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MINOUW

Science, Technology and Society Initiative to Minimize Unwanted Catches in European Fisheries

WP2. Technological and Social Solutions

Deliverable 2.6 Training Materials on Technological Solutions

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T2.6 Modifying existing fishing practices

D2.6 Training materials on the technological solutions developed and tested with end users (pdf and hard copies)

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Introduction

Fish capture methods in the case studies covered by the MINOUW project include otter bottom trawling, purse seining, trammel- and gill- netting, longlining and bivalve dredging (refer to the project deliverable D1.1 for a full description or to http://minouw-project.eu for a quick overview). Due to the different modes of operation of these five types of fishing, the technological solutions tested to enhance selectivity and reduce unwanted catches are different. The solutions tested were discussed with the fishers participating in the multi-actor sessions from mid-2015 to mid-2016, during the first year of the project (multi-actor process and technologies selected described in project deliverables D2.1 and D2.3). The field work was carried out during the second year of the project, from mid-2016 to mid-2017 approximately, and the results of the successful trials are produced here as a collection of reports/leaflets briefly describing the design, its properties and results. This material is intended for an audience of fishers and fisheries managers, without presuming strong knowledge of fisheries technology, and it can be used in demonstration sessions or seminars with stakeholders, or as lecture material in advanced fisheries courses, as planned in WP6 of the project.

The objective of the technologies tested was to reduce unwanted catches. Included in these unwanted catches can be non-commercial species and the undersized fraction of regulated commercial species (or less valuable specimens in TAC regulated fisheries, which usually are juveniles even if above legal size). In the first case, the devices are designed for *species selectivity* while in the second they are designed for *size selectivity*. Often a given design can achieve gains in both size and species selectivity. For towed demersal fishing (e.g. bottom trawl, dredges) reducing the bycatch of benthic invertebrates can, additionally, help maintain sea bottom biodiversity while reducing wear on the fishing gear and time spent sorting the catch.

The reduction of undersize (or above quota) fractions of regulated commercial species is of importance for compliance with the Landings Obligation (or discards ban) in the revised Common Fisheries Policy (Art. 15 of EU Reg. 1380/2013) and is expected to be beneficial to the fisheries industry because, in the short term, sorting time can be reduced and, in the medium and long terms, rebuilt stocks with larger sizes should generate higher economic returns.

Perfect size or species selectivity is almost impossible to achieve in practice. Size and species selectivity are rarely ideal, modifications may be too difficult or expensive to implement, or result in unacceptable loss of target individuals. The solutions tested under MINOUW are practical ones developed in cooperation with fishers that would not impose excessive costs on the producer or be difficult to monitor and enforce.

Fundamentals

The largest share of fish production in south European seas is harvested using either bottom trawl (demersal resources) or purse seine (small pelagic fish). Small scale fishing using bivalve dredges, set nets (trammel nets and gillnets) or longlines can be locally important and produce high quality seafood in small quantities. Bottom trawling (and other towed gears, such as dredges) is the most problematic fishing gear in terms of size and species selectivity. The other fishing gears studied here, in their standard configuration and when used properly, have relatively lower unwanted catches (SOMFI 2016, p. 52-60; Kelleher 2005).

Selectivity in bottom trawl

The fish selection process in bottom trawls is well known and has been the object of numerous studies in recent decades. A review of the effectiveness of conventional bycatch reducing methods was produced in Deliverable D2.8 of the MINOUW project. Trawl selectivity is strongly related to the mesh size of the codend, but is also affected by the number of meshes in the circumference of the codend, the length of the extension twine thickness, mesh geometry or catch size (Misund et al. 2002) A variety of devices and configurations have been used to improve the selectivity properties of bottom trawls, for example: larger meshes in different parts of the trawl, different mesh geometries (diamond, square, T90, hexagonal), sorting grids, escape windows and overall innovative design (Catchpole and Gray 2010; Suuronen 2008).

The effectiveness of a given design will depend critically on the behavioural response of the fish when encountering the trawl. Some species tend to swim towards the top part of the trawl extension and codend (e.g. whiting, Vogel et al. 2017). This escape reaction can be exploited by designing appropriate panels on the upper part of the trawl to facilitate escape of unwanted catches. The use of square mesh panels on the upper part of the extension piece have become mandatory in the North Sea and the discards of gadoids have significantly decreased, likely contributing to the arrest of the decline of stock biomass in these species (Heath and Cook 2015)

By-catch reducing devices made of a combination of sorting grids and escape panels have been effective in species selection for mixed fisheries, where the different organisms caught have contrasting behaviours, physical sizes and morphologies. For instance, in bottom trawl fisheries targeting crustaceans, semi-pelagic fish (blue whiting, boarfish) can be guided upwards to escape panels, while crustaceans are directed downwards towards the codend (Campos and Fonseca 2004).

Some types of netting, for instance square mesh and T90, are resistant to traction and will not close, facilitating water flow and maintaining sufficiently large openings for non-target fishes to escape. The type of netting and materials in the codend is important not only with regards to increasing the probability of escape of unwanted fishes, but also when considering other aspects related to profitability, such as quality of the retained catch and energy consumption of the trawler (related to gear drag) (Madsen et al. 2015).

Visual stimuli can also be used to direct fish along a path of escape within the trawl or through escape windows (Glass et al. 1995; Glass and Wardle 1995; https://www.sntech.co.uk). The use of artificial light stimuli to attract target species or repel unwanted catches has been demonstrated in some cases (e.g. Hannah et al. 2015), but further research on the different types of vision systems of marine organisms is needed and their behaviour during the capture process (Arimoto et al. 2010; WGFTFB 2012).

Selectivity in purse seine

Purse seines surround shoals of fish near the surface (in South European fisheries, generally small pelagic fishes). Fishers progressively close the net, concentrating the fish to facilitate their brailing or pumping onboard. The meshes employed in purse seines are small and in practice are not selective, i.e. they retain all the fish caught. Size or species selection should preferably be carried out early in the capture process, because survival of fish released decreases as they become crowded (Marçalo et al. 2008; Tenningen et al. 2012). Pre-catch identification using hydro-acoustic methods (i.e. sonar, echo-sounders) is well known and practiced by fishers in South European purse seine fisheries. Additionally, the mortality of fish released (“slipped”) from purse seines can be reduced by during the capture process by using an opening in the net to facilitate uncrowded escapes (Breen et al. 2012).

Selectivity in trammel net

Trammel nets capture fish through a variety of methods: trammelling or “pocketing”, gilling, wedging, and entangling (Erzini et al. 2006). In general, trammel nets show a dome selection pattern centred around a modal size related to mesh size. The selection range is, however, generally greater than for gill nets (Karakulak and Erk 2008). That is to say, a greater range of sizes is captured than for a gillnet with similar mesh size. The greater selection range, which is sometimes bimodal, is the result of the catch process being determined by more than one capture method (for instance, some individuals are gilled while others pocketed, for the same species: Erzini et al. 2006).

Size selection can be improved by decreasing the ratio between the inner and outer panels ("vertical slack", Misund et al. 2002, Erzini et al. 2006), inner panel mesh size (Erzini et al. 2006, Stergiou et al. 2006) and time / location of deployment.

However, species selectivity can be poor because this type of passive gear can catch most species encountering it. Furthermore, scavengers attracted to the organisms already caught in the net can in turn be caught. The accidental by-catch of endangered marine fauna (such as pelagic sharks, turtles, sea birds or marine mammals) can be an additional source of unwanted catches in trammel netting.

Selectivity in longline

Because the capture process of longlining is based on the feeding behaviour of marine organisms, good size and species selectivity can be achieved by the proper choice of bait, hook size, hook type (circle, J-shaped, wide-gape) and time or location of deployment (Misund et al. 2002). Longlining is a very selective fishing method and the accidental by-catch of endangered marine fauna (such as pelagic sharks, turtles, sea birds or marine mammals) can be further reduced by adding deterrent visual or acoustic cues ("pingers") to the fishing gear (Kaiser and Jennings 2002).

Selectivity in bivalve dredge

Bivalve dredges are towed gears with selectivity properties similar to bottom trawls (i.e. low control on size and species composition). They are built around a metallic frame with long teeth in the lower part that dredge the sediment and a bag that retains the catch in the aft part of the metallic frame. Selectivity can be improved by modifying the tooth length, increasing mesh size or changing the retaining bag from the traditional fibre net to a rigid metallic cage (Gaspar et al. 2001, 2003; Leitão et al. 2009). These modifications allow for more selective bivalve dredge fisheries, with lower impact on the sea floor and better product quality (Gaspar and Chícharo 2007).

Results from MINOUW

Selected results of the field tests carried out during the MINOUW field implementation phase (2016-2017) are presented in the following set of reports. The reports are intended to be self-contained, i.e. they can be used in communication activities (primarily, short-term courses to fishermen or fisheries controllers) individually and printed or extracted from the main document.
It is important to note that field tests were carried out in commercial fishing operations using voluntary fishers with their own fishing gear, comparing the specific technological modification described against normal practice in the fleet studied. The choice of technological modifications and the process leading to field testing those modifications are described in Deliverables D2.1 and D2.3

MINOUW training materials – Sheet nº 01

T90 netting on the bottom trawl extension piece to reduce unwanted catches

The EU discards ban embedded in Art. 15 of EC 1380/2013 EC, 2013 or Landing Obligation has the objective of reducing discards in EU fisheries and working towards more selective fishing by incentivising fishers to apply appropriate technical solutions, among other changes in fishing practices.

Investigating the effect of simple modifications of current bottom trawl designs are interesting because these modifications may work towards reducing unwanted bycatch, without undue changes to the fishing practices of fishers or expensive modifications that would entail additional costs.

Here we show the relative catch performance of a simple modification to the extension piece of a bottom trawl with regards to the two species that characterize the fishery, European hake *Merluccius merluccius* and red mullet *Mullus barbatus*, which are subject to the discards ban from Jan. 1st 2017 in the Mediterranean sea, for individuals below a minimum conservation reference size of 20 cm TL and 11 cm TL, respectively.

Our results show that using T90 netting in the extension piece can reduce the amount of undersize hake to 50% of that caught in the standard bottom trawl.

The diamond-mesh extension-piece of 53 mm, as used in NW Mediterranean bottom trawls and the experimental extension piece with netting turned 90º (T90) are shown below. The rationale behind this experiment is the improved selection properties of T90 nets, evidenced in trawl codends used in North European fisheries (Madsen et al. 2012; Wienbeck et al. 2011).

Design & experiment

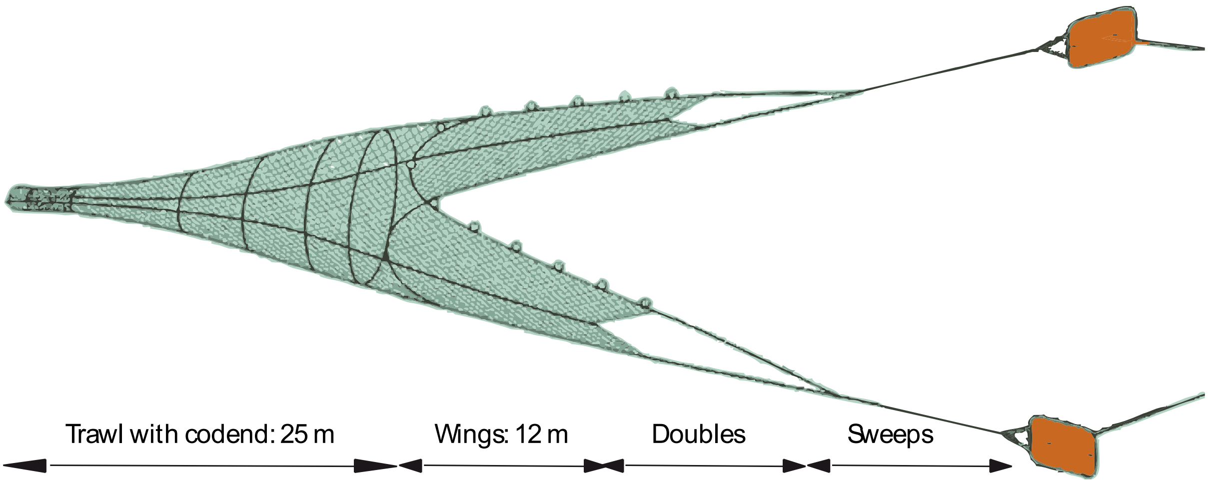
The sampling design consisted in paired hauls using a local commercial fishing vessel 15 m LOA and 261 kW. Twelve alternate trawl hauls were carried out on consecutive days over the same geographical coordinates during August and September 2016.

Tow time was limited to 1 h and towing speed was 2.7 – 2.9 knots.

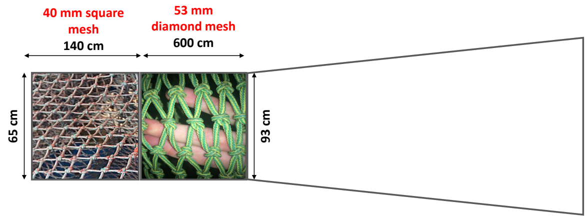
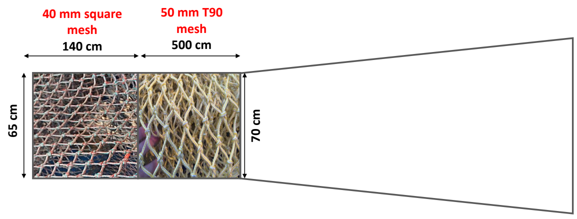
Specifications of the standard and modified bottom trawls

CODEND/ENTENSION PARAMETERS	DM53	T90
Nominal mesh codend size (mm)	40	40
Nominal mesh extension size (mm)	53	50
Netting material	PE	PE
Nº meshes around codend circumference	130	130
Nº meshes codend length	55	55
codend length (m)	1.40	1.42
Nº meshes extension circumference	206	140
Nº mesh extension length	81	100
Longitudinal extension length (m)	5.15	4.36

General description of the bottom trawl used



Detail of the experimental modification

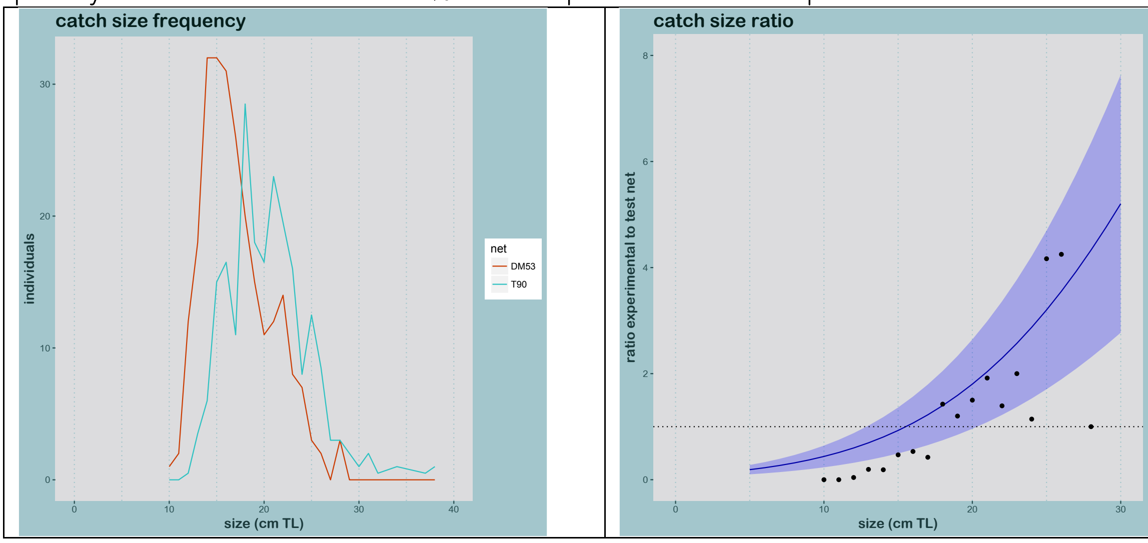
	Aft part of bottom trawl **standard configuration** with regulation 40 mm square mesh codend. Extension fitted with 53 mm diamond mesh (DM53)
	Aft part of bottom trawl **experimental configuration** with regulation 40 mm square mesh codend. Extension fitted with 50 mm T90 mesh (T90)

Results

For each target species, we compared the catch ratio of the standard trawl (control; 1) with that of the experimental trawl (2), with the catch comparison method of Holst and Revill (2009).

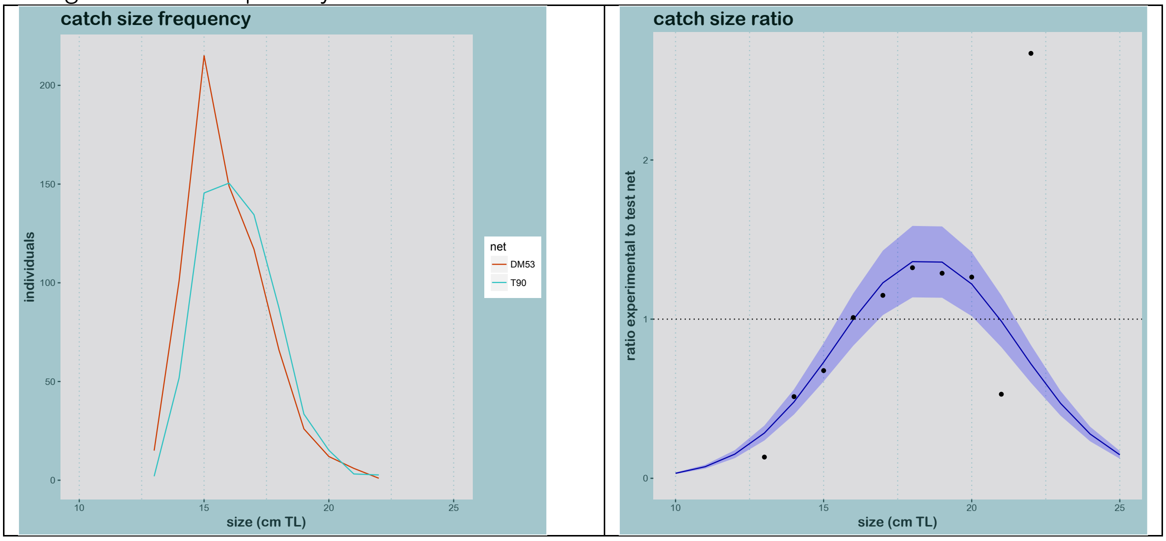
Hake (*Merluccius merluccius*)

The size frequency of hake was shifted to the right in the experimental trawl, with a modal length of capture around 18 cm TL, while the mode in the control trawl was 15 cm TL. The catch ratio shows that the experimental trawl has higher catches of hake larger than about 16 cm than the standard trawl, with a strong reduction in catches of individuals in the smaller size classes. The quantity of undersize hake was 52% in the experimental net compared to the standard net.



Red mullet (*Mullus barbatus*)

The size frequency of red mullet lies in a narrow range of 13 to 22 cm with a single peak at 15 cm for the control trawl and a model around 16 cm for the experimental trawl. The experimental trawl has a higher catch ratio in the 16 – 21 cm size classes approximately, but in both configurations the quantity of undersize fish was nil.



More information:

https://www.youtube.com/watch?v=nXiBu8uOU-M

Holst, R. and A. Revill. 2009. A simple statistical method for catch comparison studies. Fisheries Research 95: 254-259.

Madsen, N., Herrmann, B., Frandsen, R.P., Krag, L.A. 2012. Comparing selectivity of a standard and turned mesh T90 codend during towing and haul-back. Aquatic Living Resources, 25 3, 231-240.

Wienbeck, H., Herrmann, B., Moderhak, W., Stepputtis, D. 2011. Effect of netting direction and number of meshes around on size selection in the codend for Baltic cod Gadus morhua. Fisheries Research, 109 1, 80-88.

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MINOUW training materials – Sheet n° 02

Juvenile and Trash Excluder Device (JTED) to limit capture of unwanted species during trawling

In recent decades discard has been considered a main problem in fisheries management, as it accounts for a great part of the overall impact of fishing activities on the environment (Jennings amd Kaiser 1998; Ramsay et al. 1998; Sanchez et al. 2000; Gorelli et al. 2016). Together with socio-economic and ecological matters, discarding is also considered a moral issue, as the waste of natural resources is considered ethically wrong. Within this framework the reduction of unwanted catches in fisheries is one of the pillar of the reformed Common Fishery Policy of the European Union (Art. 14 & 15 of Reg. EC 1380/2013).

In the Mediterranean, the poor selectivity of trawlers is a challenging problem for the reduction of unwanted catches. Studies conducted over the past decade have shown that the selectivity of fishing gear can be improved through the use of innovative systems that enable the capture of certain species and in certain sizes (e.g. Valdemarsen and Suuronen 2003; Hall et al. 2007; Kennelly 2007; Lucchetti 2008).

We evaluated the use of a type of grid, named JTED (Juvenile and Trash Excluder Device) to limit the catch of juveniles in the "Sicilian type" bottom trawl net. In the Strait of Sicily, deep water crustacean fisheries are the most important fisheries in terms of landings and revenue (Gancitano et al. 2016). Among the target crustaceans, the deep water rose shrimp, *Parapenaeus longirostris* represented more than 40% of the total landings of bottom trawlers in the Strait of Sicily in 2015, with 6150 t valued at 39 million €. Unwanted catches ranged between 25 and 40% of the total catch with a huge amount of undersize deep water rose shrimp and European hake (*Merluccius merluccius*) (Milisenda et al. 2017), regulated with a Minimum Conservation Reference Size (MCRS), of 20 mm carapace length and 20 cm total length, respectively.

Comparing the catches of standard bottom trawl-net and the experimental trawl-net with JTED grids our results showed a reduction in the amount of undersize deep water rose shrimp and European hake up to 31% and 20%, respectively. Our grid design 1 resulted the best device for the reduction of catches of juveniles of these regulated species.

Design & experiment

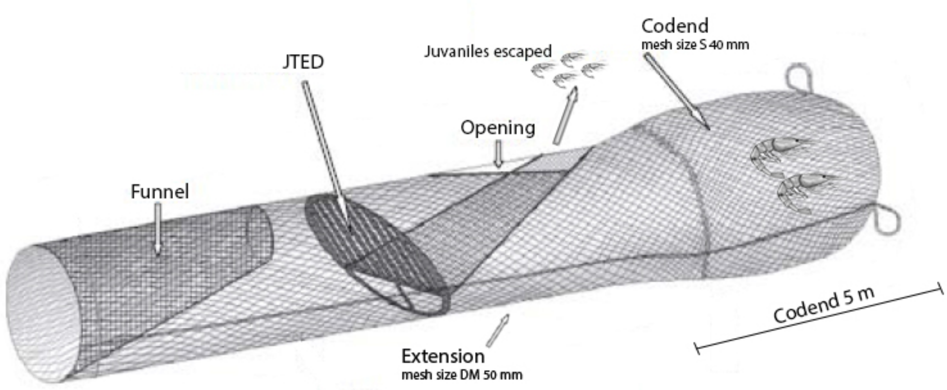
The rationale behind this experiment is the improvement of selectivity with the adoption of sorting grids during crustacean fisheries as evidenced by several authors (e.g. Bahamon et al. 2007; Eayrs et al. 2007; Pravin et al. 2011; Boopendranath et al. 2013). The sampling design consisted in repeated hauls using a local commercial fishing vessel 21.5 m LOA and 316 kW.

Picture of the local commercial fishing vessel used in the scientific surveys

Forty-eight trawl hauls were carried out on consecutive days over the same geographical coordinates during November 2015. In September 2017 a new survey was conducted with the same vessel for a total of further 42 hauls. During the surveys standardized haul using the experimental trawl net with grid and without grid (control) were carried out. Tow time was limited to 1 h and towing speed was 2.7 – 3.0 knots. The results hereafter reported concern only the 2015 survey.

General description of the bottom trawl used

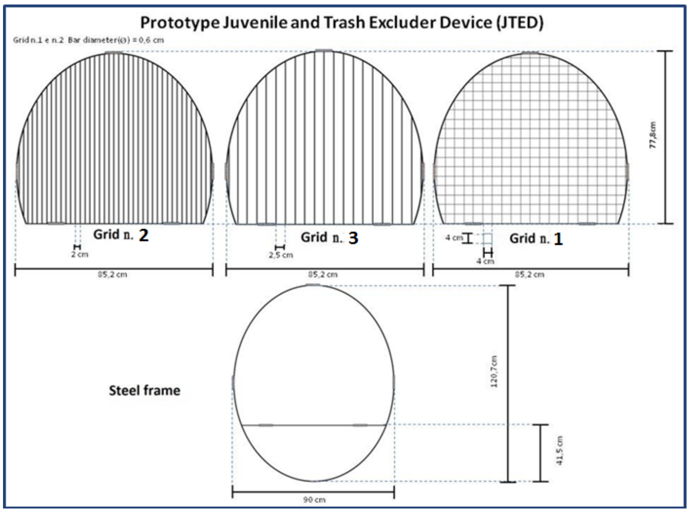
Among the several ways available in literature to increase escape opportunities for unwanted catch, in our case-study we used the configuration (opportunely adapted for our fisheries) proposed by Bahamon et al. (2007). The following figure show the scheme of the experimental bottom trawl net using sorting grid separators and separator panels.



Comparison of the codend / extension parameters between standard trawl-net (commercial type) and experimental trawl-net (used during the surveys); S: square – DM: diamond

CODEND/EXTENSION PARAMETERS	Experimental trawl-net	Standard trawl-net
Nominal mesh codend size (mm) -	S 40	DM 50
Nominal mesh extension size (mm)	DM 50	DM 55
Netting material	organic PA	organic PA - artificial PA
N° meshes around codend circumference	210	300
N° meshes codend length	125	120
Codend length (m)	5	6
N° mesh extension circumference	305	350

An interchangeable system was devised to adapt, on a fixed frame, grids with different selectivity. In particular, three different grids types were realized: Grid 1, Steel & Net, mesh size 40 mm square; Grid 2, Steel, space among the bars 2 cm; Grid 3, Steel, space among the bars 2.5 cm.



Measurements of the grids used during surveys in the Strait of Sicily.

Results

For both target species, deep water rose shrimp and European hake a comparison of the length frequencies distribution of (1) individuals escaped through grids, (2) retained in the cod-end during the hauls with grids and (3) retained in the cod-end during the hauls without grids (control), was performed. A mathematical model was used to assess the statistical difference among the length frequencies.

Deep water rose shrimp, *Parapenaeus longirostris*

Grid 1: the length frequency of the escaped hake showed a marked peak shifted to the left below the minimum conservation reference size, while most of retained portion in the cod-end was above this size, as in the control net. The statistical analysis confirmed differences among the three size frequencies.

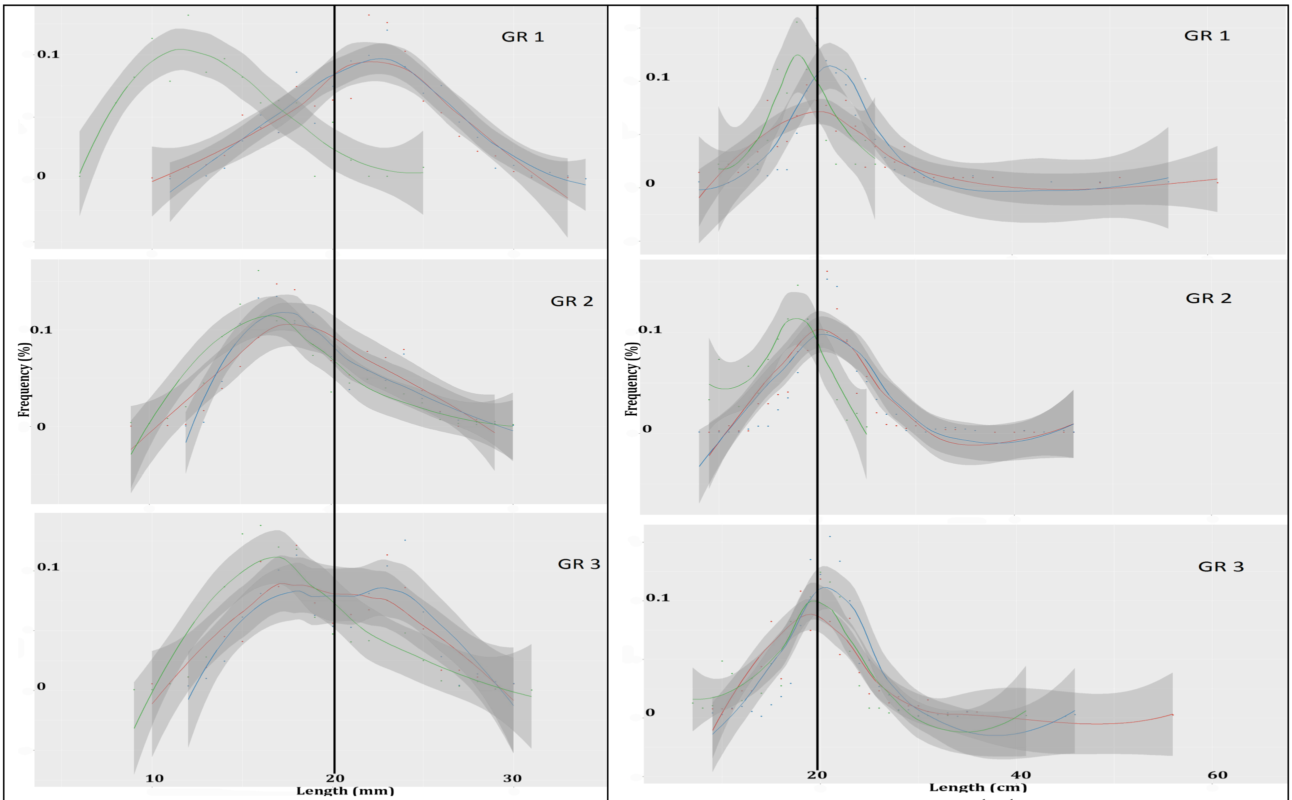
Grid 2: the length frequency showed a peak shifted to the left below the minimum conservation reference size. Contrary to grid 1 the portion of the retained individuals in the cod-ends over reference size was lower. Nevertheless, the statistical differences were shown.

Grid 3: the length frequency of the cod-ends showed two peaks, one shifted below and one above the minimum conservation reference size, respectively. On the contrary, the length frequency of the escapees showed a marked peak shifted to the left below the reference size. The overall size frequencies showed statistical differences.

European hake, *Merluccius merluccius*

Grid 1: the length frequency of the escaped hake showed a peak shifted to the left below the minimum conservation reference size, while most of retained portion in the cod-end was slightly over the reference size. Finally, the size frequency of the control showed a peak overlapping the reference size. The statistical analysis confirmed differences among the three size frequencies.

Grids 2 and 3: the length frequencies obtained with grids 2 and 3 were similar. The only difference consisted in a peak of the escaped fraction more shifted to the left with grid 2. The size frequencies did not show statistical differences (p-value > 0.05).



Deep water rose shrimp
cod-end (control: hauls without grid)
escaped-cod-end (hauls with grid)

European hake
cod-end (control: hauls without grid)
escaped-cod-end (hauls with grid)

More information

http://minouw-project.eu/

Bahamon, N., Sardà, F., Suuronen, P. (2007). Selectivity of flexible size-sorting grid in Mediterranean multispecies trawl fishery. Fisheries Science, 73(6), 1231-1240.

Boopendranath, M. R., Pravin, P., Gibinkumar, T. R., Sabu, S., & Madhu, V. R. (2013). Investigations on juvenile fish excluder cum shrimp sorting device (JFE-SSD). SpringerPlus, 2(1), 271.

Eayrs, S., Hai, N. P., Ley, J. (2007). Assessment of a juvenile and trash excluder device in a Vietnamese shrimp trawl fishery. ICES Journal of Marine Science 64,1598–1602.

Gancitano, V., Milisenda, G., Ben Meriem, S., Colloca, F., Arneri, E., Ceriola, L., Jarboui, O., Ben Abdallah, O., Gambin, M., Mifsud, R., Fiorentino, F. (2016). Assessment of deep water rose shrimp in the MedSudMed area. General Fisheries Commission for the Mediterranean, Scientific Advisory Committee (SAC – SCSA), Working Group on stock assessment of demersal species, Roma, 07-12 Novembre 2016. http://www.fao.org/gfcm/reports/technical-meetings/detail/en/c/471253/

Gorelli, G., Blanco, M., Sardà, F., Carretón, M., Company, J. B. 2016. Spatio-temporal variability of discards in the fishery of the deep-sea red shrimp *Aristeus antennatus* in the northwestern Mediterranean Sea: implications for management. Scientia Marina, 80, 1–10.

Hall, M. A., Nakano, H., Clarke, S., Thomas, S., Molloy, J., Peckham, S. H., Laudino-Santillán, J., Nichols, W. J., Gilman, E. L., Cook, J., Martin, S., Croxall, J. P., Rivera, K., Moreno, C. A., Hall, S. J. (2007). Working with fishers to reduce by-catches, in: Kennelly, S.J. (Ed.) By-catch reduction in the World's fisheries. Reviews: Methods and Technologies in Fish Biology and Fisheries, 7: pp. 235-288.

Jennings, S., Kaiser, M. J., (1998). The Effects of Fishing on Marine Ecosystems Advances. Marine Biology, 34, 201-352.

Kennelly SJ (ed) (2007) Bycatch Reduction in the World's Fisheries, Reviews: Methods and Technologies in Fish Biology and Fisheries Vol. 7. Springer, The Netherlands, p 288.

Lucchetti, A. (2008). Comparison of diamond- and square-mesh codends in the hake (*Merluccius merluccius* L. 1758) trawl fishery of the Adriatic Sea (central Mediterranean). Scientia Marina 72 (3), 451–460.

Milisenda, G., Vitale, S., Massi, D., Enea, M., Gancitano, V., Giusto, G. B., Badalucco, C., Gristina, M., Garofalo, G., Fiorentino, F. (2017). Discard composition associated with the deep water rose shrimp fisheries (*Parapenaeus longirostris*, Lucas 1846) in the south-central Mediterranean Sea. Mediterranean Marine Science, 18(1), 53. doi:10.12681/mms.1787

Valdemarsen, J. W., Suuronen, P. (2003). Modifying fishing gear to achieve ecosystem objectives. In M. Sinclair and G. Valdimarsson, eds. Responsible fisheries in the marine ecosystem, pp. 321-341. FAO and CABI International Publishing. 426 pp..

Pravin, P., Sabu, S., Gibinkumar, T. R., Boopendranath, M. R. (2011) Hard bycatch reduction devices for bottom trawls – a review. Fishery Technology, 47(2),107–118.

Ramsay, K., Kaiser, M. J., Hughes, R. N. (1998). Responses of benthic scavengers to fishing disturbance by towed gears in different habitats. Journal of Experimental Marine Biology and Ecology, 224, 73-89.

Sanchez, P., Demestre, M., Ramon, M., Kaiser, M. J. (2000). The impact of otter trawling on mud communities in the northwestern Mediterranean. ICES Journal of Marine Science, 57, 1352-1358.

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MINOUW training materials – Sheet n° 03

Artificial lights in trawl fisheries targeting shrimps in Northern Tyrrhenian Sea: effects on target species and by-catch

The EU discards ban embedded in Art. 15 of EC 1380/2013 EC, 2013 or Landing Obligation has the objective of reducing discards in EU fisheries and working towards more selective fishing by incentivising fishers to apply appropriate technical solutions, among other changes in fishing practices. Investigating the effect of simple modifications of current bottom trawl designs are interesting because these modifications may work towards reducing unwanted bycatch, without undue changes to the fishing practices of fishers or expensive modifications that would entail additional costs.

The objective of this intervention is to evaluate the effects of artificial lights attached to the headline of the trawl net to 1) reducing fish bycatch (and discards), and 2) increasing catches of targeted crustaceans. Trawl fishermen in Tuscany started to use lights on nets in deepwater rose shrimp fisheries in recent years. Those lights are claimed to be efficient in increasing the catch rates of shrimps; currently, there is no scientific evidence in support of this anecdotal belief. The aim of the study is to evaluate whether those lights are efficient in increasing the catch of the target species, and, at the same time, in decreasing by-catch and discards.

The study area comprised the commercial fishing grounds of the continental shelf and slope in the northern Tyrrhenian Sea (NW Italy). Those fishing grounds are routinely exploited by the trawl fleets of Porto Ercole and Porto Santo Stefano, practicing mixed bottom trawl fisheries targeting European hake, *Merluccius merluccius*, red mullet, *Mullus barbatus*, horned octopus, *Eledone cirrhosa*, deep-water rose shrimp, *Parapenaeus longirostris*, as well as Norway lobster, *Nephrops norvegicus*, in deeper waters.

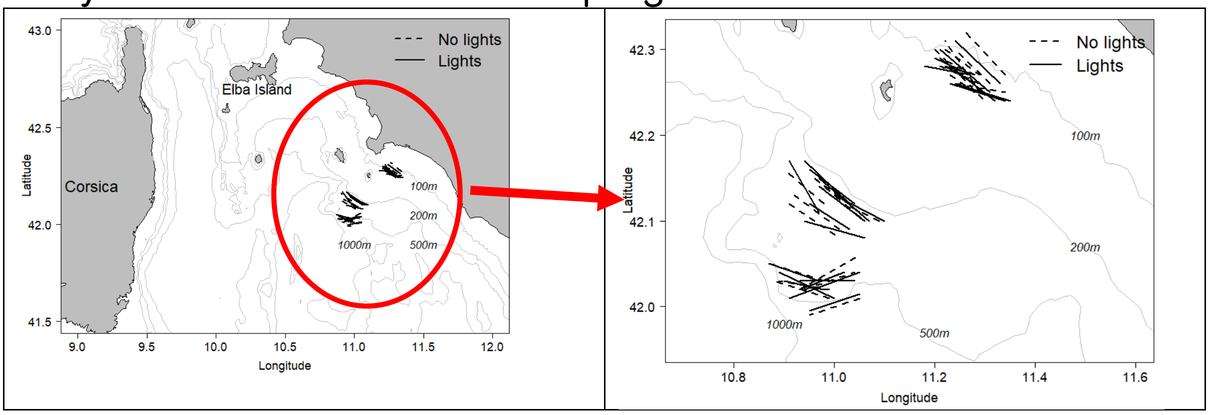
The use of artificial lights on the headline of the trawl net seems to be effective in reducing the capture of European hake under the MCRS in the fishery targeting deep-water pink shrimp. The use of artificial lights placed on the headrope of the trawl net can be a simple and economical solution to reduce unwanted catches of European hake without loss of the commercial fraction.

Design & experiment

The sampling design consisted in paired hauls using a local commercial fishing vessel (FV Angela Madre, 22.7 m LOA and 210 kW), that was the same over the duration of the experiment, alternating the control bottom trawl net with the one equipped with lights on the headline. The field trials were conducted on consecutive days in three different seasons (summer 2016, autumn 2016, and spring 2017), for a total of 52 hauls (26 with lights, 26 without lights). Trawling was performed at 3.1-3.4 knots. In each haul, the trawl net was equipped with SIMRAD sensors to monitor the geometry of the net during the towing. In addition, a TD probe (DST centi Star:Oddi) was placed on the net to record bottom temperature.

Sorting was performed by fishermen to avoid any bias in discarding practices. The commercial fraction was divided by species, and total weight by species and commercial category recorded. Individual size (total length for fish, mantle length for cephalopods and carapace length for crustaceans) was measured from sub-samples by species and commercial category. Total weight of discards was recorded, and sub-samples brought to the lab for sorting and identification at the lowest taxonomic level possible (i.e., species). For each taxon, number of individuals and total weight were recorded. For each haul and for each taxon identified (both in the commercial and discarded fraction), biomass and density indices (kg/km^2 and N/km^2) were calculated (swept area method, Sparre and Venema, 1992).

Study area and location of the sampling sites



Images of the experimental trials

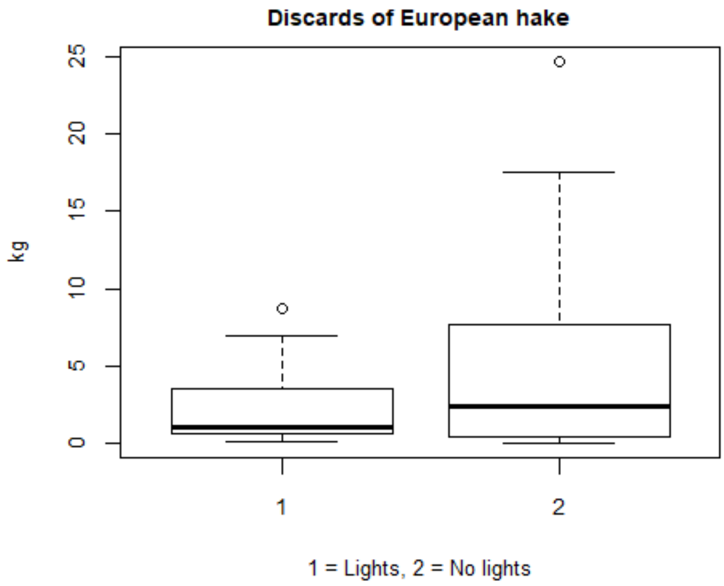
Top and center left: deployment of the commercial fishing trawl with lights on the head rope. Center right: detail of artificial light model employed in the experiments. Bottom: trawl catch with and without lights.

Results

The results show that the use of lights affects the unwanted catches of species regulated by MCRS (mostly fish), and in particular European hake, *Merluccius merluccius*. The analysis shows that unwanted catches of European hake are significantly higher in the hauls performed without lights attached to the headline of the trawl net (27.4 kg/km^2 vs 11.6 kg/km^2). The use of lights did not affect the catch rates of commercial catches. In particular, using lights did not affect the catch of the main target species, deep-water rose shrimp, *Parapenaeus longirostris*.

This is the first study aimed at investigating the effects of artificial lights on the catches of trawl nets. The results, although indicating a promising scenario, need to be confirmed by further investigations, both in time and in space. Limited experiments carried out in the Catalan sea using a similar methodology on a bottom trawler targeting Norway lobster (*Nephrops norvegicus*) at 400 m depth provided comparable results.

Box-and-whisker plot showing the discard rates of European hake with lights (1) and without lights (2).



More information:

https://www.youtube.com/watch?v=YZCvXHuKI34&feature=youtu.be

Hannah R.W., Jones S.A., Lomeli M.J.M, Wakefield W.W. 2011. Trawl net modifications to reduce the bycatch of eulachon (*Thaleichthys pacificus*) in the ocean shrimp (*Pandalus jordani*) fishery. Fish. Res. 110, 277-282.

Hannah R.W., Lomeli M.J.M, Jones S.A. 2015. Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: strong but opposite effects at the footrope and near the bycatch reduction device. Fish. Res. 170, 60-67.

Miller T.J. 2013. A comparison of hierarchical models for relative catch efficiency based on paired-gear data for US Northwest Atlantic fish stocks. Can. J. Fish. Aquat. Sci. 70: 1306-1316.

Sartor P., Sbrana M., Reale B., Belcari P. 2003. Impact of the Deep Sea Trawl Fishery on Demersal Communities of the Northern Tyrrhenian Sea (Western Mediterranean). J. Northw. Atl. Fish. Sci. 31, 275-284.

Sparre P., Venema S.C. 1992. Introduction to tropical fish stock assessment. FAO Fish. Tech. Pap. 306. FAO, Rome.

MINOUW training materials – Sheet nº 04

Modified slipping procedures to improve survivorship of sardines in the purse seine fishery

Introduction

The EU discards ban in Art. 15 of EC 1380/2013 EC, 2013 or Landing Obligation has the objective of reducing discards in EU fisheries and working towards more selective fishing by incentivising fishers to apply appropriate technical solutions, among other changes in fishing practices. Exemptions to the landing obligation can be claimed when high survival of discarded fish can be demonstrated conclusively.

In small pelagic purse seine fisheries, despite advances in sonar technology and highly experienced fishers, it is currently difficult to determine the species composition and a reliable quantity and size of fish before the catch has been densely crowded towards the end of the haul and after potentially fatal crowding densities. It is also difficult to control the catch size, and excessively large catches may exceed the quota or the hold capacity of the vessel. "Slipping", the release of the entire catch or portions of the catch from the purse seine, is a common method of regulating the size and quality of the catch, leading to post-harvest mortality of unwanted catches. In the case of the sardine (*Sardina pilchardus*) fishery, slipping is due to over quota catches, and the standard way of doing it is known to cause a significant amount of mortality (Stratoudakis et al. 2002). To mitigate slipping mortality, a new method was tested, the "Modified Slipping", which is uses weights to lowering the float line creating an opening that allow fish to escape alive from the nets.

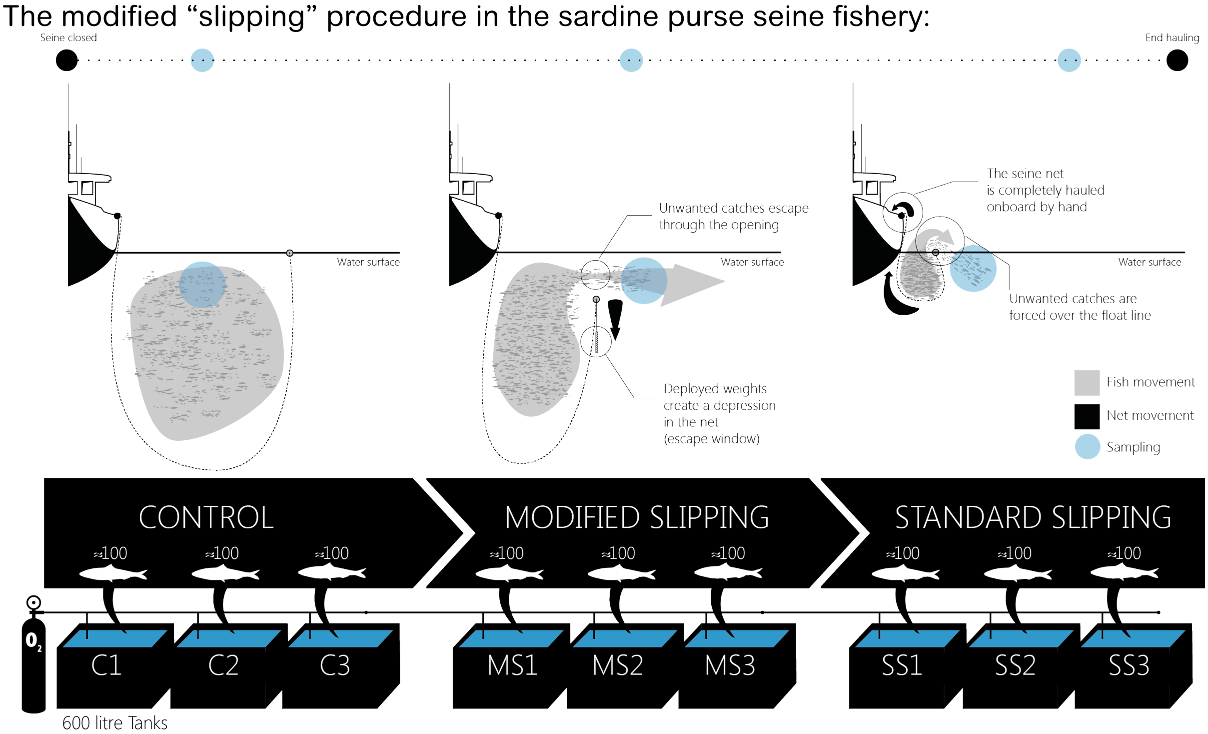
Our results show that using the modified slipping technique improves survivorship of the released sardines from 10-15% to 45-50%.

Design & experiment

Two slipping procedures for the sardines (*Sardina pilchardus*) were evaluated: the first one is based on the fastest, easiest and most extensively used technique in the purse seine fleet in the Algarve (Standard slipping) and second is based on a more complex technique that uses weights to lowering the float line which is used by some fishing captains in the Algarve – Portugal (Modified slipping).

Fishing trials to test the practicability and efficiency of different slipping techniques for the sardines were carried out. One survival experiment was performed by obtaining sardines from one commercial fishing trip comparing two different slipping methods (standard and modified) and a control. Fish were transported to the laboratory and monitored in captivity for 28 days. Survival, scale loss, physiological and biological (weight, length) parameters were measured. The survival of sardines over time was modelled using a parametric Weibull mixture distribution model.

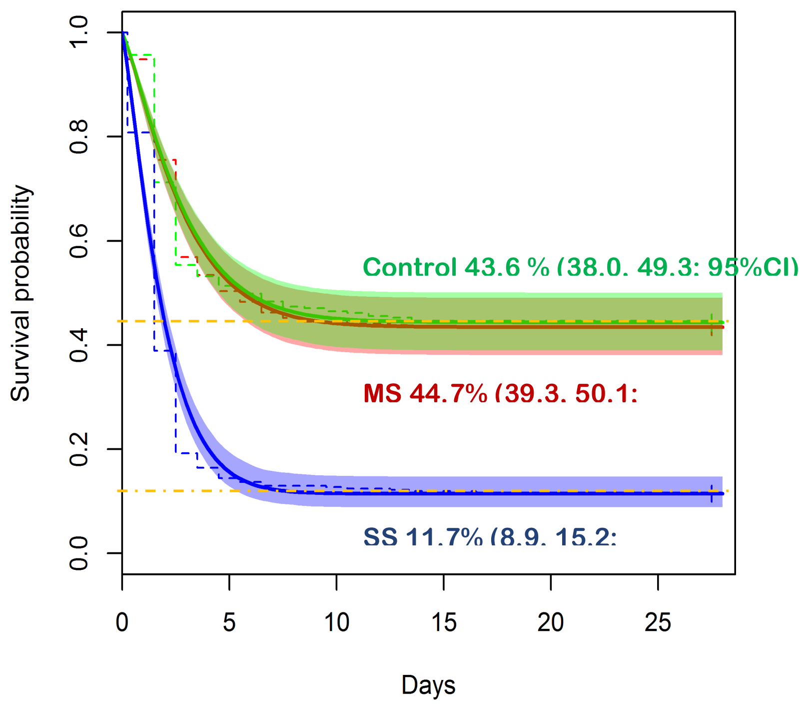
The modified “slipping” procedure in the sardine purse seine fishery:



In Marçalo et al. 2017 Submitted to PLOSOne

Results

Survival of sardine under two experimental conditions (SS: Standard Slipping; MS: Modified slipping) against control (non-slipped sardine). The chart shows that the survival of sardine under the modified technique is not statistically different than non-slipped sardine.



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The survival at asymptote (with 95% CI) was estimated at 43.6% (CI: 38.0 to 49.3) for the control, 44.7% (CI: 39.3 to 50.1) for the modified slipping and 11.7% (CI: 8.9 to 15.2) for the standard slipping treatments.

The estimated time to asymptote was shorter for the standard slipping treatment at 9.8 days (8.9 to 13.0) compared to the other two treatments 14.6 days (10.8 to 16.2), confirming that all delayed mortality had been observed within the 28 days.

Median sardine scale loss for the first two days in captivity for both of the two slipping treatments was of 48.8 and 70.6 % for the modified and standard slipping respectively, with the standard treatment showing significant differences from the control (42.3 %) and modified treatment for the relevant pair groups.

Using a modified slipping technique during purse seine operations, may significantly improve survival of slipped pelagic fish.

The results of the present study demonstrate that using a modified slipping technique during purse seine operations, may significantly improve survival of slipped pelagic fish.

The most important outcome is that complete bunting and ultimately slipping over the headline, causes more physical injury and reduces the probability of survival of slipped fish (3 times lower than controls or modified technique).

The use of the modified slipping technique during purse seining operations implies an application of the weights to submerge the floating line prior to the complete bunting, the fish escapes freely out of the net, the number of weights depends on the size of the window needed which is directly related to the size of the catch to be released. When mix schools are present, usually sardines swim on top and chub mackerel at the bottom; during the sardine ban, sardines must be released and fishermen keep the chub mackerel. Therefore, this method is very practical and easy to use which favours the acceptance of the fishermen to use it to obtain cleaner catches and/or release excess or unwanted catch.

More information:

EU Common Fisheries Policy (CFP) Reform: https://ec.europa.eu/fisheries/cfp_en

International Guidelines on Bycatch Management and Reduction of Discards: http://www.fao.org/fishery/nems/40157/en

Stratoudakis, Y.; Marçalo, A. (2002). Sardine slipping during purse-seining off northern Portugal. ICES Journal of Marine Science 59: 1256–1262.

http://minouw-project.eu/the-slipping-method-can-a-net-modification-improve-by-catch-survival-rates/

*Training material produced by EU H2020 project "**Science, Technology and Society Initiative to minimize Unwanted Catches in European Fisheries**" (MINOUW)*
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MINOUW training materials – Sheet n° 05

Modifications to the metallic grid bivalve dredge, featuring a Bycatch Reduction Device

Introduction

The low selectivity of many dredging gears inevitability results in some level of unintended catch and not all individuals captured will be landed. Although a more efficient and selective dredge was recently introduced in the Algarve (South Portugal) bivalve fishery, the amount of by-catch is still high (Gaspar et al. 2001; 2003). In some periods (late spring, early summer), it was observed that the quantity of by-catch could surpass the catch of the target species (Gaspar and Chícharo 2007). Although in the Portuguese dredge fishery most discarded species are invertebrates (bivalves, gastropods and echinoderms), most catches are only sorted at the end of the fishing day which may decrease the survival of discarded individuals (Gaspar and Monteiro 1999; Gaspar et al. 2003). Therefore, efforts to reduce the by-catch in Portuguese dredge fisheries must be carried out in order to modify the grid dredge to further improve selectivity and minimise by-catch. We believe that the amount of unwanted catch can be significantly reduced by the introduction of **bycatch reduction devices (BRDs)** in dredges as observed in trawls.

In the present work, in order to reduce by-catch, a prototype dredge frame was designed and tested. This frame consisted of a rigid grid, made of stainless steel mounted at a 45-50° degree angle in the middle of the retention system of the dredge. Thus, individuals larger than the openings could be expected to be guided upwards to the escape exit, while smaller individuals should pass through the openings of the frame.

Both by-catch and discards in abundance and biomass were fewer (62.0% and 76.5% less in numbers and in biomass, respectively) in the BRD-equipped dredge (BRD-D); the BRD-D resulted in a decrease of 46.9% in numbers and 44.7% in biomass of the target species probably due to the decrease of the dredge efficiency; and the amount of debris was lower in the BRD-D, being almost two to four-fold less the debris retained in (St-D) decreasing the timing needed to sort the catch.

Design and experiment

Fishing surveys were carried out in 2017 (off Fuzeta and Vila Real de Santo António, southern Portugal and off Lagoa de Santo André, Occidental coast of Portugal) on-board the IPMA research vessel “Diplodus”. The samples were collected on sandy bottoms between 3 and 8 m depth, using a standard dredge (St-D) and BRD-equipped dredge (BRD-D). Six types of BRDs were tested and consisted of a rigid grid, made of stainless steel mounted at a 45-50º degree angle in the middle of the retention system of the dredge, aiming to guide part of by-catch individuals and debris to an opening on the top of the dredge (Fig. 1). Three of the BRDs had a square mesh grid (SM) (mesh size of 31, 41 and 51mm) whereas the other 3 consisted in a grid with 31, 41 or 51 mm bar spacing (BG). BRDs with square meshed grids and bar grids are referred to as SM and BG, respectively. To compare the catch from BRD-D with St-D, two identical dredges were towed simultaneously side-by-side. For each BRD, 5 to 11 tows were performed. Every tow was conducted for 5 min. at 2 knots, the speed currently used by commercial dredgers. The duration of dredge hauls was measured from the time the winch stopped paying out the towing cable to the time when the winch was restarted. A total of 96 tows were performed.

Fig. 1. Modified dredge showing the BRD used in the experiments.

Results

There were caught 115,198 individuals (40,380 from BRD-D and 74,818 from St-D) that corresponded to 667.7 kg (231.1 from BRD-D and 436.6 from St-D). The target species (*Spisula solida* and *Chamelea gallina*) dominated the catches, comprising respectively 96.1% and 89.7% of the total catch in abundance and biomass, being of 95.8% and 87.6% for the St-D and of 96.7% and 94.2% for BRD-D.

Regarding fishing yields (the proportion of the catch that is landed) it was observed that for all pairs the mean fishing yield were consistently higher for the St-D (Fig. 2). Mean fishing yields ranged from 6,434 to 10,452 g/5 min. tow and between 2,772 and 5,786 g/5 min. tow for St-D and BRD-D, respectively. Notwithstanding, Kruskal-Wallis Anova and paired t-test analysis (or Mann-Whitney) did not detect statistically significant differences between dredges, independently of the dredge pair comparison analysed.

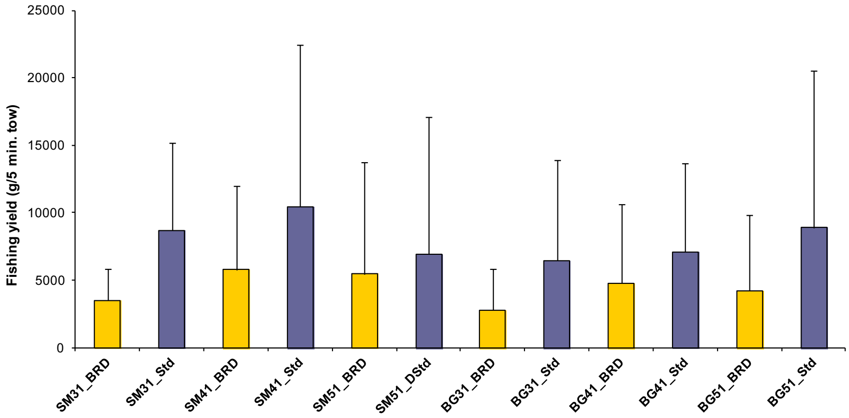

Figure 2. Comparison of the mean fishing yield obtained for dredges equipped with (yellow) and without (violet) BRDs. SM–Square mesh grid; BG–Bar grid; BRD–BRD-equipped with dredge; Std–Standard dredge.

The proportion of by-catch was always higher in the catches from **St-D** than from **BRD-D** either in weight or number. The mean proportion of by-catch in weight varied from 2.3 to 22.2% (12.3±6.9%) in **BRD-D** and ranged between 11.4 and 37.6% (23.5±9.5%) in **St-D**. In number, the mean proportion of by-catch ranged between 1.6 and 26.4% for **BRD-D** and between 3.1 and 23.8% for **St-D**. The ANOVA on ranks analyses carried out revealed the inexistence of significant differences on the proportion of by-catch in weight and number. However, pair comparisons analysis, showed statistically significant differences between the dredges with and without squares mesh BRD devices.

The length frequency distributions obtained for *Spisula solida* and for each tow combination (**BRD-D** vs **St-D**) are shown in Fig. 3. The mean SL obtained for all combinations ranged between 26.9 and 28.6 mm being similar for all pairs (For **BRD-D** and **St-D** respectively: SM31- 28.1, 28.6 mm; SM41- 27.1, 27.0 mm; SM51- 26.9; 27.4 mm; BG31- 27.7, 27.8 mm; BG41- 27.3, 27.0 mm; BG51- 27.4, 27.9 mm). Despite the similarity of both mean SL and shape of the SL frequency distributions, the results from the Kolmogorov–Smirnov test showed statistically significant differences between all of them.

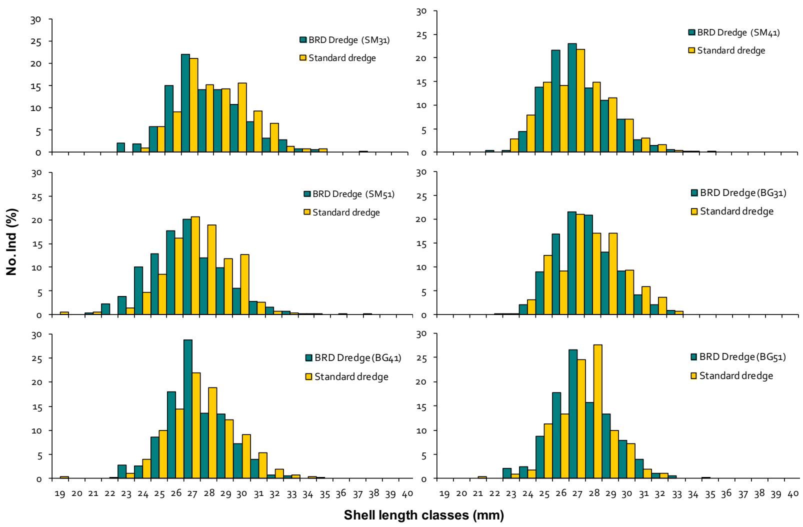

Figure 3. *Spisula solida*. Shell length frequency distributions for each tow combination (BRD-equipped dredge *vs* standard dredge). SM - Square meshes grid; BG – Bar grid.

As it was expected, the amount of debris was lower in the **BRD-D**, being almost two to four-fold less the debris retained in **St-D** (Mean values. For **BRD-D** and **St-D** respectively: SM31- 4.66 kg, 15.52 kg; SM41- 5.46 kg, 12.52 kg; SM51- 8.01 kg, 13.81 kg; BG31- 7.65 kg, 20.92 kg; BG41- 5.98 kg, 16.35 kg; BG51- 1.81 kg, 7.44 kg). Nevertheless, the results of both ANOVA and t-test or Mann-Whitney showed that these differences are not statistically significant.

Conclusion

Although the use of BRD was effective in reducing by-catch, discards and debris it also affected the amount of the target species that entered the dredges, decreasing fishing yields, which is related to the decrease of the dredge efficiency during the tow. The loss of fishing yields by around 40% is certainly outside the limits for fishermen to accept the use of BRD in dredgers, even if by-catch reduction is exceptionally good. Notwithstanding the use of BRDs show promise for by-catch and discards reduction in the Portuguese dredge fishery.

More information:

EU Common Fisheries Policy (CFP) Reform: https://ec.europa.eu/fisheries/cfp_en

Gaspar, M.B., Chícharo, L.M., 2007. Modifying dredges to reduce by-catch and impacts on the benthos. In: By-catch reduction in the world's fisheries (S. Kennelly, ed.), Springer: pp 95-140.

Gaspar, M.B., Dias, M.D., Campos, A., Monteiro, C.C., Santos, M.N., Chícharo, A., Chícharo, L., 2001. The influence of dredge design on the catch of *Callista chione* (L. 1758). *Hydrobiologia* 465: 153–167

Gaspar, M.B., Leitão, F., Santos, M.N., Chícharo, L., Damásia, D., Chícharo, A., Monteiro, C.C., 2003. A comparison of direct macrofaunal mortality using three types of Portuguese clam dredge. *ICES J Mar Sci* 60(4): 733–742.

Gaspar, M.B., Monteiro, C.C., 1999. Indirect mortality caused to juveniles of *Spisula solida* due to deck exposure. *J Mar Biol Assoc UK* 79(3): 566–568.

International Guidelines on Bycatch Management and Reduction of Discards:
http://www.fao.org/fishery/nems/40157/en
http://minouw-project.eu/can-modified-dredging-gear-reduce-discards-in-clam-fisheries/

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MINOUW training materials – Sheet n° 06

Use of a guarding net to reduce catches of unwanted species in monofilament trammel nets from the Algarve (southern Portugal)

Trammel nets are among the most widely used static gears in southern European waters, targeting species such as cuttlefish, soles, hake, rays, sea breams and red mullets. Monofilament trammel nets have low species selectivity; a study in the Algarve (southern Portugal) reported 105 species of fish and invertebrates were discarded, with 49.4% of the total catch in numbers discarded.

One of the goals of the Common Fisheries Policy is to promote more sustainable fisheries by reducing discards of unwanted species through the development and implementation of technical solutions. Here we report on fishing trials comparing standard cuttlefish métier monofilament trammel nets with trammel nets modified with a strip of multifilament netting (termed "selvedge" or, more exactly, "guarding net") on the bottom between the footrope and the trammel net. The purpose of the guarding net is to reduce the catches of unwanted species, thereby providing savings in terms of time needed to clean the net.

The results of the fishing trials showed that bycatch abundance and biomass were lower (41.8% and 17.3% respectively) in the trammel nets with a guarding net. Timing the removal of the main bycatch species showed significant savings in time and labour (approximately 33%) in trammel nets with a guarding net.

Design & experiment

The trammel net métier selected for this study was that for cuttlefish. The standard nets consisted of a 120 mm stretched mesh inner panel (0.3 mm diameter monofilament) and 600 mm stretched mesh outer panels (0.6 mm diameter). The modified trammel nets had a 3 mesh high strip of 140 mm stretched mesh (210/12 polyamide) between the footrope and the trammel net.

Standard trammel net

52 PE Ø 7

3	600 mm	PA 199	0.60 Ø
40	120 mm	PA 995	0.30 Ø
3	600 mm	PA 199	0.60 Ø

55.20 PE Ø 7

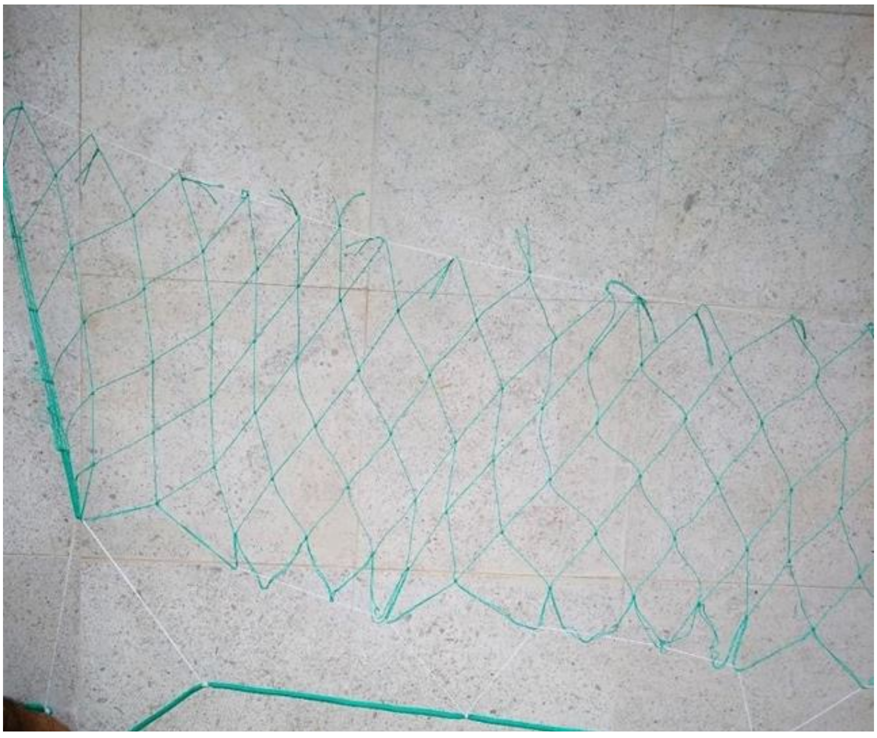
Trammel net with guarding net

52 PE Ø 7

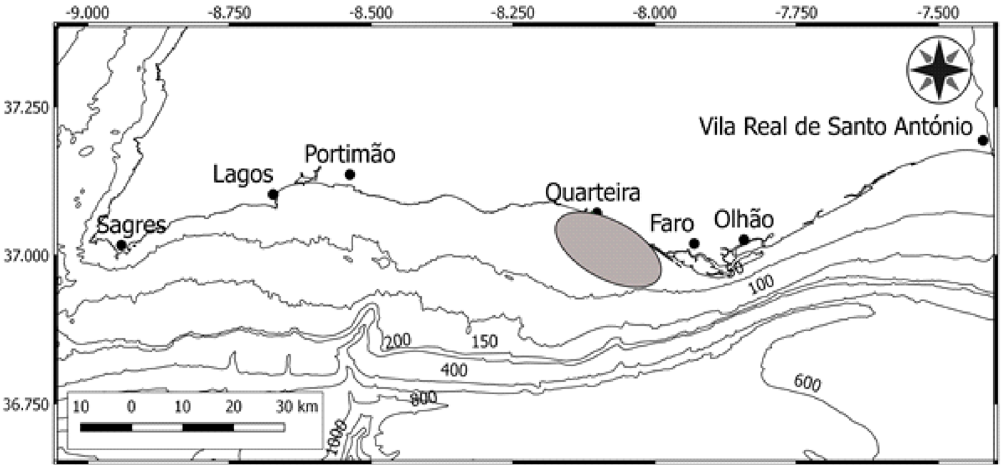
3	600 mm	PA 199	0.60 Ø
40	120 mm	PA 995	0.30 Ø
3	600 mm	PA 199	0.60 Ø
3	140 mm	PA 995	210/12no

55.20 PE Ø 7

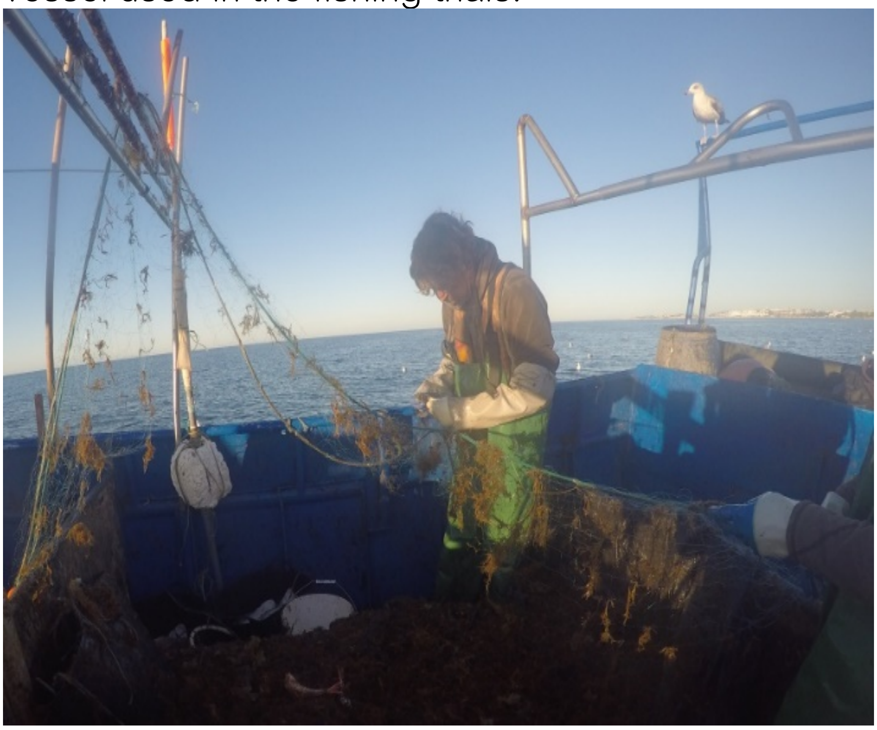
Guarding net used in the fishing trials



Normal commercial fishing practices were followed with nets set at dawn and hauled approximately 24 hours later, at depths between 10-30 m, from October 2016 to February 2017. A total of 15 standard nets (45 m) and 15 nets with guarding net (45 m) were fished, with a gap of 2 m between series of 3 nets of each type. Fishing took place near the port of Quarteira in the south of Portugal.



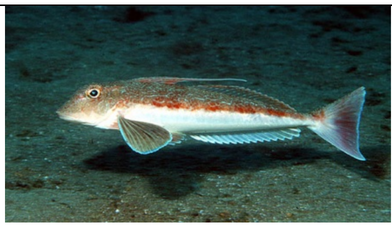
Removing the catches and cleaning the nets on board the commercial vessel used in the fishing trials.



Results

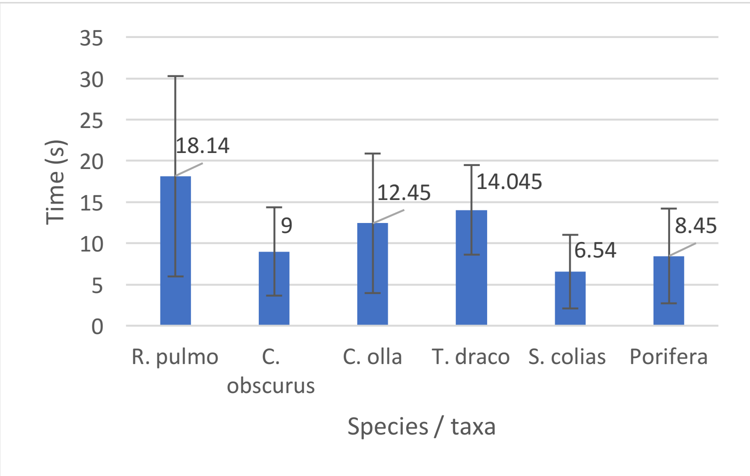
Catches of bycatch species (discard species with no commercial value) were lower (n = 411, 45.4 kg) in the trammel nets with a guarding net, than in the standard trammel nets (n =706, 54.9 kg).

Most important non-commercial discards

Species		Net with guarding net (n)	Standard net (n)
Chelidonichthys obscurus		79	209
Trachinus draco		81	121
Sphaerechinus granularis		7	77
Cymbium olla		14	39
Pinna nobilis		5	11

However, the total values of the catches of the two types of nets differed: 647 € for the trammel net with the selvedge compared to 1043 € for the standard trammel net. This was due to the dominance of soles and bastard soles in the commercial catch and the relatively few cuttlefish that were caught. Soles and bastard soles come into contact with the trammel net near the footrope so their catches are reduced when a selvedge is used. Normally in this fishery cuttlefish dominate the commercial catch and their catches are not expected to be significantly by the use of a guarding net. Thus, the results are influenced by the unusually poor fishery for cuttlefish in 2016/2017. Mean average removal times for the six most important bycatch taxa (85% of bycatch by numbers for the modified nets and 73% for the standard trammel nets) ranged from 6.5 to 18.1 s per individual. Our calculations show that trammel nets with a guarding net will require approximately 33% less time to remove these species. Extrapolating these results to the total lengths of trammel nets used by the local and coastal vessels, a considerable savings in time and labour is expected if guarding nets are adopted by the fleet.

Average removal time for the 6 most important bycatch taxa



More information:
Aydin, I., Gokce, G., and C. Metin. 2013. Mediterranean Marine Science, 14: 282-291.
Erzini, K., Gonçalves, J.M.S., Bentes, L., Moutopoulos, D.K., Hernando Casal, et al. 2006. Fisheries Research 79: 183-201.
Gonçalves, J.M.S., L. Bentes, R. Coelho P. Monteiro, J. Ribeiro, et al. 2008. Fisheries Management and Ecology 15: 199-210.
Metin, C., Gökçe, G., Aydın, İ. and İ .Bayramiç. 2009. Turkish Journal of Fisheries and Aquatic Sciences, 9:133-136.
Szynaka. M.J. 2017. Reduction of by-catch and discards in the Algarve small-scale coastal fishery using a modified monofilament trammel net. MSc Thesis, Master of Science in Aquaculture and Fisheries, University of the Algarve, 76 pp.

*Training material produced by EU H2020 project "**Science, Technology and Society Initiative to minimize Unwanted Catches in European Fisheries**" (MINOUW)*
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MINOUW training materials – Sheet nº 07

Modifications to spiny lobster trammel net to reduce unwanted catches

Trammel nets have been the main fishing gear for spiny lobster, *Palinurus elephas*, since the 1960s-1970s in the Mediterranean, when the use of traps started to be abandoned due to their low productivity and this coincided with an increase in fishing effort due to the modernization of the fishing fleet. Lobster trammel net fishery is the most relevant for the 2004-2015 period, in terms of effort (21.9% or 3,204.1 fishing trips/year), landings (13.8% or 58.4 tons/year) and revenues (25.7 % gross revenues or 999,674 €/year) in Mallorca Island. The fishery operates in summer and has an important commercial by-catch fraction that contributes to the revenues of the fishery. However, fishermen themselves have expressed their concern to ensure the lobster fishery sustainability by reducing any potential impact in agreement with the EU discards ban embedded in Art. 15 of EU Reg. 1380/2013 (EC, 2013) or Landing Obligation. Three simple changes in the trammel nets have been tested with the objective of reducing the production of discards in trammel net fisheries targeting the spiny lobster. In parallel, we tested the survival to capture of undersized spiny lobsters to explore the suitability of requesting an exemption to the landing obligation.

Our results show that there are no relevant differences in fishing revenue and on weight of discards in trammel nets using two different fibres or the guarding net in the footrope. However, the species composition of the discards fraction was different when using the guarding net. Interestingly, undersized spiny lobsters captured with the trammel net showed high survival on the laboratory. Therefore, it is recommended that an exemption from the EU landing obligation regulation for undersized lobsters is accepted for the Balearic Trammel Net fishery. Releasing undersize lobsters will be beneficial for stock conservation.

Design & experiment

We tested three deployments of trammel nets differing in 1) the type of fibre (standard polyamide multifilament, PMF; or a new polyethylene multi-monofilament, MMF); or 2) in the use of “greca”, which is a guarding net mesh piece added to the foot rope, intended to prevent some invertebrates to climb the net from the sea bottom and prey upon the commercial catches. We analysed the results in terms of commercial biomass, revenues and species composition of commercialized catches and unwanted catches.

The sampling consisted in on-board surveys in three boats from two ports carried out in 2015 and 2016. A total of 1550 netting walls corresponding to 70 trammel nets and 35 fishing trips were surveyed. The fishing depth ranged from 63 to 130 m. The average soaking time was 45 hours. The handling of the catch was generally fast; disentangling any items from the net takes 2 minutes at most.

A trammel net set consisted of several (usually between 10 and 30) panels (hereafter netting walls) each approximately 100 m long and with a mesh size of 160 mm. The manufacturing material could differ between nets and also between the netting walls of the same net. The two manufacturing materials tested were either the standard polyamide multifilament (PMF) or a new polyethylene multi-monofilament (MMF) (Fig. 1a, b). A total of 981 PMF and 499 MMF netting walls were sampled. Additionally, conventional MMF nets were compared with MMF nets with an additional modification, the so called “greca”, also referred to as a guarding net. The greca is a piece of net approximately 20 cm high made of a thicker nylon material and a mesh size of 45 mm, that is sown to the bottom of the main net along its entire length (Fig. 1c). The greca is thought to reduce the capture of unwanted benthic organisms. Trammel nets to test the effect of the greca were composed by 20 netting walls alternating between 10 MMF with greca and 10 MMF without greca. Data from a total of 14 trammel nets deployments were recorded; in total 70 netting walls with and 70 without greca.

Additionally, short-term survival (7 days) was assessed for the spiny lobster. Sixteen undersized lobsters (less than 90 mm carapace length) were transferred into small, aerated and refrigerated tanks and transported to an onshore laboratory (LIMIA facilities). There, the lobsters were placed in a 5000 litre fiberglass tank and supplied with a continuous flow of 100 μm filtered and refrigerated water; the temperature was maintained below 18°C. The tank was also equipped with plastic tub shelters. The individuals were fed once per day with fish.

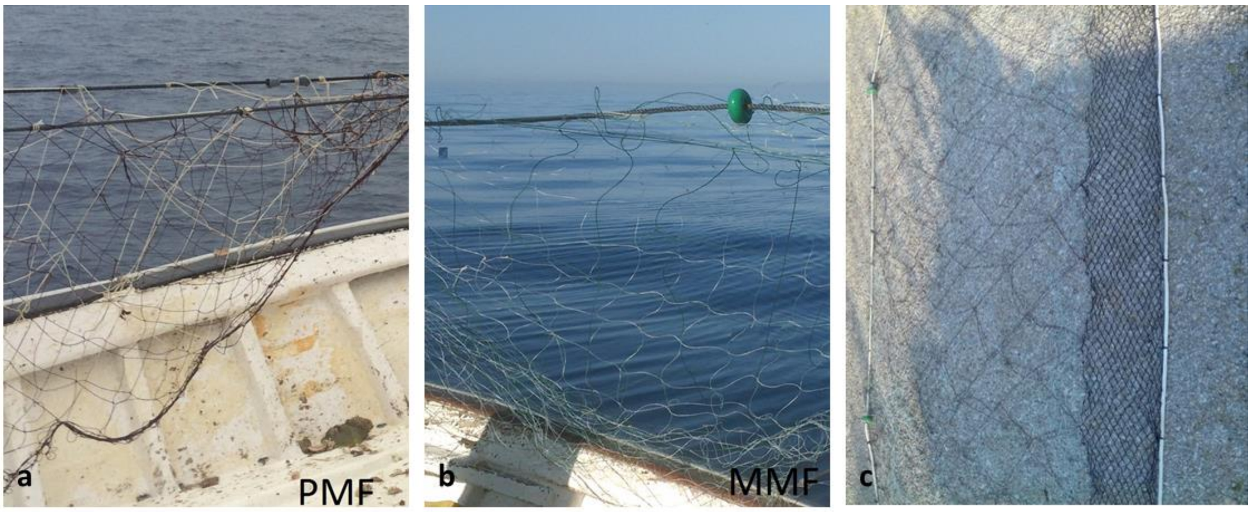

Figure 1. Spiny lobster trammel nets: a) standard polyamide multifilament, PMF; b) polyethylene multi-monofilament, MMF; c) with “greca” or guarding net attached to the footrope.

Results

A total of 706 items, from 19 species, comprised the wanted or marketable catch. As expected, the most frequently recorded species was the spiny lobster, but other highly prized species such as *Scorpaena scrofa* (17.68 €/kg[1]) or *Zeus faber* (20.94 €/kg[1]) were also frequently caught. The total number of discarded species was 47. The number of discarded animals was 1,465. The most frequent discards were elasmobranchs (mainly rays). But it is also noteworthy that the 5th most commonly discarded species was the target species, i.e. undersized spiny lobster. The number of discarded items per netting wall ranged from 0 to 4, with a median of 1. The biomass caught ranged from 0 to 4.6 kg / per netting wall (median 0.03 kg and mean of 0.68 kg).

The proportions of netting walls/panels with some marketable catch were similar in both types of net material: PMF = 0.31 versus MMF = 0.28 (Fig. 2). The estimated mean revenue in netting walls with some marketable items was also similar: PMF = 41.5 € versus MMF = 42.3 €. The mean revenue for an average trammel net (22 netting walls) was similar in the two types of fibre: PMF = 262.1 €/net and MMF = 242.5 €/net, but with high variability.

Concerning the standard MMF vs MMF + greca comparison (Fig. 2), the differences in the probability of obtaining some commercial catch were relevant, with the deployment sing greca producing higher commercial catch: MMF = 0.33 versus MMF + greca = 0.44. However, the estimated mean revenue was not different: MMF = 40.5 € versus MMF + greca = 39.5 € per netting wall. Combining these estimates, the differences in the expected mean revenues from the pooled net (22 netting walls) was 90.0 €/net higher in the MMF + greca combination, but with high variability (from 540.9 to -331.7 €/net).

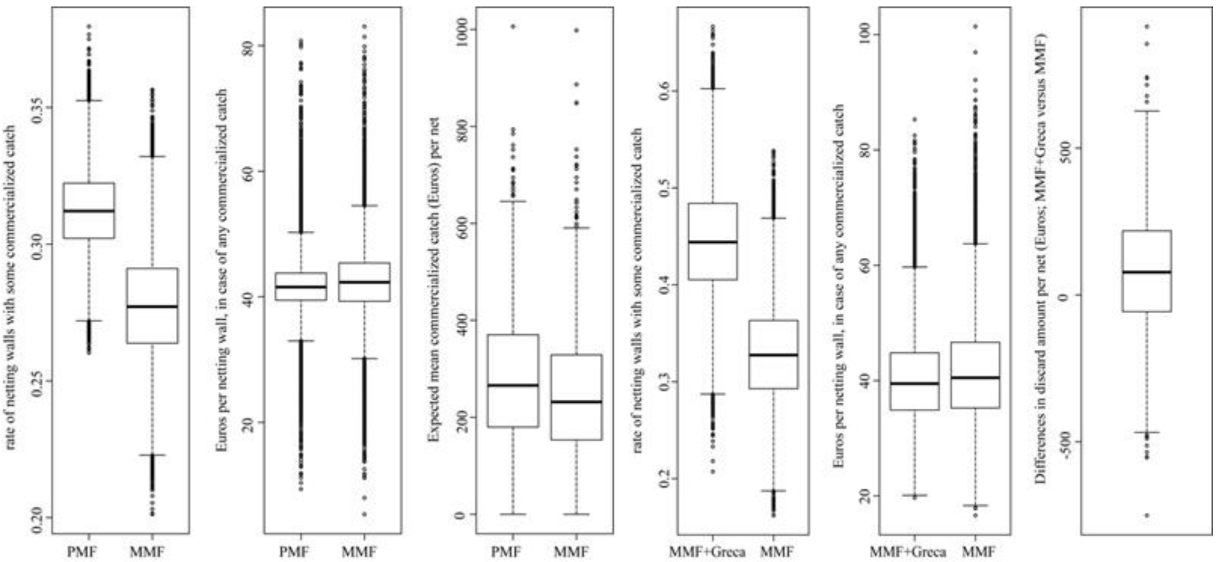

Figure 2. Comparing PMF versus MMF and MMF versus MMF + greca by (i) the ratio of netting walls with some catch (left panels); (ii) the revenue (€) of the commercialized catches or the weight of the discards per netting wall with some catch (middle panels); and (iii) the revenue (€) of the commercialized catches or the weight of the discards for an average (22 netting walls) net (right panels). Only items attributable to a given netting wall were used in these comparisons.

[1] Ex-vessel price

The MMF + greca netting walls tended to retain some unwanted by-catch more frequently than the MMF netting walls, but of lower mean weight. Hence at the net level, the estimated amount of discard per net was smaller for MMF + greca, although the difference was not statistically significant (mean difference: 5.43 kg). When comparing the differences in species composition between net types, the main differences in species composition between MMF/PMF versus MMF + greca were due to the relative abundance of *Scyliorhinus canicula* (which has a smaller body size and was more frequently caught with MMF + greca) and Rajidae species (which have a larger body size and were more frequently caught with MMF/PMF).

Survival

A total of 1216 animals from 8 species were examined at arrival on-board, and 353 were alive (Table 1). The immediate survival probabilities of the most abundant discarded species (n > 30; *P. elephas*, *L. naevus*, and *P. regalis*) were all greater than 0.6. In contrast, the survival probability of other commonly discarded species was less than 0.2.

Species	Number of observed animals		Immediate survival probability
	Alive	Total	
Palinurus elephas	82	127	0.64
Parastichopus regalis	30	33	0.92
Leucoraja naevus	193	296	0.65
Raja sp.	5	229	0.02
Raja clavata	26	224	0.11
Scyliorhinus canicula	12	161	0.07
Scorpaena scrofa	4	100	0.04
Lophius piscatorius	1	46	0.02

Table 1. The number of animals discarded that were alive at on-board arrival. Only species with more than 30 observations are detailed. The immediate survival probability is indicated.

A sample (n = 16) of living, undersized spiny lobsters (mean 7.1 ± 0.9 cm CL) was kept in captivity for 7 days. From that sample, only one lobster died that already had a 'poor' vitality status on day zero. In contrast, the animals that were classified with a "good" vitality status on day zero quickly improved vitality status to "excellent" (Fig. 3). Therefore, their probability of surviving catch is high, recommending their release back to sea after capture.

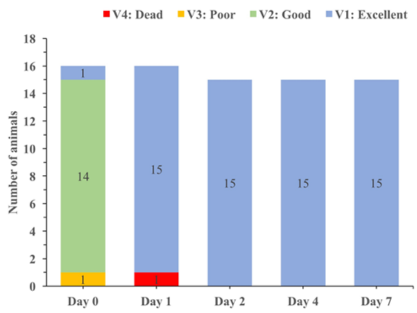

Figure 3. Changes in vitality status over time for the spiny lobsters caught and held in captivity for up to 7 days.

More information:

Catanese G. et al. 2017. Comparing the wanted and unwanted catches from different trammel nets designs targeting common spiny lobster (*Palinurus elephas*), in terms of biomass, composition and revenue. Fisheries Research (submitted).

Training material produced by EU H2020 project "Science, Technology and Society Initiative to minimize Unwanted Catches in European Fisheries" (MINOUW)
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MINOUW training materials – Sheet n° 08

Modifications to trammelnet to reduce unwanted catches

The EU discards ban embedded in Art. 15 of EU Reg. 1380/2013 (EC, 2013) or Landing Obligation has the objective of reducing discards in EU fisheries and working towards more selective fishing by incentivising fishers to apply appropriate technical solutions, among other changes in fishing practices.

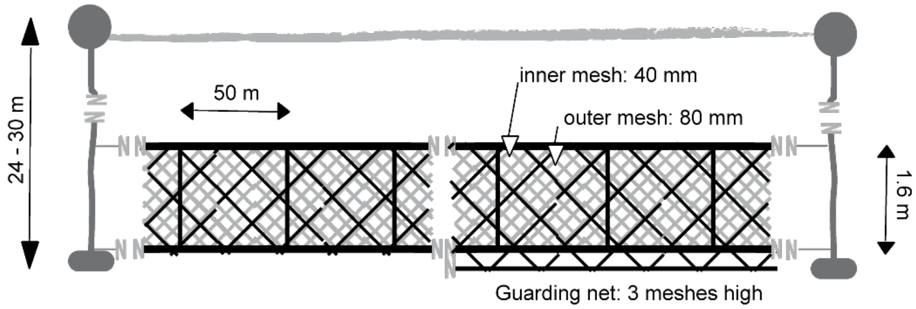
Investigating the effect of simple modifications of trammelnet designs are interesting because these modifications may work towards reducing unwanted bycatch, without undue changes to the fishing practices of fishers or expensive modifications that would entail additional costs.

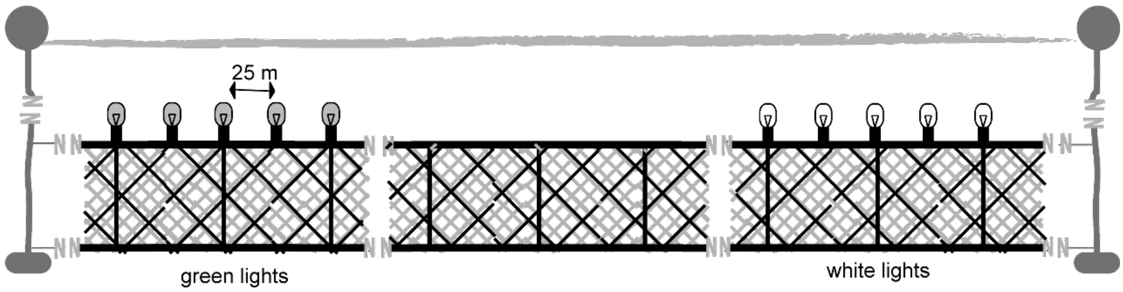
Here we show the relative effect of two modified trammel nets compared to a standard cuttlefish (*Sepia officianlis*) trammelnet. The first modification consisted in adapting a guarding net to the footrope of the trammelnet. The second consisted in fitting artificial lights (green and white) to the floatrope of the trammelnet. The results are discussed in terms of catch efficiency of the target species and reduction of unwanted by catch in three broad categories: i) undersize catches under Art. 15 of EU Reg. 1380/2013, ii) damaged fraction of commercial species, and iii) non-commercial fraction of the catch, usually composed of epifaunal invertebrates.

Our results show that using a guarding net on the footrope of the trammelnet, overall commercial catches increase (by 32%) and, particularly, the catches of the target species, cuttlefish, practically doubled (95% increase). The catches of damaged specimens or non-commercial invertebrates decreased significantly to 25% of the values reported in the standard net.

Design & experiment

Two local fishing boats practicing the cuttlefish métier were used to carry out the experiments with the modified trammelnets. In the first boat two identical trammelnets of 1500 m length and 1.6 m high were employed (inner panel: 80 mm Nylon (polyethylene) mesh; outer panel: 160 mm Nylon mesh) in normal commercial conditions, a control net and an experimental net. The fishing gear was set on sandy bottoms between 24 and 30 m depth at 3 am and recovered at 9 am, approximately, from 2 to 23 March 2017. The experimental trammelnet was divided in three sections with artificial green or white lights fixed on the floatline of two of the sections (i.e. 500 m of white lights and 500 m of green lights). A 3-meshes high (240 mm) polyethylene guarding net in the third section of the experimental trammelnet was used. The lights or the guarding net were fixed on different sections of the net on consecutive days, to randomize the effect of position. The second fishing vessel only carried out the part of the experiment testing artificial lights, in similar conditions, and from 10 April to 16 May 2017.



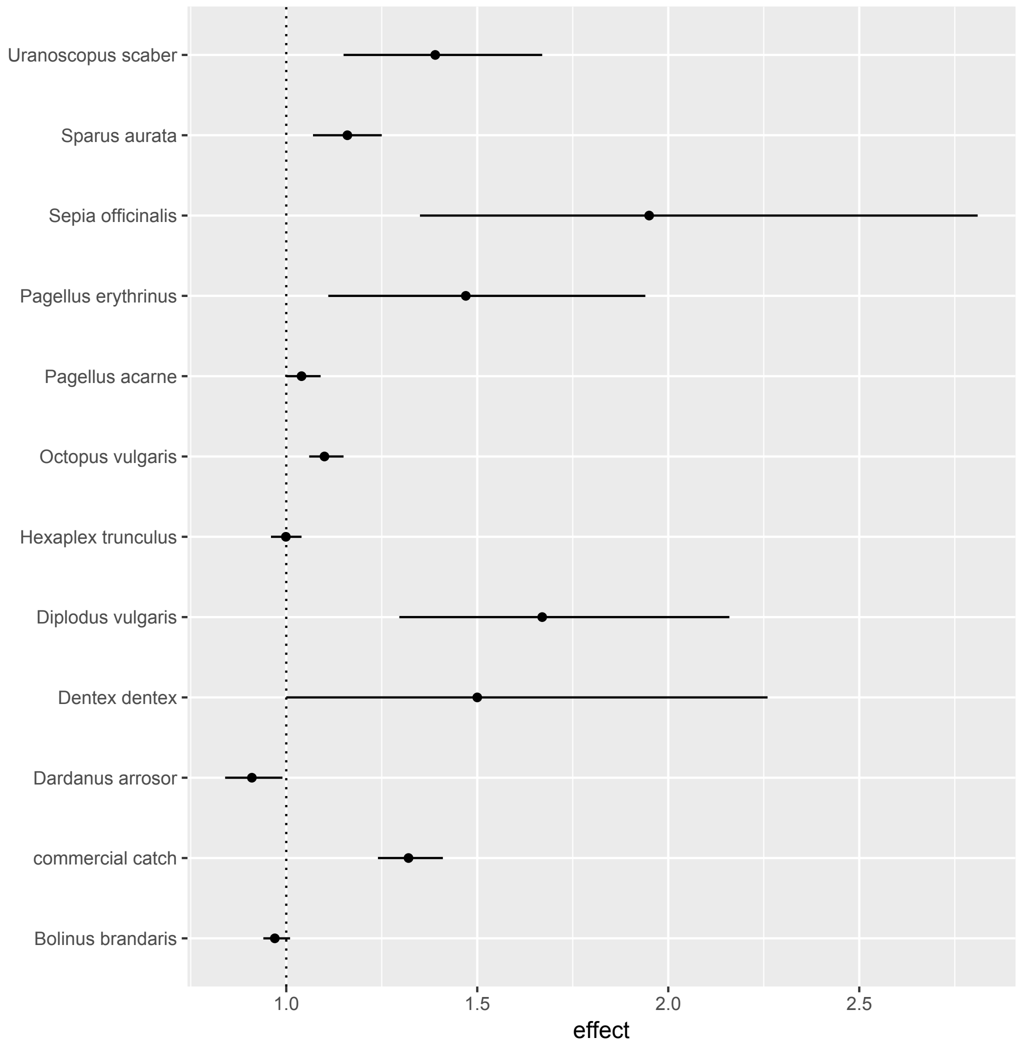


Results

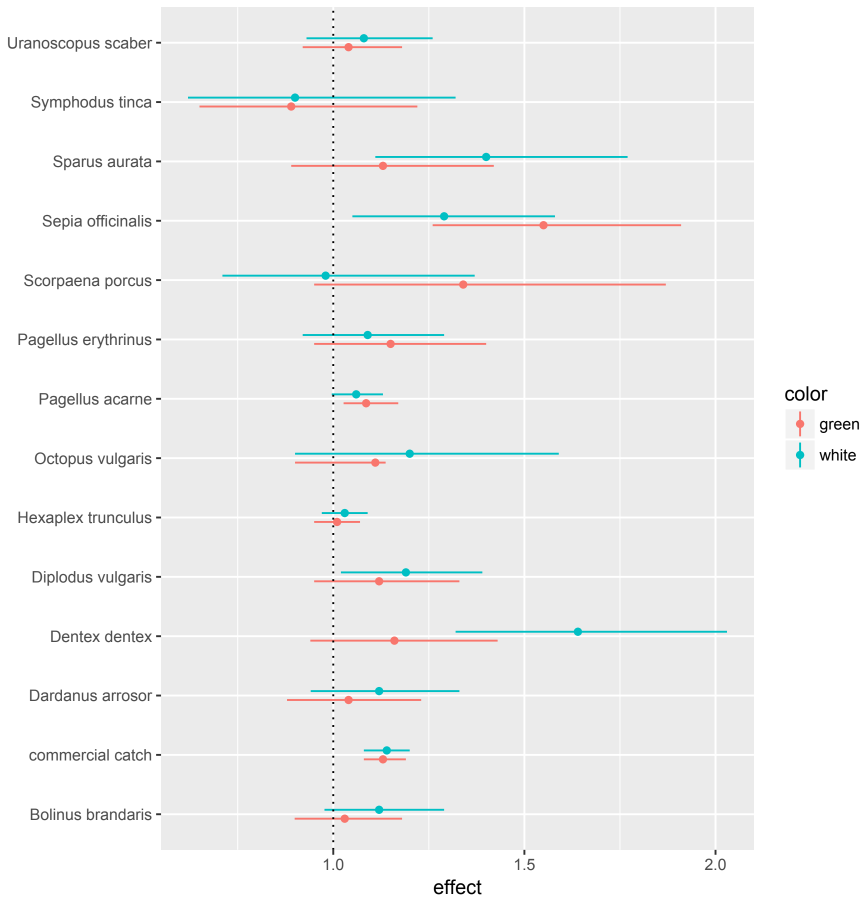
Summary results of the trammelnet experiments. UWC: unwanted catches that would normally be discarded. Discarding reasons: (D) Undersize individuals falling under the Landings Obligation (Art. 15 of EU Reg. 1380/2013); (K1) damaged individuals of otherwise commercial species; (K2) non-commercial benthic invertebrates.

	control trammelnet	guarding net	green lights	white lights
Commercial catch (ind / 100 m h)	208.81	272.28	229.29	243.62
Commercial catch (kg / 100 m h)	49.11	64.04	53.93	57.30
Total UWC (ind / 100 m h)	40.39	19.81	69.52	64.83
Undersize UWC (D, ind / 100 m h)	8.44	7.77	2.31	7.15
Damaged UWC (K1, ind / 100 m h)	11.24	5.69	26.03	20.39
non-commercial UWC (K2, ind / 100 m h)	20.71	6.35	41.18	37.29
Percentage of UWC in weight	45%	24%	56%	53%
Percentage of D UWC, in weight	9%	9%	2%	6%
Percentage of K1 UWC, in weight	13%	7%	21%	17%
Percentage of K2 UWC, in weight	23%	8%	33%	31%

Relative measure of effect of guarding net on the catches of the main commercial species in cuttlefish trammelnets (average and 95% confidence interval). A value of 1 corresponds to no effect (i.e. catches in kg/ 100 m h of the modified net are not different from the standard net). Overall commercial catch increase by 32% in the trammelnets fitted with a guarding net. The species with the highest effect (95% increase) was the target species, the cuttlefish *Sepia officinalis*. Other species with notable increases were the sparid dentex (*Dentex dentex*), the seabream *Diplodus vulgaris*, the Pandora *Pagellus erythrinus* and the golden seabream *Sparus aurata*, as well as the stargazer *Uranoscopus scaber*. Note how the catches of two commercial scavenger invertebrates (the purple dye murex *Bolinus* brandaris and the hermit crab *Dardanus arrosor*) decreased in the modified trammelnet.



Relative measure of effect of lights mounted on the headrope on the catches of the main commercial species in cuttlefish trammelnets (average and 95% confidence interval). A value of 1 corresponds to no effect (i.e. catches in kg/ 100 m h of the modified net are not different from the standard net). No significant differences were observed in the majority of taxa and no significant difference was observed between green and white lights. Only the target species, *Sepia officinalis* showed a relative increase in catches. However, the amount of unwanted catches in the experiments with lights were also higher than in the control net.



More information:

Sartor, P., Silvestri R., Sbrana M., Voliani A., Rossetti I., Bulgheri G. 2007. Sperimentazione di accorgimenti tecnici per la riduzione dello scarto nella pesca con reti da posta lungo il litorale livornese. Biol. Mar. Mediterr, 14 (2): 360-361.

Stergiou K. I., Moutopoulos D. K., Soriguer M. C., Puente E., Lino P.G., Zabala C., Monteiro P., Errazkin L.U., Erzini K., 2006, Trammel net catch species composition, catch rates and métiers in southern European waters: A multivariate approach. Fish. Res. 79, 170–182.

Training material produced by EU H2020 project ***"Science, Technology and Society Initiative to minimize Unwanted Catches in European Fisheries"*** *(MINOUW)*
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MINOUW training materials – Sheet n° 09

Technological solution (guarding net) to limit the unwanted catches in the caramote prawn set net fisheries in the Ligurian Sea (W Mediterranean)

The EU discards ban embedded in Art. 15 of EC 1380/2013 EC, 2013 or Landing Obligation has the objective of reducing discards in EU fisheries and working towards more selective fishing by incentivising fishers to apply appropriate technical solutions, among other changes in fishing practices. Investigating the effect of simple modifications of current bottom trawl designs are interesting because these modifications may work towards reducing unwanted bycatch, without undue changes to the fishing practices of fishers or expensive modifications that would entail additional costs.
Although discarding is known as a major problem in trawl fishing, also the set net fisheries, especially on certain types of bottoms, can capture large amounts of organisms belonging to the non-commercial species. The presence of large amounts of discards, principally made by crabs, gastropods, echinoderms, is a recurrent phenomenon in trammel net fisheries, such as the one targeting caramote prawn, *Penaeus kerathurus*. This aspect is often a limiting factor for these fisheries, which normally are very profitable: the "unwanted" catches substantially lengthen the working time for sorting the catch and cleaning the nets, and cause premature deterioration of fishing gear. The caramote prawn fishery is very important for some small-scale fishing fleets in Tuscany (FAO-GFCM GSA 9). Unfortunately, the catch of target species is often associated with large amounts of unwanted catches (mostly crabs and other benthic invertebrates); this often generates high discards and damages to the nets, with consequent environmental impacts and associated costs for fishermen.
We examined a technological solution based on fitting a “guarding net” (locally known as *greca*) on the footrope of the trammelnet to limit the unwanted catches in the caramote prawn set net fisheries in the Ligurian Sea (W Mediterranean). Experiments were carried out to test the value of this device in reducing unwanted catches. Some fishermen were already using this device in the area and preliminary observations provided encouraging results that were tested empirically.

Our experiments showed that the addition of a guarding net to traditional trammel nets can reduce bycatch significantly. The guarding net fitted to trammel nets proved to be an effective solution to decrease discards and unwanted catches. The economic loss due to the slightly reduced catch of commercial species was offset by decreased sorting time and labour costs.

Design & experiment

In the period July 2015-May 2016 preparatory work was carried out. Meetings with fishermen and other stakeholders were held to present the objectives and work plan of the case study. Fishermen suggestions provided useful technical indications for constructing the experimental nets:

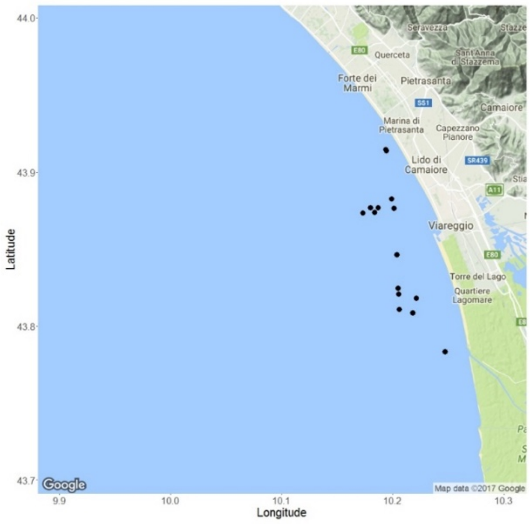
- a professional standard trammel net commonly used to exploit caramote prawn (STN);
- two experimental trammel nets provided with two types of guarding net, placed at the bottom of the standard trammel net, just above the lead line: 20 cm (SE20) and 30 cm (SE30) height, respectively. The guarding net was a mono-panel strip placed at the bottom of the trammel net.

From June to July 2016, fifteen experimental fishing trials were performed, using a professional vessel belonging to the small-scale fishery fleet of Viareggio, normally involved in the caramote prawn fishery.

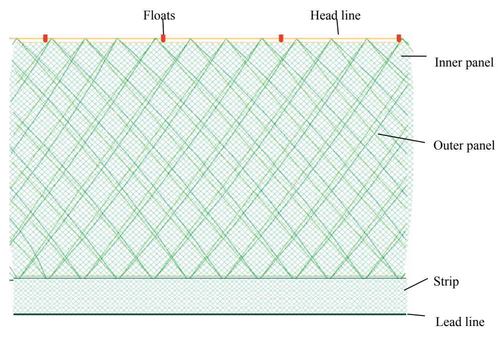
In each experimental trial, four net sheets of 100 m of each type of trammel net (STN, SE20, SE30) were used. The twelve sheets were tied in a single gang leaving an escaping area of about 1.5 m between adjacent nets to avoid any guiding effect. The sheet position was changed randomly at each trial, to achieve similar catch probability of each sampling gear.

The impact evaluation was oriented to both the target species and the other captured organisms. The experimental protocol consisted in comparing capture efficiency and selectivity of a control trammel net and two different types of guarding net. Standard trammel net catches were compared to those by the two types of experimental trammel nets (one with a high guarding net, 30 cm, and one with a low guarding net, 20 cm). Sampling with the three types of trammel nets occurred during the prawn fishing period (June-July 2016), along the coastal area of Viareggio.

All the catches with the three different nets were characterized from both a qualitative (species identification) and a quantitative (biomass and number of individuals) point of view. For the main target species, the demographic structure (individual size) was recorded. The effects of the different types of net on the catchability of targeted species and discards was assessed. A cost-benefit evaluation of the usability of these trammel nets in a professional fisheries context was also performed. Interviews with the local fishermen involved in the caramote prawn fishery were performed to collect socio-economic information, in order to characterise the performance of this fishery and to evaluate the effects of the introduction of the selvedge technical device.



Study area and location of the sampling sites



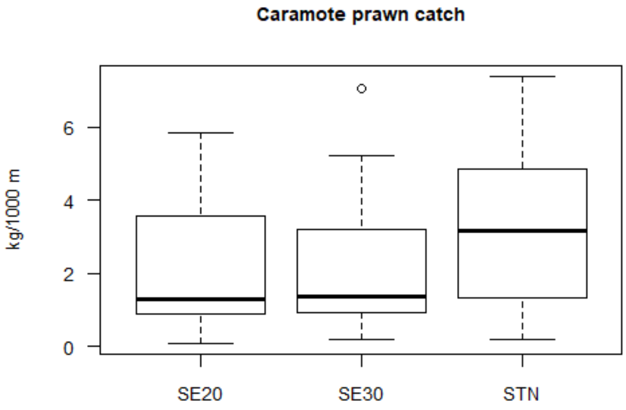
Scheme of a trammel net equipped with a selvedge (or "Greca") strip

Images of the experimental trials

Results

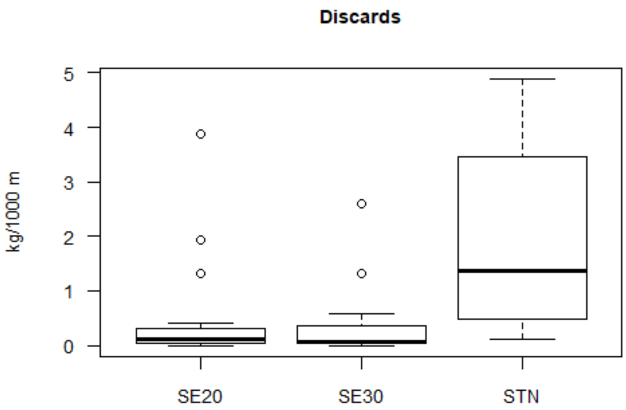
Our study, originated through a multi-actor approach and tested under commercial fishing conditions, revealed that the use of a modified trammel net equipped with a guarding net can significantly reduce the amount of discards (mostly represented by benthic species, such as crabs, gastropods, etc.) in the trammel net fishery targeting caramote prawn. The proposed modification is relatively inexpensive (the cost of the modified trammel net is more or less the same as the standard trammel net). However, it reduces the total commercial catch of the vessel. Nonetheless, it is expected that the economic loss can be offset by decreased sorting time and labour costs, in the immediate short term.

Box-and-whisker plot of the catches of the target species, caramote prawn (*Penaeus kerathurus*), with the three different types of net.



SE20 = selvedge 20 cm, SE30 = selvedge 30 cm, STN = no selvedge

Box-and-whisker plot of the discards with the three different types of net.



SE20 = selvedge 20 cm, SE30 = selvedge 30 cm, STN = no selvedge

More information:
http://minouw-project.eu/training-exchange-in-viareggio-italy/

Rossetti I., et al. 2006. Pesca di mazzancolla, *Penaeus kerathurus* (Forsskål, 1775), con reti da posta presso la marineria artigianale di Viareggio (Mar Ligure sud-orientale). Biol. Mar. Mediterr. 13(2): 284-285.

Sartor P., et al.. 2007. Sperimentazione di accorgimenti tecnici per la riduzione dello scarto nella pesca con reti da posta lungo il litorale livornese. Biol. Mar. Mediterr. 14 (2): 360-361.

MINOUW training materials – Sheet n° 10

Circle hooks to reduce unwanted catches in surface drifting long-line fisheries targeting swordfish

Background

The Mediterranean fisheries targeting swordfish by means of surface drifting long-lines are typically employing J-hooks baited either with mackerel or squid. The fisheries are to a large extent mono-specific but, depending on the area and season, incidental catches of vulnerable species, such as sea-turtles and sharks have been reported. In addition, catches of undersized swordfish individuals are always occurring despite the existing temporal fishery closures (ICCAT, 2015).

In certain Atlantic swordfish fisheries, (e.g. US) circle hooks are used to mitigate sea-turtle by-catches but past studies have shown that the efficiency of circle hooks in reducing sea-turtle by-catch depends on the turtle species and fishing practices (Amorim et al. 2014; Gilman and Huang 2016). Similarly, the impact of circle hooks on swordfish catch rates depends on the particular characteristics of the fishery (target age-class, fishing ground, etc.) Hence, due to inherent variability of the response of pelagic species to longlines with circle hooks, performing localized studies are necessary before adopting fisheries management measures.

In the present study, we attempted to evaluate the impact of gear modifications (i.e employment of circle hooks instead of the traditional J-type ones) on the catch rates of the target species and on unwanted by-catch.

Although the relatively low number of experimental fishing trials did not allow to draw definite conclusions, the results suggested that the employment of circle hooks favors the reduction of undersized swordfish catches without affecting the volume of landings. Regarding the capture of vulnerable species, such as sharks, the current study did not reveal important differences between hook types, while no conclusions can be made for sea-turtles, as no such catches occurred during the fishing trials.

Design & experiment

The experimental sampling scheme included fishing trials with surface drifting long-lines in the South Aegean and Cretan seas. The fishing gear used had equal number of Circle and J-type hooks alternating each other (400 hooks in total). A total of 36 experimental sets were conducted following the typical practices of the fishermen, i.e gear setting was done after sunset and hauling at dawn, using mackerel as bait.

Circle (size 16/0, offset 10°) and J (size 9/0) hooks used in the fishing trials

Results

Comparisons between hook types included: (a) Catch rates of the target species (both commercial and undersized fractions), (b) Catch rates of by-catch species including incidental catches of vulnerable ones.

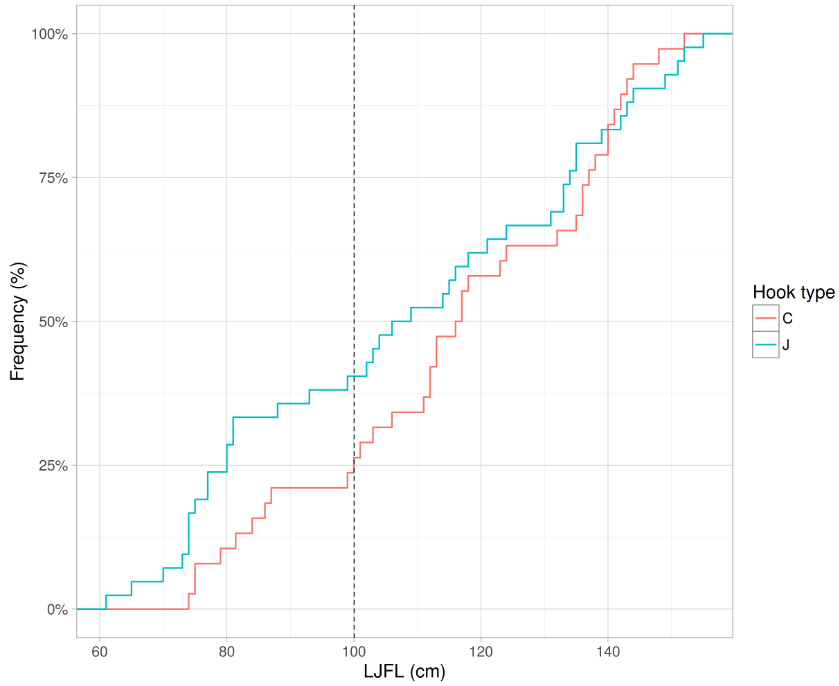
A total of 138 individuals were caught belonging to 11 different species. Sixty eight specimens were captured in circle hooks and 70 in the J-type ones. The majority of them (~60%) were swordfish.

List of species caught during the experimental long-line sets.

Hook type	Species	Total Number
C	BLUEFIN *(Thunnus thynnus)*	8
C	BLUE STINGRAY (*Pteroplatytrygon violacea*)	6
C	DOLPHINFISH *(Coryphaena hippurus)*	2
C	OILFISH *(Ruvettus pretiosus)*	4
C	BLUE SHARK *(Prionace glauca)*	2
C	SHORT FIN MAKO *(Isurus oxyrinchus)*	6
C	SPEARFISH *(Tetrapturus belone)*	2
C	SWORDFISH *(Xiphias gladius)*	38
J	ALBACORE (*Thunnus alalunga)*	2
J	BLUEFIN *(Thunnus thynnus)*	10
J	BIGEYE THRESHER *(Alopias superciliosus)*	2
J	BLUE STINGRAY (*Pteroplatytrygon violacea*)	4
J	BLUNTNOSE SIXGILL SHARK *(Hexanchus griseus)*	2
J	DOLPHINFISH *(Coryphaena hippurus)*	2
J	OILFISH *(Ruvettus pretiosus)*	2
J	BLUE SHARK *(Prionace glauca)*	2
J	SPEARFISH *(Tetrapturus belone)*	2
J	SWORDFISH *(Xiphias gladius)*	42

Regarding swordfish catch rates expressed in terms of kg/1000 hooks, these did not statistically differ among hook types, but proportionally fewer swordfish smaller than the minimum size of 100 cm were captured on the circle hooks than on the J ones (24 % vs. 40%).

Cumulative length frequencies of captured swordfish, by hook type (C= Circle hook, J= J hook). The vertical dashed line indicates the minimum landing size as per ICCAT regulations (100 cm lower jaw to fork length).



Catches of vulnerable species (sharks), were comparable among gear types, representing around 10% of the total catch in terms of numbers. No sea turtles were captured with either gear, thus no conclusions can be drawn about the efficacy of circle hooks in reducing their catches.

More information:

Amorim, S., M. N. Santos, R. Coelho, and J. Fernandez Carvalho. 2015. Effects of 17/0 circle hooks and bait on fish catches in a Southern Atlantic swordfish longline fishery. Aquat. Conserv. 25:518–533.

Gilman, E., Huang, H. 2016. Review of effects of pelagic longline hook and bait type on sea turtle catch rate, anatomical hooking position and at-vessel mortality rate. Rev Fish Biol Fisheries, DOI 10.1007/s11160-016-9447-9.

ICCAT. 2015. Report of the 2014 ICCAT Mediterranean swordfish stock assessment meeting. Collective Volume of Scientific Papers ICCAT 71:1870-1979.

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Literature cited

Arimoto T., C. W. Glass and X. Zhang. 2010. Fish vision and its role in fish capture. In He, P. (ed.) Behavior of marine fishes: capture processes and conservation challenges. Wiley-Blackwell, Ames, Iowa, pp. 25-40.

Breen M., B. Isaksen, E. Ona, A. O. Pedersen, G. Pedersen, J. Saltskår, B. Svardal, M. Tenningen, P. J. Thomas, B. Totland, J. T. Øvredal and A. Vold. 2012. A review of possible mitigation measures for reducing mortality caused by slipping from purse-seine fisheries. *ICES CM* 100: 12.

Campos A. and P. Fonseca. 2004. The use of separator panels and square mesh windows for by-catch reduction in the crustacean trawl fishery off the Algarve (South Portugal). *Fisheries Research* 69: 147-156.

Catchpole T.L. and T.S. Gray. 2010. Reducing discards of fish at sea: a review of European pilot projects. J. Environ. Manage. 91, 717–723. http://dx.doi.org/10.1016/j. jenvman.2009.09.035.

Erzini K., J.M.S. Gonçalves, L. Bentes, D.K. Moutopoulos, J.A. Hernando Casal, M.C. Soriguer, E. Puente, L.A. Errazkin and K.I. Stergiou. 2006. Size selectivity of trammel nets in southern European small-scale fisheries. *Fisheries Research* 79: 183-201.

Gaspar M. B., M. D. Dias, A. Campos, C.C. Monteiro, M. N. Santos, A. Chícharo, L. Chícharo. 2001. The influence of dredge design on the catch of *Callista chione* (Linnaeus, 1758). *Hydrobiologia* 465(1-3): 153-167.

Gaspar M.B., F. Leitão, M.N. Santos, M. Sobral, L. Chícharo, A. Chícharo and C.C. Monteiro. 2003. Size selectivity of the *Spisula solida* dredge in relation to tooth spacing and mesh size. *Fisheries Research* 60: 561-568.

Gaspar M. B., and Chícharo, L. M. 2007. Modifying dredges to reduce by-catch and impacts on the benthos. In *By-catch Reduction in the World's Fisheries* (pp. 95-140). Springer Netherlands.

Glass C. W., C.S. Wardle, S.J. Gosden and D.N. Racey. 1995. Studies on the use of visual stimuli to control fish escape from codends. I. Laboratory studies on the effect of a black tunnel on mesh penetration. *Fisheries Research* 23(1): 157-164.

Glass C.W. and C.S. Wardle. 1995. Studies on the use of visual stimuli to control fish escape from codends. II. The effect of a black tunnel on the reaction behaviour of fish in otter trawl codends. *Fisheries Research* 23(1-2): 165-174

Hannah R.W., M.J.M. Lomeli and S.A. Jones. 2015. Tests of artificial light for bycatch reduction in an ocean shrimp (*Pandalus jordani*) trawl: Strong but opposite effects at the footrope and near the bycatch reduction device. *Fisheries Research*, 170: 60-67.

Heath M.R., R.M. Cook. 2015. Hind-casting the quantity and composition of discards by mixed demersal fisheries in the North Sea. PLoS One 10, e0117078. http://dx.doi.org/10.1371/journal.pone.0117078.

Kaiser M.J. and S. Jennings. 2002. Ecosystem effects of fishing *Handbook of Fish and Fisheries*, Vol. 2, Chapter 16, 342-365.

Karakulak F. S. and H. Erk. 2008. Gill net and trammel net selectivity in the northern Aegean Sea, Turkey. *Scientia Marina* 72(3): 527-540.

Kelleher K. 2005. Discards in the World's Marine Fisheries. An Update, Rome, FAO.

Leitão F., M. B. Gaspar, M. N. Santos and C. C. Monteiro. 2009. A comparison of bycatch and discard mortality in three types of dredge used in the Portuguese *Spisula solida* (solid surf clam) fishery. *Aquatic Living Resources* 22(1): 1-10.

Madsen N., K. Hansen and N.A.H. Madsen. 2015. Behavior of different trawl codend concepts. *Ocean Engineering* 108: 571-577.

Marçalo A., P. Pousão-Ferreira, L. Mateus, J. H. D. Correia and Y. Stratoudakis. 2008. Sardine early survival, physical condition and stress after introduction to captivity. *Journal of Fish Biology* 72: 103–120.

Misund O.A., J. Kolding and P. Fréon. 2002. Fish Capture devices in industrial and artisanal fisheries and their influence on Management. *Handbook of Fish and Fisheries*, Vol. 2, Chapter 2, 13-36.

SOMFI 2016. The state of Mediterranean and Black sea fisheries. FAO-GFCM, 152 pp.

Stergiou K.I., D.K. Moutopoulos, M.C. Soriguer, E. Puente, P.G. Lino, C. Zabala, P. Monteiro, L.A. Errazkin and K. Erzini, 2006. Trammel net catch species composition, catch rates and métiers in southern European waters: a multivariate approach. *Fisheries Research* 79: 170–182.

Suuronen P. 2008. Effectiveness and applicability of technical measures in bycatch management. American Fisheries Society Symposium. *American Fisheries Society*, p. 1311.

Tenningen M., A. Vold and R.E. Olsen. 2012. The response of herring to high crowding densities in purse-seines: survival and stress reaction. *ICES Journal of Marine Science* 69(8): 1523-1531.

Vogel C., D. Kopp, F. Morandeau, M. Morfin and S. Méhault. 2017. Improving gear selectivity of whiting (*Merlangius merlangus*) on board French demersal trawlers in the English Channel and North Sea. *Fisheries Research*, 193: 207-216.

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