Considerations on the impact of fishing gear in bottom trawling in the NW Mediterranean Sea

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The impact of bottom trawling fishing gear in deep-sea ecosystems is well-studied (e.g. Norse et al., 2012; Roberts et al., 2006, Jones, 1992). Aside from the direct impacts on benthic fauna and their habitats (Watling and Norse, 1998), 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 produced 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), having different effects in cohesive or uncohesive sediments. The contact of the trawling gear with the seabed also causes the resuspension of sediments which are then transported by ambient currents (Puig et al., 2012; Martín et al., 2014b). The present document addresses a particular concern recently raised regarding the role of bottom trawling fisheries in the carbon balance of the ocean system, and also the efforts that are already being made in the Northern GSA6 to reduce the impact of deep-sea bottom trawling on sediment resuspension, and to preserve the organic-rich surface sedimentary cover over the fishing grounds.

The question about carbon flux in deep-sea sediments

The risk of carbon disturbance associated with the resuspension of sediments by trawling activities, was one of the objects of a recent multi-purpose study on the establishment of no-take MPAs to ensure the protection of biodiversity, resilience to climate change, and the continuity of global food provisioning (Sala et al. 2021). The study points at trawl fisheries sediment disturbance as a cause for remineralization of the organic carbon previously sequestered in marine sedimentary deposits after being resuspended. This mechanism will eventually increase the fluxes of CO_2 into the water column, which would contribute to ocean acidification and add to the buildup of atmospheric CO_2. However, the assumptions in this study have arisen concerns by various authors, mainly arguing that Sala et al. (2021) model exercise overestimates the CO_2 fluxes as they fail to acknowledge the many uncertainties that stem from trying to produce an estimate of organic carbon dynamics caused by fisheries at a global scale (Hiddink et al. 2022, Hillborn and Kaiser 2022).

In particular, the study by Sala et al. (2021) does not take into account the different degrees of reactivity of organic matter, (i.e. the capacity of the sediment to react with the aqueous medium and effectively remineralize into CO_2) deposited into the sedimentary record. According to the literature, the more reactive fractions of the sediment are remineralized in the upper sediment layers by natural processes, regardless of trawl disturbance, leaving only a fraction of organic carbon available in deeper sedimentary layers for remineralization by trawling, which generally is less reactive (Burdige 2006, Hiddink et al. 2022). Another inaccuracy in the study concerns the degree of penetration of the trawling otter boards in the sediment. Sala et al. (2021) assume that trawling resuspends the sediment of a 2.4-cm layer of the sediment bed, while field observations in continental shelf environments show that this value varies between 0.01 and 0.8 cm (Hiddink et al. 2022 and references therein). Finally, the uncertainty of the transport dynamics of the resuspended sediment is not adressed, and so it is assumed that all resuspended carbon is remineralized regardless of the ambient currents in the trawled area. For instance, the resuspended sediment in low current velocity environments would immediately sink back to the bottom and would likely not contribute the CO_2 flux through the water column, and more unlikely into the atmosphere. For all these reasons, Hiddink et al. (2022) conclude that Sala et al. (2021) could have overestimated the influence of bottom trawling in the carbon flux in the deep sea by one or more orders of magnitude.

Another response to the study argues that the global scope of the study by Sala et al. (2021) is unsuitable for the available data and generates undisclosed uncertainties (Hillborn and Kaiser 2022). Furthermore, they point to the absence in the proposed strategy of fisheries management and policies that have already proven to be effective, such as limits to the catches, restrictions of when and where fisheries can operate, and gear limitations. They also claim for a regional approach that highlights potential differences between regions, since most of the issues regarding fisheries can be solved at this scale (Amoroso et al., 2018).

The 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. They support the thesis that sustainable fisheries are systems that are managed, informed by science and have enforcement. Basing the solution of fisheries issues only following the considerations of Sala et al. (2021) study should be regarded rather as a reconversion of the fishing sector than as a management strategy, and is bound to have severe socioeconomic consequences.

A self-regulated initiative for reducing fishing gear impact on sediments

In recent years, tests have been carried out with a different type of otter boards which have less contact with the sea floor to reduce the direct impact of trawling gear with the seabed. Part of the fleet in the Northern GSA6 has already initiated the change towards less aggressive fishing gear with satisfactory results. In 2013, the bottom trawling fleet of the port of Palamós (NW Mediterranean Sea) that targets de deep-sea blue and red shrimp *Aristeus antennatus*, guided by the Palamós fishermen's guild, started a collaborative project with the scientific community to regulate the use of otter boards. This change in gear aimed to address three main aspects, namely the reduction of the capacity to resuspended sediments, the potential decrease in fossil fuel consumption by the fleet, and the potential recovery of benthic habitat.

Preceding studies in the area had shown that, with the use conventional demersal otter boards, the trawl-induced resuspended sediment clouds were highly concentrated and transported away from the fishing grounds towards deeper areas (Palanques et al., 2006; Puig et al., 2012; Martín et al, 2014b), impoverishing the surface sediments in organic carbon, which is the base of the food web (Martín et al, 2014c, Pusceddu et al., 2014). As a result, the Palamós fishermen guild initiated a self-regulated endeavor, aimed to conduct a more sustainable fishery and to protect their fishing grounds. The main goal was to convince the fishermen and the shipowners to accept a change of otter board for a new type that would be more environmentally-friendly. Six different types of otter boards available in the market were tested (Fig. 1, Palanques et al. 2018).

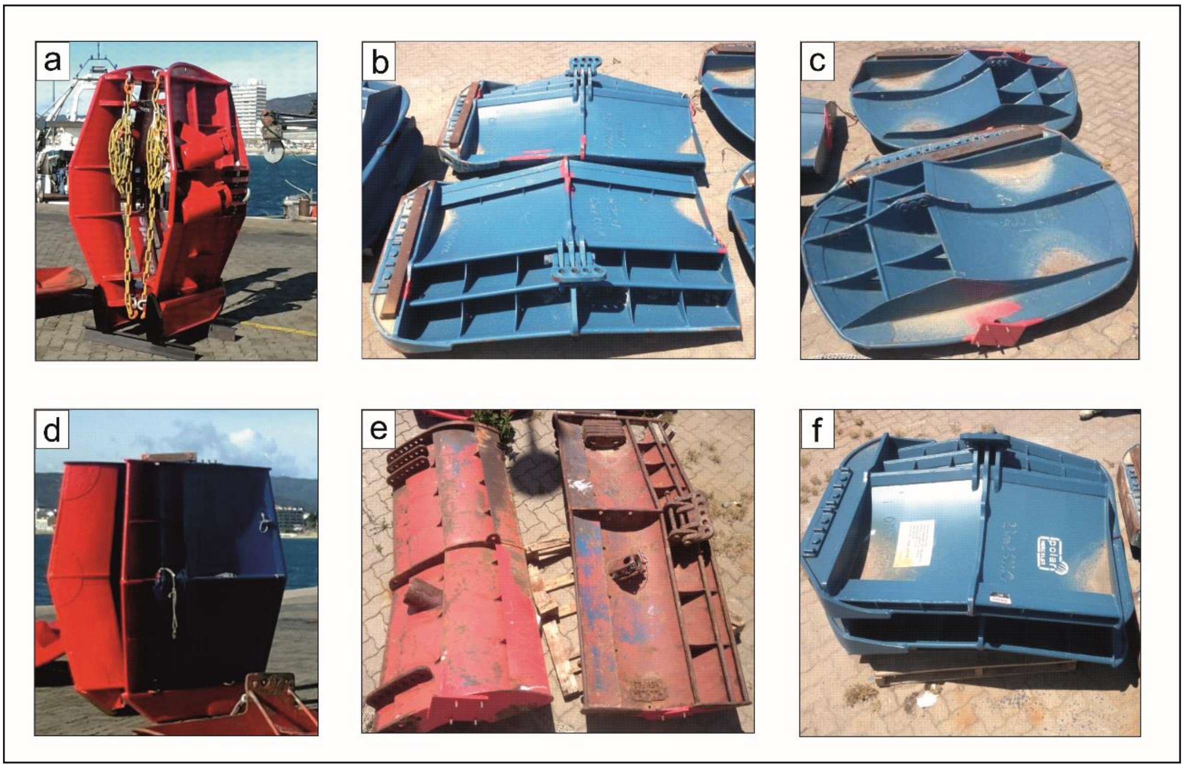

Figure 1: Six different models of otter boards selected to test for capacity of sediment resuspension. a: Injector Sparrow; b: Polar Mercury; c: Polar Neptune; d: Poly-Ice El Cazador; e: Thyboron T15-VF; f: Poly-Ice Viking. From: Palanques et al. (2018).

The study basically consisted in performing several hauls on the same fishing ground using different models of commercial otter boards, with the final objective to select those that would work properly with the use nets and that, based on their hydrodynamic behavior, would create less friction over the seafloor. During these trials, conducted in early 2015, an instrumented oceanographic mooring was deployed downslope of the monitored fishing ground to record currents and turbidity parameters and to identify the capacity of each type of otter board to resuspend sediment. To avoid any interferences from the rest of the trawling fleet, during the first 3 weeks of the mooring deployment, the monitored fishing ground was only visited by a single trawling vessel (Estrella del Sur III), using different otter boards on consecutive days, while the rest of the trawling fleet was fishing on different fishing grounds. After this period, all the trawlers were allowed to visit the monitored fishing ground, and we could study the cumulative resuspension effects of the entire fleet. The results demonstrated that the trawling nets equipped with demersal otter boards (i.e., in permanent contact with the seafloor) generated suspended sediment concentrations (SSC), reaching > 900 mg/l at 5 m above seafloor (Fig. 2). On the contrary, the nets equipped with pelagic and semi-pelagic otter boards did not cause any noticeable resuspension (Fig. 3).

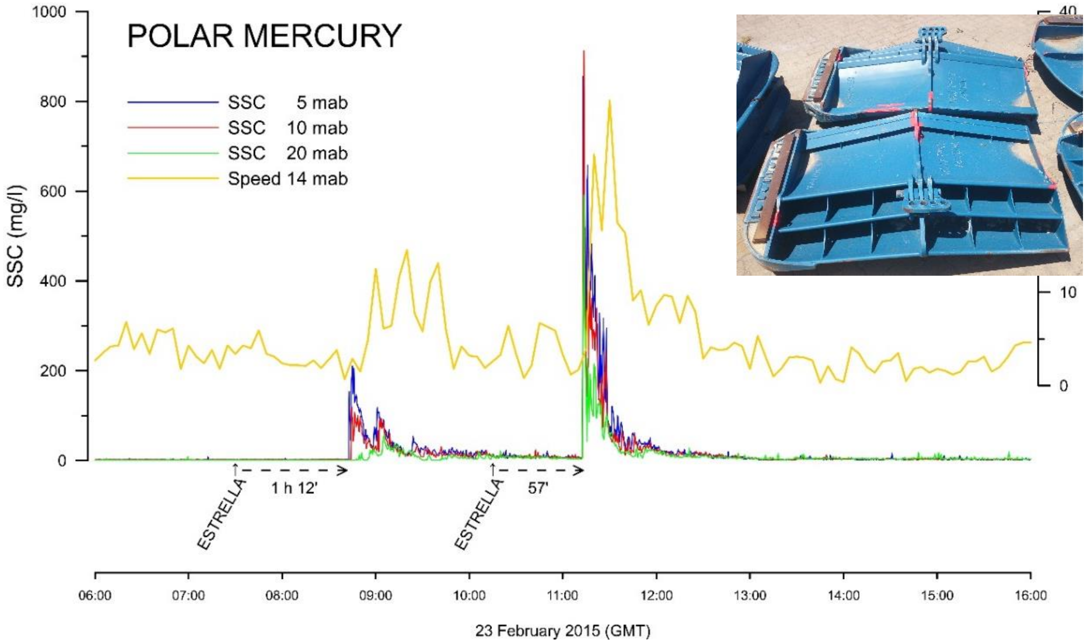

Figure 2. Time series of suspended sediment concentration (SSC) and current speed recorded at different heights (meters) above the bottom (mab) during the trial of the "Polar Mercury" demersal otter board model on 23 February 2015 collected by an instrumented mooring deployed in a tributary valley on the northern flank of Palamós Canyon. See location in Figure 3. Note the two resuspension peaks after the passage of the two hauls of the vessel Estrella del Sur III next to the mooring site. From: Palanques et al. (2018).

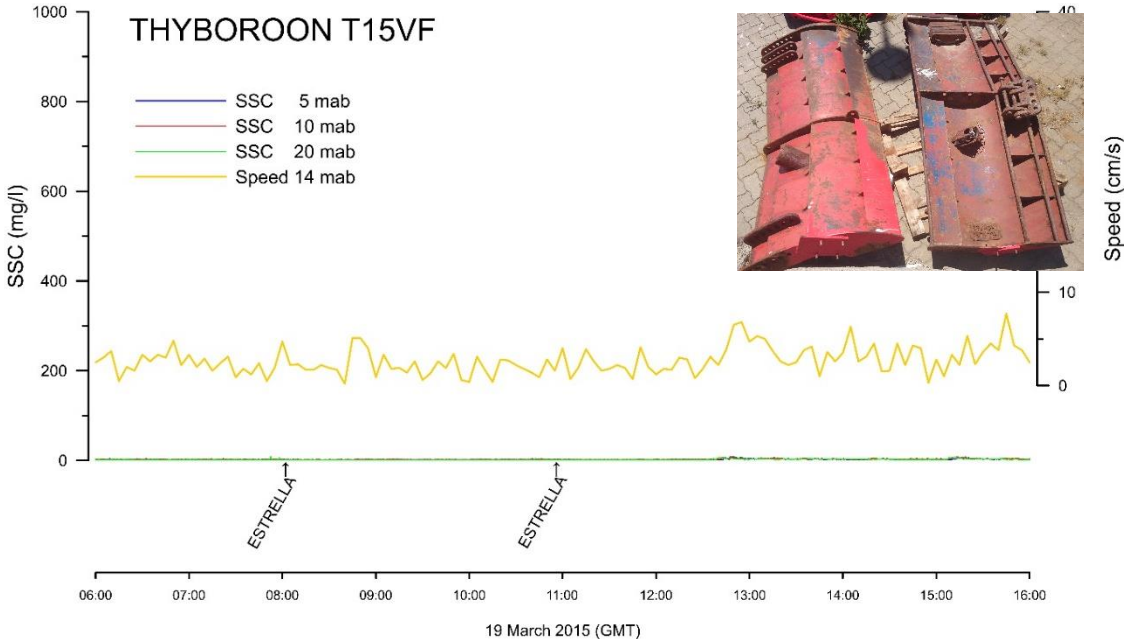

Figure 3. Time series of suspended sediment concentration (SSC) and current speed recorded at different heights (meters) above the bottom (mab) during the trial of the "Thyboroon T15VF" pelagic otter board model on 19 March 2015 collected by an instrumented mooring deployed in a tributary valley on the northern flank of Palamós Canyon. See location in Figure 3. Note the absence of resuspension peaks after the passage of the two hauls of the vessel Estrella del Sur III next to the mooring site. From: Palanques et al. (2018).

Based on these results, in 2017 the bottom trawling fleet of the port of Palamós started to change their gear to these low-contact otter boards, and in 2019, a year and a half after the change of gear, the sediment resuspension peaks observed had decreased significantly (Fig. 4).

The results of this study show that the use of low-contact otter boards would allow for the reduction of the impact of trawl fishing activities, and would contribute to preserve the integrity of the seafloor. The results also bring out the need for the fishing sector to effect a change that ensures a lower impact of the fishing gear on the benthic ecosystems.

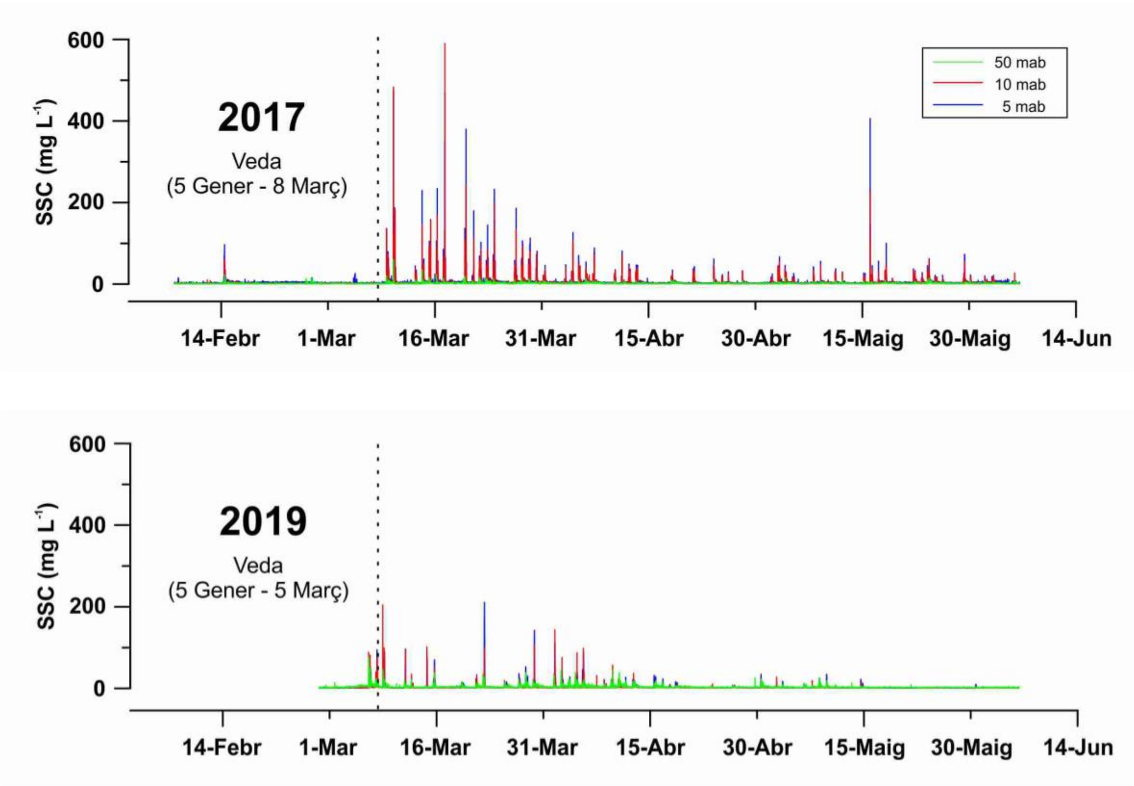

Figure 4: Time series of suspended sediment concentration (SSC) registered at 980 m depth in the northern wall of the submarine canyon of Palamós at the beginning of 2017, when the fleet started to gradually change to low-contact otter boards, and at the beginning of 2019, a year and a half after the change. From: Palanques et al. (2018).

Besides the effect of reducing fishing gear impact on sediments, the change of trawling gear may have other positive effects such as the potential decrease in fossil fuel consumption by the fleet. Although studies are in process to quantify the effect of the change to low-contact otter boards on fuel consumption, the preliminary tests suggest that low-contact otter boards promote a significantly lower consumption (~15 %) of fossil fuels during the trawling operation. In addition, observations done with Remotely Operated Vehicles (ROV) show a rapid recovery of the seabed after the implementation of restrictions to the fishing fleet with conventional otter boards (Vigo et al., 2023). Although there are no studies yet comparing the previous physical impact of conventional otter boards on the structure and biogeochemistry of the surface sediments compared to that of low-contact otter boards, it can be assumed that this effect would be reduced (several research initiatives are at present being conducted by scientific teams of ICM-CSIC and ICATMAR). The extent of this reduction as well as the consequences for territorial burrowing species such as the Norway lobster (*Nephrops norvegicus*) still need to be assessed, but there are certainly prospects of improvement.

Efforts are already being undertaken in the NW Mediterranean Sea to mitigate this impact while ensuring the sustainability of the sector.

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