the Port-Cros National Park (France) offered no protection against the immigration of *Caulerpa taxifolia* (Chlorobionta, Plantae), once it was present along the coasts of the French Riviera (Cottalorda *et al.*, 1996; Robert, 1996; Robert and Gravez, 1998).

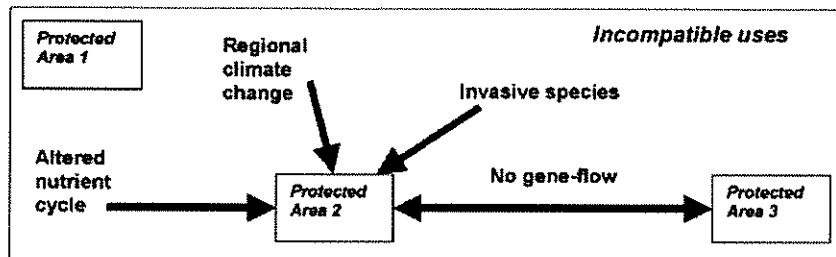


Fig. 1. Protected areas (e.g. 1 through 3) seen as "islands" of nature and tranquillity surrounded by incompatible resource uses. Arrows: negative impacts on protected areas.

In the 1970s, the notion of protected areas moved on to a more general concept of nature conservation, then to a more dynamic one of nature management. Protected areas therefore need to be part of a broader regional approach to land (and sea) management (McNeely, 1994; Agardy, 2001; Raffin, 2001; Babin, 2002; Boudouresque, 2002). Furthermore, it is recognized that conserving nature requires a flexible approach in which local people should not be excluded *a priori*.

Nowadays, the aims of the Marine Protected Areas (MPAs) are six-fold. (i) To set up conservatories for threatened species and habitats. (ii) To provide sites for public education on the environment (e.g. underwater nature trails, public awareness leaflets). (iii) To provide reference areas for scientific research. (iv) To provide attractive landscapes for tourism (bathing, pleasure craft, snorkeling, diving). (v) To establish no-take areas where fish density and sex-ratio make mating and spawning possible, and which subsequently export eggs, larvae and adults to surrounding unprotected areas and therefore enhance catches by fishermen. (vi) To manage the different uses of the sea (e.g. commercial fishing, recreational fishing, pleasure boating and tourism) in a rational way, so that they do not conflict with each other or with conservation aims (Agardy, 1997; Dayton *et al.*, 2000; Planes *et al.*, 2000; Sumaila *et al.*, 2000; Francour *et al.*, 2001; Malakoff, 2001; Roberts *et al.*, 2001; Boudouresque, 2002; Kenchington *et al.*, 2003; Neubert, 2003). Obviously, MPAs, together with integrated coastal zone management (ICZM) of user conflicts, result in economic benefits, both for fishermen and the tourism industry, in such a way that there should no longer be a need to try to set off environmental values against economic values (Ramos, 1992; Ribera-Siguan, 1992; Boudouresque, 1996). For example, it has been estimated that the tiny (20 km² of land and sea) Port-Cros National Park (France, Mediterranean Sea), produces, directly and indirectly, a mean annual turnover of 300 million € per year (IRAP, 1999; Boudouresque, 2002).

Marine Protected Areas are often perceived by the public at large as well as by the stakeholders and other users of coastal areas as a

burdening collection of prohibitions. In fact, with the exception of spear fishing, prohibitions usually concern only a small part of the MPA's surface area (**Table I**). This is the case in the Port-Cros National Park: artisanal fishing is authorized in most of the park area (1380 ha), with the exception of a few hectares (**Fig. 2**) (Boudouresque, 2002).

Table I. Main prohibited activities within French Mediterranean Marine Protected Areas, as a percentage of the total surface area (nearly 9 000 ha). From Harmelin *et al.* (1998).

Prohibited activity	Percentage of the total surface area
Anchoring of pleasure boats	7%
Artisanal commercial fishing	7%
Scuba diving	17%
Recreational fishing (angling)	20%
Recreational fishing (spear fishing)	100%

Recreational fishing

In the Mediterranean, which accounts for one third of total world tourism, recreational fishing catches, whether it be by spear fishing or angling, are far from negligible (2.8-8.4 t/km²/a; **Table II**) as compared to those of the artisanal fishing industry (0.5-1.1 t/km²/a; Geronimi, 1988; Aboussouan and Boutin, 1993; Culioli, 1995; Bernard *et al.*, 1998; Daniel *et al.*, 1998), even if it must be emphasized that recreational fishing is carried over a much smaller surface area than artisanal fishing. The overlap between the catches of spear fishing and angling is usually weak. In contrast, the overlap between catches of recreational and artisanal fishing may be significant (Daniel *et al.*, 1998; but see Delaunay, 2003).

Table II. Catches from recreational fishing. The studied surface area or shore length is mentioned (in brackets). md: missing data.

Locality	Spear fishing (t/km ² /a)	Angling from the shore (t/km/a)	Angling from a boat (t/km ² /a)	Total recreational fishing (t/km ² /a)	Reference
Rayol-Canadel (French Riviera)	1.3 (2.4 km ²)	< 0.1 ^a (7.5 km)	0.2 (7.5 km ²)	2.8 ^b	Chavoïn and Boudouresque, 1997
Port-Cros MPA (French Riviera)	Prohibited	0.2 ^c (26 km)	0.4 ^c (14 km ²)	8.4 ^b	Combelles, 1991
Riou Archipelago (Provence)	1.3 (8.5 km ²)	0.1 (26 km)	1.3 (21 km ²)	6.3 ^b	Daniel <i>et al.</i> , 1998
Riou Archipelago (Provence)	Md	Md	1.1 ^c (21 km ²)	md	Bonhomme <i>et al.</i> , 1999
Cerbère-Banyuls MPA (French Catalonia)	Prohibited	0.1 ^c (5 km)	0.5-1.1 ^c (5.8 km ²)	4.5-5.1 ^b	Athias-Binche, 1996

^a Exact value: 0.033 t/km/a.

^b At places where the different types of recreational fishing coexist, and assuming that angling from the shore concerns a 25 m wide littoral belt.

^c Calculated from the author's data.

^d Later on (1999), angling from the shore was banned and angling from a boat restricted to some areas (see Fig. 2).

^e A lower value is mentioned by Daniel *et al.* (1998), due to miscalculation.

At Port-Cros Island, spear fishing has been prohibited since the establishment of the National Park, in 1963. Since 1999, angling has been prohibited from the coast to the offshore limit of the park marine area (East and South) and from the coast to 50 m offshore (North and West) (Fig. 2). In addition, any kind of harvesting of living organisms from the shore is prohibited. If one considers catches from recreational fishing in other coastal areas, these prohibitions can be seen to significantly relieve the fishing pressure on the Port-Cros fish stock.

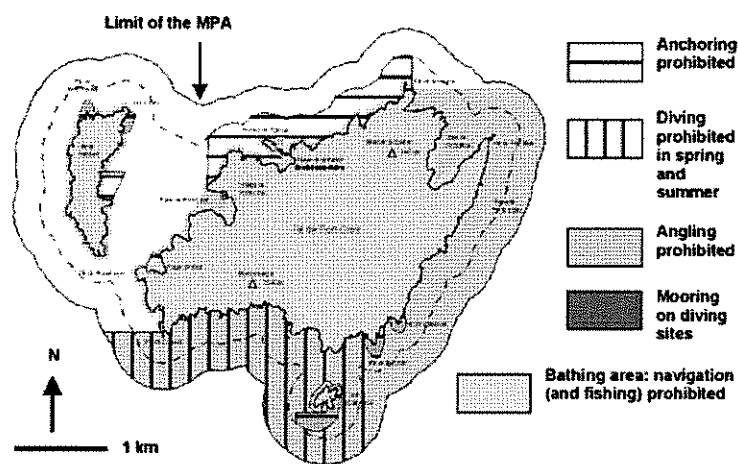


Fig. 2. Regulation in the Marine Protected Area of the Port-Cros National Park. Artisanal fishing authorized everywhere, with the exception of yellow and green areas. Protection of bathing and diving and prohibition of navigation result in an indirect prohibition of both recreational and artisanal fishing. Constraints to artisanal fishing: general legislation + wider mesh size, limited amount of gear per fisher, time for the setting and removal of gear, prohibition of trawling and restriction of hook use (long-lining included) to certain periods and places. Spear fishing is prohibited in the whole area. From Parc national de Port-Cros in Boudouresque (2002, simplified).

Artisanal fishing

Artisanal fishing at Port-Cros consists of small boats (< 12 m) run by one fisherman using trammel nets, gillnets and traps.

The granting of permission to fish within the Park waters is conditional on the signing every year of a fishing agreement ("*Charte de partenariat de la pêche professionnelle dans les eaux du Parc national*") with Park managers, which includes the acceptance of some constraints (e.g. wider mesh size on nets, limited amount of gear per fisher, time for the setting and removal of gear, restriction of hook use, including long-lining, to certain periods and places) and the filling in of a fishing log book. Trawling has been prohibited since the creation of the National Park. In addition, it is worth noting that general regulations concerning commercial fishing are actually enforced within the Park area, as in other MPAs, contrarily to non-protected areas.

The form of the log book has been proposed by scientists and adapted on the basis of the park managers' and the fishermen's suggestions. The fishermen themselves record one page of the log book for each outing (one day) in the park waters. They have to specify the fished sector, the characteristics of the gear used, the total number of net-pieces (an indicator that is more informative for the fishing effort than the number of nets) and finally their catches per selected target species (Le Diréach *et al.*, 2004). Size classes (small, medium, large) were defined as one third of the maximum total length-minimum total length range, according to Harmelin-Vivien *et al.* (1985). The log books are collected at the end of the fishing season (Le Diréach *et al.*, 2004).

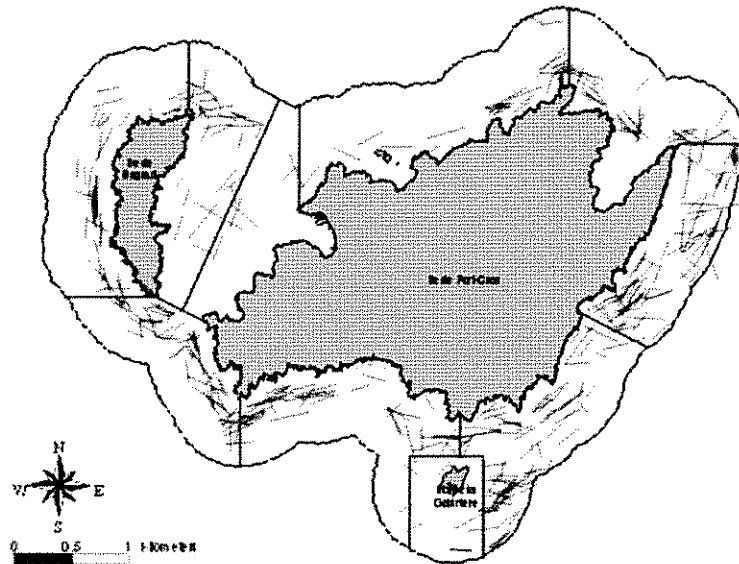


Fig. 3. Localization (black lines) of the fishing nets in the Port-Cros National Park, between March and September 2001. Cumulated data from 63 daily surveys. From Cadiou *et al.* (2002).

In addition, park officers or scientists establish charts of the distribution of fishing gear. The variables determining the fishing effort are collected for each type of gear which has been observed: the time of observation, name of the sector of use, the name of the boat (recorded from the gear buoys), the type of gear (if possible). Surveys are performed once a day, if possible early in the morning (before the fishermen haul in their nets), and last about one hour (Fig. 3; Cadiou *et al.*, 2002; Le Diréach *et al.*, 2004).

It is worth noting that mean preliminary estimates of the fishing effort based upon log books are congruent with those based upon gear censuses by scientists and park officers (Le Diréach *et al.*, 2003; but see Guerin, 2003). On average, 20 fishermen sign the fishing agreement

every year, but only 10 of them actually fish in Port-Cros waters, some of them very occasionally (Cadiou *et al.*, 2002; Guerin, 2003). Since 1996, the mean number of fishermen and the spatial localization of the fishing effort seem to have been stable (Le Corre, pers. comm., from Guerin, 2003 data).

Interactions between artisanal fishing and nature conservation

The question which arises is twofold. Firstly, taking into account the constraints that characterize the practice of artisanal fishing within a MPA like Port-Cros National Park, does this activity threaten one of the MPA's major aims, nature conservation? To answer this question is of great importance since artisanal fishing is an activity that is profoundly rooted in Mediterranean customs and traditions. Secondly, do the constraints imposed on artisanal fishing hinder that activity, for example reduce the fishing effort, catch per unit effort (CPUE) and/or catch per surface area unit?

The benthic ecosystems of the Port-Cros National Park are healthy and habitat diversity is well preserved: e.g. meadows of the seagrass *Posidonia oceanica*, the coralligenous and sea-cave communities, and *Cystoseira* forests (Augier and Boudouresque, 1976, 1979; Loquès *et al.*, 1995; Belsher and Houlgatte, 2001; Harmelin, 2003; Harmelin *et al.*, 2003; Hereu *et al.*, 2003). Species diversity of macrophytes, invertebrates and fish is high (Harmelin, 1973; Belsher *et al.*, 1976; Harmelin-Vivien, 1982; Francour and Chauvet, 1993; Hereu *et al.*, 2003; Noël, 2003). Of course, natural fluctuations may affect these populations, as a result of e.g. warm water episodes and disease (Boudouresque *et al.*, 1980, 1981; Azzolina *et al.*, 1983; Meinesz and Mercier, 1983; Harmelin and Marinopoulos, 1994; Perez *et al.*, 2000; Garrabou *et al.*, 2001). As far as emblematic species are concerned, the brown meager *Sciaena umbra* is not uncommon (1-4 individuals/ha) though less abundant than in other Mediterranean MPAs (Harmelin and Marinopoulos, 1993). The population of the dusky grouper *Epinephelus marginatus* is in steady expansion¹ (Table II; Harmelin, 1999; Harmelin and Robert, 2001; Harmelin *et al.*, 2003). The mean density of the noble pen shell *Pinna nobilis* is 9-11 individuals/ha (adults), with much higher density, 100 individuals/ha, within its preferred habitat, the *Posidonia oceanica* meadow (Vicente *et al.*, 1999; Medioni and Vicente, 2003). In non-protected areas of the north-western Mediterranean, mean adult density is of less than one individual per hectare (Richardson *et al.*, 1999). The success of Port-Cros as a hot spot for scuba diving (Lopez, 2003) confirms the quality of its species, habitat and landscape (seascape) diversity, in particular fish density, which is particularly appealing for

¹ Clearly, the prohibition of spear fishing, together with restriction of long-lining and the banning of trawling have played a major role in the expansion of the *Epinephelus marginatus* population.

divers. All in all, on the basis of present day knowledge of Port-Cros biodiversity, it cannot be claimed that artisanal fishing, the way it is practised (see above), seriously hinders one of the aims of the MPA, biodiversity conservation.

Table II. Patterns of change over time of the population (number of individuals) of the dusky grouper (*Epinephelus marginatus*) of the Port-Cros National Park (ca 14 km²), censused visually by snorkeling and scuba diving. md: missing data.

Year	Gabinière Island	Other sites	Total	References
1973	7	8-11	15-18	unpublished data in Harmelin, 1999
1983-1987	23-28	md	md	Robert <i>et al.</i> , 1987; Chauvet and Francour, 1990; Chauvet <i>et al.</i> , 1991; Groupe d'étude du Mérrou, 1996
1988-1989	29-34	md	md	Groupe d'étude du Mérrou, 1996
1993	34	52	86 (100*)	Harmelin, 1999; Harmelin and Robert, 2001
1996	84	76	160	Harmelin, 1999; Harmelin and Robert, 2001
1999	156	143	299	Harmelin and Robert, 2001
2002	210	200	410	Harmelin <i>et al.</i> , 2003

* Estimate.

To answer the question in reverse (i.e. do the constraints imposed on artisanal fishing at Port-Cros hinder that activity?) is more difficult. In the northwestern Mediterranean Sea, quantitative data on artisanal fishing are scarce and quite difficult to compare, due e.g. to differences in the methods used, the sampling season, the type of gear taken into account, the target species and to the importance, usually unknown, of other catches (recreational fishing, trawling) and the target stock. In addition, the surface area of the regions studied is not a reliable datum, since it may include areas not suitable for artisanal fishing. In Port-Cros waters, the mean number of fishers was, in summer, 1.8/d in 2000 and 2.8/d in 2001 (Cadiou, 2002). The fishing effort can be better estimated on the basis of the length of nets, or the number of 100 m net sections, per day and per ha (**Table III**). Comparison between Port-Cros MPA and the non-protected surrounding area (**Fig. 4**) shows that fishing effort is not lower, and may be higher, within the park than outside (**Fig. 4**). Although these data are only based upon the fishermen who signed the ‘*Charte de partenariat de la pêche professionnelle dans les eaux du Parc national*’, resulting in a possible over-evaluation of fishing in Port-Cros waters, the possible bias may be weak, since only one of these fishers uses Port-Cros as his main fishing area, two for 25% of their fishing time, six for less than 10% of their fishing time, and the others never fish at Port-Cros (Cadiou, 2002; Guerin, unpublished data). As far as CPUE (catch per unit effort) is concerned, on the basis of available data, fish yield cannot be considered as lower at Port-Cros than in non-protected areas. (**Table III**).

Table III. Data on artisanal fishing in some localities of the French Mediterranean coast. Fishing effort: number of 100 m net section per ha and per year (or day). CPUE: catch per unit effort, i.e. kg per 100 m of fishing net and per day (= per outing). md: missing data. upd: unpublished data.

Locality	MPA area	Surface effort	Fishing	CPUE	Total catch	References
Côte Bleue (Provence)	No ^a	ca 13 km ²	0.07/ha/d ^b (summer)	0.7-2.5 kg/100 m/d (summer)	md	Delaunay, 2003
Côte Bleue (Provence)	No ^a	-	md	0.7 kg/100 m/d (summer)	md	Jouvenel and Bachet, 2002
Riou Archipelago (Provence)	No	21 km ²	13.3/ha/a ^c	Md	md	Bernard <i>et al.</i> , 1998
Port-Cros (Provence)	Yes	14 km ²	5.4/ha/a ^c	1.2 kg/100 m/d ^e 0.8-1.2 kg/100 m/d ^a 1.4-1.5 kg/100 m/d ^d	1.9-3.2 kg/ha/a ^d	Cadiou, 2002; Guerin, 2003; Guerin, upd
Galeria-Ghjirulata (Corsica)	Yes	md	md	1.1 kg/100m/d (April)	md	Le Diréach <i>et al.</i> , 2002
NW Corsica	No ^a	md	md	1.0 kg/100 m/d (July)	md	
NW Corsica	No	md	md	0.9 kg/100 m/d	md	Riutort, 1989
Lavezzi Islands (Corsica)	Yes	37 km ²	7.9/ha/a	0.8-0.9 kg/100 m/d	6.2 kg/ha/a	Culioli, 1995

^a An MPA is present in the vicinity ("Parc Marin de la Côte Bleue"). ^b Calculated from the author's data. ^c Based upon Guerin (2003). ^d Year 2001. ^e Only target species, *Conger conger* and *Muraena helena*, for example, are not taken into account. ^f Under-evaluation: value based upon the fishing log books of 6 out of the 9 fishers who were observed fishing in Port-Cros waters.

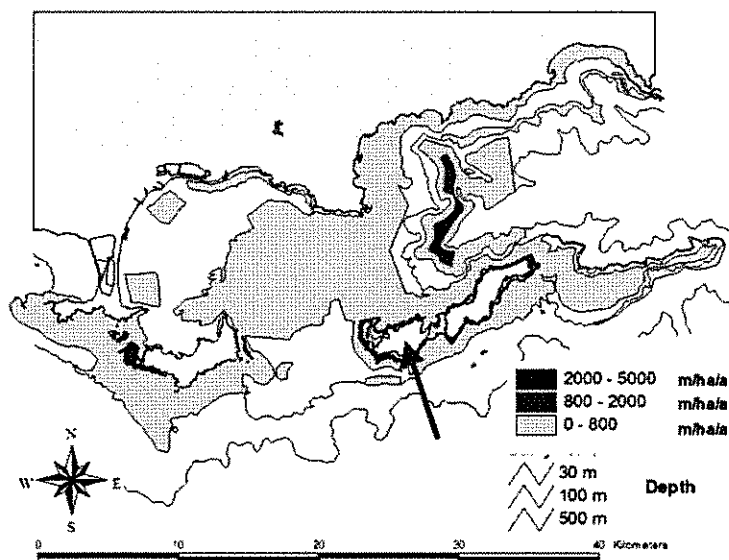


Fig. 4. Fishing effort (gill nets and trammel nets) in the waters of the Port-Cros National Park (arrow) and in surrounding non-protected areas: mean length of nets/ha/a. There is a possible bias since data are based upon the fishermen who signed the "Charte de partenariat de la pêche professionnelle dans les eaux du Parc national" (see text).

Conclusions

On the basis of available data, it cannot be claimed that there is a negative interaction between biodiversity conservation and artisanal fishing in a Marine Protected Area, the Port-Cros National Park. The good state of preservation of Port-Cros benthic habitats and species populations suggests a rather weak impact of fishing, the way it is practised (e.g. prohibition of trawling and spear fishing, semi-prohibition of angling, reinforced regulation of artisanal fishing).

Furthermore, it must be emphasized that an apex predator, the monk seal *Monachus monachus*, formerly occurred in the area (Marchessaux, 1989a, 1989b). In the absence of this fish-eating seal, a no-take area for artisanal fishermen would not represent a natural environment since the seal's prey could proliferate and cause a shift in the natural equilibrium. Fishermen may therefore contribute to mitigating the ecological impact of the monk seal's local extinction.

On the other hand, the survey of artisanal fishing within Port-Cros waters does not provide evidence that the constraints included in the "*Charte de partenariat de la pêche professionnelle dans les eaux du Parc national*" significantly hinder fishing activities.

The present results are fragmentary and deal with a few areas and years and must therefore be considered with considerable caution. Should further studies confirm the absence of serious negative interaction between conservation and artisanal fishing in the background of an MPA, this could be due, in part, to the prohibition of spear fishing and the semi-prohibition of angling, catches from which are far from being negligible. This could also be due to the effectiveness of regulation of the artisanal fishing, resulting in an increase of the stocks of target species, via the so-called "reserve effect": Allee effect, presence of large individuals and spawning enhancement.

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² Clearly, the prohibition of spear fishing, together with restriction of long-lining and the banning of trawling have played a major role in the expansion of the *Epinephelus marginatus* population.