Oceanological and Hydrobiological Studies

International Journal of Oceanography and Hydrobiology

Volume 52, No. 3 September 2023
pages (366-373)

sciendo

ISSN 1730-413X
eISSN 1897-3191

# The effects of two different net modifications on reducing discards in the trammel net fishery for prawn in Mersin Bay

by

Adem Sezai Bozaoğlu*
(ORCID: https://orcid.org/0000-0003-4078-5159)

DOI: **https://doi.org/10.26881/oahs-2023.3.09**
Category: **Original research paper**
Received: **April 30, 2023**
Accepted: **June 28, 2023**

[1]*Yüzüncü Yıl University, Fisheries Faculty, Zeve Campus, Van, 65080, Türkiye*

## Abstract

The discarded species caught in prawn trammel nets damage the nets and cause a serious labor loss problem for fishers. In the present study, a 15 cm high greenhouse plastic film and a greenhouse shade cloth net were fitted between the lower parts of the nets and the lead collars to reduce discards in the trammel net fishery. The modified nets were tested in Mersin Bay with twenty-one fishing operations between September and December 2021. The results showed that, compared to commercial trammel nets, the nets equipped with greenhouse plastic film and greenhouse shade cloth did not significantly reduce the catch of the target species green tiger prawn (*Penaeus semisulcatus*). However, the total number of discards significantly decreased. The discard rates in the commercial net, greenhouse plastic film net, and greenhouse shade cloth net were 45%, 26%, and 22%, respectively. Furthermore, when the incomes from the nets' hauls were calculated, the net equipped with greenhouse garden film and the net equipped with greenhouse shade cloth generated 24.77% and 14.41% more profit than the commercial net, respectively.

**Key words:** By-catch, discards, greenhouse plastic film, greenhouse shade cloth, Mersin Bay, trammel net

* email: sbozaoglu@yyu.edu.tr

online at www.oandhs.ug.edu.pl

## 1. Introduction

In commercial fisheries, discard is the part of the total organic material of animal origin in the catch thrown back into the sea (Kelleher 2005). In recent years, discarding has been considered an important problem in fisheries management (Hall&Mainprize 2005, Tsagarakis et al. 2014, Borges 2015, Roda et al. 2019, Tiralongo et al. 2021). Small-scale fisheries play a vital role in global fisheries (GFCM 2021), and awareness of the impact of this fishery on marine sustainability and its role in achieving sustainable development goals is emerging (Jones et al. 2019).

Mersin Bay is rich in prawn population (Gökçe et al. 2016). All prawn production in Turkey is obtained by capture fisheries. The green tiger prawn (*Penaeus semisulcatus* de Haan, 1844) with a total production of 551.9 tonnes, is caught in the Mediterranean Sea (TUIK 2020). The most commonly used fishing gears in the Mediterranean Sea in prawn fishing are trawl and trammel nets (Thomas 2003, Bayhan&Gökçe 2010, Bozaoğlu 2012, Gökçe et al. 2016, Saidi et al. 2016, Maynou et al. 2021, Bayhan et al. 2022).

Discard is one of the most critical problems in prawn trammel net fishing in the Mediterranean (Bozaoğlu 2012). The amount of discarded fish in the Mediterranean region is estimated to be 230,000 tonnes (FAO 2018). The discard rate of trammel nets in the Mediterranean Sea is less than 10% (FAO 2018). Tsagarakis et al. (2014) reported that the discard rate of trammel nets may exceed 40% in some fishing areas in the Mediterranean Sea. Bozaoğlu (2012) showed that this rate might exceed 60% in prawn fishing with trammel nets, particularly in summer, due to the movement of species with increasing water temperatures to inshore regions for reproduction. In this context, there are several studies on the reduction of discards in the trammel nets used in the Mediterranean and Black Seas (Metin et al. 2009, Bozaoğlu 2012, Aydın et al. 2013, Gökçe et al. 2016, Szynaka et al. 2018, Catanese et al. 2018, Sartor et al. 2018, Eryaşar et al. 2020). However, the solutions proposed by previous studies were either costly to implement or required significant effort, and they have not been adopted by fishers to date. Therefore, this study aimed to provide a cost- and labour-effective solution to the discard problem in prawn fisheries using trammel nets.

One of the most significant expenses for fishers is net costs. Due to the discarded species (crab and mantis shrimp), the lifespan of the nets becomes considerably shorter. Because these species live on the ground and have little swimming ability, they are usually caught close to the net's lead collar. Therefore, while the cork side of the nets remains intact, the lead-collar side wears out much more quickly, and after a short period (1-2 months depending on the season and the amount of catch), the nets can no longer be used (Bozaoğlu 2012). In addition, discarded species damage the nets and increase the effort required for net maintenance. In this study, prawn trammel nets were modified with two different materials on the upper parts of the lead collar to develop alternative guarding nets that will help reduce discards in prawn fisheries.

In this study, a polyethylene greenhouse plastic film and a polyethylene greenhouse shade cloth were used in the first and second guarding net designs, respectively. The guarding nets successfully reduced discards; however, they were not preferred by fishers because of the extra costs of equipping the nets. Therefore, we aimed to reduce costs by simply sewing our greenhouse plastic film and greenhouse shade cloth nets at the bottom of a ready-made mesh manually. Because of the transparent structure of the greenhouse plastic film, it is assumed that the target species will not recognize the net and will ascend, and discarded species such as crabs will not be able to hold on to this material. Nets equipped with greenhouse plastic film and greenhouse shade cloth were compared with commercial trammel nets to minimize the discarded amount of catch without decreasing the efficiency of the gear for the target species.

## 2. Materials and methods

This study was conducted in Mersin Bay between September and December 2021. (Fig. 1). A commercial boat with a length of 8 m and engine power of 105 HP was used in 21 fishing trials.

In this study, three units of trammel nets, each 100 m long, were used: greenhouse plastic film (GPlastic film), greenhouse shade cloth net (GNet), and commercial trammel net (CNet). All the nets were made of knotted polyamide multifilaments. The mesh sizes of the inner and outer nets were 48 mm and 250 mm, respectively. The hanging ratio was set to 0.50. (Fig. 2). Thus, alternative nets were stitched to the upper part of the lead collar of the commercial nets, with 15 cm high parts made of greenhouse plastic film and greenhouse shade cloth overlapping both sides of the net (Fig. 3-6). Additionally, the design was strengthened by applying glue to the GPlastic design. The nets' heights were designed at 15 cm for easier handling, that is, their deployment and collection, and to prevent the currents from hindering the operation of the nets in the water column.

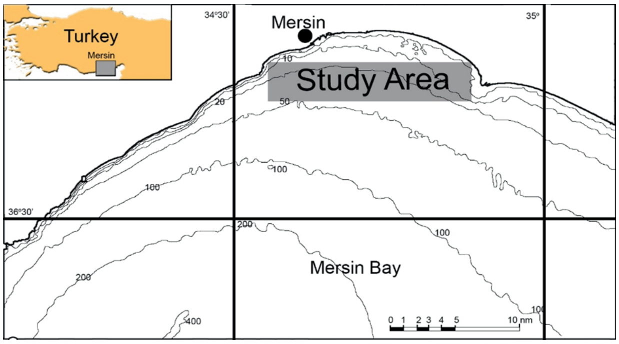


**Figure 1**

Study area

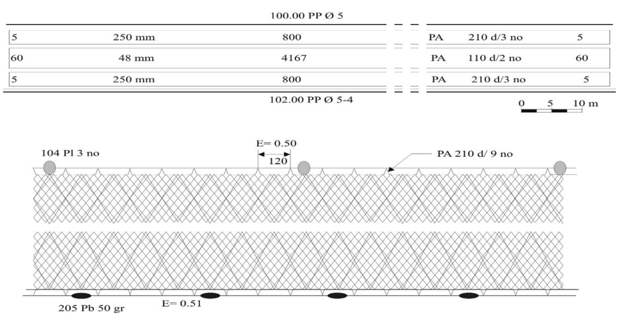


**Figure 2**

Technical plan and illustration of commercial nets (Cnet)

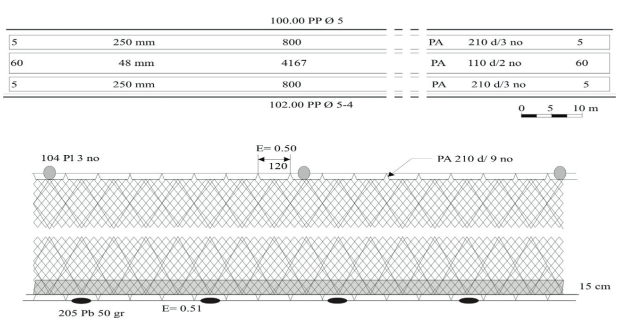


**Figure 3**

Technical plan and illustration of greenhouse garden film nets (GPlastic)

Two experimental nets and two commercial nets were set in juxtaposition with a 1-m distance between all the net groups being tested. All the nets were deployed before dusk at depths between 11 and 28 m on sandy and muddy soft-bottom benthic habitats and hauled in after 12 h of soaking time. The order of deployment of the nets was determined randomly by the drawing of lots.

The fishers classified the species as discard, target, and by-catch, and the weights of the specimens were measured by the researcher. For each discarded

**Figure 4**

Greenhouse garden film nets (GPlastic)

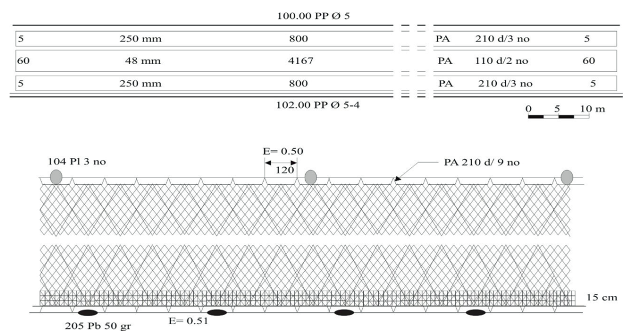


**Figure 5**

Technical plan and illustration of greenhouse nets (GNet)

**Figure 6**

Greenhouse nets (GNet)

species, the removal times from the nets were recorded for 20 specimens, and the average removal time for each species was calculated. Furthermore, the average removal times for the species were multiplied by the total number of discarded species, and the handling times of the nets were calculated.

The Kruskal–Wallis H test was used to compare the three nets in terms of the number and weight of each species caught. Furthermore, Dunn's multiple comparison test was used to assess any significant differences between the nets. All statistical analyses were performed using JMP version 13.

## 3. Results

Twelve species (nine commercial and three discarded species) from four classes (seven Osteichthyes, four Crustacea, and one Cephalopoda) were identified. The species captured by each trammel net are listed in Table 1.

The number of discards decreased significantly in the GPlastic and GNet nets ($p < 0.05$). There were no significant differences between the number of target species – green tiger prawn – caught by commercial nets and experimental nets ($p > 0.05$). Although there were no statistical differences between the catch numbers for the three discarded species ($p > 0.05$), there were statistically significant differences between the CNet and both the GPlastic and GNet ($p < 0.05$) when the total amount of discards by weight was considered. 45% of the catch by number and 13% by weight were discarded from the CNet. In the GPlastic and the Gnet, 26% and 22% of the catch by weight and 5% and 4% of the catch by number, respectively, were discarded. The landings were 28970 g in the CNet, 42140 g in the GPlastic, and 39222 g in the GNet.

The weights and prices per kilogram of the nine commercial species and total income from the nets are listed in Table 2. At the end of the trial, the total revenues from the CNet, GNet, and GPlastic were calculated as 232.06, 289.53 and 265.49 USD, respectively. There was no loss of income in the modified nets and profits increased by approximately 25% for the GPlastic and 15% for the GNet.

Three discarded species were caught: *the Charybdis longicollis*, an invasive swimming crab; *Goneplax rhomboides*, an angular crab, and *Rissoides desmaresti*, mantis shrimp. For each species, the duration of removal of 20 individuals from the net was recorded. The most challenging species to be removed from the nets was the mantis shrimp with 60.7 ± 10.78 seconds, and the most easily removed species was the angular crab with 17.65 ± 3.27 seconds (Table 3).

**Table 1**

All the species captured by the standard and alternative trammel nets

| | | (CNet) | | | | GPlastic | | | | GNet | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | CS | N | % N | W(g) | % W | N | % N | W(g) | % W | N | % N | W(g) | % W |
| *Charybdis longicollis* (invasive swimming crab) | D | 175 | 22.97 | 2780 | 7.19 | 88 | 12.39 | 1890 | 3.87 | 108 | 14.81 | 1620 | 3.5 |
| *Goneplax rhomboides* (angular crab) | D | 90 | 11.81 | 200 | 0.52 | 47 | 6.62 | 110 | 0.22 | 46 | 6.31 | 102 | 0.22 |
| *Mullus barbatus* (red mullet) | L | 59 | 7.74 | 4190 | 10.84 | 61 | 8.59 | 4390 | 8.77 | 84 | 11.52 | 6160 | 13.29 |
| *Nemipterus randalli* (randall's threadfin bream) | L | 120 | 15.75 | 10290 | 26.63 | 184 | 25.92 | 16000 | 31.97 | 178 | 24.42 | 15850 | 34.2 |
| *Penaeus semisulcatus* (green tiger prawn) | L | 168 | 22.05 | 7220 | 18.68 | 157 | 22.11 | 7030 | 14.05 | 137 | 18.79 | 6350 | 13.7 |
| *Rissoides desmaresti* (mantis shrimp) | D | 54 | 7.09 | 1390 | 3.6 | 22 | 3.01 | 490 | 0.98 | 23 | 3.16 | 600 | 1.29 |
| *Saurida undosquamis* (brushtooth lizardfish) | L | 26 | 3.41 | 1980 | 5.12 | 64 | 9.01 | 4310 | 8.61 | 71 | 9.74 | 4810 | 10.38 |
| *Sciaena umbra* (brown meagre) | L | 13 | 1.71 | 6400 | 16.56 | 23 | 3.24 | 10000 | 19.98 | 8 | 1.1 | 3350 | 7.23 |
| Scomber japonicus (chub mackerel) | L | 1 | 0.13 | 100 | 0.26 | 21 | 2.96 | 1550 | 3.1 | 18 | 2.47 | 1400 | 3.02 |
| *Solea solea* (common sole) | L | 52 | 6.82 | 3600 | 9.31 | 30 | 4.23 | 2070 | 4.14 | 38 | 5.21 | 2100 | 4.53 |
| *Sparus aurata* (gilt-head sea bream) | L | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0.69 | 2200 | 4.75 |
| *Sepia officinalis* (common cuttlefish) | L | 4 | 0.52 | 500 | 1.29 | 13 | 1.83 | 2200 | 4.4 | 13 | 1.78 | 1800 | 3.89 |

CS = Commercial status; N = Number; W = Weight; D = Discard; L = Landed

**Table 2**

Income obtained by using commercial nets (CNet) and alternative nets (GPlastic and GNet), and projected economic loss in changing from commercial to alternative nets

| Species | CNet Weight (g) | Unit Price (USD) | Income (USD) | GPlastic Weight (g) | Income (USD) | GNet Weight (g) | Income (USD) |
|---|---|---|---|---|---|---|---|
| *Nemipterus randalli* (randall's threadfin bream) | 10290 | 3.35 | 34.47 | 16000 | 53.6 | 15850 | 53.10 |
| *Penaeus semisulcatus* (green tiger prawn) | 7220 | 13.35 | 96.39 | 7030 | 93.85 | 6350 | 84.77 |
| *Mullus barbatus* (red mullet) | 4190 | 8.89 | 37.25 | 4390 | 39.03 | 6160 | 54.76 |
| *Solea solea* (common sole) | 3600 | 3.35 | 12.06 | 2070 | 6.93 | 2100 | 7.04 |
| *Saurida undosquamis* (brushtooth lizardfish) | 1980 | 3.35 | 6.63 | 4310 | 14.44 | 4810 | 16.11 |
| *Sciaena umbra* (brown meagre) | 6400 | 6.67 | 42,69 | 10000 | 66.7 | 3350 | 22.34 |
| *Sepia officinalis* (common cuttlefish) | 500 | 4.45 | 2.23 | 2200 | 9.79 | 1800 | 8.01 |
| *Scomber japonicus* (chub mackerel) | 100 | 3.35 | 0.34 | 1550 | 5.19 | 1400 | 4.69 |
| *Sparus aurata* (gilt-head sea bream) | 0 | 6.67 | 0 | 0 | 0 | 2200 | 14.67 |
| Total Value (USD) | | | 232.06 | | 289.53 | | 265.49 |
| Profit (%) | | | | | 24.77 | | 14.41 |

**Table 3**

Removal times of discarded species from the net (sec)

| Discard species | Average removal time | CNet N | CNet removal time (sec) | GPlastic film N | GPlastic removal time (sec) | GNet N | GNet removal time (sec) |
|---|---|---|---|---|---|---|---|
| *Charybdis longicollis* (invasive swimming crab) | 21.20 ± 4.35 | 175 | 3710 | 88 | 1866 | 108 | 2290 |
| *Goneplax rhomboides* (angular crab) | 17.65 ± 3.27 | 90 | 1589 | 47 | 830 | 46 | 812 |
| *Rissoides desmaresti* (mantis shrimp) | 60.70 ± 10.78 | 54 | 3278 | 22 | 1335 | 23 | 1396 |

## 4. Discussion

The trammel nets equipped with greenhouse plastic film and greenhouse shade cloth in the lower parts had fewer discards than the commercial trammel net. Moreover, there was no significant decrease in the catch of the target green tiger prawn species. Similar results were found in previous studies in the Mediterranean and the Black Seas. (Gökçe 2004, Metin et al. 2009, Aydin et al. 2013, Gökçe et al. 2016, Eryaşar et al. 2020).

The application of guarding nets to the lower parts of trammel nets has been previously investigated. (Gökçe 2004, Metin et al. 2009, Aydin et al. 2013, Gökçe et al. 2016, Eryaşar et al. 2020). Metin et al. (2009) found that although the ratios of the discarded species, i.e., crab (*Goneplax rhomboides*), spottail mantis shrimp (*Squilla mantis*, Linnaeus, 1758), and purple dye murex (*Bolinus brandaris*, Linnaeus, 1758) in the catch decreased by 35.62%, 40.71% and 44.77%, respectively, experimental guarding nets also decreased the catch of the target species by 36.46%. Gökçe et. al. (2016) showed that experimental guarding nets decreased discarded species, i.e., the lesser swimming crab (*Charybdis longicollis*, Leene, 1938), mantis shrimp (*Rissoides desmaresti*, Risso, 1816) and the blue swimming crab (*Portunus pelagicus*, Linnaeus, 1758), by 85%, 66% and 75%, respectively; however, they caused an 8% loss in revenue. Szynaka et. al. (2018) reported that experimental nets reduced discard species by 68.2%, but revenues also decreased by 38%. Eryasar et. al. (2020) calculated a revenue loss of 20% due to reductions in catches of the target species with the implementation of guarding nets. Sardo et. al. (2023)

found that guarding net implementation reduces discards by 20% while causing an economic loss of 40% due to a decreased amount of catch of the target species. Overall, in other studies to date, the technical implementation of guarding nets has decreased the amount of discards in the catch in trammel net fishery; however, this is along with a decrease in revenue due to decreases in catches of the target species. This was related to the technical modifications made to the nets to decrease discards, which also negatively affected the selectivity of the nets for the target species. Contrary to previous studies, the technical method of implementing guarding nets adopted in our study proved that the net using greenhouse nylon led to 24.75% more profit than the commercial nets, and the net using the greenhouse net led to 14.39% more profit than the commercial nets. The most important reason for the high economic gain in this study is the simple and effective implementation of guarding nets by modifying commercial nets in a cost- and labour-effective way compared to previous studies. Furthermore, the technical implementation of guarding nets in our study also caused increases in catches of other commercially important species without leading to a statistically significant decrease in the catch of the green tiger prawn, as opposed to previous studies.

These modifications were usually made while equipping the nets. One side of these modifications was fitted to the outer panel of the net, and the other side was fitted to the lead-collar side. In addition, outer guarding nets were added to both sides of the net; therefore, the modifications required a significant effort to equip the nets. The cost of the nets increased; hence, they were not preferred by the fishers. Therefore, in this study, the aim was to reduce the cost by simply sewing a 15-cm high greenhouse plastic film and greenhouse shade cloth to the lower part of the ready-made nets. To the best of our knowledge, this is the first study to apply a post-design to ready-to-use nets. The results indicated no loss of income in the modified nets, and there were increases in profits of approximately 25% in the GPlastic and 15% in the GNet. This increase in profitability could be related to the capture of more by-products by the post-design nets used in this study. The post-design nets suffered less damage because they caught fewer discarded species. Therefore, as the usage duration of nets increases, post-design nets are predicted to catch more economically valuable species than commercial nets, and their profitability is predicted to increase.

Target species are usually caught in the lower part of the net in the prawn trammel net fishery because both the target species and discarded species live on the ground, and their swimming abilities are limited (Gökçe et al. 2016). Consequently, the lower parts of the mesh were damaged more rapidly. In our study, the commercial nets caught nearly two times more discarded species than the post-design nets. Therefore, post-design nets can be deployed for longer periods than commercial nets. This study observed that the most destructive species to the nets was the invasive swimming crab. The species caused severe damage to the net by wrapping it around and cutting the nets with their claws.

Another problem with trammel nets is the labour required to remove discarded species from the nets (Bozaoğlu 2012). Mantis shrimp was the most difficult species to remove from the nets (~60 s). Mantis shrimp required two times more labour to be removed from the commercial net than from the post-design nets. Considering that the reported amount of discards was very high, especially in the summer months in this region (Bozaoğlu 2012), there would be a significant reduction in the labour and time spent on removing discards from the nets when GPlastic and GNet were used.

The height of the parts added to the net in the GPlastic and GNet designs was 15 cm. We did not choose to increase the height of the part because this may prevent the net from functioning when the currents are strong. However, we hypothesize that further research is needed to optimize the heights of the designs, as more extended parts could further increase the amount of target catch and decrease the discard rate. Considering the GNet structure, using more extended parts in the designs would not create a problem, as the GNet parts have water permeability. However, the GPlastic design is not water permeable. If GPlastic designs are used, drilling holes in the material may facilitate water flow through the net and make the design function more effectively.

Because the amount of discards is too high in prawn fishing with trammel nets in Mersin Bay during specific periods, fishers sometimes cannot deploy their nets in the sea the day after a haul because they cannot clean them (Bozaoğlu 2012). If these designs are used in these specific periods, it will be possible for fishers to catch more fish. In addition, it was observed that only the lower parts of the trammel nets were damaged. We also suggest covering the damaged sections with the designs used in this study, so that these nets can be used for fishing for an extended period.

This study showed that using greenhouse plastic film and greenhouse cloth in the lower parts of commercial trammel nets for prawn fishing in Mersin Bay reduced discards. The modifications resulted in less damage to the nets and shortened their cleaning times. The durability of the nets increased and the costs related to the nets, such as maintenance, repair, and renewal, decreased. Finally, whether the fishers would prefer these designs should be considered. Although post-design nets are much easier to equip and cheaper than previously tried-and-true designs, manual production of these post-design nets may hinder their adoption by fishers. Therefore, we suggest that fabrication or mounting of these nets by sticking them to the nets will increase the adoption of these post-design nets by fishers.

## Acknowledgements

We would like to thank the local fishing boat captains Erol YAVAŞ and Sinan YAVAŞ.

## Conflict of interest

The author has no conflicts of interest relevant to the content of this article to declare.

## Availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

## References

Aydın, I., Gökçe, G., & Metin, C. (2013). Using guarding net to reduce regularly discarded invertebrates in trammel net fisheries operating on seagrass meadows (*Posidonia oceanica*) in İzmir Bay (Eastern Aegean Sea). *Mediterranean. Marine Science*, *14*(2), 282-291. https://doi.org/10.12681/mms.425

Bayhan, Y. K., & Gökçe, G. (2010). Shrimp fishery in northeast Mediterranean Sea and technical specifications of the shrimp nets. *Journal of FisheriesSciences.Com, 4*(2), 129-135, (in Turkish) https://doi.org/10.3153/jfscom.2010012

Bayhan, Y. K., Çiçek, E, Ünlüer, T., & Özdöl, M. (2022). Catch Composition and Abundance of Shrimp Species in the Bottom Trawl Fishery from Northeast Mediterranean, Türkiye. *Journal of Marine Sciences and Fisheries*, *5*(2), 150-159. (in Turkish) https://doi.org/10.46384/jmsf.1181780

Borges, L. (2015). The evolution of a discard policy in Europe. *Fish and Fisheries*, *16*(3), 534-540. https://doi.org/10.1111/faf.12062

Bozaoğlu, A. S. (2012). Determination of By-Catch and Reduction in Trammel Net Fishery for Prawn in Mersin Bay. PhD Thesis, Mersin University, Mersin (in Turkish)

Catanese, G., Hinz, H., Gil, M. D. M., Palmer, M., Breen, M., Mira, A., Pastor, E., Grau, A., Campos-Candela, A., Koleva, E., Grau, A. M., & Morales-Nin, B. (2018). Comparing the catch composition, profitability and discard survival from different trammel net designs targeting common spiny lobster (*Palinurus elephas*) in a Mediterranean fishery. *PeerJ, 6*, e4707. https://doi.org/10.7717/peerj.4707

Eryaşar, A. R., Ceylan, Y., Özbilgin, H., & Bozaoğlu, A. S. (2020). Are Cloth Tarpaulin Mounted Nets Effective for Discard Reduction in Trammel Nets? *Turkish Journal of Fisheries and Aquatic Sciences*, *21*(2), 63-71. https://doi.org/10.4194/1303-2712-v21_2_02

FAO. (2018). The State of Mediterranean and Black Sea Fisheries. General Fisheries Commission for the Mediterranean Rome.

GFCM. (2021). New programme to empower small-scale fishers https://www.fao.org/gfcm/news/detail/fr/c/1392277/

Gökçe, G. (2004). Research on reduction of non-target species in shrimp trammel nets. PhD Thesis, Ege University Natural Science Institute, Izmir (in Turkish)

Gökçe, G., Bozaoğlu, A. S., Eryaşar, A. R., & Özbilgin, H. (2016). Discard reduction of trammel nets in the Northeastern Mediterranean prawn fishery. *Journal of Applied Ichthyology*, *32*, 427–431. https://doi.org/10.1111/jai.13015

Hall, S. J., & Mainprize, B. M. (2005). Managing by-catch and discards: How much progress are we making and how can we do better? *Fish and Fisheries*, *6*, 134–155. https://doi.org/10.1111/j.1467-2979.2005.00183.x

Jones, B. L., Unsworth, R. K., Udagedara, S., & Cullen-Unsworth L. C. (2018). Conservation concerns of small-scale fisheries: By-catch impacts of a shrimp and finfish fishery in a Sri Lankan lagoon. *Frontiers in Marine Science*, *52*(5), https://doi.org/10.3389/fmars.2018.00052

Kelleher, K. (2004). Discards in the world's marine fisheries. An update. FAO Fisheries Technical Paper No. 470 (draft), Rome.

Maynou, F., García-de-Vinuesa, A. G., Martínez-Baños, P., Sánchez, P., & Demestre, M. (2021). Relative catch performance of two gear modifications used to reduce bycatch of undersized fish and shrimp in Mediterranean bottom trawl fisheries. *Marine and Coastal Fisheries*, *13*(5), 518-533. https://doi.org/10.1002/mcf2.10178

Metin, C., Gökçe, G., Aydin, İ., & Bayramiç İ. (2009). Bycatch reduction in trammel net fishery for prawn (*Melicertus kerathurus*) by using guarding net in İzmir Bay on Aegean Coast of Turkey. *Turkish Journal of Fisheries and Aquatic Sciences*, *9*(2), 133-136. https://doi.org/10.4194/trjfas.2009.0202

Roda, M. A. P., Gilman, E., Huntington, T., Kennelly, S. J., Suuronen, P., Chaloupka, M., & Medley P. A. (2019). A third assessment of global marine fisheries discards. Food and Agriculture Organization of the United Nations.

Saidi, B., Enajjar, S., & Bradai, M. N. (2016). Elasmobranch captures in shrimps trammel net fishery off the Gulf of Gabès (Southern Tunisia, Mediterranean Sea). *Journal of Applied Ichthyology*, *32*(3), 421-426. https://doi.org/10.1111/jai.13061

Sardo, G., Vecchioni, L., Milisenda, G., Falsone, F., Geraci, M. L., Massi, D., Rizzo, P., Scannella, D., & Vitale, S. (2023). Guarding net effects on landings and discards in Mediterranean trammel net fishery: Case analysis of Egadi Islands Marine Protected Area (Central Mediterranean Sea, Italy). *Frontiers in Marine Science*, *10*, 1011630. https://doi.org/10.3389/fmars.2023.1011630

Sartor, P., Li Veli, D., De Carlo, F., Ligas, A., Massaro, A., Musumeci, C., Sartini, M., Rossetti, I., Sbrana, M., & Viva C. (2018). Reducing unwanted catches of trammel nets: Experimental results of the "guarding net" in the caramote prawn, *Penaeus kerathurus*, small-scale fishery of the Ligurian Sea (Western Mediterranean). *Scientia Marina*, *82*(S1), 131-140. https://doi.org/10.3989/scimar.04765.15B

Szynaka, M. J., Bentes, L., Monteiro, P., Rangel, M., & Erzini, K. (2018). Reduction of by-catch and discards in the Algarve small-scale coastal fishery using a monofilament trammel net rigged with a guarding net. ). *Scientia Marina*, *82*(S1), 121-129. https://doi.org/10.3989/scimar.04734.16B

Thomas, S. N., Edwin, L., & George W. C. (2003). Catching efficiency of gill nets and trammel nets for penaeid prawns. *Fisheries Research*, *60*(1), 141–150. https://doi.org/10.1016/S0165-7836(02)00057-7

Tiralongo, F., Mancini, E., Ventura, D., De Malerbe, S., Paladini, De Mendoza, F. P., Sardone, M., Arciprete, R., Massi, D., Marcelli, M., Fiorentino, F., & Minervini R. (2021). Commercial catches and discards composition in the central Tyrrhenian Sea: A multispecies quantitative and qualitative analysis from shallow and deep bottom trawling. *Mediterranean Marine Science*, *22*(3), 521-531. https://doi.org/10.12681/mms.25753

Tsagarakis, K., Palialexis, A., & Vassilopoulou V. (2014). Mediterranean fishery discards: Review of the existing knowledge. *ICES Journal of Marine Science*, *71*(5), 1219-1234. https://doi.org/10.1093/icesjms/fst074

TUIK. (2020). Fishery production [www Document]. URL <https://data.tuik.gov.tr/Bulten/Index?p=Su-Urunleri-2020-37252> (accessed 6.04.22) (in Turkish)