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Institut Català de Recerca per a la Governança del Mar

Fisheries advisory report for the Northern GSA 6

2023

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This report conveys ICATMAR's considerations on fisheries management actions supported by data from its monitoring program.

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Figures and tables

1

Highlights from ICATMAR stock assessment

The following paragraphs present a brief summary of the stock assessment carried out with 2019-2022 data from ICATMAR, integrated with a discussion on our findings. Length-Based Spawning Potential Ratio (LB-SPR) model was applied to all species in the Western Mediterranean Multi-Annual Plan (WMMAP) as well as to the target species of the purse seine fleet.

Recruitment for the European hake in the Northern GSA 6 has followed an increasing trend since 2019 (Figure 1). In this region, small hake individuals are discarded and never sold in auction, and fishers actively steer clear of areas where juveniles dwell to avoid dealing with time-consuming triage operations and a fraction of the catch that they will not be able to sell.

The stock assessment models applied for the European hake in the Northern GSA 6 concur that, for 2022, the stock is overexploited, with only slight nuances in the level of certainty and relative reference parameters depending on the biological parameters used for the species (Figure 2). The fact that LBSPR model assumes a constant recruitment when this does not seem to be the case according to our series of data makes it difficult to draw straightforward conclusions from these types of models. Also, the literature has been reporting overexploitation in this species since the 1950s (Bas et al., 1955), while the fishing activity has not only not ceased, but has in fact increased during the end of the 20th century up until the relatively recent implementation of fishing effort regulations. Biomass has been on a downwards trend for 20 years, and only in the last three has this trend been reversed (ICATMAR, 23-03). It seems plausible that effort reduction has not been a sufficient measure to overcome decades of overexploitation, since fishing mortality has not yet seen the expected decrease.

Establishing a correlation between the recent biomass increase in juvenile individuals and other factors is not a simple task, since the recruitment in hake is reportedly variable year after year, and peaks can occur in con-

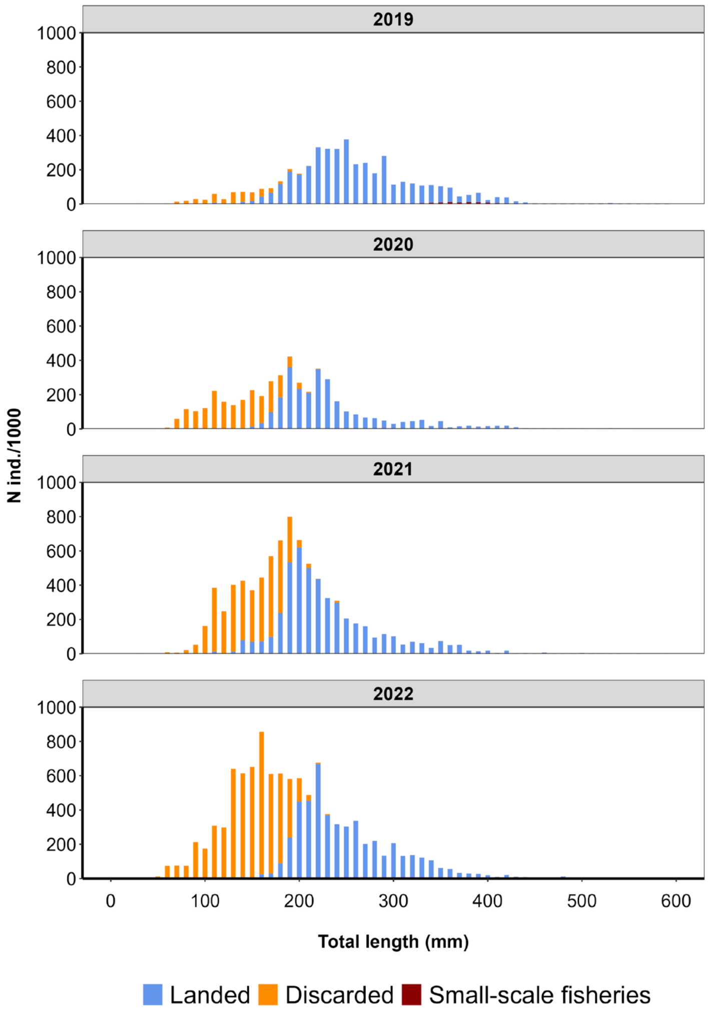

Figure 1. Annual length frequency distributions of hake from bottom trawling and small-scale fisheries (SSF). The data from bottom trawling is raised from ICATMAR data and details landed and discarded hake. The data from SSF is obtained from DCF (Data Collection Framework) dataset.

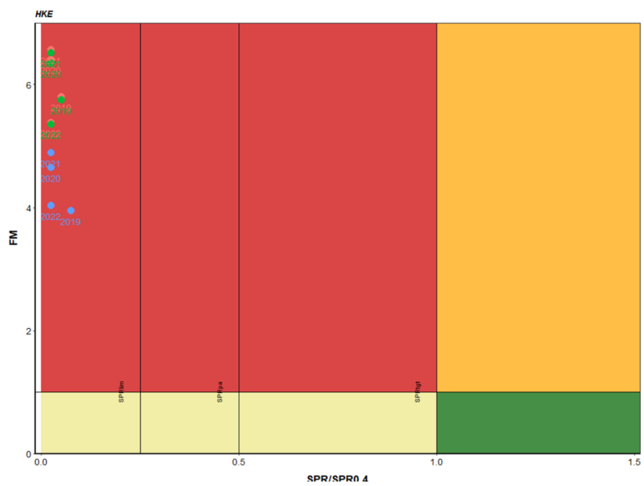

Figure 2. Kobe plot for hake by scenario (1-3) and year. Scenarios vary in the inputs used for biological parameters (e.g. Linf, k, Lmat50; see ICATMAR, 23-08 for details). SPR: spawning potential ratio, SPR0.4: spawning potential ratio with 40%, F: fishing mortality; Ftarget: target fishing mortality.

secutive years due to environmental conditions (Recasens et al., 2008). The data could also be compatible with a positive response of the stock to management measures implemented since 2019, but this trend cannot yet be visible in larger (reproductive) individual sizes due to the long-lived nature of the species. A longer series of data is needed to assess the causes and effects of this peak in recruitment in the stock status. Indeed, the favorable trend in biomass could be taken as an opportunity to boost the protection of these juveniles, by both establishing closure areas in nursery spots and especially increasing the mesh size of the codends to avoid their catch.

Regarding the rest of the species in the WMMAP, there is uncertainty about the status of the stocks depending on the models used. In our case, the LBSPR results show that the Spawning Potential Ratio (SPR) of both the deep-water rose shrimp and the Norway lobster is over Blim, while it remains lower than Blim for the rest of the species (Figure 3), but we are confident that the use in 2024 of data-demanding models that take into account both the size structure of the population and different priors, such as Stock Synthesis (SS3), will yield a more accurate fit to our data.

The stock assessment model shows the SPR of both species over Blim, and anchovy SPR above the threshold value in all scenarios studied (Figure 3).

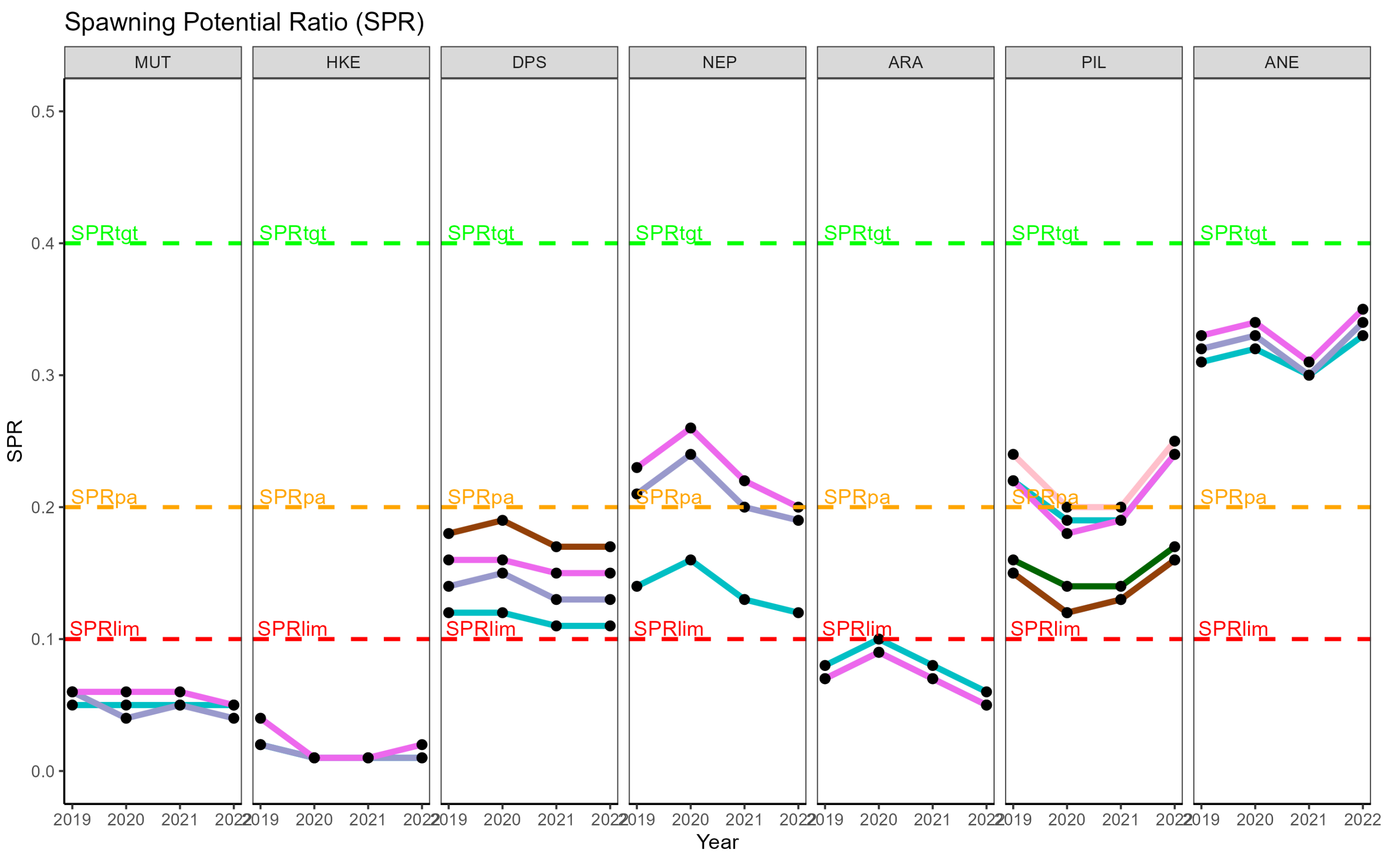

Figure 3. Spawning potential ratio (SPR) per year (2019, 2020, 2021 and 2022) and scenario (1 to 6) for the seven stocks evaluated with LBSPR model. Scenarios vary in the inputs used for biological parameters (e.g. Linf, k, Lmat50; see ICATMAR, 23-08 for details). MUT: red mullet, HKE: hake, DPS: deep-water rose shrimp, NEP: Norway lobster, ARA: blue and red shrimp, PIL: European sardine, ANE: anchovy. LBSPR: Length-Based Spawing Potential Ratio. Btgt: Biomass target; Bth: Biomass threshold; Blim: Biomass limit.

2

Towards a more sustainable bottom trawl fishery in the Northern GSA 6

1. Changes in fishing gear

1.1. Low-contact otter boards

The impact of bottom trawling fishing gear affects benthic fauna and their habitats, and the dragging of trawling gears along the seafloor causes the scraping and ploughing of the seabed (Jones, 1992; Martín et al., 2014a). The degree of environmental perturbation caused by bottom trawling on the seafloor largely depends on the type of gear, the towing speed, and the nature of the surface sediment (Fonteyne, 2000; O'Neill and Summerbell, 2011; Ivanovic et al., 2011). Additional concerns were recently raised regarding the role of bottom trawling fisheries in the disturbance of the carbon balance of the ocean system (Sala et al. 2021), although several responses to this article agree in the fact that the interactions between these processes are complex, and that we currently do not know enough about the impact of trawling on seabed carbon dynamics to make global projections (Hiddink et al. 2023, Hillborn and Kaiser 2022).

Figure 5. Example of a low-contact otter board model (Thyboroon T15VF) used in the 2013 study in Palamós.

Based on a 2013 collaborative project between scientists at the ICM-CSIC and the fishers' guild of Palamós (Northern GSA 6) that tested the impact on the sediment of different types of trawl doors (Palanques et al. 2013), the bottom trawl fleet of Palamós has progressively changed their gear to feature only low-contact otter boards (Figure 5) that ensure a reduction in the resuspension of the sediments, and may additionally decrease fossil fuel consumption.

In June 2023, a cruise within project LIFE-ECOREST used Remotely Operated Vehicle (ROV) imaging to compare the state of the seabed in trawled zones with low-contact and conventional (full-contact) otter boards. The images show a smooth seabed in the areas regularly fished using low-contact otter boards, in contrast with the ploughed seabed of the areas fished with conventional gear (Figure 6).

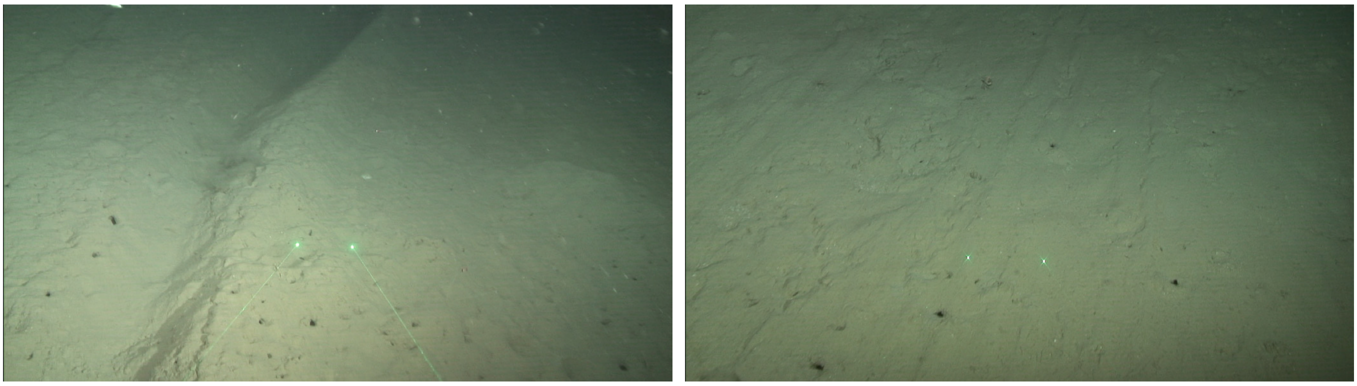

Figure 6. Remotely Operated Vehicle (ROV) images showing areas currently fished with conventional otter boards near Vilanova i la Geltrú (left), and low-contact otter boards near Palamós (right).

These preliminary results show that a standardized use of low-contact otter boards in the bottom-trawl fleet would allow for the reduction of the impact of trawl fishing activities, and thus contribute to preserve the integrity of the seafloor. The self-regulated initiative promoted by the bottom-trawl fleet of Palamós brings out the need for the fishing sector to effect a change that ensures a lower impact of the fishing gear on the benthic ecosystems. However, this measure is currently not compulsory and is only followed by 34 of the 207 vessels (16% of the fleet; Figure 7).

1.2. Gear selectivity improvement

In the Northern GSA 6, gear selectivity improvement is encouraged with compensation measures of additional fishing days (up to 3.5% increase) for vessels or guilds that officially commit to changing to a wider mesh size, from 40 to 45 mm in coastal fisheries and from 40 to 50 mm in deep-sea fisheries (EU Regulation 2023/195). For 2023, data from the Spanish Ministry of Fisheries show that only 10.8% of the 203 vessels in the Northern GSA 6 have commited to apply gear selectivity improvement in exchange for an increase in fishing days (Figure 8). The applications for compensation measures were exclusively issued by the ports in the Northern zone, i.e. Llançà, Roses, Palamós and Blanes (Girona province).

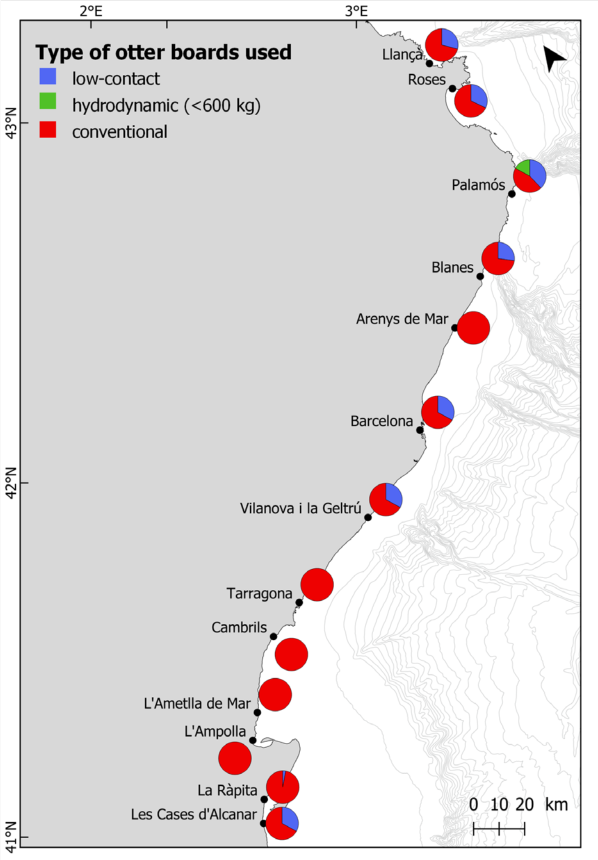

Figure 7. Spatial distribution of the use of different types of otter boards in the bottom trawl fleet as of March 2023. Results in % of total number of vessels in each guild.

According to these data, the current approach to gear improvement as a means to receive compensation measures to other restrictions is showing signs of low engagement in the sector and is a strategy that could be revised. Yet, our studies have repeatedly shown that a change to a 45-mm codend in coastal fisheries and to a 50-mm codend in deep-sea fisheries would act as an immediate relief measure to these populations, reinforcing the current management measures in place instead of hindering them, e.g. ensuring the protection of hake juveniles and of blue and red shrimp individuals under 25 mm cephalothorax length.

It seems that the addition of fishing days is not a sufficient compensation and most fishers deem it more convenient not to apply for it. This situation could be detrimental to the general engagement level of the sector in the design and implementation of management measures, since invested individuals might feel under-compensated, isolated or even disadvantaged when choosing the more sustainable practices.

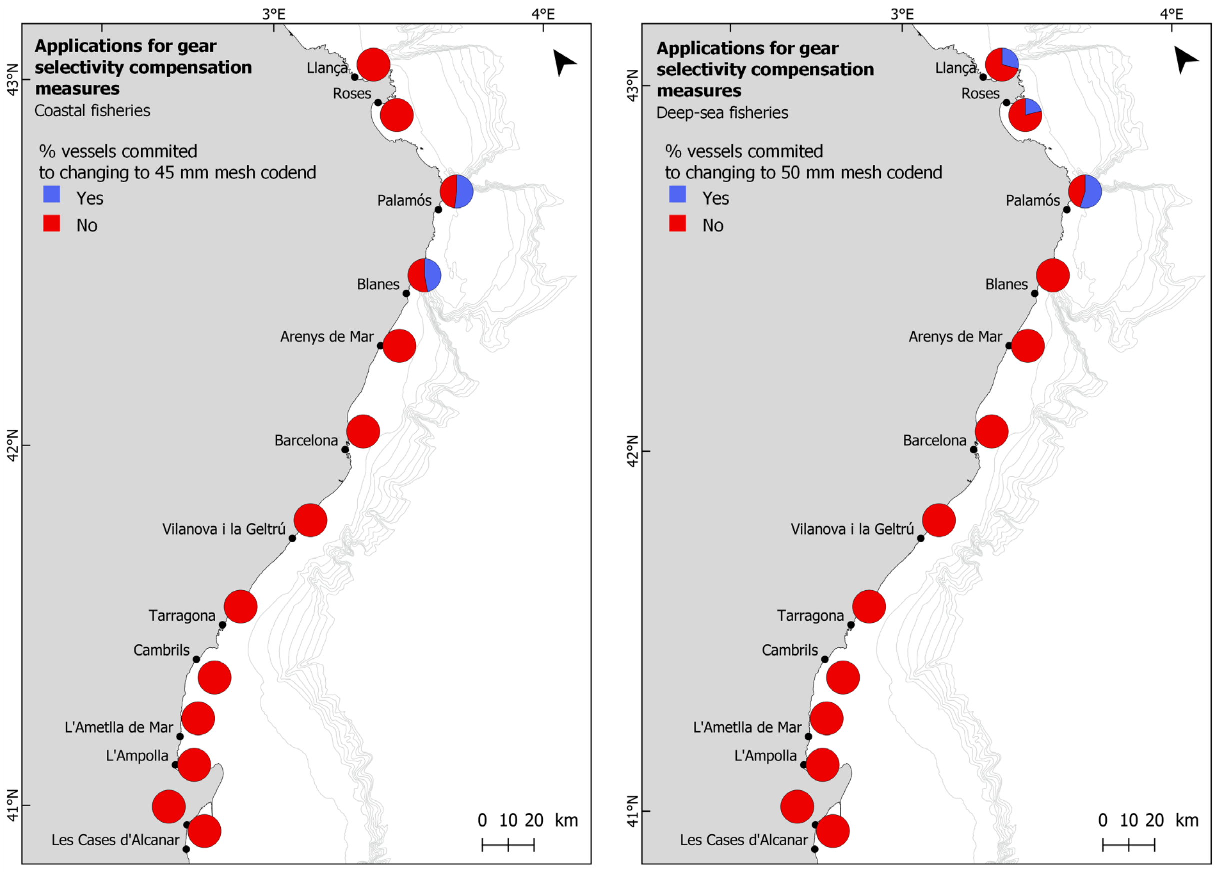

Figure 8. Spatial distribution of the applications received for selectivity compensation measures in coastal and deep-sea fisheries. Results in % of total number of vessels in each guild.

2. Spatial and temporal restrictions to bottom trawling

2.1. Temporary closures

The fishing ports along the Northern GSA 6 have a long tradition of establishing self-regulated 1- or 2-month temporary closures every year, ever since the first experiments in fisheries management in the 1970s (Pla Castelló). The closure calendar is updated yearly and each port can decide how to best manage them, also taking into account the distribution of the limited yearly fishing days allowed by the regulations in the WMMAP. Figure 9 shows the closure calendar for 2022 along with the reproductive periods of the main target species.

In general, the temporary closures for the bottom-trawling multispecific fishery have a mixed effect on the different target species. Winter closures in the northern ports (north of Barcelona) are only related to the recruitment of the blue and red shrimp. For this species, the most vulnerable period is the summer, where reproductive females aggregate closer to the coast, but closure is probably not feasible during these months, since the species is at its highest market price and the individuals caught are the largest in all year. Recruitment for the European hake occurs in spring/summer and is protected in the Southern ports (south of Arenys de Mar). Reproductive individuals of the species are not protected by these closures, but are not part of the bottom trawling catch anyway, since they are targeted with trammel nets. For the Norway lobster, mating season is protected in the South: this measure mainly protects the females which, after remaining burrowed throughout the winter months, become exposed in the summer.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HKE					■	■	■					
MUL			■	■	■							
ARA						■	■	■	■			
NEP					■	■	■	■	■			
DPS				■	■					■	■	
Port	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
LLANÇÀ	◕	○	○	◕	◕	●	●	●	●	●	◕	●
PORT DE LA SELVA	◕	○	○	○	◑	●	●	◕	●	●	●	●
ROSES	◕	○	○	◑	●	●	●	●	●	●	●	●
PALAMÓS	○	○	◕	◕	◕	◕	●	●	◑	◕	◕	◕
BLANES	◑	○	○	◕	●	●	●	●	●	●	●	◕
ARENYS DE MAR	◑	○	○	◕	●	●	●	●	●	●	●	●
BARCELONA	●	●	◑	○	○	◕	●	●	●	●	●	●
VILANOVA I LA GELTRÚ	○	○	◑	◕	●	●	●	◑	●	●	◕	●
TORREDEMBARRA	●	◕	●	◑	○	○	●	◔	◑	●	●	●
TARRAGONA	●	●	◕	◑	○	○	●	●	●	●	●	●
CAMBRILS	◕	●	◕	◔	○	○	●	●	●	◕	●	◑
L'AMETLLA DE MAR	◕	◕	◕	◔	○	○	●	●	●	◕	◕	◕
L'AMPOLLA	●	◕	◕	◔	○	○	●	●	●	●	◕	●
LA RÀPITA	●	●	◔	◕	●	●	○	○	●	●	●	●
LES CASES D'ALCANAR	●	●	◔	◕	●	◕	○	○	●	●	●	●

Figure 9. Schematic representation of the reproductive peaks of main target species by port and the number of fishing days per month and month in 2022. HKE: European hake; MUL: Mullets; ARA: deep-sea blue and red shrimp; NEP: Norway lobster; DPS: deep-water rose shrimp. Full black circle: >= 80% fishing days (relative to the monthly average days per port); 3/4 circle: >= 60% fishing days; 1/2 circle: >= 40% fishing days; 1/4 circle: >= 20%; white circles: < 20% fishing days.

In the case of the purse seine fleet, fhe fisheries for the two main target species of the purse seine fleet, the European sardine and European anchovy, are not easily separable from a practical point of view – in 2022, over 25% of the fishing days yielded a mix of both species (Figure 10). On the other hand, even though the total bio-

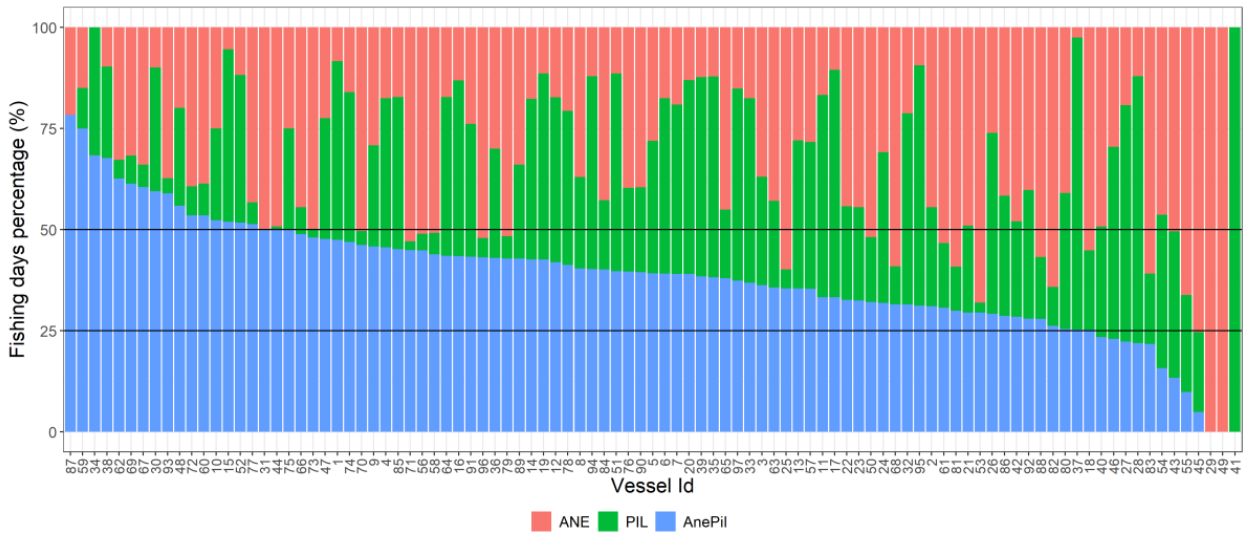

Figure 10. Percentage of yearly fishing days in 2022 with catches of only anchovy (ANE, in red), only sardine (PIL, in green), or a mix of both species (AnePil, in blue) by vessel.

mass of sardine is lower than that of anchovy, the latter has suffered a steep decrease in landings in the last few years (ICATMAR, 23-03). The autumn/winter closures protect the reproductive individuals of the European sardine and the juveniles of the European anchovy, but a summer closure would be needed to protect the sardine juveniles and anchovy reproductive individuals.

2.2. On the discussion about changes in bottom depth limitations

In November 2022, following an EU proposal, the GFCM decided to assess the potential impact of changing the depth limits of the existing fishing restrictions established by the GFCM in depths below 1000 m, as stated in the Spanish legislation since 2006 (Company et al., 2003; Cartes et al., 2004, GFCM-FAO, 2005; BOE, 2006). The assessment is being carried out with a view to possibly introducing restrictions in shallower waters. To respond to this call for data, we analyzed the revenue data of the bottom trawling fleet of the Northern GSA 6 associated with the different depth ranges, assessing eventual limitations to bottom trawling fishing from 600 m and from 800 m instead of the current limitation at 1000 m. The analysis had a special focus on the fleet dedicated to the deep-sea blue and red shrimp *Aristeus antennatus*, which is the most economically profitable species for the fleet and has a bathymetric distribution that falls entirely within the lowest range of the legal fishing area. In April 2023, after a first consultation with experts, the Subregional Committee for the Western Mediterranean (SRC-WM) acknowledged the advice of considering the 600-800 m and the 800-1000 m strata separately, as the two had very different characteristics in terms of fishing effort exerted and consequent socioeconomic impacts. The eventual modification currently considered is to extend the 1000-m FRA to 800 m, since the 600-800 m depth range was found to be key in supporting the fishery of the deep-sea blue and red shrimp.

For our analysis, the spatial distribution of the total annual revenue of the bottom trawling fleet was calculated yearly using geolocation data of the vessels (Vessel Monitoring System, VMS) provided by the Spanish Government, paired with landings data provided by the Catalan Government (ICATMAR 23-06). The VMS data were interpolated using the algorythm described in Russo et al. (2010), and the landings and revenues of each day were evenly distributed among all the interpolated VMS positions of that same date.

The 800-1000 m depth range represents 1% of total catches and revenues for the bottom trawl fleet (Figure 11). In the case of the catches and revenues corresponding only to the deep-sea blue and red shrimp, this value is 3% in both cases. The spatial distribution of the revenues for the blue and red shrimp in 2021 (Figure 12) shows that the 800 m falls right at the border of the fishing grounds, and so it could be relatively feasible to enforce provided that a precise limit is defined, also to facilitate control and account for the difference in the position of the vessel and that of the fishing gear, which can differ substantially.

In view of these data, extending the 1000-m FRA to 800 can act as a precautionary measure to deter eventual advances in fishing technology to fish deeper. It can also be an effective addition to the current strategy of building a permanent marine protected area network. However, it may pose challenges for control and enforcement without geographically defined limits other than a bathymetry line, due to the complex geomorphology of the fishing grounds areas.

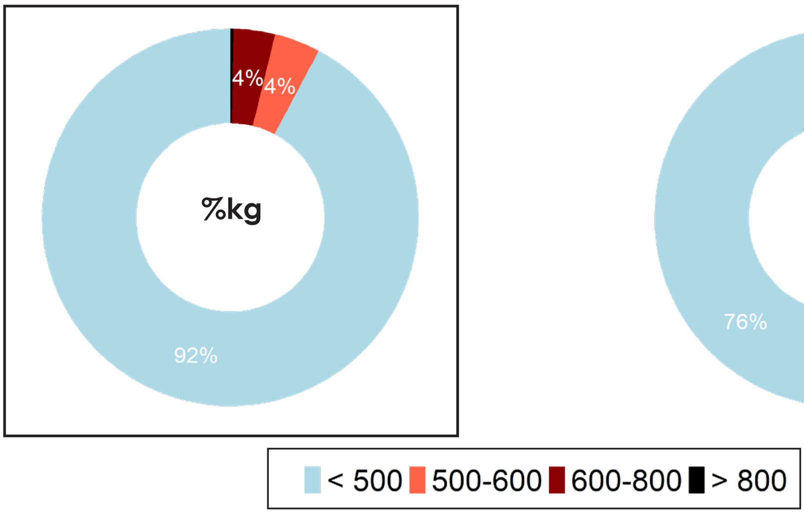

Figure 11. Average proportion of total yearly landings (on the left, in % kg) and revenues (on the right, in % €) by depth range (in m) over the years 2017-2021. The range "< 500 m" refers to the minimum legal fishing depth, which is 50 m or 3 nautical miles from the coast down to the 500 m isobath.

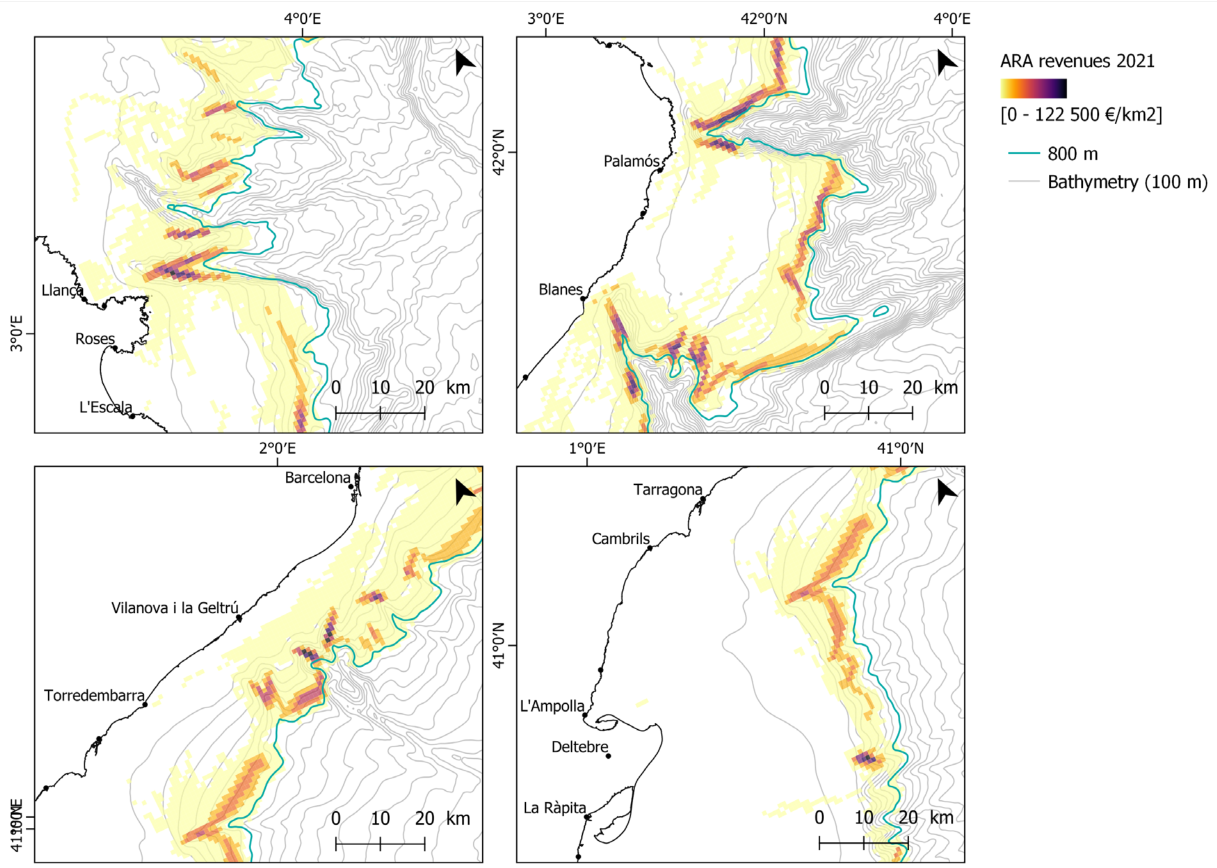

Figure 12. Spatial distribution of the annual revenues for the blue and red shrimp in 2021 off the ports of A: Llancà and Roses; B: Palamós and Blanes; C: Barcelona, Vilanova i la Geltrú, Torredembarra and Tarragona; and D: L'Ametlla de Mar, L'Ampolla and La Ràpita. Blue line shows 800 m isobath.

2.3. Spatial WMMAP fishing closures effectiveness: effort redistribution and spillover effect

Between 2014 and 2021, a total of 27 closure areas have been established in the GSA 6 (Spanish Mediterranean coast), 23 of which are permanent and 4 temporary, with different fisheries and ecological conservation objectives (e.g. protecting European hake juveniles, Norway lobster habitat recovery; Figure 13). The effects of a closure area are not straightforward and depend on various variables, such as area size, time since protection, species mobility and biology, habitat continuity, the presence of a buffer zone, or fishing surveillance.

In a technical report (ICATMAR 23-06), ICATMAR presented a proposal and preliminary results of a new monitoring methodology for all closure areas within the GSA 6 in order to evaluate the fishing effort trends, effort redistribution and spillover effects after the establishment of the closures, using fisheries data to evaluate before and after protection changes in fishing yields and effort around protected areas. The results showed an overall reduction of the fishing effort in both permanent and temporary closure areas after protection. In the case of temporary areas, fishing effort values do indeed decrease during the closing period, but this did not translate into an effective reduction in the yearly effort in the area. The reduction of the fishing effort inside the protected areas was not related with a redistribution of the fishing effort on the surrounding areas. In general, permanent closure areas showed good results for the spillover of middle-sized epibenthic and benthopelagic fishes. For territorial species such as *N. norvegicus*, permanent closures are effective at increasing density values and individual size inside the closure. We found spillover evidence in 6 out of 13 analyzed species (mullets, the four-spot megrim, the bottom-feeding sea robins of the Triglidae family, the blackbelly rosefish, the scorpion-fish and rockfish of the genus *Scorpaena*, and the John Dory, Table 1), with the first spillover evidence detected between 1 and 3 years after protection and stabilizing after at least 5 years of protection.

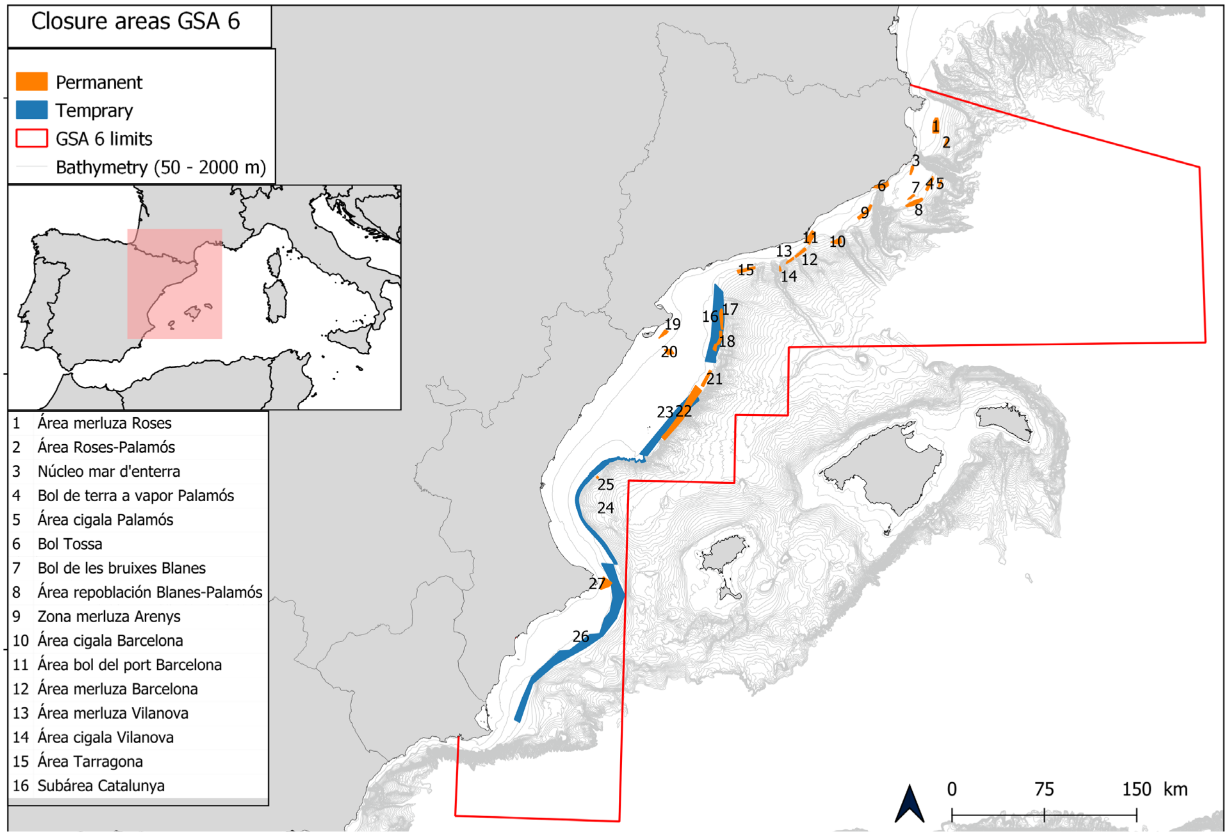

Figure 13. Closure areas in the GSA 6.

Table 1. Summary of the spillover effects for the 12 species analyzed in closure areas 1, 2, and 3. "LPUE increase" is indicated when landings per unit of effort (LPUE) for each species in each closure area increased after protection in the buffer areas. "LPUE gradient after" is indicated when there is a gradient in LPUE from nearest to farthest buffer around the closure area. "No habitat" is indicated when the closure area is not located within the species depth range distribution.

			1-Área merluza Roses		2-Área Roses-Palamós		8-Área repoblación Blanes-Palamós	
Species information		**Scientific name**	**LPUE increase**	**LPUE gradient after**	**LPUE increase**	**LPUE gradient after**	**LPUE increase**	**LPUE gradient after**
MAP species		*Mullus spp.*	yes	yes	no commercial habitat	no commercial habitat	yes	yes
		Merluccius merluccius	no	no	no	no	no	no
		Nephrops norvegicus	no	no	no	no	no	no
		Parapenaeus longirostris	yes	no	yes	no	yes	no
Epibentic species	Flat shaped	*Lepidorhombus boscii*	no	yes	no	no	yes	yes
	Oblong shaped	*Triglidae spp*	yes	yes	yes	yes	yes	yes
		Helicolenus dactylopterus	no commercial habitat	no commercial habitat	no commercial habitat	no commercial habitat	yes	yes
		Scorpaena spp	yes	yes	no habitat	no habitat	yes	yes
		Lophius spp	no	no	no	no	no	no
Benthopelagic species	Oval shaped	*Zeus faber*	no commercial habitat	no commercial habitat	no commercial habitat	no commercial habitat	yes	yes
	Anguilliform	*Conger conger*	no	no	no	no	no	no
Cephalopod		*Eledone cirrhosa*	no	no	no	no	no	no

3
Fisheries management advice

- The current approach to gear improvement as a means to receive compensation measures to other restrictions is showing signs of low engagement in the sector and is a strategy that could be revised. We would recommend to effectively regulate improvements to the fishing gear such as the shift to low-contact otter boards and more selective mesh sizes.

- Regarding temporary closures of the fleet, together with the redistribution of fishing days attending to the reduction implemented in the WMMAP, it would be interesting to open the discussion about the timing of these closures and its relation to the biology of the different target species. Linking both aspects might be challenging in the case of a multispecific fishery, but a discussion on the matter might bring on strategies that can better adjust to the protection of vulnerable phases of the life cycle of some species, such as the spawning and recruitment periods, especially if the temporary closures are combined with gear selectivity regulations.

- For the purse seine fleet, the fishery of the European sardine and the European anchovy are not easily distinguishable in the Northern GSA 6. Eventual management measures should then take into consideration both target species at the same level and ensure the protection of both their life cycles.

- The extension of the 1000-m FRA to 800 could act as a precautionary measure to deter eventual advances in fishing technology to fish deeper. It can also be an effective addition to the current strategy of building a permanent marine protected area network. However, it may pose challenges for control and enforcement without geographically defined limits other than a bathymetry line, due to the complex geomorphology of the fishing grounds areas.

- In the context of Marine Protected Areas, permanent closures are more efficient in reducing yearly fishing effort than temporary closures and therefore more suitable for promoting habitat recovery and generating a spillover effect. The establishment of the closures is not related to a redistribution of the fishing effort to adjacent areas, and spillover effect differs among species groups. According to our preliminary results, the strategy of building a network of closure areas along the coast seems worthy to be pursued and reinforced.

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